Investigating the Influence of Cultural Differences on Systems Engineering: A Case Study of the Manned Spaceflight Programs of the United States and China

by

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ABSTRACT

The current trend of globalization as well as the growing complexity of multilateral systems engineering endeavors will contribute to the increasingly cross-cultural nature of systems engineering programs and teams in the future. It is thus vital to investigate if cultural differences have an influence on systems engineering endeavors in order to better understand culture's potential contribution, or impediment, to critical systems engineering outcomes. This thesis proposes a definition of culture that will be meaningful to such an investigation, selects Hofstede's cultural dimensions theory as a tool to apply this definition of culture, and analyzes the manned spaceflight programs of the US and China as a case study to determine if culture does indeed have an influence on systems engineering.

The results of this analysis reveal that cultural differences do impact systems engineering endeavors from strategic to operational levels. Important differences in the US and China manned spaceflight programs primarily stemming from differences in the cultural norms of the US and China were found in three main areas of analysis. Firstly, in terms of the purpose of the programs, cultural differences led to differences in the kind of motivations each country had for achieving manned spaceflight, the organizations set up to achieve this goal, and the way leadership approval for the programs was attained. Secondly, in terms of the programs themselves, differences in cultural attitudes towards risk and launch failure led to differences in program schedule, program scope, the nature of the flight-testing schedule, and the extent of quality control measures. Thirdly, in terms of the people involved in the programs, differences in cultural norms led to differences in decision-making styles, use of authority, motivations and earnings of the engineers and astronauts, extent of astronaut involvement in the programs, the extent of manual control built into manned spaceflight launches, the degree of formality of the launches, and media coverage of the launches.

Furthermore, these two very different programs were eventually judged to be a success in each nation precisely because of these cultural differences, even though each country's program would have been considered a pyrrhic victory in the other. The conclusions of this thesis propose how this demonstrated influence of culture on systems engineering should be used to inform systems engineering endeavors in the future.

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“We knew they were going to do it! Vanguard will never make it. We have the hardware on the shelf. For God’s sake, turn us loose and let us do something. We can put up a satellite in sixty days…Just give us the green light and sixty days!”

- Wernher von Braun in response to the successful launch of Sputnik I by the former Soviet Union on October 4, 1957 (McDougall, 1997)

“We have a long way to go in this space race. We started late. But this is the new ocean, and I believe the United States must sail on it and be in a position second to none.”

- President John F. Kennedy in remarks following the successful Friendship 7 flight of Colonel John Glenn on February 20, 1962

"It's really some exciting news to share. The world's spacefaring nations have been joined by a new member tonight: China."

- ISS Spacecraft Communicator Mike Fossum from Houston informing Expedition 7 Commander Yuri Malenchenko and Science Officer Edward Lu of the successful Shenzhou 5 launch carrying Chinese taikonaut Yang Liwei on October 15, 2003 (NASA, 2003)

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1. Introduction

1.1 Problem Statement

"Do cultural differences have an influence on a systems engineering endeavor?"

This question may elicit a variety of responses when posed to various individuals, whose answers may be founded upon a multitude of things including their past experiences, their observations of the world around them, their assumptions, their beliefs regarding how our world should be, and most importantly, what they think the question means. It is certainly not a question with a straightforward answer, not least because the nebulous concept of "culture" and the less nebulous (but still complex) concept of "systems engineering" inevitably mean different things to different people.

Nevertheless, this question needs to be answered because our increasingly globalized world and the concomitant increase in systems engineering projects that involve people from various countries are bringing into starker relief the differences and boundaries among national cultures. At the same time it is precisely this trend that is feeding the belief that cultural boundaries will eventually become meaningless in our globalized world. In order to continue tackling these cross-cultural systems engineering projects that will only grow in size and complexity, we need to know which of these should be the guiding principles for systems engineering endeavors in the future. Are cultural considerations an important factor when carrying out systems engineering endeavors? Or is culture merely a quaint concept that will soon become irrelevant in our global village, much less the realm of systems engineering?

1.2 Research Questions

The primary research question that this thesis hopes to answer is

Do cultural differences have an influence on a systems engineering endeavor?

In relation to this primary research questions, three secondary research questions are:

- How should culture be defined in a manner that is meaningful and relevant to an investigation of its influence on systems engineering?

  As the concept of "culture" or "cultural differences" has a great many definitions in the literature, it Is important to define this concept in a way that allows for a meaningful investigation of its influence on a systems engineering endeavor. Too narrow a definition risks not capturing the full nature or extent of such an influence, and too broad a definition risks generating conclusions that are far from meaningful. A well-considered and appropriate definition is thus needed for any such investigation to take place.

- What is the nature of such a potential influence and through what mechanisms might it impact a systems engineering endeavor?

  If cultural differences do have an influence on systems engineering, it is important to explore the nature and extent of this influence. Are these influences merely cosmetic or do they have actual repercussions in reality? Do they only influence a systems engineering endeavor at the tactical or lowest operational levels or do they impact such an endeavor at the strategic level? What aspects of a systems engineering endeavor do they have an influence on?

- If such an influence does exist, what implications does this have and what recommendations can be drawn for systems engineering endeavors in the future?

  If proven to exist, what do cultural differences imply for systems engineering endeavors in terms of how they should be approached in the future? Should they seek to incorporate all sorts of different cultural norms in accordance with specific program needs, or should the geographical context that such an endeavor is situated in be the overriding factor with the endeavor being architected in line with prevailing cultural norms? How should one utilize this influence to the benefit of the systems engineering endeavor at hand?

1.3 Methodology

First, a literature review was conducted to determine how the concept of culture should be defined in way that is most relevant and useful for the problem statement at hand. This involves a selection and justification of what kind of cultural factors are being looked at, what lines these factors will be compared along, and what level such a comparison will take place at. Potential criticisms regarding such a framing are also considered and addressed. **Second**, the nature of the relationship between culture and systems engineering is explored, taking into consideration the current literature that speaks to this relationship, and the need to explore this relationship is justified. **Third**, the choice of manned spaceflight programs of the US and China as a case study to demonstrate and explore this relationship is proposed, explained and justified. **Fourth**, the choice of Hofstede's Cultural Dimensions Theory as a framework to examine the effects of cultural differences on the manned spaceflight programs of the US and China is explained and justified, and its intended method of application elaborated on.

Fifth, Hofstede's framework is applied to an analysis of the US and China manned spaceflight programs in an iterative manner. In the initial stages, a possible method of application of the framework is proposed and the case study analyzed, using the results of this analysis to further inform the method of application of the framework. The mode of application of the framework is then modified and reapplied to the case study. This iterative process has resulted in the analysis of the two manned spaceflight programs from three different angles (purpose, program and people), utilizing three out of the six cultural dimensions of Hofstede as the main explanatory dimensions due to their demonstrated superior explanatory capabilities compared to the other three dimensions. **Lastly,** lessons that can be drawn from this analysis are elaborated on, and recommendations are made for systems engineering endeavors in the future where cultural considerations are a relevant factor.

1.4 Potential contributions

Investigating the effects of culture on systems engineering allows us to better understand its potential contribution, or impediment, to the engineering outcomes that matter so much to the people involved. Doing so gives us the opportunity to maximize cultural capital to its fullest potential, while ignoring it may very well lead one into pitfalls where the prevailing culture works contrary to the systems engineering endeavor when such a conflict might have been avoided with more awareness and foresight.

With increasingly complex systems engineering projects that involve an increasing number of countries, span across a greater diversity of fields and require an immense amount of cooperation and coordination among different cultures, the effects of culture on systems engineering will only become increasingly pronounced.

The primary goal of this thesis is thus to demonstrate that culture does have a real influence on systems engineering, outline the nature of this influence, and characterize the influence for systems engineering endeavors. In doing so, its secondary goal is to provide a vision for the future where:

1) On the very first level, within a national systems engineering endeavor, people may architect systems engineering endeavors in ways that align with the prevailing national culture for maximum effect, or if found to be beneficial in certain cases, adopt aspects of cultures foreign to their own for systems engineering projects where a targeted dissonance or disruptive effect is the one desired.

2) On the second level, within a bicultural or multicultural systems engineering endeavor, people may accept that cultural differences are not an imagined construct and do have a real impact on the way people from different cultures perceive the world and work towards their goals. This would greatly assist in avoiding cultural pitfalls or negative reactions to cultural differences in order to prevent disruptions to the overall efforts of systems engineers working together.

3) On the third level, within a global systems-engineering ecosystem, people may see cultural diversity as a resource or opportunity rather than a source of irritation or a threat, and leverage differences in culture to enhance complex systems engineering endeavors rather than merely tolerating them.

1.5 Thesis outline

The outline of this thesis is as follows:

- **Chapter 2** proposes a definition of culture that is most relevant for answering the research questions at hand, explores potential criticisms for such a framing, discusses the relationship between culture and systems engineering with reference to available literature, and explains the choice of manned spaceflight programs of the US and China as a case study for exploration of this relationship.
- **Chapter 3** presents Hofstede's Cultural Dimensions Theory as a framework that will be utilized for the comparison of cultures of the US and China, justification for this framework, and an elaboration of how this framework will be used.
- **Chapter 4** presents an introduction to the US and China manned spaceflight programs, the historical motivations that led up to the beginning of both programs, as well as the cultural differences that influenced these historical motivations in different ways.
- **Chapter 5** presents how the US and China manned spaceflight programs were carried out operationally, illustrates the differences between these actual programs in terms of program schedule and program scope, and explains how these differences were culturally motivated.
- **Chapter 6** presents the people side of the US and China manned spaceflight programs, and illustrates differences with regards to the engineers and astronauts in terms of how decisions were made, how authority was exerted, how astronauts were involved in the program among others, together with cultural explanations for these differences.
- **Chapter 7** concludes the thesis with lessons that can be drawn from the above analyses, recommendations for the future, limitations of this work, and future extensions for work in this area.

2. Systems Engineering and Culture

This chapter serves to define the two concepts of systems engineering and culture for exploration in this thesis, explain the rationale for defining them as such, justify the importance of investigating the influence, if any, that culture may have on a systems engineering endeavor, as well as explain the choice of the manned spaceflight programs of the US and China as a case study to investigate such an influence.

2.1 Systems Engineering and Systems Thinking

The International Council on Systems Engineering (INCOSE) defines Systems Engineering as "an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem" (INCOSE, 2004). NASA defines Systems Engineering as "a methodical, disciplined approach for the design, realization, technical management, operations and retirement of a system" as well as "a way of looking at the 'big picture' when making technical decisions" and "the art and science of developing an operable system capable of meeting requirements within often opposed constraints" (NASA, 2007).

Other definitions and choices of words for defining Systems Engineering exist, and these are all very much driven by the mandates, circumstances and challenges of those individuals or organizations doing the defining. Still, there are common threads that run through these various definitions, ideas such as "interdisciplinarity", "holism", "tradeoffs", "emergence" and "complexity", and the concept of Systems Engineering in this thesis would essentially comprise these concepts put forward by INCOSE and NASA; these ideas will play an important part in the discussion of whether culture plays a role in systems engineering.

A related and perhaps equally important concept to be addressed at this point would be the concept of "systems thinking". In a similar fashion to systems engineering, many definitions of systems thinking exist. For example, INCOSE UK defines systems thinking as the recognition "that the world is a set of highly interconnected technical and social entities which are hierarchically organised producing emergent behaviour" (INCOSEUK, 2010). These various definitions display commonalities including a focus on holism (or wholes), emergence, interrelationships, complexity and context (Lamb, 2009). Systems thinking thus involves the ability to appreciate, comprehend and utilize these ideas when looking at a system, which would imply not considering a system solely in terms of its individual components, but viewing it as a holistic entity where complex interrelationships exist among its parts and the context the system is situated in, which may give rise to emergent behavior.

Systems thinking and systems engineering are thus very much intertwined. One may say that systems thinking is that philosophy or habit of mind which drives a successful system engineering process. Insofar as systems engineering is an activity that involves decisions and choices and which is conducted by human beings, who bring along with them their own values, opinions, preferences and biases into the process, it seems plausible that the culture of those involved in a systems engineering process may play a role in the outcomes, even though the presence and magnitude of this role certainly requires further discussion.

The term "systems engineering endeavor" is used in this thesis to broadly refer to any endeavor that is systems engineering in nature and which draws upon systems engineering principles, methods and/or tools. This might be a project, a program, a design effort etc., and the rationale behind the choice of this term as opposed to a systems engineering "program" or "project" is to avoid restricting the scope of the discussion to only systems engineering endeavors of a particular size or scope, as well as to avoid implying that only large and complex endeavors deserve consideration of culture's possible influence on them.

While people may achieve fairly broad agreement on what the terms "systems engineering" and "systems thinking" encompass, the concept of "culture" warrants a more extensive discussion.

2.2 "Culture" – What does it mean?

The word "culture" means different things to different people, and the literature up to today has demonstrated that it is virtually impossible to come up with a definition that all would agree with. Rather than attempt to crystallize a definition of "culture" based on popular precedent, it is more useful to think about what sort of definition would be most constructive for investigating the influence of culture on systems engineering. As such an investigation would essentially involve looking across different cultures, any definition should be framed with the intent of such comparisons in mind. To that end, three fundamental questions must be answered with regards to this definition: 1) What are we comparing if we were to compare various cultures? 2) Along what lines are we making such comparisons? And 3) At what level are we making such comparisons?

2.2.1 What are we comparing across cultures?

In response to the first question, it is important to point out three broad categories of things that the word "culture" may refer to. The first would be cultural artifacts – items such as cuisine, art, movies, literature, languages etc. that may be readily exported from one culture to another; these might be known as "stock cultural factors". They exist independently of the people that they originate from, and are usually the "ambassadors" of the culture that they represent. The second would include things such as actions, words, habits etc., or visible manifestations of a person's culture when interacting with someone else, which might be known as "transactional cultural factors" (Proctor, 2012). They require the person that they originate from as well as a receiver in order for them to be observed. Lastly, the third would include things such as worldviews, values, norms, and attitudes etc. that exist within a person, which might be known as "inherent cultural factors". These are considered to be an inherent part of a person and their existence does not rely on the presence of a receiver.

Connections exist among these three types of factors, most obviously the way in which inherent cultural factors are translated into transactional cultural factors, but more interestingly, one might define culture using any of these three types of factors or a combination of them, depending on one's motives. If we consider how culture plays out along a particular line such as geographical lines (one example of a dimension of cultural differences), campaigns by nations to promote their soft power, such as Confucius Institutes and Goethe-Instituts, allow people to experience Chinese or German culture through the practice of Chinese calligraphy, German films and of course, the learning of Mandarin and German; they would thus focus more on "stock cultural factors". Cross-cultural negotiation teams and cultural intelligence trainers in MNCs tend to focus on "transactional cultural factors", reminding their members to, for example, not attempt to be openly critical in front of British or not say anything one doesn't mean literally in front of Japanese. The last set of "inherent cultural factors" tend to be favored by those in academia, as they are seen to be the driving force of many other manifestations of culture, and the fundamental source of what people might view as "cultural differences". Unfortunately, they also tend to be the most complex, least easily quantifiable, and most difficult to truly understand. With this recognition that different people would take the word "culture" to possibly refer to any one or any combination of the above three types of factors, and would be equally valid in doing so based on their intentions and fields, the question then would be which sort of cultural factor to focus on when comparing the influence of different cultures on systems engineering endeavors.

2.2.2 Along what lines are we comparing across cultures?

The next question, upon deciding what sort of cultural factor to use as a basis of comparison, would be to ask what sort of lines it would be useful to think along when we are considering if culture plays a role in systems engineering. Should we think of cultural differences along geographical lines, as mentioned above, which can be done in terms of the simplest dichotomy (the different cultures of the West and East), or in an incredibly granular fashion (such as the different cultures of people living in Boston and Cambridge)? Should we think of cultural differences along ethnic/ethnoreligious lines, such as “Asian culture” or “Jewish culture”? Linguistic lines such as speakers of English versus speakers of Mandarin? Organizational lines such as the cultures of different companies or teams? Occupational lines such as the cultures of the people from the military versus that of educators? The list goes on and it is possible to argue that any sort of grouping that a person belongs to has its own culture that can be contrasted with that of a different grouping in the same category. A choice, then, has to be made regarding which particular line any comparison of cultures will take place along.

In fact, “culture” is a relative concept. A culture probably cannot be said to exist on its own without a counterweight, a culture of another grouping that serves to crystallize the unique characteristics of the original group that are seen as its culture. This means that in the process of focusing on the characteristics that bind a cultural group as one, we inevitably imply that somewhere out there, there is a group that embodies characteristics that are not the same. Cultural similarities and cultural differences ultimately go hand in hand in any discussion of culture.

2.2.3 At what level are we comparing across cultures?

After deciding what sort of cultural factor to compare and along what lines, a final decision to be made concerns the level at which this comparison is to take place. Here a clear distinction needs to be made between the “the line of comparison” and “the level of comparison”. The former, as explained in Subsection 2.2.2 above, has to do with the nature or characteristics of the individual(s) being compared – i.e. whether the differences are seen in an occupational light or geographic light or organizational light. The level of comparison has to do with the number of individuals that form the basic entity for comparison, i.e. whether we want to compare individuals, or a group of 100 individuals, or a whole nation of individuals.

One’s choice of level may thus range from the most granular – an individual, to the less granular – a team, an organization, a country or even an entire geographical region. The former would place the individual involved in a systems engineering endeavor at the center of the analysis, and investigations would entail looking at how certain cultural characteristics of an individual may influence the outcome of his efforts. In contrast, the latter approach would look at a group of individuals as a whole (with the total number of individuals increasing with decreasing granularity), and investigations would involve studying how the overall cultural characteristics of this group might influence a systems engineering endeavor on this level.

2.3 Comparing Inherent Cultural Factors along Geographical Lines at a National Level

How culture comes into the picture when considering systems engineering thus needs to be framed by the three questions above. I would put forward that considering how inherent cultural factors distinguished along geographical lines and at a national level have an influence on systems engineering is a meaningful way of framing this discussion. In other words, I have chosen to explore the role that national geographical culture plays in systems engineering.

2.3.1 Inherent Cultural Factors as a Point of Comparison

Why should we focus on inherent cultural factors – values, norms and beliefs for example, when exploring the role that culture plays in systems engineering, as opposed to say transactional cultural factors like cultural habits or traditions? In looking at the role of culture in systems engineering or thinking, we may of course be interested in what someone does, how he/she behaves and acts and treats others around him. But there are necessarily more fundamental factors at work that determine why two individuals from different cultures act differently, or more interestingly, act in the same way. They might demonstrate the same transactional cultural characteristics but for entirely different reasons, or even demonstrate different transactional cultural characteristics with the same motives. Studying cultures at the transactional level would be akin to attempting to combat a disease by targeting the symptoms; without an understanding of the underlying motives and drivers of these transactional cultural characteristics, the discussion of the role of culture in systems engineering would be incomplete.

This choice of definition for culture ties in with that proposed by many researchers such as Rohner, who according to Smith et al. suggests culture "lies in the shared way in which individual interpret what goes on around them." (Rohner, 1984) (Smith, 2006) This means that a culture may exist among individuals if they are able to interpret events around them, including behaviors of people or the context where these behaviors occur, in a shared way. The greater the extent to which such similarities in interpretation exist, the greater the confidence in which we can say that these individuals share a culture. (Smith, 2006) Therefore, culture as defined as such may be interpreted as having similar worldviews, values, norms, attitudes and beliefs, which can all be summed up as having a similar way of interpreting that which goes on around them.

2.3.2 Comparing Cultures along Geographical Lines

Why should we address these inherent cultural factors along geographical lines, i.e. culture that can be ascribed to a particular geographical region, as opposed to say organizational or occupational lines? It is necessary to address the choice of geographical location as a dimension along which to compare cultural differences. In other words, why should we be looking at geographical location and separation as a dimension for comparison when we are considering the ways in which peoples' worldview, values, attitudes and norms (i.e. their cultural characteristics) differ?

To be completely accurate, geographical distance in and of itself isn't a true indicator or predictor of cultural differences (people aren't culturally different just because they live further apart), but the way in which modern human society has evolved from its early years means that it is still a pretty good proxy when we are looking to enhance the extent of cultural differences being compared.

There are two types of factors that may be thought of as having an influence on an individual's culture: natural environment factors and human environment factors. Natural environment factors refer to those factors that arise from nature, such as land formation, climate, wildlife etc. Human environment factors refer to all those other factors that arise from or are created by humans, including societal institutions, laws, family units, infrastructure, social policies, and of course the culture of those other individuals that form the society that this individual exists in.

In order to understand how geographical separation contributes to cultural differences, it is useful to consider some theories on how cultures are "created" and shaped. Tong and Chiu believe that certain values, attitudes and norms become relatively "popular in a group if it can facilitate attainment of individual goals under a set of physical and human-made constraints and opportunities". (Tong & Chiu, 2012) In other words, people adopt a certain culture, a certain way of viewing the world, because it makes sense to do so in the cultural milieu that they are located in geographically. Culture is not a biologically programmed concept; people are not born a certain way or to think in a certain manner. Rather, it is the environment that they are located in, both the physical and manmade aspects of it, which imprint on and shape the culture of an individual. This is also in line with Hofstede & Hofstede's claim that "An individual human being acquires most of her or his programming during childhood, before puberty. In this phase of our lives we have an incredible capacity for absorbing information and following examples from our social environment: our parents and other elders, our siblings and playmates. But all of this is constrained by our physical environment: its wealth or poverty, its threats or safety, its level of technology. All human groups, from the nuclear family to society, develop cultures as they go. Culture is what enables a group to function smoothly." (Hofstede & Hofstede)

As an example, a study by Tong and Chiu focused on determining the proportion of people within their American and Chinese experimental groups who engaged in a certain cultural practice known as dispositional attribution (or the tendency to attribute an act to the disposition of the actor) versus intentional or situational attribution (the tendencies to attribute an act to the intention or the situation of the actor respectively). They discovered that although these three types of tendencies existed in both the American and Chinese experimental groups, there were significantly higher dispositional attribution tendencies in the American group compared to the Chinese group. They propose that this is due to American societies being relatively open, in which Americans are encouraged to exert their freedom of choice through various institutions and channels. This results in individuals realizing that it indeed makes sense to act in accordance with their individual dispositions and traits as they have the freedom to do so and because there is value in such pursuits, as well as to attribute the actions of others to their disposition because probabilistically speaking, they would be right more often than not. Human biases notwithstanding, the ability and tendency of humans to observe and latch on to patterns and trends encourages the learning and internalization of such cultural characteristics that seem to make sense and serve them practically, and this is a plausible explanation for the relatively higher percentage of dispositionists in American society. Conversely, decisions and choices in a Chinese community may be driven more often than not by societal expectations, where people are more often expected to act in ways not because they want to, but because they are expected to. It would thus make sense for relatively less Chinese to engage in dispositional attribution because attempting to do so too often may end up backfiring with regards to their judgments of people. (Tong & Chiu, 2012) Obviously, it is not the case that Americans will always act in ways that completely mirror their individual dispositions, and neither do Chinese always lack the freedom to act in accordance to their dispositions, but the relative frequency in which these behaviors occur in these different cultural groups tends to encourage a more popular or more dominant way of thinking.

It is expected that many cultural characteristics are shaped in a similar fashion, where a cultural group internally reinforces certain cultural mindsets and values, and works to imprint these same cultural characteristics on new entrants into that group, by making it logical or attractive for people within the group to adopt those characteristics. This process essentially takes place from the birth of an individual, who, when old enough, then takes on the mantle of imprinting his by then acquired culture onto the next generation. Hofstede et al. refer to this "powerful stabilizing" cycle as "homeostasis" and claim that "Parents tend to reproduce the education that they received, whether they want to or not." (Hofstede, Hofstede, & Minkov, 2010). Tong and Chiu also support this view and claim that "widely shared cultural knowledge provides individuals with a consensually validated framework to interpret otherwise ambiguous experiences. It informs individuals in the society what ideas or practices are generally considered to be true, important, and appropriate". (Tong & Chiu, 2012) In the words of Gelfand and Diener, "Culture as a key source of sustained experience, intricately affects such phenomena as neural structure and function; memory; decision making; the self; personality; and developmental group, organizational, and national processes. In turn, such processes reinforce and sustain the very cultural contexts in which they are embedded.” (Gelfand, 2010) These cultural imperatives in turn shape societal institutions, laws, infrastructure, and social policies, which together with those very cultural imperatives reinforce and maintain the culture of a group. In fact, in testimony to the importance of these human environment factors in shaping culture, there have been certain historical events around the world that probably changed the societal incentives to act and think in a certain way sufficiently to actually transform the culture of a geographical group.

If the culture of a group within a certain geographical region is indeed self-reinforcing and maintaining, with the caveat that significant societal upheavals do have the potential for cultural transformation effects, this begets the question of how these differences arose in the first place. As we trace the origins of various geographical groups back into history, it is hard to imagine the earliest human settlers intentionally choosing to act in different ways without a very clear impetus to do so. This ultimately points to the natural environment and the natural circumstances that humans first found themselves in, the very first set of constraints and opportunities that encouraged certain cultural characteristics and discouraged others, and which set the foundation for future cultural differences to come into stark contrast in our modern world today.

The world is a geographical diverse place, and the peculiarities of various regions resulted in individuals settled in those areas adopting different ways of hunting, agriculture, communication, structuring their society and consequently different values, attitudes and norms in which they came to understand and interpret the world around them. The fact that geographical distance in the past was actually not easily overcome until very recently in human history also played a part in encouraging the formation of distinct cultures in different locations. The fields of cultural geography and environmental determinism are devoted to espousing such a view.

Hofstede et al. point to various geographical factors that explain why different communities might adopt different survival practices which in turn encouraged certain cultural values at the expense of others, such as differences in climate (with temperate climates encouraging agriculture compared to colder climates), the land areas on different continents, and their distance from Africa (which influenced the historical period when they were colonized and thus the level of intelligence of their colonizers), and claim that “The first reason for cultural diversity has been adaptation to new natural environments. As humankind gradually populated almost the entire world, the need for survival led to different cultural solutions” (Hofstede, Hofstede, & Minkov, 2010). Hofstede & Hofstede suggest that “The result of these developments [in human civilization] is the huge spectrum of cultures of today…hunter-gatherers have had rather individualistic, small power-distance, uncertainty tolerant, long-term oriented cultures. Agriculture and massive societies have led to more collectivistic, large power distance, uncertainty avoiding cultures” (Hofstede & Hofstede). Hofstede et al. also cite a study by Monique Borgerhoff Mulder, a US anthropologist, and her team, which demonstrated that “hunter-gatherer and horticulturalists had societies that were as egalitarian as the most egalitarian of modern societies, while agriculture was associated with a strong hierarchy in society”. (Hofstede, Hofstede, & Minkov, 2010). Thus as early human civilizations developed, the different geographical environments that they were in imposed different imperatives on them in terms of such practices needed to survive and flourish, and these encouraged the evolution of different cultures.

Along the way, as manmade institutions and societies began to take hold, these undoubtedly also contributed towards shaping the culture of various geographical regions, but researchers often find it challenging to attribute cultural differences solely to such human creations. For example, one might think that the level of development or modernity of a society would have an impact on its culture, but one can easily point to places all around the world, with similar levels of modernity, but which have vastly different cultures. The same goes for other manmade or human imposed institutions such as choice of political system or legal institutions. In other words, although the human aspects of a society do contribute to the evolution of a culture, it is important to consider that many of the cultural differences that we observe now have their roots in environmental factors that do not seem immediately obvious in the globalized world of today.

This explains why it has always been attractive to researchers to attempt to group countries that are in geographical proximity to one another as a cultural group. For example, the “Global Leadership and Organizational Behavior Effectiveness”, also know as the GLOBE study, groups countries into various clusters that reveal a preference for geographical clustering (House, 2004). However, there are also certain exceptions, where countries that are not necessarily in geographical proximity are placed in the same group; these are however more of the exception than the rule. Reasons for these tend to fall under the category of significant societal upheavals or large-scale human migrations, which can be seen from the grouping of Australia and USA together with other “Anglo” countries such as England and Ireland, and the grouping of Singapore not within the “Southeast Asian” grouping with its neighboring countries but within the “Confucian” grouping together with China, which can both be explained by mass migration phenomena.

In summary, the ways in which natural and human environment factors primarily influence the culture of a regional group are different. Different natural environmental factors in different regions largely *kickstarted* the adoption and promotion of certain cultural characteristics over others, and subsequently human environmental factors primarily *maintained* or *reinforced* these cultural characteristics. As summarized by Hofstede et al., “The exposure of different peoples to different means of subsistence varies widely. So do their climates, flora, fauna, and geographical contextual factors. Moreover, if selective pressures differ in different places, evolution tends to diverge. Selection mechanisms at the group level tend to keep values and some practices stable within the group and to maintain symbolic boundaries between groups. As a result, the present world shows an amazing variety of cultures, both in terms of values and in terms of practices.” (Hofstede, Hofstede, & Minkov, 2010). Still, it should be noted that natural environmental factors may also continue to maintain and reinforce cultural characteristics, and that changes in human environment factors may also result in significant societal upheavals that transform the culture of a place.

Nevertheless, due to the fact that natural environmental factors played an important role in the establishment of different cultures and that the advent of globalization only really took off in the last fifty years, giving previously relatively isolated geographical groups sufficient time to internalize and entrench certain cultural characteristics via their created societal institutions, geographical location and separation still continue to play a part in explaining cultural differences. That said, it is useful to keep in mind that geographical proximity is no guarantee of cultural similarity, nor is geographical distance a guarantee of cultural dissimilarity. But the current state of the world is such that geographical separation still remains a useful proxy for delineating the variation of culture among human individuals.

2.3.3 Comparing Cultures at a National Level

When comparing cultures along geographical lines, we may choose any level ranging from the most granular approach of comparing the culture of individuals from different geographical regions, to arguably the least granular approach of comparing the cultures of the East and the West. Why should we then choose to compare cultures at the national level, i.e. the cultures of different nations?

A study that is highly relevant to this issue was conducted by Shalom Schwartz whereby the importance of a set of 40-50 values to people of different nationalities was analyzed, both at the individual level and at the nation level. From his individual level analysis, Schwartz identified ten value types, such as security, power, conformity etc. ordered along two major dimensions: openness to change vs. conservation and self-enhancement vs. self-transition. From his nation level analysis, Schwartz obtained seven international value types along three polar dimensions: hierarchy versus egalitarianism; mastery versus harmony; and conservatism versus intellectual and affective autonomy. (Schwartz, 1992)

Interestingly, Schwartz found that the level of endorsement of certain values on the nation level actually differed from the level of endorsement on the individual level. This implies that results of studies which consider each individual as a separate case might differ from those of studies that consider each nation as a separate case, even though on the surface the same sort of aggregation is taking place for both methods. For example, Schwartz found that in his values survey, "humble" and "authority" might be endorsed equally strongly at a nation-level but yet appear at opposite ends of the spectrum at an individual level. An explanation for this would be that while a nation as a whole values certain individuals acting with authority and certain individuals being humble, reflecting a certain importance attached to social hierarchy, a particular individual would rarely endorse both values to an equally high extent; rather, it is the interplay among individuals that contribute to the overall endorsement of both values at a nation level. (Smith, 2006) Triandis also illustrates how national and individual levels of analysis may be distinct by suggesting that while at the national level, individualism and collectivism are seen as two ends of a spectrum, there may exist a correlation between collectivist and individualist outlooks in an individual, and that individuals who live in both sorts of environments may grow up embodying both characteristic traits. (Triandis, 2004)

Ultimately, Smith et al. point out that "nations are not individuals", and neither are individuals nations (Smith, 2006); to infer that a relationship that exists at the nation level also exists at the individual level is fallacious, dubbed the "ecological fallacy" by Hofstede, and to infer the opposite is also similarly fallacious, known as the "reverse ecological fallacy". (Hofstede G. H., 2001) A nation level comparison thus reflects the broader cultural trends that run through a cultural group, but in doing so does not clearly reflect the interplay of different values and beliefs on an individual level. These concepts are in a way related to the idea of cultural characteristics as probability distributions within a certain cultural group. Just because a group may have an overall cultural characteristic does not imply that individuals need necessarily embody that characteristic, and the individual characteristics of respondents need not always translate directly into overall group characteristics. Indeed Hofstede et al. are determined to remind us that "the culture of a country [as a nation level comparison]…is not a combination of properties of the "average citizen", nor a "modal personality." It is, among other things, a set of likely reactions of citizens with a common mental programming. One person may react in one way, and another in another way. Such reactions need not be found within the same individuals, but only statistically more often in the same society." (Hofstede, Hofstede, & Minkov, 2010)

Therefore, the choice of level of comparison is not a trivial decision; deciding to compare the cultures of individuals would yield very different results from a comparison of the cultures of nations or even the East and the West. Either extreme on this spectrum has its own pros and, more importantly, cons.

There are three main reasons why comparing the cultures of individuals, such as by seeing how individuals from different cultures may perform a systems engineering-related task differently, would not be very useful, even if some form of aggregation of individual results is eventually carried out. One disadvantage of comparing the culture of individuals is the fact that intracultural variation (the variation among individuals considered to be belonging to the same culture) is usually not insignificant. While this does not in itself invalidate the idea of these different individuals belonging to the same culture (as explained by Schwartz) it does mean that any analysis that focuses on the individual will often be affected by too much noise to yield conclusive results especially with small sample sizes. Secondly, even if some form of aggregation is eventually carried out to account for such noise in the form of intracultural variation, the fact remains that the culture of a group is more than the sum of its constituent parts, or in other words, a certain form of cultural emergence exists when considering the culture of a group of individuals as a whole, implying that focusing solely on the culture of individuals is insufficient for understanding the culture of the group. Thirdly, any systems engineering endeavor is invariably a team effort; the actions of individuals as influenced by their culture cannot be meaningfully viewed or evaluated in isolation. Any effort to study how individual cultural differences impact systems engineering would be far removed from the realities of what happens in actual systems engineering projects, even if it might admittedly reveal some interesting insights.

Would we then be better off comparing the cultures of the West and the East, arguably the highest-level dichotomy that the world may be split into? One obvious disadvantage of doing so would be to lose the ability to make nuanced comparisons – few people would claim that, for all their similarities, the countries considered to be of the West are similar enough to be justifiably seen in the same light; the same could also be said of the countries considered to be of the East. And just as systems engineering results are not borne out of an individual's work, neither are they borne out of the work of the entire West or the entire East.

In light of these issues, the choice of the nation as the level to carry out cultural comparisons on seems to be a logical compromise between choosing a high enough level of comparison to account for cultural emergence, i.e. the nation-level culture of Schwartz that arises out of the interaction amongst the myriad individuals that constitute it, and choosing a low enough level of comparison to not lose the cultural nuances and subtleties that exist between nations. Lending support to such choice of level is also the well-established modern worldview of nation-states as well-demarcated cultural entities, as well as the fact that the way nation-states function in our world today encourage the further crystallization of unique cultures; characteristics such as distinct languages and systems such as economic, political and society institutions all serve to encourage cultural homogeneity within a nation and cultural diversity outside of it, making the nation-state arguably the most intuitive and logical level of comparison. Indeed, Hofstede et al. assert that "they [nations] are the source of a considerable amount of common mental programming of their citizens". (Hofstede, Hofstede, & Minkov, 2010)

Furthermore, from a more practical viewpoint, some of the most symbolic and complex systems engineering projects were carried out on a national level. To the extent that nation states will most certainly continue to carry out systems engineering projects of national importance to themselves well into the future, the choice of nation as the level of comparison would speak most clearly to these projects that often have a high degree of significance and complexity attached to them.

2.4 Challenges to Cultural Comparisons along Geographical Lines at a National Level

There will necessarily be doubts over the proposed choice of line and level along which cultural differences are considered, i.e. along geographical lines and at a national level. There are potentially four main reasons for such doubts.

Firstly, there might be critics who would be uncomfortable with the treatment of such a subject. These are people who feel strongly against "stereotyping", who find it difficult to accept claims that people from China tend to be such and such or people from the US tend to behave in such and such a manner which then results in different systems engineering results. To them, it is morally wrong to engage in such stereotyping behavior, which is naïve at best and imperialistic, arrogant, and over-assuming at worst. They might ask "What right do we have to reinforce such (at times negative) stereotypes and assumptions about people?" Even if the cultural characteristics ascribed to a group are positive, it does come with a tinge of insult, to claim that we know all about an individual just by looking at where he/she comes from.

Secondly, even if any moral issues can be resolved or at least put aside when looking at cultural differences along geographical lines, critics may still claim that when it comes down to actually engaging with individuals, one's personality and one's occupational/organizational affiliation have a greater influence on how one interacts with others than one's geographical region of origin. It is thus questionable if it is meaningful to attempt to distill geographical cultural differences to explain people's behavior. For example, an American manager acts towards his employees in a certain way not because he is "American" but because he has an outgoing personality and is in a position that requires him to act in such a manner. Another way of looking at this issue is the fact that within a certain “geographical culture”, the existent of sufficient variation from person to person points to the fact that the link between cultural characteristics and geographical location is tenuous at best. It is obvious that for any set of cultural characteristics that one may ascribe to a geographical region, it is no challenging feat to find a reasonable number of people in that region that do not fit the bill. Attempting to pigeonhole individuals into certain “cultures” is thus not useful at best, and has the potential for gross inaccuracy at worst, since there are a whole host of other differences, such as personal and occupational differences, that are going to play equally important, if not more important, roles in determining one’s “culture”.

Thirdly, even if it is meaningful to look at cultures along geographical dimensions, the idea of the culture of a person from a certain geographical region is an incredibly complex concept to deal with. Are there any realistic ways of quantifying or even qualifying this? How do we measure a “culture”? How can any descriptive scale or method of measurement ever hope to comprehensively and accurately quantify a concept that is so abstract and nebulous? There will be individuals who are, understandably, doubtful of the way people deal with such ideas and attempts at such quantification or classification. Indeed, the debate in international academia on how to describe or quantify a culture has been going on for decades and it hardly seems that a consensus is going to be reached any time soon (although some models are indeed more popular than others). Attempts at such quantification may thus be met with raised eyebrows, as there will always be doubts and disagreements over the validity of such methods.

Fourthly, even if it is indeed possible to measure cultures along geographical dimensions in a meaningful way, critics might claim that such a choice of dimension is irrelevant; due to the rate and extent of globalization in our world today, subscription to “international norms” implies that there is more often than not a common way of thinking, acting and saying things that transcends differences in geographical origins. Business leaders in international conference calls of an MNC do not need to pay unnecessary attention to whether their counterpart is calling from India or Saudi Arabia in order to close a deal, and neither do representatives to the United Nations need to consider the cultures of a hundred other countries in order to reach an agreement. There is a set of international rules and prescribed norms already in play and people already possess the knowledge and ability to (willingly or grudgingly) play by these rules in order to get things done. This applies all the way down to the smallest of system design teams, and any problems, friction or conflicts that arise due to “cultural differences” are merely products of people “not playing nice” and not because they are inexorably programmed to act in a certain manner. Considering “cultural differences” is quaint and interesting, but is irrelevant when we consider that people have been and will continue to get things done despite these “differences”.

In short, these four main criticisms can be summed up as:

1. Assigning cultural differences is undesirable
2. Analyzing cultural differences is meaningless
3. Quantifying cultural differences is impossible
4. Considering cultural differences is irrelevant

Through the process of addressing these criticisms, the link between culture and systems engineering and thinking will hopefully be brought into greater clarity. Subsections 2.4.1-2.4.4 below that do so do not seek to serve as a comprehensive exploration of all the relevant issues at hand, but serve to provide enough justification in the face of these four criticisms that it is indeed a meaningful exercise to consider what role geographical culture at a national level might have in a systems engineering context.

2.4.1 Is assigning cultural differences undesirable?

The idea of discussing how the place a person comes from affects his behavior in a systems engineering context may understandably be a tricky and often sensitive proposition. However, it is important to note that the analysis of such cultural differences carried out in this thesis acknowledges that stereotyping on the individual level is neither logically accurate nor meaningful. Rather, the focus is on the fact that certain national cultural trends do exist across geographical boundaries and that to shun this fact or pretend it does not exist not only immediately eliminates any opportunity that one might have to better understand cultural realities and utilize them for the benefit of people, but also ironically exposes the continued existence of the flawed underlying assumption that certain cultural practices are "better" or "worse" than others, as well as the fact that we have not come far enough as a human race to be able to talk about these differences in a measured and mature manner.

Without detracting from the efforts of those who campaign against stereotyping, negative stereotyping reveals precisely a lack of understanding that no culture or cultural practice is inherently better than another; ignoring cultural differences does no good for this lack of understanding. Rather, what is needed is not a blanket ban on any such discussion but rather a great deal more discussion until the point where it is no longer needed. As long as such discussion is framed in a constructive and analytical manner that acknowledges what exists in reality and seeks to harness it for good, it is perhaps those who would feel most uncomfortable with such discussion that would benefit the most from engaging in it.

2.4.2 Is analyzing cultural differences meaningless?

This particular criticism involves two related arguments. The first is that within a certain geographical culture, the fact that one can point to variation among individuals in terms of values, norms and attitudes implies that it is more appropriate to accept that there is a whole host of factors that influences an individual and that everyone is unique, rather than attempting to come up with a stereotypical cultural description for this geographical region or erroneously assuming that one will behave and think in a certain manner ascribed to his/her culture. The second is that one's personality and one's occupational/organizational affiliation have a greater influence on how one interacts with others than one's geographical region of origin, and that it is thus questionable if it is meaningful to attempt to distill geographical cultural differences to explain people's behavior.

With regard to the first argument, it is hard to imagine any researcher or writer claiming that people from a certain geographical region will act and think in a certain way with absolute certainty, or even a high degree of certainty. It is important to note from the outset that cultural descriptions and differences are often probabilistic in nature and represent an average or a tendency across a large group of individuals. The pertinent question, then, is if intercultural variation among geographic regions is greater than intra-cultural variation among a certain geographic region, or if we were to think in terms of means and standard deviations, if there is a statistically significant difference between the cultures of two regions. If so, the analysis of cultural differences would be far from meaningless as it would demonstrate and subsequently be based on significant differences in the cultures of individuals in general from two regions. However, if the attempted demonstration of a "cultural difference" were found to be overwhelmingly overshadowed by the existence of intracultural variation, then this would severely detract from the value of considering that "cultural difference".

Therefore, this implies that the existence alone of intracultural variation does not by itself invalidate the value of studying and utilizing intercultural variation for systems engineering purposes. Ultimately, whether any findings are of import boils down to the researcher's choice of granularity as well as the degree of separation of geographical region. Granularity, or level of comparison, would refer to how specific the groups of interest are; comparing different nations would be at a lower level of granularity than comparing different selections of local students from different universities. Having lower granularity in the selection of geographical region would allow for the cultural difference signal to emerge more clearly from the noise due to other factors such as institutional or organizational culture. Degree of separation of geographical region would refer to how far the groups of interest are geographically separated from one another. Having a higher degree of separation in terms of geography would also increase the chance of there being significant cultural differences being observed (although this is not necessarily the case as explained in Subsection 2.3.2). Thus, it would probably be easier to observe significant differences in culture between nations from the West and the East than to demonstrate significant differences in culture between university students from Boston and Cambridge. This is the reason why many studies intentionally choose geographical areas that are extremely well separated, and which are large enough to encompass a significant population, such as the US versus Japan, or the US versus China. As Proctor et al. point out, "Of the research that has considered cultural differences, for the most part the studies have compared only two distinct cultures, typically one from the East and one from the West." (Proctor, 2012)

Tong and Chiu also argue "cultures differ from one another primarily in the relative popularity of different mental practices". In other words, no particular geographical culture has a monopoly on certain values, norms and attitudes; different values and mental practices may all exist in different cultures, albeit in different proportions or with different relative popularities. With regard to their aforementioned study where they discovered that although three types of tendencies (dispositional, intentional and situational attribution) existed in both American and Chinese experimental groups, there were significantly higher dispositional attribution tendencies in the American group compared to the Chinese group, which led to them positing that "cultural differences in cognition are probabilistic rather than absolute" and that "the previously obtained East-West difference in the tendency to make spontaneous trait inferences is a consequence of the relatively greater prevalence of dispositional attribution in American contexts". (Tong & Chiu, 2012)

It is challenging however to attempt to quantify these relative probabilities. One might never know what percentage of Americans actually engage in dispositional attribution, and thus it is common to use broad, general statements such as "Americans tend to be dispositionists and are more likely to commit the fundamental attribution error" to describe the fact that researchers are pretty confident that if they were to go out and take a census of all Americans, they would probably find a higher percentage of dispositionists relative to other types of attributional tendencies compared to the Chinese. This statement on its own, however, risks opening itself up to criticism because 1) It is not supplemented by the other cultures that are used as a basis for comparison, which is important because the statement would be meaningless if it happened that the Chinese also showed the same distribution of dispositionists in the population, implying that this observation is probably not a culturally rooted one, and 2) The necessarily vague terms such as "tend" and "more likely", due to the researcher's inability to ever pin such probabilities to a certain number, suggest to the reader that a great deal more assumption and conjecture went into this statement than scientific analysis, thus eliciting reactions such as "I for one don't engage in such behavior. The author is clearly trying to paint all Americans with the same stereotypical brush". On the other hand, it is probable that people would raise less objections to the statement that "If one were to select a random American, there is a higher chance that he/she will be a dispositionist compared to if we were to select a random Chinese. It is thus useful, for practical purposes, to engage in design and decision making that takes into account the fact that one's target American audience is more likely a dispositionist than not, and that one's target Chinese audience is more likely not to be a dispositionist than to be one".

Methodological limitations clearly limit our ability to quantify such cultural probabilities with certainty, since we can never really know the extent to which a certain cultural characteristic is prevalent in a population. As Smith et al. put it, "There will be some degree of consensus in the psychological consequences of the social system, but there will not be uniformity. The average level of endorsement of a value or belief in one cultural group, however, would probably differ from that in another because of the homogenizing influence of the social system characterizing each cultural group" (Smith, 2006). Intracultural variation has and always will continue to exist, and the fact that cultural differences are not absolute or perfectly assignable is no reason to not discuss their value or relevance in systems engineering. Instead, approaching these differences with a correct and informed understanding of cultural realities as well as an appreciation of the fact that absolute judgments neither exist or are desired will allow for more nuanced and useful conclusions about those cultural differences that do exist on average and which are significant enough to have implications for systems design and engineering. This is infinitely preferable to not attempting to broach the subject in the first place.

Furthermore, as Schwartz points out, intracultural variation in and of itself sometimes leads to cultural emergence, or the arising of a particular cultural characteristic that is essentially borne out of this intracultural variation. Such cultural emergence by virtue of intracultural variation clearly points to the fact that intracultural variation certainly does not negate the validity of comparing cultures; instead, when studied in a holistic manner, it may present to us unique cultural dimensions that do not exist on the individual level but which may be brought into being on a national level. (Schwartz, 1992)

Therefore, on a more practical note, it is important going forward to take on the burden of proof to demonstrate that any cultural differences that are claimed to be due to differences in geographical origin are indeed so and not due to mere variations in factors such as individual personality or occupational training. This brings us to the second argument, which claims that there exist multiple dimensions along which cultures might be differentiated; one may speak of the cultures of different companies, occupations, teams/working groups, institutions, age groups, or even gender etc. It is hard to imagine anyone claiming that geography is the only dimension along which cultural differences may be clearly observed. A healthy dose of skepticism would point out that one may easily envision how high-ranking politicians may come to imbibe a certain culture that is similar regardless of which country they hail from; and the same may go for bureaucrats, salesmen, soldiers, engineers, social workers etc.

Might we then be better off focusing on the cultural differences between bureaucrats and engineers regardless of where they come from, than to attempt to artificially tease out cultural differences due to different countries of origin? Clearly, there exist cultural differences along non-geographical lines that may or may not challenge the significance of geographical comparisons. However, even though different companies, institutions and teams may engender and impose their unique brands of “culture” on the people that belong to them, there is still a more fundamental and more underlying thread of cultural variation that lies along geographical lines, and which often transcends institutions, social class, professions and organizations within a region. Perhaps, given a thousand years and an unceasing movement of people from place to place, these geographical cultural differences may be diluted and cease to exist. But for now, geographical distance and separation are important, because geographically different natural environment factors sowed the very first seeds of cultural difference and the resultant social groups that were separated geographically subsequently continued (and still continue) to maintain and perpetuate existing cultural differences within their respective geographical regions. It would be quite difficult to believe that cultures and traditions that have lasted for centuries in a geographical location play no part in shaping a person who grew up in and lives there, and that only his/her occupation or organizational experiences matter. Hofstede et al. also assert the view that while there may be other dimensions of culture apart from geographical culture, the fact that these other dimensions only appear in later stages of one’s life implies that these other dimensions would be, in their view, “more changeable. This is the case, in particular, for organizational cultures”, and are thus ultimately relatively less significant than geographical culture; according to them, “National value systems should be considered given facts, as hard as a country’s geographical position or its weather.” (Hofstede, Hofstede, & Minkov, 2010)

Knowing this, it would thus be important to also consider such geographical cultural differences in systems design and engineering, for these differences have implications that are just as important, if not more important, than cultural differences along other dimensions such as organizational or professional culture. A caveat though, would be to retain a degree of respect for the fact that geographical culture isn’t the be all and end all of how people interpret the world around them differently, and to give non-geographical factors their due when it is deserved, especially for multiethnic regions where variations in ethnicity and levels of integration may introduce significant confounding factors.

2.4.3 Is quantifying cultural differences impossible?

It would not be surprising to encounter the opinion that attempting to study geographical culture's role in systems engineering is a scientifically questionable pursuit, especially among those in the scientific and engineering disciplines. Teerikangas and Hawk point out that in the analytical and mechanistic traditions of "developed Western societies" (though these societies do not have a monopoly on such traditions) and in the pursuit of objective scientific knowledge, the idea of culture, something that cannot be easily identified, described or quantified, would tend to be seen as "too subjective a nature to warrant the effort of study". (Teerikangas & Hawk, 2002)

This has ultimately resulted in two groups of people who are willing to take on the subject of culture. The first consists of cross-cultural sociologists who are comfortable with the non-analytical and non-mechanistic nature of culture and who seek to advance human understanding in underlying cultural theories, i.e. those who look at transactional cultural factors and seek to determine the inherent cultural factors that are driving them, and whose work is largely qualitative in nature. The second group consists of cross-cultural management scientists who "fit" the concept of culture into neat categories through simplification, attempt to bring out the objectivity of cultural differences, and who focus on practical endeavors such as the dos and don'ts of cross-cultural communication and negotiation. (Teerikangas & Hawk, 2002) To be perfectly clear, both of these groups are certainly doing valuable work, but a divide exists between them and also with the scientific and engineering community that is more comfortable with certainty and analytical reductionism, with the result that the cultural theories that may have very well provided the frameworks of the cross-cultural management scientists with greater explanatory power are not utilized to their fullest potential, causing these frameworks to have applications in only those areas where transactional cultural factors dominate (e.g. negotiations and marketing), but not in those areas which require a more holistic consideration of the inherent cultural factors that are driving people's actions (e.g. policy choices, system engineering choices). The fact that each of these groups and their sub-groups all treat and define culture in different ways also does not facilitate inter-disciplinary work in this area, which would seem to be the next logical step: to utilize the qualitative cultural theories developed by social scientists to provide explanatory power to the quantitative frameworks of management scientists, both of which are needed to help drive predictions and meaningful conclusions in areas of scientific and engineering endeavor where cultural differences will have a significant impact on outcomes.

