THE REPRESENTATION OF INTERNATIONAL STATES, SOCIETIES, AND CULTURES IN TWENTY-FIRST CENTURY SPACE-THEMED EXHIBITS: AN ANTHROPOLOGICAL INQUIRY INTO MUSEUMS IN CALIFORNIA, OREGON, WASHINGTON, AND BRITISH COLUMBIA

A Thesis

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in

Anthropology

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Fall 2017

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A Thesis

by

William Robert Townsend

Fall 2017

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DEDICATION

I dedicate this thesis in memory of my grandmother,

Elizabeth Ann Gerisch,

for having taken me to Italy and, in doing so,

inspiring my interest in cultural history.

Grazie, nonna.

ACKNOWLEDGEMENTS

Foremost, I would like to thank my wonderful wife, Yaneli Torres Townsend, who has been by my side through the excitement, stress, and countless sleepless study-nights of both undergraduate and graduate school. *Forever and always.* I would also like to thank my amazing mom, Mary Ann Townsend, for always believing in me and for encouraging me to aim a little higher. As for my dad, Edward Townsend, thank you for taking me adventuring under the stars during our camping trips when I was young—our walks and philosophical conversations inspired my awe of the cosmos, and this thesis is undoubtedly an extension of that wonderment.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

THE REPRESENTATION OF INTERNATIONAL STATES, SOCIETIES, AND CULTURES IN TWENTY-FIRST CENTURY SPACE-THEMED EXHIBITS: AN ANTHROPOLOGICAL INQUIRY INTO MUSEUMS IN CALIFORNIA, OREGON, WASHINGTON, AND BRITISH COLUMBIA

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This thesis investigates the inclusion and exclusion of cultural information within museum exhibitions at space and science centers, aerospace museums, planetariums, and public astronomical observatories in California, Oregon, Washington, and British Columbia. Aside from the Smithsonian National Air and Space Museum, museums with content on space exploration have received sparse academic attention and, prior to this thesis, no study has investigated the use of cultural content at space museums in these four regions. This topic is explored by amalgamating archival documents on the historical development of space museums, and through the study of exhibit labels and panels at 19 space museums, including a case study of the Chabot Space and Science Center in Oakland, California.

The theoretical frameworks of anthropology are used to assess the ways in which space museums use exhibit panels and labels to create specific cultural narratives. To accomplish this, data mining techniques were used to quantitatively assess how and to what extent culturally affiliated terms were incorporated into museum exhibit panels and labels. In so doing, this research both quantitatively and qualitatively assesses the extent at which international cultures and histories are represented.

In part, this thesis is intended as a critique on the current state of space museums and their exhibitions, and provides brief samples of diverse cultural narratives that might be of interest to future exhibit designers and curators, such as pre-colonial Mayan cosmology, Germany’s role in the origins of spaceflight, and the activities of modern East Asian space programs. Ultimately, this thesis demonstrates the potential data mining has for museum research, finding that space-exhibits do present multicultural narratives to varying extents, but that such narratives are less common in Southern California and become increasingly abundant the further one travels north.

CHAPTER I

INTRODUCTION TO THE STUDY

The purpose of this thesis is to investigate the representation of foreign and domestic cultures at twenty-first century space museums in California, Oregon, Washington, and Vancouver. That is, this thesis examines how space museums in these four regions display information on international space agencies, world-wide historical events, cultural histories, and information on pre-spaceflight cosmologies. Although museum objects are an important part of this discussion, my investigation focuses especially on the texts that museums present to visitors through exhibit panels and labels. I conducted this research using a variety of means, including quantitative data analysis of museum exhibit panels and labels, qualitative analysis based on field research and relevant literature, the distribution of surveys to various space museums, and through a case study at the Chabot Space and Science Center in Oakland, California.

Museum exhibitions with outer space related themes range in content, with topics spanning basic astronomy to historical narratives. Although I do briefly discuss exhibitions that are intended to be strictly scientific, my primary focus is on content with underlying cultural themes. To accomplish this, I use quantitative data mining and qualitative analysis to demonstrate that some of the investigated space museums do incorporate moderate amounts of topically relevant cultural content, whereas other space museums prefer narratives that exclusively or predominantly showcase domestic interests. Although focusing exclusively on domestic contributions to space exploration may be in the best interest of some museums—with this depending on their restrictive parameters such as floor space or budget—the consequence is that museum visitors may be misled into believing that foreign states, societies, and cultures have not contributed significantly to space exploration.

Because of the popularity of space museums for school groups, tourists, and other visitors with an interest in space science and space history, it is imperative that museums present balanced and fair representations of science and industry. My research findings demonstrate that many institutions unintentionally perpetuate a Cold War-era understanding of space history, depicting the United States as triumphant over Russia rather than incorporating relevant historical information made available after the collapse of the Soviet Union. In doing so, these space museums overlook an opportunity to include educational information about foreign space industries and cultures, such as those of Japan, China, and Europe. Critically, this risks disseminating misinformation about the history of space exploration by giving museum visitors the impression that only the United States has played a notable role in its developments.

As many other twenty-first century museums have become increasingly cognizant of their role as cultural leaders, exhibits have been more frequently designed to foster an inclusive and culturally informed global community (Fletcher 2013: 297-305), but space museums have been comparatively slow to do so. This poses a problem. Visitors with national or cultural affiliations other than those on display are likely to feel like outsiders, and may be mistakenly led to believe that people sharing their cultural heritage have not contributed to space exploration. Not only would such a belief doubtfully be correct, as many nations around the world have space programs of their own, but it also undermines the *raison d'être* of many space museums—to inspire a passion for science in all visitors so that they might take part in the growth of science and engineering.

Chapter Overview

I anticipate that some readers may begin reading this thesis wondering how anthropology is relevant to space science. A stereotyped view of anthropology and its applications conjures images of outland field researchers living among indigenous cultures, or archaeologists unearthing the artifacts of prehistory. While anthropology has been applied to a wide variety of areas of academic interest beyond these examples, it is true that the multidisciplinary approach of using anthropology to understanding human spaceflight is a nascent area of academic interest. Rarer still, few academics have used anthropology to study the ways in which museums present narratives on space history and culture. These concerns are addressed in *Chapter II: The Relevance of Anthropology to Studying Space-Themed Museum Exhibits*, in which I briefly outline how the Boasian four-field approach has been used to better understand various areas of space science, and why this approach is therefore a good fit for studying space museums.

Despite that museums are the keepers of history, few historians have studied the development of museums themselves (Conn 1998: 10). Although the Smithsonian National Air and Space Museum has adequately tracked and published on its own history, the history of space museums as a whole is notably understudied, and virtually no studies have been devoted to the development of space museums on the West Coast of the United

States. For this reason, I devote the first sections of *Chapter III: Literature Review* to presenting original research on the historical development of the space museum. The timeline I present begins with president John Quincy Adam's State of the Union Address, in which he decried the United States' lack of astronomical observatories, and concludes with a discussion of twenty-first century space museums and the challenges they face.

The remaining sections of *Chapter III: Literature Review* are intended to provide the reader with some examples on how different cultures, prehistoric and modern, have interacted with the cosmos. These sections are not exhaustive; essentially all societies have formed their own distinct cultural perspectives about space (Campion 2012: 1-10), and an entire dissertation could be devoted to how just one of those societies perceives the cosmos. Instead, I have included synopses of a few sample cultures. My purpose is two-fold: to provide information on a few cultural groups that will come up in the discussion sections of later chapters, and to provide exhibit designers with examples of cultural narratives that might be of interest.

The first of these sections, *Cultural Cosmologies before Spaceflight*, conveys that an interest in the stars is a deeply ancient experience. Societies distributed across geography and time have formed their own particularly systems of belief, sometimes leaving them behind as objects and architectural features which archaeologists can now attempt to decipher, or through oral and written narratives for historians to unravel. Such narratives are popular topics among planetarium lecturers, yet have received comparatively less attention from exhibit designers.

The subsequent sections of *Chapter III: Literature Review* present examples of national space efforts in modernity. The initial sections begin with a discussion of how German science fiction stimulated and inspired engineers to begin experimenting in rocketry after the First World War. The sections that follow trace Nazi Germany's development of the V-2 rocket, which laid the groundwork for the Space Race and, thereafter, the creation of space exploration programs in places like Europe, China and Japan. I include these narratives as an alternative to the standard exhibit storytelling that often lionizes the history of space exploration without a discussion of some of the more harrowing aspects of space history, like Nazi involvement, or discussion of the non-Cold War-era space programs, such as those of East Asia.

In *Chapter IV: Theoretical Framework*, I layout the major conceptual approaches I have used during the process of gathering and organizing information for this thesis, which I use to integrate diverse research into a synthesized whole. In particular, one of the theoretical approaches I use is the application of semiotics to the understanding of material culture—such as artifacts on display in a museum—as having symbolic meanings. This also involves the use of applied linguistics, an approach that has found favor among some activist anthropologists in which an understanding of language is used to solve real-world problems. This approach is particularly useful when considering exhibit panels and labels, and how they might be restructured to become more socioculturally inclusive. I also integrate some aspects of new museum theory, which has been used to examine the underlying intents of museum narratives.

Chapter V: Methodology lays out the primary means by which I gathered and analyzed information for this thesis, and in *Chapter VI: Results*, I discuss my research findings and interpretations. This includes a discussion of the Chabot Space and Science Center, where I interned during the summer of 2014. Because of its historic role as a West Coast space museum, I use the Chabot as a case study in this thesis. During the summer of 2015, I continued this research by traveling to 18 other space museums across California, Oregon, Washington, and British Columbia to document the content of all their relevant exhibit panels and labels. Using data analysis, I then examined the textual content at these museums to assess how and to what extent they display information related to foreign cultures.

I chose California, Oregon, Washington, and British Columbia as the focus of my study due to budgetary constraints that prevented me from traveling elsewhere to conduct this study. California was also an ideal candidate for this study because of its considerable historic role in developing space technology, and because it has an abundance of space museums. The further inclusion of Oregon, Washington, and British Columbia allowed me to examine whether Californian space museums differ from those elsewhere. To countervail my being unable to directly study space museums beyond these four locations, I distributed 244 surveys to 109 institutions across the United States and Canada. By doing so, I was able to assess how space museums in California, Oregon, Washington, and British Columbia compare to other space museums throughout North America.

In the final chapter, *Chapter VII: Conclusion*, I recapitulate some of the more interesting findings of my research. For example, that exhibit content on multiculturalism is uncommon in Southern California, but becomes increasingly common the further one travels north, reaching its peak at the space museums of Washington and British Columbia. In this chapter, I also discuss some of the limitations of my thesis and the consequent areas that should be explored in future research. Given that this thesis is one of the few research projects to investigate space museums, there is substantial room for further investigation; it is my hope that this thesis will inspire further studies that explore the historical development of the space museum and the role that these museums play in a world that is increasingly socially, politically, and culturally complex.

Background to the Study

My interest in applying anthropology to the study of human space exploration began during my undergraduate studies at the University of California, Santa Cruz. Many of my anthropology courses included brief lectures on the effects of spaceflight, such as in a course on human adaptability, where a day was devoted to considering how the human body reacts to a weightless environment and how the physiological changes that occur can help us to understand human evolution. In my senior thesis, I presented research on how the *Columbia* and *Challenger* disasters are examples of how forensic anthropology can be used to understand the hazards of emerging space technology. In addition to anthropology, I also studied earth science as an undergraduate, and a substantial portion of my courses were spent considering how humans interact with, and affect, their environments.

During this time, I also had the good fortune of studying as an intern for the historian Dr. Alan Christy. In the initial stages of the internship, we researched the experiences of a stranded Japanese solider and his struggles to adapt to the unfamiliar terrain of Manchuria immediately following the Second World War. One of the memorable anecdotes from the former soldier's interviews involved his using celestial navigation to find his way across unfamiliar and unforgiving terrain in East Asia. We later traveled to Japan to continue our research, stopping to visit various history museums along the way. I recall being deeply intrigued by Japan's museum narratives, which differed substantially from those I had been familiar with in the United States. Unsurprisingly, exhibit content at Japanese museums focused especially on the Japanese experience of history—but in ways that were at times deeply nationalistic, often forgoing the concerns and perspectives of other cultural groups.

These experiences were, in part, my reason for pursuing a graduate degree in anthropology and museum studies at California State University, Chico. My interest in cultural history developed further in Dr. Eaton's seminar course in anthropology, and greatly benefited from his allowing me the opportunity to write a final research paper on a topic of my choice. Until then, my knowledge of space history was limited to that of the United States and Soviet Union. I took up this opportunity to learn more about an exhibit panel I had seen in Japan. The text had spoken proudly and affectionately about their national space agency, JAXA. While doing research for the assignment in Dr. Eaton's class, I was impressed by the complexity of East Asia's history in terms of space exploration, and also surprised by how understudied it is.

This led me to the topic of my thesis. Initially, I began this thesis with three hypotheses to examine, compare, and contrast how space-themed museum exhibits of the West Coast portray domestic and foreign space history. The first hypothesis considered the possibility that space-history exhibits in California, Oregon, Washington, and British Columbia primarily discuss events which convey national pride and prowess, focusing especially on domestic contributions to space exploration. The second hypothesis was intended to consider whether these exhibits ignore the achievements of other modern nations in favor of almost exclusively discussing Cold War powers. Finally, the third hypothesis considered the possibility that when these museums do discuss foreign, non-Russian societies and cultures, that they draw most heavily from archaeological knowledge to depict ancient cultures as exotic and mysterious, with little to no attention given to how their modern counterparts perceive the cosmos or are involved in space science and industry.

Research for this thesis began during the spring of 2014 after speaking with Dr. Valerie Olson, an anthropologist at the University of California, Irvine, who specializes in the anthropological study of human spaceflight. Though she encouraged my pursuit of this thesis topic, she also cautioned that few anthropologists have pursued research related to space science, and that it remains a niche area of study. We both agreed that the paucity of studies that examine the relationship between culture and space exploration make the research topic an important and worthwhile pursuit. Such research has the potential to expand upon the current breadth of anthropological study and understanding by examining a curious aspect of the human condition: an interest in the cosmos.

Contribution to Anthropology and Museum Studies

The application of anthropology to understanding space exploration is a relatively new area of academic study. My thesis adds to the sparse literature by establishing that an anthropological approach is ideal for understanding how modern space museums present cultural narratives about the history of space exploration. This thesis contributes directly to the field of anthropology by demonstrating that this non-traditional topic is a viable area of research for anthropological inquiry, and by laying some of the groundwork for future anthropological research on related topics. Through this thesis, I also contribute to museums studies by weaving together historical documents and modern publications on astronomical observatories, science centers, planetariums, and aerospace museums to present a comprehensive study on their historical development and the role these museums play in the twenty-first century.