Nevertheless, there has indeed been much effort by researchers worldwide to quantify and qualify geographical cultures, to attempt to fit this inherently non-objective concept into objective categories and scales that might be used to drive predictions and derive conclusions. It would be instructive to look at some of these methods of quantification.

There are three main concepts related to culture that are proposed by Smith et al.: values, beliefs and behavior. Values is defined as "what is desirable" to individuals; beliefs is defined as what is thought to be true", and values and beliefs together are used to direct as well as to interpret the actions of individuals in a culture. The greater the extent to which values and beliefs are shared, the higher the probability that a particular behavior will be interpreted in the same fashion, and the greater the justification for there being a shared culture. (Smith, 2006) Various researchers have attempted to score or classify nations according to their prevailing values, beliefs and behaviors in order to quantify the culture that might be associated with that nation.

With this in mind, we can turn to some examples of studies that have looked at how values differ from nation to nation. One of the more influential of such researchers was Geert Hofstede, a Dutch social psychologist, who defines culture as "the collective programming of the mind that distinguishes the members of one group or category of people from another" (Hofstede G. H., 2001). Hofstede initially carried out an analysis of IBM employee value surveys collected between 1967 to 1973 and which comprised respondents from more than 70 countries. Using factor analysis, he developed a set of four dimensions: Power Distance, Uncertainty Avoidance, Individualism (versus Collectivism) and

Masculinity (versus Femininity) which aimed to culturally characterize the ways in which nations were different from one another (Hofstede G. H., 1980). Subsequent studies resulted in him adding a fifth dimension, Long Term Orientation, in 1991, and a sixth dimension, Indulgence (versus Restraint) in 2010 (The Hofstede Centre).

Another important study was conducted by Shalom Schwartz (1992) whereby the importance of a set of 40-50 values to people of different nationalities was analyzed, both at the individual level and at the nation level. From his individual level analysis, Schwartz identified ten value types, such as security, power, conformity etc. ordered along two major dimensions: openness to change vs. conservation and self-enhancement vs. self-transition. From his nation level analysis, Schwartz obtained seven international value types along three polar dimensions: hierarchy versus egalitarianism; mastery versus harmony; and conservatism versus intellectual and affective autonomy. (Schwartz, 1992)

A third study that also employs nation-level analysis is the World Values Survey, which surveys attitudes in different nations towards a variety of topics including gender equality, the impact of globalization, the environment, work, family, politics, religion etc. The databank of this survey is significant due to the extent of its global coverage of the world's population (estimated at 90%). From this data, Ronald Inglehart and Christian Welzel put forward that there exist two major dimensions of cross-cultural variation: Traditional values versus Secular-rational values and Survival values versus Self-expression values. (World Values Survey).

A fourth study is known as the Global Leadership and Organizational Behavior Effectiveness study, or GLOBE study. It surveyed middle managers from various countries and identified nine cultural competencies (which build on the work of the previously mentioned studies) as well as ten culture clusters. (House et al., 2004).

As can be seen, there are currently a number of studies available that aim to quantify culture at a national level. Chapter 3 will propose the selection of Hofstede's framework for this thesis and explain the rationale behind such a choice.

2.4.4 Is consideration of cultural differences irrelevant?

How do we know for sure that such geographical cultural differences are indeed relevant in the globalized world of today? This criticism essentially revolves around the idea of cultural convergence – the idea that, with globalization and technological advances increasingly facilitating the flow of individuals, information and ideas, that different cultures might gradually become more like each other, either by being subsumed under an overriding dominant culture, or by morphing into a unique "global culture"; under such a phenomenon, the idea of cultural differences might become increasingly irrelevant. Empirically though, Teerikangas and Hawk point out that although globalization has helped to create a global business environment, "there is growing evidence that companies were not effective transformed into global organizations and that they are in many respects unable to manage their global operations" (Teerikangas & Hawk, 2002). They cite cultural differences in negotiation styles, communication, and expectations as some of the challenges that global ventures still continue to face up to this day.

The fundamental question, then, is if cultures change over time. While it is largely accepted that cultures vary geographically, might culture in a particular geographical area vary temporally? In other words, do cultures evolve, especially in the face of the forces of globalization? If not to the point of morphing into one single "global culture", might cultures still change given the right combination of manmade forces?

It was previously argued that different natural environmental factors in different regions largely "kickstarted" the adoption and promotion of certain cultural characteristics over others, and that subsequently human environmental factors primarily maintained or reinforced these cultural characteristics. This would probably be accepted as having a certain degree of validity up till the 20th or 21st century, during which, it could be argued, humans first started wielding an abnormal amount of control over the physical geographical environment that they were located in. Hofstede et al. point out that "We are in a rapid process of conquering nature, as a result of which our human environment is becoming relatively more important." (Hofstede, Hofstede, & Minkov, 2010) Certainly, given the rapid advancement of technology that implies that individuals are increasingly less subjected to the forces of nature, perhaps it should be suspected that geographical cultures in the 21st century may have changed over the recent past few decades.

Ultimately, there are two related arguments that demonstrate why such a suspicion would probably not be true. Firstly, the current reduced influence of environment factors or its potential future lack of influence is, on its own, insufficient to open the door to cultural change. If we accept that the process of our acquisition of culture from birth implies that our surrounding human environments essentially act to preserve and maintain existing cultural values, it would require drastic changes in our human environment to actually produce some resemblance of cultural change, and until then, the alleged removal of the environmental factor from the equation is insufficient to cause a change in culture, especially since its primary role was ultimately to seed cultural diversity millennia ago. The second argument addresses the follow-up question on whether the forces of globalization and modern technological revolutions are indeed sufficient to constitute a "drastic change" in our human environment to actually cause cultures to change. Hofstede et al. argue that this is in fact an incorrect conceptualization of the relationship between the phenomenon of "innovations…happening in a frenzy of change around us" and existing cultures; rather, they claim that "practices and technology can change so fast only because, and as long as, societies function in stable ways. A society requires cultural homogeneity at the level of implicit values in order to have capacity for collective action, which is a condition for a group to be adaptive to its environment. And cultural homogeneity does not allow for rapid chance in values...while groups with common cultural values will be good at collectively responding to circumstances, they will be slow to shift their shared value system even if changes in circumstances would give such value shifts survival advantages" (Hofstede, Hofstede, & Minkov, 2010).

This ultimately means that while there may be concepts like "international norms", cultural differences and cultural diversity are unlikely to go away any time soon. Hofstede et al. assert that "Research about the development of cultural values has shown repeatedly that there is little evidence of international convergence over time…Value differences among nations described by authors centuries ago are still present today, in spite of continued close contacts. For the next few hundred years at least, and probably for millennia afterward, countries will remain culturally diverse." (Hofstede, Hofstede, & Minkov, 2010) And this has important implications for this study, because it not only means that cultural differences continue to remain relevant up to this day, but also that they will continue to stay relevant for quite some time into the future. This certainly warrants a closer look at what they really entail for systems engineering.

2.5 Geographical Culture and Systems Engineering

If we accept that geographical cultural factors at the national level are relevant to systems engineering, that there is value and meaning in attempting to distill such cultural factors, and that it is possible to quantify such cultural differences in an accurate and valid manner, the next issue would be to address exactly how geographical culture may influence systems engineering and thinking.

2.5.1 Culture and Systems Engineering in the Literature

In 2007, Michael Griffin, then Administrator of NASA, gave a Boeing lecture entitled "Systems Engineering and the 'Two Cultures' of Engineering". In his lecture, he discussed the two cultures embedded in engineering – the culture associated with hard science and analysis (making sure the engineered system works right), and the culture associated with soft design and creativity (making sure that the right system is engineered), and expressed his opinion that systems engineering seeks to bring these two cultures together. He stated that "the fact remains that designers simply do not think or work in the same way as analysts, and this does on occasion produce a certain cognitive dissonance. When it occurs in the context of a complex system development, catastrophe is a likely result…an understanding of the broad issues, the big picture, is so much more influential in determining the ultimate success or failure of an enterprise than is the mastery of any given technical detail. The understanding of the organizational and technical interactions in our systems, emphatically including the human beings who are a part of them, is the present-day frontier of both engineering education and practice" (Griffin, 2007).

It is important to note that the term "culture" as used by Griffin is that which is distinguished along occupational lines, i.e. the different cultures of those engaged in the science vs. the art of engineering, and not culture which is distinguished along geographical lines which is the focus of this study. But his lecture raises an interesting point that is relevant to our discussion: that system engineers are not pure scientists or designers, but rather people who are "generalists rather than specialists", and who engage in "tradeoffs and compromises", seeking a "balanced design in the face of opposing interest and interlocking constraints". In his words, systems engineering is "the link which has evolved between the art and science of engineering" and the systems engineer "is not an analyst; rather, he focuses analytical resources upon those assessments deemed to be particularly important, from among the universe of possible analyses which might be performed, but whose completion would not necessarily best inform the final design. There is an art to knowing where to probe and what to pass by, and every system engineer knows it". (Griffin, 2007)

By describing the job of a systems engineer as such, Griffin elucidates why the role of a systems engineer provides fertile ground for the influence of geographical cultural factors to creep in. Tradeoffs, compromises, decisions and judgments all stem from what an individual values and how he perceives those values to be constrained. And where values are concerned, one should start to suspect that geographical cultural differences may very well lead to different decisions made in different places with regards to the same system at hand. In fact, one might very well suspect that geographical cultural differences may contribute more to different decisions being made by systems engineers working on similar projects than other factors such as occupation or organizational culture.

As mentioned earlier, Griffin's lecture is also one example of many in the literature that use the word "culture" to refer to organizational or occupational culture, and which illustrate how such organizational or occupational cultural differences give rise to interesting phenomena in various fields. There is, however, a seeming reluctance to talk about such cultural differences along geographical lines, even when there is a plausible reason to do so.

Sato, in his paper exploring cultural conflict at NASA's Marshall Space Flight Center, tells us about the story of Wernher von Braun and his shaping of the "engineering style and social structure of the Marshall Center as a local engineering community" (Sato, 2005). Sato argues that von Braun “pursued a holistic approach, seeking consensus and team harmony”; he eschewed “a clear-cut division of labor”, made efforts to keep “engineering work in-house”[1] and championed qualities like “identity, honesty, mutual respect and trust”, intangible values that “enabled maximum delegation of authority and an efficient and continuous system of communications”. In particular, Sato illustrates how a “local style for reliability assurance” was reflected through his advocating that “the unremitting effort of individual engineers” was fundamental to reliability as opposed to statistical methods, his emphasis on “engineering judgment founded on broad experience”, and a conservatism that allowed “potential problems to happen to make sure they would not let to catastrophic failure”. Apart from individual expertise, Sato also talks about how a “local style for systems integration” was reflected through von Braun’s “principle of automatic responsibility” which expected directors to be “automatically responsible for any issues involving their respective disciplinary fields….without being told to do so by anyone” (a practice that Sato deems “ambiguous, ad hoc….unconventional and even risky for a formal organization”), his implementation of “horizontal as well as vertical communication”, and his ability to create “a unanimous feeling of a sense of direction” during meetings. In fact, due to von Braun’s personal recruitment of many of the Germans on his team, he was able to not only achieve an extremely low turnover rate but also develop “a stable community” with a “unique, unified, self-sufficient engineering capability”, albeit one that generated conservatism due to “a fear of making mistakes and causing failures” and the subsequent “loss of credibility and undermining (of) one’s place on the team”. (Sato, 2005)

This however led to conflict between von Braun and Joseph Shea, the director of systems engineering in the Office of Manned Space Flight. Whereas von Braun “sought harmonious consensus and maximum delegation of authority”, Shea believed that “engineering approaches and decisions should be spelled out and communicated in words and formulas” and his demand for “analytical scrutiny” of various details raised protests from von Braun. Such conflict worsened in 1963 when George Mueller and Samuel Phillips took command of the Apollo Program and tried to impose configuration management, requiring detailed definitions of design changes and systematic recording of all processes, and championed “a clear, detached, finely segmented division of responsibility”, virtually standing in opposition to von Braun’s “consensual method of accommodating design changes” and avoidance of “petty supervision”. Sato concludes that “Systems Engineering”, in reference to Mueller and Phillips’s requirements, “was not only redundant at Marshall but also fundamentally at odds with the center’s values and assumptions. Its analytical, segmenting orientation contradicted the unitary, integrated rocket-building capability of von Braun’s team, organically nurtured over many years…It’s formalized demand for accountability offended their rich, unarticulated engineering judgment.” (Sato, 2005)

Sato’s work thus raises two curious issues. The first would be his implied definition of systems engineering, which seems to fly in the face of what Griffin was expounding on in his 2007 Boeing lecture. Sato conveys the impression that systems engineering is characterized by clear division of responsibility, meticulous recording of processes, structured and standardized work processes, and impersonal and almost bureaucratic control of the organization, whereas what von Braun stood for – holism, consensus, team harmony, autonomy, informality and organic spontaneity – was not systems engineering. Through his work, Sato has unintentionally invoked what Griffin refers to as the conflict between the “two cultures of engineering”, and his view of what constitutes “Systems Engineering” illuminates, to a certain extent, which camp he belongs to. In fact, many of the things that Griffin espouses about systems engineering as a “holistic, integrated discipline” seem to square more with von Braun’s methods than those of Shea, Mueller and Phillips, who in hindsight appear to have been too caught up in the emphasis of standardized methods, formal meticulous reporting and segmentation of responsibility for accountability to keep in mind the “big-picture view” as Griffin puts it.

That said, while it would be shortsighted to claim that meticulous and standardized processes and division of responsibility are sufficient to constitute a successful systems engineering endeavor, it would also be erroneous to say that they would not be helpful to such an endeavor, or that von

[1] Von Braun believed that “his engineers would run away if they were deprived of opportunities to work on

Braun's philosophy, while successful in the face of the development of the Saturn launch vehicles, would have been sufficient when dealing with multiple, far more complex programs. It would be fairer to say that Mueller and Phillips' emphasis on details of processes, requirements and interfaces would have been vital insofar as they did not interfere with the autonomy and spontaneity that von Braun so treasured, a goal that was in fact demonstrated to be achievable through Marshall's reorganization in 1963 that separated the Research and Development Operations Directorate from the Industrial Operations Directorate (Sato, 2005). In fact, it could be plausibly argued that if von Braun were to have handled a project ten times the complexity of the Saturn vehicles that involved hundred times more employees, he might have very well appreciated a bit more of the techniques of the "lovers of detail" that he so disapproved of. Sato thus presents an unfortunately false dichotomy between "Systems Engineering" and von Braun's "local engineering", which upon careful consideration represent, respectively, a possible set of systems engineering tools/best practices and a set of systems engineering principles, neither of which would have succeeded on its own in the face of growing engineering complexity. They are essentially the "art" and "science" that Griffin feels are both necessary to make possible the development of "an operable system capable of meeting requirements within imposed constraints" (Griffin, 2007).

The second curious issue that Sato's work raises is that of his attribution of such differences in "engineering culture". It is easy to suspect that such differences might have been attributed, at least in part, to geographical cultural differences between von Braun's German team and his American colleagues, especially given the circumstances under which von Braun and his German team were non-organically instated within the American space program. In fact, Sato indirectly alludes to this source of cultural difference, bringing up the "recollection of an American engineer" regarding "the mentality of the Germans", as well as how the director of the Marshall Center in 1974 "steadily drove out the German engineers and reformed the center"; he also compares Shea's embodiment of the "American ideal of mobility" in contrast to von Braun's "traditional German aristocratic family" upbringing, and even invoked the environment of postwar America, with its emphasis on "cleverness, competitiveness, individual achievement and locational mobility", in explaining why American systems engineers behaved as they did with their "data-oriented", "technocratic", rational and impersonal mentality towards systems engineering (Sato, 2005). But there is almost a kind of shyness, on Sato's part, of directly attributing these differences to cultural differences between Germans and Americans.

2.5.2 Cultural Differences: The West and the East

Despite the general lack of enthusiasm towards ascribing aspects of actual systems engineering outcomes to geographical cultural factors, there is a romantic tendency in the literature to compare Western and Eastern cultures' "natural disposition" towards systems thinking. This difference stems from what researchers essentially believe is a fundamental difference in philosophy of thought. Western thought is seen as being founded upon ancient Greek thought which emphasizes analytical reasoning, cause and effect, and a one/many dichotomy, which implies the autonomy of each element (Matthew & Busemeyer, 2012), and subsequently upon the Newtonian traditions of linearity, determinism, reductionism, and the scientific method (Teerikangas & Hawk, 2002). The result of this analytical thinking or reductionist style is a tendency to break down a complex problem or subject into individual parts, upon which individual analyses can be undertaken, cause and effect patterns explored, and these findings subsequently aggregated to arrive at an overall evaluation or result. On the other hand, Eastern thought is seen as being founded upon Confucian thought, which emphasizes a part/whole dichotomy, and "special focus on relationships between the elements rather than the elements themselves" (Matthew & Busemeyer, 2012), as well as "contextualized thinking" and a "distinctive emphasis on holism", implying that a system needs to understood as a whole, and that the individual behavior of a system's components cannot fully explain the overall properties or behavior of the system (Tong & Chiu, 2012).

These fundamental philosophical differences have been cited as reasonable justifications for measurable and demonstratable differences in perception and decision-making between people from the West and the East. Research has shown that East Asians are better at perceiving changes in backgrounds and Westerners are instead better at perceiving changes in focal objects (Kitayama, Duffy, Kawamura, & Larsen, 2003), and that East Asians have a tendency to have a wider area of focus and attend more to the scene before them as a whole, while Westerners attend more to focal objects (Boduroglu, Shah, & Nisbett, 2009) (Masuda & Nisbett, 2001).

But perhaps more convincing than the idea that ancient philosophies alone have such a pervasive influence on the cognitive styles and habits of perception of their modern descendants, is the finding that a correlation exists between the two constructs of social orientation and cognitive style. The two ends of the social orientation construct – independence (emphasis on autonomy, uniqueness and individual rights) and interdependence (emphasis on social harmony, community before self) – are commonly associated with Western and Eastern cultures respectively. In a similar fashion, the two ends of the cognitive style construct – analytic (emphasis on focal objects, categorization, taxonomy, and causality) and holistic (emphasis on perceptual field, interrelationships, and context) – have been found to be correlated with independent and interdependent cultures respectively (Na, Grossmann, Varnum, Kitayama, Gonzalez, & Nisbett, 2010). This may imply that a culture in which independence is valued is more likely to promote or reward an analytic cognitive style, and a culture in which interdependence is key is more likely to promote or reward a holistic cognitive style, leading to the more frequent occurrence of each style in its respective culture. It must be recognized though that a chicken-and-egg relationship may exist between social orientation and cognitive style; it is also entirely plausible that ancient philosophical traditions, modern social orientations, and cognitive styles all work to influence and reinforce one another.

The conclusion implied from these cultural differences in perception and cognitive style is that the “Eastern Worldview” with its holistic traditions is naturally suited for systems thinking compared to the “Western worldview” with its analytical traditions (Teerikangas & Hawk, 2002), with some going further by advocating that the origins of systems thinking are in fact found in traditional Chinese philosophy, specifically in Confucian thought and Taoist precepts (Xu, 2005).

Interestingly though, it isn’t just scholars from countries of the East who are hailing those of Eastern culture to be naturally inclined towards systems thinking. Bob Browne, the CEO of the Great Plains Coca-Cola Bottling Company (GPCC) in the 1990s, when studying the systems-thinking oriented teachings of W. Edwards Deming, put forward a theory that the reason why Deming’s teachings were readily implemented by Japanese but not by Western cultures was that “the traditional Western “left-brained” mindset, and the consequential linear cause-and-effect approach to thinking, might be what were hampering the ability to understand what Deming was trying to say… the “right-brained” mindset, and more cyclical approaches to thinking associated with Asian cultures, could be what enabled their societies to more easily grasp these new concepts.” (Browne, 2011).

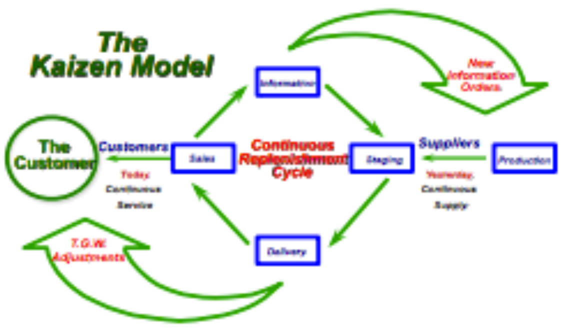

Figure 1: Company Flow Chart from GPCC (Taken from Browne, 2011)

Browne believed that, for his company's flow charts drawn with blue boxes (what system dynamics terms "stocks") and green arrows (what system dynamics terms "flows") as shown in Figure 1, "that the Japanese understood something more about the Green Arrows, but needed help with the Blue Boxes, while westerners always understand the Blue Boxes but need help with the Green Arrows…. The Blue Boxes represent the working parts of the system, and it is understood that the workings of these parts must be precise. It is a left-brained concept, not hard to understand for most westerners. The Green Arrows, on the other hand, represent relationships in need of constant feedback, and it is understood that these relationships must be "Caring." This is a little more right-brained, and it really tugs at the traditional western mindset when it is said that these people don't work for their boss". Browne eventually developed a new business model for the GPCC described as "a logical left-brain "Western" systems thinking model that embraces an understanding of relationships similar to the more right-brained "Eastern" cultures, that better appreciate cyclic principles, with a goal of continual improvement", and also created his SYS-TAO model, which he saw as "a way to communicate the subtlety and substance of the green arrows to the predominately left-brained Western mind-set throughout the ranks of Great Plains….concepts regarding holistic, nonlinear and caring relationships (that) might (otherwise) seem strange or esoteric to the Great Plains workforce". (Browne, 2011)

Kim, in his work, presents another measured view of Eastern culture's relationship with systems thinking, acknowledging that system dynamics as a method associated with systems thinking was developed in the West (as was early feedback control devices, a physical manifestation of the West's appreciation of systems thinking), and that in fact, his students and policy makers from Korea found the "thinking style of system dynamics too strange to learn" or "too complicated to be understood"; however, he was subsequently able to greatly facilitate their comprehension and acceptance of systems thinking by invoking the myriad of links between system dynamics and Eastern philosophy, such as the *Taijitu*, the concept of *yin* and *yang*, and the five basic elements of the universe (Kim, 2003).

Does this mean that people from Eastern cultures, by extension of the above examples, have some sort of natural affinity for systems engineering or some inherent capability of excelling in systems engineering? Ultimately, while philosophical traditions and prevailing social orientation may have shaped different patterns of perception and decision making in Western and Eastern cultures, the idea that a more holistic cognitive pattern characteristic of the East is linked to some sort of natural systems engineering ability or competency is a tenuous one at best. While holistic cognitive patterns may promote an unconscious affinity for perceiving changes in backgrounds for example, it may not necessarily translate into systems thinking capabilities, and it is even less probable that it would translate into actual systems engineering competencies, which are in reality demonstrated consciously in complex situations and therefore often require a good deal of nurturing, training, and real-world experience-building.

Perhaps what can be said is that holistic cognitive patterns may lend themselves, in a certain manner, to a more efficient or successful adoption of systems thinking principles. There is still however, a sizeable leap between one's openness or affinity for broad, abstract principles and actual competencies in systems engineering. Systems engineering is not the sole preserve of the East or the West, and neither is an analytical cognitive framework anathema to systems engineering. It is interesting if one considers that the statement above regarding Eastern culture's affinity for holistic thinking was made from the reference point of the West, where analytical thought is purportedly in abundance; could there perhaps, be a parallel statement made from the reference point of the East, that bemoans the over-emphasis on holism and interrelationships and an insufficient amount of regard paid to the precise, analytical traditions of the West, which, truth be told, simply cannot be absent from any engineering effort?

2.5.3 Culture's Connection with Systems Engineering

Ultimately, it is important to move beyond the mere demonstration of a link between a culture's cognitive process and it's affinity for systems thinking, and doing so implies taking a much broader view of both sides of the equation. On the right side of this link, it is not enough to simply be satisfied with knowing how easily systems thinking principles are accepted; the hard question that needs to be asked is whether this is eventually translated into successful systems engineering endeavors in the real world, and this involves looking at many dimensions of a systems engineering endeavor, not just in terms of its success in achieving intended outcomes, but also various other factors such as the quality of these outcomes, the characteristics of the journey taken, and the foundations and legacies that arose out of this journey. And on the left side of this link, it is not difficult to imagine that there are numerous other dimensions of culture that have an influence on systems engineering endeavors than just cognitive processes; a culture's power distance, degree of risk aversion, attitudes towards individualism, and even its perception of time may all influence, to varying degrees, a particular systems engineering endeavor, and all of these constitute the inherent cultural factors that previous sections discussed. The question that needs to be explored, therefore, is whether differences in culture, along its myriad dimensions, have an influence on systems engineering.

But what reasons would we have to suspect that culture may play a part in a systems engineering endeavor? It is not unthinkable that many would ignore or underestimate the influence that geographical culture may have on systems engineering, especially since such efforts are usually characterized by analytical tools and well-defined frameworks and processes revolving around a system that works according to the laws of Science. It does not seem that one's cultural values or beliefs would have any place amongst mathematical equations, management dashboards or mechanical equipment. But as shown above, systems engineering is more than just the hard science or hard engineering that pervades most other engineering disciplines; it is among the debates over tradeoffs, the clashes between interdisciplinary fields, the chaos of complexity and the uncertainty of emergence that culture finds its place, and where one's geographical cultural background has the potential to exert a significant influence on these important decisions that have to be made via one's beliefs, values and worldview.

Furthermore, no systems engineering endeavor exists in a vacuum; and this is especially true for the increasingly complex projects that are part of our world nowadays. Even if we could conceive of a hypothetical systems engineering endeavor that involved no value judgments or where the physics involved may override the need for tradeoffs or decisions that draw on culture, such an effort would still ultimately not be driven solely by systems engineers. Systems engineering endeavors, even if seen as purely technical or scientific endeavors, will also be driven, to varying extents, by the engineers' bosses, politicians, media, citizens, and in some cases, the military and even foreign forces. A group of systems engineers may think of themselves as having just made a series of rational, logical decisions that were never affected by their culture, until they need to answer to their boss or their congressman. Systems engineering is not and will never be fully inoculated against the vagaries of politics, economics, or social sentiment. It is thus the amalgamation of these very human forces both internal to and external to the system that open the floodgates for cultural influences to exert their unique pull.

2.6 Choice of Systems Engineering Endeavor: Manned Spaceflight

In order to explore the influence of culture on systems engineering, this thesis will examine the manned spaceflight programs of the US and China, and present how particular cultural differences led to the respective outcomes of these programs.

The choice of the field of aerospace engineering as a field from which to formulate a basis for comparison is not an arbitrary one. The most compelling rationale for doing so stems from the historical development of systems engineering in both the US and China.

Griffin describes systems engineering as having "its roots in the American aerospace system development culture" and also explains how Stephen Johnson, the author of *The Secret of Apollo*, showed "the development of system-oriented disciplines to be the natural reaction to the failure of early, complex aerospace systems, including large aircraft, ballistic missiles, and spacecraft". (Griffin, 2007). Although the idea of systems engineering may have existed to some informal degree in earlier centuries, the decades after World War II saw systems engineering being developed as a formal engineering discipline in the US, when the nuclear missile and space races amidst time constraints and a competitive domestic environment necessitated the development of systems engineering-oriented tools, processes and techniques particularly within the aerospace sector. One commonly held up tool emblematic of this development is the Program Evaluation & Review Technique (PERT) developed by the United States Navy in 1957. This tool was applied to the Polaris Project, which was tasked in 1957 to develop submarines equipped with intercontinental nuclear missiles under immense time and political pressures, and its subsequent success despite enormous complexities was attributed to the PERT technique (Engwal, 2012), described as "a decision-making tool designed to save time in achieving end-objectives" (Fazar, 1959) and which "provides visibility into the potential impact on the completion date of delays or speedups in any specific task". (International Council on Systems Engineering SE Handbook Working Group, 2000).

On the Chinese front, the history of systems engineering as a formal engineering discipline began with the return of Tsien Hsue-shen to his home country in 1955 from the US. Tsien was one of the founders of the Jet Propulsion Laboratory at the California Institute of Technology and contributed significantly to the fields of jet propulsion, high-speed aerodynamics, and rocketry during his time in the US, and was even part of a team that interviewed Wernher von Braun and other German scientists following their defection from the Peenemünde rocket facility at the end of World War II (Chang, 1995); Aviation Week & Space Technology poetically describes this encounter as "No one then knew that the father of the future U.S. space program was being quizzed by the father of the future Chinese space program" (LA Times, 2009). Tsien was subsequently deported from the US on eventually unproven Communist allegations, and back in China, headed the Chinese missile program and became known as the "Father of Chinese Rocketry" for his contributions to the field of aerospace in China, in particular the development of China's first ballistic missiles and first satellite (the *Dongfeng* ballistic missiles and *Dongfanghong*-1 satellite respectively), as well as the development of the first generation of *Changzheng* or Long March rockets (Chang, 1995). But apart from his contributions to the Chinese space program, he has also been recognized as the founding father of Systems Engineering in China (Omega Alpha Association, 2009). After he returned to China, Tsien recognized that the immense complexity of China's missile program necessitated systems engineering methods, and thus developed and implemented a systems engineering management plan in 1962 that was modeled after PERT in order to streamline coordination and communication amongst the various tiers of the Chinese missile and spaceflight programs, in particular for the design of guidance systems for Chinese long-range rockets. (Chang, 1995)

It is not surprising that the evolution of systems engineering into a formal engineering discipline in both the US and China had strong roots in the aerospace field in both countries. Aerospace engineering projects bear all the hallmarks of a systems engineering endeavor – interdisciplinarity in terms of the myriad fields ranging from aerodynamics to thermodynamics to electronics, holism in terms of getting multiple subsystems to work in an integrated manner under harsh environmental pressures, delicate tradeoffs in the likes of launch weight versus performance or safety versus schedule, and the unenviable complexity that comes especially with those space missions that have never been performed before. And outside of its internal workings, space programs are also characteristically influenced by external factors such as geopolitics, economics, social conditions, military conflicts, and a whole host of other imperatives that come into play because of the scale, complexity and national significance of these programs. It is extremely difficult to conceive of a space program as a standalone endeavor that is divorced from the various national undercurrents of the times. As Handberg and Li put it, "Space activities are peculiarly driven by politics because vast sums of money and other scarce societal resources must be committed to the space effort with absolutely no guarantee of quick technical success". (Handberg & Li, 2007)

Perhaps the most quintessential systems engineering endeavor in the field of aerospace can be found in manned spaceflight programs, which increase the stakes greatly with the involvement of human lives in the engineering process and mission outcomes. The risk of loss of life clearly increases not only the complexity of the systems engineering endeavor but also the human awareness that now needs to be injected into every stage of the program. With this risk weighing on every tradeoff, decisions that may have been made relatively easily when all that was at stake was equipment and dollars are no longer that simple. Compounding this additional emotional complexity is the fact that, as of today, only three nations in the world have achieved independent manned spaceflight – Russia (under the former Soviet Union space program), the United States, and China, in that order. This implies that manned spaceflight programs are highly unique and therefore prestigious on the world stage and involve considerations of national pride, soft power and geopolitical standing, insofar as manned spaceflight capability is also a proxy for the highest level of military prowess in aerospace.

Manned spaceflight programs thus not only qualify as archetypal systems engineering projects with their evident sociotechnical nature, but also are arguably particularly susceptible to cultural influences. This is not to say that the physics or mechanics of human spaceflight are in some way affected by culture; any human spaceflight engineering effort, regardless of where it takes place, is still subjected to the same laws of physics, and arguably the same technological dependencies in the sense that manned spaceflight can only happened after mastery of satellite technology and orbital maneuvering, which in turn has to be preceded by the successful development of ballistic missile technology. Rather, it is the way the sociotechnical framework of manned spaceflight programs are conceived, developed and implemented that is receptive to cultural forces. This takes place on the two levels mentioned in Subsection 2.5.3; the first level being related to the internal complexity of the manned spaceflight systems engineering endeavor which necessitates tradeoffs, value judgments, evaluations of utility, and the second level being related to the external complexity of the manned spaceflight effort that is inextricably linked with society, politics and the international context, and which thus often requires decisions and actions that draw heavily on the human condition. This implies that differences in culture – differences in values, norms, beliefs and worldviews – may very well be a contributing factor to how the manned spaceflight programs of culturally different nations eventually play out. As put forth by Handberg and Li, "…states clearly organize their respective space programs in line with their own culture and politics….There exists no nationally unique route to the stars...There are only unique national programs reflecting domestic conditions and their general role in the international system" (Handberg & Li, 2007).

While admittedly not a terribly difficult choice to make given that only three countries are on the list, the choice of US and China as cultural actors for comparison is also significant due to the fact that these national cultures have become almost emblematic of the cultures of the West and the East respectively, and are often thought of as being diametrically opposite to each other. It stands to reason that given the vast geographical distance between the two nations, their oft-reported differences in fundamental ideologies, and various other well-documented cultural differences in areas such as degree of individualism and power-distance among others, that the effects of culture on their respective space programs when compared side by side would be reasonably significant. But would we be comparing apples and oranges when looking at the US and Chinese manned spaceflight programs in the face of other confounding variables such as their occurrence in different points in history, amidst different geopolitical situations, and with different technological readiness levels? As we will see in Section 4.4, the US and China, curiously, have sufficient contextual similarities to make such a comparison possible and reasonable, and on top of that, sufficiently different cultural characteristics that shed light on the different ways in which their manned spaceflight programs turned out in the end.

This thesis will therefore revolve around a comparison of the cultural forces that drove and influenced the first manned spaceflight programs of the US and China. From another angle, one could also view this choice of topic as being borne out of the desire to determine how the “opposing” cultures of the US and China might influence a systems engineering endeavor, followed by the selection of the two countries’ manned spaceflight programs as case studies in point, due to the fortunate existence of this common and meaningful basis of comparison.

3. Comparing the Cultures of the US and China – Hofstede's Cultural Dimensions Theory

As mentioned previously, Hofstede developed his cultural dimensions theory through factor analysis of survey responses to an IBM employee value survey conducted between 1967 to 1973 and which involved more than 100,000 questionnaires and 88,000 respondents from 70 countries. Hofstede initially used 40 of these countries to develop his four original dimensions out of conservative considerations, and subsequently included another 10 countries and 3 regions. (Hofstede G. H., 2001) From his four original dimensions of Power Distance, Uncertainty Avoidance, Individualism (versus Collectivism) and Masculinity (versus Femininity), Hofstede's model has evolved with the help of scholars Michael Harris Bond and Minsho Minkov to now comprise two additional dimensions along which a particular national culture may be characterized: Long Term Orientation, and Indulgence (versus Restraint), and the set of cultural dimension scores for 40 countries has now been extended to 76 countries and regions for the original four dimensions and 93 countries and regions for the additional two dimensions up to this day. (Hofstede, Hofstede, & Minkov, 2010) Hofstede's intention was to develop cultural dimensions along which different national cultures could be compared and contrasted, with subsequent application of this knowledge and understanding to more practical areas such as cross-cultural communication and negotiation; Hofstede himself claims that "In our globalized world most of us can belong to many groups at the same time. But to get things done, we still need to cooperate with members of other groups carrying other cultures. Skills in cooperation across cultures are vital for our common survival…[We] are committed to the development of such intercultural cooperation skills" (Hofstede & Hofstede)

Hofstede's model and work is of particular relevance to this study for a number of reasons. The first is the fact that Hofstede's cultural dimensions are dimensions of national culture; Hofstede has always been careful to highlight that his work distinguishes countries as opposed to individuals. This is in line with this study that aims to look at geographic cultural differences on the national level as opposed to an individual level. Indeed, scholars have highlighted deficiencies in the literature where Hofstede's model was erroneously applied to individuals. Yoo et al. state that "this tradition [of applying Hofstede's dimensions] is very acceptable when the unit of analysis is a country, but it is not appropriate when a study examines the effect of an individual's cultural orientation"; they raise the example of a study by Aaker and Lee in 2001 that "treated all Chinese as collectivists and all Americans as individualists" as an example of what to avoid (Yoo, Donthu, & Lenartowicz, 2011). On the other hand, Hofstede's cultural dimensions would be very appropriate when a study focuses on national cultures.

Secondly, Hofstede's cultural dimensions have been described by Yoo et al. as the "overwhelmingly dominant metric of culture" and they propose three reasons for this, namely the fact that Hofstede's cultural dimensions "fully cover and extend major conceptualizations of culture developed through decades" with Hofstede's work comprehensively encapsulating much of the literature's findings on culture, the fact that Hofstede arrived at his cultural dimensions model through large-scale empirical methods as opposed to methods couched in theory or limited in sample size, and the fact that "social sciences and cross-cultural studies have heavily replicated Hofstede's typology and found it to be the most important theory of culture types" (Yoo, Donthu, & Lenartowicz, 2011). Triandis describes Hofstede's work as "the standard against which new work on cultural differences is validated. Almost every publication that deals with cultural differences and includes many cultures is likely to reference Hofstede" (Triandis, 2004).

The subsequent sections will introduce Hofstede's six cultural dimensions, provide a definition of each dimension as proposed by Hofstede, and present comparison tables from Hofstede's work that give a selection of concrete examples of what might be expected at the opposite ends of each dimension in areas that are most relevant to this thesis's analysis – the workplace, the society, the State and others if relevant. This attempt at a quick and concise summary of the dimensions clearly does not do justice to Hofstede's work that has spanned decades; but is sufficient for a qualitative application of Hofstede's ideas. Although an in-depth explanation of each of the dimensions could have been presented instead of the comparison tables of examples, the tables were chosen as it is most probable that the reader would be able to gain a sense of the meaning of the dimensions more effectively through a heuristic mental integration of these various examples as opposed to reading a complicated explanation of the mechanism behind each dimension.

3.1 Power Distance Index (PDI)

Hofstede defines power distance as "the extent to which the less powerful members of organizations and institutions accept and expect that power is distributed unequally. Institutions are the basic elements of society, such as the family, the school, and the community; organizations are the places where people work. Power distance is thus described based on the value system of the *less* powerful members". (Hofstede, Hofstede, & Minkov, 2010)

Country index values for power distance range from 11 (Austria) to 104 (Malaysia); a lower score implies a smaller power distance and a higher score implies a larger power distance. On this dimension, China has a score of 80 and ranks 12-14 out of 76 countries, and the US a score of 40 and ranks 59-61 out of 76 countries. (Hofstede, Hofstede, & Minkov, 2010)

Table 1 below is adapted from Hofstede et al. and presents examples of how small power distance and large power distance countries may differ, with emphasis on differences between organizations.

Table 1: Differences between small PDI and large PDI countries
(Table adapted from Hofstede, Hofstede, & Minkov, 2010)

Small-power-distance	Large-power-distance
"Superiors and subordinates consider each other as existentially equal"	"Superiors and subordinates consider each other as existentially unequal"
"Hierarchical system is just an inequality of roles, established for convenience, and roles may be changed, so that someone who today is my subordinate may tomorrow be my boss""	"Hierarchy in organizations reflects existential inequality."
"Organizations are fairly decentralized, with flat hierarchical pyramids"	"Organizations centralize power as much as possible in a few hands."
"Limited numbers of supervisory personnel""	"Large number of supervisory personnel, structured into tall hierarchies of people reporting to each other"
"Subordinates expect to be consulted before a decision is made that affects their work, but they accept that the boss is the one who finally decides."	"Subordinates expect to be told what to do."
"Salary ranges between top and bottom jobs are relatively small; workers are highly qualified, and high-skill manual work has a higher status than low-skill office work. "	"Salary systems show wide gaps between top and bottom in the organization. Workers are relatively uneducated, and manual work has a much lower status than office work. "
"Managers rely on their own experience and on subordinates."	"Managers rely on superiors and on formal rules"
"Superiors should be accessible to subordinates"	"Contacts between superiors and subordinates are supposed to be initiated by the superiors only."
"Subordinate-superior relations are pragmatic"	"Subordinate-superior relations are emotional"
"Privileges and status symbols are frowned upon."	"Privileges and status symbols are normal and popular"
"The ideal boss is a resourceful (and therefore respected) democrat."	"The ideal boss in the subordinates' eyes, the one they feel most comfortable with and whom they respect most, is a benevolent autocrat or "good father". After some experiences with "bad fathers", they may ideologically reject the boss's authority completely, while complying in practice."
"Younger bosses are generally more appreciated than older ones."	"Older superiors are generally more respected than younger ones."

Small-power-distance	Large-power-distance
"Organizations are supposed to have structured ways of dealing with employee complaints about alleged power abuse".	"Being a victim of power abuse by one's boss is just bad luck; there is no assumption that there should be ways of redress in such a situation."
"The use of power should be legitimate and follow criteria of good and evil"	"Might prevails over right: whoever holds the power is right and good"
"All should have equal rights"	"The powerful should have privileges"
"Power is based on formal position, expertise, and ability to give rewards"	"Power is based on tradition or family, charisma and the ability to use force"
"The way to change a political system is by changing the rules (evolution)"	"The way to change a political system is by changing the people at the top (revolution)."
"There is more dialogue and less violence in domestic politics"	"There is less dialogue and more violence in domestic politics"

3.2 Individualism versus Collectivism (IDV)

Hofstede defines Individualism and Collectivism as such: "Individualism pertains to societies in which the ties between individuals are loose: everyone is expected to look after him- or herself and his or her immediate family. Collectivism as its opposite pertains to societies in which people from birth onward are integrated into strong, cohesive in-groups, which throughout people's lifetime continue to protect them in exchange for unquestioning loyalty." (Hofstede, Hofstede, & Minkov, 2010)

Country index values for power distance range from 6 (Guatemala) to 91 (United States); a lower score implies a greater tendency towards collectivism and a higher score implies a greater tendency towards individualism. On this dimension, China has a score of 20 and ranks 58-63 out of 76 countries, and the US, with a score of 91, ranks 1 out of 76 countries. (Hofstede, Hofstede, & Minkov, 2010)

Table 2 below is adapted from Hofstede et al. and presents examples of how collectivist and individualist countries may differ, with emphasis on differences between organizations.

Table 2: Differences between collectivist and individualist countries
(Table adapted from Hofstede, Hofstede, & Minkov, 2010)

Collectivist	Individualist
"Value standards differ for in-groups and out-groups: exclusionism"	"The same value standards are supposed to apply to everyone: universalism"
"Harmony should always be maintained and direct confrontations avoided."	"Speaking one's mind is a characteristic of an honest person"
"High-context communication prevails"	"Low-context communication prevails"
"Frequent socialization in public places"	"My home is my castle"
"Trespasses lead to shame and loss of face for self and group"	"Trespasses lead to guilt and loss of self-respect"
"Employees are members of in-groups who will pursue the in-group's interest"	"Employees are "economic persons" who will pursue the employer's interest if it coincides with their self-interest"
"Hiring and promotion decisions take employee's in-group into account"	"Hiring and promotion decisions are supposed to be based on skills and rules only"
"The employer-employee relationship is basically moral, like a family link"	"The employer-employee relationship is a contract between parties in a labor market"
"Management is management of groups"	"Management is management of individuals"
"Direct appraisal of subordinates spoils harmony"	"Management training teachers the honest sharing of feelings"
"In-group customers get better treatment (particularism)"	"Every customer should get the same treatment (universalism)"

Collectivist	Individualist
"Relationship prevails over task"	"Task prevails over relationship"
"Opinions are predetermined by group membership"	"Everyone is expected to have a private opinion"
"Collective interests prevail over individual interests"	"Individual interest prevail over collective interests"
"Ideologies of equality prevail over ideologies of individual freedom"	"Ideologies of individual freedom prevail over ideologies of equality"
"Harmony and consensus in society are ultimate goals"	"Self-actualization by every individual is an ultimate goal"
"Patriotism is the ideal"	"Autonomy is the ideal"

3.3 Masculinity vs. Femininity (MAS)

Hofstede defines masculinity and femininity of national cultures as follows: "A society is called masculine when emotional gender roles are clearly distinct: men are supposed to be assertive, tough, and focused on material success, whereas women are supposed to be more modest, tender, and concerned with the quality of life. A society is called feminine when emotional gender roles overlap – both men and women are supposed to be modest, tender, and concerned with the quality of life." (Hofstede, Hofstede, & Minkov, 2010)

Country index values for MAS range from 5 (Sweden) to 110 (Slovakia); a lower score implies a greater tendency towards femininity and a higher score implies a greater tendency towards masculinity. On this dimension, China has a score of 66 and ranks 11-13 out of 76 countries, and the US, with a score of 62, ranks 19 out of 76 countries. (Hofstede G. H., 2001)

Table 3 below is adapted from Hofstede et al. and presents examples of how feminine and masculine cultures may differ.

Table 3: Differences between feminine and masculine countries
(Table adapted from Hofstede, Hofstede, & Minkov, 2010)

Feminine	Masculine
"Relationships and quality of life are important"	"Challenge, earnings, recognition, and advancement are important"
"Both men and women should be modest"	"Men should be assertive, ambitious, and tough"
"Both men and women can be tender and focus on relationships"	"Women are supposed to be tender and to take care of relationships"
"Jealousy of those who try to excel"	"Competition in class; trying to excel"
"Job choice is based on intrinsic interest"	"Job choice is based on career opportunities"
"Management as ménage: intuition and consensus"	"Management as manège: decisive and aggressive"
"Resolution of conflicts by compromise and negotiation"	"Resolution of conflicts by letting the strongest win"
"Rewards are based on equality"	"Rewards are based on equity"
"Preference for smaller organizations"	"Preference for larger organizations"
"People work in order to live"	"People live in order to work"
"More leisure time is preferred over more money"	"More money is preferred over more leisure time"
"There is a higher share of working women in professional jobs"	"There is a lower share of working women in professional jobs"
"Humanization of work by contact and cooperation"	"Humanization of work by job content enrichment"
"International conflicts should be resolved by negotiation and compromise"	"International conflicts should be resolved by a show of strength or by fighting"
"Welfare society ideal; help for the needy"	"Performance society ideal; support for the strong"
"Permissive society"	"Corrective society"
"Immigrants should integrate"	"Immigrants should assimilate"
"The environment should be preserved: small is beautiful"	"The economy should continue growing: big is beautiful"

3.4 Uncertainty Avoidance Index (UAI)

Hofstede defines uncertainty avoidance as “the extent to which the members of a culture feel threatened by ambiguous or unknown situations. This feeling is, among other manifestations, expressed through nervous stress and in a need for predictability: a need for written and unwritten rules.” (Hofstede, Hofstede, & Minkov, 2010)

Country index values for MAS range from 8 (Singapore) to 112 (Greece); a lower score implies a lower tendency towards uncertainty avoidance and a higher score implies a greater tendency towards uncertainty avoidance. On this dimension, China has a score of 30 and ranks 70-71 out of 76 countries, and the US, with a score of 46, ranks 64 out of 76 countries. (Hofstede, Hofstede, & Minkov, 2010)

Table 4 below is adapted from Hofstede et al. and presents examples of how weak uncertainty avoidance and strong uncertainty avoidance cultures may differ.

Table 4: Differences between weak uncertainty avoidance and strong uncertainty avoidance countries (Table adapted from Hofstede, Hofstede, & Minkov, 2010)

Weak Uncertainty Avoidance	Strong Uncertainty Avoidance
“Uncertainty is a normal feature of life, and each day is accepted as it comes.”	“The uncertainty inherent in life is a continuous threat that must be fought”
“Low stress and low anxiety”	“High stress and high anxiety”
“Aggression and emotions should not be shown”	“Aggression and emotions may at proper times and places be vented”
“Comfortable in ambiguous situations and with unfamiliar risks”	“Acceptance of familiar risks; fear of ambiguous situations and of unfamiliar risks”
“What is different is curious”	“What is different is dangerous”
“More changes of employer, shorter service”	“Fewer changes of employer, longer service, more difficult work-life balance”
“There should be no more rules than strictly necessary”	“There is an emotional need for rules, even if they will not work”
“Work hard only when needed”	“There is an emotional need to be busy and an inner urge to work hard”
“Time is a framework for orientation”	“Time is money”
“Tolerance for ambiguity and chaos”	“Need for precision and formalization”
“Belief in generalists and common sense”	“Belief in experts and technical solutions”
“Top managers are concerned with strategy”	“Top managers are concerned with daily operations”
“Focus on decision process”	“Focus on decision content”
“Better at invention worse at implementation”	“Worse at invention, better at implementation”
“Motivation by achievement and esteem or belonging”	“Motivation by security and esteem or belonging”
“More ethnic tolerance”	“More ethnic prejudice”
“Positive or neutral toward foreigners”	“Xenophobia”
“Refugees should be admitted”	“Immigrants should be sent back”
“Lower risk of violent intergroup conflict”	“High risk of violent intergroup conflict”
“In philosophy and science, there is a tendency toward relativism and empiricism”	“In philosophy and science, there is a tendency toward grand theories”
“Scientific opponents can be personal friends”	“Scientific opponents cannot be personal friends”

3.5 Long Term Orientation versus Short Term Normative Orientation (LTO)

Hofstede defines long-term versus short-term orientation as follows: "long-term orientation stands for the fostering of virtues oriented toward future rewards – in particular, perseverance and thrift. Its opposite pole, short-term orientation, stands for the fostering of virtues related to the past and present – in particular, respect for traditions, preservation of "face" and fulfilling social obligations" (Hofstede, Hofstede, & Minkov, 2010)

Country index values for LTO range from 0 (Puerto Rico) to 100 (South Korea); a lower score implies a greater tendency towards short term orientation and a higher score implies a greater tendency towards long term orientation. On this dimension, China has a score of 87 and ranks 4 out of 93 countries and regions, and the US, with a score of 26, ranks 69-71 out of 93 countries and regions. (Hofstede, Hofstede, & Minkov, 2010)

Table 5 below is adapted from Hofstede et al. and presents examples of how short-term orientation and long-term orientation cultures may differ.