Past studies on space museums have focused almost exclusively on the curatorial concerns of aerospace collections, the technical details of planetarium projectors, the research findings of observatory telescopes, or pedagogies used in classroom-style workshops and summer camps at space science centers. Few academic studies have considered the exhibit narratives used by space museums, and consequently no museum theory has been developed to specifically address the content of space museums. To proceed without a previously developed theoretical framework, I incorporate a multidisciplinary anthropological approach that utilizes new museum theory, applied linguistics, and semiotics to assess how museum exhibit panels, labels, and objects are used to convey specific narratives about space history. This demonstrates the viability of using museum and anthropological theories to study space museums.

My intentions for this thesis are also, in part, as a pilot study to explore data mining as a tool for studying museums within an anthropological context. Data mining is a computational method for revealing patterns in large bodies of data, then re-organizing the results in a way that provides insight into relationships between the data. Within the context of this thesis, I use data mining to aggregate the text of museum panels and labels, then mark key terms associated with the same culture group, such as the words “Russia” and “cosmonaut.” This allows for the designated terms to be clustered to objectively show how frequently they appear and their relationship with other terms.

Despite that data mining is widely used in many areas of industry and academic research, anthropologists have only limitedly used data mining. Prior to this thesis, no research projects had been undertaken to use data mining as a means for studying museum texts. For this reason, I pursue this research to assess the viability of using data mining for studying museum exhibits and exhibitions, and also to explore and develop some of the data mining techniques that might be used for assessing museum panels and labels in other future studies.

By taking this multidisciplinary approach that has anthropology and museum studies at its core, I show that space museums vary in the narratives they present on cultural history. Some might struggle to see the relevance of using anthropology to study issues related to human spaceflight, but this problem is due mostly to the relative newness of this area of study rather than the feasibility of using anthropology in this way. To the contrary, anthropology is especially well suited to studying a wide range of issues related to space exploration, whether they be cultural or biological in nature, and is therefore also useful to understanding how these issues are contextualized in museums.

CHAPTER II

THE RELEVANCE OF ANTHROPOLOGY TO STUDYING SPACE-THEMED MUSEUM EXHIBITS

Applications of anthropology to space science and history are at times regarded with some aversion, if not derision (Boutsikas and Ruggles 2011: 55-56). The effect of this has been a gap in academic study and knowledge; studies on the development of spaceflight typically focus only on technical history, with few instances of integration with sociocultural history (Bainbridge 1983: 87). In these uncommon instances where such integrations do occur, non-Cold War powers generally go undiscussed. With its Boasian four-field approach using biology, archaeology, linguistics, and cultural studies bound together by an emphasis on social history (McGee and Warms 2008: 117-118), anthropology can be used to understand both modern and ancient interactions with space as a deeply human phenomenon. When combined with museum studies, anthropology is uniquely suited for observing how space-themed museum exhibits present cultural histories within specific paradigms of understanding.

Instances of anthropology's four fields are readily apparent throughout space-themed exhibits. This supports that anthropology is a meaningful way of assessing the content of space museums. For example, exhibit panels and texts can be considered using linguistic and cultural anthropology, while their content on prehistoric or ancient sites have their origins in research conducted by archaeologists. Though museum presentations on physical anthropology will not be the focus of this thesis, its presence in space museums nonetheless demonstrates the potential of using anthropology's holistic four-field approach.

In space science research, an understanding of physical anthropology has been notably important to recognizing some of the consequences of terrestrial evolution; humans physiologically evolved in response to Earth's gravitational pull, with observable repercussions in a weightless environment. Aside from humans having an obvious inability to maintain normal locomotion in space, long-duration spaceflight causes atrophy of muscles, bone degeneration such as osteoporosis, redistribution of body fluids, and a suppressed immune system (Clément 2011: 181-212, 273-285). Such maladies are especially exciting to laypeople, who find themselves intrigued by the daring and dangerous lives of astronauts surviving an extreme, unfamiliar, and unforgiving environment (Olson 2010: 1-309). For this reason, exhibits focusing on the physical ailments of living in space are notably popular at many space-themed museums.

In regard to archaeology, its applications to space science have tended to be temporally broad; research has varyingly explored topics on prehistory, history, the present, and even the future. Space-themed museums with exhibits on ancient cultures may draw from a variety of sources, but the research resources used for creating such exhibits can likely find their roots in archaeology. Archaeological efforts with a research emphasis on cosmology—termed archaeoastronomy—have focused on understanding how ancient peoples looked to the night sky for cultural meaning, and on how celestial patterns were used by ancient peoples for practical concerns like farming and hunting. Research in archaeoastronomy has used fieldwork to investigate the cosmological significance of sites, features, and artifacts by applying an interdisciplinary understanding of cultural anthropology, architecture, and astronomy, which in turn influences museum representation when these topics are used for discussion on exhibit panels and labels (Ruggles and Saunders 1993).

Research endeavors in archaeoastronomy have been diverse, having included investigations of solar and lunar alignments of megalithic monuments erected throughout the British Isles during the Late Neolithic (Thom 1967; Wood 1978; Burl 1999), celestial correlations of Hellenistic architectural structures (Boutsikas and Ruggles 2011: 55-68), pre-colonial Native North American use of ritual calendar spaces used to inform agricultural decision-making (Bostwick 2010: 165-189), and depictions of zodiac constellations on artifacts discovered in Mesoamerica (Trejo 2000: 32-42). In turn, space-themed museum exhibits have presented archaeoastronomy-derived representations of Stonehenge, Greek astrology, Native American cosmology, Mesoamerican astronomical sites, and other ancient cultures which had a documented interest in the cosmos.

Though beyond the scope of this thesis, it is worth mentioning that archaeology has recently been applied to sites beyond Earth's lithosphere. Mindful that, with the passage of time, technical instruments and discarded objects used during space exploration will inevitably become important artifacts themselves, anthropologist Beth O'Leary (2015: 5) stated, "Orbital debris can be thought of in some senses as what archaeologists term lithic debitage." Sites such as Trinity Base, the location of the first lunar landing, are thus archaeologically relevant because of the material discarded there and their significance to cultural heritage (Reynolds 2015; Westwood 2015). Related research into the effects of space on such artifacts has relevance to curatorial concerns. These include the degradation of space-exposed artifacts in museum collections which may have undergone collision with foreign particulates, exposure to plasma and ionizing radiation, and extreme temperature changes. Furthermore, these objects may also have greater susceptibility to decay due to the short longevity of materials used to construct them (Darrin 2015).

Of the four anthropological subfields and their application to space studies, linguistics has inarguably been the most neglected. Despite the intricacies of tech-speak in modern space industries, which at times draws upon a rich and diverse cultural heritage, few publications consider the potential social impact of how such words are used. This poses a significant oversight; both ancient and modern cultures have been subtly and profoundly affected by cosmological concepts. Within the museum context, linguistic anthropology can be used to understand and evaluate how museums present space-related topics (Kockelman 2013: 33-61).

Finally, cultural anthropology is highly relevant, if not necessary, to understanding the history and modernity of cosmology and their representations in museums. Interest in the night sky is deeply ancient; it would not be unreasonable to suggest that virtually all societies have taken some interest in the stars and assigned distinct meanings to them (Cornell 1981). This is no less true of modern public support for space programs, which are often dictated by culturally-motivated political trends (Krug 1991). Therefore, the purpose of the literature review sections of *Chapter III* will be to provide an overview of geographically and temporally diverse societies that have interacted with the cosmos. In the results and discussion sections of *Chapter VI*, this thesis then compares and considers these overviews of cultural history as they relate to the exhibit displays included in this study. In so doing, this thesis applies anthropological understanding to illuminate how space museums produce narratives that sometimes overlook foreign cultural histories.

CHAPTER III

LITERATURE REVIEW

Introduction

Virtually all cultures across time and space have taken some interest in the stars (Campion: 2012: 1-10), verbally weaving-them into their myths, using them as navigational tools, establishing hobbies and careers around their study, or pondering their existence through literature, film, and museum exhibitions. This chapter chronicles some of those cosmological beliefs and societal developments, both ancient and modern, which have occurred across the world. Although this is by no means an exhaustive study of cultural astronomy—to maintain brevity, many societies are omitted or are considered only briefly—this chapter is intended as an overview to provide readers with a basic knowledge of cultural cosmologies, historic events, and technological innovations. The inclusion of these overviews of cultural history will allow for a more meaningful discussion of space museums and their exhibit content in later chapters, while also providing some examples of potential topics for future exhibit designers to consider.

This chapter begins with two sections that detail the origin of the modern space museum, with the first section discussing the roots of space museums in the formation of publicly-accessible museums of natural history, and the second section focusing predominantly on historic developments of space museums along the West Coast. The creation of public observatories, planetariums, and aerospace museums are considered, and followed with a summary of the development of space museums in the late twentieth and early twenty-first centuries. The initial section that follows provides an overview of a few prehistoric and historic cultures that predated spaceflight, and includes discussions of cosmological systems, sites with archaeoastronomical relevance, and important events which contributed to the later development of spaceflight. The final sections of this chapter then discuss the origins and development of the Space Age, as well as brief discussions of multinational space efforts in modernity.

A Brief History of Museums before the Twentieth Century

The origin of museums predates that of the space museum by nearly three centuries, and many of the defining aspects of space museums can be traced to their historic developments. In particular, the development of the natural history museum, beginning in the seventeenth-century, has had an enduring effect on the operations of science museums today, of which space museums are no exception. Although modern museums are closely associated with their purpose as places of public education, accessibility was not always a defining characteristic of museums. Formerly, museums were reserved mostly for academic elites and people of wealth, and the notion that museums should be made available to the public was atypical. It took several centuries for public accessibility to become a norm.

The hobby of collecting relics and intriguing naturally-formed objects was popularized before the first museums were constructed. During the sixteenth-century, collecting was a popular endeavor for scholars and hobbyists interested in the oddities of the natural world (Findlen 1996: 115). Such collections were generally hoarded in private, and were only shared with others who similarly possessed both the status and wealth to partake in such a pastime. Sometime around the 1590s, the apothecary Ferrante

Imperato inadvertently created one of the earliest proto-museums when, determined to display his collection in a more accessible form, he suspended his taxidermy specimens of plants, mammals, birds, and aquatic animals—including the corpse of a large crocodile—to the ceiling and walls of the cathedral of Seville (Zytaruk 2011: 3-5).

Ole Worm, a seventeenth-century Danish scientist and royal physician, later visited Imperato's display and was so inspired by it that he set out to create one of his own. Worm was motivated, in part, by his antipathy for the academic pedagogy of the time, which blindly espoused the teachings of Pliny and Aristotle rather than encouraging students to directly investigate the behaviors of nature themselves (Shackelford 1999: 65-71). Worm's collections were more than idle fascination with the bizarre. They were teaching aids—objects of nature, ethnography, and archaeology—which he used to supplement the education of his students and peers (Purcell 2004: 46-48). These collections, intended as instructional tools, were also an important step in the development of the museum. As can be seen in one of the drawings in his book, *Museum Wormianum*, his collections were also thoughtfully categorized and arranged so that like objects, such as conches of various sizes and forms, pieces of sulfur, and fragments of metal, were displayed together for the convenience of his students (see Figure 1). This is the origin of what has come to be known as "cabinets of curiosity."

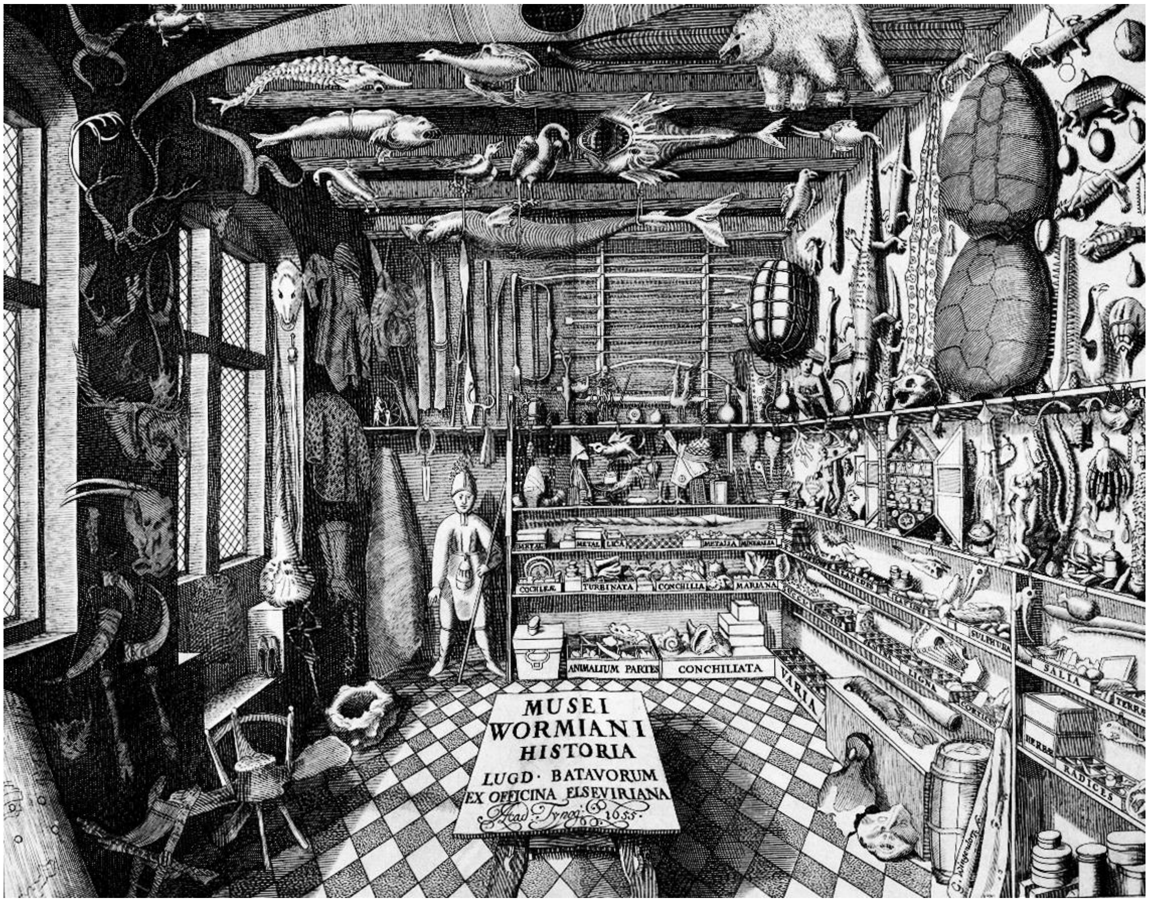

Figure 1. Ole Worm's collections on display in his museum, one of the first in the world (Worm 1655: xiv).