Table 5: Differences between short-term orientation and long-term orientation countries (Table adapted from Hofstede, Hofstede, & Minkov, 2010)

Short-term Orientation	Long-term orientation
"Proud of my country"	"Learn from other countries"
"Tradition is important"	"Children should learn to persevere"
"Family pride"	"Family pragmatism"
"Students attribute success and failure to luck"	"Students attribute success to effort and failure to lack of it"
"No special skills for mathematics"	"In East Asia, better at mathematics"
"Talent for theoretical, abstract sciences"	"Talent for applied, concrete sciences"
"Slow or no economic growth of poor countries"	"Fast economic growth of poor countries"
"Small savings quote, little money for investment"	"Large savings quote, funds available for investment"
"Appeal of fundamentalisms"	"Appeal of pragmatism"
"Social pressure toward spending"	"Thrift, being sparing with resources"
"Efforts should produce quick results"	"Perseverance, sustained efforts toward slow results"
"Concern with social and status obligations"	"Willingness to subordinate oneself for a purpose"
"Concern with 'face'"	"Having a sense of shame"
"Respect for traditions"	"Respect for circumstances"
"Concern with personal stability"	"Concern with personal adaptiveness"
"Main work values include freedom, rights, achievement, and thinking for oneself"	"Main work values include learning, honesty, adaptiveness, accountability, and self-discipline"
"Leisure time is important"	"Leisure time is not important"
"Focus is on the 'bottom line'"	"Focus is on market position"
"Managers and workers are psychologically in two camps"	"Owner-mangers and workers share the same aspirations"
"Meritocracy, reward by abilities"	"Wide social and economic differences are undesirable"
"Personal loyalties vary with business needs"	"Investment in lifelong personal networks, *guanxi*"
"Concern with possessing the Truth"	"Concern with respecting the demands of Virtue"
"There are universal guidelines about what is good and evil"	"What is good and evil depends on the circumstances"
"Dissatisfaction with one's own contributions to daily human relations and to correcting injustice"	"Satisfaction with one's own contributions to daily human relations and to correcting injustice"
"If A is true, its opposite B must be false"	"If A is true, its opposite B can also be true"
"Priority is given to abstract rationality"	"Priority is given to common sense"
"There is a need for cognitive consistence"	"Disagreement does not hurt"
"Analytical thinking"	"Synthetic thinking"

3.6 Indulgence versus Restraint (IVR)

Hofstede et al. define indulgence versus restraint as follows: “Indulgence stands for a tendency to allow relatively free gratification of basic and natural human desires related to enjoying life and having fun. Its opposite pole, restraint reflects a conviction that such gratification needs to be curbed and regulated by strict social norms.” (Hofstede, Hofstede, & Minkov, 2010)

Country index values for IVR range from 0 (Pakistan) to 100 (Venezuela); a lower score implies a greater tendency towards restraint and a higher score implies a greater tendency towards indulgence. On this dimension, China has a score of 24 and ranks 75 out of 93 countries and regions, and the US, with a score of 68, ranks 15-17 out of 93 countries and regions. (Hofstede, Hofstede, & Minkov, 2010)

Table 6 below is adapted from Hofstede et al. and presents examples of how indulgent and restrained cultures may differ.

Table 6: Differences between indulgent and restrained countries
(Table adapted from Hofstede, Hofstede, & Minkov, 2010)

Indulgent	Restrained
“Higher percentage of very happy people”	“Lower percentages of very happy people”
“A perception of personal life control”	“A perception of helplessness: what happens to me is not my own doing”
“Higher importance of leisure”	“Lower importance of leisure”
“Higher importance of having friends”	“Lower importance of having friends”
“Thrift is not very important”	“Thrift is important”
“Loose society”	“Tight society”
“More likely to remember positive emotions”	“Less likely to remember positive emotions”
“Less moral discipline”	“Moral discipline”
“Positive attitude”	“Cynicism”
“More extroverted personalities”	“More neurotic personalities”
“Higher optimism”	“More pessimism”
“Smiling as a norm”	“Smiling as suspect”
“Freedom of speech is viewed as relatively important”	“Freedom of speech is not a primary concern”
“Maintaining order in the nation is not given a high priority”	“Maintaining order in the nation is considered a high priority”

3.7 Comparison of the Cultures of US and China

Table 7 below gives a summary of the US's and China's scores for each of Hofstede's six cultural dimensions, together with their ranking and approximate percentile. The interpretation for each of the dimensions with regards to the US and China is also provided. It should be noted that "significant" in this case is used in the qualitative sense and not in the statistical sense. Figure 2 presents the cultural dimension scores of the US and China in graphical format.

Table 7: Comparison of Cultural Dimension Scores of US and China (Hofstede, Hofstede, & Minkov, 2010)

Cultural Dimension	US			China			Interpretation
	Score	Rank[2]	Percentile	Score	Rank	Percentile	
Power Distance Index (PDI)	40	59-61 /76	21	80	12-14 /76	83	Significant difference in PDI between US and China. The US has a significantly small-power-distance culture while China has a significantly large-power-distance culture.
Individualism versus Collectivism (IDV)	91	1/76	99	20	58-63 /76	20	Significant difference in IDV between US and China. The US has a significantly individualist culture (the most individualist culture among all countries/regions surveyed) while China has a significantly collectivist culture.
Masculinity versus Femininity (MAS)	62	19/76	75	66	11-13 /76	84	Small difference in MAS between US and China. Both countries have a significantly masculine culture, but China has a relatively more masculine culture than the US.
Uncertainty Avoidance Index (UAI)	46	64/76	16	30	70-71 /76	7	Small difference in UAI between US and China. Both countries have a significantly weak uncertainty avoidance culture, but China has a relatively weaker uncertainty avoidance culture than the US.
Long term orientation versus short term orientation (LTO)	26	69-71 /93	25	87	4/93	96	Significant difference in LTO between US and China. The US has a significantly short-term oriented culture while China has a significantly long-term oriented culture.
Indulgence versus Restraint (IVR)	68	15-17 /93	83	24	75/93	20	Significant difference in IVR between US and China. The US has a significantly indulgent culture while China has a significantly restrained culture.

[2] A range given for a rank, for example the US ranking 59-61/76 for power distance, means that the US had the same score as two other countries and all three were ranked in the 59^{th}-61^{st} place out of 76 countries.

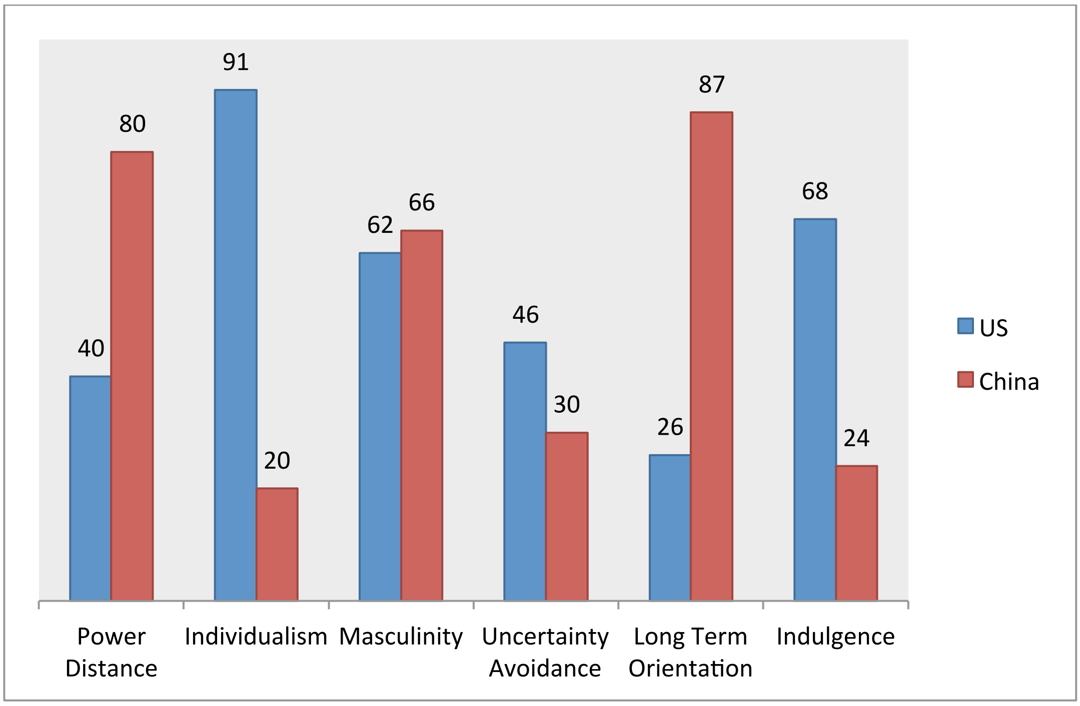

Figure 2: Graphical representation of scores of US and China along Hofstede's Six Cultural Dimensions (Hofstede, Hofstede, & Minkov, 2010)

The scores above have several interesting implications. Firstly, among the six dimensions, the US and China tend to either score very differently or fairly similarly along a particular dimension; more specifically, the US and China differ greatly on

- Power Distance (US – small PDI, China – large PDI),
- Individualism (US) vs. Collectivism (China)
- Long Term (China) vs. Short Term (US) Orientation, and
- Indulgence (US) vs. Restraint (China)

Both countries are fairly similar for both Masculinity vs. Femininity and Uncertainty Avoidance, with both countries possessing relatively significant masculine culture and relatively significantly weak uncertainty avoidance. This implies that if Hofstede's cultural dimensions are indeed applicable to a cultural comparison of the US and China in terms of their manned space programs, one would expect to see clear culturally-driven differences as well as similarities on the basis of their scores along the six cultural dimensions.

The next question then is how these dimensional scores should be used for such a comparison. Hofstede, in a discussion of how his culture dimensional scores may be used in further research, gives four areas in which his model has been applied - "reviews and criticisms, replications, extensions to new countries and regions, and paradigmatic uses" (Hofstede G. H., 2001). This study falls under the last category of paradigmatic uses. Hofstede states that both quantitative and qualitative paradigmatic applications of his model exist in the literature, and that with qualitative applications, "the model can serve to explain to help us understand observed similarities and differences between matched phenomena in different countries…qualitative use is possible for any comparison of 2 or more cases" (Hofstede G. H., 2001).

More significantly, Hofstede admits that his model has a long way to go, and lists six steps that he feels must be taken to further develop his cultural dimensions model. Hofstede describes one of these steps as follows: "Most important, the *consequences for organizational, national, and international policy* of a better insight into dimensions of national culture should be elaborated. My theory of cultural differentiation is like a product of the research laboratory, which awaits the efforts of the development technicians to elaborate it into something of practical use…for example… how the new insights can contribute to turning cultural conflict in multicultural organizations into cultural synergy."

(Hofstede G. H., 2001). This study thus hopes to contribute to this step by applying Hofstede's model to a practical case study, the results of which may be used to inform policy or process in the field of systems engineering.

3.8 Potential Areas of Concern

There are three main areas of concern with regards to applying Hofstede's cultural dimensions model to a comparison of the US and China manned space programs. Firstly, if one were to glance at the two columns in the comparison tables above and attempt to relate the descriptions in the respective columns to the US and China, certain questions may arise. For example, it may be the case that a particular description for small power distance is found to not apply at all to the US, even though we have seen that the US is a country with a significantly small power distance culture. Or it may be the case that certain descriptions for Long Term Orientation are at best debatable for China, even though China is a country with a significant Long Term Orientation.

It should be noted that even if a certain country scores particularly low or high in a dimension, this does not imply that it necessarily has to fulfill perfectly all of the characteristics in its corresponding column; conversely, even if there exist characteristics in a column that do not apply to a country that is supposed to belong to that column, this is no cause for alarm. Hofstede cautions that "(1) [the dimensions are] a continuum, so countries are not just polarized between "high" and "low" but may be anywhere in between; (2) statements [in the table] are based on the situation in particular countries or on statistical trends across a number of countries, but not every statement applies with equal strength to all countries; and (3) individuals in countries show a wide range of variation around the country's societal norms" (Hofstede G. H., 2001). Therefore, the examples in the comparison table should serve as a guide towards an intuitive understanding of the dimensions, but do not in and of themselves comprehensively define what is, for example, an individualist or a collectivist country. It should thus be kept in mind that the US and China actually lie along a continuum for a particular dimension instead of the extremes as represented by the column, as well as the fact that the examples in a particular column will inevitably vary with strength depending on the country of focus and thus should be considered as a whole.

Secondly, as will be elaborated on later, the manned spaceflight program of the US actually took place in the 1960s, whereas the manned spaceflight program of China took place in the 1990s and lasted into the new millennium. The question then is whether Hofstede's cultural dimensions and the scores associated with them can be applied to situations that are separated in time by a few decades. More specifically, given that Hofstede developed his cultural dimensions model based on data collected around 1970, it may be arguable that they may represent the culture of the US in the 1960s, but would they truly represent the culture of China in the 1990s-2000s?

The history behind how the cultural dimension scores were obtained sheds light on this problem. It was mentioned earlier that Hofstede initially developed his four original cultural dimensions based on employee surveys conducted between 1967 to 1973 from 40 countries; the US was part of this group of 40 countries which implies that the current scores for the first four dimensions for the US are indeed reflective of the culture of the US during that period of time. Barring a difference of 5-10 years, it would be fair to say that the scores for the first four dimensions that are now available for the US would be applicable to a study of US cultural dimensions during the 1960s when the US manned spaceflight program was taking place.

China, however, was not part of the original sample of 40 countries, nor was it included in the subsequent extension to 50 countries and 3 regions. The reason for this is that China was never sampled in the IBM values survey during the 1970s. In fact, the dimensions scores for China were obtained from replications of the original IBM questionnaire or certain segments of it to a larger group of countries which included China. These replication studies took place over the period of 1990-2002 (Hofstede, Hofstede, & Minkov, 2010), which actually corresponds almost exactly with the period of time from the beginning of the Chinese manned spaceflight program up till the first successful manned spaceflight (1992-2003). In this sense, the dimensions scores for China for the first four dimensions are, entirely out of pure coincidence, applicable to the period of time when the Chinese manned spaceflight program was taking place.

What then of the remaining two dimensions? The scores for both the US and China for these two dimensions were derived from the World Values Survey, which spanned the period from 1995-2004. This implies that the scores for China for LTO and IVR may be applicable to the Chinese manned spaceflight program, but the application of the scores of the US to a program that took place approximately three decades before may be called into question.

That said, however, Hofstede assert that critics that call his data from the IBM survey “old and therefore obsolete” should realize that “The dimensions found are assumed to have centuries-old roots…they have since been validated against all kinds of external measurements and recent replications show no loss of validity” (Hofstede G. H., 2001). According to Hofstede, and as mentioned earlier, it is unlikely that the cultural values of a nation will change significantly over a relatively short span of time such as a few decades, and that in fact, “The IBM national dimension scores (or at least their relative positions) have remained as valid in the year 2010 as they were around 1970, indicating that they describe relatively enduring aspects of these countries’ societies” (Hofstede, Hofstede, & Minkov, 2010). The implication, if we accept this to be true, would be that not only would the country scores on all six dimensions be applicable to the US and China during the respective periods of history that their manned spaceflight programs took place because of the relatively immutable nature of a nation’s cultural values, but also that the findings from such a study would still continue to be generalizable into the reasonably near future; as Hofstede et al. put it, “The Hofstede dimensions of national cultures are rooted in our unconscious values. Because values are acquired in childhood, national cultures are remarkably stable over time; national values change in a matter of generations. What we see changing around us, in response to changing circumstances are practices: symbols, heroes and rituals, leaving the underlying values untouched. This is why differences between countries often have such a remarkable historical continuity” (Hofstede & Hofstede).

The third area of concern would be the question of whether all six dimensions should be treated equally, or in other words, if they are equally relevant to the topic at hand. Hofstede cautions that “Paradigmatic users sometimes forget to choose among the dimensions; some believe their phenomena should be related to all of the dimensions, one by one. This is based on a misunderstanding. The strength of the model is precisely that it allows conceptual parsimony: It allows us to detect which dimension is responsible for a particular effect and which dimensions are not.” (Hofstede G. H., 2001) Therefore, it is not a necessity for the six dimensions to be fully applied in equal measure when attempting to understand a particular difference between the US and China programs, and that some dimensions will inevitably be more salient to a particular discussion than others. Thus, the true value of the cultural dimensions lies in their explanatory power when applied to a relevant situation, and should not be seen as a checklist or the absolute truth.

4. The Purpose – Why Embark on Manned Spaceflight Programs?

"*I don't know of any reasons why the scientists should have come in and urged that we do this before anybody else could. Now quite naturally, you will say, "Well, the Soviets gained a great psychological advantage throughout the world," and I think in the political sense that is possibly true. But in the scientific sense it is not true…And I think that within time, given time, satellites will be able to transmit to the earth some kind of information with respect to what they see on the earth or what they find on the earth. But I think that that period is a long ways off when you stop to consider that even now, and apparently they have, the Russians, under a dictatorial society, where they had some of the finest scientists in the world, who have for many years been working on it, apparently from what they say they have put one small ball in the air. I don't – I wouldn't believe that at this moment you have to fear the intelligence aspects of this.*"

- President Dwight D. Eisenhower on October 9, 1957, in the first press conference after Sputnik I's launch, in response to questions on whether American scientists "made a mistake in not recognizing that we were, in effect…in a race with Russia" and whether Sputnik I had "immense significance" (White House, 1957)

"*We are very concerned that we do not put a man in space in order to gain some additional prestige, and have the man take a disproportionate risk, so we are going to be extremely careful in our work; and even if we should come in second in putting a man in space, I will still be satisfied if, when we finally put a man in space, his chances of survival are as high as I think they must be*."

- President John F. Kennedy in a news conference on February 8, 1961, in response to a question on whether he had "ordered an acceleration of our space program" or if he considered "for psychological or other reasons, that we are in a race with the Russians to get a man into space" (JFK Library, 1961)

"苏联去年把卫星抛上了天，美国在几个月前也把卫星抛上了天。那么，我们怎么办？...我们也要搞人造卫星！...我们要抛就抛大的...也需要先从小的抛起，但我们也要从一两千公斤的开始，我们不干美国鸡蛋大的！" (The Soviet Union threw a satellite up into the sky last year; the US also threw a satellite up a few months ago. So what are we going to do about it?...We will also build satellites!...But if we are going to throw one up we should throw a big one…perhaps we need to throw a small one up first, but one that is at least one to two thousand kilograms, we won't build one like the Americans' chicken egg!)

- Mao Zedong, then Chairman of the People's Republic of China, during the 8th National Congress of the Communist Party of China on May 17, 1958 (唐国东, 2012)

"*1961 年苏联第一个载人，美国是 1962 年。1957 年苏联第一颗卫星上天，美国人马上就总结经验，说美国技术落后了，要赶上来...因此，建议静静地、坚持不懈地、契而不舍地去搞.... 今天我们就做这样一个决策，发展我们自己的载人航天。" (The Soviet Union sent a human into space in 1961, and America in 1962. When the Soviet Union launched their first satellite in 1957, America immediately reflected on themselves and admitted that American technology had fallen behind, and that the US needed to catch up…Therefore, I propose we do this [manned spaceflight] quietly, determinedly, tirelessly…today we will make this decision, to develop our own manned spaceflight capability*)

- Jiang Zemin, then General Secretary of the Communist Party of China, in an internal top-level party meeting on September 21, 1992 (唐国东, 2012)

4.1 The Mercury and Shenzhou Programs

The first successful manned spaceflight program of the US was called Project Mercury, named after the patron god of travelers Mercury[3] in Roman Mythology, whose Greek counterpart, Hermes, was the Messenger of the Gods. Project Mercury was officially approved on October 7, 1958, and announced to the US public on December 17, 1958. The first successful suborbital and orbital manned spaceflights were performed by astronauts Alan Shepard and John Glenn respectively on May 5, 1961 and February 20, 1962 respectively, approximately 2.5 and 3.5 years after Project Mercury started. The very last Mercury flight took place on May 15, 1963. (Catchpole, 2001)

The first successful manned spaceflight program of China was called the Shenzhou Program[4] (神舟), which means “divine vessel”. The Shenzhou Program was officially approved on September 21, 1992 and the first successful orbital manned spaceflight (no suborbital manned spaceflight was attempted) was performed by taikonaut Yang Liwei on October 15, 2003, approximately 11 years after the Shenzhou Program began (Harvey, 2013). The Shenzhou program is still ongoing.

4.2 The Case for Manned Spaceflight

It is apt to begin a discussion of the US and China manned spaceflight programs with a comparison of the rationale for each nation eventually deciding to embark on an attempt to achieve independent manned spaceflight capability.

It should be noted that firstly, the decision to embark on a manned spaceflight program should be evaluated in the context of, but not analogous to, a nation’s decision to embark on a space program. There are currently many nations who have developed their own space programs, including India, Japan, France, Iran, South Korea, Israel and others apart from the US, Russia and China, but only the latter three have achieved manned spaceflight capability. It stands to reason that the impetus for embarking on a manned spaceflight program is not entirely the same as that for embarking on a general space program, and neither is manned spaceflight a natural or inevitable step in the progression of a country’s space program. Secondly, the decision to embark on a manned spaceflight program is certainly not a trivial one; as will be shown later, it takes a particular confluence of factors and a unique combination of historical and geopolitical circumstances to make such a decision possible in the first place.

The reason why manned spaceflight is such a special case is because it involves risks that are not only enormous but also unnecessary from a technical standpoint. Apart from the natural increase in technological and engineering complexity when human lives are involved in spaceflight, which inevitably drives up costs and demands larger amounts of economic and human resources, this complexity is often unwarranted because most, if not all, of the tasks that a human may be asked to perform on manned spaceflight missions can just as easily be conducted by computers and automation, arguably at times with far greater precision and efficiency (Handberg & Li, 2007). From a purely practical point of view, it often does not make economic or technical sense to carry out spaceflight missions that are manned, much less devote years of effort and resources toward this goal as the US, Russia and China have done. This is markedly different from other unmanned space missions, such as the launching of space probes or satellites, which not only have clearly practical aims and whose utility is more easily justifiable in front of a board of decision makers, but which also do not carry the

[3] Mercury is also the “patron god of financial gain, commerce, eloquence (and thus poetry), messages/communication (including divination), travelers, boundaries, luck”, all of which are attributes which seem to hold much relevance to a manned spaceflight program. Unfortunately, Mercury also happens to be the patron god of “trickery and thieves…he is also the guide of souls to the underworld”, attributes that were probably not in the minds of Glennan and Dryden from NASA at that time. (Wikipedia)
[4] Shenzhou is a play on another name for China, 神州, which means “divine land” and is also pronounced “shenzhou”.

baggage of risk to human life. The caveat, though, is that this argument is probably most clearly applicable to that period of time when the US and China first embarked on their manned spaceflight programs; manned spaceflight programs may indeed with a practical value insofar as they open up the door to future possibilities that unequivocally require a human presence, such as the colonization of Mars or commercial space tourism.

But even though the reasons for manned spaceflight may be unique compared to those for embarking on a general space program, any discussion of manned spaceflight necessarily has to begin with the conception of a nation's aerospace journey, due to the technical dependencies of manned spaceflight on other accomplishments in aerospace, notably the development of ballistic missile technology and the successful delivery of satellites into orbit. Launius has proposed five major reasons that may be used to explain the motivations behind national spaceflight programs – national security and military applications, national prestige/geopolitics, economic competitiveness and commercial applications, scientific discovery and understanding, and human destiny/survival of the species (Launius, 2004), and the subsequent discussion will use these five major reasons as a starting framework to explore the motivations of the US and China with regards to manned spaceflight.

Arguably, the motivations of both the US and China manned spaceflight programs can be traced back to the fateful launch of Sputnik I by the former Soviet Union on October 4, 1957. An examination of the historical events leading up to and following Sputnik I is needed to truly understand what drove these two nations to develop manned spaceflight capabilities. Section 4.3 below will lay out the developments leading up to the conception of the manned spaceflight programs of the US and China, as well as the motivations that drove each nation to achieve manned spaceflight.

4.3 The Motivations behind the US and China Manned Spaceflight Programs

The narratives below that describe the developments leading up to the conception of the manned spaceflight programs of the US and China, as well as the motivations that drove each nation to achieve manned spaceflight are primarily based on the available literature on the Mercury and Shenzhou programs, and serve as context for subsequent analyses on the differences between these two programs.

Subsection 4.3.2, as well as subsequent chapters, draw upon Chinese source material, in particular original quotes, in order to demonstrate certain arguments. These quotes are presented in Chinese for readers interested in the original quotes, and an English translation is provided immediately after each of these quotes[5].

4.3.1 The Lead-up to Project Mercury

The US had decades before Sputnik-I's launch already began the early seeds of its space program (the development of ballistic missile technology) due to reasons of "national security and military applications". With the relocation of former German Peenemünde engineers to Huntsville by 1950 and under the leadership of Wernher von Braun, the team of mostly German scientists under the Army Ballistic Missile Agency at Redstone Arsenal were given orders by the Pentagon to "develop a large tactical rocket capable of delivering a nuclear warhead a distance in excess of 200 miles" (Burgess, 2014). The Korean War played a large role in this development; the Hermes C project of the Army at that time, which initially focused on building a missile with a 500-mile range, was modified to focus on "the development of a single-stage, surface-to-surface ballistic missile having only a 200-mile range but with high mobility, allowing field deployment", a task which eventually led to the development of the Redstone missile (Launius & Jenkins, 2002). The PGM-11 Redstone, the first large American ballistic missile, was first flight tested on 20 August, 1953 and continued to be improved on up until 1958 through 37 test flights (Burgess, 2014). Perhaps unknown to von Braun and his team then in 1952, the PGM-11 Redstone would eventually form the basis for the Redstone family of rockets, among them Juno I and Mercury-Redstone 3, which would launch America's first satellite and first man in space respectively about a decade later (Parsch, 2002).

While America was said to have well had the capability to place a satellite in orbit before the Soviets did, two obstacles stood in the path of a satellite launch before the Soviets. Firstly, the pragmatism of political realities in the time leading up to Sputnik I's launch did not see as justifiable the diverting of a great deal of resources to orbiting a satellite from other efforts seen as more critical at that time, such as ballistic missile development (Handberg & Li, 2007), much less the pursuit of manned spaceflight. Even though von Braun's briefings following his surrender to the US Army in 1945 planted the idea of satellite development in the form of the Navy's Earth Satellite Vehicle Program, budget constraints imposed in part by Truman led to the cancellation of this project on June 22, 1948. According to McDougall, Truman's successor, Eisenhower, was also loathe to devote resources to military programs, saying that "Every gun that is made, every warship launched, every rocket fired signifies, in the final sense, a theft from those who hunger and are not fed, those who are cold and not clothed." McDougall describes Eisenhower as a President intent on "slashing the defense budget, and reining in the generals and admirals whose ever-growing demands for new hardware threatened the integrity of the treasury". Nevertheless, Eisenhower did recognize the need to maintain the US's military capabilities, a balance that was referred to as "The Great Equation"; his administration clearly prioritized programs such as the ICBM and USAF spy satellite programs, but a satellite program merely for the purposes of national prestige did not feature very high on his spending priority list. (McDougall, 1997)

[5] During the translation of these Chinese quotes into English, care was taken to preserve the original structure and meaning of the quotes as far as possible; some translations may thus seem unnatural if read out due to inherent grammatical differences between English and Chinese, but the intended meaning should not be affected.

If the first obstacle was economic in nature, the second obstacle was quintessentially political. The US clearly understood that launching a satellite before the Soviets did was critical to national prestige; upon the recommendation of the Special Committee for the International Geophysical Year (CSAGI) that governments proceed with satellite development for scientific purposes, the American Rocket Society advocated a satellite development program, and von Braun, in particular, championed the idea of launching a satellite using a Redstone vehicle under the joint Project Orbiter between the Office of Naval Research and Redstone Arsenal, saying that "It would be a blow to U.S. prestige if we did not do it first". Indeed, the idea of a satellite had earlier been reinvigorated by the release of the RAND satellite report exactly 7 years before Sputnik I on October 4, 1950, but the same report also recommended treading wisely given the possible reactions of the Soviets if a satellite was indeed launched, most notably the interpretation of a satellite flying over the Soviet Union as an act of war; this clearly removed any desire to rush headlong into a satellite launch race with consequences that would be regretted later. The Technological Capabilities Panel and the Science Advisory Committee also stated in a report that "[C]onsiderable prestige and psychological benefits will accrue to the nation which first is successful in launching a satellite. If the Soviets were first, it could have important repercussions on the determination of Free World countries to resist Communist threats" but also warned against inciting any kneejerk reactions that would hamper the US's other interests. Even when the White House Press Secretary James Hagerty announced on July 28, 1955 the approval by Eisenhower to embark on a small satellite program, the political obsession with ensuring that the satellite program be as non-military in nature as possible in fear of Soviet reprisals led to the choice of the scientific Viking rocket over the military Redstone missile, even though only the latter had a realistic chance of putting a satellite in orbit before the Soviets. This eventually became known as Project Vanguard, and it faced a whole host of difficulties such as its "civilian nature" which made securing financing difficult, and the project's contractor, Martin, objecting to the relationship it had with the NRL and allocating its best employees to the military Titan missile. This eventually resulted in the Soviets winning the race to orbit a satellite on October 4, 1957 while von Braun and his team could do nothing but watch the competition unfold; indeed upon receiving the news that the Soviets had won, von Braun exclaimed "We knew they were going to do it! Vanguard will never make it. We have the hardware on the shelf. For God's sake, turn us loose and let us do something." (McDougall, 1997).

McDougall describes Sputnik's launch as "the greatest defeat Eisenhower could have suffered" and that "The tragedy is that Eisenhower, or perhaps just his DoD advisers, failed to imagine the use that would be made of a Soviet 'surprise' by those who yearned to overthrow his policies, his party, and his philosophy of government". There was expectedly a great public outcry over the implications of Sputnik I's launch, described by McDougall as "ear-splitting...No event since Pearl Harbor set off such repercussions in public life" with allegations of "interservice rivalry, underfunding, complacency, disparagement of 'egghead' scientists, inferior education, lack of imagination in a White House presided over by a semiretired golfer, and a general lethargic consumerism". (McDougall, 1997) Eisenhower himself tried to downplay the significance of the Soviet launch and granted an addition $4 million to Project Orbiter on October 30, 1957 while approving it as a back-up to Project Vanguard (Catchpole, 2001), but his efforts did not work well amidst a media frenzy that preyed on the insecurities of the public and seemingly contradictory statements put out by his administration; in fact, despite recommendations from the Gaither Report and the CIA that claimed that the US was facing "a critical threat" and "a grave national emergency" from the Soviets, Eisenhower refused to issue a strong financial response to the panic. (McDougall, 1997)

The subsequent launch of Sputnik II on November 3, 1957 seemed to be the last straw and a special inquiry was launched into the Eisenhower administration's satellite and missile programs the following day headed by Lyndon Johnson. McDougall states that Johnson saw the Sputniks as "a technological Pearl Harbor" and that specific explanations of "bitter rivalries in the military, underfunding, and bureaucratic blindness" did nothing to temper more sweeping general explanations, such as Vannevar Bush stating that "Americans were complacent, egoistic, and spoiled…[Sputnik] was one of the finest things that Russia ever did for us…It has waked this country up". Party politics notwithstanding, the unfortunate and embarrassing failure of Vanguard TV-3 on December 6, 1957 lent further momentum to the inquiry and Johnson released, together with his recommendations, a statement that "We have reached a stage of history where defense involves the total effort of a nation". In response to these recommendations, Eisenhower "confessed his failure to anticipate the psychological impact of the first satellite" and reluctantly put military R&D on the fast-track, committed huge financial resources to civilian science, devoted large investments to education (in the form of the 1958 National Defense Education Act) and approved the creation of the civilian agency NASA on October 1, 1958, a significant departure from his previous attempts to keep a tight rein over military expenditure and R&D and his long-held determination to prevent a slide towards a technocratic state, but a compromise, nonetheless, with his principles of limited government interference, due to the temporariness built into these measures and the insistence of a civilian flavor in space R&D. In Eisenhower's mind, technology policy, including space policy had to be "subservient to national strategy and economic prudence" and the White House. (McDougall, 1997)

The establishment of NASA marked a turning point in the US's journey towards manned spaceflight. According to McDougall, the President's Science Advisory Committee concluded that "apart from reconnaissance satellites, the major goals of spaceflight in the near term were scientific and political", that this "suggested the wisdom of a civilian agency", and that they thus recommended that "An American space organization should leave military satellites in the Pentagon, but otherwise be lodged in an open, civilian agency. " The National Aeronautics and Space Act of 1958 stated that "aeronautical and astronautical activities…should be the responsibility of a civilian agency except where associated with weapons systems, military operations, and defense. The purposes of space activities were the expansion of human knowledge, improvement of aircraft and space vehicles, development of craft to carry instruments and living organisms through space, preservation of the United States as a leader in space science and applications, cooperation with other nations, and optimal utilization of American scientific and engineering resources." Indeed, as McDougall puts it, "There was widespread concern, born of idealism and propaganda both, that the United States show the world an open space program" and that a Senate committee staff memo stated that "The main reason why we must have a civilian agency is because of the necessity of negotiating with other nations and the United Nations from some nonmilitary posture". (McDougall, 1997)

The role of the establishment of NASA in the US's race toward manned spaceflight was the clearest in the year leading up to the approval of Project Mercury. In January 1958, the Advanced Research project Agency (ARPA) was set up by the DOD to guide the various manned satellite initiatives existing at that time, of which there were two major ones (Catchpole, 2001). The first was led by the USAF – from March 10-12, 1958, the Air Force Air Research and Development Command (ARDC), in discussion with representatives from NACA and other contractors led to a project named "Man In Space Soonest" (MISS) which aimed to adopt a "quick and dirty approach to manned space flight". ARDC attempted to push the project through as quickly as possible, and applied for $133 million worth of funding from ARPA for the following year with the goal of achieving the first manned spaceflight by October 1960, but their efforts were ultimately kept in check by ARPA's unwillingness to release the full amount of funds both due to the amount required as well as impending legislation on NASA as a civilian space agency (Encyclopedia Astronautica). ARPA was hesitant to spend on a project that might not be retained within the military realm, and the USAF's MISS program was eventually rejected by ARPA. At around the same time, the second effort was led by von Braun from the ABMA, who proposed a "Man Very High" project to achieve manned spaceflight using a Redstone IRBM, which was rejected by both the Army and the USAF. The Army renamed the project "Project Adam", proposing to achieve manned spaceflight using a Redstone missile with a recoverable capsule, but this was also eventually rejected by ARPA. (Catchpole, 2001)

In August 1958, T. Keith Glennan was eventually chosen as the first NASA administrator after the original candidate, NACA director Hugh Dryden, stated in front of the House Space Committee that "sending a man into orbit inside a Redstone nose cone has about the same technical value as the circus stunt of shooting a young lady from a cannon", a remark that did not sit well with members of congress that wanted "a daring space program designed to 'leapfrog' the Soviets". Glennan personally held the belief that "the propaganda value of spaceflight was not of primary importance, but neither could it be ignored". The USAF, however, would not let NASA off easy on the issue of manned spaceflight, seeing themselves as "the most logical agency to achieve this military [space] power", but as McDougall points out, "the prestige motive cancelled out all USAF logic" as "NASA astronauts would be 'envoys of all mankind'", resulting in Eisenhower choosing NASA over the USAF when the issue came to his attention in August 1958, as "the United States' image required that such a high-profile program be civilian." A Joint Manned Satellite Panel proclaimed the need "to achieve at the earliest practicable date orbital flight and successful recover of a manned satellite". (McDougall, 1997) The former NACA"s proposal for ballistic spacecraft was presented to ARPA on October 3, 1958 and to Glennan on October 7, 1958, who then proclaimed "Let's get on with it", officially approving what would eventually become the US's first successful manned spaceflight program. The Space Task Group was set up in November 5, 1958, led by Robert Gilruth (Catchpole, 2001), and it was responsible for managing the first US manned spaceflight program, which was named "Project Mercury" on November 26, 1958.

McDougall states that "to the layman the true conquest of space would be represented by manned spaceflight", and that NSC-5918, "U.S. Policy on Outer Space" puts forth a recommendation "to achieve and demonstrate an overall U.S. superiority in outer space without necessarily requiring U.S. superiority in every phase of space activities…the United States should select and stress projects that offer the promise of obtaining a demonstrably effective advantage, and proceed with manned spaceflight 'at the earliest practicable time'", with the end result of an increase in funding for Project Mercury. (McDougall, 1997)

The launching of Sputnik I thus pushed the US into a space race with the then Soviet Union which eventually culminated in President Kennedy's speech in 1961 that promised to land a man on the moon and return him safely to Earth before the end of the decade, a race with such a lofty end-goal that the US would probably never have intended to enter, at least not so early, if not for the actions of the Soviet Union. "National prestige/geopolitics" was thus the primary motivator of the US manned spaceflight program, which comprised a mixture of the desires to beat the Soviets resoundingly in a space-related milestone thereby establishing geopolitical dominance over the Soviet Union amidst the backdrop of the Cold War, to appeal to domestic political constituents and counter political opponents, and to reestablish the US's international standing on the global stage to win the hearts and minds of those who were as of then still non-aligned.

4.3.2 The Lead-up to the Shenzhou Program

A look at the Chinese manned spaceflight program may reveal similar patterns with Project Mercury to a certain extent. But while the US motivations for a manned spaceflight program were relatively straightforward, a study of the motivations of the Chinese is complicated by the fact that there were not one, but two attempts at manned spaceflight spanning the decades from the 1960s to 2000, with only the second attempt succeeding in its intended goals.

It should be noted that even before Sputnik I, the Chinese had already began ballistic missile development in the beginning of 1956, arguably primarily due to Tsien Hsue-shen's return to China, who brought with him the pool of knowledge of rocketry that he had painstakingly built up over the past few decades in the US (Harvey, 2004). China's urgency in developing missiles and rockets was, as expected, due to military and national security concerns. Mao Zedong, then paramount leader of China, had this to say about atomic bomb technology on January 1, 1955: "我们要不要搞原子弹啊，我的意见是中国也要搞，但是我们不先进攻别人。别人要欺负我们，进攻我们，我们要防御，我们要反击" (Should we build an atomic bomb? My opinion is that China should, but we won't attack others first. If others want to bully us, attack us, we will defend ourselves, we will counterattack). This same philosophy shaped Mao's views on missile technology when Tsien raised the idea to develop missiles upon his return to China and wrote a secret proposal to "establish research facilities for aeronautics and missile development", leading the Chinese leadership to set up the Fifth Academy of the Ministry of National Defense on October 8, 1956, with Tsien as its inaugural director. In June 1958, Mao proclaimed "原子弹就是这么大的东西，没有那个东西，人家就说你不算数，那么好吧，我们就下决心搞一点吧….搞一点原子弹、氢弹、洲际导弹，我看有十年功夫是完全可能的" (An atomic bomb is just that big, but without it, others won't take you seriously. Fine, we will get serious about making one….Making an atomic bomb, hydrogen bomb, intercontinental ballistic missile, this should be entirely possible with ten years of work.) (唐国东, 2012)

Military intentions not withstanding, however, it should also be noted that Mao also often presented such scientific and technological development, including the development of missile and rocket technology, as a way of catching up with the rest of the world. He stated, on January 25, 1956, "我国人民应该有一个远大的规划，要在几十年内，努力改变我国在经济上和科学文化上的落后情况，赶上世界先进水平" (Our citizens should adopt a visionary plan, to make efforts to remedy our nation's economic and scientific backwardness, and catch up to the forerunners in the World.) Perhaps the end goal of such catching up was indeed to preserve a military balance of power, but the act of catching up was often presented to the scientific community as an end in and of itself.

And while many believe that China's manned spaceflight program was always decades behind the US, it was arguably also Sputnik I that launched China's ambitions for manned spaceflight. Sputnik I probably left as deep an impression on Mao as it did on then Senator John Kennedy. Mao was said to have congratulated the Soviets when he landed in Moscow 28 days after Sputnik I's launch in spite of his intense dislike of Nikita Khrushchev (then Premier of the Soviet Union). Sputnik I also resulted in China's scientists in the field of rocketry and satellite technology (including Tsien Hsue-shen) mobilizing to study the potential applications of satellite technology to China's development (Kulacki & Lewis, 2009). Mao's sense of urgency was probably increased by the launch of the US's first and second satellites, Explorer 1 and Vanguard 1, on February 1, 1958 and March 17, 1958 respectively, as well as the Soviet satellites Sputnik 2 and Sputnik 3 on November 3, 1957 and May 15, 1958 respectively. On May 17, 1958, during the Second Session of the 8th National Congress of the Communist Party of China[6], Mao was said to have asked "苏联去年把卫星抛上了天，美国在几个月前也把卫星抛上了天。那么，我们怎么办？" (The Soviet Union threw a satellite up into the sky last year; the US also threw a satellite up a few months ago. So what are we going to do about it?). He subsequently announced that "我们也要搞人造卫星！ …我们要抛就抛大的，要干就干一两万公斤的。也需要先从小的抛起，但我们也要从一两千公斤的开始，我们不干美国鸡蛋大的！" (We will also build satellites!...But if we are going to throw one up we should throw a big one, if we are going to build one we should build one that weighs one to two thousand kilograms. Perhaps we need to throw a small one up first, but one that is at least one to two thousand kilograms, we won't build one like the Americans' chicken egg[7]!). (唐国东, 2012)

Mao's charisma and ambition not withstanding, China was still unable to escape the basic technological dependencies that launching a satellite entailed. Qi Faren (then involved in design of the *Dongfanghong*-1 and current Chief Designer of Chinese Spacecraft) stated that "1958 年我们也打算

[6] Kulacki and Lewis have attributed these quotes of Mao to the "Second Plenary Meeting of the Eighth Party Congress", which is potentially confusing as it may be interpreted to refer to the Second Plenary Session of the Eighth National People's Congress (第八届全国人民代表大会第二次会议); such plenary sessions, or plenums, of the NPC take place about once a year during a 5-year span. The congress in this case should have been translated as "Second Session of the Eighth National Congress of the Communist Party of China" (中国共产党第八次全国代表大会第二次会议); such National Congresses of the CPC (or National CPC Congresses) are only held about once every 5 years, and the term "plenum" or "plenary session" is traditionally not used in their context.

[7] The "chicken egg" might refer to either Explorer 1, which weighed 13.97 kilograms (30.8 lbs.) (NASA), or Vanguard 1, which weighed 1.4 kg (3 lbs.), though the latter seems more likely, compared to *Dongfanghong*-1 which weighed 173 kilograms (381.4 lbs.) (NASA). Mao was clearly more unforgiving than Khrushchev who referred to Vanguard 1 as "the grapefruit satellite" (White, 2010)

搞人造卫星，但实际上那时候连导弹都没搞出来，更不用提运载火箭” (In 1958 we were also planning to build an artificial satellite, but the fact of the matter was that China had not even developed missile technology, much less satellite launch vehicle technology). Deng Xiaoping (then General Secretary of the Secretariat of the CPC), wisely said “我们现在没有能力搞，我们不搞卫星，集中能力搞两弹（导弹、原子弹）” (We lack the resources to do this…we won't build satellites but instead concentrate on “two bombs” [referring to missiles and the atomic bomb]) (戚发轫, 2011). It was only after China's first successful launch of a Chinese missile on November 5, 1960 and first successful nuclear test on October 16, 1964 that China eventually launched its first satellite, the *Dongfanghong*-1 (literally “The East is Red”), on 24 April 1970 (Harvey, 2013) (Chang, 1995).

But just like the US, China could very well have focused its resources in those decades on military-oriented ballistic missile technology or satellite technology with practical applications instead of considering manned spaceflight. The impetus to do so came about with Yuri Gagarin's spaceflight on April 12, 1961, which resulted in the Chinese Academy of Sciences holding a series of twelve meetings led by Tsien starting that summer and which lasted until 1964. A book written by Tsien in 1963, “星际航空概论” (Introduction to Interplanetary Flight) also espoused manned spaceflight, and on March 4, 1966, the idea of manned spaceflight was discussed in a secret closed-door session during a conference on space development. Eventually, a committee formed by COSTIND[8] determined that if China succeeded in developing recoverable satellite technology, a manned spaceflight program would be implemented; this program was named *Shuguang* (Dawn) in January 1968. Tsien was subsequently appointed first assistant of the Institute of Space Medicine set up in April 1968, and requested that COSTIND and the Air Force begin astronaut selection. (Harvey, 2004) In May 1970, the Fifth Academy of the Ministry of National Defence and the Air Force drafted a report on *Shuguang*-1 which was approved by COSTIND and the CMC[9], and on July 14, 1970, Mao, Lin Biao and Zhou Enlai formally approved this plan, leading the *Shuguang* program to be codenamed Project 714[10] (唐国东, 2012).

Shuguang actually got off to a pretty promising start. China's first batch of 19 astronauts was confirmed in April 1971 and started their training in May, with the launch of *Shuguang*-1 planned for 1973 (Kulacki & Lewis, 2009). In fact, China had earlier sent two dogs into space on July 15, 1966 and July 28, 1966, both of which were recovered successfully. However, the plan to send a monkey into space in September (Harvey, 2004), as well as China's first attempt at manned spaceflight, were stymied by a series of unfortunate events. Lin Biao, then China's Minister of Defence, guided Project 714 but perished in a plane crash on September 13, 1971 after a purportedly unsuccessful coup against Mao. This “913 incident” resulted in the Air Force turning against Lin's legacy out of political necessity, which seriously disrupted the astronaut-training program and essentially paralyzed the program after October 1971. (邸乃庸, 2011) Exacerbating this problem was the ongoing Cultural Revolution which generated an overall atmosphere of chaos and anti-institutionalism, and the fact that China was extremely cash-strapped at that time, with insufficient funds for running the country, much less devote financial resources towards manned spaceflight. Mao then declared “先把地球上的事搞好，地球外的事往后放放” (Let's get the things on Earth in order first, things outside of the Earth come later); Project 714 was thus suspended on March 1975 (邸乃庸, 2011).

A series of critical political events beginning with Mao's passing in September 1976, the defeat of the Gang of Four, the end of the cultural revolution and Deng Xiaoping's re-emergence as the new paramount leader of China by 1977 allowed China's space program to slowly return to normalcy. However, Deng adamantly stated that “As far as space technology is concerned, we are not taking part in the space race. There is no need for us to go to the Moon and we should concentrate our resources

[8] Commission for Science, Technology and Industry for National Defense, the Chinese equivalent of DARPA in the US

[9] The CMC, or Central Military Commission (中央军事委员会), controls the People's Liberation Army

[10] It has been the practice in China's space program to codename projects after a significant month and day, or significant year and month, usually the start of the program.

on urgently needed and functional practical satellites" (Harvey, 1998). Wang Zhuanshan, then Chief Engineer of CALT[11] claimed that "China postponed a manned spaceflight for at least ten years due both to economic considerations and a reappraisal of Chinese space aims and objectives" (Harvey, 2004), signaling the priority that the leadership wanted to give to China's economic growth.

Nevertheless, the dream of manned spaceflight never really went away. If it was the Soviets who provided the impetus for China's first manned spaceflight program, it was arguably the Americans who provided the impetus for the second. On March 23, 1983, Ronald Reagan announced the Strategic Defense Initiative, which launched a debate in China amongst governmental organizations and research centers, chiefly between those who felt that China should also start investing in advanced technology in the spirit of national development, and those who preferred the status quo and wanted to defer such technological investments until China was on a more solid economic footing. (Kulacki & Lewis, 2009), This debate continued for three years until March 3, 1986, when four prominent Chinese scientists, through a brilliant stroke of political shrewdness, managed to deliver to Deng a proposal entitled "关于跟踪研究外国战略性技术发展的建议" ("Recommendations On Keeping Pace with Foreign Strategic Technology Development") by calling in a favor from Deng's son-in-law, Zhang Hongxian. The proposal stated that "第一，谁能够准确判断当前的发展动向，谁就能在竞争当中占优势；第二，高新技术是花钱买不来的；第三，要想取得成果，是要花时间花力气的；第四，只有通过这样大的工程，才能凝聚人才，锻炼人才" (Firstly, whoever can accurately predict current development trends will gain a competitive advantage; Secondly, new advanced technology cannot be bought with money; Thirdly, results can only be obtained through expenditures of time and effort; Fourthly, only through such major projects can we unite and develop the talent of our people) (唐国东, 2012). In a fairly surprising policy U-Turn, Deng, who had to that point championed pragmatic satellite development over a high-technology space race, just two days later on March 5 directed that this suggestion was of utmost importance and was not to be delayed. Deng's decision to proceed with national R&D efforts into advanced technology became known as Project 863, which aimed to catch up to international standards and reduce the technological gap between China and foreign nations in seven high-tech fields, one of which was aerospace. (邸乃庸, 2011)

There was in the initial period of discussion a debate between two camps – one that wanted advanced technology development to be military-oriented and another that preferred a civilian orientation. Deng had to resolve this debate by instructing that a dual-use technology approach be selected, but with civilian applications as a priority. After a great deal of discussion and planning, expert group 863-2 was established to detail a road map for China's space development, in particular plans for a manned spacecraft and space station. Even then however, the future China's manned spaceflight effort was far from assured. Numerous debates ensued over the program (唐国东, 2012), with some arguing for the program on the basis of its benefits such as technological advancement, a boost to China's international prestige and soft power, and an increase in national pride, while others argued against the program on the basis of the risks of manned spaceflight, the more practical areas where the funds could be spent, and the fact that China would merely be copying a feat that was successfully carried out long ago by the US and the Soviet Union; furthermore, by this time, the myth that manned spaceflight would generate scientific benefits had already been debunked on the admission of the two Cold War powers. (Kulacki & Lewis, 2009)

Years of debate were finally put to an end in another political masterstroke when the deputy director of the Aerospace Ministry Liu Jiyuan personally wrote a proposal for manned spaceflight and secretly ensured it landed in the hands of Deng's brother-in-law, Li Qianming, during a meeting on January 30, 1991, with the hope that this would ultimately be passed on to Deng[12]. In his proposal, Liu stated that

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[11] China Academy of Launch Vehicle Technology

[12] At that time, Liu decided to look for Li Qianming to seek for his help in getting his proposal to Deng. Li Qianming replied "这是大事，你写吧，剩下的我来办。" (This is a serious issue, go write it, and I'll take care of the rest.) On the day of the meeting, Liu who had just arrived back in Beijing instructed Zhang Hongxian, Deng's son-in-law who was working in the Aerospace Ministry then, to fetch the proposal from his office and

“上不上载人航天，是政治决策，不是纯技术问题，也不是科技工作者能定得了的。要靠下面统一认识，是不可能的。我国航天事业的发展，是老一辈无产阶级革命家领导创建的，来之不易的航天国际地位存在着得而复失的危险。恳请中央尽快决策。” (“Whether or now we pursue manned spaceflight program is a political decision, not a purely technical question, and is not something that scientific workers can make a decision on. Relying on a consensus amongst the lower levels is impossible. The progress of our space program was painstakingly built up by the older generation of proletarian revolutionaries, and our hard-earned international standing in the spaceflight arena is in danger of being lost. I urge the Party to come to a decision quickly” (李鸣生, 2009).

As a result of this effort, Li Peng, then Premier of China, subsequently requested a meeting with Liu's superior in the Aerospace Ministry Ren Xinmin[13] and Qian Zhenye to discuss the possibilities of manned spaceflight; indeed, the Premier requesting for a meeting with mere scientists would have been a very rare event at that time. After their briefing, Li Peng eventually stated that manned spaceflight was indeed a worthwhile pursuit, to which Ren, probably with the intention of cheering Li Peng on in his decision, responded that this was indeed a wise decision by the Party. Li Peng then replied “载人航天谈不上什么英明决策，但它确实是一个决策问题” ([The decision to proceed with] manned spaceflight can't be called a wise decision, but it is one that has to be made) (李鸣生, 2009). This meeting was followed by a report on June, 1991 that stated “中国是一个大国，根据世界发展的动向，一定要搞载人，而且要马上搞，马上做准备，否则的话我们就会落后” (China is a big nation; with regards to the trends in international development, we thus definitely need to pursue manned spaceflight, and what's more we need to do so immediately, we need to make preparations immediately, or we will surely fall behind). On January 8, 1992, Li Peng stated that “发展我国载人航天是必要的” (Developing China's manned spaceflight capability is a necessity). (唐国东, 2012)

Finally, on September 21, 1992, Jiang Zemin, then General Secretary of the Communist Party of China finally announced in an internal top-level party meeting that China would indeed be going ahead with a manned spaceflight program consisting of three phases which would achieve manned spaceflight, the construction of a manned spacelab and finally a manned space station in that order. Jiang concluded by saying “发展载人航天，这是件大事，大家同意，我完全同意，要下决心搞。1961 年苏联第一个载人，美国是 1962 年。1957 年苏联第一颗卫星上天，美国人马上就总结经验，说美国技术落后了，要赶上来。搞这个在政治、经济、科技、军事上都有意义，是综合国力的标志。因此，建议静静地、坚持不懈地、契而不舍地去搞....今天我们就做这样一个决策，发展我们自已的载人航天。” (Developing manned spaceflight capability is a big thing, everyone agrees, and I also agree, that we need to start doing it seriously. The Soviet Union sent a human into space in 1961, and America in 1962. When the Soviet Union launched their first satellite in 1957, America immediately reflected on themselves and admitted that American technology had fallen behind, and that the US needed to catch up. Doing this [manned spaceflight] has value in terms of politics, economics, science and technology and military power, and is a symbol of comprehensive national strength. Therefore, I propose we do this [manned spaceflight] quietly, determinedly, tirelessly…today we will make this decision, to develop our own manned spaceflight capability). (唐国东, 2012) And with that, Project 921 began, thirty-five years after the flight of Sputnik-I, and was given the name *Shenzhou* or divine vessel in 1994 (Harvey, 2013).