The term "cabinet" is a bit of a misnomer for the exhibits of odd objects and curious collections that rose to popularity in the seventeenth and eighteenth centuries. Later exhibits were displayed in wooden cabinets, as the name implies, but the initial cabinets of curiosity were merely rooms that housed and conveniently displayed collections for the amusement of the collector's guests. Nor were cabinets of curiosity exclusively scientific. Unlike Ole Worm's cabinet of curiosity, many other cabinets were populated by objects that were treasured for their peculiarities rather than their value to understanding the natural world. For example, anthropomorphic items, like digitated fruit and mandrake, made for especially popular displays in many cabinets of curiosity (Zytaruk 2011: 2).

Other museums sporadically cropped up across Europe, most of them private and a few of them public, and were subsequently closed due to financial ruin or the death of their benefactor. On 22 July 1747, the Tarsia Museum was opened to the public and underwent this typical cycle. The museum had been built at the request of Ferdinando Vincenzo Spinelli, Prince of Tarsia, and was intended mostly to bolster his prestige. The opening ceremony alone was said to have been at least as costly as his daughter's wedding, and the museum quickly became one of the primary Neapolitan attractions for intellectual travelers. The Tarsia Museum was a library as much as it was a museum, and its collections of mathematical and astronomical instruments were made available so that its visitors could engage in experiments of natural science. Despite the museum's initial success and popularity, it was ultimately closed several decades after Spinelli's death in 1753, whereupon its collections were sold to the king for his sole enjoyment (Bertucci 2013: 119-136).

In the late seventeenth-century, the Museum of Fine Arts and Archeology (French *Musée des Beaux-Arts et d'archéologie de Besançon*) opened in Besançon, became France's first publicly-available museum, and remains open today. Private museums remained the norm throughout most of the eighteenth-century, however. It was not until the French Revolution was in its midst that museums began a steady trend toward becoming places of public accessibility. Upon the execution of Louis XVI in 1793, many of the old notions of elitism died away with the French monarchy. In the same year, the National Convention, being France's new government during the

Revolution, affirmed that the private collections of the deposed king no longer belonged to the monarchy. The contents of the Cabinet du Roi and the Cabinet d'Histoire Naturelle, were thus declared to belong instead to the people of France (Lee 1997: 385).

Initially, eighteenth-century museums in the United States were similarly reserved for academic elites. In the mid-part of the century, the American Philosophical Society briefly opened an exhibition room devoted to science lectures and demonstrations, but its availability was short-lived. As with many eighteenth-century exhibition attempts, the efforts of the American Philosophical Society focused more heavily on gaining the respect of other academics and aristocrats (Sellers 1980: 25). An exception to this norm arose in 1773, when the Charleston Library Society began actively and openly exhibiting its collection of animals, plants, and minerals related to the natural history of South Carolina. The Charleston Library Society's exhibition was America's first museum in the modern sense of the word (Pitman 1998: 4). Public museums were not the standard until after the efforts of Charles Willson Peale, however.

During the American Revolution, the young Charles Willson Peale, then only in his twenties, made a name for himself by painting his superior officers and fellow soldiers (Sellers 1980: 25). Peale ultimately became an important painter of figures of renowned and historic importance, such as George Washington, but his interests were not solely in art. Natural history intrigued him, and he devoted part of his available time to studying the wonders of the natural world. In this capacity, his ability as a painter served as a tool for recording much of what he observed. Although he did not know it at the time, his competence as a painter—and the respect he gained for it—was preparing him for establishing one of America's most influential museums (Sellers 1969; Sellers 1980; Walsh 2011: 77).

By his early forties, Peale's professional art career was still struggling despite that his art was well respected. He attempted to showcase his artwork at an art gallery of his own making, hoping that doing so would gain him greater fortune. Nathaniel Ramsey, a colonel during the American Revolution, was among the gallery's visitors. The colonel confessed that the familiar wartime faces in Peale's art did not hold his interest. After all, painting galleries were common and therefore had less allure. Luckily, Peale, in his whimsy, had also displayed a pile of mastodon bones in his art gallery, and Colonel Ramsey found himself fascinated by them. In this transfixed state of mind, Ramsey made the bold suggestion that Peale should devote his gallery to objects like the mastodon skeleton instead, as that would gain Peale a larger and more appreciative audience (Sellers 1980: 25).

In 1794, Charles Willson Peale relocated his personal collection of art and objects of natural history, placing them instead in an exhibition space within public view. Initially, he chose not to charge admission (Pitman 1998: 4). Peale's decision to establish the museum as being both open to the public and free of charge was both philosophical and moral. In keeping with Enlightenment era ideals, he viewed the museum as a practical instrument for public education (Sellers 1980: 26). Additionally, Peale's museum was notable for the orderliness of its arrangement (Pitman 1998: 4). Drawing upon his knowledge of science, Peale carefully displayed his botanical taxidermy collections, much of which he had collected himself, in an arrangement which adhered to a Linnaean system of classification (Walsh 2011: 77). Peale ultimately shaped the future in one other way: upon the persuasion of Colonel Ramsey, Peale abandoned his idealism and began charging visitors 25 cents to view his exhibits. This was an enticing decision for other potential investors, who realized that they might turn a profit by establishing museums of their own (Sellers 1969: 27).

Following Peale's death in 1827, the contents of his museum were sold to P.T. Barnum, a showman who had made his fortune operating a traveling circus (Pitman 1998: 5). According to the museum historian Steven Conn (1998: 8), P.T. Barnum's American Museum had marked contrast to that of Peale's museum, despite that their collections were mostly the same, stating that "random clutter created a sensory overload which bored visitors and defeated the purposes of a museum in the first place." Such a claim should be dismissed as hyperbole. If anything should be stated about P.T. Barnum's exhibits, it should not be that they were boring. As with his circus, Barnum used his theatrical style and expertise to make his museum a source of entertainment, and his museum was immensely popular for it (Curry 2001: 48).

According to Steven Conn, Barnum's American Museum also exemplified the cabinets of curiosity that were the norm in America prior to the Civil War, and that such cabinets waned in popularity after the rise of the display case. That is, until it became standard for museums to use glass cases, museum exhibit collections were haphazardly arranged for display. In Conn's (1998: 8) words, "The new museums of the post-war era distinguished themselves from their antebellum predecessors precisely because they strove for a rational, orderly, systematic ideal. In place of the freakish, these museums highlighted the representative and the ordinary." Again, Conn's claim is an overstatement.

Though many cabinets of curiosity were quite literally wooden cabinets crammed full of strange and inexplicable objects, other cabinets of curiosity, going as far back as Ole Worm's museum in the sixteenth-century, were distinguished for the orderliness of their arrangement. Given that the development of museums was contemporary with that of science, it would be far more surprising if the arrival of organized museum exhibits occurred only after the American Civil War. Even Barnum's American Museum, with its antebellum origin and entertainment-driven focus, had clear elements of thoughtful and organized exhibiting.

In 1860, a year before Confederate soldiers initiated the American Civil War with their attack on Fort Sumter in South Carolina, Barnum's American Museum published *An Illustrated Catalogue and Guide Book to Barnum's American Museum*. The opening page of the book describes Barnum's museum as "a simple repository for the most curious specimens of Natural History." In part, the book appears to have been both advertisement and keepsake. More than that, it was also a guide to the museum. Contrary to Conn's supposition that Barnum's museum lacked rational order, the book neatly organized the various exhibition rooms and its collections into accessible, educational sections.

Barnum's book was split into parts describing each of the exhibition halls, which it referred to as "saloons." Each room had thematic differences. For example, the first saloon was distinguished by its cosmoramas, with painted scenery depicting famous landmarks around the world and moments of historic significance, such as the funeral procession of Emperor Napoleon at the Hôtel des Invalides in Paris. The saloons that followed mostly contained specimens of the natural world, and were organized accordingly. The second saloon, for example, mostly contained taxidermy animals, whereas another saloon, which the book referred to as its “Aquaria Department,” was an aquarium with live animals, including a beloved seal named “Ned,” and the museum’s sixth saloon contained an exhibition on the institution’s mineral collection.

One of the more fascinating aspects of *An Illustrated Catalogue and Guide Book to Barnum's American Museum* was that it functioned as a portable collection of museum labels. Sections of the book were further broken down into subsections in which the museum’s exhibit cases were listed, and along with each list, the book provided a paragraph-long description of the object on display, and often also included an illustrated sketch as well. In addition to the display cases being discussed by name and number, the book further contained illustrations of its saloons, with visibly organized display cases that blatantly contradict the notion that Barnum’s exhibits were chaotically arranged (Barnum's American Museum 1860; see Figure 2).

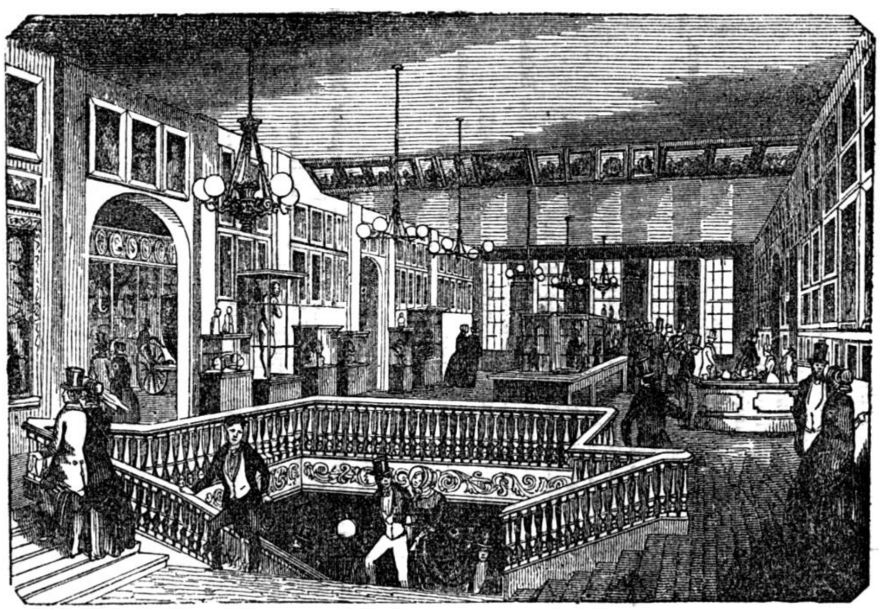

Figure 2. Drawing of an exhibition “saloon” at Barnum's American Museum in 1860, with exhibit cases visible in the background (Barnum's American Museum 1860: 12).

Despite that Barnum's American Museum did incorporate many elements of educational merit, the museum also readily exhibited collections lacking in scientific legitimacy. Sensationalism existed as the museum's core value, sometimes at the cost of the authenticity of its collections (Curry 2001: 48). The museum's "Lecture Room" was maintained only as an extension of P.T. Barnum's circus, and though the "freak show" was isolated from the museum's other collections (Barnum's American Museum 1860: 103-115), it is unsurprising that academics of the time and thereafter have derided the intellectual worth of Barnum's American Museum. Nonetheless, P.T. Barnum's museum has had sustained influence on the exhibition practices of the museums which followed. The museum was an abrupt departure from museums being a destination for cognoscenti, instead becoming an exciting destination for laymen. For better or worse, Barnum also proved that a museum could exert cultural influence by existing as a source of entertainment.

Other museums, often balancing collections of natural history with works of art, opened throughout the nineteenth-century. A notable case occurred after the English scientist James Smithson, despite never having set foot in the United States, left his wealth to the founding of a museum in Washington. In his view, the democratic values of the United States morally contrasted to the aristocratic practices of Europe. Having been born out of wedlock to Hugh Percy, an English duke, Smithson's childhood lacked the comforts of a patrician lifestyle and, despite James Smithson's own successes, he retained some bitterness toward the exclusiveness of European institutions. With clear resentment toward his homeland, Smithson bequeathed his personal fortune to the United States government to form "an Establishment for the increase and diffusion of knowledge among men" (Painter 1982: 30-35).

Twenty-six years after Smithson's death, the Smithsonian Institution Building opened its doors to the American public. The museum was met with enormous and enduring success, later expanding to include other buildings devoted to a diversity of topics. Merely a little over a century after the Smithsonian Institution was founded, it further expanded to include the National Air and Space Museum—a museum which benefited from the curatorial and exhibit practices developed over several centuries at museums across the world. Like its parent building, the National Air and Space Museum succeeded in becoming one of the world's most influential museums, but it was not the only space museum to do so, nor was it the first.

Development of the Space Museum

It is difficult to definitively state a point of origin for the modern space museum. In part, this is because only modest academic attention has been devoted to the history of museums, and even less to studying museums that focus on topics of outer space. Another contributor to this issue is that modern space museums are not only varied in terms of content, but also in terms of their exhibition styles. This issue, and its relevance to this thesis, will be explored at greater depth in the discussion section of *Chapter VI: Results*. What can be stated here is that twenty-first century space museums have been influenced especially by earlier natural history museums, astronomical observatories, flight museums, and planetariums. Albeit simplified, this section provides a historical overview of how space museums developed, with special emphasis given to institutions along the West Coast.

In many respects, the modern space museum can be traced to the development of observatories during the nineteenth-century. Early into his presidency, John Quincy Adams (1825: 12) declared, "In assuming her station among the civilized nations of the earth, it would seem that our country had contracted the engagement to contribute her share of mind, of labor, and of expense to the improvement of those parts of knowledge which lie beyond the reach of individual acquisition, and particularly to geographical and astronomical science." His speech went on to enviously claim that Europe had more 130 "lighthouses of the skies," yet the United States could not boast ownership of a single astronomical observatory.

President Adams' claim may not be precise—it is likely that small and inconsequential American observatories had existed prior to the 1820s, and used only simple astronomical instruments rather than sophisticated telescopes. Moreover, a few statesmen and wealthy individuals, such as Thomas Jefferson, are known to have owned portable telescopes and engaged in astronomy to varying extents before that time (Shapley 1943: 234), though it does not appear that anyone had built an architectural structure devoted solely to the purpose of serving as an astronomical observatory. The changeover occurred in 1836, when a professor at Williams College in Williamstown, Massachusetts, took it upon himself to construct an astronomical observatory modeled after those used in England (Milham 1937a: 467-469).

Albert Hopkins, a professor in mathematics and natural philosophy since 1829, was unusually determined to build an observatory for Williams College.

Reportedly, he was so devoted to this cause that he quarried and cut the stones for its structure with his own hands. After nearly a decade of work, and through enlisting the occasional help of his students, he completed the 48-by-14-foot structure that was to become America's first notable observatory. Officially opened in 1838, the Hopkins Observatory was markedly sophisticated, complete with a revolving dome and a state-of-the-art Troughton & Simms telescope. The observatory was also unique in one peculiar respect: the ceiling of its dome had been painted with gold stars to represent the constellations—an artistic precursor of the planetarium (Milham 1937b: 6-10; see Figure 3).

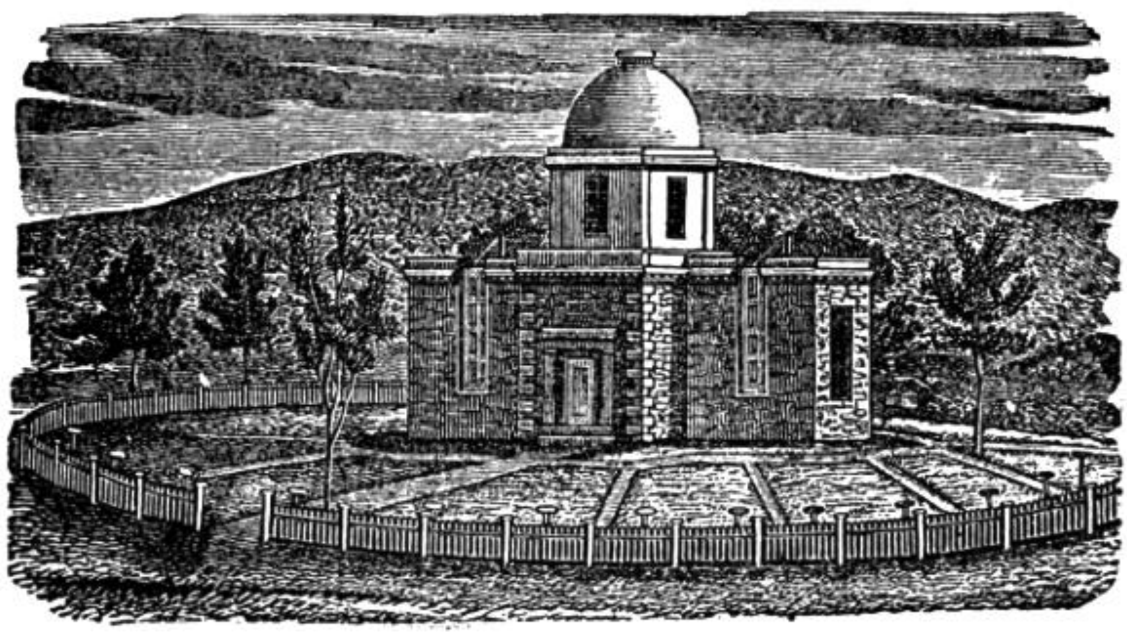

Figure 3. Xylograph of the Hopkins Observatory in 1838-1839 (Milham 1937b: 10).

For the most part, nineteenth-century museums around the world were reserved only for the few academics pursuing natural history and astronomy (Milham 1937b; Keenan 1991; Aubin 2003; Aubin et al. 2010; Werrett 2010; Bell 2011; McAleer

2013; Rebekah 2014; Eicher 2015). Although museums with observatories had been a rarity in the early 1800s, they had rapidly proliferated by the time the century was nearing its end (Aubin et al. 2010: 2-3). The West Coast was no exception. In California, an affluent and eccentric patron named James Lick announced his decision to leave part of his will to the University of California toward the construction of a new astronomical observatory. Among other stipulations, he demanded that the observatory bear his name.

Despite his generous gift, James Lick proved overwhelmingly cantankerous. His personality was so volatile that the first and second board of trustees chose to resign rather than continue working with Lick, with the third board of trustees only finding success upon Lick's timely death. The Lick Observatory opened in 1888, and did so with the inclusion of an unusual stipulation: James Lick had required that he be entombed beneath the observatory's telescope and that fresh flowers must be kept at his placard until the end of time. Though perhaps less strange in retrospect, the Lick Observatory was notable for one other oddity: rather than having been constructed within an urban setting, as had been the norm for other astronomical centers, the Lick Observatory was built perched upon a rural mountain (Smiley 1938: 128-129). This was a harbinger of sorts for observatories built in later decades, many of which had to be relocated to escape the cities and their light pollution; as urban populations increased, city lights increasingly obstructed clear views of the night skies, making observatories nearly useless.

One such institution was the Oakland Observatory, a museum destined to become a trend-setter in public accessibility. Owing to John Lick's finicky behavior and the delays it caused in constructing his observatory, the Oakland Observatory managed to open five years before the Lick (see Figure 4). The conception and construction of the

Oakland Observatory was largely due to the patronage and good-will of Anthony Chabot, well known at the time as one of California's most successful hydraulic mining tycoons. Unlike its contemporaries, the Oakland Observatory was built with the intention of making it accessible to the public rather than a place of academic exclusivity, becoming one of the first observatories in the world—if not the first—to do so. The observatory underwent construction again in 1893, and by then had been renamed the Chabot Observatory as a memorial of its patron and founder. Unfortunately, even with its reconstruction, the bright lights of downtown Oakland posed a serious problem for the Chabot Observatory (Burckhalter 1984: 85-86).

Figure 4. Dome of the Crossley Reflector telescope at the Lick Observatory, circa late nineteenth-century (Keeler 1900: 149).

Despite its issues with light pollution, the Chabot Observatory had modest success over the next several decades (see Figure 5). On 10 November 1894, astronomers at the Chabot Observatory observed, recorded, and published an article on the transit of Mercury, commenting on the extreme blackness of Mercury seen against the backdrop of the Sun (Burckhalter 1894b: 271-272), and in 1914, the Chabot Observatory acquired a new telescope with a 28-foot-long focal length and a jena-glass objective lens that had been crafted by the John A. Brashear Company (Aitken 1914: 53-54). Despite the determination of the Chabot's astronomers to study the night sky, and despite their acquisition of a new and more powerful telescope, the encroachment of urbanization was too much. The lights of downtown Oakland had become unmanageable.

Figure 5. Negative of the Chabot Observatory, 1894 (Burckhalter 1984a).

In 1916, the Chabot Observatory was relocated to the nearby Berkeley Hills mountain range to distance it from the meddlesome city lights. The Chabot Observatory move quickly proved a success; complete with its two telescopes, new clocks and other astronomical instruments, and a large enclosure to serve as a shelter for the equipment, the Chabot Observatory established itself as one of the most technologically sophisticated observatories in the country. The Chabot Observatory had not only become a legitimate center for basic scientific research, but also succeeded in its continued role as an educational center for San Francisco Bay Area denizens. School trips were arranged to visit the observatory so that children could listen to astronomers deliver passionate speeches about the cosmos, and the general public similarly took up the opportunity to escape from city life and peer through the observatory's telescopes (Aitken 1919: 198-199). Through their educational efforts, the Chabot Observatory laid much of the groundwork for what would later become the modern space museum.

By this time, astronomical observatories were becoming common on the West Coast. Facilities of various sizes and levels of sophistication had recently been erected at locations such as Mount Wilson in Los Angeles County, Mare Island in Vallejo, Pomona College in Claremont, the University of Santa Clara, the University of California in Berkeley, and at the University of Washington in Seattle, with another planned for opening near Victoria in British Columbia, Canada (Crawford 1915: 221). Meanwhile, another important event was underway that would become revolutionary to space museums. In Germany, craftsmen at the Carl Zeiss optics company were busy inventing a modernized device that could cast light onto a dome to create patterns resembling the stars of a night sky (Cunningham 2005: 10).

Max Wolf, an astronomer at the University of Heidelberg, had been inspired by earlier attempts at projecting light onto walls to depict the celestial sphere. Dreamily, he proposed a new idea to Oscar von Miller, the director of the technology-focused German Museum (German *Das Deutsche Museum*) in Munich, with a claim that a comparatively more sophisticated light projection could be carried out to cast the stars of the celestial sphere onto the walls of an entire exhibition room. In Wolf's vision, such rooms would be devoted solely to bringing starry nights to daytime visitors (Chant 1935: 144-146).

Wolf's exhibition concept, today referred to as the "planetarium," was intended to be more than mere static spots of light on a ceiling. Instead, Wolf set out to produce a complex instrument that could show visitors the skies of the past, present, and future, while also providing visual demonstrations of topics like planetary orbits. Building such a sophisticated instrument was no easy feat, however, and the design and constructing of the new Deutsches Museum exhibition, Zeiss Planetarium, took well over a decade. Finally, during the spring of 1925, the first dynamic planetarium was opened to the general public (Volz 2013: 82-83).

The Deutsches Museum's "sky theater" was immediately well received by both professional astronomers and laymen visitors. An article later published in the *Journal of the Royal Astronomical Society of Canada* vividly described the novel experience, reporting that, "The Zeiss planetarium is a living replica of the heavens, so true as to make the observer forget he is not under nature's own sky; and yet it is so completely at man's command that days, years, and millenniums may be made to pass before the eyes of the spectator in a brief space of time" (Chant 1935: 147-148). The surreal and intellectually-compelling experience of viewing the celestial heavens within an artificial structure was more than enough to stimulate the interests of investors beyond Germany. Within only a few years of the opening of the Zeiss Planetarium, work was already underway to construct a planetarium near Chicago's Field Museum of Natural History, with other planetariums planned for further locations (Teale 1929: 130; see Figure 6).

Figure 6. Dome construction for the Zeiss Planetarium, circa 1920s (Todd 1925: 454).

The businessman Max Adler was transfixed by a utopian romanticism of the planetarium. He imagined that by bringing Americans the entertainment of sky shows, the public would become cognizant of their own mortal insignificance against the grandeur of the universe. Such an awe-inspiring experience, he hoped, would create a sense of global community that would stymie humanity's tendencies towards violence (Raloff 1992: 142). With these high-aspiring dreams, Max Adler funded Chicago's first astronomy museum. The planetarium was to serve as the museum's central exhibition (Fox 1932: 128), and Adler's collection of hundreds of scientific instruments were intended as side exhibits (Raloff 1992: 142).

The Adler Planetarium opened in the spring of 1930, a mere five years after Germany's creation of the world's first planetarium (Fox 1932: 125). Only three years later, another exhibition, the Fels Planetarium, opened at the Franklin Institute in Philadelphia (Stokley 1934: 194). The planetarium trend continued and, by 1935, twenty Zeiss planetariums existed around the world: a dozen in Germany, two in the United States, two in Italy, and one each in the Netherlands, the Soviet Union, Sweden, and Austria (Chant 1935: 152). While construction of the Hayden planetarium was underway in New York, Southern Californians anxiously awaited the opening of the first planetarium on the West Coast (Leonard 1934: 191-193).

In 1935, Griffith Observatory opened to the general public in a distinctly modern Art Deco building (Fortmeyer 2007: 154). Located atop the Los Feliz hillside in Los Angeles, Griffith Observatory was more than just a dome housing a telescope. It was a fully modern astronomy museum equipped with novel science exhibits worthy of a world's fair. Many of the exhibits were interactive, allowing visitors to push buttons or flip switches to activate one of the museum's 64 exhibits on topics such as astronomy, chemistry, and geology (Gleason 1936: 14). Though these exhibits were designed to resemble science experiments, they were intentionally basic. It was assumed that visitors would find highly technical exhibits too overwhelming, and that simplified examples of scientific discoveries would be enough to stimulate visitor learning (Socha 1935: 157).

Writing in the monthly magazine *Popular Science* less than a year after Griffith Observatory opened, science journalist Sterling Gleason (1936: 14-15) described his experience of the museum as, "like visiting a big research laboratory. Switches click, motors hum, an arc cackles. High voltage electricity buzzes in gas-filled tubes. The thumping of pistons, as vacuum pumps suck air from glass bulbs, mingles with the ghostly rapping of a mechanical hand as it taps on glass to align iron filing about the poles of a magnet." Thus, the public was treated to a range of concepts and instruments that would have normally been unknown to them, like the museum's assortment of glass mirrors that had been carefully arranged to cast sunspots and illuminate banded wavelengths of light by means of spectrohelioscopes (see Figure 7). As with the Chabot Observatory in Oakland, the public also benefited from having a place to observe heavenly bodies and their peculiarities—such as the enormous rings of Saturn—through a telescope, which would have otherwise been accessible only through black-and-white pictures (Haas 1939: 248-249).

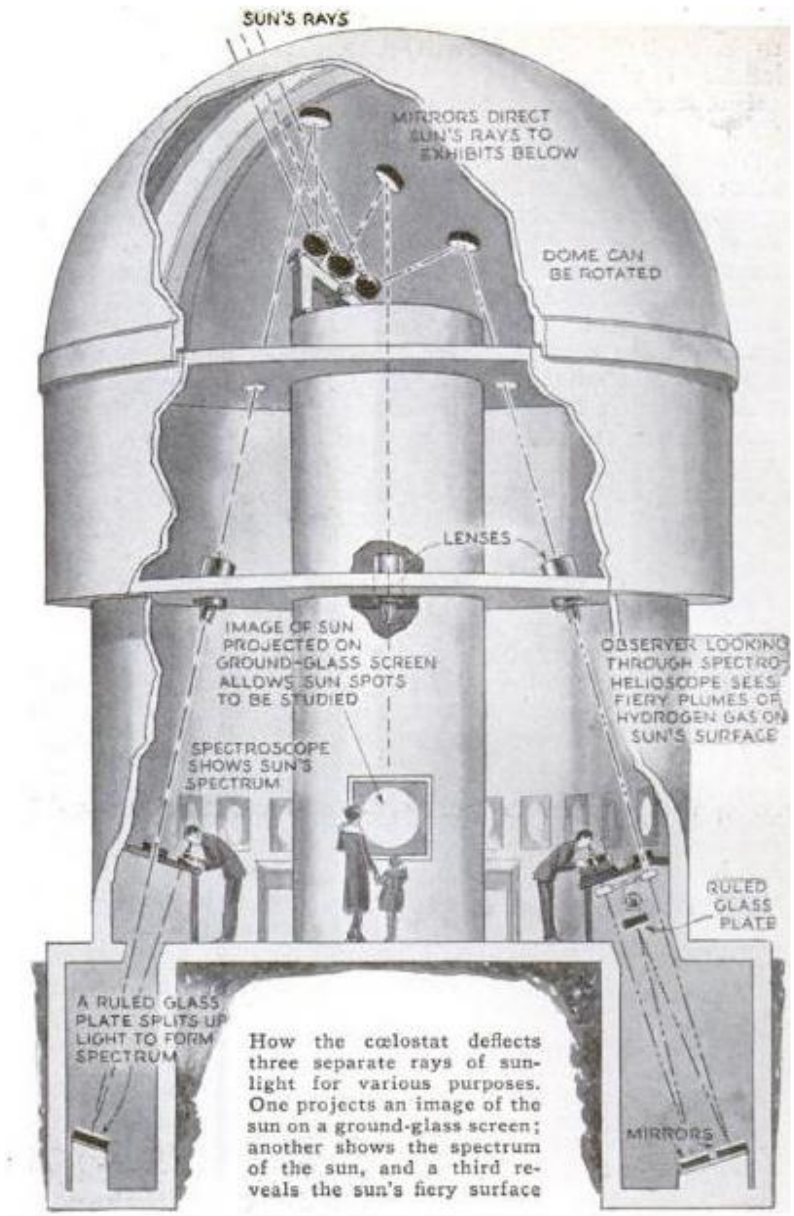

Figure 7. Diagram of interactives at Griffith Observatory, 1936 (Gleason 1936: 14).