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hand it to Li Qianming without saying anything. Li Qianming, upon receiving the proposal, said “你告诉刘副部长，我一定送到。”(Tell deputy chief Liu that I will definitely deliver this.) (邓宁丰, 2004)

[13] At that time, Ren Xinmin was the senior technical advisor of China's Aerospace Ministry (许秀华, 2004) and has been said to have had the “most significant influence on China's space and missile development” besides Tsien Hsue-shen (Burkitt, Scobell, & Wortzel, 2003). He was also chief manager of the Long March 1 rocket that eventually placed China's first satellite into orbit. (Harvey, 2013)

4.4 The Basis for Comparison

Two interesting things can be noted from the relatively brief overviews above of the complex turn of events that respectively led to Project Mercury and the Shenzhou Program. The first is that Project Mercury and the Shenzhou Program had many striking differences – the programs took place in different countries, at different points in history, amidst different international geopolitical and domestic situations, and were driven by different political systems and supported by different economic systems.

The second is that for all their obvious differences, a surprising number of common threads underlie these two manned spaceflight programs. Both countries started their space program out of military and security reasons – for the US, the impetus to do so was borne out of tensions arising from the Korean War and the Cold War, and for China, the impetus to do so was also out of the desire to preserve national security amidst a build up of the missile arsenal of countries, most notably the US. Both countries were in a position where economic realities did not afford them the luxury of engaging in manned spaceflight pursuits for purposes that did not yield any practical value – the US had emerged from WWII fourteen years prior to the start of Project Mercury, China had recovered from the Cultural Revolution sixteen years before the Shenzhou Program, and neither would have been in a hurry to jeopardize their country's hard-won seat on the road towards economic progress and development by devoting resources towards a program with no concrete benefits. Both countries had leaders who would have been loathe to commit their country to a manned spaceflight effort that was correctly perceived to not have any practical or instrumental value, but who both ultimately approved the respective programs for reasons of national prestige, in reaction to external events perceived as challenges as well as to domestic pressures. Both countries threw the weight of the nation behind these programs, promised the individuals in charge whatever resources they needed, and eventually succeeded in achieving manned orbital spaceflight without loss of life.

It thus not only seems that a case can be made for a comparison of Mercury and Shenzhou, but also that the case *should* be made for a comparison of Mercury and Shenzhou. For all their differences, the motivations, rationales, challenges and conflicts that characterized Mercury and Shenzhou are remarkably similar, aided by the fact that the US and China are both large, powerful countries; according to Handberg, "A uniquely American perspective has arisen that treats China as the other example of exceptionalism operating in the international system besides the United States itself. Both states, it is argued, operate as if the existing international rules do not apply to their actions and policies because both states operate from a sense of historical uniqueness (clearly different in terms of origin) that excuses their behavior (at least in their eyes)…." (Handberg & Li, 2007)

There are foreseeably two main reasons for objections to such a comparison. The first would be the argument or perception that technology readiness levels for the US and China would have been significantly different at the start of the Mercury and Shenzhou programs –American engineers would have had to develop and test the required technology for manned spaceflight, most notably the Mercury Spacecraft, without historical precedent, while the Chinese would have had not only the benefit of knowledge regarding what the Americans had accomplished, but also Russian technological assistance (as will be elaborated on subsequently in Subsection 5.1.2). That said, the idea that the Chinese had a significant technological advantage over the US at the beginning of the Shenzhou Program is, at best, questionable. While the Chinese did obtain technological assistance from the Russians, this assistance was often limited and necessitated the development of much indigenous technology by the Chinese themselves. For example, while China did obtain a Soyuz capsule from the Russians, this was an empty shell devoid of the required electronics (Harvey, 2013). Furthermore, as Handberg points out, "attempts to deny their [the Chinese] success in the West by attributing any success to the Soviets' (later Russians') assistance were rejected by most observers. Every state at some point has received assistance either directly or indirectly in pursuing space activities" (Handberg & Li, 2007). Without detracting from the contributions of American engineers and managers, it is probably erroneous to view Project Mercury as a completely indigenous effort due to the immensely valuable contributions of the work of German engineers that was transferred to the US after WWII. In fact, insofar as Russian rocket technology was originally built on the work of those German engineers that did not defect to the American side in the last moments of WWII, one could potentially trace the ancestry of both the Mercury and Shenzhou rockets back to their humble beginnings in Peenemünde. This ultimately means that while the Chinese may have started three decades after the US, it is not a forgone conclusion that this granted them a significant technological advantage that would have allowed Shenzhou to technologically leapfrog Mercury. As will be seen later, this was arguably not the case.

The second challenge would be the fact that the Mercury and Shenzhou programs took place a good 33 years apart, and the respective achievement of manned spaceflight by the programs took place 41 years apart; the validity of comparing programs separated by a few decades is thus questionable. A counter-argument would be that if a meaningful comparison of these two programs is sought, the degree of similarity of circumstance is perhaps a more reliable measure of the appropriateness of such a comparison than temporal position. In other words, it is probably more important that these programs were situated in similar contexts and circumstances than for them to have taken place in the same period in history for such a comparison to be valid. It would not have mattered if Mercury and Shenzhou had taken place at exactly the same time if the US and China had embarked on manned spaceflight for vastly different reasons, or for vastly different end-goals. As it stands, the similarities between the programs outlined previously make a strong case for such a comparison, and if one were to look closely at history, it is not difficult to imagine that if not for the unfortunate pair of events that Mao brought upon China, as well as China's falling out with the then Soviet Union, that China could possibly have been competing with the US in the field of manned spaceflight in the 1960s and 70s. The Great Leap Forward and the Cultural Revolution can thus be viewed to have merely delayed China's achievement of manned spaceflight, the dream of which was never really completely extinguished; once China had recovered from the damage caused by these events and was given the right nudge, it was once again back on the path towards manned spaceflight in the form of the Shenzhou Program. In fact, it may also be argued that the delay of more than three decades allowed China to more closely approach the levels of political and social stability, as well as economic and technological development that the US possessed during Project Mercury, which would strengthen the case for a comparison.

Ultimately, as Handberg puts it, "China's experience mirrors, albeit with critical differences based on culture and economics, similar events that occurred in the Soviet Union and the United States, though not as dramatically… many of the same political concerns and issues, which drove those states in their original pursuit of space activities, drive China" (Handberg & Li, 2007). It is therefore arguably justifiable to carry out a comparison of Project Mercury and the Shenzhou Program as comparable systems engineering projects driven by different cultural forces.

4.5 Analysis of Motivations

As mentioned before, it is apt to begin such a comparison with a look at the rationale for manned spaceflight capability in the US and China. But why should the rationale for the respective programs matter? One may argue that the main focus of such a comparison should be almost entirely, if not exclusively, on the actual systems engineering endeavor itself. However, I would argue that the turn of events leading up to the decision to proceed with a large-scale complex systems engineering endeavor is remarkably worthy of consideration. Without detracting from the fact that what happens during the systems engineering endeavor itself is of course critical to its eventual success, even the most well-thought out or sophisticatedly implemented systems engineering endeavors mean nothing if they do not get approved in the first place or manage to retain continual support. *Shuguang*'s promising start, with the support of top level leaders, eventually amounted to nothing amidst the political and societal turmoil in China at that time, while ironically it was political turmoil, albeit of a different brand, that kickstarted Project Mercury. Conceptualizing the idea of a systems engineering endeavor, securing the financial resources for it, obtaining the buy-in from top level leadership, making a strong case for the project to garner public support, finding the right people to sustain it, and ensuring its continued survival in the face of future obstacles are far from trivial considerations due to the complexity and huge amounts of resources, capital and sacrifices required for such systems engineering projects. Regardless of how justified a systems engineering project is on the merits of its utility to stakeholders, these non-technical issues have and will always continue to play a huge role in the process towards eventual approval of any such project.

Furthermore, the path towards the approval of such systems engineering endeavors inevitably has implications for how the systems engineering process is eventually carried out. The process of achieving stakeholder buy-in, securing financing and winning high-level support begins to shape the systems engineering endeavor even before it begins – high-level features of the program need to be decided upon, promises have to be made, risks need to be evaluated – and these decisions all leave their mark on the end result of the project.

The subsequent Sections 4.5.1-4.5.3 will thus examine the motivations and processes leading up to the beginning of Project Mercury and the Shenzhou Program, and demonstrate how cultural differences and similarities between the Americans and the Chinese had a part to play in these paths.

4.5.1 Same National Prestige, Different Flavors

It has been shown previously, and it is generally agreed on in the literature, that national prestige was the key reason that led to the approval of both Project Mercury and the Shenzhou Program (McDougall, 1997) (Handberg & Li, 2007), with the US striving to regain national prestige in the face of the actions of the then Soviet Union, and China striving to regain national prestige in the face of American and Russian space activity. To put it crudely, the US didn't want to lose out to the then Soviet Union, and China didn't want to lose out to the both of them. But even though the term "national prestige" may very broadly encapsulate the spirit of why the US and China wanted to embark on a program to achieve something that their perceived competitors had beaten them to, there exist subtle differences in the sort of "national prestige" that the two countries were looking for or were trying to regain when they started their respective programs.

It was earlier shown that the US is characterized as a nation with an overwhelmingly individualist culture (more than any other nation studied under Hofstede's framework), whereas China is characterized as a nation with a significantly collectivist culture. One interesting aspect of the individualist-collectivist dimension is how one reacts to the perception that one has "lost out" or not fulfilled the obligations that one is perceived to have. In individualist cultures, this manifests as "guilt and loss of self-respect", whereas in collectivist cultures, this manifests as "shame and loss of face for self and group" (Hofstede, Hofstede, & Minkov, 2010). The difference between guilt and shame is that guilt is more inward looking and centered on the individual; the individual feels guilt for not living up to certain expectations, irrespective of what others think, because he/she measures his/her self worth against those expectations. Shame, or loss of face, on the other hand, is perceived by an individual in relation to what others think of him/her, including the members of one's in-group; it is a more collectivist concept and materializes only when external judgments exist or are perceived to exist. (Hofstede G. H., 2001)

On the flip side, what happens when these failures to meet obligations are corrected is also different for both types of cultures. For individualist cultures, what is gained is self-respect, which is a sort of fulfillment that originates from the individual. For collectivist cultures, what is gained is the concept of "face", or the ability to stand in front of others without having to feel as if others are judging one for not meeting his/her obligations.

It can thus be seen from the narratives above that such characterizations of individualist and collectivist countries are remarkably applicable to the collective emotions of the US and China when dealing with what both perceived to be their falling behind their competitors in the field of manned spaceflight. For the US, losing out to the Soviet Union in being the first to achieve manned spaceflight was undesirable because it was an affront to American self-respect and the standards that they held themselves to. The public outcries after the Sputnik launches and Gagarin's flight involved arguments that came from various angles but which largely revolved around the US at the center – how these Soviet achievements were a threat to American superiority, how they were a result of "American complacency, self-indulgence and poor education", and how such actions would help to "keep us [Americans] on our toes" (McDougall, 1997). The focus was thus clearly on what these Soviet actions meant to the US, what damage they had caused to the US psyche, and how this perceived injustice in the grand scheme of things had to be corrected. It did not matter a great deal what other countries thought about the Americans falling behind the Soviets, and the concept of "loss of face" was not particularly salient for the Americans; rather, what was most prominent was the affront to American dignity and the threat to, if not superiority over the Soviets, at the very least the idea that Americans would not lose out to the Soviets if their sense of self-worth could help it.

This is not to say that at no point in time was the effect that these Soviet actions had on the image of the US in other countries considered, but rather that the overriding motivation to do something about the perceived loss to the Soviets came from within the American psyche, not without. The US did not need the validation of other countries for its aerospace efforts, and did not rely on their approval or disapproval as a yardstick to measure its aerospace achievements. In fact, even when arguments were made about winning over non-aligned countries to the US side, these were made not in the spirit of "saving face" in front of them, but simply out of a pragmatic goal of not having these countries on the opposition front. For all the talk of racing with the Soviets, perhaps deep down, the only entity the US was truly racing against was itself.

In its efforts to catch up with the Soviets and regain its self-respect, the individualist culture of the US is probably best captured by McDougall's description of the aftermath of John Glenn's flight in 1962 – "The United States had matched the Soviet feat! And all the suppressed emotion of the Space Age...above all perhaps the nagging suspicion that can-do Yankee ingenuity had had its day – all this came tumbling out in a national catharsis unparalleled in the quarter century of the Space Age. Not the first U.S. satellite, or the first flight of the Space Shuttle in 1981, or even the landing on the moon – all occasions for proud and tearful celebration – matched the social release into which John Glenn, after five hours in space on February 20, 1962, incredulously stepped. It seemed that he had given Americans back their self-respect, and more than that – it seemed Americans dared again to hope." (McDougall, 1997). Ultimately, the US sent John Glenn into space and back not for the Soviets, nor for anyone else, but for themselves.

On the other hand, the Chinese have a quite a different story to tell. Where the US largely concentrated on itself and what its losing out to the Soviets meant for America, the Chinese were arguably more concerned with what the actions of the US and the Soviets meant for their image in the eyes of other countries. When Mao publicly announced that China would also start launching satellites, he did not make any references to an affront to Chinese pride to justify his goals, but implied that China had to do so simply because the US and the Soviets had already done so and were, as can be inferred from his choice of words, watching for China's next move (or at least were perceived to be doing so). In other words, Mao chose to embark on launching a satellite not because Chinese self-respect had been threatened, but because not doing so would probably have been seen as a loss of face for his country. His rhetorical question of what China was to do now that the US and the Soviets had launched their own satellites reveals the "loss of face" frame that he was operating under, and his alluding to the American satellite as a "chicken egg" demonstrates how he, in this frame of mind, believed that the US's inability to launch something heavier should have, in turn, been a loss of face for the Americans.

In the years leading up to the eventual launch of the Shenzhou program, justification for a manned spaceflight program as elaborated on in Subsection 4.3.2 included China's hard-earned international standing in the spaceflight arena being in danger, as well as China needing to pursue manned spaceflight because it was a big nation and risked falling behind, with the implication that not doing so would be a loss of face for a big country. And in 1992, in a manner uncannily similar to Mao more than three decades ago, Jiang Zemin raised the issue of the US and the Soviets having already achieved manned spaceflight in 1961 and 1962 respectively as the very first reason justifying his intention to have China embark on a similar effort; the fact that events that had happened three decades ago still continued to hold such significance in 1992 demonstrates the long-standing focus on what others perceive China to lack over what China perceives itself to lack.

Furthermore, after Yang Liwei's successful flight in 2003, Hu Jintao, then President of China, during the official commemoration of China's first successful manned spaceflight, announced that "这一举世瞩目的重大科技活动向世界庄严宣告，中国已成为世界上第三个独立掌握载人航天技术的国家。这是中国人民在攀登世界科技高峰的征程上完成的又一个伟大壮举，是我国航天发展史上耸立的又一座里程碑，是我们在推进中国特色社会主义事业的进程中取得的又一个辉煌成就，也是中国人民为世界航天事业作出的又一个重要贡献。这一伟大胜利，进一步提高了我国的综合国力和国际竞争力，极大地增强了全党全国人民冠冕建设小康社会、实现中华民族伟大复兴的自信心。" (This technological feat of great importance has captured the attention of the world and has solemnly proclaimed to the world that China has become the third nation to independently master manned spaceflight technology. This is yet another great accomplishment of the Chinese people in scaling the technological peaks of the world, is yet another milestone in China's aerospace history, is yet another spectacular accomplishment we have achieved in the process of promoting socialism with Chinese characteristics, and is also yet another vital contribution that the Chinese people have made to the international aerospace field. This great victory has increased our nation's comprehensive strength and international competitiveness, and greatly increased the confidence of the Party and the citizens in building a prosperous society and bringing about the great rejuvenation of the Chinese nation.) (邓宁丰, 2004) Keeping in mind that official Chinese comments are scripted and that the order in which ideas or concepts are brought up reflects their relative significance, this proclamation reveals that the aspect of the Shenzhou Program that China was most proud of was the fact that it captured the attention of the world and proved to the world that China was no longer a big nation that didn't have manned spaceflight capability. Conversely, it was only towards the end of the proclamation that the concept of national pride or confidence was brought up.

Admittedly though, it is a difficult task to demonstrate clearly the difference between an avoidance of loss of self-respect and an avoidance of loss of face between the individualist culture of the US and the collectivist culture of China, primarily because they are prompted by the same actions (perceiving that one has lost out to another) and result in the same general desire (the desire to achieve what one does not have). The difference ultimately stems from internal motivations that cannot be physically observed, and it is only through subtle societal observations that evidence can be found for either. Perhaps one last piece of evidence would be the terminology used by each country to describe their situation after the Soviets had achieved manned spaceflight – for the US, such terminology revolved around "losing the race" with the Soviets, placing the US in the center of the frame and striving for individual "firsts" for self fulfillment (and ultimately succeeding with being the first to land on the moon). For the Chinese, such terminology revolved around proving that they could also do what other big nations could do; in particular, Deng Xiaoping uttered in 1986 that "我国在世界高技术领域一定要占有一席之地" (Our country has to occupy our rightful place [lit. a place for our mat] in the international field of advanced technology), with his words implying that "中国不能在太空缺席" (In the field of space, China cannot be missing from the table) (陈晓东, 2003). Kulacki and Lewis point out that the metaphor "一席之地" (a place for one's mat) used to describe China's motivations reveals their belief that China's manned spaceflight program was needed to prove that "the Chinese deserve a seat at the table…the Chinese metaphor carries the connotation of joining a club, becoming a member…This is not so much 'prestige' as 'keeping up with the Joneses'" (Kulacki & Lewis, 2009).

Essentially, the US was prompted by the actions of the Soviets, and China was prompted by the actions of the Soviets and the US, to act in similar ways but driven by different internal motivations, with the former driven by the need to rectify a loss of self-respect, and the latter driven by the need to rectify a loss of face. The question, then, is of what implication this difference has. Does it really matter whether a country is driven by self-respect or face preservation if it still results in the same decisions? Ultimately, this distinction still resulted in marked differences in the way Project Mercury and the Shenzhou Program were structured as systems engineering projects, and this will be explored in Chapter 5. More immediately though, this distinction had an immediate contributory impact on the nature of the organizations that were set up to direct the respective manned spaceflight efforts.

4.5.2 NASA and the People's Liberation Army

While the organization in charge of Project Mercury was the Space Task Group within NASA, the Chinese equivalent was the Chinese Manned Space Engineering Office (CMSEO, 中国载人航天工程办公室), sometimes translated as the Human Spaceflight Project Office, which is now a special department based under the General Armaments Department of the People's Liberation Army (PLA) of China (Stokes & Cheng, 2012). While the CMSEO, a civilian organization, was in charge of the coordination of the program, the operational management of the manned spaceflight program was actually performed by military elements of the PLA (Kulacki & Lewis, 2009). Either as a result of this arrangement or as a cause of it, the Chinese manned spaceflight program was covered in a thick veil of secrecy when it first started, and it was only towards the late part of the decade that the Shenzhou Program was revealed to the Chinese public (Harvey, 2013); one would also guess that the program would have been even more tightly guarded from foreign countries, and that guess would be correct. In fact, Jiang Zemin even went so far as to use the phrase "静悄悄地搞" (quietly carry out [the manned spaceflight program]) twice in quick succession during his internal announcement of Project 921, effectively intentionally exhorting those in the know to ensure that the program be kept under wraps (唐国东, 2012). In fact the slogan "多干、少说" (work more, speak less) and its evolutionary counterpart "只干、不说" (just work, don't speak) came to apply to China's top secret manned spaceflight program (邓宁丰, 2004). This was also the reason why the Shenzhou Program was codenamed Project 921 from its conception, with the name "Shenzhou" only being revealed much later, most probably after the first Shenzhou flight. In contrast, Project Mercury was announced to the public a mere two months after it was officially approved. One key difference then, between Project Mercury and the Shenzhou Program, was the level of openness of the programs. While Project Mercury under NASA was a clearly civilian, but more importantly, open affair, the Shenzhou Program, with both civilian and military elements, was an extremely tightly guarded endeavor that was only known to those involved when it began. Indeed, for example, Shenzhou-1 took off in the absence of any pre-launch announcement, and the only reason the world knew about it at that time was unofficial photographs taken by a Dutch engineer who happened to be at the launch site and serendipitously caught the rocket on film (Harvey, 2013).

It is interesting how these two very similar engineering projects were created and carried out under very different levels of openness. Indeed, a consideration of the various reasons for and against openness or secrecy seems to indicate that both countries should have gone down a similar path. If expediency or organizational effectiveness was a primary consideration, which would explain the Chinese decision to engage military elements, then the US should have simply placed the manned spaceflight program under the purview of the US Air Force, which would have had a much higher chance of accomplishing its goals sooner (The argument of preserving non-military flavor in fear of Soviet retaliation applied to earlier satellite efforts but not in this case), especially since the US was probably in a much greater hurry to achieve manned spaceflight at the earliest possible time compared to China. After all, the Soviet achievements with the Sputnik launches had already prompted editorialists in the US to put forth that "in a totalitarian country scientists are told what to do. They can be quickly mobilized and their mass effort directed at any single objective" and to consider if "some advantages of tight, totalitarian control will be helpful to our democratic processes" (McDougall, 1997).

On the flipside, why did the Chinese choose to implement a manned spaceflight program shrouded in so much secrecy when there were no foreseeable negative implications of allowing the Chinese public or foreign media to know about it? The idea of guarding state secrets to explain such Chinese secrecy in the 1990s does not seem to be very plausible; perhaps this argument might be applicable in this day and age, but in the 1990s, it was the US and Russia that were holding the technological know-how and secrets that China so desired (and eventually paid for), and in fact, the US National Reconnaissance Office had begun monitoring the Chinese launch site in the mid-1990s and already knew about their efforts (Harvey, 2013); such secrecy was thus unlikely to have been for the primary purpose of guarding valuable information. The desire to avoid triggering public opposition to the program was also an extremely unlikely reason; no amount of public discontent would have stopped the Chinese manned spaceflight effort if China's top leadership wanted to push for it. In addition, in another twist to this story, while literature and information on the Shenzhou Program was virtually non-existent before China's first successful manned spaceflight, such information on the early stages of the Shenzhou Program up to Shenzhou 5 is now readily available to the public (albeit in Chinese).

This difference can ultimately be explained by invoking two of Hofstede's cultural dimensions – that of power distance as well as individualism/collectivism. Power distance, as mentioned earlier, has to do with the "extent to which the less powerful members of organizations and institutions accept and expect that power is distributed unequally" (Hofstede, Hofstede, & Minkov, 2010). The US and China differ greatly in power distance, with the US having a significantly small power distance culture and China having a significantly large power distance culture. In a small power distance culture like the US, "competition between groups and leaders is encouraged, control by leaders is limited because members can join several organizations, democratic politics are fostered, and information sources are independent of a single organization" (Hofstede G. H., 2001). The logical conclusion in such a culture, then, is that for a manned spaceflight effort with non-military goals –to further science, develop human knowledge and perhaps most importantly establish US leadership in the field – such an effort would not seek to establish steep hierarchies or create need-to-know cultures, but rather be open, accessible and accountable to the public, as well as be centered around organizational structures that reflect small power distance norms such as "subordinates are people like me", "openness with information, also to nonsuperiors", and "decentralized decisions structures; less concentration of authority" (Hofstede G. H., 2001). These all point to the formation of a civilian entity that values openness among its employees and with the public. As McDougall puts it, "An "honest" space program might have been one single, coordinated effort run by the DOD…. [but] US space institutions at least reflected the values of free, open, international inquiry and discovery for the elevation of the human spirit" and that "There was widespread concern, born of idealism and propaganda both, that the United States show the world an open space program" (McDougall, 1997).

On the other hand, for China, with a large power distance culture, it made perfect sense that those with power in the manned spaceflight effort were "existentially unequal" from those who were not, i.e. the public; organizational norms belonging to a large power distance culture such as "Contacts between superiors and subordinates are supposed to be initiated by the superiors only" and "Organizations centralize power as much as possible in a few hands" (Hofstede, Hofstede, & Minkov, 2010), as well as “information constrained by hierarchy” and “superiors consider subordinates as being of a different kind” (Hofstede G. H., 2001) imply that no wrong would be found in not making public a non-military effort if there was no practical need for the public to know about it. In other words, such organizational norms not only rationalized the leveraging of military hierarchical structures for the implementation of China’s manned space program, but also extended down into the societal realm with its hierarchical control of information. There was no sense of consultation of the public or accessibility to the public that would otherwise be promoted ideals in a small power distance culture, but rather a sense that those in power had the right to preserve a hierarchy of information and secrecy if they so desired. Because of these differences in power distance, Project Mercury was close to the people, while the Shenzhou Program was closed to the people.

Another contributing explanation for these organizational differences may be derived from the individualism/collectivism dimension. As addressed earlier, the US was focused on regaining self-respect, while China was focused on regaining face. The purpose of Project Mercury, then, would largely be defeated if it were kept under wraps as a secret project; the whole point was, essentially, to involve the public in an endeavor that would give them back the pride needed to stand up to the Soviets again. Although the practical outcome may have been the same had the project been placed under the Army and John Glenn’s successful flight announced only after it happened (and succeeded), this would simply not square with the prevailing mood at that time, that of a collective and concerted effort to regain American national pride. On the Chinese side however, it did not matter that the Chinese public was entirely unaware of the leadership’s efforts at manned spaceflight; what mattered was the successful accomplishment of manned spaceflight that would then be broadcast to the world to prove that the Chinese was indeed a big nation as worthy of recognition as the US or Russia. On the flip side, if anything untoward were to happen to the Shenzhou Program, an open program would be disastrous, as it would lead to further embarrassment to the Chinese and a further loss of face both abroad and within domestic Chinese constituents. The fact that information and literature on the Shenzhou Program was made readily available after the fact supports this hypothesis; once the intended goals had been achieved, there was no need to guard against any potential loss of face and the successful program could be readily promoted for other benefits, mostly in the realm of propaganda.

In some sense, while it may seem counterintuitive given that the US was racing against the Soviets and China was seemingly advancing on its own schedule for manned spaceflight, it was the journey that mattered more to the Americans who needed to prove to themselves that they were worthy of national exceptionalism, but the destination that mattered more to the Chinese who needed to prove to everyone else that they were worthy of the same. And as will be seen subsequently, this difference had influences that extended far beyond organizational structure and into the actual workings of the system engineering effort.

4.5.3 Masculinity of the Two Cultures

As mentioned earlier, “a society is called masculine when emotional gender roles are clearly distinct: men are supposed to be assertive, tough, and focused on material success, whereas women are supposed to be more modest, tender, and concerned with the quality of life. A society is called feminine when emotional gender roles overlap – both men and women are supposed to be modest, tender, and concerned with the quality of life.” (Hofstede G. H., 2001). The US and China are relatively masculine cultures, scoring in the 75th and 84th percentile respectively for masculinity among 76 other countries (Hofstede, Hofstede, & Minkov, 2010).

The pursuit of manned spaceflight is not an endeavor that any country would readily enter into. As Handberg puts it, “Space operations occur within a very unforgiving physical environment in which any errors of commission and omission are brutally punished by catastrophic flight or subsequent operational failure in orbit” and that “The political difficulty is that the investment demanded is a continuous one rather than a single or short-term allocation…Technology development can be slow and erratic with multiple testing failures, the comparative cost becomes a real problem…The process only gets more expensive as the technologies grow more efficient and sophisticated" (Handberg & Li, 2007). A manned spaceflight program therefore demands sufficiently widespread societal and political approval of a overwhelmingly challenging endeavor, the resolve to devote human and capital resources to the task, and the courage of individuals to step up to the plate to attempt to succeed in a mission where so much is at stake and so much could go wrong.

It is therefore perhaps of significance that both the US and China as countries who have successfully achieved manned spaceflight are purported to possess qualities of masculine cultures such as "challenge and recognition in jobs [are] important", acceptance of "higher job stress", "work very central in a person's life space", "high mastery: ambitious, daring, independent", "live in order to work (as opposed to work in order to live)", "Big and fast are beautiful (as opposed to small and slow are beautiful)" and "Managers expected to be decisive, firm, assertive, aggressive, competitive, just" (Hofstede G. H., 2001). These qualities may have been instrumental to the US and China in bolstering the success of their manned spaceflight efforts; for all their differences in terms of power distance or individualism/collectivism, these cultural qualities or norms that apply to both their masculine cultures seem to suggest an overall go-getter attitude that isn't afraid of challenges, stress or hard work, and which seems to possess the desire and capabilities to rise up to the challenge at hand.

But beyond facilitating a manned spaceflight effort with all its procedural challenges and harsh demands, perhaps these qualities might have been critical to even ensuring that the manned spaceflight programs were even fought for in the first place. It should be recalled that none of the top leaders in both countries during the conception period of the respective manned spaceflight programs (Eisenhower and Kennedy in the US and Deng and Jiang in China) actually came to the conclusion on their own to fully push for a manned spaceflight program. Far from it, they were actually opposed to such a program due to more pragmatic considerations, mostly of an economic nature, for it was correctly perceived then and known with more certainty now that manned spaceflight is not justifiable on economic utility or scientific grounds. Even Kennedy, whom one might have expected to have hit the ground running where space policy was concerned based on his campaign rhetoric, "showed hesitancy about space rather than bold forays into this new frontier" during the first few months of his administration (McDougall, 1997).

It should perhaps be considered that the leaders of nations do not always necessarily reflect the prevailing national culture; in certain situations the myriad of considerations that they also have to take into account, including matters of economic importance and external affairs, constrain their ability, as it were, to follow their heart. Ultimately, for both the US and China, the people came through. Eisenhower eventually caved in to demands by his citizens to issue a meaningful response to Soviet space achievements that reflected what they perhaps thought was the ideal spirit of the American people. Kennedy, despite Jerome Wiesner's report that (perhaps justifiably) lambasted Project Mercury, was eventually swayed by the recommendations of the NAS Space Science Board that promoted a space program that would be "the greatest inspirational venture of this century", by James Webb who fought for Americans becoming "leaders in space, science and technology" which would allow the US to be "pioneering on a new frontier" and "develop the emerging world forces", and perhaps most importantly by the US Congress's reaction to Gagarin's flight which demanded, in essence, that "the White House do whatever was necessary to gain unequivocal leadership in space", not to forget the equally vital efforts of individuals such as Johnson, McNamara, von Braun, Schriever and John T. Hayward among many others in pushing for a space program (McDougall, 1997). On the Chinese front, it took the unrelenting efforts of Chinese scientists and officials in the Aerospace ministry to convince Deng and later Jiang of the importance and value of devoting resources to a manned spaceflight program. These individuals in both the US and China were perhaps driven by that thirst for challenge, recognition, ambition, and mastery, topped off with the desire to fight for what they believed in (albeit in different ways), qualities that were necessary for those involved in the early conceptual stages of the programs to have fought for them despite the reluctance of top leadership. Without these qualities, and indeed if the cherished values of these cultures were those belonging to feminine cultures such as an emphasis on well-being and "quality of work life", "work not central in a person's life space", "lower job stress", "sympathy for the weak", and "preference for fewer hours worked", Project Mercury and the Shenzhou program with their overwhelming challenges and harsh and demanding work conditions might not have been sustained over time, if they had even materialized at all.

4.5.4 Convincing the Leadership

However, even if they were aiming for the same goal, the methods that were employed by the Americans and the Chinese in convincing their top leadership were quite different; and the most relevant dimension that speaks to this difference would be individualism vs. collectivism. More specifically, collectivist countries like China have a set of cultural characteristics which include "Value standards differ for in-groups and out-groups: particularism", "Private life is invaded by institutions and organizations to which one belongs", "Relatives of employer and employees preferred in hiring", "Treating friends better than others is normal and ethical", and "In business, personal relationships prevail over task and company". On the other hand, the corresponding set of characteristics for individualist countries like the US are "Value standards should apply to all: universalism", "Everyone has a private life", "Family relationships seen as a disadvantage in hiring", "Treating friends better than others is nepotism and unethical", and "In business, task and company prevail over personal relationships". (Hofstede G. H., 2001)

It is not difficult to infer a pattern from these sets of characteristics. The set of characteristics for collectivist countries invoke the idea of *guanxi*, a well-known Chinese term in the cross-cultural literature that means "personal connections" which "links the family sphere to the business sphere" (Hofstede G. H., 2001). The idea is that familial and personal relationships may "invade" the business or work sphere by exerting undue influence on what would normally be expected to be a professional and impersonal affair or task. Such an idea may be seen as anathema to individualist countries like the US where personal relationships are not seen as having a rightful place in business or formal decision-making and where such practices may be construed to be bordering on nepotism, but may be viewed less unfavorably in more collectivist cultures. This difference in cultural values clearly plays out in the narrative of both countries. In China, critical turning points in the path towards the conception of the Shenzhou Program were facilitated by the reliance on such *guanxi*, more specifically familial relations. As shown in Subsection 4.3.2, three years of debate between those who wanted China to start investing in advanced technology and those who wanted China to wait until it was economically stronger were finally put to rest in 1986 by relying on Deng's son-in-law, which lead to the decision to embark on Project 863 which cemented aerospace's position as an area in which China would devote national R&D efforts to. An estimated three to four more years of debate between those who advocated the pursuit of manned spaceflight and those who advocated devoting resources to more practical areas were put to rest in 1991 by relying on Deng's brother-in-law, which led to the decision to finally embark on Project 921, the Shenzhou Program. In both cases, reliance on relatives of Deng was instrumental to nudging the top leadership one step closer towards approving a manned spaceflight program, without which the program would have been stuck behind numerous roadblocks in the form of debates between rival camps.

In contrast, the corresponding set of characteristics for individualist countries like the US emphasize objectivity and impartiality in making judgments and decisions, in other words the idea that such processes should be based on facts and arguments and not be influenced by personal relations. It is not surprising that critical points in the path towards the approval of Project Mercury were primarily driven by due process and the reliance on formal channels such as advisory committees, inquiries, conferences, petitions and reports. Numerous public debates after the Sputnik launches amongst the American public and the mass media were put to rest by the Johnson hearings in 1957 whose formal recommendations spurred Eisenhower to devote more resources to relevant R&D fields and to approve the establishment of NASA. Subsequent (often heated) debates amongst multiple parties such as the USAF, the Army and NACA representatives over who should retain control over the manned spaceflight program were settled by such avenues as the President's Science Advisory Committee's recommendations that contributed to Eisenhower deciding that the US manned spaceflight effort should be a civilian program housed under NASA. And after the formation of NASA, in an uncanny foreshadowing of almost exactly the same debate that would take place in China almost exactly three decades later, a conflict emerged between two groups within the Greenewalt committee formed in 1959 to "examine into the significance of competition with the USSR for space leadership", one of which advocated more practical uses of resources instead of plunging into a race for national prestige, and the other insisting on the importance of counteracting Soviet space dominance. After carefully listening to both sides of the debate, then Vice President Nixon expressed his conclusion that the US should indeed commit itself to a competition in space, eventually leading to Eisenhower approving NSC-5918, "U.S. Policy on Outer Space" which secured Project Mercury's financial future. (McDougall, 1997) It is probably safe to say that no major decision or step forward for Project Mercury was primarily influenced by personal relationships, nor would the top levels of US leadership have condoned or trusted such a practice.

At the same time, another opposing set of characteristics along the individualism/collectivism dimension was also at play in the US and China decision making processes. Individualist countries subscribe to such characteristics as "Speaking one's mind is a characteristic of an honest person", "Confrontations are normal" and "Belief in individual decisions", whereas collectivist countries value characteristics such as "Harmony should always be maintained and direct confrontation avoided" and "Belief in collective decisions" (Hofstede G. H., 2001). The various debates in the US revolving around space policy, whether it was over how the US should react to Soviet space feats or whether manned spaceflight was a wise endeavor, were characterized by various individuals not afraid to speak their mind, even if it meant clashing head-on with someone from an opposing faction. The belief was that any such conflicts or clashes should be allowed to take place within procedural boundaries, and it was only with such honest confrontation and sometimes fiery debate that the way forward would crystallize. Major decisions were also often attributed to individuals, most notably Eisenhower and later Kennedy.

On the other hand, the various debates in China almost certainly touched on very similar topics that were fought over in the US three decades before – the necessity of competing with other countries in the field of aerospace, the wisdom of pursuing manned spaceflight etc. – and while many committees and meetings were convened to explore these various issues, they rarely seemed to produce a breakthrough on their own that propelled China's spaceflight effort forward. Instead, it was the importance ascribed to harmonious consensus, avoidance of direct clashes and confrontation, and the need to reach a decision collectively that often prolonged such decision-making efforts due to, naturally, neither side being willing to back down from their point of view. Even when the reliance on *guanxi* catalyzed decisions from the top leadership that put these debates to rest, such decisions were usually framed as collective decisions when announced to the larger group, not decisions made by Deng or Jiang, but decisions that were made by the nebulous concept of "us".

4.6 Conclusion

Ultimately, the subtle differences in the ways that the US and China viewed the national prestige that their respective manned spaceflight programs would allow them to regain had far reaching consequences on the Mercury and Shenzhou programs. The more individualist culture that Project Mercury was situated in viewed national prestige as a way to regain self-respect, not so much to prove to other nations what the US was capable of, but to prove to the American people themselves what their country was capable of. This, together with the relatively lower power distance of American society, had an impact on the formation of NASA as an open organization that did not seek to keep the first US manned spaceflight program under wraps but rather promote it as an honest, open endeavor whose worth came from involving the public in the journey. On the other hand, the more collectivist culture that the Shenzhou program was situated in viewed national prestige as a way to regain face, to prove to other nations that China as a large power did indeed deserve a seat at the manned spaceflight table together with other large nations like the US and Russia that the Chinese perceived themselves to be equals with. This, together with the relatively higher power distance of Chinese society, had an impact on the creation of the Shenzhou Program as a top secret program that the top leadership had no intention of sharing with the Chinese public or the world until it succeeded, in order to avoid any loss of face that might result from the highly uncertain process leading up to the final goal. The very different natures of these programs subsequently had an impact on their operations from program management to their popular representation in the media, as will be explored in the subsequent chapters.

Furthermore, the decision making process leading up to the eventual approval of the programs was also significantly different for the US and China. Differences along the individualism vs. collectivism dimension reveal how cultural differences may significantly influence the decision making process for a systems engineering endeavor. Although both the US and China got to the same decision end-point where manned spaceflight was concerned, their respective paths were quite different. The path to Project Mercury was characterized by impersonal decision-making processes, intense and stark debate that did not shy away from confrontation, and individual ownership over opinions and decisions, whereas the path to the Shenzhou Program was characterized, to a certain degree, by *guanxi* and relationships (both formal and informal), debate that sought a harmonious consensus, and constructed collective ownership over opinions and decisions. That is not to say that personal relations had zero influence on the decision-making processes in the US, or that professional, impersonal judgments were completely absent from the decision-making processes in China; rather it is the relative amounts of what would be construed to be cultural norm respectively in individualist and collectivist cultures that differ.

Was one of these modes, then, better than the other? It is certainly neither meaningful nor desirable to attempt to make such a judgment. There is no universal standard for how people should make decisions, especially where cultural values and contexts are concerned, because such evaluations are always so context dependent that generalized value judgments are almost certainly not going to be helpful. What is meaningful, then, is to consider how these cultural differences impacted the actual decision making process and how they hint at certain tradeoffs that might exist. The process of finalizing Project Mercury was certainly shorter for the US, lasting about 1-2 years after the launch of Sputnik-I in October 4, 1957, and involved a great deal of fast-paced and intense argument and decision making, but which in turn probably left a sour taste in the mouths of those whose opinions or positions were eventually overridden by the individuals who won these arguments. The process of finalizing the Shenzhou Program was decidedly much longer, lasting approximately 9 years, and involved serious but mostly slow moving debates punctuated by attempts to break the stalemate through covert reliance on back-door *guanxi* maneuvers. Perhaps a lot less animosity would have been created through such a process, but it was a long-drawn out battle that may have raised questions regarding the objectivity of these decisions among certain stakeholders, though they, in reality, would probably have been resigned to the existence, and perhaps importance, of such patronage networks.

5. The Programs – Management of Mercury and Shenzhou

"*the United States…is perversely ill-suited to what spaceflight requires. Not as ill-suited as that fraudulent technocracy, the Soviet Union, but ill-suited nonetheless. Given the costs, lead-times, and distances involved, the pioneering of space requires a coherent, sustainable, long-term approach, predictably financed and supported by a patient people willing to sacrifice and delay gratification even over a generation or more. Americans do not fit that description*"

- Walter A. McDougall[14], during a conference held on October 22-23, 2007 titled "Remembering the Space Age", commemorating 50 years since the fateful launch of Sputnik I. (Dick, 2008)

"*在长期的奋斗中，我国航天工作者不仅创造了非凡的业绩，而且铸就了特别能吃苦，特别能战斗，特别能攻关，特别能奉献的载人航天精神。载人航天精神…是我们伟大民族精神的生动体现，永远值得全党、全军和全国人民学习。*"
("*During this long battle, China's spaceflight personnel have not only achieved extraordinary results, but have also forged a spirit of manned spaceflight, a spirit characterized by an exceptional willingness to bear hardship, an exceptional motivation to fight on, an exceptional ability to achieve breakthroughs, and an exceptional desire to dedicate themselves to their work. This spirit of manned spaceflight…is a vivid embodiment of our national spirit, and will forever be worthy of emulation by all members of the Chinese Communist Party, the People's Liberation Army, and the Nation.*")

- Chinese President Hu Jintao, in a speech on November 7, 2003 at the Great Hall of the People in commemoration of the successful flight of Shenzhou 5 and China's first manned spaceflight (邓宁丰, 2004)

5.1 Overview of the US and China Manned Spaceflight Programs

The following two subsections 5.1.1 and 5.1.2 will present a brief overview of Project Mercury and the Shenzhou Program. For the purposes of this thesis, only those flights up until the first successful manned orbital spaceflight will be included in the analysis for both programs.

This effectively translates into the first 23 flights of Project Mercury lasting from the date of its official approval on October 7, 1958 until John Glenn's successful Friendship 7 flight on February 20, 1962, a total duration of approximately 3 years and 4 months. (The entire Project Mercury comprised 26 flights in total (25 if Mercury Scout 1 is excluded) and lasted till May 15, 1963, a total of approximately 4 years and 8 months) (NASA, 1963)

For the Shenzhou Program, this translates into the first 5 Shenzhou flights lasting from the date of its official approval on September 21, 1992 to Yang Liwei's successful Shenzhou 5 flight on October 15, 2003, a total duration of approximately 11 years. (Harvey, 2013) (The entire Shenzhou Program comprises 10 flights as of today and is still ongoing, with Shenzhou 11 planned for the future).

[14] Walter A. McDougall is an American historian who won the Pulitzer Prize for History in 1986 for his book "The Heavens and the Earth: A Political History of the Space Age", described as a "landmark contribution to the literature of the history of astronautics" (Hallion, 1987) and which serves as a central source for the motivations that drove Project Mercury in this thesis.

5.1.1 Project Mercury

According to the Mercury Project Summary (NASA SP-45), Project Mercury had three objectives: "1) Place a manned spacecraft in orbital flight around the earth. 2) Investigate man's performance capabilities and his ability to function in the environment of space. 3) Recover the man and the spacecraft safely." And upon finalizing these objectives, four guidelines were stipulated to "insure that the most expedient and safest approach for attainment of the objectives was followed"; these guidelines are: "1) Existing technology and off-the-shelf equipment should be used wherever practical. 2) The simplest and most reliable approach to system design would be followed. 3) An existing launch vehicle would be employed to place the spacecraft into orbit. 4) A progressive and logical test program would be conducted." (NASA, 1963) With regards to the third and fourth guidelines, according to Dr. Robert Gilruth, the STG's director, "To this end existing ballistic missiles (the Atlas and Redstone) were selected as the primary propulsion systems…. Since a new era of flight was being approached, it was planned to use a build-up type of flight-test program, in which each component or system would be flown to successively more severe conditions in order first to prove the concept, then to qualify the actual design, and finally to prove, through repeated use, the reliability of the system." (Burgess, 2014)

A planned flight schedule for Project Mercury was developed in early 1959 and is displayed in Figure 3 as taken from NASA's Mercury Project Summary. As can be seen from the schedule, there were 27 major launches planned that can be divided into three main categories: Research-and-development tests, flight qualification of the production spacecraft, and manned orbital flight tests. Combinations of four types of launch vehicles (the Little Joe, the Mercury-Redstone, the Mercury-Jupiter, and the Mercury-Atlas) as well as two types of Mercury spacecraft (boilerplate and production spacecraft) were to be used for each of these launches[15]. (NASA, 1963)

[15] According to NASA SP-45, " Four Little Joe flights and two of the Atlas powered flights, termed Big Joe, were planned to be in the research and development category to check the validity of the basic Mercury concepts. The qualification program was planned to use each of the four different launch vehicles. The operational concept of the qualification program provided for a progressive build-up of flight test system complexity and flight-test conditions. It was planned that the operation of all hardware items would be proven in those environments to which they would be subject in both normal and emergency conditions associated with attainment of the planned mission conditions. One qualification flight test was planned with the use of the Little Joe launch vehicle. This test was planned to qualify the operation of the production spacecraft in a spacecraft-abort situation at the combination of dynamic pressure, Mach number, altitude, and flight-path angle that represented the most severe condition anticipated for the use of this system during an orbital launch. There were eight flight tests planned with the use of the Redstone launch vehicle. The first two were intended to be unmanned tests used to qualify the production spacecraft and to qualify the production spacecraft launch-vehicle combination. The remaining six Mercury-Redstone flights were to be used to train and qualify Mercury astronauts for later orbital flights. Two flight tests were planned in which the Jupiter launch vehicle was to be used. The first one of these was to be made to qualify the production spacecraft for those flight conditions which produced the greatest load factor during reentry. The second Jupiter powered flight was scheduled as a backup to the first. The qualification program for the production spacecraft also included plans for three flight tests using the Atlas launch vehicle and the remainder of the flights were expected to be used for manned orbital flight if the flight qualification achieved at the time so warranted." (NASA, 1963)

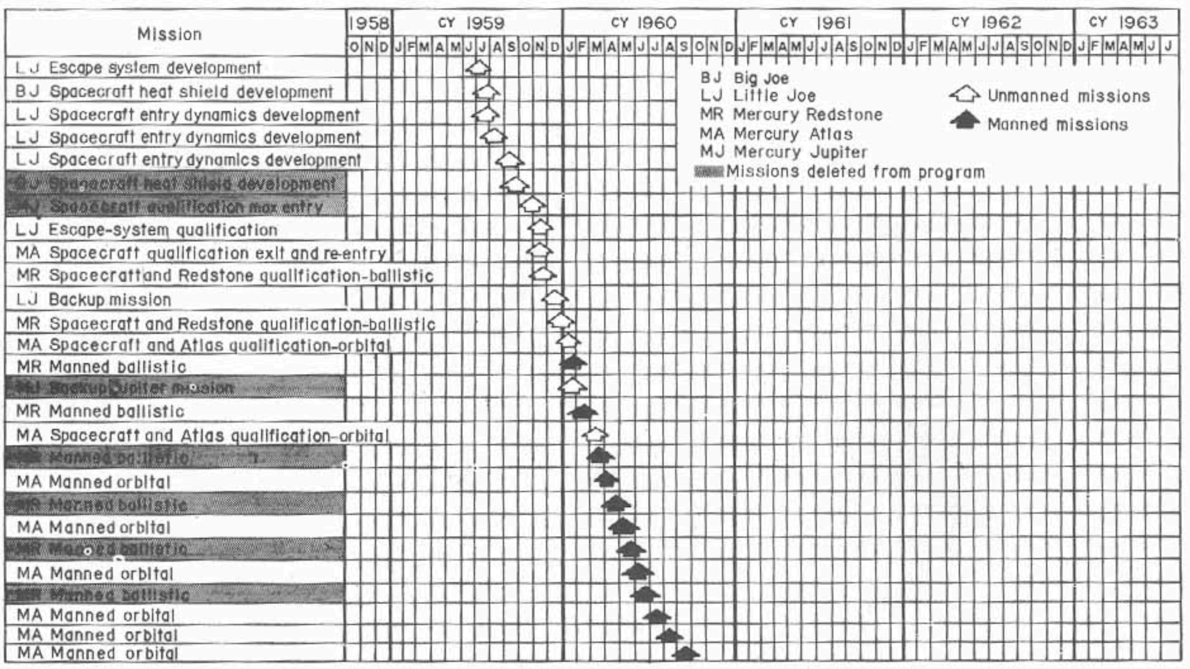

Figure 3: Project Mercury Planned Flight Schedule in Early 1959 (NASA, 1963)

The actual flight schedule for Project Mercury is presented below in Figure 4 as taken from NASA's Mercury Project Summary.

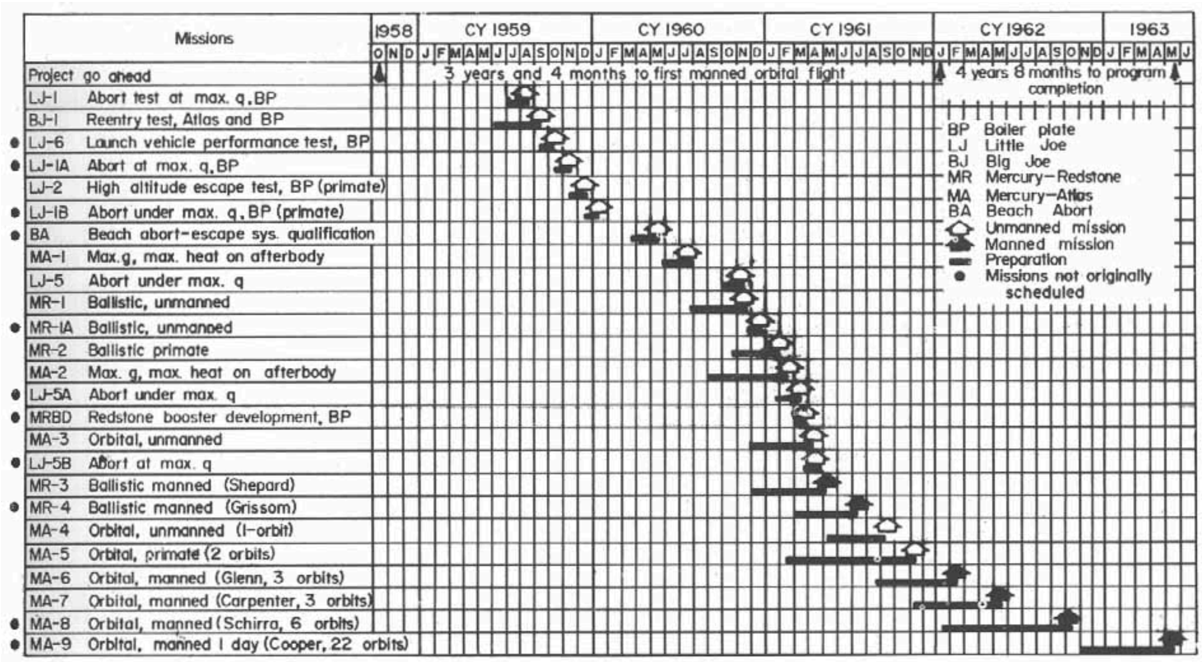

Figure 4: Project Mercury Actual Flight Schedule (NASA, 1963)

A summary of the Project Mercury flights up until the first successful manned orbital flight, including their outcomes and purposes, is presented in Table 8.

Table 8: Summary of Project Mercury Launches up until First Successful Manned Orbital Flight (Catchpole, 2001) (Burgess, 2014) (Grimwood, 1963) (Godwin, 2001) (Godwin, 1999) (NASA, 1963)

No.	Mission Name	Launch Date	Launch Vehicle/ Spacecraft	Type	Outcome	Purpose
1	Little Joe 1 (LJ-1)	August 21, 1959	Little Joe/ Prototype Mercury spacecraft	Unmanned	Failed	Test operation of Launch Escape System (LES) under maximum aerodynamic pressure (max q)
2	Big Joe 1 (BJ-1)	September 9, 1959	Atlas 10D/ Boilerplate Mercury spacecraft	Unmanned	Partial Success/ Failure	Test of new ablative heat shields and test Mercury Atlas configuration for manned orbital flight
3	Little Joe 6 (LJ-6)	October 4, 1959	Little Joe/ Boilerplate Mercury spacecraft	Unmanned	Partial Success/ Failure	Qualify Little Joe launch vehicle
4	Little Joe 1A (LJ-1A)	November 4, 1959	Little Joe/ Mercury prototype spacecraft	Unmanned	Partial Success/ Failure	Repeat of LJ-1 goals
5	Little Joe 2	December 4, 1959	Little Joe/ Mercury prototype spacecraft	Unmanned (carrying monkey)	Success (Monkey named SAM survived)	Test operation of LES with primate under high altitude, low-pressure conditions
6	Little Joe 1B	January 21, 1960	Little Joe/ Mercury prototype spacecraft	Unmanned (carrying monkey)	Success (Monkey named Miss SAM survived)	Repeat of LJ-1 goals with primate
7	Beach Abort	May 9, 1960	Mercury LES/ Production standard spacecraft SC-1	Unmanned	Success	Simulate abort from launch vehicle on launch complex
8	Mercury-Atlas 1	July 29, 1960	Atlas 50D/ SC-4	Unmanned	Failure	First test launch of production standard Mercury Spacecraft
9	Little Joe 5	November 8, 1960	Little Joe/ SC-3	Unmanned	Failure	Test combination of production standard Mercury spacecraft and LES during max-q
10	Mercury-Redstone 1 (MR-1)	November 21, 1960	Redstone/ SC-2	Unmanned	Failure	Test combination of Mercury Spacecraft and Mercury Redstone launch vehicle for manned suborbital flights
11	Mercury-Redstone 1A	December 19, 1960	Redstone / SC-2	Unmanned	Success	Repeat goals of MR-1 launch
12	Mercury-Redstone 2	January 31, 1961	Redstone/ SC-5	Unmanned (carrying monkey)	Success (HAM survived)	Test launch of primate on suborbital space flight (to qualify ECS), with the initial goal of manned suborbital flight on MR-3 if it

No.	Mission Name	Launch Date	Launch Vehicle/ Spacecraft	Type	Outcome	Purpose
						succeeded
13	Mercury Atlas 2	February 21, 1961	Atlas 67D / SC-6	Unmanned	Success	Repeat goals of MA-1
14	Little Joe 5A	March 18, 1961	Little Joe / SC-14	Unmanned	Failure	Repeat goals of LJ-5
15	Mercury-Redstone BD	March 24, 1961	Redstone / Boilerplate Mercury spacecraft	Unmanned	Success	Test modifications to the Redstone launch vehicle meant to remedy MR-1 and MR-2 malfunctions. Last test flight of Redstone
16	Mercury Atlas 3	April 25, 1961	Atlas 100D / SC-8	Unmanned	Failed	Attempt orbital flight with robotic astronaut
17	Little Joe 5B	April 28, 1961	Little Joe/ SC-14	Unmanned	Success	Repeat goals of LJ-5/LJ-5A. Last flight of Little Joe program.
18	Mercury-Redstone 3 (Freedom 7)	May 5, 1961	Redstone / SC-7	Manned suborbital (Alan Shepard)	Success	First manned suborbital flight
19	Mercury Redstone 4 (Liberty Bell 7)	July 21, 1961	Redstone / SC-11	Manned suborbital (Gus Grissom)	Success	Second manned suborbital flight; repeat of MR-3 goals
20	Mercury Atlas 4	September 13, 1961	Atlas 88D / SC-8	Unmanned orbital	Success (First successful orbital flight)	Repeat of MA-3 goals
21	Mercury Scout 1	November 1, 1961	Blue Scout II D-8	Unmanned	Failure	Test tracking network for Mercury Atlas orbital flights
22	Mercury Atlas 5	November 29, 1961	Atlas 93D / SC-9	Unmanned orbital (carrying chimpanzee)	Success (Enos survived)	Test of orbital flight with primate. Last test flight of Mercury Atlas.
23	Mercury Atlas 6 (Friendship 7)	February 20, 1962	Atlas 109D/ SC-13	Manned orbital (John Glenn)	Success	First manned orbital flight.

As can be seen from the information above, both the planned and actual flight schedule of Project Mercury followed a logical sequence of launches. As existing launch vehicles were already available, what was needed was the testing of new technology, in particular the Launch Escape System (LES) and the Mercury Spacecraft, under increasingly severe conditions, as well as the testing of these new technologies in combination with the existing launch vehicles to ensure that the system worked as a whole. As a simplification, the flight schedules began with the testing of the LES and the testing of the heat shields, followed by tests of production standard Mercury Spacecraft, tests of the production standard Mercury Spacecraft in combination with the LES and the Redstone and Atlas launch vehicles, and finally the actual suborbital and orbital flights themselves using the Redstone and Atlas launch vehicles respectively.

However, the actual flight schedule of Project Mercury was significantly different from that of the planned flight schedule, most notably because of the failed launches, which can be divided into those launches that were primarily intended to test new technologies, and those launches that were primarily intended to test combinations of new technologies with existing technologies.

With regards to the first type of launches, the failure of the first flight, Little Joe-1 (LJ-1), whose purpose was intended to test the operation of the LES under maximum aerodynamic pressure, resulted in the addition of LJ-6 to qualify the launch vehicle itself and the addition of LJ-1A which both partially failed, before the successful LJ-1B flight. The failure of MA-1, which was intended as the first test launch of the production standard Mercury spacecraft, resulted in the addition of a successful MA-2 flight.

For the second type of launches, the failure of LJ-5, which was intended to test the combination of the LES with a production standard Mercury spacecraft, resulted in the addition of LJ-5A which also failed, before the successful LJ-5B flight. The failure of MR-1 intended to test the combination of the Mercury spacecraft and the Redstone launch vehicle resulted in the addition of the successful MR-1A flight. The failure of MA-3, which was intended to test the Mercury spacecraft and the Atlas launch vehicle in an orbit around the Earth, resulted in the addition of the successful MA-4 flight.

Table 9 below presents the reasons for the failures or partial failures of the relevant launches, problems for launches that succeeded but which were nevertheless problematic, as well as corrective actions taken for these problems.

Table 9: Reasons for Failure or Partial Failure for Project Mercury Launches (Catchpole, 2001) (Burgess, 2014) (Grimwood, 1963) (Godwin, 2001) (Godwin, 1999) (NASA, 1963)

No.	Mission Name	Outcome	Purpose	Problems/Reason for Failure/Partial Failure	Corrective Action Taken
1	Little Joe 1 (LJ-1)	Failed	Test operation of Launch Escape System (LES) under maximum aerodynamic pressure	Electrical Failure triggered LES prematurely	“Re-routing of the single wire between the destruct system solenoid coil and the rapid abort plug”
2	Big Joe 1 (BJ-1)	Partial Success/ Failure	Test of new ablative heat shields and test Mercury Atlas configuration for manned orbital flight	Failure of booster separation	-
3	Little Joe 6 (LJ-6)	Partial Success/ Failure	Qualify Little Joe launch vehicle	“Hot gases…melted the polystyrene nozzle pressure seals…and ignited their solid rocket propellant prematurely”	-
4	Little Joe 1A (LJ-1A)	Partial Success/ Failure	Test operation of LES under maximum aerodynamic pressure (max-q) (Repeat of LJ-1 goals)	Desired aerodynamic pressure for test conditions was not reached due to Escape Motor taking longer than expected to reach full thrust.	-
7	Beach Abort	Success	Simulate abort from launch vehicle on launch complex	“some electrical cables had been accidentally fitted in reverse and would cause the telemetry transmitters to perform poorly through the flight”	-
				“exhaust plume from the Jettison Motor had impinged on the LES tower structure…resulted I considerably shorter than the planned separation distance between the LES and SC-1”	“single Jettison Motor exhaust nozzle was replaced…by three nozzles”
8	Mercury-	Failure	First test launch of	“New thin-skinned liquid	Installation of a “horse

No.	Mission Name	Outcome	Purpose	Problems/Reason for Failure/Partial Failure	Corrective Action Taken
	Atlas 1		production standard Mercury Spacecraft	oxygen tank conical section collapsed". Skin of Atlas 50D which had been thinned under a weight reduction program could not withstand max-q	collar" on the liquid oxygen tank dome
9	Little Joe 5	Failure	Test combination of production standard Mercury spacecraft and LES during max-q	Air loads caused Marman Clamp to deflect, prematurely closing the abort switch and launching the LES. But spacecraft did not separate either, due to errors in the wiring of the limit switches in the Marman Clamp.	Structure of the Marman Clamp was improved and wiring errors corrected
10	Mercury-Redstone 1 (MR-1)	Failure	Test combination of Mercury Spacecraft and Mercury Redstone launch vehicle for manned suborbital flights	Launch vehicle engines were prematurely shut down when the Redstone was but an inch above the launch pad due to problems with the electrical wiring	New ground strap installed for subsequent Redstone launch vehicles and shutdown signal was prevented from triggering a shutdown during first 30 seconds after launch.
12	Mercury-Redstone 2	Success (HAM survived)	Test launch of primate on suborbital space flight, with the initial goal of manned suborbital flight on MR-3 if it succeeded	Problems with a valve resulted in abnormally high thrust and acceleration; there were also undesired harmonic vibrations	Components modified and stiffeners added
14	Little Joe 5A	Failure	Repeat goals of LJ-5	Air loads caused Marman Clamps to deflect yet again and at least two limit switches in the Marman Clamp closed, sending an abort signal prematurely.	Shielding installed around the clamps and limit switches modified.
16	Mercury Atlas 3	Failed	Attempt orbital flight with robotic astronaut	"Contamination on one of the flight programmer's pins, combined with in-flight vibrations caused the programmer to either fail to start, or to start and shut down again…The roll maneuver did not occur." And orbit was not reached.	-
21	Mercury Scout 1	Failure	Test tracking network for Mercury Atlas orbital flights	"Pitched and yaw rate gyros had been wired in reverse" resulting in "unacceptable aerodynamic loads and caused it to begin to break up."	-

Table 10 presents those launches for which relatively significant delays occurred and the reasons for these delays.

Table 10: Delays for Project Mercury Launches
(Catchpole, 2001) (Burgess, 2014) (Grimwood, 1963) (Godwin, 2001) (Godwin, 1999) (NASA, 1963)

No.	Mission Name	Outcome	Purpose	Duration of Delay	Reason for Delay
1	Little Joe 1 (LJ-1)	Failed	Test operation of Launch Escape System (LES) under maximum aerodynamic pressure	Approximately 1 month	"Difficulties in producing the prototype spacecraft"
2	Big Joe 1 (BJ-1)	Partial Success/ Failure	Test of new ablative heat shields and test Mercury Atlas configuration for manned orbital flight	Approximately 1 month (pushed back from July 4, 1959 to mid-August)	Atlas 10D failed an inspection
				Second launch date cancelled and set for 9 September	"Engineers had difficulty overcoming problems in telemetry system"
				19 minutes (on launch day)	"Rogue reading on the Boroughs computer that was to guide the launch vehicle….Fault was ignored and countdown resumed"
8	Mercury-Atlas 1	Failure	First test launch of production standard Mercury Spacecraft	A period of time before the launch	Due to rain
				45 min (on launch day)	"Difficulties topping off the Atlas liquid oxygen tank, and with receiving some of the launch vehicle's telemetry and also the recurring bad weather"
9	Little Joe 5	Failure	Test combination of production standard Mercury spacecraft and LES during max-q	Original launch date in December 1959 but pushed back to October 8, 1960, then to November 11, then to November 16. Launch brought forward to November 7 when production spacecraft was ready in advance	"Difficulties in the manufacture of the production spacecraft"
				November 7 launch date moved to November 8	Bad weather
10	Mercury-Redstone 1 (MR-1)	Failure	Test combination of Mercury Spacecraft and Mercury Redstone launch vehicle for manned suborbital flights	13 days (Launched pushed back from November 7, 1960 to November 21, 1960)	"Launch was cancelled due to a pressure drop in the spacecraft RCS helium supply" which required replacement of parts on the spacecraft including the hydrogen peroxide tank
				1 hour (on launch day)	Problem with hydrogen peroxide system

No.	Mission Name	Outcome	Purpose	Duration of Delay	Reason for Delay
11	Mercury-Redstone 1A	Success	Repeat goals of MR-1 launch	40 min (on launch day)	Strong wind conditions
				3 hours 15 min (on launch day)	Solenoid failure in hydrogen peroxide system
12	Mercury-Redstone 2	Success (HAM survived)	Test launch of primate on suborbital space flight, with the initial goal of manned suborbital flight on MR-3 if it succeeded	Launch delayed from 8am to 1155.am (on launch day)	Overheating of inverter
					Same inverter overheated again
					Same inverted overheated a third time
14	Little Joe 5A	Failure	Repeat goals of LJ-5	4 hours (on launch day)	-
18	Mercury-Redstone 3 (Freedom 7)	Success	First manned suborbital flight	4 days: Original launch date on May 1, 1961 pushed back to May 5	Bad weather conditions
				1 hour 26 min (on launch day)	Problems with an inverter
				1 min (on launch day)	Slight increase in fuel pressure in Redstone
19	Mercury Redstone 4 (Liberty Bell 7)	Success	Second manned suborbital flight	Original launch date of July 17, 1961 pushed back to July 19	Bad weather conditions
				Second launch date of July 19 pushed back to July 21	Bad weather conditions
				30 min (on launch day)	Countdown held for “a misaligned bolt holding the side hatch in place”
				-	Undesirable cloud cover.
22	Mercury Atlas 5	Success (Enos survived)	Test of orbital flight with primate. Last test flight of Mercury Atlas.	1 hour (on launch day)	Hatch cover insulation was not installed.
				1 hour 25 min (on launch day)	One particular switch in wrong position
				4 min (on launch day)	Faulty data link
				3 min (on launch day)	Problem with pulse beacon.
23	Mercury Atlas 6 (Friendship 7)	Success	First manned orbital flight	Original launch date of December 19, 1961 pushed to January 16, 1962	“minor problems dealing with the cooling system and positioning devices in the Mercury Spacecraft”
				Launch date of January 16 pushed to January 23, 1962	Problems with propellant tanks in launch vehicle
				Launch on January 23 cancelled and new launch set for January 27	Problems with oxygen system in launch vehicle
				Launch on January 27 cancelled and pushed to February 1	Unacceptable cloud cover
				Launch on February 1 cancelled and pushed to February 13	Leakage of propellant during prior attempt at launch
				Launch on February 13	Bad weather

No.	Mission Name	Outcome	Purpose	Duration of Delay	Reason for Delay
				cancelled and pushed to February 14, then February 15, then February 16, then February 18, then February 20	
				50 min (on launch day)	Problems with transponder in launch vehicle
				55 min (on launch day)	Broken hatch torque bolt
				15 min (on launch day)	Problem with oxygen pump outlet
				2 min (on launch day)	Problems with power supply to Bermuda tracking station's mainframe computer

5.1.2 The Shenzhou Program

On August 1, 1992, almost two months before Jiang Zemin announced the approval of Project 921, the outline for China's manned spaceflight program was presented in an internal meeting. It was known as 三步走, or "three step journey", and these three steps, or phases, referred to a first phase involving the launch of two unmanned flights and one manned flight by 2002, with the aim of establishing preliminary manned spaceflight engineering expertise and commencing scientific experimentation in space; a second phase upon the successful completion of a manned spaceflight launch which would involve mastering docking technology as well as the launch of an 8 ton space laboratory to meet the need for a short-term manned space station by 2007; and a third phase involving the construction of a 20 ton space station to meet the need for a large-scale, long-term manned space station after 2010. (邓宁丰, 2004) More significantly, the very first unmanned test launch was given the goal of "争八保九", literally translated as "Strive for 8, Guarantee 9", essentially meaning that the program should strive to launch the first unmanned test flight by 1998, and failing to do so, guarantee by all means that it be launched by 1999. (唐国东, 2012)

Wang Yongzhi was appointed as overall project manager of the Shenzhou Program[16], and stated that "我们是在美苏之后 40 多年才搞的，我们搞个什么样的飞船呢？如果我们也像他们当初搞的那么一个飞船，照猫画虎搞那么一个飞船，我们怎么样提高我们民族的自信心呢？这就很难交代。。。我们瞄准联盟 TM，我们一步到位，迎头赶超，一出来就和你并驾齐驱" (We have begun 40 odd years after the Americans and the Soviets, what kind of spacecraft should we build? If we use an exact replica of their spacecraft, how are we going to increase our people's confidence? It will be hard to answer to them…We will aim for the Soyuz, arrive [at that level of technological sophistication] in one step, and overtake it. We will be on the same footing [as the Soviets and Americans] on the very first day). Qi Faren, the chief designer of China's spacecraft, also stated that "我们在新的历史条件下，不可能再像当年苏联、美国那样，一切从头开始，我们不想重复国外的老路，为的是奋力追赶拉大的距离" (We are in different historical conditions [compared to the Americans and Soviets], and simply cannot start from scratch like the Soviets and Americans did. We do not wish to repeat the same path as these foreign countries; we intend to devote ourselves to closing this large gap.) (唐国东, 2012) The driving philosophy of the Shenzhou Program, then, was to use whatever technology was available as a starting point, and then surpass it through indigenous Chinese efforts, with the simultaneous goals of closing the gap of decades of technological development as well as stamping China's own brand on its manned spaceflight endeavor.

[16] Incidentally, Wang Yongzhi was a disciple of Vasili Mishin, the Soviet Chief Designer of Korolev's OKB-1 Design Bureau (Harvey, 2013)

In order to reach such a starting point, the Chinese signed a deal with Moscow in March 1995 in which they were promised astronaut training, a spacecraft life-support system, a Soyuz capsule without internal equipment or electronics, a *Sokol* spacesuit, a docking module, and a Kurs rendezvous system. Due to the high prices charged by the Russians for space technology, the Chinese eventually settled for a shell of the Soyuz, and also forwent a LES stabilizer, deciding to build their own (Harvey, 2013). Harvey also explains that "[Shenzhou's] Overall internal volume is 13% larger, making Shenzhou, they say, larger, roomier, and better. It has a different docking system…Shenzhou is clearly influenced by the Soyuz design, but to describe it as a "copy" would be both inaccurate and unfair. The Chinese became sensitive to allegations of copying and at press conferences stressed that Shenzhou was "Made in China" ("Made in China" stated emphatically in English)." (Harvey, 2013)

Table 11 below presents the five spacecraft launches leading up to China's first successful manned orbital flight.

Table 11: Summary of Shenzhou Program Launches up till First Successful Manned Orbital Flight (Harvey, 2013) (Handberg & Li, 2007)

No.	Mission Name	Launch Date (Local time)	Launch Vehicle/ Spacecraft	Type	Outcome	Purpose
1	Shenzhou 1	November 20, 1999	CZ-2F / Shenzhou (Limited functions)	Unmanned orbital	Success	Test launch of CZ-2F rocket, orbited Earth 14 times
2	Shenzhou 2	January 10, 2001	CZ-2F / Shenzhou (Fully functional)	Unmanned orbital	Success	More comprehensive testing of the launch vehicle and a now fully functional Shenzhou spacecraft
3	Shenzhou 3	March 25, 2002	CZ-2F / Shenzhou	Unmanned orbital	Success	Further testing of launch vehicle and spacecraft now equipped with LES (with dummies)
4	Shenzhou 4	December 30, 2002	CZ-2F / Shenzhou	Unmanned orbital	Success	Last and most comprehensive rehearsal of orbital flight (with dummies)
5	Shenzhou 5	October 15, 2003	CZ-2F / Shenzhou	Manned orbital (Yang Liwei)	Success	First manned orbital flight

Table 12 below presents the known delays and problems associated with these five flights of the Shenzhou Program.

Table 12: Delays for Shenzhou Program Launches
(Harvey, 2013) (Handberg & Li, 2007) (邸乃庸, 2011)

No.	Mission Name	Purpose	Duration of Delay	Reason for Delay	Reason for Failure/Partial Failure	Corrective Action Taken
1	Shenzhou 1	Test launch of CZ-2F rocket, orbited Earth 14 times	Incident happened in September. Launch delayed for at least 2 weeks.	"service module had to be taken apart … Engineers uncovered wiring problems and a gyroscope failed and had to be replaced."	"Failure to transmit a command to the onboard computer for initiating reentry."	"On the final orbit, success was achieved."
2	Shenzhou 2	More comprehensive testing of the launch vehicle and a now fully functional Shenzhou spacecraft	More than half a month	Problem with gyroscopes	"assumed that the parachute landing system did not completely deploy, with a hard landing the result"	-
			5 days	Problems with indication signal		
			5 days	"a crane hit and dented the second stage of the launcher"		
3	Shenzhou 3	Further testing of launch vehicle and spacecraft now equipped with LES (with dummies)	Three months	Problem with electrical connections	-	-
			20 days	Problem with avionics		
4	Shenzhou 4	Last and most comprehensive rehearsal of orbital flight (with dummies)	-	-	-	-
5	Shenzhou 5	First manned orbital flight	-	-	-	-

5.2 Analysis of the Mercury and Shenzhou Programs

5.2.1 Differences in Program Management

There exist a great many differences between how Project Mercury and the Shenzhou Program were eventually run. The subsections below will outline these differences and elaborate on the questions (and contradictions) these differences raise. Throughout Section 5.2, these differences will be fleshed out using Project Mercury as a “default” or “normal” scenario, and the Shenzhou Program as a “new” scenario that will be considered to have behaved differently from Project Mercury. There is no particular reason why this could not have been done in the opposite fashion (i.e. taking the Shenzhou Program as the “default” scenario and Project Mercury as a “new” scenario that behaved differently), apart from the fact that Project Mercury occurred first in history, which to some extent makes it a logical base case, and also the fact that considerably more is known in general about Project Mercury than the Shenzhou Program, making Project Mercury the more natural choice for a basis for comparison, even if not an automatic one.

The first difference that jumps out upon a first glance at the actual flight schedules of each program would be the obvious difference in the number of launches that it took to achieve each country’s first successful manned orbital flight. The US took a total of 23 launches, while China took a total of 5 launches, almost a fifth that of the Mercury launches.

Secondly, the first US launch took place on August 21, 1959 and John Glenn’s flight flew on February 20, 1962, a total of exactly 30 months to the day. The first Chinese launch took place on November 20, 1999 and Yang Liwei’s flight flew on October 15, 2003, a total of approximately 47 months. This means that Project Mercury was averaging about 0.77 launches a month, while the Shenzhou Program was averaging about 0.11 launches a month over the duration of their respective actual flight schedules.

Thirdly, in terms of total program duration, Project Mercury took 3 years and 4 months from the date of its official approval on October 7, 1958 to achieve manned orbital flight, while the Shenzhou Program took a total duration of approximately 11 years from the date of its official approval on September 21, 1992 to achieve the same feat.

Fourthly, clear and meaningful technological milestones can be deduced from Project Mercury’s flight schedule, such as testing the LES under maximum aerodynamic conditions, followed by testing production standard Mercury Spacecraft, before proceeding on to testing combinations of these subsystems to determine overall performance, before embarking on final rehearsals with primates, and eventually ending with the actual suborbital/orbital flights. During this flight-testing process, mistakes or deficiencies were discovered during failed or problematic launches, subsequently corrected, and re-tested to ensure that they had been fixed or satisfactorily improved on. Out of 23 Mercury flights, there were a total of 13 successes and 10 failures or partial failures, and the flight schedule only proceeded on to the next milestone when the previous milestone had been satisfactorily cleared or was deemed to have been cleared via a successful launch. However, a study of the objectives of the various launches on the Shenzhou Program flight schedule does not seem to reveal any clear pattern of problem discovery or learning. Each launch differed from the previous one by gradually adding on functions/components, with Shenzhou 2 allowing for a transition from a functionally limited spacecraft to a fully functional spacecraft, Shenzhou 3 equipping the spacecraft with a LES, and Shenzhou 4 serving as the last rehearsal before the actual flight. Out of the 5 Shenzhou flights, every single one succeeded and no failures were reported.

The following subsections 5.2.2-5.2.3 examine the questions that the observations above raise with regards to the Shenzhou Program’s scope and schedule.

5.2.2 Questions Raised regarding Program Schedule

The observations above raise a couple of questions regarding the Shenzhou Program's schedule. Firstly, the technological readiness levels of the US and China with regards to manned spaceflight technology were probably approximately in the same neighborhood at the start of the program. Both nations already possessed tried and tested launch vehicles – Redstone and Atlas for the US and the Long March rocket series for China. Both nations had to modify these launch vehicles for the accommodation of manned spacecraft and automatic escape systems. Both nations before the start of the program had prototypes of the spacecraft that was intended for use, but this spacecraft, in particular its internal equipment and electronics, had to subsequently be developed and constructed for manned spaceflight. Maxime Faget, the chief designer of the Mercury Spacecraft, had originally begun designs for a ballistic re-entry capsule known as the Type A capsule in the early 1950s, which evolved to the Type C capsule in October 1958, before calls were made for bids from commercial aerospace companies to develop and construct such a capsule. McDonnell, who won the prime contract on 12 January 1959, had to develop and incorporate internal subsystems such as the Environmental Control System and instrumentation and displays, as well as other components such as the LES and heat shields, eventually delivering the first production standard Mercury Spacecraft to the Manned Spacecraft Center (now the Lyndon B. Johnson Space Center) on January 25, 1960. (Catchpole, 2001)

China managed to leapfrog over much of Faget's work before 1958 by purchasing a shell of a Soyuz capsule from the Russians, but still had to contend on their own with much of the development and testing of spacecraft subsystems that McDonnell had to carry out, in part due to their unwillingness to pay for such Russian technology (Harvey, 2013). For example, the Chinese had to rely on Russian TsNIIMASH facilities to test the performance of the heat shields around the Shenzhou spacecraft (Encyclopedia Astronautica). China also had to develop and test LES technology; these tests failed in April and August 1995, and when they eventually succeeded in April 1997, the LES was too heavy and only after its weight was reduced was a production standard LES successfully tested on 18 October 1998 (Harvey, 2013). In fact, when Russian experts visited the Chinese in September 1996, they were surprised to find that the Chinese had already completed the development of the spacecraft electronics on their own, remarking "原来你们东西都做出来了…我们原来还想要帮你们做设计方案，你们已经做到了这一步，看来用不着我们帮忙了" (So you have already finished all these things…we originally thought of helping you with the designs [of these components], but since you have already got this far, it seems you won't be needing our help) (唐国东, 2012).

Therefore, as mentioned previously, it is not clear that either nation had a significant technological advantage over the other for their manned spaceflight program. That being the case, why did the US only take 3 years and 4 months from the approval of Project Mercury to achieve manned orbital spaceflight while China took 11 years? Even if one were to account for the time needed to procure Russian space technology, this still results in an 8-year period between China's obtaining of Russian technology and the flight of Shenzhou 5. Why then, did the Chinese take significantly longer than the US to achieve the same goal of manned orbital spaceflight, especially with over three decades of historical precedent to tap on and arguably more advanced techniques available by then? (Ironically, the popular myth that Russian technological assistance to the Chinese essentially helped them to overcome all their technological obstacles further exacerbates this discrepancy. If Russian technological assistance to the Chinese was indeed as extensive and instrumental to the Shenzhou Program as claimed by some scholars, why did the Chinese still take so long to achieve their goals in spite of it?)

Secondly, why did the Chinese take a total of 47 months to complete a mere 5 launches, when the US only took 30 months to complete almost 5 times as many launches? It seems that the Chinese launches were inordinately slow, and apparently for no clear reason purely from an observation of the launch schedule. For example, the key difference between Shenzhou 3 and Shenzhou 2 was that Shenzhou 3 was equipped with LES technology that had already been successful ground-tested in

1998 (Handberg & Li, 2007), redundancies for the control systems as well as other scientific experiments (邸乃庸, 2011), yet it only took place 14 months after Shenzhou 2, a time lag that would have been unthinkable for Project Mercury; it is hard to imagine that such a long period of time would be needed to equip the same rocket that flew successfully in Shenzhou 2 with an LES and redundant components. As a further illustration, the Shenzhou 5 launch used a launch vehicle and spacecraft identical to that of Shenzhou 4, which flew successfully as the last dress rehearsal for the manned space mission, but it only took place 8 months after Shenzhou 4 (Yuan, 2002). Given that Alan Shephard's flight was scheduled slightly more than a month after his flight's final dress rehearsal (MR-BD), and that John Glenn's flight was scheduled a mere 20 days after his flight's final dress rehearsal (MA-5), 8 months does seem like an exceedingly long amount of time to prepare for a second launch involving virtually identical equipment, even if for an actually manned version. Any explanation for this would therefore not be due to deficiencies in technological readiness, for it is clear that China's trajectory of manned spaceflight technological development by the time the first two Shenzhou launches were achieved would not have precluded an earlier launch of Shenzhou 5.

What other plausible reason could there be for such a slow flight schedule? Perhaps the approximate 1-year interval between launches might hint at some seasonal factors that were at play. Indeed, the Chinese might have favored launches during the winter because "seas were at their calmest in the southern seas where the tracking ships were located" (Harvey, 2013). However, this does not seem sufficiently explanatory, not only because the conditions for tracking ships is only one out of many concerns for a test launch (many of which are arguably more important), but also because this does not preclude the logical choice of having more than one launch during a winter season that lasts from October to March.

Might the Shenzhou program have been facing financial difficulties that caused it to have to experience delays while the necessary funding was being secured? This is also unlikely, as both the Mercury and Shenzhou programs, once they obtained official approval from their respective governments, were sufficiently well funded until they achieved their intended goals, even if other areas of governance were equally, if not more, wanting for money. This was in part due to the original motivations that drove both countries to embark on their programs remaining valid throughout their duration, in part due to the recognition and acceptance by top leadership that a manned spaceflight program would not succeed if adequate funds were not disbursed, and in part due to the lack of motivation to withhold funding, especially towards the later stages of the programs, when so much had already been sunk into them. Keith Glennan, then administrator of NASA, was said to have stated that "Congress always wanted to give us [NASA] more money…Only a blundering fool could go up to the Hill and come back with a result detrimental to the agency"; indeed the NSC-5918 policy paper "recommended a 60 percent increase in the NASA budget for FY 1961", with the BoB adding onto that sum another $108 million for Project Mercury and congressional committees further adding on another $50 million for Project Mercury together with other NASA projects. (McDougall, 1997)

What about China, which one might suspect would have been in a less financially secure position at the beginning of 1990? During the previously mentioned meeting on March 15, 1991 between Li Peng (then Premier of China), Ren Xinmin and Qian Zhenye, Li Peng asked Ren and Qian to give him an estimate of how much it would cost to achieve manned spaceflight capability. Qian timidly gave an estimate of 3 billion RMB, which Li Peng agreed to immediately and responded "钱的问题，国家目前的确是有苦难的，但对我们这样一个大国来说，几十个亿还是可以解决的嘛…不过，在经费预算上，你们也不要抠得太紧了！要给自己留点余地….不可预见的钱，也是必要的，可以理解的" (Regarding our finances, it is true that the country is facing its difficulties, but for a big country such as ours, coming up with a few billion [RMB] is certainly doable…but [as a word of caution] for your budget, don't cut it too close! Give yourself a bit of room…unforeseen expenditures are also necessary, and are also understandable). Indeed Liu Huaqing, then vice chairman of the Central Military Commission and advisor to the Central Committee of the Communist Party of China, stated in a letter to Li Peng, Jiang Zemin and Yang Shaokun (then President of China) that "我国的载人航天技术，建议中央下决心干起来，不要再拖延。经济是个大问题，但二十多年的时间，每

年分担出，也是可行的。当前财政实在困难，动用国库存的金子，每年出点也得干” ([Regarding] our country’s manned spaceflight technology, I advise that Party Central get serious about it without any further delay. Financing it is a big issue, but coming up with the funds over twenty plus years is possible. At the moment, our financial situation is certainly tight, but [we can] tap on our country’s reserves, we have to do this even if we have to draw on it every year.) (李鸣生, 2009) According to Kulacki and Lewis, Liu’s “expression of support at this critical moment, while dismissing the fiscal constraints, surely had a significant effect on the CCP leadership’s final decision” (Kulacki & Lewis, 2009). This continuous willingness to guarantee that the success of the Shenzhou Program would not be compromised by a lack of funds was demonstrated again in 1998, when then Premier Zhu Rongji arrived at Beijing Aerospace City, and upon spotting a defect in a piece of equipment, stated that “我们航天科技人员一定要严上加严，细上加细，慎之又慎，不要担心经费问题” (Our aerospace engineers have to be extremely cautious and meticulous [with their work], budgetary problems should not be a concern of yours) (邓宁丰, 2004).

Ultimately, even if it cannot be said that they were flush with cash, neither Project Mercury nor the Shenzhou Program found itself wanting of the necessary financial resources; financial difficulties then would not have been an explanatory factor for the Shenzhou Program’s slow pace. Therefore, taken together with the previous question, it seems that the Chinese were consciously carrying out the entire Shenzhou Program at a much slower pace, and not just for reasons related to technological readiness. If one were to propose that the much longer time to achieve manned spaceflight for the Chinese was simply due to a longer time needed to reach the required technological readiness levels, this would still fail to explain the overall longer than expected time for the actual flight schedule itself.

5.2.3 Questions Raised regarding Program Scope

A close observation of the scope of the Shenzhou program raises the key question of why the nature of the actual flight schedules of both programs differed so significantly. The Shenzhou flight schedule was “unusual” in the sense that i) it had only about a fifth of the Mercury’s number of flights, ii) achieved a 100% success rate of launch compared with Mercury’s 57% success rate, and iii) had an actual flight schedule that hardly resembled what one would expect of a manned spaceflight effort, which would logically be expected to reveal overlooked problems or deficiencies in design during test flights, some of which would be problematic and some of which would be successful, leading up to successfully validated penultimate flights followed by a final successful flight. The Shenzhou Program flight schedule seems to paint too perfect a picture; there was clearly an iterative process of testing, failing, learning and succeeding going on throughout the Project Mercury flight schedule, but the Shenzhou Program seemed to merely be a very smooth process of confirming what the program engineers already knew – that the relevant spacecraft and launch vehicle components would indeed work. This is not to say that the Shenzhou flights were just for show or did not yield any useful information; indeed they involved rigorous tests, validation of equipment, and critical capability building required for the eventual Shenzhou 5 launch. Rather, it is the fact that everything was achieved so steadily, smoothly and perfectly to the point that it gives one the impression of a routine flight schedule rather than a country’s first attempt at manned spaceflight that is of particular interest.

Might this have been due to the Chinese government covering up certain failed launches? After all, in 2001, the official announcement regarding Shenzhou 2 was that the capsule had landed smoothly back on Earth and the mission had been entirely successful, but no photographs of the landing were published, nor was the capsule publicly displayed in celebration as it was for Shenzhou 1. Amidst rumors and speculations amongst foreign space watchers, China eventually “stopped denying that there had been a hard landing, resulting from a broken parachute connection. It also emerged later that the spacecraft had briefly tumbled out of control during the separation of the orbital module” (Harvey, 2013). What constitutes a successful launch is of course highly subjective; the common trend for both Project Mercury and the Shenzhou Program was to impose a value judgment as to how bad a problem had to be to be considered to have made the launch a “failure”. Problems that did not result in catastrophic failure, prevent the achievement of intended learning objectives, or affect the overall launch too adversely, were often overlooked in favor of claiming that a launch was successful. In reality, if the criterion for a successful launch were the complete absence of any problems or unexpected consequences, far fewer launches than now (if any) would be considered successful for both countries.

Might there then possibly have been failed launches in China that were purposefully covered up, which would easily explain why all Shenzhou launches were considered successful? Ultimately, it is quite unlikely that this was the case for two reasons. Firstly, it is one thing to cover up problems during the launch process, but quite another to cover up an entire launch, and a failed one at that; this was especially so in the beginning of the 21st century with the availability of communication technology. It is probable that a failed launch, especially if it were a serious one, would have at least led to rumors leaking out from the launch site. Secondly, even if a failed launch were entirely covered up, foreign space watchers would have actually known how to tell when China was preparing for their launches by observing the location of its tracking ships, which would be deployed to particular locations in the Pacific, Southern, Atlantic and Indian oceans for a tracking network before an impending launch. This technique was also used during the Soviet era to track Soviet space missions. (Harvey, 2013) Therefore, any launch, failed or not, would not have escaped the eyes of these foreign space watchers, who would surely have raised the alarm if an apparent launch did not eventually translate into official announcements; indeed it was these space watchers that called the Chinese out on their suspected difficulties with Shenzhou 2's landing. Thus if Shenzhou's officially announced flight schedule is accepted to be what indeed truly transpired, the question above would still continue to hold.

In summary, the questions that the differences in program management of Mercury and Shenzhou raise pertain either to its

1) Program schedule, more specifically i) Why did the Shenzhou Program take significantly longer than Project Mercury when the starting conditions for both nations suggest that there should have been, at least, a smaller difference in program duration? And ii) Why did the Shenzhou Program take significantly longer than Project Mercury to accomplish far fewer launches in its actual flight schedule when evidence suggests that this need not have been the case?
2) Program scope, more specifically why the Shenzhou flight schedule involved i) significantly fewer launches, ii) a significantly higher (indeed perfect) success rate, and iii) a flight schedule that differed so much from Project Mercury's, to the point of looking like a routine flight operation than an experimental attempt at manned spaceflight?

Perhaps the contradiction between these two groups of questions that pertain to program schedule and scope may be apparent at this point – on one hand, Shenzhou's program schedule seems to paint a picture of a program beset by slow progress, difficulties, and delays, while on the other hand, Shenzhou's program scope seems to paint a picture of a overwhelmingly successful launch schedule that hints that the Chinese had a far easier time achieving manned spaceflight than Project Mercury.

5.2.4 Actual vs. Planned Flight Schedules

Some might point out that a distinction has to be made between actual flight schedules and planned flight schedules. Might it not be possible that the Shenzhou Program was indeed planned in such a way that the significant differences mentioned above were originally of a lesser extent or non-existent, and that it was perhaps a curious combination of detrimental events and fortunate circumstances out of China's control that simultaneously delayed the Shenzhou Program and allowed it to get by with far fewer, overwhelming successful flights? Putting aside the unlikeliness of such an assertion, a look at not just the actual flight schedules of Mercury and Shenzhou but also at the planned flight schedules when the programs first began reveals some interesting insights.

In early 1959, not long after Project Mercury was official approved, a planned flight schedule was drawn up that showed that the first manned orbital launch was planned for April 1960, about 18 months after the start of the program, and this would be preceded by 18 other launches, with the first of these launches occurring in July 1959, about 9 months after the start of the program. In Mercury's actual flight schedule, this eventually translated into 22 launches and 40 months before John Glenn's successful flight, with the first launch occurring about 10 months after the start of the program. (Catchpole, 2001)

In August 1992, China's planned flight schedule was drawn up, with the first manned orbital launch planned to be accomplished by the end of 2002, about 10 years and 3 months after the start of the program. This would be preceded by 2 other unmanned launches, with the first of these launches occurring latest by the end of 1999, about 7 years and 3 months after the start of the program. In Shenzhou's actual flight schedule, this eventually translated into 4 launches, and 11 years and 1 month before Yang Liwei's successful flight, with the first launch occurring 7 years and 2 months after the start of the program. (Harvey, 2013)

The above information is summarized in Table 13 below.

Table 13: Differences in Program Schedule between Project Mercury and the Shenzhou Program (Catchpole, 2001) (Harvey, 2013)

Program		Project Mercury	Shenzhou Program
Official Start Date		7 October, 1958	September 21, 1992
First Test Launch	Planned Date	July 1959	End of 1999
	Planned Duration from Start Date	9 months	7 years and 3 months
	Actual Date	August 21, 1959	November 20, 1999
	Actual Duration from Start Date	10 months	7 years and 2 months
	Duration of Delay	**1 month**	**(1 month earlier)**
First Successful Orbital Flight	Planned No. of Preceding Flights	18	2
	Actual No. of Preceding Flights	22	4
	No. of Additional Preceding Flights	4	2
	Planned Date	April 1960	End of 2002
	Planned Duration from Start Date	18 months	10 years and 3 months
	Actual Date	February 20, 1962	October 15, 2003
	Actual Duration from Start Date	40 months	11 years and 1 month
	Duration of Delay	**22 months**	**10 months**

As can be seen, both nations managed to carry out their first test launch pretty much on schedule, but while Mercury eventually had to add on 4 more launches and experienced a 22 month delay before achieving its first manned orbital flight, China only had to add on 2 more launches and only experienced a 10 month delay before achieving its first manned orbital flight. This means that while both countries eventually failed to meet the deadlines that they had set for themselves for their first manned spaceflight, the original Mercury planned flight schedule was actually far more ambitious than the Shenzhou Program's planned flight schedule when compared to their respective actual flight schedules. Essentially, the planned flight schedules for both programs further exacerbates the differences between Mercury and Shenzhou in terms of program schedule, with the gaps in terms of overall program duration, time taken to achieve a first successful orbital flight, and number of launches needed to achieve a first successful orbital flight growing even larger for the planned flight schedules compared to the actual flight schedules.

5.2.5 The Effect of the Space Race

A popular explanation that some might propose, at least for questions related to program schedule, would be that the US was in a space race against the former Soviet Union, while China, beginning its manned spaceflight program in the 1990s, was in truth racing against no one but its own ambitions. In their view, it is thus obvious that the US would devote its resources and structure its program in such a way that it would accomplish as many launches as it needed in the shortest possible time in order to beat the Russians to space milestones, and that even if some of these launches were failures, it wouldn't matter as long as they "got there first". The Chinese on the other hand were seen by others as being too far behind the US and Russia in space to actually be racing anyone, and could thus proceed with their own program at whatever pace suited them. This would explain the significantly longer amount of time they took to achieve their first manned spaceflight; as Handberg puts it, "unlike the early space race from 1958 to 1969, there existed no external competitive pressures. China had to get it right rather than fast and right, unlike the Soviets and the Americans." (Handberg & Li, 2007)

However, such a view, while not invalid or untrue, is only part of the picture, and adopting such a view to explain the differences in Project Mercury and the Shenzhou Program is flawed, at least partially, for two main reasons. Firstly, the argument that "China had to get it right rather than fast and right" is in and of itself not a sufficient explanation for the long duration of the Shenzhou Program and the slow pace of launches; in other words, just because "getting it right" was more important to China than "being fast" does not mean that China couldn't have chosen to "be fast" or had no reason to "be fast". Such an argument might be sufficient if "being fast" had absolutely no advantages for China, in which case it would be logical to argue that it would have been in China's clear interest to go slow. However, "being fast" certainly had advantages for China – it would allow it to achieve its goal of national prestige as soon as possible, it would allow it to reduce the overall costs of maintaining a standing workforce and infrastructure for each milestone (i.e. the longer it takes China to achieve manned spaceflight, the more costly the overall program gets, and unnecessary delays would be quite unacceptable no matter how important the program), and it would allow it to more quickly reap the often touted technological benefits of mastering such manned spaceflight technology. Of course, this is not to say that "being fast" did not have its disadvantages as well, most notably the detrimental effects of schedule pressure on a complex systems engineering program, but just because China didn't have to "be fast" does not automatically lead to the foregone conclusion that China had to choose not to be.

The second reason for such a view being at least partially flawed is that the belief that China was under no time pressure because it wasn't racing the US or Russia in space is not completely accurate. Indeed the goals that were set right at the beginning of the Shenzhou Program were not so much driven by technological realities as they were by political ones. Throughout the Shenzhou Program, important dates in China were often used as deadlines for milestones, in part for their significance, and also in part to allow for these milestone accomplishments to be broadcast during those important dates, thereby utilizing them for their fullest propaganda value. Indeed, during Li Peng's meeting with Ren Xinmin and Qian Zhenye in 1991, Li Peng, in response to Qian's estimate that 3 billion RMB be required for a manned spaceflight program, asked "要是这样的话，九六年上天行不行？" (If that's the case [and you get your money], is going up [for the first test launch] in 1996 possible?) Qian and Ren at this point remained silent, most probably stunned by the implication that this would give them 5 years to build up a manned spaceflight program from literally nothing. In the face of their silence, Li then responded with "九七年呢？九七年上天行不行？" (How about 1997? Is going up in 1997 possible?), to which Qian reluctantly agreed. Li then ended with a proclamation that "九七年发射，争取建国五十周年载人飞船上天" ([We] launch in 1997, and strive to achieve manned spaceflight for the 50th anniversary of the founding of the People's Republic of China [in 1999]). (李鸣生, 2009)

Perhaps to the relief of the Chinese aerospace engineers, Li's desire to achieve manned spaceflight by 1999 did not eventually translate into an actual goal for the Shenzhou Program. The planned flight schedule for the Shenzhou Program essentially stipulated that the first Shenzhou test launch be characterized by the goal of "争八保九" or "Strive for 8, Guarantee 9", requiring that the first test launch be carried out by 1998 if possible, but failing which by 1999 at the latest. This was not entirely due to technological considerations and practical realities; indeed such a goal was established to allow the first Shenzhou launch to be achieved in time for the 50th anniversary of the PRC's founding on October 1, 1999 (邸乃庸, 2011). Manned spaceflight was given a deadline of the end of 2002, and this was planned to allow for the manned launch to take place in time for the 16th National Congress[17] of the Communist Party of China, which was held on November 8-14, 2002. This essentially meant that a great deal of political pressure was being piled on the engineers of the Shenzhou Program to meet these critical and politically-loaded milestones, and failure to do so would not have just technological but also political implications.

In fact, in December 1997, it was discovered that the entire Shenzhou program was actually experiencing a delay in schedule of approximately a whole year, which effectively ruled out the possibility of a first test launch by 1998. Left with only the “Guarantee 9” portion of the first launch goal, Shen Rongjun, the deputy general director of the Shenzhou program made a personal trip to Shanghai to extract a commitment from the Shanghai Academy of Spaceflight Technology regarding the completion of the Shenzhou spacecraft. Upon arriving, Shen essentially reiterated the goal of achieving a first test launch by the end of 1999 at the latest, when at that time, the engineers present knew that the program would take until 2001 to deliver a production standard spacecraft if it were to proceed as planned. (邓宁丰, 2004) Eventually Shi Jinmiao, the deputy chief designer of spacecraft systems stepped up and said “我们用最大的努力来支持这样的大决策…我们觉得拼搏一下还是可以的” (We will use our greatest effort to support this [Shenzhou] plan…if we go all out it should be possible.) Shen then departed from Shanghai, satisfied with this promise that he had obtained from SAST. One can only imagine the immense stress that the engineers felt with regards to meeting this deadline from their superior. (唐国东, 2012) The Shenzhou engineers were thus under a great deal of time pressure leading up to the deadline of 2002 for the first manned launch, and even though China was technically not racing anyone, the politically-loaded deadlines that had been set right from the start of the program meant that they might as well have been.

Interestingly, it has been pointed out that upon observation of the Project Mercury actual and planned flight schedules in Figure 5 below, the extent of schedule slippage (reflected by the horizontal distance between the solid and dashed lines) actually started widening in May 1961, increasing from approximately a year to 22 months by the time the first manned orbital flight was achieved, with the corresponding rate of achieved schedule (reflected by the gradient of the solid line) decreasing over time. In his paper, Wood suggests that while this could have been due to the increasing complexity of launches, it is hard to not suspect that Gagarin’s flight which took place on April 12, 1961, might have had a role in “removing some of the urgency from the Mercury Project”, causing the rate of achievement to decrease significantly from what was initially planned. (Wood, 1965)

[17] The National Congress of the Communist Party of China is held once every five years, and is the “Party's legislature and supreme leading authority”, where important leadership changes are made and the Party’s Central Committee is elected. (China.org.cn) Hu Jintao was elected general secretary of the CPC Central Committee at the 16th CPC National Congress in 2002. (China Daily, 2007)

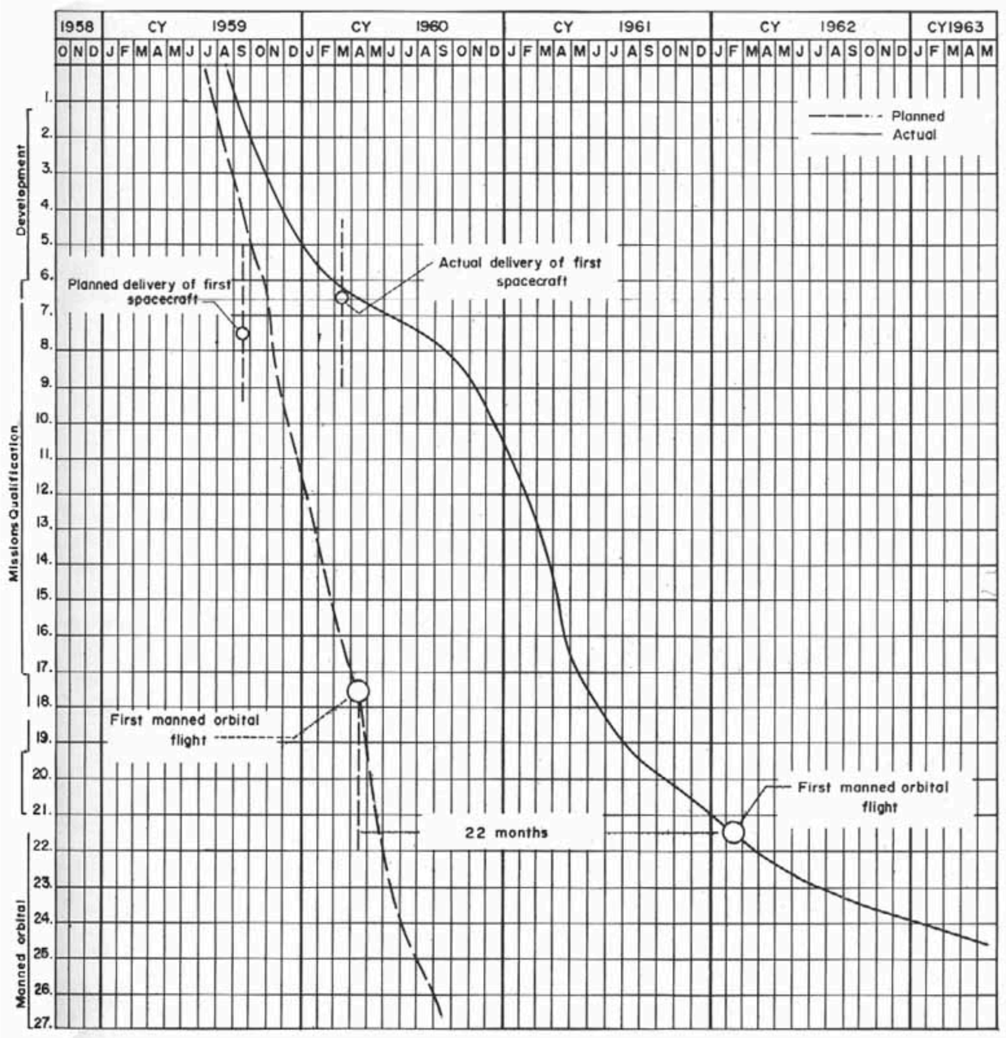

Figure 5: Project Mercury Planned and Actual Flight Schedules (NASA, 1963)

Ultimately, the argument that the reason the Shenzhou Program's schedule was significantly longer than that of Mercury's was primarily due to the absence of a Space Race for China and the presence of one for the US is not entirely valid. This does not mean that this argument is irrelevant; rather, as will be shown subsequently, the primary effect of the absence of a Space Race for China wasn't that it made a much longer program schedule with a slower pace the logical choice, but rather that it made it relatively more acceptable, since China's own ambitions, no matter how lofty or politically anchored, could always eventually be adjusted, unlike the actions of other nations. Comparatively, the US had less of the luxury that China had with regards to delaying its flight schedule, since Kennedy's speech on May 25, 1961 which set the wheels of the Apollo program in motion gave Mercury another reason to achieve its goals as soon as possible (McDougall, 1997).