North America's fifth planetarium had a less typical origin. Until 1936, planetariums were strictly attractions at science and technology museums. Some of these museums did have historical collections, but these generally included arcane scientific instruments or objects of scientific curiosity. Although their exhibit topics were not always strictly concerned with astronomy, those museums that did stray from discussions of astronomy remained bound by the other sub-disciplines of natural philosophy. This changed when the Ancient Mystical Order Rosae Crucis (AMORC), a Rosicrucian sect, decided to set up their own planetarium in San Jose, California.

According to Rosicrucian beliefs, an enlightened metaphysical understanding of the cosmos had been preserved by elite members of their secret society and were to be shared only with its members. As an occult Christian sect (Heindel 1911), AMORC members envisioned their organization as a mystic extension of Ancient Egyptian beliefs (Wilson 2014). Since intellectual pursuit was considered an important component of the Rosicrucian system, the AMORC sect set out to build its own museum. For the most part, their museum was intended to exhibit Egyptian and Babylonian artifacts, but would also establish the Rosicrucian cosmic connection through the funding of its own planetarium as well (Lewis 1929: 185).

The Rosicrucian Egyptian Museum and Planetarium was, for the most part, ignored by astronomers and other academics. Among its projected displays of stars, planets, and movements of the Sun, the planetarium also included wispy clouds to "show how in the beginning of the creation of the universe moisture preceded the creation of everything else." Additionally, adjacent exhibits displayed pseudo-scientific collections of occult paraphernalia (McConville 2007: 72-73). Despite the disapproval of other museum professionals and academics, the Rosicrucian Egyptian Museum and Planetarium provided Northern California with the closest thing to experiencing a Zeiss Planetarium without having to trek the state to visit Griffith Observatory in Los Angeles.

Observatories had been the first important step toward developing the space museum, and planetariums had been the second. The third, in which aerospace museums would exhibit the great achievements of spaceflight, would not come until after the Second World War. However, earlier aeronautical museums contributed significantly to what would later become the aerospace museum. Among these, France's Air Museum (French *Musée de l'air*), which had opened in 1919, was especially important to developing the exhibition style that would later influence similar institutions.

Located at the Le Bourget Airport in Paris, the Air Museum modeled itself after other museums of the time. By using glass cases to create orderly displays of its collections, its aeronautical objects were carefully arranged to convey their chronological and categorical relationships. This included displayed model airplanes and aircraft parts. Collections too big for display cases, such as aircraft engines and the institution's collection of planes, were similarly arranged on the exhibition floor (Crouch 2007: 20-21).

After the success of the Air Museum in Paris, other aeronautical museums appeared around the world. These museums were driven in part by the post-war romanticism of biplane dogfights in the First World War and the pivotal role of comparatively advanced aircraft in the Second World War (Fopp 1997: 4-5). Such museums were more than just places of intellectual luxury; placing warbirds on display was an effective propaganda tool used to evoke a sense of pride in the museums' respective national military histories (Crouch 2007: 22; McMahon 1981: 281). For Americans, aviation museums were also testaments to the vitality of flight in the United States and the nation's many accomplishments at the start of the decade. Merely 24 years after the Wright brothers' North Carolina flight, Charles Lindbergh had succeeded in crossing the Atlantic, commencing a period of rapid proliferation of aeronautical developments in the United States while also stirring international interest in aviation (Bryson 2013: 146, 426-427).

Of the aeronautical museums in North America, the Smithsonian's National Air Museum was undoubtedly the most influential. The National Air Museum opened in Washington, D.C., only a year after the Second World War came to an end, and included exhibits on jet engines (Hermione 2014: 63-67), foreign and domestic planes, and an assortment of artifacts intended to memorialize the United States' contributions to the development of aviation. Only after the Space Race was in full storm did the institution rename itself The National Air and Space Museum, upon which it began exhibiting displays on the innovations of spaceflight in a manner similar to its earlier aviation exhibitions (Crouch 2007: 22).

The West Coast experienced a sudden proliferation of air and space museums beginning in the 1960s, most notably with the San Diego Air and Space Museum opening in 1963, the Museum of Flight in Seattle opening in 1965 (Banks 1995: 38), and the H.R. MacMillan Space Center opening in Vancouver in 1968. Space had been a popular subject before, and the Space Race made it even more so. The general public was enamored by the topic, and museums were eager to partake in this trend. This emergence of new air and space museums continued unabated with several new institutions appearing on the West Coast each decade. Most recently, these have included the Evergreen Aviation and Space Museum in 1992, which features Howard Hughes' enormous *Spruce Goose*, followed by Oakland's USS Hornet Museum in 1998, and the 2011 opening of Novato's "The Space Station Museum."

Twenty-First Century Space Museums

Today's space museums are diverse in terms of their exhibition content and styles of presentation, all of which are determined by a range of factors such as budget, available floor-space, and the extent of the institution's collections. These points are elaborated upon within the context of West Coast museums in *Chapter VI: Results*. Although twenty-first century space museums do vary by content and style, they remain committed to the mission set by the Chabot Observatory nearly a century earlier: accessible public education. However, the means by which twenty-first century space museums meet their educational goals varies between institutions. In this regard, museum objects play a considerable—albeit somewhat controversial—role.

Unsurprisingly, museums with a predominant focus on aerospace innovations remain heavily reliant on their collections. For example, the USS *Hornet* Museum in Alameda, California, primarily focuses on U.S. naval and aviation history, accomplishing this in part by displaying its large collection of aircraft from the 1940s and onward (Belcher 2002: 13-14; Editorial 2014a: 34-35; Editorial 2014: 32-33). Consequently, the exhibition sections that the USS *Hornet* Museum does devote to spaceflight are similarly artifact-oriented, and are intended to celebrate the success of the USS *Hornet (CV-12)* in recovering Apollo astronauts after their missions concluded with their space capsules crash landing into the Pacific Ocean (De Alba 2014: 38-39; Editorial 2014b: 14). Likewise, the aerospace focus of the Museum of Flight in Seattle, Washington, is tied closely to the institution's impressive collection of aircraft and aviation artifacts (Huntington 1997: 74; Moen 2004: 62-65; Mauro 2006: 72; Price 2008; Updike 2008: 28-29), and its exhibitions on space history are continuations of the museum's artifact-oriented approach (Price 2008).

Many science museums, however, are taking decreasingly object-oriented approaches with their education models and exhibitions, thereby calling into question the notion that space and science museums must have objects to be considered museums (Conn 2010: 22). Although there was some variation in the importance of exhibit collections between museums of the twentieth-century, this trend has been especially influential on twenty-first century science museums, and more particularly, space museums and space exhibitions, where participatory interactives have become the norm. Such museums commonly use the display methods popularized in the twentieth-century by institutions like Griffith Observatory, choosing to include participatory science exhibits that require visitor interaction instead of static artifacts and labels (Caulton 1998: i; Atkins et. al. 2009: 162- 163; Simon 2010).

Though the interactive exhibits of modern space museums can trace their roots to early twentieth-century science centers, which sought to mimic the experience of experimenting in a laboratory setting (Gleason 1936: 14), twenty-first century science centers have been decried by some as being too reliant on merging entertainment with education (Balloffet et. al. 2014: 4). This trend is popularly referred to using the "edutainment" portmanteau. The proponents of the edutainment paradigm argue that museum visitors are more likely to have memorable and engaging experiences than with the stale education models of the twentieth-century (Addis 2005: 729, 736), and that the financial incentives for doing so are too great to ignore (Balloffet et. al. 2014). The detractors of edutainment, however, contend that this trend has been turning today's museums into little more than amusement parks (Chaumier 2005, 2011).

The space museums that do remain committed to their collections are similarly confronting their sense of educational purpose and place within the twenty-first century. Decades before the rise of space museums, the museum educator Thomas Adam (1939: 148-149) criticized aviation museums as favoring salesman-like showmanship over a benevolent intention to educate. Aviation museums were often propaganda tools, intended mostly to promote airplane manufacturing companies and domestic military campaigns. According to Michal McMahon (1981) of the Franklin Institute, science museums never matured beyond this point. Even Tom Crouch (2007: 20), a senior curator at the Smithsonian's National Air and Space Museum, lamented that aerospace museum exhibits are "shrines to progress," often forgoing cultural nuance and politically balanced messages in favor of grandiose depictions of scientific achievement.

In referring to the Smithsonian's National Air and Space Museum, McMahon (1981: 281-282) contended that, "On the surface, the museum celebrates the romance of aviation, but in the exhibition of the artifacts of air and space technology there is a fundamental message which proclaims the fact and the value of technological progress — of the unmixed blessings of continued technical advance and, by implication, economic growth," and went on to state that, "a merging of ideology with the collections can be found, reflected in the selection and labeling of artifacts, in the design of exhibits, and in the congressional discussions which began with the 1946 Air Museum Act and continued to the time of the building of the museum in the 1970s."

Although the National Air and Space Museum has more recently strived to give comparatively balanced historical accounts, such as by displaying the *Enola Gay* with exhibit panels that discuss the destruction of Hiroshima rather than only describing the event as a feat of heroism (Hubbard and Hasian 1998; Kohn 1995; Mayr 1998), it cannot be denied that the National Air and Space Museum has left its mark as the nationalistic in which many aerospace museums present their exhibits (Crouch 2007). Though many twenty-first century space museums retain a core value of educating their visitors about science and engineering, they are simultaneously institutions for indoctrinating visitors with patriotic sentiments that, depending on the institution, may verge on jingoism.

The developing role of culture in places of public education is especially important to twenty-first century space museums, and is of primary focus in this thesis. Space museums with collections may be the caretakers of artifacts with potentially deep cultural significance, such as Canadian astronaut and International Space Station commander Chris Hadfield's space gloves (Hadfield 2016: 30-31), Soviet descent modules (Blatchford and Sidlina 2015), or even an entire space shuttle, such as the housing of the *Endeavor* at the California Science Center in Los Angeles (Bernardini 2014; Natural History 2012; Reid 2013). Further, space museums are not confined to the collection, display, and discussion of twentieth and twenty-first century artifacts. Any artifacts relevant to the history of stargazing, whether they be eleventh-century Chinese astronomical instruments (Svoboda 2004: 82) or ancient Egyptian artifacts depicting cosmological deities (Stagnaro 1999), have the potential for display, depending on the intentions of a given space museum's curators and exhibit designers.

Some institutions, particularly those with planetariums, are now recognizing that space museums provide an opportune medium for discussing *both* science and culture to facilitate tolerance and understanding (Ciotti 2010: 1-14). For example, the Chabot Space and Science Center put on a temporary exhibit lasting until 2005, named "Dragon Skies: Astronomy of Imperial China," to demonstrate the impressive depth of Chinese historical knowledge about astronomy (Svoboda 2004). More recently, the Chabot presented "Begin the Baktun," a temporary exhibition that included panels on Maya systems of celestial knowledge, a planetarium show called "Tales of the Maya Skies," and an opening ceremony by Chan Kahal, a local Maya dance group (PR Newswire 2012).

As stated by the space archaeologist Alice Gorman (2005: 85), "No longer the last wilderness or the final frontier, interplanetary space can be seen as a cultural landscape forged by the organic interaction of the space environment and human material culture." This idea of space as a cultural landscape is not limited to scientific explorations of space. Rather, the cultural landscape includes any endeavor into the cosmos, whether they be the use of Polynesian navigational astronomy (Esteban 2000: 64-74), Navajo sand-paintings to depict the cosmoscape (Berlo 2011: 10-13), Australian Aboriginal lore about celestial deities (Clarke 2008: 39-58), or Maya worship of skygods (Bošković 1989).

Cultural Cosmologies before Spaceflight

The early twentieth-century anthropologist Hugh Stayt is said to have been confronted with a South African riddle. He was asked, "I counted *which* stars and had to give up?" The answer to the riddle was *Pleiades*, a numerically ambiguous asterism which can be counted either as six or seven stars (Snedegar 1995: 532). The riddle itself is more than entertaining wit; it hints at a cultural legacy of humans looking to the night sky and trying to discern patterns, then categorizing them into meaningful structures. More so, the riddle speaks to the ambiguity of celestial patterns in the sky—patterns which have given rise to a myriad of differing cultural interpretations, social lore, and systems of religious belief.

When looking to Pleiades, the Ancient Greeks generally saw seven stars, and for them, the asterism was intrinsically bound to maritime navigation because of its usefulness in predicting the seasonal changes of the Mediterranean Sea (see Figure 8). The term *Pleiades* itself is thought to be derived from the Greek "pleio," meaning "to sail," and was preserved through myths about the seven daughters of the Titan Atlas, who carried the sky on his back, and Pleione, an Oceanid nymph (Laouli 2006: 5-10). By contrast, the Japanese counted six stars among the asterism and called it *Subaru*—which roughly translates to "clustered"—a name which was later adopted by Fuji Heavy Industries and incorporated into a logo of six stars atop a blue backdrop to represent the companies that merged to form the Subaru automotive division (Miller 1988: 1-25; Palmer 2010: 312-313). For modern astronomers, the number of stars that make up *Pleiades* is not a question of six or seven, but of numbers exceeding a thousand (Converse and Stahler 2009: 666).