5.3 The Issue of Face

This section thus aims to provide an explanation for the questions that the differences in program management of Mercury and Shenzhou raise. To reiterate, these are regarding:

1) Program schedule, more specifically i) Why did the Shenzhou Program take significantly longer than Project Mercury when the starting conditions for both nations suggest that there should have been, at least, a smaller difference in program duration? And ii) Why did the Shenzhou Program take significantly longer than Project Mercury to accomplish far fewer launches in its actual flight schedule when evidence suggests that this need not have been the case?
2) Program scope, more specifically why the Shenzhou flight schedule involved i) significantly fewer launches, ii) a significantly higher (indeed perfect) success rate, and iii) a flight schedule that differed so much from Project Mercury's, to the point of looking like a routine flight operation than an experimental attempt at manned spaceflight?

Ultimately, all of these questions can be answered with reference to one particular aspect along the individualism/collectivism dimension – the extent to which cultures along this dimension view the importance of "face". At the risk of sounding like an oversimplification, these differences all arose because the Chinese didn't want to lose face in front of other nations and (to a lesser extent) in front of their domestic constituents. On the other hand, the concept of "face" was less salient for the people involved with Project Mercury.

While this may seem to be an overly simplistic explanation, this concept of "face" as an underlying cultural motivation did eventually gave rise to key guiding principles, some written and some unwritten, that determined how the Shenzhou Program actually turned out. The subsequent subsections will show that this desire to avoid losing face primarily manifested itself as a determined avoidance of any sort of failed launch at all costs, which in turn was translated into an extremely risk averse mindset throughout the Shenzhou Program. This risk averseness eventually resulted in two defining features of the Shenzhou Program – firstly, the designing of a flight-test schedule with test launches that were not only limited in number but which also only involved validation of systems that the Chinese had already thoroughly tested on the ground and which they were highly confident in. And secondly, an almost neurotic level of quality control at all levels of the program to minimize as far as humanly possible any risk of failure during launch.

5.3.1 The Concept of Face

Although mentioned previously in the analysis of the different motivations of China and the US in embarking on their respective manned spaceflight programs, it is probably apt to further expound this concept due to its central importance in explaining the above aspects of the Shenzhou Program.

Face is a concept that is characteristic of collectivist cultures like China, and the concept of "losing face" is an expression that "penetrated into the English language from the Chinese; English had no equivalent for it" (Hofstede G. H., 2001). According to Ho, "Basic differences are found between the processes involved in gaining versus losing face. While it is not a necessity for one to strive to gain face, losing face is a serious matter which will, in varying degrees, affect one's ability to function effectively in society. Face is lost when the individual, either through his action or that of people closely related to him, fails to meet essential requirements placed upon him by virtue of the social position he occupies. In contrast to the ideology of individualism, the question of face frequently arises beyond the realm of individual responsibility" (Ho, 1976).

Hofstede claims that "the importance of face is the consequence of living in a society that is very conscious of social contexts" (Hofstede G. H., 2001). In contrast, Ho states that "the Western mentality, deeply ingrained with the values of individualism, is not one which is favorably disposed to the idea of face. For face is never a purely individual thing. It does not make sense to speak of the face of an individual as something lodged within his person; it is meaningful only when his face is considered in relation to that of others in the social network." Ho is careful to clarify that he does not mean that "the expectations of others toward oneself are excluded from consideration in the ideology of individualism", but rather that "others' expectations are existent insofar as they have been incorporated into the individual's own subjective frame of reference, that is, into his own definition of their significance for his own action. The individual, and not the reciprocity between individuals, remains the focal point of concern". (Ho, 1976) What can be taken away from this is that for a collectivist culture like China, face would have been a very important thing indeed, while for a more individualist culture like the US, the idea of face would not be as important or salient.

What would constitute a loss of face in the context of manned spaceflight? Answering this would require a definition of those "essential requirements placed upon him [one] by virtue of the social position he occupies" (Ho, 1976). From the Chinese standpoint, this would refer to the perceived essential expectations that other countries would expect of it, a large country determined to prove its rise and its rightful position amongst the other major space powers. These perceived essential expectations would thus primarily be a demonstration of manned spaceflight capability without embarrassing launch failures, most particularly the loss of human life.

An important thing to note is that face is not equivalent to prestige; it is possible to lose face even if prestige is not lost, and it is also possible to avoid losing face even if one is robbed of prestige. This nuance is evidenced by the attitudes of the Chinese towards the prospect of a failed launch.

5.3.2 The Consequences of Launch Failure

The differences between the US and China along the individualism/collectivism dimension with regards to the concept of face resulted in differences in how the two nations viewed the consequences of a failed launch. In his book examining the cultures at NASA, McCurdy states that "Some level of failure was normal given the missions that NASA was expected to perform, especially during the early stages of a program. As part of their culture, NASA employees came to believe that risk and failure were normal" and that one NASA official stated that "We knew that we were going to have a lot of failures. I used to refer to our attempts to launch as random successes. That was okay at the time, because we were forging such brand new ground…. People expected people to make mistakes and we didn't have enough knowledge about what we were doing to avoid taking risks." (McCurdy, 1993) Putting aside the practical value of such failed launches and solely considering the attitude towards failed launches, why was the US able to adopt such a positive attitude towards such failed launches at that time, to the extent of normalizing such failures and treating them as the order of the day? This was essentially because very few, if any, cared about how these failed launches might be viewed in the eyes of others. The Project Mercury engineers were not afraid of "losing face" in the eyes of anyone, especially not in the eyes of other nations whose views or impressions were in all honesty probably not relevant at all to Mercury.

On the other hand, any failed launch, even if it were an unmanned one, would have had disastrous consequences in terms of a huge loss of face for the Chinese – the Western media would almost certainly give such an incident wide coverage for a variety of reasons, many of them political, and such an incident would also be viewed negatively in the eyes of the Chinese public. The very image of the Shenzhou Program would be tarnished and the central goal of proving that China deserved a seat at the table with the two other nations who had achieved manned spaceflight would be jeopardized to quite an extent. It should be noted that how these external parties would truly view a failed Shenzhou launch is less important than the Chinese *perception* of how these external parties would view a failed Shenzhou launch, for it is these perceptions that drove the desire to avoid such a loss of face and therefore avoid any failed launches at all costs. It is for these reasons that China was so determined to avoid a failed launch, even if the failure of an unmanned launch in reality would not have actually impacted its eventual ability to achieve its goal of manned spaceflight (and might have even allowed it to do so faster by directly revealing serious problems in need of rectification).

Were the Chinese merely being paranoid? Was this all just in their heads? How do we know for sure that loss of face was so important to them? An unfortunate incident that occurred in 1992 is a clear demonstration of why the Chinese were so afraid of losing face and the effect that this had on the Shenzhou Program. In 1988, the very attractive launch prices offered by the Chinese prompted the Hughes Aircraft Company to sign a contract with the China Great Wall Industry Corporation[18] to launch two Aussat satellites using Chinese Long March-2E rockets, with the first launch scheduled for March 22, 1992. This launch was particularly important for the Chinese for two reasons – it was the very first commercial launch that China was offering to the international market and would greatly influence their future ability to capture such a market, and secondly, this launch would have an influence on the fate of the proposed Chinese manned spaceflight program that was being debated at that time. As a result, this launch was given a great deal of attention by both domestic and international media, with the Chinese media even providing domestic and international live coverage of the launch, which was viewed by all the top leaders including Jiang Zemin and Li Peng. The Chinese leaders even invited the ambassadors from the US and Australia to watch the launch, and firecrackers, songs and congratulatory messages were all prepared beforehand for when the successful launch was completed. (邓宁丰, 2004)

Unfortunately, after the tense countdown, the LM-2E rocket failed to lift off after seven seconds and eventually settled down on the launch pad in a cloud of billowing smoke, prompting an emergency abort. Within a few minutes, various media outlets including AFP, the Associated Press and United Press International had rushed out media coverage on the abort of the Chinese Aussat launch, prompting a worldwide discussion about it. One Chinese guest present at the launch issued a sharp critique – "你们做过广泛的宣传，说火箭如何如何精良，如何如何可靠，把中国推到全世界面前，可结果呢？事与愿违，没有像发射“亚星”那样为国争光，而是给中国人丢了脸！" (You generated so much publicity about this rocket, saying how sophisticated it was, how reliable it was, and pushed China onto the international stage, and what happened? Instead of winning honor for our country like the Asiasat launch, the launch was a loss of face for all Chinese people!) Perhaps even more depressing was the fear that this failed launch might cause the inchoate Shenzhou Program to turn into another Shuguang. Nine days after the incident, Jiang and Li issued separate statements that exhorted the engineers to solve the problem and get ready for the next successful launch. The problem was found to be due to a stray sliver of aluminum which had fallen off when a screw had been tightened. The result of this "3.22" incident, as it was known after the event, was to cause the Chinese Aerospace sphere to adopt a "失败不起，没有退路，只能成功" (We cannot afford to lose, there is no way back, we can only afford to succeed) attitude. And in what can be considered a more uplifting ending to this debacle, the next launch of the Aussat satellite on August 14 succeeded and paved the way for the approval of the Shenzhou program on September 21. (邓宁丰, 2004) The 3.22 incident, although technically not directly related to the Shenzhou Program, left a huge mark on it, and is arguably the first incident that instilled in the Chinese the real fear of a huge loss of face in the event of a failed Shenzhou launch, for they realized that it wasn't just the engineers at the launch site who were watching their every move, but the entire world.

In a reflection of how determined the Chinese were to avoid a launch failure, a ceremony was held on January 16, 2003, about eight months before the scheduled launch of Shenzhou 5, the first manned launch of the program. During this ceremony, the vice chairman of the China Aerospace Science and Technology Corporation (CASC) represented the Party group of the CASC to present gold-colored plaques to the top leaders of the various organizations involved in the Shenzhou effort, each stating (for example in the case of Yuan Jiajun) "中国空间技术研究院院长袁家军，务必确保神舟 5 号飞船飞行圆满成功，飞船安全返回，不许失败" (Yuan Jiajun, Chairman of the China Academy of

[18] The China Great Wall Industry Corporation (CGWIC) is "the sole commercial organization authorized by the Chinese government to provide satellites, commercial launch services and to carry out international space cooperation." (China Great Wall Industry Corporation)

Space Technology, has to ensure that the flight of Shenzhou 5 is successful and returns to Earth safely; failure is not an option.) Each of these leaders solemnly received their respective plaques in turn, each feeling the weight of the order that had just been given to them. The ceremony ended with Li Andong, the deputy director of the People's Liberation Army General Armaments Department stating "我刚才注意到，吴燕生、袁家军领责任令时都不笑，因为今年他们完不成责任令，那是要"提头"来见的" (I observed just now that Wu Yansheng and Yuan Jiajun weren't smiling when they received their responsibility plaques, because if they don't carry out their responsibilities successfully, their heads will be on the chopping board[19].) Not surprisingly, this statement was met with complete silence in the ceremonial hall. (邓宁丰, 2004)

The Chinese view of a launch failure – something that had to be avoided at all costs and with no compromises – thus stood in stark contrast to how the US viewed the Mercury launches, which were described as aiming to achieve manned orbital spaceflight "with a reasonable degree of reliability and safety" and to obtain the "best chance of mission success and flight safety" (NASA, 1963) The Americans took a tempered approach to launches, stating that they would do the best they possibly could but without denying the possibility of errors or failures, while the Chinese refused to accept nothing less than complete success; according to Kulacki et al., Qi Faren, the chief designer of the Shenzhou spacecraft, stated that "the most important thing lacking in the Chinese space effort was 'the freedom to fail'" (Kulacki & Lewis, 2009). This eventually impacted the levels of risk aversion that both nations had towards launch failure.

5.3.3 Attitudes towards Risk

The differences in attitude that the US and China had towards the prospect of failed launches resulted in different levels of risk aversion towards launch failure, or taken in the larger context (given that it is a entire manned spaceflight program which is being considered), different levels of risk aversion towards a flight schedule with a high risk of launch failure. The risk of launch failure in a flight schedule is typically increased either through an increase in the number of test launches, or a decrease in the extent to which the equipment/systems being tested on flight test launches were previously validated by ground tests. Taken together, a flight test schedule with a much heavier emphasis on flight testing than ground testing, both in terms of the number of test flights and the relative extent of reliance on flight testing as opposed to ground testing, would have a higher risk of launch failure.

With regards to the US, McCurdy explains that "NASA employees understood that they could not explore space without taking risks. They sought to minimize risks, but they could not eliminate them. To totally eliminate risk they had to cease exploring, an unacceptable option given their mandate". (McCurdy, 1993) It is important to note that this does not mean that NASA was completely comfortable with launch failure or was ambivalent to it; clearly NASA would choose to avoid any failed launches if it knew it could. McCurdy quotes a program leader at NASA as saying "We were well aware of the risks we were taking. On the other hand – and I emphasize this very, very carefully – we would never fly a manned vehicle if we knew something was wrong with it until we fixed it." (McCurdy, 1993) It is not the case that NASA was completely blasé towards launch failures; rather, what NASA's attitude towards risk reflects is the acknowledgement of a tradeoff – an attitude of acceptance of a higher risk of launch failure in exchange for the advantages that such a testing regime would confer.

Essentially, such a testing regime with a heavier emphasis on flight-testing and a corresponding higher risk of launch failure has two main advantages that are somewhat related. Firstly, and most importantly, a heavier reliance on flight tests would allow for the more effective discovery of flaws or deficiencies that would only have surfaced in a real flight environment. McCurdy explains that "Ground tests do not simulate the flight environment precisely", that "NASA culture viewed flight

[19] The Chinese expression used literally translates into "report back with their heads raised", in the sense of orientating one's head into a position that would facilitate the beheading process.

tests as the most important method for studying and verifying the performance of space-bound machines and experimental aircraft. Ground tests and computer simulations were important, but actual flight provided the ultimate test of how something worked" and that an assistant of von Braun explained that "In spite of the fact that the engine had already passed two tests or three tests on the ground, you still can have a material failure…In spite of the fact that you may have checked it out completely under [ground] testing, there are always things which still slip somehow and which you find out during a flight." (McCurdy, 1993) In other words, an increased amount of ground testing is not a good substitute for flight-testing, while an increased amount of flight testing would be a good, or perhaps even better substitute for ground testing. Secondly, a relatively heavier reliance on flight tests as compared to ground tests would probably allow for a much faster overall testing schedule. If one has to proceed with a testing schedule that requires one to reduce the reliance on flight tests, the amount of ground testing that has to be done to compensate for this reduced reliance on flight tests would take much longer than the flight tests themselves because of the greater extent to which the testing environment differs from the actual operational environment. A greater amount of time would need to be spent on ground testing to prove that the same components or systems would also work in space due to the obvious differences in testing environments. Conversely, an actual test launch of these same components or systems would, in one shot, reveal their existing weaknesses or deficiencies, albeit in a possibly more disastrous manner. Essentially, a heavier reliance on flight-testing would allow the main goals of testing – that of identifying and remedying design problems as well as verifying the required system capabilities – to be achieved more effectively and more efficiently.

In fact, this tradeoff was experienced by von Braun and his team during the Apollo program, when George Mueller ordered them to conduct all-up tests (which entails a flight test of all stages of the Saturn V rocket at the same time) as opposed to incremental flight tests. This had the effect of severely limiting the number of flight tests that von Braun was allowed to conduct, which meant that they had "to test on the ground what the bearers of the old technical norms previously tested in flight." As a result, this required "a most comprehensive ground test program, which prevented the revelation of hardware weaknesses in flight." The rationale for Mueller's decision was to allow American astronauts to arrive on the moon before the end of 1969; indeed if von Braun had been allowed to proceed with his incremental testing program, Kennedy's deadline for the moon landings would never have been met. (McCurdy, 1993) Although the Apollo program's overall reduced reliance on flight-testing was borne more out of urgency than an aversion towards launch failure, it demonstrates that in the event of a curtailing of actual test launches, there will most likely be a reliance on a necessarily more comprehensive and longer ground testing schedule that would also be less effective than flight test launches[20].

Of course, there exist downsides to a flight test schedule that is heavily reliant on flight-testing, of which there are two main ones. The first is that of cost – it is more expensive to conduct flight-tests due to the actual equipment and resources that have to be expended during a test flight, and the second is that of the risk of launch failure – a greater reliance on flight-testing implies that problems do get discovered, but often through a failed launch. Therefore, a space program for which these two main downsides are less important than the advantages that can be gained from a testing schedule heavily reliant on flight-testing would probably opt for it, while a space program for which these two main downsides are more important than the advantages from a flight-testing heavy schedule would probably not do so. Thus, the reason why NASA was relatively less risk averse to failed test launches

[20] A question may be raised here as to why Mueller's decision to reduce flight testing actually led to an even faster overall project schedule when it was argued in the previous paragraph that reducing flight testing in favor of ground testing would probably lead to a slower project schedule. The distinction here is that Mueller reduced flight testing by eliminating von Braun's incremental flight tests (i.e. testing of each stage of the Saturn V rocket before proceeding to testing of the next stage). Although this led to comprehensive ground tests being required due to constraints on the number of all-up launches, the simultaneous elimination of von Braun's traditional, slow-paced incremental testing method led to an overall reduction of the time that was taken to achieve the moon landings.

during Project Mercury was not only due to the fact that they did not have serious budgetary concerns, but also because they could live with failed test launches, even catastrophic ones, if only to reap the benefits of such a testing regime.

On the other hand, the Chinese would have been extremely risk averse to a testing regime that was heavily reliant on flight testing and which would thus have a higher risk of launch failure. Although they understood that the most effective and efficient way of revealing deficiencies in their equipment was to carry out flight tests, the cultural consequences of a loss of face if a launch failed were so severe for them that the advantages of carrying out a flight-test heavy testing regime were irrelevant; they were determined to avoid any sort of launch failure, even if it could have helped to reveal vital flaws. This risk aversion to launch failure ultimately caused the Shenzhou Program to differ from Project Mercury in two main ways – firstly, in terms of the nature of the Shenzhou flight-test schedule, and secondly in terms of the way quality control was managed during the program. These two differences will be explored in Sections 5.4 and 5.5.

5.4 The Nature of the Mercury and Shenzhou Flight-test Schedules

Due to the fact that the Project Mercury engineers were willing to overlook launch failures if it allowed them to identify and remedy design flaws or deficiencies, the Mercury flight schedule was designed with this in mind. The test launches, then, were not so much about achieving successful launches as they were about revealing fatal flaws if they existed. McCurdy quotes one of NASA's top engineers as saying "You flew things to try them out, not to prove that you were so smart that your design wouldn't fail to begin with…You flew things to find out if they would work, not to prove that we knew how to build them so that they wouldn't fail…[If we wanted to find out how a spacecraft would heat up upon reentry] we put some instruments on it and we would fly it and we would find out what the heating was. You made experiments to find things out. Separating a flight test from an experiment never occurred to us." According to McCurdy, "The first parachute tests on the Mercury capsule were designed to find out whether the parachute would actually slow the descent of the capsule, not to prove that the parachute worked. NASA officials conducted seventeen unmanned flight tests of the Mercury capsule to see how it would work before they let John Glenn fly one into orbit around the earth" and that "If we [NASA] had needed more, we would have flown more times." (McCurdy, 1993)

The Chinese, on the other hand, were absolutely adamant that all their test launches be successful. They probably would not have launched any test flights if they could help it, but since flight tests are ultimately required in case of design problems that are only revealed in a flight environment as well as a final means of validation, they tried to reduce the risk of launch failure as far as possible by limiting the number of test launches to only those necessary, as well as designing the test launches such that they only tested systems that they were perfectly satisfied with and had the utmost confidence in at the time of the launch. In other words, this differed greatly from NASA's philosophy of using flight tests to actually reveal flaws and test the performance of equipment. The Chinese would never have launched any piece of equipment that needed to be "tested"; rather in their minds the only thing that was supposed to occur during a test launch was "validation" – proving that their systems and equipment were indeed absolutely flight-ready after an entire process of development and improvement using ground tests.

An interesting case study that sheds light on this difference would be how both nations carried out the development and testing of the Launch Escape System (LES) for their manned spaceflight programs. A LES serves to quickly separate the manned capsule carrying the astronaut(s) from the launch vehicle in the event of a malfunction or launch failure that may threaten the lives of the astronaut, and subsequently deliver the astronaut to the ground in a safe landing. For Project Mercury, Maxime Faget first proposed a concept for an LES in July 1958, and a series of ground tests, in particular wind tunnel tests, were then run on these LES prototypes to determine their performance. (Catchpole, 2001) But apart from these ground tests, the Mercury Project Summary explains that "Sometimes the [ground] test conditions are not realistic enough or are not sufficiently demanding to reveal system weaknesses. During Mercury, for some of the subsystems, it was not until the actual unmanned flights that a system could be fully qualified for manned operation. For example, the launch escape tower was subjected to all expected environmental conditions, an exhaustive series of load tests, and the operational situations associated with the launch-escape-system performance tests. Yet in the actual qualification flight program the heating loads on the truss structure of the tower were found to be more critical than had been calculated. " (NASA, 1963) As such, ground testing of the Mercury LES was also accompanied by the various flight-test launches in Table 14 below, which can roughly be divided into Beach Aborts (testing the launch of the LES on the ground) as well as flights of the Little Joe program, which was meant to qualify the performance of the LES under actual operational conditions (particularly under maximum aerodynamic pressure) through actual launches of launch vehicles carrying the LES (Catchpole, 2001).

Table 14: Flight Test Launches of Project Mercury Launch Escape System[21] (Catchpole, 2001) (NASA, 1963)

No.	Type	Date	Outcome	Improvements
1	Beach Abort with prototype LES and boilerplate spacecraft	8 March, 1959	Partial failure – spacecraft tumbled	Graphite throat redesigned
2	Launch of 0.33 scale models of spacecraft (5 launches)	13-15 April, 1959	Some unstable, some stable	Angle of exhaust outlets on Grand Central Escape Rocket Motor adjusted.
3	Beach Abort with prototype LES and boilerplate spacecraft	14 April, 1959	Successful	-
4	Beach Abort with production LES with production spacecraft	22 July, 1959	Partial failure – spacecraft tumbled	-
5	Beach Abort with production LES with production spacecraft	28 July, 1959	Successful	-
6	Little Joe 1 (LJ-1) to test operation of Launch Escape System (LES) under maximum aerodynamic pressure	August 21, 1959	Failure	Rerouting of wire to prevent electrical failure
7	Little Joe 1A (LJ-1A) to repeat LJ-1 goals	November 4, 1959	Partial Failure	-
8	Little Joe 2 to test operation of LES with primate under high altitude, low-pressure conditions	December 4, 1959	Successful	-
9	Little Joe 1B to repeat LJ-1 goals with primate	January 21, 1960	Successful	-
10	Beach Abort with production LES with production spacecraft	May 9, 1960	Successful (though separation insufficient)	Single exhaust outlet replaced by three-point outlet
11	Little Joe 5 to test combination of production standard Mercury spacecraft and LES during max-q	November 8, 1960	Failure	Structure of the Marman Clamp was improved and wiring errors corrected
12	Little Joe 5A to repeat LJ-5 goals	March 18, 1961	Failure	Shielding installed around the clamps and limit switches modified
13	Little Joe 5B to repeat LJ-5 goals	April 28, 1961	Successful	-

China's development of the Shenzhou LES tells quite a different story. The development of an LES requires information and parameters associated with launch failure modes; this information is required to determine, say, how quickly the manned capsule has to be separated away from the launch vehicle in the event of an explosion. Although the US and the former Soviet Union had the benefit of parameters associated with launch malfunctions due to their extensive launch history (and its concomitant failures), China did not possess such information nor was it able to obtain it from these other nations. As a result, the Chinese carried out a huge amount of simulation to develop over 300 possible failure modes, and then used another four years to carry out further simulation of 11 of these failure modes that had the highest probability of occurring. In order to obtain the relevant parameters associated with launch failure (e.g. the power of explosions), they carried out a great number of experiments in a mountain valley to simulate explosions during launch. It was only after they were armed with this experimental data from simulations that they were able to develop prototypes of an LES. For testing of the flight capabilities of the LES, such as testing of the grid fins used to stabilize

[21] A second Beach Abort flight was alluded to by Catchpole after May 9, 1960, but more information on this flight was unobtainable at the time of writing; this unverified flight has been excluded from the table.

the LES in flight, the team traveled to locations such as Harbin, Inner Mongolia and Russia to carry out wind tunnel tests, especially when the necessary facilities were not available at the development locations. (邓宁丰, 2004)

Eventually, a launch-ready LES was delivered for a ground abort test that was scheduled to be carried out in October 1998. However, on October 9, during a check on the system, it was found that an indication light was malfunctioning, throwing the workers into a frenzy of diagnosis which was eventually solved after many hours of checks and two days worth of further simulations. That was not the end of it though, as the chief designer of the LES Sun Genshui, upon arrival at the launch site, felt a niggling sense of suspicion with the supporting frame of the LES motor. Eventually he realized that the frame might not be structurally strong enough and voiced his suspicions to his superiors at the very last stages of test preparation. Not surprisingly, he was berated for being overly paranoid, but an analysis carried out through the night proved his suspicions. After a few more days of overtime and sleepless nights, the Chinese produced a new supporting frame, and the pad abort test was successfully carried out on October 19, 1998. The launch was described as "试验的圆满成功，证明了逃逸系统设计的正确性" (The success of this test launch has proven that the LES was designed correctly) (邓宁丰, 2004). Eventually, it was only until the launch of Shenzhou 3 on March 25, 2002, that a production-standard LES was installed and "tested" on the Shenzhou 3 rocket; "tested" because the system was in stand-by mode during the entire flight due to all stages of the Shenzhou 3 launch proceeding without any problems. (邸乃庸, 2011)

It is clear that there were major differences between the development of the LES for the Mercury and Shenzhou Programs. The Mercury engineers knew and accepted the limitations of ground tests (in particular wind tunnel tests) of the LES, primarily the fact that the LES would only be subjected to real operational conditions if it was actually launched into space on a launch vehicle. They therefore carried out at least 12-13 flight tests of the LES, comprising a mixture of Beach Aborts and Little Joe flight-tests, that actually put the LES through its paces and allowed them to observe how it performed from the moment of ignition to the final delivery of the manned capsule back to Earth via a safe landing. During these 12-13 test launches, problems with the design were revealed through partially failed/failed launches, and improvements were made on these in a logical fashion until the engineers were satisfied that they had a system that would not only launch reliably on the ground but also in actual operating conditions in space. From the first time that Faget proposed his idea for an LES, it took the Mercury engineers 8 months to get to the first Beach Abort test launch of a prototype LES, 9 months to get to the first successful Beach Abort test launch, about a year to get to the first flight test of an LES on a Little Joe flight, about 1.5 years to achieve a first successful flight test of an LES, and about 2 years and 9 months to achieve the first successful flight test of the LES with a production standard Mercury spacecraft.

On the other hand, the Chinese spent a significantly longer amount of time on the development of their LES. In perhaps a cruelly ironic twist, they had to spend at least four years to carry out simulations of failure modes of rockets because they did not have sufficient failed launches from past experience to determine the parameters needed to develop the LES. Most significantly, throughout the development of the LES, not a single test launch was actually conducted until a production-standard LES was fully developed and used for the first ground abort test on October 19, 1998. As a result, the Chinese had to rely on a huge amount of simulations and ground testing in order to produce a launch-ready LES in time for the ground abort test; they simply were not given the mandate to carry out ground-abort tests of prototype launch escape systems that might fail catastrophically. It is thus no surprise that when the Chinese ground abort test actually came around, it was never intended to reveal design flaws in the LES, or even to "test" if it worked; rather, it was intended to prove beyond all doubt that the LES was indeed 100% functionally capable and problem free. The amount of tension and overnight work that the engineers and test managers experienced in the lead up to the ground abort test would in all honesty be more reminiscent of an actual manned spaceflight launch than a simple ground abort test; but they were compelled to do so because the nature of the ground abort test gave them no room for failure. Furthermore, a production-standard Shenzhou LES was only installed on a launch vehicle on March 25, 2002 for the Shenzhou 3 launch, and similar to the previous ground abort test more then three years prior to this launch, Shenzhou 3 was not intended to test if the LES would stand up to actual operating conditions in space, but was intended to prove that it would work. Ironically, the Shenzhou 3 launch never got around to proving that the LES would indeed work as it didn't necessitate the operation of the LES. In what may perhaps come as a shock to the Mercury engineers, this effectively means that the Shenzhou LES was never once fully tested in flight, and if it can be assumed that available records are accurate and complete, the Shenzhou LES was only validated in that single ground-abort test carried out in 1998. This stands in great contrast to the extensive testing program that Project Mercury subjected the Mercury LES to.

Compared to the 9 months that the Mercury engineers took to achieve their first successful Beach Abort test, the Chinese took at least 4 years to achieve their first successful ground-abort test, and while the Mercury engineers had an LES installed on a launch vehicle for a flight test within a year, the Chinese only did so approximately 6-7 years after work on the Shenzhou LES began. Ultimately, the fact that Chinese risk aversion to failed launches resulted in a limit to the number of test launches as well as a stipulation that launches could only involve systems that engineers were perfectly confident in resulted in a single known ground-abort test and no eventual actual flight-test of the Shenzhou LES. It is also very probable that the lack of freedom for the Chinese to conduct flight-tests of the LES was the primary reason for the long development times needed for the LES due to the extensive ground testing required to qualify the LES in an absence of flight-tests. On the other hand, the significantly greater number of flight tests that the Mercury engineers had the freedom to carry out allowed them to directly discover, albeit in a more severe manner, the flaws and deficiencies in their LES design and correct them progressively until they were thoroughly satisfied. Indeed, if one considers that all the knowledge and learning gained from the 12-13 test launches that Project Mercury carried out to develop and validate the Mercury LES would have to be obtained more or less to the same degree by the Chinese but in less realistic ground testing conditions, it is perhaps not surprising that a much longer amount of time was needed to get the Shenzhou LES to the desired levels of operation.

Ironically, the Chinese were doing with their test launches what the top NASA engineer quoted previously had sneered at – proving that they were indeed "so smart that [their] design wouldn't fail to begin with" and that they "knew how to build them so that they wouldn't fail". This had the effect of lengthening their development schedule and potentially raising some doubts about the actual operational capabilities of the LES in flight. Perhaps it is fortunate that, in both programs up to this day, neither the Mercury nor the Shenzhou LES ever needed to be activated in an attempt to save an astronaut's life.

5.5 Quality Control in Mercury and Shenzhou

Apart from the different natures of their flight schedules, Project Mercury and the Shenzhou Program also differed in terms of the way quality control was managed during the program. This section will show that because of their higher risk averseness towards a launch failure, the Chinese were incredibly neurotic with regards to quality control, whereas the Americans were relatively less so.

At this point, it should be clarified that this does not mean that the American engineers involved in Project Mercury were somehow lax with quality control or shoddy in their duties. Far from it, as the Mercury Project Summary states, “A very important feature of the Mercury approach to flight safety was the assignment of personnel with a high level of technical competence to the performance and monitoring of all preflight tests and preparations at the launch site….This high level of competence also extended into the quality control and inspection areas at the launch site….The Mercury Project has featured extremely tight quality screening for deficiencies during all preflight checkout operations” (NASA, 1963) Lest doubts are raised regarding the objectivity of NASA’s own post hoc evaluation of its efforts, it should be noted that evidence of the seriousness with which quality control was treated can be easily found in actual NASA operations. For example, even though critical equipment like the Mercury Spacecraft was contracted out, NASA employees did not just take delivery of the spacecraft, trust the documentation from the external contractors regarding the required tests having been carried out, and equip it directly to the launch vehicle to be sent up. Instead, NASA employees would carry out their own set of tests on the components or systems that they received from external contractors, and would only use them in launch tests when they had satisfied themselves that the contractors had indeed delivered a product that met their specifications. McCurdy explains that “Abrogation of that responsibility would have violated the NACA/NASA test and verification culture…Good scientists do not accept the findings of their colleagues simply because their colleagues are trustworthy. Good scientists want to test and verify those findings themselves” and he quotes a launch director as saying “We used to take the spacecraft apart in the Mercury and Gemini program and do a thorough inspection and then reassemble it and test it…[The contractors had to] ship the hardware ready to shoot it, but be prepared that we are going to give it a thorough wring out before we commit it to flight” and another NASA scientist as saying “The components were retested because experience had shown that such retesting was necessary to catch mistakes made by the contractors.” (McCurdy, 1993)

But if the American engineers working on Project Mercury took their work seriously, the Chinese engineers working on the Shenzhou Program arguably took their work to the extremes. The difference was that even though Project Mercury engineers adopted a serious attitude towards product quality, they probably accepted that striving for 100% reliability, or 0% failure, was not a practically feasible concept. Doing so would probably have caused unreasonable delays in schedule, drive up program costs unreasonably, or in some cases be physically impossible. Rather the mindset was to bring measures of reliability as close to 100% as possible without insisting on reaching perfect reliability. In their minds, there was always the recognition that regardless of how careful quality control checks were implemented, there was always the risk of a deficiency or flaw that may result in launch failure, in part founded upon the acknowledgement that it was neither realistically possible nor wise to attempt to guarantee the perfect functioning of every single component and of the entire system as a whole, especially since the most rigorous statistical demonstrations of reliability were not always achievable within time constraints nor perfectly accurate. The Mercury Project Summary states that “The problem was therefore to decide, by a combination of engineering judgment, common sense, experience and intuition, just when the last serious ‘early development’ types and human-induced types of failure had been eliminated”. (NASA, 1963) McCurdy quotes a leader at NASA saying that despite their best efforts at eradicating such flaws, “That isn’t to say that there weren’t some unknowns. That isn’t to say that we didn’t recognize the risks involved in the operation every damn time we went to the pad” (McCurdy, 1993). Ultimately, the Mercury engineers decided to “specify an overall numerical reliability goal” that was “apportioned or budgeted through a mathematical model down to the various subsystems…the subsystem designer should be required to show that his subsystem is capable of absorbing the expected number of random or statistical type failures of parts without serious consequences” (NASA, 1963).

The Chinese, however, would have balked at such a "frivolous" mindset. In their mind, it was absolutely imperative that an absolutely non-compromising mindset be adopted with regards to their launches and the equipment that they sent up into space; everything had to work perfectly with zero malfunctions. Even though the Shenzhou engineers may have understood that this may have been an extremely difficult goal to reach or even one that was physically impossible, they were in an atmosphere where this was constantly emphasized and was what was expected of them. Indeed, during the ceremony before the launch of Shenzhou 5 that was mentioned previously, Li Andong, the PLA General Armaments Department Deputy Director stated that "'不许失败'，从科学规律上推敲是不可能的，但是从对国家的责任感出发，又是合情合理的。" ('Failure is prohibited', this may be impossible speaking from the point of view of the laws of Science, but speaking from a sense of responsibility to our country, this is logical and reasonable.)

On the most fundamental level, this insistence on 100% success and a complete eradication of any malfunctions or failures was demonstrated through the principles, both formalized and unwritten, that were used to guide the launch efforts of the Shenzhou Program. One of these rules was the emphasis on "三零原则：让每项工作零缺陷，让每个部件零故障，让每个人心中零疑点", or "Principle of 'three zeros' – zero flaws in every task, zero malfunctions in every component, zero doubts in the minds of everyone" (Southcn.com). Another principle that was closely abided by was the principle of "不让火箭带任何疑点上天" (Don't allow the rocket to rise into space carrying any doubts/problems) (邓宁丰, 2004). But perhaps the clearest reflection of how obsessed the Chinese were with the concept of ""zero failures" was the way they handled flaws that were discovered during the preparation for the Shenzhou launches.

On October 3, 2001, about a month before Shenzhou 3 was scheduled to be launched and when the rocket had already been rolled out onto the launchpad, a check on the electrical systems of the launch vehicle revealed that there was a problem with the electrical conductivity of a connection on one of the pressure sensors. A debate ensued as to whether this was a problem that affected only that particular electrical socket or a problem with the entire batch of electrical sockets, of which there were 77 installed on the Shenzhou launch vehicle. There were two courses of action that could be taken – the first would be to ignore the malfunctioning electrical connection in that socket, and even if the problem was existent in the entire batch of sockets, the fact that the malfunctioning connection had a redundant connection would still allow it to work; this would make sense in light of the fact that ordering a replacement component would have taken at least three months to be delivered, delaying the entire Shenzhou 3 launch over what was as of then an unproven hypothesis. However, this suggestion was automatically rejected by Yuan Jiajun and Qi Faren (the Chief Commander and Chief Designer of the Shenzhou spacecraft respectively) because of the argument that if they already had to rely on the redundant connection(s) when the rocket was still on the ground, there was no telling what would happen to it when it eventually had to fly into space without the planned level of redundancy. Ultimately, a decision was made to disassemble the launch vehicle (a move that would introduce doubts about its reliability if it were to be reassembled), and Zhu Mingrang, an expert from CASC, was sent to the Xichang launch site to supervise the checking of all the existing sockets. The more than 70 sockets with more than a 1000 connections were found to be perfectly operational save for that one original faulty connection. But this didn't satisfy the Chinese engineers at all; the Deputy Chief Commander of the Shenzhou Program Hu Shixiang arrived on site at the Xichang launch site, and after a week of continued deliberation over the problem, he asked the Vice manager of CASC and another Deputy Chief Commander of the Shenzhou Program Zhang Qinghong to drop everything he was doing in Shenzhen and head to the launch site immediately. Arriving at Hu's room, Zhang expressed his view that "双电备份能保证信号的畅通，这只是一条保进度的退路，从载人航天的要求来讲，飞船不能带问题上天，既然地面上已经发现了问题，就必须要把它解决好。" (The fact that the component has redundancy should still guarantee an electrical connection, but relying on such a mindset is honestly just an excuse to remain on schedule. From the point of view of manned spaceflight, the launch vehicle cannot be launched with any problems; since we have discovered one on the ground, we absolutely have to solve it). (邓宁丰, 2004)

The debate then shifted as to whether the problem was a batch production problem or a one-off defect, which yielded no conclusion until Hu Shixiang led a delegation to the actual production facility of the electrical sockets which revealed that it was indeed a batch production problem due to problems with the design. Although this indicated that the sockets should all be replaced, this would most definitely delay the Shenzhou 3 launch by at least 3 months, past the targeted launch date of the end of 2001. A high level meeting in Beijing at the end of October wanted to approve the postponement of the Shenzhou 3 launch, but this decision was eventually sent up to President Jiang Zemin due to the fact that it would eventually affect the entire Shenzhou flight schedule. President Jiang then declared "要绝对保证安全，既然发现了问题，一定要彻底解决，切勿抢时间" (We absolutely have to guarantee safety [of the launch], since we have discovered a problem, we have to fix it entirely, we absolutely cannot rush into it.) With President Jiang's order, the launch of Shenzhou 3 was officially postponed. During the announcement of this delay, Zhang Qingwei announced that "对于神舟 3 号的这次撤场，我个人的体会是不亚于 1992 年的 3.22 事件，我们又一次推到了失败不起的境地…同志们，不要以为我们手中不过是一个接插件或是一个焊点，他影响的是航天员的生命安全！…对载人航天工程来讲，那只有一句话，就是万无一失…我们唯一赶进度的理由，就是原来设想在党的十六大前完成首次载人飞行。要赶进度的话，前两次飞船用的都是这个插座，而且都发射成功了，这 1000 多个点中就这一点，还双点双线，我们可以发射。但这一个点可能波及到许多点，很可能导致神舟 3 号飞船的失败，结果我们只能得零分"(With regards to the delay of the Shenzhou 3 launch, my personal takeaways are no less than from the 3.22 incident, we have yet again been pushed into a situation in which failure is not an option…Comrades, do not think that it's just a mere component or a welding spot, it influences the lives of the taikonauts!...For manned spaceflight, only one thing matters, and that is never having any failures…the only reason why we are rushing our schedule is to achieve manned spaceflight before the 16th National Congress. And considering that we are rushing our schedule, the previous two Shenzhou launches also used these same sockets, and both succeeded; this time, only this particular connection out of a thousand had problems, furthermore it also had redundancies, so we could have very well gone ahead with the launch. But at the same time this connection might affect other connections and bring about the failure of Shenzhou 3, causing us to get zero points [like in a test]) (邓宁丰, 2004).

This one example is remarkable for a number of reasons. During the entire debacle, there were many arguments at various points in time that logically pointed to the fact that Shenzhou 3 could still be launched on time with a high probability of there being no incident. Firstly, when the malfunctioning electrical socket was first discovered and everything else checked out, the Chinese could have simply replaced that socket and proceeded with launch. Secondly, even if doubts still existed about the other sockets, the Chinese could have just relied on the built-in redundancy in the other sockets to guarantee their functioning. Thirdly, when all the sockets were eventually dug out from the launch vehicle and thoroughly checked, the fact that they all checked out fine should have been reason enough to put them back into the vehicle and proceed as planned. Fourthly, they could have relied on the argument that the very same electrical sockets worked perfectly fine on the first two Shenzhou launches to justify proceeding as planned. None of these arguments, however, stood any chance against the absolute determination to guarantee "zero flaws in every task, zero malfunctions in every component, zero doubts in the minds of everyone". Perhaps most remarkable was that this was in spite of the fact that postponing the launch would cause the Shenzhou program to miss its goal of achieving manned spaceflight before the end of 2002 and the 16th National Congress. Although not a perfect comparison, doing so would arguably have political implications almost as huge as the Apollo Program failing to meet Kennedy's deadline of landing a man on the moon and returning him safely before 1970. But the Chinese were willing to sacrifice all of that, even when all signs were pointing to the fact that Shenzhou 3 would most probably be successful as long as the malfunctioning component was replaced.

As another illustration of the extent to which the Chinese were willing to go to to eradicate any flaws in product quality, during the lead up to the launch of Shenzhou 1, a problem was found with the electronics and the Environmental Control and Life Support (ECLS) system. Diagnosing this problem entailed removing the spacecraft's base, which also served as a heat shield for the spacecraft. This was a very serious issue as the sealing of the base of the spacecraft was always intended to be an irreversible operation; the act of opening and resealing the base could thus damage the components in the spacecraft, with an estimated 96.3% probability of this act resulting in component damage. An improper sealing operation would also likely lead to the deaths of the astronauts upon reentry. According to Yuan Jiajun's analysis, 4 out of the 14 risks of opening up the base of the spacecraft were fatal risks, and disrupting these relevant components (especially the explosive components) could lead to an explosion of the spacecraft and a huge blow to the Shenzhou Program. A debate thus ensured as to whether the base of the spacecraft should be opened; from a logical standpoint, the fact that the ECLS was a non-critical component of the spacecraft for the Shenzhou 1 launch as well as the fact that it also possessed redundancies both pointed to the conclusion that the spacecraft base shouldn't be opened. (邓宁丰, 2004)

But before the ECLS problem was even solved, it was also discovered that the gyroscopes of the reentry module were faulty in subsequent tests, and any examination of the gyroscopes would also require the opening of the spacecraft's base. The same dilemma still applied – the gyroscopes also had redundancies and the team could in theory rely on these redundancies and still ensure their successful operation without risking the problems associated with opening up the spacecraft; however this clearly violated the principle of not allowing the rocket to bring any problems into space. The various experts involved with the Shenzhou spacecraft debated for days over whether to open its base but they were unable to reach a conclusion. In a pattern of problem solving that would be eventually mirrored by the Shenzhou 3 launch, the deputy chief commander of the Shenzhou Program Shen Rongjun and Chief of Staff of the PLA General Armaments Department Hu Shixiang arrived at the launch site and presided over a discussion that became, as a Chinese author describes, "extremely intense", but which also failed to yield any conclusion. The President of the Aviation Industry Corporation of China Wang Liheng and his vice president Zhang Qingwei then arrived on site and eventually decided that as the issue was too delicate to put to a vote, that all the designers and commanders should take a few hours to deliberate over the issue and make a decision the following day. The Chief of the PLA General Armaments Department Cao Gangchuan eventually held an emergency meeting and proclaimed that "不拆大底，就不会捅出新的娄子，就会保证发射的进度。如果备用件在天上听话，还能保证试验飞船的试验内容，上下全好交代。不错，保九，我喊得最多…现在飞船肚子疼，我们要让它到天上去拉稀吗？大家盼着我来，有盼着说一个字的，有盼着说两个字的。我就说一个字，拆！" (If we don't open up the base of the spacecraft, we will guarantee the progress of the launch. And if the redundant components operate as they should, then this will also guarantee the required operation of the spacecraft, and everything will be fine. Yes, "Guarantee 9"[guarantee that the first manned launch take place before 1999], I have emphasized this slogan the most often out of anyone…but now the spacecraft has a stomachache, are we going to let it go into space and have a bout of diarrhea[22]? Everyone is looking at me now, some are hoping that I will say one word, some are hoping I will say two. I will say one word – Open! [the spacecraft]) In the end, the spacecraft was opened up and the problem diagnosed to be a wire that was crushed when sealing the base of the spacecraft. (邓宁丰, 2004)

Again, this incident with Shenzhou 1 mirrors that of Shenzhou 3's very closely. All signs logically pointed to the fact that Shenzhou 1 could still have been launched without incurring the incredible risks of opening up the spacecraft, as the affected components all had redundancies. In addition, the opening up of the spacecraft severely risked delaying the launch to the point that the "Guarantee 9" deadline would be missed; the entire Shenzhou team had worked so hard under immense pressure to meet this deadline, and it made little sense to put to waste all that they had worked for and incur serious political implications for a problem that may not have eventually materialized. But the leaders of the Shenzhou Program were still willing to sacrifice all of this solely for the sake of eradicating every single problem from the Shenzhou spacecraft before it was launched.

[22] This is a literal translation of what was uttered.

However, it would be difficult to find incidents of a similar nature and extent in Project Mercury; in fact, there were instances during the Mercury launches when problems occurred and were eventually ignored in favor of not delaying the launch unnecessarily. During the final countdown for the Big Joe 1 launch, an unexpected reading appeared on the guidance computer for the launch vehicle, caused by a faulty transistor; this problem was eventually ignored due to the existence of redundant systems and the countdown was resumed. During the final countdown for the Mercury Redstone 2 launch, the countdown had to be paused when a particular inverter (a component that converts DC current into AC current) began to overheat; this same faulty inverter went on to overheat another two times, causing two further delays in the countdown, but was never replaced and the rocket was eventually launched five minutes before the deadline in an attempt to meet it. Perhaps the quintessential example that the Chinese would never have even dreamed about accepting was during the final countdown for Mercury Redstone 4, a flight manned by Gus Grissom, when a bolt that was meant to secure the side hatch of the capsule was found to be misaligned; a decision was eventually made to remove the bolt and continue the launch anyway, and this very bolt was given to Grissom after he successfully completed his flight. During the Mercury Atlas 6 flight of John Glenn, the insulation between the propellant tanks was found to be damaged, but because a previous unmanned flight to launch the Ranger 3 moon probe using an Atlas launch vehicle had went on successfully without this insulation, it was decided that Glenn's rocket would be launched without the propellant tank insulation. Furthermore, two hours before launch, Glenn found that his respiration sensor was in an incorrect position, but he was told to ignore it to avoid having to open his faceplate. (Catchpole, 2001)

To be clear, these incidents do not in any way imply that the Mercury engineers were frivolously ignoring problems with their launch equipment. Rather, they demonstrate that the engineers understood and accepted the nature of risk, and weighed each problem with its potential implications and the potential costs of attempting to solve it. According to a NASA employee interviewed by McCurdy, "they [NASA] would not take the risk if they knew that they could not get through it. But if it was, like, one in one hundred, you would do it, you would take it". (McCurdy, 1993) Problems that they deemed were unlikely to have a serious effect on the launch or the project as a whole were ignored in favor of ensuring that launches went ahead on schedule, but if a problem was deemed to be sufficiently serious, the engineers would never have ignored it but would have ensured that it was solved even if it meant delaying the launch. For example, it is probable that one consideration that factored into the faulty inverter on the MR-2 launch vehicle not being replaced was the fact that it wasn't a manned launch, but during the final countdown of Alan Shepard's MR-3 flight, a faulty inverter was discovered and the launch director ordered it to be replaced, even though it was deemed to be a minor problem, and delayed the launch by an hour and a half, most probably because the engineers didn't wish to take any chances with a manned flight. In fact, after the inverter problem was solved and Shepard was warned of yet another delay due to problems with fuel pressure, he "heard enough of what he felt was a severe case of over-caution" and snapped "Shit! I've been here more than three hours. I'm a hell of a lot cooler than you guys are. Why don't you just fix your little problem and light this candle!" (Burgess, 2014) The Mercury engineers were wiling to take risks where necessary, but never ones that might jeopardize the very purpose they were working so hard for.

That said, the fact that a great number of test launch failures during the Mercury program were due to inadequate quality control checks cannot be ignored. Before further elaboration, it should be clarified that Mercury test launch failures should not be construed as events that should not have occurred or events that should be prevented – indeed as previously explained, a number of the failures were indeed necessary to reveal flaws in the design of the Mercury spacecraft and launch vehicles through tests under actual operating conditions, in line with NASA's testing philosophy during the program. For example, the failure of Mercury Atlas 1 eventually allowed the Mercury engineers to find a way to continue utilizing a thin-skinned oxygen tank with added reinforcements, and the failures of Little Joe 5 and Little Joe 5A allowed the engineers to continually improve the design of the Marman Clamp. (Catchpole, 2001)

However, not all test launch failures fall into such a category. The flights for which failures could have been prevented if adequate checks had been instituted during the launch preparation phase were Little Joe 1 (due to incorrect routeing of wires in design), Little Joe 5 (due to errors in the wiring of the limit switches in the Marman Clamp), Mercury Redstone 1 (due to errors with the length of the prongs of the umbilical cables), Mercury Atlas 3 (due to "contamination on one of the flight programmer's pins") and Mercury Scout 1 (due to incorrect wiring of gyroscopes). In addition, the Beach Abort test launch, while successful, was also plagued by errors in the fitting of electrical cables. (Catchpole, 2001) Although the origin of some of these errors may be attributed to the contractors responsible for supplying the Mercury spacecraft, NASA's testing and verification regime of such equipment should have subsequently been able to catch these errors. While acknowledging that the Mercury Program indeed had more important goals than completely eradicating every single possible flaw especially for unmanned test launches, and at the risk of not giving NASA engineers sufficient credit where due, it appears that the Chinese testing and quality control regime was relatively more rigorous and successful than the one at NASA, but this came, of course, at a cost to program schedule.

5.6 Conclusion

In summary, the sections above seek to shed light on the two questions that were raised at the end of Subsection 5.2.3. Differences in cultural attitudes towards launch failures between the Americans and the Chinese resulted in different levels of risk aversion towards a flight-testing schedule with a high risk of launch failure. This had the effect of, respectively, facilitating (in the case of Mercury) and severely hindering (in the case of Shenzhou) their ability to adopt a high risk flight-testing schedule, and also drove the Chinese to adopt a significantly more extreme and non-compromising approach towards quality control compared to the Americans.

The combined effect of these approaches was twofold. Firstly, it affected the program scope of Shenzhou by curtailing the number of test launches that the Chinese committed to, requiring that only those systems that they had full confidence in could be tested, and ensuring through extreme quality control measures that any chance of launch failure was minimized as far as humanly possible; it is thus not surprising that under those conditions, the few flight tests that were carried out all succeeded, achieving a launch success rate that was arguably unheard of in other programs. Only such a test schedule that systematically and uncompromisingly eradicated every single problem, proven and suspect, with the launch vehicles and spacecraft before any launch was given the go ahead would be able to boast of such a stellar track record. On the other hand, Project Mercury wasn't playing Shenzhou's game; the Mercury test launches were after all intended to reveal problems, foster learning and validate improvements; it was thus a given that test failures would be a natural, and indeed necessary, occurrence.

Secondly, it affected the program schedule of Shenzhou by lengthening the duration of the program both in terms of development and flight schedule, because of the longer duration needed for more comprehensive ground testing and also the extreme quality control measures brought upon by the above mentioned drivers; it is for these reasons that the Shenzhou Program took a much longer duration to achieve its goals than the technological headstarts of the Chinese and the much fewer test launches carried out by them would suggest. On the other hand, Project Mercury was able, through its emphasis on efficient flight-testing and the freedom to reasonably temper quality control measures with the realities of risk, especially during unmanned flights, achieve its goals in a much shorter duration.

As with the previous chapter, there may be a tendency to then pose the follow-up question of "So which program was better?" Again, no meaningful answer to this question exists; both the US and China ultimately achieved their goals to much public fanfare, even though the routes they took to get there were very different. Project Mercury enabled a program that was much faster and efficient at achieving its goals, but which involved a greater number of launch failures most probably at considerable expense. The Shenzhou Program necessitated a program that was significantly longer at achieving its goals, but which involved a fewer number of launches that were all incredibly successful. In both cases, cultural attitudes facilitated the tolerance of the chosen program's disadvantages in return for its prized advantages. If one were to imagine their roles being switched around, it is likely that each nation's manned spaceflight program would be considered a Pyrrhic victory, if not a failure, in the other party's; fortunately, the deference of the various program parameters on paper to the underlying cultural forces in each nation eventually ensured that both countries won, albeit in their own unique way.

6. The People – Engineers and Astronauts of Mercury and Shenzhou

"*But my feelings are that this whole project with regard to space sort of stands with us now as, if you want to look at it one way, like the Wright brothers stood at Kitty Hawk about fifty years ago, with Orville and Wilbur pitching a coin to see who was going to shove the other one off the hill down there. I think we stand on the verge of something as big and as expansive as that was fifty years ago...Everyone one of us would feel guilty I think if we didn't make the fullest use of our talents in volunteering for something that is as important as this to our country and the world in general right now.*"

- Colonel John Glenn when asked about his motivations during the Mercury Astronaut Team Press Conference in Washington D.C., April 9, 1959 (Godwin, 2001)

实现中华民族千年飞天梦想是一个神圣的使命，我们有幸能够担负这次任务，感到无上的光荣。我们无论是谁去执行这次任务，都代表着祖国和人民去实现这一理想" (Fulfilling the thousand year old dream of spaceflight of the Chinese race is a sacred mission, and we are incredibly honored to have been given this mission. Regardless of who carries out this mission, we will represent our nation and our people to fulfill this dream.)

- Lieutenant Colonel Yang Liwei when asked about his motivations at a press conference introducing the Shenzhou Taikonauts at the Jiuquan Launch Site, October 14, 2003 (王艳梅, 2005)

The following chapter will examine the people who made Project Mercury and the Shenzhou Program possible – the engineers and the astronauts. The first four subsections focus mainly on the work of the Mercury and Shenzhou aerospace engineers, and highlight differences between these two groups in terms of the way decisions were made, how the engineers (and astronauts) were motivated in the programs, how the program leaders exercised their authority, and how the engineers viewed their compensation during their time with the program. The next four subsections focus mainly on the Mercury and Shenzhou astronauts, highlighting the differences in the extent to which the astronauts were involved in the program, the extent to which their work was characterized by levity or formality, the push for manual vs. automatic control in the programs, and media portrayal of the astronauts during launch and reentry. These observed differences in the Mercury and Shenzhou programs are explained in the context of differences in cultural dimensions for the US and China, which as will be shown below, had a huge influence on the way the engineers and astronauts made possible the goal of manned spaceflight for their respective countries.

6.1 Decision Making

Decisions often had to be made throughout the Mercury and Shenzhou programs, and these decisions were often characterized by complexity, urgency, uncertainty and quite frequently, disagreements. The interesting thing to consider is how these decisions were made under these conditions – how did people respond to such disagreements? How were differences reconciled? How was the uncertainty and complexity that often plagued such decisions handled? These are not trivial questions as they often influenced not just the success of a particular launch but also the fate of the program and at times, the fate of the life of an astronaut.

The differences in how decisions were made during these two programs can be explained by differences along the individualism vs. collectivism dimension for both nations. When faced with different competing views in a context of decision making, individualistic cultures like the US are characterized by values such as “Confrontations are normal”, “Speaking one’s mind is a characteristic of an honest person”, “Less conformity behavior”, and “Belief in individual decisions”. On the other hand, collectivist cultures like China are characterized by values such as “Harmony should always be maintained and direct confrontation avoided”, “More conformity behavior”, and “Belief in collective decisions”. Essentially these speak to two main characteristics of decision-making – the extent to which confrontations characterized decision-making, and the extent to which decisions were made on an individual level versus a collective level. (Hofstede G. H., 2001)

As shown in the examples given in Section 5.5 for the Shenzhou Program, decisions for when a solution had to be found to a complex problem were rarely made by one single individual; rather, the problem was often brought up to the group and experts and higher ranking leaders were often brought into the fray to discuss and debate the relevant issues until a group consensus could be reached on the problem. If no consensus could be reached, the problem would then be brought up to a higher level for consideration by even more senior officials. It was not uncommon for the problem to be debated for days or even weeks while the group searched for a collective response. There was a feeling of insecurity, especially if a decision had serious implications, about “making the call” by oneself, unless it was one that had been carefully considered and eventually promoted by the group.

It must be clarified that the idea of the Chinese engineers “believing in collective decisions” does not mean that there wasn’t a particular individual who eventually “made the call”. In fact, many major decisions during the Shenzhou Program were eventually settled by a senior leader making the call after a long period of discussion; after all, the initiation of a “collective decision” ultimately has to come from someone in the first place. Rather, what is emphasized by this concept is the fact that a Chinese engineer’s reaction to any major problem discovered or any serious doubt faced would probably be to bring it up to the group for consideration and discussion, as opposed to attempting to “go at it alone” especially if there was uncertainty involved. Upon subsequent discussion and indeed after the call was eventually made, the decision would be viewed as being owned by the group, as opposed to belonging to some particular individual, and such decisions that were arrived at after group discussion and debate were seen as more reliable or trustworthy compared to those decisions that were arrived at by a particular individual without any group consultation. Furthermore, despite the often-conflicting views, it was considered taboo for such differences in opinions to spin off into direct confrontation or “shouting matches”. There was an emphasis on harmony and cooperation as opposed to direct confrontation which would have been seen as acting out of line.

For example, during preparations for the Shenzhou 2 launch on December 31, 2000, an error by an employee at the launch site caused the Shenzhou launch vehicle to be dented by the launch platform. Upon a careful inspection of the spacecraft, Yuan Jiajun, the commander of the Shenzhou spacecraft declared that “我们的飞船没有问题！” (Our spacecraft is perfectly fine!) However, his declaration was insufficient to end the story, even if he was the commander. Qi Faren, the chief designer of the Shenzhou spacecraft, also conducted his own observations and then stated that because of the relatively slow speeds with which the launch platform impacted the rocket, the spacecraft probably underwent impact forces that were smaller than during an actual launch. Furthermore, Huang Chunping, chief commander of the Shenzhou rocket as well as Liu Zhusheng, chief designer of the Shenzhou rocket also conducted their own investigations and concluded that the rocket should also be fine for the launch. Regardless, the deputy chief commander of the Shenzhou Program Hu Shixiang still went ahead to call for an emergency high level meeting half an hour later to discuss how to deal with this problem. The experts assembled all reach the same conclusion – “飞船没有问题，不用重

新测试” (There is no problem with the spacecraft, and no need for additional tests) but expressed doubts over the rocket. (邓宁丰, 2004)

Two more days of analysis revealed that the areas where the rocket was dented were in fact areas that had been specially reinforced and which should thus not affect the launch. However, due to the paranoia over not allowing the rocket to be launched with any flaws as addressed in Chapter 5, the top management wanted to separate the spacecraft from the launch vehicle and conduct further tests on the rocket. This of course warranted another round of discussion which took a great amount of time with many opposing views, but the engineers "一致同意…火箭原地进行排故…大家也对火箭需要测试的项目取得了一致的意见" (all reached a consensus…that checks be conducted on the rocket on the launch pad itself…and everyone also reached a consensus on the tests that would be conducted on the rocket). Upon completion of these tests which were successfully carried out, 13 experts from CASC including Ren Xinmin conducted an evaluation of the results of these tests, and this was followed by another group comprising Hu Shixiang, Zhang Qingwei, and Wang Yongzhi among others from the Chinese Academy of Launch Vehicle Technology (CALT) which evaluated the results of this very evaluation. These groups concluded that the rocket was essentially unharmed, and on January 6, a final meeting called by the command center of the Shenzhou Program passed these evaluations of the rocket and approved the launch. At the end of it all, Zhang Jianqi stated that "在这件事情上，火箭系统没有埋怨，大家都没有相互推脱责任，这是非常非常重要的事。飞船系统也是这样，碰撞之后，袁家军，戚发轫当时就给我表态，说飞船没有问题，这个支持对我来说是很大的。你把火箭撞成那样，飞船都加注过了，如果人家不表态，说没有问题，这也是正常的。如果表态模凌两可，我这个指挥长就没法下决心。" (During this incident, [people in charge of the rocket] did not complain, no one tried to push the blame on someone else, and this was extremely, extremely important. It was the same for the spacecraft, after the incident, Yuan Jiajun and Qi Faren made known their position that the spacecraft was fine, and this was a great source of support for me. After denting the rocket so badly, it would have been natural if they had been unwilling to take the position that the rocket was fine. If they had been vague about it, I would have been unable to carry on with the launch.) (邓宁丰, 2004)

The above example, as well as the incidents with the Shenzhou 1 and Shenzhou 3 launches elaborated in Section 5.5, demonstrate the extent to which collective decision making was relied on in the Shenzhou Program, the level of distrust in decisions that were made on an individual basis (with even the managers doubting their own decisions and requiring the validation of others), and the extent to which decisions that were made and/or validated by the group were seen as more trustworthy and reliable. Furthermore, such debates were never allowed to spiral into heated confrontations or blame games; regardless of the severity of the issue at hand, harmony always had to be preserved with conflicts being kept out of the picture in deference to the community.

On the other hand, in NASA as McCurdy states, "mid-level managers and engineers felt unrestrained in voicing warnings and dissent … a spirit of open communication, however, did not mean that everyone got along with everyone else. People fought hard over their ideas." McCurdy also quotes officials and engineers at NASA as claiming that "There was no tolerance for the 'yes' man" and "There were a lot of strong personalities there…It required a strong leader to make sure that everyone had a chance to speak and to make people listen to the opposition." (McCurdy, 1993) The spirit at NASA, therefore, was more accepting of the need for confrontation, believing that it was but a by-product of an honest, frank and open discussion that would lead to better decisions.

In addition, there was stronger faith in decisions that had to be made by individuals when the situation called for it. As McCurdy puts it, there were three elements responsible for shaping a certain culture at NASA – an acceptance of risk and failure as a natural and valuable source of learning, a "frontier mentality", and "values that the first generation of NASA employees and scientists brought to the infant space program" by virtue of them having grown up during the Great Depression and WWII. This culture was described as one in which "NASA civil servants felt empowered to exercise a high degree of discretion and technical judgment in carrying out their work", which stresses "open communications, technical judgment of people in the field", and which has "a decentralized matrix structure rather than a centralized hierarchy…[and an] organizational culture [that] is clear and tends to favor individual initiative and risk taking" (McCurdy, 1993). Essentially, during Project Mercury, NASA engineers were given a relatively significant amount of technical discretion – the idea that employees, often at lower levels of the "hierarchy", would be in a better position and possess the needed information to make the necessary decisions.

For example, during the launch of Mercury Redstone 1, problems with the umbilical cords eventually resulted in the Redstone rocket lifting just less than four inches before settling back onto the launch pad. Failed launch aside, at that time the Mercury engineers were facing two new problems – the first was the liquid oxygen tank that was building up pressure and which could potentially explode if left alone, and the second was that the rocket's circuitry was still active with armed retrorockets that could be fired into the oxygen tank. Essentially, something had to be done to both vent the oxygen tanks as well as deactivate the rocket's circuitry to prevent an explosion on the launch pad. According to Burgess, Guenter Wendt, who was then Pad Leader, recounted that "I go back to the blockhouse, and the next thing I hear are [Kurt] Debus and John Yardley discussing it. Debus tells the pad safety officer to call the base and get some guns, because he is going to shoot holes in the oxygen tank to relieve the pressure! John Yardley says, "Like hell you do! I have a perfect, safe spacecraft out there, it's the only one I have right now. If you shoot holes, the thing is going to blow up and I'll have no spacecraft". Wendt explains that at that time, "The first thing is, we have to get rid of the pressure in the oxygen tank. One of the ways is to send a mechanic out there, into the tail end of the rocket, to hook up a quarter-inch nitrogen line, then open up a hand valve. However, we don't know what will happen, so when we open it, we run like hell back to the blockhouse! A guy by the name of Sonny came, he went out, opened it, ran like hell, and just about hit the blockhouse when a big stream of gas, tens of feet long, came out. But nothing blew up.…So now, we are looking for someone to go out there and deactivate the circuitry…we were looking for people with no dependents to volunteer. If the retrorocket had fired, that would be it...Some of us volunteered to go out and do it.…We went up there…We got the hatch open, found the two switches: click, click, and we were safe. We saved the spacecraft, though we needed a new booster." (Burgess, 2014)

The above example demonstrates the very different ways in which the Mercury engineers handled launch problems as compared to the Shenzhou engineers. If a similar problem had occurred during a Shenzhou launch, there would almost certainly have been a huge discussion with committees being formed, and various senior leaders and management called in to discuss what the best course of action would be; Shenzhou management would never have allowed mere engineers on the launch pad to decided what to do without their oversight and approval, and neither would these engineers themselves have desired to implement their own individual decisions without consulting the larger group and higher management. However, the problems with MR-1 prompted many individuals to propose their own solutions to the problem, and they would probably all have gone ahead to implement them once they were given the green light. There was much greater confidence in the decisions that individuals themselves made, and these individuals were willing to take ownership of their views and defend them if necessary. As Wendt puts it, "The people who made the decisions [about MR-1] were right there, and they made the decisions. That's what we got paid for. " (Burgess, 2014)

In addition, the exchange above shows that the Mercury engineers also felt no need to conform to the ideas of the group, hold back from speaking one's mind, or shy away from constructive confrontations when the situation called for it. The prevailing view was that in times of crisis, it was precisely such diversity of opinions, honesty in voicing them, and the tolerance of head-on confrontations that would eventually produce the best decision for the group. This is not to say that the Mercury engineers saw no value in consensus building and group harmony, or that the Shenzhou engineers saw no value in voicing out disagreements or individual views when the situation called for it; elements of both styles would have been found in both the Mercury and Shenzhou engineers, but close observation of decision making trends in the respective programs would reveal that the Mercury engineers had a greater tendency to engage in a more individualistic style of decision making, while the Shenzhou engineers had a greater tendency to engage in a more collectivist style of decision making. More fundamentally, it was the relative differences in levels of trust in decisions arrived at in one style over the other that eventually led to actual differences in the way decisions were made.

6.2 Motivations of the Engineers and Astronauts

There were also differences in how the individuals involved in the Mercury and Shenzhou Programs were motivated to continue dedicating themselves to the program. With reference again to the individualism vs. collectivism dimension, individualist countries like the US are characterized by "Emphasis on individual initiative and achievement: leadership ideal", "More importance attached to freedom and challenge in jobs", "Employees perform best as individuals", "Management is management of individuals", "Incentives to be given to individuals" and "Extravert[23] and acting behavior". On the other hand, collectivist countries like China are characterized by "Emphasis on belonging: membership ideal", "More importance attached to training and use of skills in jobs", "Employees perform best in in-groups", "Management is management of groups", "Incentives to be given to in-groups" and "Other-directed behavior". (Hofstede G. H., 2001)

Essentially, NASA in line with the cultural ideals of the US mentioned above did indeed play to those individualist values that would have appealed to the NASA engineers at that time. McCurdy quotes a NASA executive saying that NASA's predecessor NACA "gave you [engineers] great responsibility almost immediately. A very young man in the NACA could get access to facilities and make decisions on carrying out his own program", giving them "a lot of confidence that there was no technical problem in flight that [they] couldn't understand." Indeed, another NASA executive was quoted as saying that "NASA had been given just an incredible responsibility and freedom to carry that responsibility out" and that working for NASA "was almost like a war 'in the challenge and responsibility that it put on individuals'". (McCurdy, 1993) It is not a coincidence that these descriptions by NASA employees focus very much on the individual and emphasize what the individual was given. Work at NASA was designed to appeal to the values of individual initiative, achievement, leadership, freedom and challenge that would have been most in line with the values desired by the NASA engineers at that time, a decision that was probably made due to the recognition that doing so would be the best way to motivate employees who were driven by these individualist values. In line with the ideals of "Employees perform best as individuals", "Management is management of individuals" and "Incentives to be given to individuals" (Hofstede G. H., 2001), responsibilities and opportunities were handed out with the individual at the center, not the group.

In contrast, the employees of the Shenzhou Program were motivated by appealing to their collectivist mindset and ideals, essentially communicating to them that their efforts would allow them to be rewarded with a sense of satisfaction of having contributed to the collective group, that they should be eager to work together as a group for the better good, and that if they failed in their duties, they would be a hindrance to the group and be shamed for it. Their strongest motivations, therefore, stemmed from what good they could do for the collective group, as well as how they would let down the entire group if they failed.

For example, during the development phase of the CZ-2E rocket, which was given 18 months to be completed, President of the Chinese Academy of Launch Technology Wang Yongzhi stated that "希望大家要团结一致，准备打一场硬仗，打一场恶仗！我们这支队伍究竟怎么样，就在这次任务中证明自己吧！至于我自己，已向不领导表明态度，如果在 1990 年 6 月 30 日之前不能将"长二捆"火箭竖立在发射塔上，就撤了我的职，罢了我的官" (I hope that everyone will come

[23] Although the original psychological term was spelt "extravert", the spelling "extrovert" is more commonly used nowadays. When quoting Hofstede's work, the spelling "extravert" is used in the way it appears in his work.

together and work as a team, and be prepared to fight a long and hard battle. Let's prove the worth of our team through this mission! As for myself, I have already told my superiors that if the CZ-2E rocket is not standing on the launch pad by June 30, 1990, then I should be [unceremoniously] removed from my position [for having failed]). (邓宁丰, 2004) The concepts of collective responsibility to the nation and to the program and an emphasis on belonging and responsibility by virtue of membership of an in-group were already invoked before the Shenzhou Program officially started, and continued throughout the program when motivation of the Shenzhou employees was necessary in challenging times.

During the lead up to Shenzhou 1, when SAST was experiencing a serious lag in developing the Shenzhou spacecraft which necessitated a visit by Shen Rongjun to Shanghai (see Section 5.2.5), Shi Jinmiao, then deputy chief designer of the Shenzhou Spacecraft told his team "就算是有困难，载人航天工程也不能因为我们而拖了后腿" (even if we have difficulties [with the spacecraft development], we cannot allow the manned spaceflight program to be delayed just because of us). (邓宁丰, 2004) Qi Faren, the chief designer of the Shenzhou spacecraft, recounted "在会上经常听到领导同志讲，希望飞船不要拖载人航天工程的后腿" (During our meetings, we often heard our comrade leaders tell us that they hoped the [development of the] spacecraft wouldn't hold back the rest of the manned spaceflight program) (唐国东, 2012). Shi Jinmiao's promise to deliver the Shenzhou spacecraft in time was described as such – "这承诺不是个人的承诺，这是上海航天技术研究院向载人航天工程的郑重承诺，也是上海航天人向全党全国人民的郑重承诺" (This promise isn't a promise by an individual, it is a serious promise by SAST to the manned spaceflight program, and also a serious promise by SAST to all members of the Communist Party and the Nation). And the day before the launch of Shenzhou 1, Cao Gangchuan announced that "这次发射关系到我国在 21 世纪的国际地位和声望，也关系到载人航天工程在今后几年的发展前景，甚至是中国载人航天工程的命运，只许成功，不许失败！"(This launch concerns our country's international standing and reputation, the development schedule of manned spaceflight in the future, and even the fate of the Chinese manned spaceflight program. Only success is allowed, failure is not an option!) (邓宁丰, 2004)

It was thus extremely common to hear such appeals to collectivist mindsets in the speeches of senior management. But it is one thing to respond to appeals to collectivism in times of relative calm and another thing to respond to it in times of disaster when personal well-being is at stake. China's space program had its share of incidents or situations where lives were at stake, but even in such situations, the sense of collective dedication to the group often overcame concerns on an individual level. For example, in the spring of 2003, Beijing was particularly badly hit by an outbreak of Severe Acute Respiratory Syndrome (SARS), which necessitated the implementation of strict precautionary measures amongst the Shenzhou employees. At that time, a team from SAST was in Beijing to assist with launch preparations; they could have returned to Shanghai to escape the fatal epidemic, but chose to remain in Beijing and risk their lives. The assistant to the chief designer from SAST spoke of his experience, stating "我不是没有想到过自身的安全，但我想的更多的是神舟 5 号飞船的试验工作不能耽误，想的更多的是如何与实验队员同命运、共患难。实验堆那么多双眼睛盯着我，作为一名共产党员，在'大敌'当前的时候，怎么能逃兵" (It's not that I wasn't thinking about my own safety, but I was more concerned about not delaying the launch of Shenzhou 5, I was more concerned about how to share in with the fate of my colleagues and pull through this incident together. There are so many of my colleagues looking at me, as a member of the Communist Party, in the face of a "great enemy", how could I possibly flee?) (邓宁丰, 2004)

In addition, the very first attempted launch of the CZ-2E rocket actually resulted in a very serious failure – a leak of toxic rocket fuel occurred, with engineers on site collapsing due to exposure to the toxic gases. Wang Yongzhi, as well as the deputy commander of the rocket Yu Longhuai both fainted due to toxic exposure, and an engineer Wei Wenju lost his life in the process of trying to save as many of his fallen comrades as possible. When the senior leaders finally recovered, a meeting was convened with all the relevant experts representing the rocket's different subsystems and they were asked for their opinion on whether the launch should still proceed. One by one they all invariably replied "没问题！" (No problem!), with Wang Yongzhi also echoing their views; this eventually drove Liu Jiyuan to issue the final decision to proceed with the launch, which fortunately took place successfully on July 16, 1990 (邓宁丰, 2004). At that time, rumor had it that the launch would be cancelled due to the horrifying consequences of the toxic fuel leak, but a combination of striving for the collective good and a desire to acquiesce to the will of the in-group led to a unanimous on-the-spot declaration of everyone's willingness to proceed with the launch.

In addition, if motivations to do one's best were collective in nature, punishments to deter mistakes were also collective in nature. In the aftermath of Shenzhou 3's electrical socket incident, Hu Shixiang announced that "为了整个中华民族的利益，我们不能讲情面，不好的作风必须坚决改变…取得成绩，要论功行赏，奖励到人；出了问题也不要讲情面，板子到人！" (In the interest of the welfare of the entire Chinese race, we cannot spare consideration for people's feelings, we absolutely have to correct any undesirable working styles…[in the Shenzhou program] if we succeed, we will reward people, but if problems occur we won't get soft, the paddle will fall[24]!). Yuan Jiajun then announced that all employees of the China Academy of Space Technology would be given a 10% annual paycut, and that among them the employees that were working under the Shenzhou program in particular would be given a 15% annual paycut (邓宁丰, 2004). Such a form of collective punishment and implication of collective responsibility would never be even remotely imaginable in Project Mercury.

Apart from the Mercury engineers, the phenomenon of people related to Project Mercury being motivated by individualist values also extended to the astronauts. If the Mercury engineers were driven by values such as individual initiative, achievement, leadership, and challenge, the Mercury astronauts were most certainly driven by the same set of values, albeit in a different field. For example, following the outcome of the MR-2 flight (unmanned but carrying a chimpanzee), a decision was made by von Braun to conduct another unmanned Mercury Redstone flight (MR-BD) due to some problems encountered during the MR-2 flight. This decision greatly affected Alan Shepard, who was scheduled to have been on the very next flight, which would also have been the first US manned suborbital spaceflight. Shepard had originally been against NASA's decision to send a chimpanzee up before him, saying "The irony of playing second fiddle to a chimpanzee was particularly galling to us…NASA had decided to send a chimp into space before sending me…The agency meant well. But all I could think about were Russian boosters rolling to their pads for the first manned space flight." After the MR-2 flight, Shepard recounted that "I knew I could've survived that trip…If only the damn chimp's ride had been on the mark, I'd have launched in March…I confirmed that the problem with Ham's Redstone had been nothing more than a minor electrical relay. The fix was quick and easy…'For God's sake, let's fly. Now!' I begged NASA officials, but Dr. von Braun stood fast…So I walked away, brooding. The March 24 Redstone flight was an absolute beauty. I could've killed. I should've been on that flight. I could've led the world into space." (Burgess, 2014) Unfortunately, this delay eventually cost the US the race into space, with Vostok 1 carrying Gagarin launching successfully less than a month after the MR-BD flight that Shepard was supposed to have been on. (Catchpole, 2001)

The above incident shows how individual initiative, achievement and leadership were the driving motivators in the Mercury astronauts. Shepard probably understood the reasons for von Braun's decision, but still desired to place his individual ambitions above the collective purpose of the group. From a broader perspective, it was probably more beneficial to the entire Mercury program to have conducted one more test flight to validate the improvements made to the Redstone vehicle, but this did not square with Shepard's desire to fulfill his individual ambitions. This does not imply that he was reckless or selfish; after all the greatest risks of the launch concerned his life. Rather, he felt that from an individualistic point of view, the freedom to strive for leadership and achievement as an

[24] In reference to paddling as a form of corporal punishment

individual with full awareness of what he was getting into was more important and salient than considerations of what might be better for the larger group or Project Mercury as a whole. Such "extravert and acting behavior" would have been extremely out of place in the Shenzhou Program; indeed an individual going around making demands for his individual ambitions to be placed before the needs of the larger group would be seen as taboo in a culture that prizes "other-directed behavior", even if he had the purest of intentions.

But perhaps the clearest reflection of the differences in motivation of the Shenzhou and Mercury astronauts might be found in their answers to the press when they were first introduced to the public and were asked essentially the same question – "what were your motivations?". The answers of the Mercury astronauts were, in order, "It is just a natural expansion of flight…This is an excellent opportunity to be in on something new, to begin with." (Slayton), "The Project Mercury is just one part of the endeavor toward space travel. I quite personally am intensely interested in it and just delighted to have been given the opportunity to participate" (Shepard), "I think in my answer to what is my motivation, I think it is typical of most of us in this country: We are interested in new things." (Schirra), "My career has been serving the nation, serving the country, and here is another opportunity where they need my talents." (Grissom), "this whole project with regard to space sort of stands with us now…like the Wright brothers stood at Kitty Hawk about fifty years ago…I think we stand on the verge of something as big and as expansive as that was fifty years ago" (Glenn), "I think the others have expressed very well and I think we are motivated by – I myself, I should say – am motivated by the fact that I am a career officer, career pilot, and this is something new and very interesting " (Cooper), and "It is a chance to serve the country in a very noble cause. It certainly is a chance to pioneer on a grand scale" (Carpenter). (Godwin, 2001) In comparison, Yang Liwei's answer to this same question was "实现中华民族千年飞天梦想是一个神圣的使命，我们有幸能够担负这次任务，感到无上的光荣。我们无论是谁去执行这次任务，都代表着祖国和人民去实现这一理想" (Fulfilling the thousand year old dream of spaceflight of the Chinese race is a sacred mission, and we are truly honored to have been given this mission. Regardless of who carries out this mission, we will represent our nation and our people to fulfill this dream.) (王艳梅, 2005)

Lest a false dichotomy be inferred, this does not mean that the Mercury astronauts only had "individual initiative and achievement" in their minds or that the Chinese astronauts only had a collectivist "belonging" mindset in their minds; we can see that the Mercury astronauts also felt a sense of duty to their country, just as the Chinese astronauts probably valued the opportunity to excel as a chosen astronaut. Nevertheless, one gets a much stronger sense of the individualist ideals of freedom, challenge, leadership and individual achievement from the answers of the Mercury astronauts, and a stronger sense of the collectivist ideals of group-membership and serving the collective group from the answers of the Shenzhou astronauts. One may point to the fact that perhaps these answers were scripted; a more likely scenario for the Shenzhou astronauts than the Mercury astronauts, but this would likely, if anything, reinforce the point above. To the extent that scripted comments are meant to appeal to social values and reflect the prevailing social norms, they would probably be an even better reflection of the very cultural values of interest than an off-the-cuff answer.

6.3 Leadership and Power

Differences also existed in terms of how senior leaders in Mercury and Shenzhou exercised power in a position of authority. The cultural dimension that would be most relevant for explaining this would be power distance. Low power distance cultures like the US would be characterized by values such as "Hierarchy in organizations means an inequality of roles, established for convenience", "Subordinates influenced by bargaining and reasoning", and "Subordinates are people like me". On the other hand, high power distance cultures like China would be characterized by values such as "Hierarchy in organizations reflects the existential inequality between higher-ups and lower-downs", "Subordinates influenced by formal authority and sanctions", and "Superiors consider subordinates as being of a different kind". (Hofstede G. H., 2001)

Essentially, this meant that senior management in the Mercury Program did not view the lower level engineers as inherently being in a lower position compared to them. Of course, a hierarchy existed within NASA, but this was not for the purpose of "putting employees in their place" but rather established for practical and convenient reasons, such as delegation of work and division of responsibility. As a result, Mercury employees were treated more like equals in relation to their superiors; their work and opinions were valued, and they were to be treated with respect as individuals who had a great deal to contribute to the management of the entire program. McCurdy quotes a Mercury engineer as saying "there was a great deal of democracy in the management. Everybody was free to state his or her feelings. No one was treated any different if he objected to what management would think than if he praised what management would think" and that management "shied away from the heavy-handed approach of saying, okay, I've decided what we're going to do and you do that and you do that" (McCurdy, 1993).

On the other hand, top management of the Shenzhou Program never shied away from "heavy-handed approaches" if they felt they were necessary. To them, hierarchy existed for a reason and reflected the idea that those in higher positions of power were inherently different from the "lower-downs", and that they most certainly had the right to exert their formal authority on their subordinates when the situation called for it. This was especially the case when management felt that the engineers were not going to be able to meet the hard deadlines of the Shenzhou program and wanted to issue them an ultimatum. Due to the mindset that subordinates were considered "as being of a different kind", top level management did not see any problem with issuing directives or giving orders that one might view as being unreasonably dictatorial. To them, their position of authority in the hierarchy gave them the right to tap on this "existential inequality" by relying on methods that could never have been applied to one's equals.

For example, during the development of the Shenzhou LES in the spring of 1998, Liu Jiyuan, then director of the China Aerospace Corporation (now defunct) was extremely concerned about the progress of the LES development, in particular the delays in the production of the payload fairing of the launch vehicle. He made a special trip to Beijing and made a statement "1998 年 3 月，火箭要拉近酒泉发射场，与神舟号飞船进行首次合练只剩下几个月的时间，可我们火箭的整流罩在哪儿呢？….黄春平…你作为火箭系统的总指挥，必须不惜一切代价，于 1997 年 6 月 10 日前，完成长征 2 号 F 火箭整流罩的生产，否则，以重大失职行为论处" (On March 1998, the [Shenzhou] rocket will be transported to the Jiuquan launch site; there are only a few months remaining before the first rehearsal of the rocket and the spacecraft, but where is our payload fairing?...Huang Chunping…as the Chief Commander of the Shenzhou rocket, you have to ensure at all costs that production of the payload fairing for the CZ-2F rocket will be completed before June 10th, 1997. If you fail to do so, this will be treated as a serious dereliction of duty and you will be punished accordingly.) (邓宁丰, 2004)

In response to this ultimatum from his superior, on May 10, 1997, Huang Chunping in turn issued a "dispatch order" to the chief dispatcher of the Capital Astronautics Company that was responsible for production of the payload fairing. Such a dispatch order was, in fact, similar to a military order in terms of severity and urgency, and was actually extremely rarely given out; it was an order that was not to be violated. This "dispatch order" required the company to produce and deliver the payload fairing by the midnight of June 10. However, this task was far from an easy one; the payload fairing was needed to protect the spacecraft and function accurately in a launch escape procedure and was thus an extremely critical component for the launch, but the engineers had only recently finalized the design – a period of 30 days was deemed unreasonable not only in terms of the engineering complexity involved but also the fact that the importance of the payload fairing would require extensive testing to reduce the great uncertainties that existed for this piece of new technology. When the engineers tried to tell Huang Chunping that this would be very difficult, he replied in an unforgiving tone "难？调度令是干什么用的？6 月 10 日零点前必须交付产品" (Difficult? What's the point of my issuing the dispatch order? Deliver the product before midnight on June 10). The company was thrown into a frenzy with workers working 24 hours around the clock to finish production of the payload fairing. Fortunately, all work on the fairing was completed on June 9, mere hours before the deadline. (邓宁丰, 2004)

In another incident that also reflects top management's willingness to resort to such autocratic processes, during the previously mentioned incident in the lead-up to the Shenzhou 1 launch in Section 5.5, the decision was made to open up the sealed base of the Shenzhou 1 spacecraft to diagnose the cause of the problems discovered. This was an extremely complicated and delicate operation, with any false moves during the process having the potential to not only irreversibly damage the spacecraft but also lead to fatalities due to the presence of explosive components on board. To compound the problem, the Chief of the PLA General Armaments Department Cao Gangchuan stated in his orders to the employees that "谁拆谁得立军令状，绝对不允许拆出问题" (whoever opens it [the base of the spacecraft] will be issued a military order, they are hereby prohibited from committing any mistakes or creating any problems while opening it). In other words, the employees who were at that time facing probably one of the most challenging and pressurizing operations that they would have to perform during the Shenzhou Program were also being ordered in a dictatorial fashion to not commit a single mistake in the process on pain of severe punishment. (邓宁丰, 2004)

It would be difficult to imagine the above incidents occurring during the course of Project Mercury. In these cases, the engineers that were trying to solve the respective problems that occurred through no direct fault of their own were already facing a multitude of challenges and most certainly a great deal of pressure. However, a person used to a low power distance culture would probably be shocked to find out that instead of giving these workers the necessary leeway (in the form of a reasonable amount of extra time) or encouragement (such as motivating them to give their all in a more constructive fashion), absolute orders were handed down that essentially necessitated compliance purely on the basis of hierarchy instead of a more comprehensive consideration of the delicate situation that the employees were in. And these are far from the only cases where deadlines and orders were autocratically imposed on the Shenzhou engineers. Development of the CZ-2E rocket was ordered to be completed in the span of 18 months when even US engineers would have taken at the very least a few years to develop a rocket; even though the senior engineers involved "异口同声地说这是一个不讲理的计划" (unanimously thought that this was an unreasonable plan), they still forced themselves to produce the CZ-2E rocket by the deadline, a feat which made overtime a norm for every single employee involved in the project during those 18 months. And as previously mentioned, the top leaders of the Shenzhou Program were issued absolute orders to make the Shenzhou 5 launch successful at the risk of having their "heads on the chopping board". (邓宁丰, 2004)

But this is in itself is not remarkable; after all it is not hard to imagine dictatorial tendencies in people in positions of power. What makes it remarkable is the acceptance of such phenomena amongst lower-level Shenzhou workers and their willingness to just take it in their stride and do whatever their leaders were autocratically demanding they do, even if it meant forgoing sleep, material comforts, and even what may be viewed as the basic rights of workers in many other countries. They viewed their leaders as being existentially superior individuals, which then made sense to obey their commands without question. This is the reason why Hofstede defines power distance as "the extent to which the less powerful members of organizations and institutions accept and expect that power is distributed unequally" (Hofstede G. H., 2001) – a high power distance culture is characterized as such not just from the desire of individuals in positions of authority to exert their power on the basis of their position, but also from the willingness of individuals in lower positions to accept this exertion of power and comply with it.

To be sure, this does not imply that a hierarchy didn't exist in Project Mercury or that orders were not given by top-level management to the Mercury engineers; rather as Hofstede explains, hierarchy in societies like the US would be seen more as "an inequality of roles, established for convenience" (Hofstede G. H., 2001). This means that such hierarchy would be exercised for project management purposes but within reasonable limits imposed by the acknowledgement of subordinates as inherently equal human beings even if they were lower down in the organizational hierarchy. On the other hand, hierarchy in societies like China would tend to reflect "the existential inequality between higher-ups and lower-downs" (Hofstede G. H., 2001); this would allow for and possibly even justify within Chinese organizations the use of hierarchical authority to impose demands on subordinates that may seem unreasonable in the eyes of societies that have lower power distance, demands that would only be acceptable if the implicit assumption was that subordinates were inherently "of a different kind" and would accede to such formal authority on the basis of differences in hierarchical position.

6.4 Earnings of the Engineers

One interesting finding of Hofstede was that countries with a high individualism score like the US were characterized by "Earnings more important than interesting work", whereas countries with a low individualism score like China tended to be characterized by "Interesting work as important as earnings." Hofstede attributes it to the assumption of "more 'moral' involvement with the organization where collectivist values prevail and more 'calculative' involvement where individualist values prevail"; in his view, because collectivist societies promote a kind of emotional attachment in the employee towards the company or firm that he/she belongs to, the meaningfulness of work as well as the financial remuneration involved are both seen as ways in which the organization "takes care" of its members. On the other hand, because individualist societies promote an emphasis on the individual and thus less of such emotional attachment to the organization, it is expected that an individual employee contributes his efforts in exchange for a good remuneration package, in line with a "calculative involvement" with the company as opposed to an emotional one. (Hofstede G. H., 2001)

It is perhaps no coincidence that the 1958 National Aeronautics and Space Act allowed Keith Glennan, then NASA administrator, to "establish 260 positions for which NASA could pay salaries as nearly as possible competitive with those being paid 'in the best modern research and development organizations in industry'" in order to "attract and retain the specially qualified scientific, engineering and administrative personnel necessary to maintain this nation's leadership in aeronautical and space activities". Eventually, NASA was able to create more than 700 such positions that were not subjected to typical federal pay regulations. (McCurdy, 1993)

In contrast, a popular saying in China during the 90s was that "搞导弹的不如卖茶叶蛋的" (Those [in China] involved in missile research earn less than those selling Chinese tea leaf eggs). It was a well-known and public fact that the earnings of aerospace engineers were comparatively low. Jiang Zemin, upon the successful return of Shenzhou 1, stated that "我们现在在报酬方面，不公的现象还是很多的。我就在想我们的飞船总设计师，刚才没好问，我可以肯定工资不会太高" (With regards to our remuneration policies, there's still quite a bit of unfairness in this area. I'm thinking of the chief designer of our spacecraft [Qi Faren], I didn't get the opportunity to ask him just now, but I'm sure his salary isn't too high.) In the view of Wang Liheng, previously a senior leader in the China Aerospace Corporation, "航天系统虽然待遇低，却创造了这样一个气氛：让跃跃欲试的知识分子有活儿干，有机会去磨练，有舞台去展示自己" (Even though the financial prospects of working in the [Chinese] aerospace industry were low, this created a kind of atmosphere where enthusiastic intellectuals could apply themselves to their work, had the opportunities to train themselves, and had the stage to demonstrate their abilities). (邓宁丰, 2004)

Of course, this does not mean that earnings were the overriding consideration in the decision of the Mercury engineers to take on their line of work, nor does it mean that the Chinese engineers did not value high earnings commensurate with the amount of work that they had to put into the Shenzhou Program. After all, even the most competitive salaries would not have motivated the best engineers to join NASA without "the attractiveness of the program, the challenge [and] personal reward involved,", and one NASA official stated that "There was a certain amount of 'do what you can for your country'" in his decision to join NASA. (McCurdy, 1993) Similarly, it is hard to imagine any Chinese employee turning down the offer of a higher salary if such an offer was put on the table. Nevertheless, the more “calculative involvement” that NASA employees were expected to have made necessary the provision of not only fair but indeed competitive remuneration, while the more “moral involvement” that characterized the views of the Chinese engineers towards their respective aerospace companies probably downplayed the importance of fair remuneration in return for the sense of belonging they felt towards their organization and the value of the work they were given the opportunity to do. In fact, Wang Liheng believes that the Shenzhou Program was single-handedly responsible for stemming the brain-drain of Chinese aerospace engineers into foreign aerospace firms in the critical decades after 1990, and tells the story of one young employee who was poached by a foreign firm on the promise of a substantial salary, only to eventually return to China after a few years, apparently due to Wang Liheng telling him before his departure that “你执意要去，我不拦你，但你什么时候回来，我都欢迎” (If you insist on going, I’m not going to stop you, but whenever you return, I will always welcome you back.) (邓宁丰, 2004)

6.5 Involvement of the Astronauts

Another interesting difference between Project Mercury and the Shenzhou program was the extent to which the program’s astronauts were involved in the respective programs. This is most readily explained by power distance, with low power distance cultures like the US characterized by values such as “Subordinates expect to be consulted”, “Consultative leadership leads to satisfaction, performance, and productivity”, and “Openness with information, also to nonsuperiors”. On the other hand, high power distance cultures like China would be characterized by values such as “Subordinates expect to be told”, “Authoritative leadership and close supervision lead to satisfaction, performance, and productivity”, and “Information constrained by hierarchy” (Hofstede G. H., 2001).

In this aspect Project Mercury differed from the Shenzhou Program most significantly in that the seven Mercury astronauts were not selected merely to pilot the Mercury spacecraft, but were also included in the design and development phase of the Mercury spacecraft. NASA’s Mercury Project Summary states that apart from training the astronauts in the operation of the spacecraft, they were also expected to contribute to the “Design of the Mercury spacecraft”, “Development of operational procedures”, “Development of in-flight test equipment” and “Public Relations activities” (NASA, 1963). Catchpole explains that the Mercury astronauts were “encouraged to participate in the design and building of the hardware that they would fly into space. This gave them a certain amount of power, which they used to have the capsule’s design changed to meet their own requirements” (Catchpole, 2001). For example, the Mercury astronauts were involved in spacecraft mock-up reviews at McDonnell Aircraft Corporation and on September 10-11, 1958, they requested that changes be made to the spacecraft, which included the installation of a manual control system (as a backup in case of problems with the automatic system), a larger window in place of two smaller portholes, a hatch which could be removed through explosive charges (for more effective escape), more comprehensive displays on the main instrument panel to provide them with more information on their flight status, and also that people refer to the spacecraft as the “Mercury Spacecraft” as opposed to the “Mercury capsule”. They also helped to develop the procedures that they would use for the manned flights and the equipment that would be used on these flights. (Catchpole, 2001)

According to Burgess, the Mercury astronauts essentially visited most of the facilities that were related to the Mercury spacecraft and its launch, and also paid visits to all the subcontractors involved in Project Mercury (Burgess, 2014). The reason for this, according to Catchpole, was to firstly allow the astronauts to be “directly involved with the design and development of their spacecraft and their launch vehicles”, and secondly to meet contractor employees “with the intention that the employees would perform their work to a higher standard if they had met and spoken to the men whose lives would depend on the machines they were building”. In fact, Grissom’s fairly awkward pronouncement to Convair employees to “Do good work” eventually became their motto. Each astronaut was also given an area of specialization, with Shepard specializing in tracking and recovery, Glenn specializing in the Mercury Spacecraft Crew Compartment layout, Slayton specializing in the

Atlas launch vehicle etc. (Catchpole, 2001). As stated in the press conference in Washington when the Mercury astronauts were first introduced, "they [the astronauts] will participate all the way through…Perhaps the most important single reason for cutting from twelve to seven, so as to give all of them a maximum participation in the program." (Godwin, 2001)

However, the Shenzhou taikonauts' role in the Shenzhou program was viewed in a very different manner. Essentially, they were recruited to carry out orders and perform their duties as instructed. Although they went through the required training programs that were common to both Mercury and Shenzhou, such as low gravity training, training to use the Launch Escape System etc., in order to allow them to perform their duties during launch, it is highly unlikely that they were involved in the design and development of the spacecraft and launch equipment as the Mercury astronauts were; no source consulted so far has indicated or hinted at such involvement. Indeed, before the launch of Shenzhou 5, Xu Dazhe, the head of the Shenzhou 5 spacecraft launch team, told Yang Liwei "你放心，为了这次飞行万无一失，航天科技工作者以零缺陷、零故障的标准打造送你上天的火箭和飞船，经过无数次检测和评审，证明这枚火箭和这艘飞船是质量最好的产品，他们一定能够胜任中华民族梦圆飞天的使命" (Don't worry, in order to ensure the success of this mission, we have built this rocket and spacecraft according to our criteria of "zero flaws, zero defects", and countless tests and evaluations have proven that these are products of the best quality; they certainly can fulfill the mission of achieving manned spaceflight of the Chinese race.) A letter that was placed in a folder at the back of Yang Liwei's seat in the Shenzhou spacecraft contained 500 signatures from the Shenzhou employees and stated "我们研制了“神舟”和“神箭”，您光荣地成为中国第一位遨游太空的航天员….我们虽然岗位不同，职责不同，但我们所肩负的责任和使命相同，为实现中华民族伟大复兴的目标相同，为共同圆一个古老的飞天梦想相同" (We developed the Shenzhou spacecraft and the rocket, and you have honorably become China's first taikonaut in space…Although our [job] positions and responsibilities are different, our goals are the same, our goal of bringing about the great revival of the Chinese race is the same, and our goal to fulfill an ancient dream of spaceflight is the same.) (邓宁丰, 2004)

The key difference then was that the NASA managers and the Mercury astronauts themselves saw the role of an astronaut as one that was equal in relation to the managers and engineers that were working on Project Mercury, as opposed to seeing them as an air force pilot who had been selected as a mere human apparatus to be sent up on a rocket. In relation to this and the expectation of the Mercury astronauts that they be consulted with regards to the design and implementation of their mission objectives, a consultative leadership style was applied with the understanding that this would lead to "satisfaction, performance, and productivity" (Hofstede G. H., 2001). The Mercury astronauts were kept well informed of every step of the process, and indeed far beyond what their job scope might have entailed. They were called upon to inspect the various iterations of the spacecraft, make recommendations, and even assume areas of specialty with regards to the launches, with the other Mercury astronauts in the control room communicating directly with their colleague that was in space during manned launches. This was all in keeping in line with the view that they were not there to just carry out orders but partake in the mission as equals.

On the other hand, the Chinese taikonauts were treated quite differently; they were not involved in the design and development process of the Shenzhou launch vehicle or spacecraft and were chiefly taught what they needed to know. This does not mean that they were disrespected or not given the "right treatment", but rather that they were seen as subordinates of the Shenzhou Program who would be told what to do to complete their mission and probably little else. "Authoritative leadership and close supervision" was the leadership style implemented to give Yang Liwei the best chance of succeeding in his mission in the eyes of the Shenzhou commanders. There was no need for Yang to participate closely in the design process as the engineers that were specifically trained for this job would know what they were doing; all he needed to do was to train to use the spacecraft that would be delivered to him. Indeed, when it was time for the launch of Shenzhou 5, the Shenzhou engineers metaphorically handed the spacecraft over to Yang Liwei with the implication that their job was done and it was now time for his, assuring him that what they were handing over was indeed the best they could give him.

There was no indication that the greater involvement of the Mercury astronauts in the various processes of Project Mercury as compared to the Shenzhou taikonauts in the Shenzhou Program had an adverse effect on the Shenzhou spacecraft or the program itself. Although astronaut input is obviously a valuable source of input, it is by no means the only source that can provide design ideas and improvements; after all the Chinese were working with the knowledge accumulated from decades of American and Russian experience. In addition, neither is astronaut involvement in the command room during actual launches the only way for astronauts to learn how to perform their missions. Instead of attempting to evaluate the superiority of one style over the other, it is probably fairer to acknowledge that differences in power distance in the US and China led to tendencies to view the role of the astronaut/taikonaut in the respective programs in a different light. The former was in a position where he was consulted to a greater degree, involved in the program far beyond his basic job scope, and given information freely. The latter was in a position where he was instructed to a greater degree, involved in the program under close supervision and asked to focus primarily on the tasks that he needed to perform, and was not necessarily given information that he did not need. These different styles were in line with how subordinates in a program would be viewed in cultures with different levels of power distance.

6.6 Levity and Formality

In a departure from the commonly examined dimensions of power distance and individualism vs. collectivism, the dimension of indulgence vs. restraint deserves an examination, most notably with regards to the behavior of the astronauts and taikonauts involved in the Mercury and Shenzhou programs. According to Hofstede et al., indulgent cultures like the US are more likely to exhibit characteristics such as “positive attitude”, “more extroverted personalities”, “higher optimism”, “less moral discipline”, “more likely to remember positive emotions”, “higher importance of leisure” and “smiling as a norm”. On the other hand, restrained cultures like China are more likely to exhibit characteristics such as “cynicism”, “more neurotic personalities”, “more pessimism”, “moral discipline”, “less likely to remember positive emotions”, “lower importance of leisure” and “smiling as suspect”. (Hofstede, Hofstede, & Minkov, 2010)

This implies that one might guess that American astronauts would have been more given to expressions of optimism, extroversion and positive attitudes during the Mercury Program, and this guess would be right. In 1959, during a press conference in Washington, the seven Mercury astronauts were being introduced to the media and the public when a question was posed asking who was “ready to go into space then and there”; all seven astronauts enthusiastically raised their hands, with Schirra and Glenn raising both of their hands to “double their vote”. (Carpenter, et al., 1962) In response to a question regarding what motivated them to volunteer, John Glenn joked that “it probably would be the nearest to Heaven I will ever get and wanted to make the most of it.” (Godwin, 2001) The astronauts projected a strong atmosphere of optimism, enthusiasm, courage, determination and an all-round positive attitude that would continue on into their training and their missions.