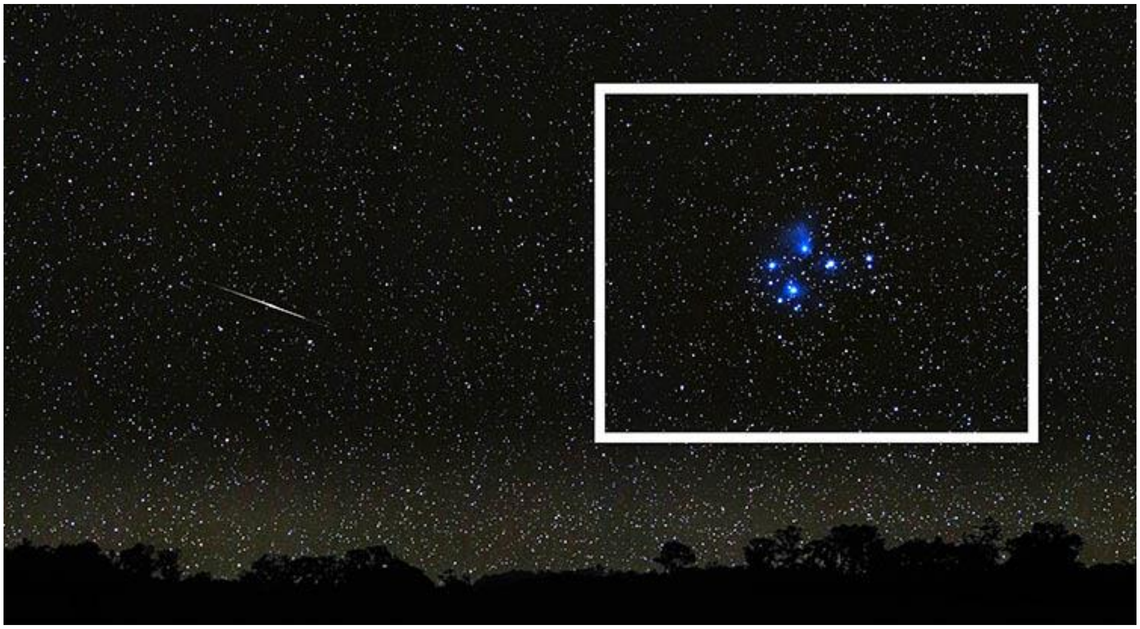

Figure 8. The Messier 45 open star cluster, commonly known as the asterism "*Pleiades*." Photograph by Luis Argerich, distributed under a CC-BY 2.0 license. Image modified by author.

Messier 45, along with other asterisms and constellations, was recorded in the *Popol Vuh* (Low 2016), one of the few surviving texts that documented the beliefs of the K'iche' Maya kingdom (Baraga 2013). The *Popol Vuh*, which translates roughly to "Record of the Community," begins with accounts of Mayan mythology, transitions to discussing local history, and, in its finale, recounts the hero-myth saga of the Maya people (Woodruff 2011). Among its many tales, the *Popol Vuh* tells the story of Xbalanqué and Hunahpú, the Hero Twins, and their place within the heavens (Spence 1908).

According to the legend, Xbalanqué and Hunahpú were extremely skilled at *pitz*, a Mesoamerican ballgame. Confident in their abilities, the Hero Twins descended into Xibalba, the Maya underworld, and challenged the death gods to a game of *pitz*.

After overcoming a series of the death gods' trickeries, Xbalanqué and Hunahpú proved victorious and took the body of their father, Hun Hunahpu, as their prize. However, they could not revive him from the dead (Bošković 1989: 203-207). After a series of adventures that followed, the Hero Twins eventually ascended to become the Sun and Moon (Braakhuis 2010: 18).

Maya artifacts are imbued with symbolism—rich with dualities that depict life and death, destruction and renewal, darkness and light (Spence 1908). While investigating a channel developed to deliver rainwater to the Guatemalan city El Mirador, archaeologists uncovered a sculptural panel from 200 BCE that depicted Xbalanqué and Hunahpú swimming into Xibalba, the land of the dead, to retrieve their father's severed head (Kissinger 2009: 18; Zorich 2010: 23). Such carvings appear to have been more than mere static imagery to be taken at face-value. In this case, the journey of the Hero Twins appears to have served as a metaphor for the path of the Sun as it takes its descent over the horizon (Bošković 1989: 206).

In other Maya traditions, the Moon appears as a goddess, and worship of her was likely widespread (Braakhuis 2010: 19). In this mythos, the whiteness of the Moon represented virginity and chastity (Bošković 1989: 207-211), and the lore deviates from the Sun and Moon being embodiments of Xbalanqué and Hunahpú. Instead, the Sun and Moon are betrothed, with their movements about the sky acting as a metaphor for bridal capture (Braakhuis 2010: 19). Though Maya lore regarding stars and planets varied by region and time, the importance of the cyclical nature of the Sun and Moon to Maya society cannot be understated. Recognizing their patterns allowed the Maya to predict the seasons and, with the seasons, when to crop and harvest maize, the lifeblood of Maya civilization (Weeks 2009: 185).

El Caracol, a Maya structure at Chichen Itza in central Yucatán, has been of special interest to archaeoastronomers. The name itself, being Spanish for “snail,” refers to the spiral stairway that extends through the middle portion of El Caracol (Thomas 1898: 299; see Figure 9). The purpose of El Caracol eluded scholars for decades, and although it was identified as an observatory as early as 1875, the “Observatory” namesake was given to El Caracol only because of its shape; it was thought to resemble observatories built in modernity, but no one was seriously suggesting that the design of El Caracol was intended for such a sophisticated purpose. Initially, the “Observatory” title was regarded as nothing more than a misnomer (Aveni et al. 1975: 977).

Figure 9. Camera obscura drawing of El Caracol, circa 1841 (Stephens 1843: 315).

The archaeologist Oliver Ricketson (1928: 440-444) was one of the first to recognize the likelihood that El Caracol had been built, in part, for making astronomical observations. Previously, Maya knowledge of astronomy had been proved through study of their calendrical system and mythologies, but less attention had been devoted to the possible links between their architecture and astronomy. After meticulously measuring El Caracol during its excavation, Ricketson discovered, entirely by accident, that the structure's four corners matched the cardinal points found on a compass, and that its windows were arranged to mark celestial events, such as the vernal equinox and the declination of the Moon (see Figure 10).

Figure 10. Photograph taken after the excavation and repair of El Caracol in 1930 (Ruppert 1935: 62).

The celestial importance of El Caracol was not exclusive to tracking solar and lunar movements. Later investigations of El Caracol found that the base and top alignments of the tower had also been put in place to correlate with the setting extremes of Venus (Aveni et al. 1975: 980-985). The evidence of El Caracol's purpose as an astronomical observatory has only grown. Of this, Boston University archaeologist Clemency C. Coggins (1988: 260) firmly stated that, "Caracol was built to check on the timing and location of the relevant astronomical events, particularly of Venus as Evening Star, and of Pleiades and solsticial settings."

Such architectural ties to observational astronomy should not be thought of as disunited from Maya history and mythology. The Maya used the cycle of Venus to record the dates of historical events, such as war (Weeks 2009: 2). Like its neighbor El Castillo, a step-pyramid temple to the northeast, El Caracol was erected in part as a monument to Kukulcan, the Maya feathered serpent deity associated with solar mythology. This celestial lore remained equally important to the Aztecs centuries later. For them, Kukulcan was known as Quezalcotal, whom also had a twin brother, Xolotl. Both were associated with the planet Venus; Quezalcotal when Venus appeared before sunrise as the morning star, and Xolotl when Venus appeared after sunset as the evening star (Aveni et al. 1975: 980-985).

As with the Maya, most ancient cultures had complex, socially-bound relationships with the night sky. An understanding of the cyclical nature of the Sun and Moon could mean the difference between life and death. The sky itself was a tool for tracking the seasonal changes of vegetation, which might bear food for gathering or cultivation, and it was a tool for predicting the migrational behaviors of animals, which could be reliable sources of food. Given the correlative power that the Sun and Moon had over life, and the vividness of the celestial specks of light in the night that were the stars and planets, it is of little surprise that countless systems of lore arose to explain the behaviors of the sky (Iwaniszewski 1988: 27-37).

Systems for tracking the movements of celestial bodies have existed for thousands of years in China (Sivin 1988: 55-64), India (Knudsen 2014: 223-226), Egypt (Kuzmin 1999: 515-527), and elsewhere, with their associated beliefs preserved as a consequence of their material culture. The architectural structures and physical objects of these cultures have thus become points of academic interest, and entire subfields of cultural astronomy are devoted to their study. Upon excavating cultural sites in search of knowledge and understanding, the artifacts of these ancient societies are sometimes moved to museums for display, their cultures are depicted in books and other forms of media, and their lore is discussed in planetarium shows and on museum panels and labels.

Because of the sensitive nature of cultural beliefs, there is enormous potential for such subject matter to be mishandled. An oversight in including the living descendants of ancient cultures in discussions of their beliefs may be interpreted as willful exclusion, and responded to with animosity. The decision to consult with indigenous groups when producing content for space museums, however, is more likely to foster a community of mutual respect (Ciotti 2010: 1-14). Even when living descendants do not exist in modernity, careless handling and thoughtless representation of ancient cultures still poses ethical dilemmas. It is doubtful that Egyptian pharaohs would have permitted their relics of celestial importance to be put on display, yet many museums nonetheless place such culturally meaningful objects within glass cases, sometimes alongside mummified remains, for the detached entertainment of museum visitors.

Understanding astronomy is necessary to understanding cultural histories. Innovations in using the stars to guide expeditions by land and sea shaped the world in profoundly complex ways, and should therefore be regarded as an imperative component of anthropology study. It is only through the façade of science-era idealism that subjects of space exploration appear purely objective, devoid of cultural meaning. To the contrary, twentieth and twenty-first century perspectives on space are entirely culturally driven. Like the ancient cultures who looked to the sky and ascribed meaning to what they saw, twentieth and twenty-first century cultures similarly ascribe their own uniquely nuanced meanings to the planets and stars based on their own cultural histories, recent political movements, and popular culture.

Germany and the Development of Modern Rocketry

Prior to the twentieth-century, people across the globe indulged an interest in the cosmos through mythologies and science, building temples to celestial deities or unraveling cosmic mysteries through mathematics and experimentation. Space had been a realm out of physical reach—an intangible place which, though increasingly described by science, remained mythically impervious to human presence. Nazi Germany brought much of this to an end. Though the Third Reich never achieved spaceflight, nor did it aggressively seek occupying outer space, the Nazi fixation on engineering innovations proved instrumental to commencing the Space Age (Neufeld 1990: 725-752; Neufeld 1993a; Neufeld 1993b: 511-538).

In the decades before Germany’s 1939 invasion of Poland, a few innovators and visionaries in Germany contemplated the technical challenges of spaceflight. The Prussian-born Hermann Ganswindt was one of the first to do so. Contrasting with the reverie of his predecessors, Ganswindt designed a spaceship that would conform to Newtonian physics rather than whimsical fantasy, and tried to popularize his concepts for a “cosmic vehicle” in Berlin during the 1890s. In his design, nitroglycerin was to be packed into steel cartridges and used as thrusters to propel his spaceship (McDonald and Hesse 1970: 5). To Ganswindt’s dismay, he found only meager support among his peers, the public ridiculed him as a fraud, and the government maintained a skeptical disinterest in funding his projects. Consequently, Ganswindt died unaccomplished and in poverty; his ideas were left idly in wait for inventors possessing greater pragmatism (Gartman 1956: 11-25).

By the 1920s, Germany underwent an unusual fad wherein spaceflight, rather than being a subject of ridicule, became a topic of public interest. Germany’s crushing defeat in the First World War had given rise to “Weimar culture,” a social trend propagated by Germany’s injured national pride, reinvigorated nationalism, consumer culture, escapism, and increased faith in the promises of technological growth. This created a prime social environment for a new space culture to emerge (Neufeld 1990: 727-728). Whereas the German public had struggled to understand Hermann Ganswindt’s vision just a few decades earlier, the subsequent invention of the airplane, its role in the First World War, and an increase in literary works of science fiction made the public more receptive.

During this time, Max Valier proved integral to popularizing the idea that spaceflight was inevitable. Merging his passion for science and writing, Valier published several works of hard science fiction that incorporated recent findings in astronomy and engineering. By doing so, he made the feasibility of spaceflight more accessible to German laymen. In his *A Daring Trip to Mars* (German *Auf Kühner Fahrt Zum Mars*), first published in 1928, Valier outlined his ideas for interplanetary travel in narrative form. In it, he imagined that a journey to Mars would benefit from solar-powered technology, where explorers would overcome the difficulty of weightlessness by using metal inserts in their shoes, allowing them to walk across electromagnetic floors in their spaceships, and a sextant would allow for the calculations necessary for navigation, guiding the journey to Mars. Valier further imagined that the red planet would have frozen water available for humans to exploit, and that, upon returning to Earth, the travelers would plummet into the ocean using parachutes, after which they would wait for a seaplane to retrieve them (Valier 2013).

Although the science fiction produced by Valier and others helped supply the German populace with the escapism they desired, it was Max Valier's public demonstrations of rocket power that awed and astonished German laymen. Aided by the financial backing of Fritz von Opel, the inheritor of the Opel automotive company, Max Valier began experimenting with the creation of rocket powered-vehicles and soon became the first to drive a rocket-powered car (see Figure 11). Tragically, his entrepreneurship and dreams of spaceflight were ended abruptly. Only several years after publishing *A Daring Trip to Mars*, one of Valier's rocket engines detonated and took his life with it (Bainbridge 1983: 48).

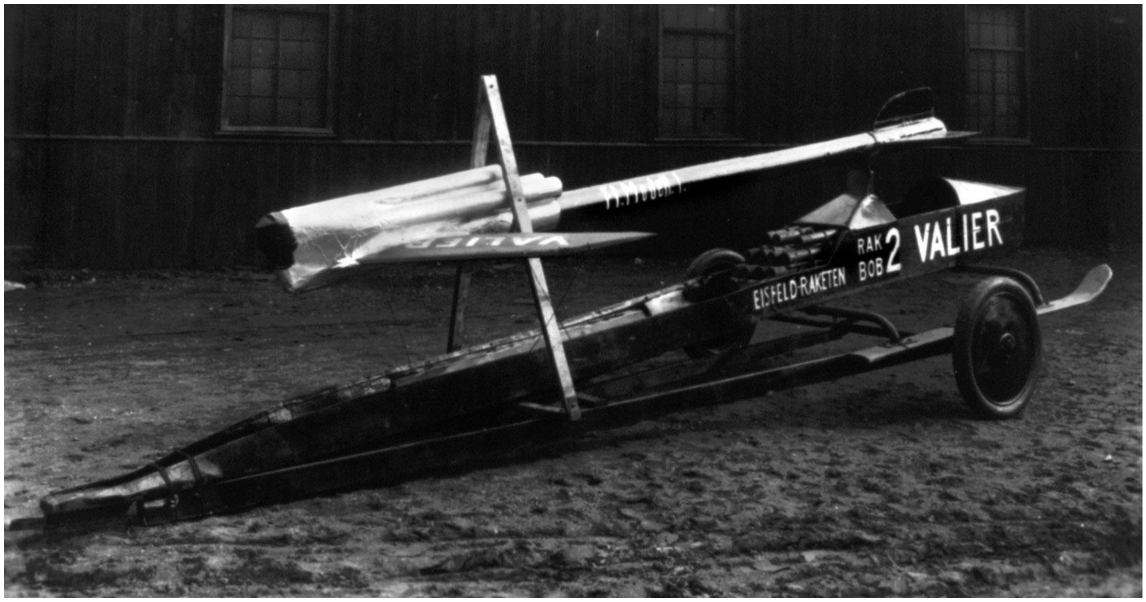

Figure 11. German rocket car developed by Max Valier, circa 1928. Photograph courtesy of the Library of Congress.

Before his death, Max Valier's dramatic life and public magnetism had played a substantial role in popularizing space exploration in Germany. In this endeavor, Hermann Oberth had been central to the development of rocket science (Salkeld et al.1978: 2). As a child, Oberth developed a passion for science fiction, particularly Jules Verne's idea of using a cannon to reach the Moon in his 1865 novel, *From the Earth to the Moon* (French *De la Terre à la Lune*). In his adulthood, an inspired Hermann Oberth began some of the first research into rocketry, which later became the topic of his doctoral dissertation in the early 1920s. To his dismay, his research was regarded as too radical and his dissertation was subsequently rejected.

With money borrowed from his wife, Oberth sought out an audience with the public by self-publishing his dissertation, *The Rocket into Planetary Space* (German *Die*

Rakete zu den Planetenräumen), in 1923 (Bainbridge 1983: 29-30). In addition to stirring the interest of niche scholars, Valier had listed Oberth's book among the greatest influences in his own pursuit of rocketry. In his gratitude, one of Valier's greatest contributions to the birth of rocketry had been helping Oberth achieve the public recognition that his work deserved (Neufeld 1990: 730).

In addition to influencing the direction of literary science fiction, Oberth's concept of a rocket-powered spacecraft marked the beginning of depicting and popularizing rockets in cinema. In the late 1920s, filmmaker Fritz Lang sought out Oberth's expertise in producing a lengthy science fiction film to portray a group of travelers making their way to the Moon by means of a rocket-powered spacecraft. Oberth obliged, and the film was released for the German public's enjoyment during the winter of 1929.

Based on a book written by Thea von Harbou, Fritz Lang's wife, *Woman in the Moon* (German *Frau im Mond*) dramatized the journey from Earth with a dysfunctional crew aboard an out-of-control spaceship. After racing alongside the crater-pocked Moon, the fictionalized rocket-ship crash-landed into the satellite's surface. In one of the film's more dramatic moments, the hard-landing stirred the lunar surface with an enormous explosion of dust that appeared to have consumed the ship along with a newly made crater; some historians have since speculated that this is the true end of the film, and that the remaining storyline is merely a display of wish-fulfillment by an otherwise dead crew (Bowers 2004: 39). Giving repetition to this fateful possibility and the peril of space travel, *Woman in the Moon* ends with two of the crew's would-be lovers, Friede and Helius, remaining eternally behind on the desolate Moon while the rest of the crew begin their return journey to Earth.

During the same year as the release of *Woman in the Moon*, and only shortly before Valier's death, Hermann Oberth published his second book, *Ways to Spaceflight* (German *Wege zur Raumschiffahrt*). Clearly flattered by his inclusion in developing *Woman in the Moon*, Oberth dedicated his book to Thea von Harbou and Fritz Lang. Its pages outlined many of the rocket formulas he had developed through scrupulous measurements and countless experiments. Rather than being a sequel to *The Rocket into Planetary Space*, his first publication, *Ways to Spaceflight* was more akin to an expanded edition which built on the included foundation of its predecessor.

In spite of Oberth's intention that *Ways to Spaceflight* would be easily read by laymen, he filled its pages with dense calculations and esoteric descriptions of his findings in rocketry. Seemingly defending this decision, Oberth confessed that Max Valier had criticized the book's reliance on formulas, but countered that Valier had frequently recruited his help in solving the difficult mathematical problems that had hindered Valier's progress in rocketry. Formulas utilizing known scientific principles, Oberth concluded, proved far more useful to advancing rocketry than trial and error ever would (Oberth 1929: 115). His book echoed another disagreement that Oberth had frequently maintained with Valier, and would ultimately prove integral in later decades: rockets using liquid-fuel, rather than solid-fuel, were substantially more effective (Neufeld 1990: 733).

In keeping with the times, Oberth made his own attempt at writing science fiction. Lodged between the otherwise arcane writing of *Ways to Spaceflight*, Oberth's struggled attempt at fiction describes what he imagined travel aboard a rocket-powered spacecraft would be like. In it, a fictional mechanical engineer, Miller, approached Oberth and offered him a ride aboard “Luna,” an aptly named rocket-ship destined for a trip around the Moon. Oberth mentioned the ship as having two hydrogen-fueled rockets accompanied by a single alcohol-fueled rocket and that—contrasting with the science fiction of his peers—any crew aboard such a vessel would have to lay on their backs to avoid being knocked off their feet during launch. Hermann Oberth then proceeded to describe the challenges of living in a ship without the comfort of gravity, including the need for specific medicine to handle bodily ailments in a weightless environment, the necessity of a spacesuit—in the case of his story, a modified diving suit—to survive any activity outside the ship, and the difficulty of drinking water that tends to float off as little liquid spheres in the absence of gravity (see Figure 12).

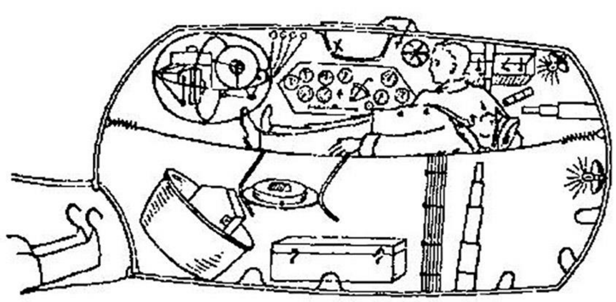

Figure 12. An imaginative sketch from Oberth’s *Ways to Spaceflight* depicting a cramped spaceship cabin in the moments before liftoff. (Oberth 1929: 414).

Abruptly, as if overwhelmed by the task of writing a fictional story of his own, Oberth ended his narrative and continued instead with the storytelling of a popular contemporary German science fiction author, Otto Willi Gail (Oberth 1929: 410-425).

Gail's *The Stone from the Moon* (German *Der Stein vom Mond*), published just three years before Oberth's *Ways to Spaceflight*, described an eclectic array of topics. With a storyline centered around a Maya woman, Tuxtla, Gail's book explored reincarnation, Maya lore, the incorrect assertion that Venus had its own moon, and spaceflight (Gail 2013). This latter topic was, of course, what had captivated Oberth's attention. Likely recognizing that Gail's writing quality surpassed his own, Oberth hoped that the inclusion of *The Stone from the Moon* would captivate his readers and provide them with insight into the sensation of space travel, thereby enticing his readers into supporting his own arguments for spaceflight (Oberth 1929: 435).

Like Hermann Ganswindt, Oberth failed to anticipate the cost of a space program, and futilely waited for the government or a wealthy entrepreneur to fund his project (Neufeld 1990: 731). Oberth's oversights of the technical challenges that would not be overcome until decades later, as well as the overwhelming expense, are retrospectively apparent throughout his book. Regarding this, Oberth's story was particularly revealing: in it, he did not imagine space travel taking place in the distant future. Instead, he envisioned the success of interplanetary travel by 1938, and imagined that he would partake as a passenger (Oberth 1929: 410).

Despite some of the failing of *Ways to Spaceflight*, Oberth's book was justly influential. Not only did it galvanize his peers, but it also succeeded in inspiring an incoming generation of engineers and scientists who would later actualize a human presence in space. Among these was the young Wernher von Braun, a Polish-born German who would later exert more influence on the development of spaceflight than almost any other figure. At a young age, Wernher von Braun had been captivated by the allure of science fiction and obsessed over the idea of space travel. When he first encountered Oberth's work, he was star-struck and set himself to the task of mastering the content of *Ways to Spaceflight*. When he later discovered that Oberth was also seeking volunteers for his rocket club, Society for Space Travel (German *Verein fur Raumschiffahrt*), von Braun asked Oberth if he could serve as an assistant. Lacking the funds to hire trained research staff, Oberth obliged (Piszkiewicz 1998: 24).

The thirties represented a transformative period during which rocket research first gained legitimate financial support. For over a century, militaries around the world had remained disinterested in using rockets for warfare. While black powder rockets had seen some action on the battlefields in earlier centuries, the success of rifled breech loader cannons during the mid-nineteenth-century had made them obsolete. Other than the most zealous of space enthusiasts, few people during the early twentieth-century deemed rockets as anything more than novelty items and sources of showmanship (Neufeld 1993a).

A few German officers viewed them differently. After Germany's humiliating defeat in the First World War, the Treaty of Versailles of 1920 had forced Germany to demilitarize. However, the trivial status of rockets at the time of the treaty's drafting meant that the treaty had made no mention of banning rocket research (Neufeld 1990: 752; Piszkiewicz 1998: 26). The Allied Powers had not—and could not have—foreseen that liquid-propellants would reinstate rockets as instruments of war.

The German military was anxious to reclaim its lost dignity, and a few officers took to exploiting the oversights of the Treaty of Versailles where possible. In 1932, Colonel Karl Becker approached Wernher von Braun, by then one of Oberth's most notable assistants, with an offer to develop rockets for the Reich Defense (German *Reichswehr*). Happy to continue researching rockets at the military's expense, he and other members of the Society for Space Travel accepted Becker's offer (Bainbridge 1983: 45; Ordway et al. 2006: 25). A mere two years later, German president Paul von Hindenburg died of lung cancer, and Chancellor Adolf Hitler took his place. By consolidating the roles of president and chancellor, Hitler established himself as dictator. In doing so, Hitler destined Germany's rocket program to become a Nazi endeavor.

In some respects, the rise of the Nazi Party was a boon for the rocket researchers. Until then, the cost of developing a serious rocket program had hindered the progress of the Society for Space Travel, but between the wane of the Great Depression and the increasingly bloated budget of Nazi military interests, Wernher von Braun and his team quickly outpaced all former rocket research. By 1934, the team had successfully developed and tested the A-series rockets (German *Aggregat*), the first ballistic missiles of their kind. As the Nazi government prepared for their inevitable war, domestic military concerns grew over the potential for leaked military secrets. In 1936, the Reich Defense, since renamed *Wehrmacht* by the Nazis, attempted to hide their rocket research by relocating it to Peenemünde, a fishing village on a remote island in the Baltic Sea (Neufeld 1993a; Ordway et al. 2006: 25-26).

Despite the military's intention to weaponize the A-series rockets, many of the primary rocket scientists dreamily worked toward their personal visions of spaceflight. This apparently became a point of concern for one of von Braun's superior officers. In preparing for Adolf Hitler's arrival to inspect the Peenemünde rocket facility on 23 March 1939, Colonel Walter Dornberger cautioned Wernher von Braun to keep his longing for spaceflight to himself. Dornberger worried that there would be a severe backlash if Hitler discovered the otherworldly ambitions of the rocket scientists, and so von Braun was required to keep his discussion strictly to Earthly matters (Bergaust 1976: 55-56). After Hitler's tour of Peenemünde—coincidentally during von Braun 27th birthday—Hitler was blatantly unimpressed. He was skeptical of Peenemünde's potential for building effective warheads (Piszkiewicz 1998: 30-31), but took no action to end the Peenemünde rocket program.

Only five months later, Hitler began the Second World War upon Nazi Germany's invasion of Poland. By then, the rocket research at Peenemünde was aggressively underway, and work at the facility only increased under wartime pressure. Despite this, numerous technical challenges and a workforce shortage slowed the development of the A-series rockets. Under Hitler's pressure to have the rockets functional so that they could support the Nazi war effort, prisoners of war and other captives were forced into the hard labor of constructing the A-series missiles. Following Nazi Germany's invasion of the Soviet Union after Operation Barbarossa on 22 June 1941, the demand for laborers was fulfilled by using enslaved Soviet soldiers and civilians (Neufeld 1993b: 529).

During the winter of 1942, Peenemünde made its first successful launch of the A-4, the missile that would become iconic of the Nazi program and would later begin the Space Age. Only a month after the first successful launch, an A-4 brushed the edge of space. At a peak altitude of 80 km, the A-4 had been a mere 20 km short of the Kármán line, the boundary of outer space as defined by The World Air Sports Federation (French *Fédération Aéronautique Internationale*) (Neufeld 1993a). With the Soviet Union turning the torrent of war back onto the Germans, Hitler's doubts about the A-series potential for war began to relent; as he became increasingly desperate for a weapon that would ensure Germany's victory, Hitler and his administration became increasingly invested in Peenemünde's missile program (Piszkiewicz 1998: 34; see Figure 13).

Figure 13. Wernher von Braun poses with fellow Nazis, including Walter Dornberger, Friedrich Olbricht, and Heinz Brandt at Peenemünde, 21 March 1941. Photograph courtesy of the German Federal Archives.

This prompted the Nazis to transform an abandoned anhydrite and gypsum mine in Thuringia into a labor camp, Mittelbau-Dora. Under the enforcement of the SS (German *Schutzstaffel*), the French, Russian, and other enslaved prisoners at Mittelbau-Dora were beaten and starved as they were worked to death constructing A-series missiles. Those that could no longer work, either because of malnutrition or the diseases that plagued the inhospitable concentration camp, were either slaughtered or left to die. Minor infractions were ruthlessly punished, and countless slaves were hung and left as dangling reminders to the workers that they had arrived at hell on earth (Schafft and Zeidler 2011: 19-35; see Figure 14).

Figure 14. Corpses of workers at the Mittelbau-Dora concentration camp, where rockets were constructed for Peenemünde, 1945. Photograph courtesy of the Library of Congress.

Meanwhile, the Nazi administration became increasingly fractious. Heinrich Himmler, commander of the SS, and Albert Speer, Minister of War Production, fought for political control over Germany's infrastructure. Himmler desired that Peenemünde be strictly controlled by the SS, and began taking measures to remove officers with loyalties to Speer (Neufeld 1993a). Among these was Wernher von Braun. While at a cocktail party, von Braun conversed incautiously with a woman he had just met, flirtatiously divulging his vision that the A-4 would become the catalyst for spaceflight (see Figure 15). He was arrested shortly afterward, and it became apparent that the woman had most likely been a Gestapo spy working for Himmler. During his two weeks of imprisonment before being freed by Major-General Dornberger, von Braun was accused—correctly—of having misappropriated Nazi military funds to pursue his own ambitions and visions of spaceflight (Bergaust 1976: 79).