This extroverted and positive attitude was also used to great practical effect, most notable for reliving the tension associated with the actual launches. Alan Shepard, as well as the other Mercury astronauts, adored Bill Dana’s routines involving the “astronaut” José Jiménez, to the point that he could “recite many of Dana’s routines off by heart, and would often slip into the Jiménez character during training in order to relieve any pent-up anxieties”. According to Shepard, “during the Ranger launching, at a moment when they stopped the countdown because something was wrong, I put the tape on at full volume there in the control room. Sometimes we like to have a little fun too. It releases the tension.” In fact, on the day of Shepard’s flight, he and Gus Grissom re-enacted a Bill Dana routine to “ease some of the nervous anticipation” on their way to the launch gantry. (Burgess, 2014)

In addition, the other astronauts and Mercury engineers did a few things to ease the tension that they felt Shepard might be experiencing before his flight. Bill Douglas gave Shepard a box of crayons, in reference to a joke "about an astronaut about to start a long mission who had taken along a coloring book to help him pass the time, but refused to fly when he found that he had forgotten his Crayolas". After Shepard had entered the spacecraft, he noticed that John Glenn had playfully left him a note on his instruments that said "Ball games forbidden in this area". Deke Slayton then initiated contact with Shepard through the spacecraft's communication system, saying "José? Do you read me José?", with Shepard then playing along with the relevant Bill Dana routine. In a remarkable sign of the freedom that Shepard felt he had to express himself, the final delay in the countdown resulting in Shepard snapping at the engineers "Shit! I've been here more than three hours. I'm a hell of a lot cooler than you guys are. Why don't you just fix your little problem and light this candle!" And during the last minute of the countdown, Shepard muttered "Deke and the man upstairs will watch over me. So don't screw up, Shepard. Don't screw up. Your ass is hauling what's left of your country's man-in-space program!" With that, Shepard embarked on what would be the first successful manned suborbital flight of Project Mercury, and upon landing back in the Atlantic, his first utterance to the retrieval crew was "Boy what a f…ing ride! Ho-lee s…! Goddam, that was something!". (Burgess, 2014)

But it wasn't just Shepard who was the only "joker" amongst the astronauts. The astronauts were known to have played pranks on each other during their training and preparation for the launches. John Glenn's flight also had its share of the moments of levity that so characterized Shepard's flight. In the lead up to the launch, Glenn was being helped into his pressure suit with doctor Bill Douglas present. At that time, Douglas "ran a small hose from the main air supply tube [for the pressure suit] and stuck it into a bowlful of tropical fish on his desk and let it bubble away night and day", with the aim of using the reaction of his fishes as a informal alarm system for contaminants in the air. When Glenn was being fitted into his suit, he "casually asked Bill if he realized that two of his fish were floating belly-up in the bowl", prompting the poor doctor to dash over to check his fish before realizing that Glenn was pulling his leg. On his way to the launch pad, someone told Glenn jokingly that he wouldn't be allowed onto the pad because he wasn't carrying a security pass on his suit. During his flight, Glenn radioed Gordon Cooper and told him "I want you to send a message to the commandant, U.S. Marine Corps, Washington. Tell him I have my four hours required flight time in for the month and request flight chit be established for me", to which Cooper replied "Will do. Think they'll pay it?....Is this flying time or rocket time?" The USS *Noa*, the vessel that picked Glenn up after he landed, presented him with a fifteen-dollar check for winning the February "Sailor of the Month" contest. (Carpenter, et al., 1962) And after his flight, Glenn related that despite all his efforts, he "did not get a banana pellet on the whole ride" in reference to the rewards that the chimpanzees on earlier flights obtained for performing their assigned tasks. (Catchpole, 2001)

These little anecdotes of the ways in which Project Mercury was livened up by the astronauts and engineers involved reflect the kind of indulgent culture that would be associated with the US. These outward displays of extroversion and indeed playful optimism were of course not intended to unnecessarily make light of a serious mission, but instead as a way to create the very kind of atmosphere that would be appreciated in such a culture. Practically, it was seen as a very effective way of relieving the tension associated with the Mercury launches, and perhaps more significantly, it was all from the ground-up. No one had scripted any of these displays and the Mercury flight manual did not specify that the astronauts or engineers had to behave in certain ways in order to relieve the tension of the mission; they initiated these acts out of their own accord.

On the other hand, it is interesting to note that the Chinese differed quite significantly in their attitude towards such "levity". In his book describing the psychological requirements for taikonauts, Tang explains that one of the important characteristics that foreign space programs look for in their astronauts is "幽默感" (humor), but this characteristic is conspicuously absent from his enumeration of the Chinese taikonaut requirements, even though both lists contain similar elements such as "emotional stability", "ability to work in teams", and "ability to handle stress". More interestingly, the Chinese taikonauts were given what was described as psychological training, in particular "心理放松训练" ("calm down" training) which taught them how to relieve stress though "有针对性的方法" (targeted stress relieving methods), including muscle relaxation techniques and "安全岛放松" ("go to your safe place" relaxation), as well as 想象训练 (imagination training) which involved "心理教练对航天员说：请你想想自己躺在一片柔软的草地上，是否感觉到草地的柔软？航天员根据心理教练的提示进行想象，慢慢会感受到草地的柔软" (psychologists telling the taikonaut, 'Please imagine yourself lying on a bed of soft grass, do you feel the softness of the grass?' Accordingly, the astronaut would carry out this imagination process and slowly feel the softness of the grass.) In fact, Tang explains that as part of the procedures to reduce the psychological stress of the Shenzhou 9 launch carrying China's first female taikonaut Liu Yang, the psychology coach asked her "在太空中的感受是不是很美妙" (Is being in space a wonderful feeling?) to which Liu replied "漂浮是很美妙，但操作起来就不容易了" (Floating around is indeed wonderful, but it makes my work difficult.) (唐国东, 2012)

In addition, the Shenzhou 5 launch was an incredibly scripted and formal affair. None of the theatrics that surrounded Shepard or Glenn's flight would have even been remotely tolerated. On the morning of Yang Liwei's launch, President Hu Jintao carried out a formal ceremony to send Yang Liwei off on his journey after a speech; Yang Liwei then responded with a formal declaration to complete his mission and not let down his country. The events that took place after were described as follows "身着乳白色航天服的首飞航天员杨利伟迈着从容而稳健的步伐，迈向问天阁航天员的专用通道….身着乳白色航天服的我国首位航天员杨利伟向中国载人航天工程总指挥李继耐请示出征…" (Decked out in his white spacesuit, the first taikonaut Yang Liwei strode forward with calm and steady footsteps into the tunnel…Decked out in his white spacesuit, our country's first taikonaut Yang Liwei requested for permission to embark on his mission from the commander of the Shenzhou Program Li Jinai). (邓宁丰, 2004) Essentially, a military ceremony was carried out on the launch pad. Yang Liwei saluted the commanding officer and reported that "总指挥同志，我奉命执行首次载人航天飞行任务，准备完毕，待命出征，请指示。中国航天员大队航天员杨利伟" (Comrade Commander, I have been presented with orders to carry out the first manned spaceflight mission, my preparations are complete and I am waiting for further orders. Chinese astronaut Yang Liwei). The order was then given to Yang to "Set off!" to which Yang replied with a proud "Affirmative!". The last words that Li Jinai said to Yang Liwei before blastoff were "希望你沉着冷静，坚定自如，按预定程序认真做好每一个动作，任务指挥部信任你，全国人民期待着你！"(I hope that you remain calm and steadfast, and fastidiously perform every task in your predetermined task list, we here at central command trust you, and every Chinese citizen will be waiting for you.), to which Yang Liwei replied "我向全国人民保证，坚决完成此次任务！"(I promise all my fellow countrymen that I will resolutely complete this mission!) (王艳梅, 2005) And as expected, there were none of the jokes that Glenn and Shepard exchanged with mission control during Yang's mission, which was instead filled with statements like "请首长放心，我一定努力工作，把后续工作完成好，向祖国和人民交一份满意的答卷" (Please do not be concerned Commander, I will definitely work hard and perform my duties well, and hand in a report that will be to the satisfaction of my country and my people). Instead, it was Yang Liwei's utterance of "明天见！" (See you tomorrow!) just before he took off in his Shenzhou 5 rocket that was described as a moment of humor by the Chinese. (邓宁丰, 2004).

That said, there was perhaps, admittedly, an attempt at a moment of levity during the Shenzhou 5 launch. In Yang Liwei's biography, he relates that while he was waiting to enter the Shenzhou spacecraft on top of the launch pad, he was accompanied by three other Shenzhou employees. At that time, all four individuals were waiting with no immediate tasks, and with the atmosphere becoming increasingly tense especially given that they were all a great distance from the ground, one of the employees suggested "咱们给利伟讲个笑话吧，放松放松心情" (Let's tell Liwei a joke, to help him relax). However, Yang recounted that none of the three was able to squeeze out a joke and the awkward silence resumed. When Yang was finally able to enter the cabin, an engineer decided to go for it and asked Yang if he knew where the engineer who had closed the hatch for Gagarin was currently working at at that time. Yang replied that he didn't know, to which the engineer said that he was working as the director of the Russian Space Museum (most likely in reference to the Memorial Museum of Cosmonautics). In the words of Yang Liwei, "其实，他讲的这个"笑话"一点也不好

笑，几个人谁都没笑出来" (Actually, his 'joke' wasn't funny at all. Not a single person laughed) (杨利伟, 2010)

One can clearly see how different the atmosphere of the Shenzhou launch and its preparations were compared to that of Project Mercury. In line with Hofstede's claim that restrained cultures like China would display "more neurotic personalities", "moral discipline", "less likely to remember positive emotions" and "lower importance of leisure" (Hofstede G. H., 2001), a great deal of formality was injected into the proceedings and a "no nonsense" attitude was adopted. Without the perceived and actual freedom to engage in informal playful acts or moments of levity as the Mercury astronauts did, the taikonauts had to be taught how to relax and calm down through formal, targeted techniques. The Mercury astronauts almost saw the manned launches as adventures that had to be treated seriously but which did not prevent them from immersing themselves into an atmosphere of playful exploration and positive displays of emotion, while the Shenzhou taikonauts would not have found such levity in line with the seriousness of their mission that, in their perception, required displays of seriousness, discipline and solemnness. Furthermore, it is interesting how the thresholds for what would be considered acceptably "humorous" were quite different for both nations. But this does not mean that the Chinese were unhappy with the state of affairs in Shenzhou; rather, they would probably have perceived that such a formal atmosphere that emphasized discipline and did away with unnecessary leisure or extroverted moments was a more comfortable and appropriate one in which to carry out a manned spaceflight program. Indeed, Yang Liwei was described as "他平时不苟言笑，一副冷峻的酷模样。熟悉他的人判断，正是因为这份冷静，才使他最终脱颖而出，成为中国飞天第一人" (He usually doesn't smile or talk very much, and often has a frosty expression. Those who know him well have judged that it was precisely because of this calmness that made him stand out and allowed him to become the first Chinese taikonaut in space.) (王艳梅, 2005) On the other hand, Mercury astronauts like Shepard would never have stood for such constraints on their freedom to express their extroversion when the situation allowed for it, in fact Ed Killian who had been involved in recovering Shepard's spacecraft said of his encounter with Shepard that "It was truly memorable, but the language was not scripted and it was just not acceptable for public audiences. Later, the astronauts would become more adept with 'politically correct' language. For now, Shepard had been honest in his reaction to the historic, and patently dangerous, personal experience." (Burgess, 2014)

6.7 Manual versus Automatic Control

Continuing with the theme of exploring the cultural dimension of indulgence versus restraint, it was previously mentioned that NASA astronauts insisted that manual controls be installed in the Mercury spacecraft while no apparent demands for the same were made by the Shenzhou astronauts. While this was in part related to differences in the level of astronaut involvement in the respective programs, it also reflected a difference in mindsets on the part of the astronauts, which can be attributed to the indulgence versus restraint dimension, more specifically views on personal life control. According to Hofstede et al., indulgent cultures like the US have a stronger "perception of personal life control" versus restrained cultures like China that have a tendency towards "a perception of helplessness: what happens to me is not my own doing." (Hofstede, Hofstede, & Minkov, 2010)

Essentially, the Mercury astronauts adopted a view that they should be in control of the mission that they would be involved in, as opposed to being a passive participant. According to Catchpole, it was initially intended for the Mercury astronauts to "ride the Mercury Spacecraft as a passenger and medical experiment", and that the only actual contribution that they would make was to "read back the instruments on the main control console". The Mercury astronauts were outraged by this and "rebelled against their passive role on the proposed flights"; they did not appreciate the idea of them being "helpless passengers" and the fact that this impression was reinforced by the use of the word 'capsule' to describe the vessel that would be carrying them, and they most certainly did not appreciate Chuck Yeager, the first US pilot to have broken the sound barrier, mocking them by claiming that a Mercury astronaut would just be a "man in a can" and that they would have to "brush the monkey shit off the seat before [they] climbed in", in a reference to the Mercury test launches involving chimpanzees. Yeager's bitterness could possibly have been due to his automatic exclusion from the Mercury selection process due to his not having a "Bachelor's degree or equivalent in engineering", but he made a fair point in pointing out that as the Mercury chimpanzees would not have actually known how to fly a spacecraft, the logical implication was that neither would the astronauts be required to do so. (Catchpole, 2001) The even more insulting expression of "spam in a can" that also existed in the public consciousness did nothing for efforts to improve the image of Mercury astronauts as being more than a "passenger on board a largely remotely controlled spacecraft" (Allen, 2009).

As a result, the Mercury astronauts demanded that all phases of their flight should provide them with manual control options, including control over their flight attitude, manual commencement of an abort sequence, as well as manual overrides for automatic procedures. In fact, the various improvements they suggested, including a larger window in place of two smaller portholes, a hatch which could be removed through explosive charges and more comprehensive displays on the main instrument panel to provide them with more information on their flight status were all made in order to give them a greater degree of control over their flight and their lives. (Catchpole, 2001) The astronauts got their wish; about three minutes after his launch, Shepard was manually controlling his spacecraft and did so for the rest of the flight using the "fly-by-wire mode" which entailed control over attitude and rate-control systems (Burgess, 2014) and Glenn also flew his Mercury spacecraft in a manual control mode upon reentry into the Earth's atmosphere (Allen, 2009).

On the other hand, there was no attempt to hide the fact that the Shenzhou launches would involve a significantly more passive role on the side of the Shenzhou taikonauts, nor was there any attempt from the side of the taikonauts to do anything about it. When it was asked at a press conference what the role of Yang Liwei would be in space, it was explained that "杨利伟在太空中要随时注意监测和管理飞船的运行，做一些微重力和空间环境试验，写飞行日志，再就是休息、饮食，还可以搞一些个人活动，如拍一些录像、照片，和地面指挥、医生通话等" (Yang Liwei will have to monitor the flight of the spacecraft at all times, perform some microgravity and space-related experiments, make entries in his journal, rest, eat, and also engage in other personal activities such as taking videos, photographs and speaking with ground command and doctors etc.) (王艳梅, 2005). As Handberg and Li put it, "Yang basically sat in his seat for the entire flight, minimizing the possibility of mishap" (Handberg & Li, 2007). During his flight, Yang fastidiously made reports regarding the status of his flight and carried out tasks such as eating and resting, but did not perform any of the manual maneuvers that the Mercury astronauts had fought so hard to be given the opportunity to do.

Of course, one could point out to the greater risk aversion of the Chinese to explain the decision of the Shenzhou management to rely on automatic systems during the Shenzhou 5 launch, but of greater interest here is the difference in reactions of the Mercury astronauts and Shenzhou taikonauts to the level of manual control that was initially planned for in their spacecraft. The Mercury astronauts wanted to ensure that they would not be passive passengers but instead have a significant degree of control over their launch, whereas the Shenzhou taikonauts were comfortable with such a passive role and made no demands for a greater level of autonomy during their flight. This eventually led to very different levels of initiative and effort that were demanded of the astronauts and taikonauts during their manned spaceflights. Indeed, Yeager would have lost the chance to continue taunting the Mercury astronauts upon the installation of manual controls in the Mercury spacecraft, but 40 years later, ironically, his taunts would become the most relevant for a program for which they mattered the least.

6.8 The Media and Popular Representation

It is perhaps apt to round off the comparison of Project Mercury and the Shenzhou Program by returning to an analysis of how these programs were eventually presented to the public since they were both originally conceived with a strong focus on conveying a message – for the US, this was the message that the Space Race would not be lost to the Russians and that American national prestige would be firmly reestablished in the space arena, and for the Chinese, this was the message that China as a big country like the US and Russia clearly deserved a place at the table amongst these two space pioneers and would prove its worth on the international stage.

Essentially, the Mercury launches were made a public affair, with the launches of Shepard, Grissom and finally Glenn covered live on television. Allen describes Shepard's flight as being "in the full glare of the American media spotlight – hundreds of film and television cameras at Cape Canaveral and live television coverage watched by more than 45 million people across the USA" and Glenn's flight as one that prompted American television networks and NASA to work "closely together to forge an event of national interest and self-affirmation which would succeed in drawing the largest possible audience American television networks had ever attracted" (Allen, 2009). According to Burgess, "following the unexpected orbital mission of Yuri Gagarin and the nation's growing eagerness for an American to be launched in to space, NASA had decided that as they were a civilian space agency and Mercury was an open program – unlike that of the Soviet Union – they would permit each flight to be televised live. On being assured about the abort system's capabilities, the thoroughness of the training…President Kennedy had agreed that the world should see the launch live." (Burgess, 2014) It was probably considered critical, therefore, for the launches to be viewed by everyone in order to achieve the very goals that Project Mercury had set out to achieve. This was eventually accomplished but at great expense, due to the need to station "hundreds of personnel across America", the long duration of the launches, as well as the fact that each launch cancellation, most notably for Glenn's flight, resulted in unrecoverable costs for the networks which would have had no way of knowing beforehand whether the launch for a particular day would actually be carried out.

On the other hand, the Chinese had always been extremely secretive about their launches, and when Shenzhou 5 came around, the Chinese government was in fact still debating during launch preparations over whether it should be covered live and broadcast on national television even though they had earlier stated that the launch would be covered live (Harvey, 2004). Eventually, they made the decision to not provide live coverage but instead released time-delayed footage, with the apparent aim of retaining control of the video feeds in the unlikely event that something did go catastrophically wrong (Handberg & Li, 2007).

In other words, both the US and China recognized that extensive coverage of the launch was important to both of their goals, but eventually differed in their choices on whether live coverage of the launch would be provided. To the US live coverage was eventually deemed necessary in spite of the significant risk and cost, while to China live coverage was eventually rejected in spite of the confident and assured image that it was trying so hard to convey to the world. Essentially these differences boiled down to the same cultural issues explored in Sections 4.5 and 5.3. The US needed to provide open, honest coverage about the launch that would bring the launch proceedings right into the homes of the American public and allow the entire nation to partake in an effort meant at regaining national pride. This did not mean that the Mercury engineers or the US government were unaware of the nature of the risks they were facing or did not have concerns about the reliability of the launches, but these were eventually overridden on the basis of assurances from reports and more importantly, for the comparably more important priority of achieving a significant collective national milestone whose message would not be lost amongst after-the-fact reports or due to the lack of live footage.

On the other hand, the Chinese had, in the years leading up to the Shenzhou 5 launch, been working tremendously hard to prove to the world that China was indeed worthy of the achievement of manned spaceflight. Live coverage of the launch would thus be the ultimate statement of Chinese confidence and technological superiority; indeed if their track record for the previous 4 launches was anything to go by, their rigorous quality control measures and incredibly meticulous planning which gave them a string of successes should have pointed to the decision to go ahead with live coverage, especially since a failed launch would hardly have escaped the public eye anyway. However, the risk of losing face, especially in the eyes of the international media, eventually proved to be too significant a risk for the Chinese to take. They were willing to sacrifice the glory that would be obtained from fearlessly pushing out live coverage and to tolerate the judgments of people regarding their time-delayed broadcasts in return for the ability to cancel the broadcasts on the off chance that anything untoward happened during the launch.

Equally interesting is the media portrayal of the eventual landing of the astronauts. Upon landing in the Atlantic Ocean, Glenn's Mercury spacecraft was picked up by the USS *Noa* with him still inside. According to Catchpole, "Glenn began preparing to exit through the neck of the spacecraft, but ultimately warned everyone to stand clear and then blew the side hatch explosive chord. His first words to the recovery crew were, 'It was hot in there'." (Catchpole, 2001) Glenn himself explains that "I was still so uncomfortably hot, however, that I decided there was no point in going out the hard way. After warning the deck crew to stand clear, and receiving clearance that all of the men were out of the way, I hit the handle which blew the hatch. I got my only wound of the day doing it – two skinned knuckles on my right hand where the plunger snapped back into place after I reached back to hit it. Then I climbed out on deck" (Carpenter, et al., 1962). The entire incident was captured and reported as it happened.

The Shenzhou 5 spacecraft, on the other hand, landed on the grassy fields of Inner Mongolia, and the landing was proudly broadcasted and claimed to be a resounding success. Yang Liwei emerged from the capsule in perfect condition and waved to the crew waiting for him outside. In fact, Deng claims that "由于跟踪及时，落点预报准确，搜救人员创造了搜救直升机与返回舱几乎同时着陆的航天奇迹，并拍摄到飞船返回舱打开主伞等壮观场面" (Due to successful tracking and accurate landing point prediction efforts, the retrieval crew created an aerospace miracle of the retrieval helicopter and the reentry module landing at almost exactly the same time, and captured magnificent footage of the opening of the main chute of the spacecraft's reentry module) and that the Shenzhou 5 launch was perfect in every way – "晴好的天气、精确的时间、准确地落地点、精干的航天员，每一个环节都完美无缺" (Beautiful weather, precise timing, accurate landing, outstanding taikonauts, every aspect [of the launch] was perfect and flawless.) (邓宁丰, 2004)

Indeed, it was precisely such an image of a perfect launch that China was so eager to show off to the world. However, it was only years later that the world found out that the landing had not been the flawless one that was reported by the Chinese media. According to Xia Lin, an official from Xinhua, the Chinese state news agency, "the mission was not so picture-perfect…a design flaw had exposed the astronaut to excessive G-force pressure during re-entry, splitting his lip and drenching his face in blood. Startled but undaunted by Mr. Yang's appearance, the workers quickly mopped up the blood, strapped him back in his seat and shut the door. Then, with the cameras rolling, the cabin door swung open again, revealing an unblemished moment of triumph for all the world to see." (Jacobs, 2010)

Concerns about media ethics (which Project Mercury is arguably not a stranger to) aside, it is interesting that the Chinese thought it necessary to clean up Yang's bloodstains and require that he exit the reentry module a second time to obtain footage deemed fit for broadcasting; after all, Yang had arrived back on Earth relatively unscathed, with only a split lip, and few people would say that this jeopardized the overall launch or detracted from China's accomplishment of manned spaceflight in any significant way. It would have been a simple matter to hand him a towel before he made any pronouncements; making him return into the cabin for a choreographed exit would probably have seemed unnatural and unnecessary if the same incident had taken place in the US during a Mercury flight. In fact, one might even go so far as to imagine that a Mercury astronaut emerging victorious from the spacecraft with superficial injuries as a mark of his surviving the country's first manned spaceflight might not be such a bad thing after all, or at least not the serious problem that the Chinese retrieval crew had made it out to be. The concern with preserving face was essentially hanging over the Shenzhou program all the way up to the moment Yang stepped out of the capsule; the Chinese perceived that having their taikonaut emerging with a bloodied face from the Shenzhou spacecraft went against the public image of a flawless launch that they were so carefully trying to cultivate, and thus decided to go all out to preserve this image even if it necessitated ordering Yang to return into his capsule and reemerge again in an awkward fashion in front of all the crew members present who knew what exactly was going on. In contrast, Glenn's flight, flaws and all, were captured and reported as they were, including his gung-ho approach to exiting his spacecraft and his emerging from the capsule conveying the can-do mentality and spirit of openness, achievement and heroism that Project Mercury had always strived to define itself by.

6.9 Conclusion

It can be seen from above that a great number of differences existed between the people of Project Mercury and the people of the Shenzhou Program, in terms of how decisions were made, how employees were motivated, how power was exercised, how astronauts were involved, how the engineers and astronauts interacted, and how the programs were represented in the media. These differences can ultimately be traced back to differences between the US and China along three main cultural dimensions – power distance, individualism vs. collectivism, and indulgence vs. restraint.

Ultimately, these differences were not purely cosmetic or merely interesting phenomena in the history of the Mercury and Shenzhou programs; they all had great implications on whether these two nations would have eventually succeeded in attaining their goals. The outcome of the manned spaceflight programs would have depended greatly on, among others, whether decisions were made effectively, whether employees were motivated, whether power was exercised wisely, whether the roles of the engineers and astronauts were scoped out effectively, and whether the story the world heard was the one the country wanted to tell.

It may be tempting to view the answers to these questions from a particular perspective, from a point of view that one is more conditioned to. For example, it may seem natural to an individual coming from a culture with a lower power distance that power should not be exercised in an unreasonable and authoritative manner by virtue of differences in position, but rather in a practical manner for convenience, keeping in mind that subordinates while lower in hierarchy are still individuals that are inherently equal to himself/herself. Not doing so and treating a subordinate as if he/she were inherently a lower being would obviously have counter-productive consequences and lead to dissent, unhappiness or perhaps even non-compliance or rebellious behavior. One would not expect the managers of Project Mercury to order the engineers to meet unreasonable deadlines that would have necessitated excessive levels of overtime, or threaten to punish employees for mistakes that they had not yet committed and would not have wanted to commit if they could help it at all. Perhaps this same individual might expect the same standards of Shenzhou Program, and might thus view some aspects of the behavior of Shenzhou managers as unreasonable or greatly in need of improvement.

In truth, there are no right or wrong answers to these issues. The Shenzhou managers acted in the way they did because they knew that that was a prerogative of people in positions of authority in a high power distance culture, and simply wanted to get the task done by utilizing methods that they judged to be the most effective. The Shenzhou employees that were the target of such treatment accepted this in the context of a high power distance culture and committed themselves to doing their best given the constraints, with an end result that was positive. To be clear, this does not mean that the Shenzhou employees were necessarily completely happy with the way things were, nor does it mean that they did not at any time wonder if things could be different. Rather, it was a function of the prevailing culture of the time and the context the employees were in that led to these outcomes.

Would the Shenzhou program have succeeded, or succeeded as quickly, if the managers had shied away from such authoritarian approaches and adopted an approach characterized by bargaining and reasoning? Would it have succeeded, or succeeded more quickly, if decisions were made on an individual basis instead of a collective basis? If the managers had motivated employees using far more individualistic incentives? If the engineers were offered very competitive remuneration? If a great deal of levity had been injected into the process? If the broadcast of the launch could not be time-delayed? There are no straightforward answers to these questions, not least because the only easy answer is the non-answer that the Chinese wouldn't have done so in the first place. But even if there are no easy answers to these questions, they are certainly worth thinking about.

7. Conclusion

7.1 Summary of Cultural Differences Explored

In summary, Chapter 4 focused on the purpose that drove the Mercury and Shenzhou programs and demonstrated that differences along the individualism vs. collectivism and power distance dimensions resulted in the US and China embarking on their respective manned spaceflight programs for the broad reason of national prestige, but more specifically, the former to rectify a loss of self-respect, and the latter to rectify a loss of face; differences in the nature of their respective organizations responsible for manned spaceflight, with the American NASA being an open organization and the Chinese CMSEO being a closed, secretive one; and lastly differences in the way each country arrived at the decision to proceed with a manned spaceflight program and the way the top leaders of each country were convinced to approve it, with the US relying on objective due process and honest, open debate, and China relying on informal patronage networks and collective decisions.

Chapter 5 focused on the program outcomes of Mercury and Shenzhou and demonstrated that differences along the individualism vs. collectivism dimension resulted in different attitudes of each country towards launch failure, which ultimately resulted in differences in the program scope and schedule of the Mercury and Shenzhou programs, more specifically in terms of the scope of the Shenzhou program being limited in its number of launches and only to those that Chinese engineers were confident of succeeding in, and the schedule of the Shenzhou program being greatly lengthened due to the need for comprehensive ground testing and extreme quality control measures compared to Project Mercury. This was ultimately due to China adopting a view that launch failures led to a loss of face and had to be prevented at all costs, and the US adopting a view that launch failures were inevitable and indeed necessary for the discovery and correction of flaws, with the concept of face being less salient.

Chapter 6 focused on the people involved in the Mercury and Shenzhou programs and demonstrated that differences along the individualism vs. collectivism, power distance and indulgence vs. restraint dimensions led to differences in how decisions were made, how the engineers (and astronauts) were motivated in the programs, how the program leaders exercised their authority, how the engineers viewed their compensation during their time with the program, the extent to which the astronauts were involved in the program, the extent to which their work was characterized by levity or formality, the relative acceptance of manual vs. automatic control in the spacecraft, and media portrayal of the astronauts during launch and reentry.

7.2 Findings and Implications

This thesis set out to answer the primary research question of "**Do cultural differences have an influence on a systems engineering endeavor?**" The analyses above and the conclusions drawn from Chapters 4, 5 and 6 demonstrate, using a case study of the US and China manned spaceflight programs, that cultural differences do indeed have an influence on a systems engineering endeavor that warrants consideration during the design and planning of such an endeavor.

With regard to the secondary research questions, the first question of "how should culture be defined in a manner that is meaningful and relevant to an investigation of its influence on systems engineering?" was addressed through Chapters 2 and 3. An approach which looks at inherent cultural factors across geographical lines at a national level was found to be the most meaningful and useful definition for culture when investigating its influence on systems engineering, and Hofstede's cultural dimensions theory has been found to be an appropriate and useful tool in qualifying this influence.

Chapters 4, 5 and 6 addressed the second question "What is the nature of such a potential influence and through what mechanisms might it impact a systems engineering endeavor?". It was shown that cultural differences have an influence on the process leading up to the commencement of the systems engineering endeavor, as well as on the endeavor itself on a strategic level down to a tactical or operational level. Cultural differences may thus have a pervasive impact on many levels of a systems engineering endeavor, and their influence cannot be underestimated.

This chapter, Chapter 7, thus seeks to answer the last secondary research question "If such an influence does exist, what implications does this have and what recommendations can be drawn for systems engineering endeavors in the future?".

Although it has been mentioned throughout this analysis, it perhaps should be emphasized once again that the differences between Project Mercury and the Shenzhou Program and their underlying cultural dimensions are not dichotomous. It is, for example, not the case that China was a purely collectivist society with no individualist elements, nor is it the case that the US is a purely individualist society with no collectivist elements. Neither is it the case, by extension, that the Shenzhou managers caring a great deal about launch failures implies that the Mercury managers were entirely unconcerned about launch failures. Rather, these differences outlined above and their cultural drivers all exist on a continuum, with relative tendencies towards one end of the continuum or the other instead of absolutes. The Shenzhou program was situated in a relatively more collectivist society than Project Mercury, and the Mercury managers were relatively less concerned about launch failures than the Shenzhou managers. It is the recognition of these degrees of relativity that is crucial for any meaningful analysis.

What implications, then, might be drawn from the analyses of the previous chapters? Was the way one program was carried out better than the other? Should we advocate a "Mercury" or "Shenzhou" approach to a country that hopes to one day become the fourth member of the current group of countries who have achieved manned spaceflight? Or should we attempt to extract the "best" elements of both programs and come up with an optimal, hybrid solution to the problem of how to architect a manned spaceflight program? Clearly the cultural differences and motivations outlined above are significant in the context of such a program; how should we tap our knowledge of them?

There are many ways to evaluate a systems engineering endeavor and just as many questions that can be posed with this intent – Did it achieve its intended goals? Did it satisfy its stakeholders? Did it reap the expected returns? Was it on schedule? Was it within budget? Did it leave a lasting impression on the minds of the people? Was it all worth it? Given another chance, would you do it all over again? Clearly, neither program would be able to yield a perfectly positive answer to all of these questions; schedule delays, budget overruns, shifting targets, unsatisfied critics, unexpected hurdles – these problems existed for both Project Mercury and the Shenzhou Program, just as they would most probably exist for any other systems engineering endeavor of comparable magnitude, complexity and significance. But what would the answer be if we put all these quantitative and formal questions aside and asked a Mercury astronaut, or a Shenzhou engineer, or an American or Chinese citizen if their country's first manned spaceflight program was worth it? If the media aftermath of Glenn and Yang's flight, the outpouring of national pride that resulted, and legacy that these two programs have left for the US and China is anything to go by, the answer would probably be a positive one.

The most interesting thing was that despite all these differences, or perhaps it was precisely because of all these differences, that both countries considered their respective manned spaceflight programs a success. A vital takeaway from the analysis above is that it cannot be said that any particular aspect of the Mercury program was better than the Shenzhou program; the US and China were being influenced by significantly different cultural drivers and ultimately, the Mercury and Shenzhou programs were shaped by the underlying culture that they were situated in and so closely tied to.

The beauty really was that there was always a tradeoff involved in each of these differences. For example, as Hofstede explains, "there is no research evidence of a systematic difference in effectiveness between organizations in large-power-distance versus small-power-distance countries. They may be good at different tasks: small-power-distance cultures at tasks demanding subordinate initiative, large-power-distance cultures at tasks demanding discipline. The important thing is for management to utilize the strengths of the local culture" (Hofstede, Hofstede, & Minkov, 2010) The large power distance culture that characterized the Shenzhou program allowed for the exertion of authority, the imposition of discipline, and the achievement of deadlines that might not have been possible under a small power distance culture; but it may have done little favors for individual initiative. The small power distance culture that characterized Project Mercury allowed for greater input from engineers at lower levels of the hierarchy, but may not have facilitated the adoption of decisions that individuals passionately disagreed with.

Similarly, Hofstede stated that "The late chairman Mao Zedong of China identified individualism as evil. He found individualism and liberalism responsible for selfishness and aversion to discipline; they led people to placing personal interests above those of the group or simply to devoting too much attention to their own things." (Hofstede, Hofstede, & Minkov, 2010) Collectivism certainly served the Shenzhou Program well, by creating a strong source of motivation for engineers and promoting harmony amongst the group; but over-reliance on the group may have prolonged decision-making unnecessarily at certain points in time. On the other hand, "devoting too much attention to their own things" is not necessarily a bad thing when the task at hand calls for individual initiative, courage and focus. Perhaps the pioneering spirit and the drive to lead the pack as an individual that was so critical to the Mercury program that was treading into unchartered territory would not have materialized if not for an individualistic thirst for challenge and glory.

But these tradeoffs never existed consciously in the minds of the architects of the Mercury and Shenzhou programs. Should we rely on individualist or collectivist methods to convince our leadership of a space program and motivate our employees? What attitudes towards power distance should drive our architecting of our national agencies for manned spaceflight? Should we allow individualism or collectivism to drive our engineers' mode of decision-making and views towards launch failure? Should we allow indulgence or restraint to prescribe the behavior of our astronauts? – The people involved in Mercury and Shenzhou would not have framed these questions in such an unnatural and stark manner and posed them to themselves. But that does not mean they did not answer them, for they did so with their actions. And because of their inherent cultural differences, these two groups of people chose to answer these questions in their own unique way, not entirely because they felt it was the best way, but primarily because it was their way. An unspoken tradeoff between the two ends of certain cultural dimensions may exist in the eyes of an external observer, but when the people who are actually affected by this tradeoff vote with their actions, it becomes clear which side of this invisible tradeoff they would rather fall on, and it is often the side that they have been conditioned to identify with throughout their lives.

The crux then is that each country adopted a style that was in line with its prevalent national culture and utilized that fit to its advantage. Falling on one side of a cultural tradeoff often implied that the "advantages" conferred by that side were accepted as more important than the "disadvantages" that came with it. Staying true to their values, the two cultures carried out their space program in line with the entrenched cultural ways in which they were used to doing things, ways that wouldn't have become entrenched in the respective societies in the first place if they hadn't been tested and validated over time to have proven to be effective cultural norms within their respective geographical contexts. This eventually allowed them to achieve success by following their own unique path.

An interesting thought experiment then, would be to consider what would happen if each country had utilized culturally-driven elements of the other country's manned spaceflight program instead. What would happen if such "cultural dissonance" had arisen, if each country had chosen to act in ways that were in opposition to what their national cultural characteristics might suggest?

It turns out that incidents of this nature were indeed present in Project Mercury. During John Glenn's Friendship 7 flight, a signal was received by the flight command that the heat shield on Glenn's spacecraft had become detached, a serious issue as the heat shield would have been vital for protection of the reentry module as it entered the Earth's atmosphere. This was eventually found out to be an erroneous signal after the mission, which at that time was what Flight Director Christopher Kraft strongly believed to be the case, but discussions with Maxime Faget and John Yardley resulted in the decision to get Glenn to reenter with his Retrograde Package still attached, in the hope that this would also keep the heatshield sandwiched between the Retrograde Package and the capsule in place for as long as possible if it truly had become detached. However, the problem and the reason for this solution were never communicated to Glenn; indeed Kraft "decided to keep Glenn oblivious of the signal suggesting that the heat shield was loose" (Catchpole, 2001). The instruction issued to Glenn was "to keep your landing bag switch in the off position. Landing bag switch in the off position. Over" with no accompanying explanation, with which Glenn complied. He was subsequently asked "Will you confirm the landing bag switch is in the OFF position?", to which he replied "affirmative", as well as "You haven't had any banging noises or anything of this type at higher rates?", to which he replied "negative." At this point in time Glenn would probably have been mildly confused; in his words "It was clear to me now that the people down on the ground were really concerned or they would not be asking such leading questions" (Carpenter, et al., 1962).

Perhaps what really gave the game away was when Glenn passed over Canton Island and was told "We also have no indication that your landing bag might be deployed.", to which he asked "Did someone report the landing bag could be down?". The Canton Island CapCom then replied that "Negative, we were asked to monitor this and ask if you heard any flapping when you had high Spacecraft rates". Eventually on Glenn's last orbit, he was asked to perform a test to test the hypothesis that the signal was indeed a faulty one, and the test results supported this hypothesis, causing Kraft to instruct the Hawaii CapCom to tell Glenn to proceed with the standard reentry sequence. However, Kraft was later overridden by Walt Williams (the Flight Operations Director) who then asked Texas CapCom to tell Glenn to leave the retro-package on instead, to which Glenn asked "What is the reason for this? Do you have any reason? Over." He was then told "Not at this time. This is the judgment of Cape Flight [Director]". Eventually, it was only when Alan Shepard started communicating with Glenn that he was told "we are not sure whether or not your landing bag has deployed", which was when Glenn "finally learned for certain what the problem was". There was finally an attempt by Shepard to "recommend to Glenn that he jettison the retro-pack as soon as the Gs built up to 1 or 1.5", but Glenn failed to receive this message due to the communications black-out. (Catchpole, 2001) (Carpenter, et al., 1962)

Fortunately, Glenn survived the flight, but he was apparently not pleased with the way events had played out. In his recount of the incident in *We Seven*, he stated that "[At that time] I was still not overly concerned because I had had no indication in the capsule that anything was wrong. Looking back on the whole event, I realize that the controllers were trying to keep me from being worried about the situation. I really don't think, however, that you ought to keep the pilot in the dark, especially if you believe he might be in real trouble. It is the pilot's job to be as ready for emergencies as anyone else, if not more so. And he can hardly be fully prepared if he is not being kept fully informed." (Carpenter, et al., 1962) In his pilot's flight report, Glenn wrote that "I feel it more advisable in the event of suspected malfunctions, such as the heat-shield-retropack difficulties, that require extensive discussion among ground personnel to keep the pilot updated on each bit of information rather than waiting for a final clear cut recommendation from the ground. This keeps the pilot fully informed if there would happen to be any communication difficulty and it became necessary for him to make all decisions from onboard information." (Godwin, 1999)

This example is a particularly interesting case because the events that occurred seem to go against what might be culturally expected of a Project Mercury manned spaceflight – withholding of information from the astronaut in-flight, lack of consultation and openness with subordinates, overriding of the technical discretion of the Flight Director by higher authority, and ignoring the importance of control of the flight to the astronaut. Glenn, who would naturally have expected to be consulted, provided with information, and involved as part of the flight team was instead purposefully kept in the dark, authoritatively given commands to follow that were related to the problem at hand without being told why these commands were given, and still was not given an explanation when he repeatedly tried to find out what was going on. To be fair, Glenn stated that this might have been done to keep him from getting worried, but he still felt that this did not justify the problem being handled in such a manner.

Another example of such "cultural dissonance" occurred during the lead up to the very first Mercury test launch – the Little Joe 1 flight that occurred on August 21, 1959. The engineers involved in the preparation for the launch had discovered erroneous wiring in the rocket but when they questioned this, it was discovered that the wiring had indeed been implemented as reflected in the official drawings of the rocket and their doubts were not acted upon. Eventually, on launch day, this error caused the LES to fire prematurely, leaving the rocket on the launch pad and damaging the spacecraft in an explosion. Catchpole states that "NASA had been encouraging the engineers preparing the launch to work overtime in order to catch up on a launch schedule that was running late. Even so, the official report lay the blame for the LJ-1 debacle at the feet of the over-tired engineers for not recognizing the potential for such an event when they had questioned the original routeing of the wire" (Catchpole, 2001). This again reflects events that would not have been expected of Project Mercury – the reluctance of the engineers to engage in confrontation when they clearly knew that a serious flaw indeed existed, their decision to conform to authority, the lack of consultation of subordinates who had raised doubts by those in positions of authority, and the blaming of subordinates lower down the hierarchy for being the ones at fault.

In the case of the Shenzhou Program, an incident of "cultural dissonance" that had the opposite effect occurred during the development of the LES. At that time, it was found that the payload fairing upon production was severely overweight, which was a huge problem. The aftermath of the discovery of this problem was described as such: Wu Yansheng, the head of the design department of the China Academy of Launch Technology, "向单位领导和老专家汇报后，等着接收来自各方面的批评。出乎他意料的是，各级领导和专家得知情况后，都积极帮助他们分析查找超重问题的原因，寻找解决的途径" (reported this problem to the various leaders and experts, and awaited the reprimands from all these parties. But in a total surprise to him, upon receiving new of this problem, the various leaders and experts went out their way to help him analyze the cause of the extra weight and develop solutions) (邓宁丰, 2004) It is perhaps very telling to note that Wu was "surprised" by the unexpected lack of punishment for failing in his duties as well as the fact that his superiors instead offered their help to solve the problem; this in a way reflects the kind of atmosphere that one might have expected of the Shenzhou program. Instead of relying on "formal authority and sanctions" which are what might be relied on in a high power distance culture due to their perceived effectiveness at influencing subordinates to perform (Hofstede G. H., 2001), Wu's superiors instead acted as the kind of consultative leaders that might be more characteristic of Project Mercury than the Shenzhou Program, which in this case had a pleasantly surprising outcome.

The examples above demonstrate, as explained above, that elements of what might be least expected of a certain culture would still exist in it in reality as none of the dimensions or tendencies of behavior are truly absolute. But they also show that when events occurred during the programs that went against prevailing cultural tendencies, the resulting emotions were either irritation or indignation if the outcome was a negative one, or surprise if the outcome was a positive one. If it is indeed true that the adoption of practices in line with prevailing cultural norms resulted in a successful outcome for Project Mercury and the Shenzhou Program, do these examples of "cultural dissonance" support this? The examples from Project Mercury seem to do so, but what about the Shenzhou Program?

Perhaps one would conclude that the Chinese should then stop relying on their traditional authoritarian mindsets and start acting in a consultative manner with their subordinates, ignoring the power distance that has long been tapped on to enforce such authority, doing away with the formal sanctions and close supervision, and focusing on using consultation as a way to motivate their employees. But in truth, it would be difficult to claim that this would definitely be a good thing. If employees who have traditionally been used to being motivated by authority and sanctions are suddenly expected to be driven by consultation and a lighter touch, repercussions on their performance and productivity may very well result. This may seem to be a fairly egregious argument, especially from the point of view of a society where consultative leadership and low power distance are believed to be certainly more effective motivators than their opposites, but it is definitely an argument that needs to be considered when the context in consideration is a society that has traditionally been characterized in many aspects of life by high power distance and where people have been culturally conditioned from young to respond most effectively to it.

In addition, a probably more convincing thought experiment would involve looking at the overall picture and moving away from individual incidents. What would have happened if Project Mercury had been carried out in the way the Shenzhou Program had been carried out, and vice versa? Would the US have been willing to tolerate losing the Space Race spectacularly due to a lengthened flight schedule even if that meant that they had a perfect launch record? Would the American public have been willing to accept a closed and secretive program when it was intended to give them back their self-respect and national pride? Would the Chinese have been willing to achieve the goal of manned spaceflight sooner if it meant that every other test launch of theirs was perceived as being mocked on the world stage and as an embarrassment in front of the entire nation? Would the Shenzhou managers have accepted even longer delays in the already lengthy program schedule just to play the role of benevolent, understanding leaders who would never authoritatively impose unreasonable demands on their employees? The answer to these questions is probably a negative one.

On the surface, this may seem like a circular argument: the US and China carried out their respective manned spaceflight programs in line with their prevailing national culture, and it was precisely this prevailing national culture that judged these actions a success. However, it should be pointed out that it cannot always be taken for granted that a systems engineering endeavor will inevitably be carried out in line with the prevailing national culture, as the above examples of "cultural dissonance" demonstrate, nor can it always be assumed that it is a straightforward matter to architect a systems engineering endeavor in line with the prevailing national culture. With reference to the fairly provocative quote at the beginning of Chapter 5 by McDougall that "*the United States…is perversely ill-suited to what spaceflight requires. Given the costs, lead-times, and distances involved, the pioneering of space requires a coherent, sustainable, long-term approach, predictably financed and supported by a patient people willing to sacrifice and delay gratification even over a generation or more. Americans do not fit that description*", it seems that it is implied that the very nature of a pioneering space program goes against the cultural norms of Americans.

However, it is probably more constructive to point out that if it is recognized that American culture does not facilitate the long-term approach that the pioneering of space requires, perhaps a different approach should be taken instead of trying to force a systems engineering endeavor that goes against this prevailing culture through to completion. How may the pioneering of space be conducted without having it be a long-term approach that will require delayed gratification? If Project Mercury is any guide to go by, perhaps a space program characterized by a greater tolerance for failure, more flexibility, and less bureaucracy might allow for the achievement of shorter-term milestones that contribute incrementally to long-term objectives and which do not require the "delaying of gratification over a generation or more", qualities that McCurdy explains used to be hallmarks of early US space endeavors like Project Mercury but which are unfortunately lacking in the NASA of today (McCurdy, 1993). Or perhaps it may be worthwhile to consider engaging in a bilateral or multilateral space exploration program that taps on other cultures that are indeed willing to take on what McDougall feels the culture of the US is "ill-suited for". The political realities of today have precluded the realization of any such program that could possibly harness the various cultural characteristics of both the US and China that this thesis has explored so far, but this may not necessarily be the case in the future.

7.3 Recommendations

Three main recommendations thus follow from the analyses above. On the first level, it is probably wise during the process of architecting a systems engineering endeavor to evaluate the culture that such an effort is situated in and consider aligning such an effort with the prevailing cultural norms for maximum effect. A caveat that immediately follows is that this would of course depend on the goals and context of the systems engineering endeavor at hand. If the systems engineering endeavor is a relatively simple one that does not have a significant degree of complexity or uncertainty, it may be more expedient to rely on efficiency or other metrics as criteria to architect such an effort instead of spending a lengthy amount of time on considering the effects of culture. In addition, another caveat would be that although aligning a systems engineering endeavor with the prevailing culture is certainly beneficial, it is not a hard-and-fast rule. Certain cultural practices that may not be commonly found in a particular culture may turn out to be beneficial for an aspect of a systems engineering endeavor, especially if this effort is intended to be a disruptive one; under such conditions, it may be found that importing "foreign" cultural practices may be of value to the overall systems engineering endeavor, although a holistic consideration of the long-term impacts of doing so should also feature in the evaluation process before such a decision is made.

On the second level, bicultural and indeed multicultural systems engineering endeavors need to be characterized by a recognition that culture is indeed an important consideration in systems engineering, and that cultural differences do have a real impact on the way people from different cultures may choose to perceive the world and work towards their goals. Especially since such efforts will only continue to become more ubiquitous in the future, such an understanding is necessary to avoid the pitfalls of negative reactions to actions that may seem indecipherable, but which are completely understandable from a cultural point of view if cultural differences are acknowledged. Negative reactions founded upon a lack of understanding or appreciation for the very real influence of cultural differences on systems engineering endeavors will most likely harm rather than facilitate the process. Acceptance that these cultural differences exist and are not something to be eradicated or ignored is a step closer to ensuring that these differences do not adversely affect a systems engineering endeavor.

On the third level, within a global systems engineering ecosystem, the day may come when such cultural differences are seen to be a source of opportunities to tap on rather than as a source of irritations or conflicts that needs to be tolerated. A greater appreciation of how different cultural makeups result in different systems engineering approaches and the pros and cons for each may result in a more efficient and informed delegation of work within a combined effort. While currently a difficult proposition to realize due to the undeniable sensitivity of the implied cultural generalizations that would come with it, it is a possibility that time and a great deal of effort by the human race may erode the source of these sensitivities. In such a world, leveraging differences in culture to enhance complex systems engineering endeavors may become a reality that is probably not achievable at present time.

7.4 Limitations and Future Work

Certain limitations exist with this thesis that hopefully can be addressed through future work. Firstly, although Hofstede's cultural dimensions theory was found to be the most appropriate framework for an investigation of the influence of cultural differences on systems engineering, there may exist other frameworks, some of which may be developed in the future, that may serve as a useful complement to Hofstede's work. Future research may focus on what elements of other frameworks could also be brought into the discussion to complement Hofstede's framework in areas that it may fall short in.

In addition, the case study of the US and China manned spaceflight programs is but one example of the influence of cultural differences on systems engineering. Further work on other areas of systems engineering may shed light on other kinds of cultural differences that may not be salient in the area of manned spaceflight but which may be significant in other fields. Studies involving other cultures and also a greater number of cultures would also serve to further improve the comprehensiveness and quality of the analysis above, as well as raise issues that may not have been brought up through a comparison of Project Mercury and the Shenzhou Program. An interesting extension would be the inclusion of the former Soviet Union or Russia into the analysis of manned spaceflight programs, thereby covering the very different cultures of all three nations who have successfully achieved manned spaceflight.

Furthermore, the recommendations of this thesis would still need to stand up to validation in the real world. Empirical case studies of systems engineering endeavors that are intentionally architected to take into account the prevailing national culture, or real-life examples of bicultural or multicultural systems engineering endeavors that intentionally draw on differences in culture to enhance the overall endeavor would eventually be needed to speak to the validity of these recommendations, which hopefully will reveal a promising opportunity for even greater cultural synergy in systems engineering endeavors in the future.

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