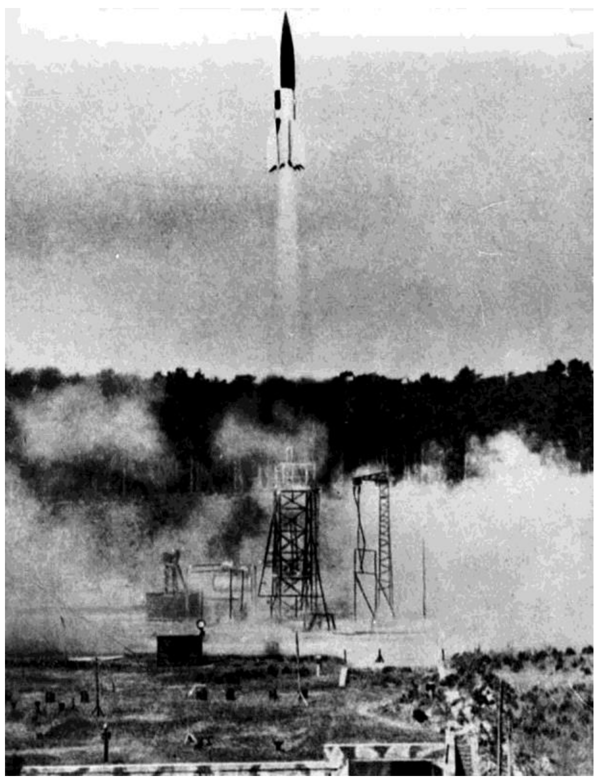

Figure 15. An A-4 rocket, renamed Vengeance Weapon 2, launched from Peenemünde in 1943. Photograph courtesy of the German Federal Archives.

As the war came to end and the Red Army of the Soviet Union marched on Germany, the Peenemünde staff hoped to find new work in the United States. Many of the engineers and scientists feared the retaliation of the approaching Soviets, and were eager to take up any opportunity to avoid Russian retribution, even if it meant surrendering to the American enemy. Wernher von Braun and his workers traveled south across the country, evading capture along the way. Their hope was that the Americans would eagerly take up the opportunity to exploit their technical expertise for military and political gain, sparing the German workers from imprisonment or prosecution. For bargaining, they brought smuggled documents describing the A-4 rocket technology, which had since been renamed the V-2, short for Vengeance Weapon 2 (German *Vergeltungswaffe*).

Only after the Second World War did the true impact of the V-2 missile become apparent. While it had had some minor success in harassing Paris and London, the rocket program had been a military failure (Neufeld 1993b: 536). Approximately 1,100 V-2 missiles successfully landed in England, of which only half struck London. While the few thousand deaths caused by their landing cannot be regarded as anything less than tragic, the mortality caused by V-2 missiles was almost inconsequential compared to other Nazi military weapons, particularly when the immense cost of developing the V-2 is considered (Bainbridge 1983: 93). In their attempt to invent the spacecraft, von Braun and his team had unintentionally aided the Ally effort by diverting funds that would have otherwise gone into comparatively useful war machines. Their actions were hardly commendable; by far the greatest toll of the A-series rocket program was the suffering at Peenemünde and Mittelbau-Dora, where thousands of captives died in agony as they slaved over the creation of the V-2 (Schafft and Zeidler 2011: 43-58).

The Soviet Union and the Birth of Spaceflight

Immediately after the Second World War, Allied powers regarded obtaining and adapting Nazi technology as a necessity. The technological spoils of war, such as rocket and aviation schematics, were viewed as safeguards against all future wars. It was assumed that mastering Nazi technological capabilities was a key step toward winning any upcoming military conflicts. Moreover, battles of posturing were already beginning, and would continue indefinitely. By boldly portraying prowess in science and industry, nations waged psychological warfare, diplomatically bullying less prosperous nations into submission. Thus, Nazi capabilities were a means to wealth and power on the international stage (Neufeld 2012: 49).

Without the Space Race between the United States and the Soviet Union, it is probable that space exploration would have been substantially delayed, and accomplishments in human exploration of space would be comparatively meager. If not for Cold War posturing, modern space museums would not exist in their current form. Instead of filling galleries with spacecraft-derived photographs of the cosmos and exhibition halls with replica models of rockets and satellites, space museums might still resemble the science centers and observatories of the early twentieth-century, in which outer space was discussed only in terms of discoveries by telescope. It is likely that exhibit panels and labels would mention historical events, such as scientific efforts by high-flying balloons and aircraft, but exhibit designers would not have the current wealth of pivotal historical moments to choose from when creating new museum exhibits.

Traditionally, the Space Race is posed as having started only after the Second World War. However, this competition between the Soviet Union and United States began as early as the 1930s. On November of 1933, an American team of balloonists achieved a flight of 61,237 feet—an impressive feat, but short of the record 62,230 feet that had been set by a Soviet team several months earlier. On landing, the American team was greeted by a telegram from Moscow which began with a mocking, "Hearty congratulations on your great achievements." As would characterize the two nations in later decades, the United States and Soviet Union alternately set new records, were beaten, set further records, and were beaten again. Also, as with the rocket races of the Cold War, the balloon race was characterized by its share of disasters (Jensen 2016: 50-55; see Figure 16).

Figure 16. *Osoaviakhim-1*, a Soviet balloon which crashed after having reached a height of 72,000 feet, killing its three-man crew in 1934. Photograph courtesy of the Library of Congress.

Though both the Soviet Union and the United states made enormous strides in achieving new aeronautical heights, neither came anywhere close to the Kármán line, which arbitrarily defines the boundary of outer space as 330,000 feet above the Earth's surface. To accomplish this, a new form of technology was needed—the V-2 rocket.

After the Second World War, the Soviet Union relocated thousands of Nazi Germany's specialists to the Soviet Union, most of them by force. These specialists, many of them prisoners of war and captives from concentration camps, were merged into teams with the Soviet Union's own experts, some of whom had similarly been prisoners, albeit in Joseph Stalin's gulags rather than Nazi labor camps (Harford 1999). Non-Soviet personnel made up over half of the initial team involved in beginning the Soviet space program. Once the V-2 design had been adequately copied and put into production, the USSR began removing the former-Nazi engineers from the engineering project. The new Soviet rocket was named the R-1, though in form and function it was still identical to the Nazi V-2 rocket. (Neufeld 2012: 51-60).

Where the Nazis had failed, the Soviet Union prevailed; on 21 August 1957, the Soviets astonished the world by launching the first intercontinental ballistic missile, or ICBM. The R-7 Semyorka missile had been designed by Sergei Korolev, an aeronautical engineer, gulag survivor, and ultimately one of the geniuses behind the Soviet Union's series of successes during the Space Race (Harford 1999). Only a little over a month after the launch of the first ICBM, the Soviet Union again astonished the world with the successful launch of *Sputnik 1*, the first artificial satellite, aboard an R-7 ICBM. The titular name was "artificial fellow traveler around the Earth" (Russian *Iskustvennyi Sputnik Zemli*), or Sputnik for short (Mieczkowski 2013: 12).

Before *Sputnik-1*, international powers had been quick to dismiss Soviet technological capabilities as menial (Wang 2008: 13), but 1957 proved to be one of the most defining years of the latter half of the twentieth-century. With the invention of the ICBM, the viability of the Soviet nuclear program—and, perilously, its potential weaponized use against noncontiguous nations—instigated an enduring period of crisis, particularly in the United States. Through it, the Cold War became more firmly rooted, and the Space Race rose to international attention. Space exploration became the means to asserting technological legitimacy and political dominance. Despite the U.S.'s enormous economic success in the wake of the Second World War, Americans suddenly felt inadequate (Mieczkowski 2013: 12).

The Soviet Union's 1957 successes were hardly over after *Sputnik-1*. At the start of November, a mere month after launching the world's first satellite, the Soviet Union used *Sputnik-2* to put the first life form into Earth's orbit: a mongrel named Laika. The event was, in part, a celebration to mark the fortieth anniversary of the Russian Revolution. Unfortunately for Laika, the voyage was one-way, intended only to test the viability of surviving a trip to space. The official statement from the Soviet government was that Laika had been euthanized at the end of her journey. It was not until decades after the Cold War that the nature of Laika's death was declassified, revealing that the mission had been only a partial success—Laika had been killed due to a design flaw that had caused her cabin to overheat (Kemp 2007: 541).

The *Sputnik-2* mission was hailed as a success in the Soviet Union, but was lampooned abroad. Even without knowing the full extent of Laika's tortuous end, international newspapers expressed sympathy for the dog's inhumane destiny (Latson

2014). Conveniently, the cruelty of the United States' failed space-bound launches of rhesus monkeys and other animals was quietly ignored (Burgess and Dubbs 2007). The Soviet Union was criticized as being incapable of safely returning a person from outer-space, but such diatribe was staunched in August 1960. *Korabl-Sputnik 2* safely carried the dogs Belka and Strelka to and from outer-space, proving that manned spaceflight was inevitable, and leaving the United States scrambling to catch up (Scientific American 1960: 98-100).

Yuri Gagarin's entry into space on 12 April 1961 is undoubtedly one of the most distinguished moments in human history, and so several of Soviet Russia's prior successes are sometimes overlooked. Fully a decade prior to Neil Armstrong stepping from his Apollo Lunar Module, becoming the first to leave a footprint in the surface of another celestial body, *Luna-1* was launched atop a modified R-7 Semyorka ICBM and sent hurling passed the Moon. The *Luna-1* had been launched with aim of colliding it into the lunar surface, but an error caused the spacecraft to miss the Moon entirely. Instead, *Luna-1* became the first man-made device to leave Earth's orbit and continue its existence as a heliocentric object (Aviation Week & Space Technology 1959: 26-29).

Subsequent lunar missions were comparatively successful. Two months after *Luna-1* became the first scientific instrument to examine the Moon up close, *Luna-2* was sent crashing into its surface, becoming the first man-made object to reach the Moon. In the same year, *Luna-3* took the first images of the far side of the Moon (Biesbroek and Janin 2000: 92). Because the Moon is tidally locked with the Earth, effectively causing only one side of the lunar surface to face Earth as the rotating Moon orbits the Earth in a process called synchronous rotation (Palen et al. 2012: 37), the far side of the Moon had never been seen prior to the Soviet mission. A total of 29 photographs were taken. Though the images were grainy and of low resolution, they were scientifically invaluable. Notably, the pictures showed that the far side of the Moon has comparatively less lunar mare—ancient and vast plains from volcanic flows of basalt—than the side visible to Earth (see Figure 17).

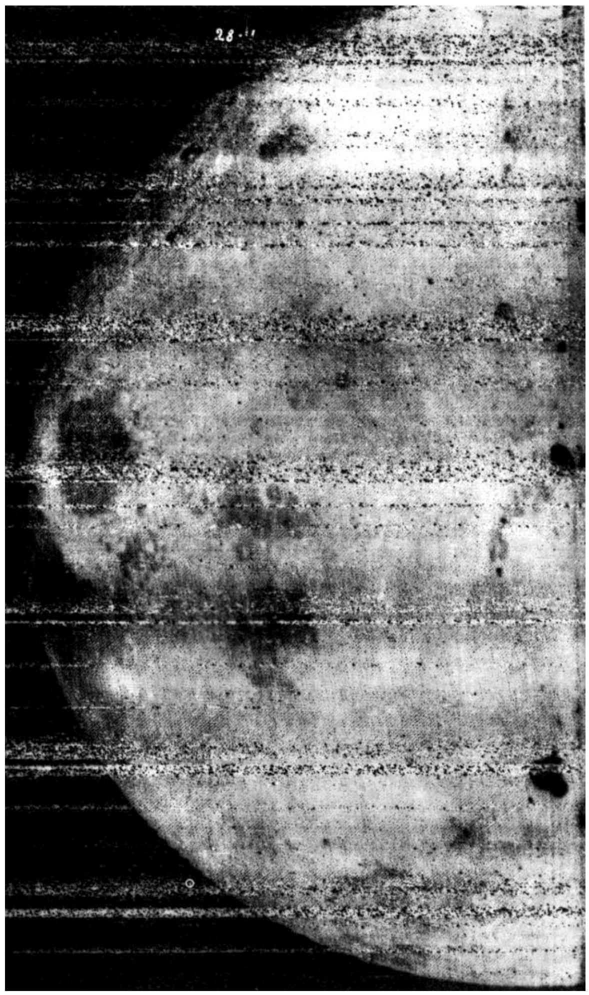

Figure 17. A view of the far side of the Moon taken by the Soviet *Luna-3* spacecraft, displaying some areas of basaltic mare on the left side of the lunar surface, but comparatively less basaltic mare than the side of the Moon that is visible from Earth. Photograph courtesy of NASA.

With each passing month, the professed “Space Race” looked more and more like an event with only a sole competitor. On 12 April 1961, the Soviet Union again shook the world. Yuri Gagarin, a 27-year-old farm boy from northwest Russia, became the first person in space. Riding aboard the *Vostok-1* spacecraft, Gagarin surpassed the Kármán line which arbitrarily marks the boundary of outer space, and orbited the Earth in a flight that lasted 108 minutes. American radar technicians recorded the signature of an R-7 ICBM—the legacy of Nazi engineering—and, soon afterward, the voice of the world’s first spaceman. The event was undeniable. The Soviet Union had beaten the United States to space (Doran and Bizonky 2011: 101-115).

Less than 60 years earlier, the Wright Brothers had made history with the first documented airplane flight, marvelously opening the skies for exploration. With Gagarin’s flight, suddenly the cosmos became a viable place for humans to venture. For the first time, human spaceflight ceased to be a notion of science-fiction-bound reverie, and instead become a twentieth-century reality. The effect of this event was profound. For many of the world powers, particularly the United States, it was a jolting surprise that the rigidly run Soviet nation was so thoroughly dominating the advancement of technology. At the same time, pride in human ingenuity was a widespread sentiment, even if it also signified a communist victory. Domestically, this success renewed nationalistic pride and further provoked the idea that a utopia could be reached through Marxist-Leninist ideals (Kohonen 2009: 114-128).

Narratives on the Space Race tend to abruptly transition to discussing the Apollo missions and the United States’ success in landing a man on the Moon, but numerous other Soviet achievements characterized this period of the Cold War and are worthy of attention. In addition to the *Luna-1*, *Luna-2*, and *Luna-3* spacecrafts, a dozen other spacecrafts of the Luna program successfully explored different aspects of the Moon. *Luna-9* became the first probe to make a soft-landing on the Moon, and *Luna-10* the first man-made satellite to orbit the Moon. Later, *Luna-16* became the first mission to successfully retrieve samples from the Moon's surface and return them to Earth for scientific analysis. Additionally, the Lunokhod program was enormously successful, with *Lunokhod-1* becoming the first remotely-controlled lunar rover (see Figure 18). These accomplishments of the Luna program contrast with the sometimes more popular narratives that downplay Soviet contributions to lunar exploration, or ignore them entirely (Gilette 1972: 731-736).

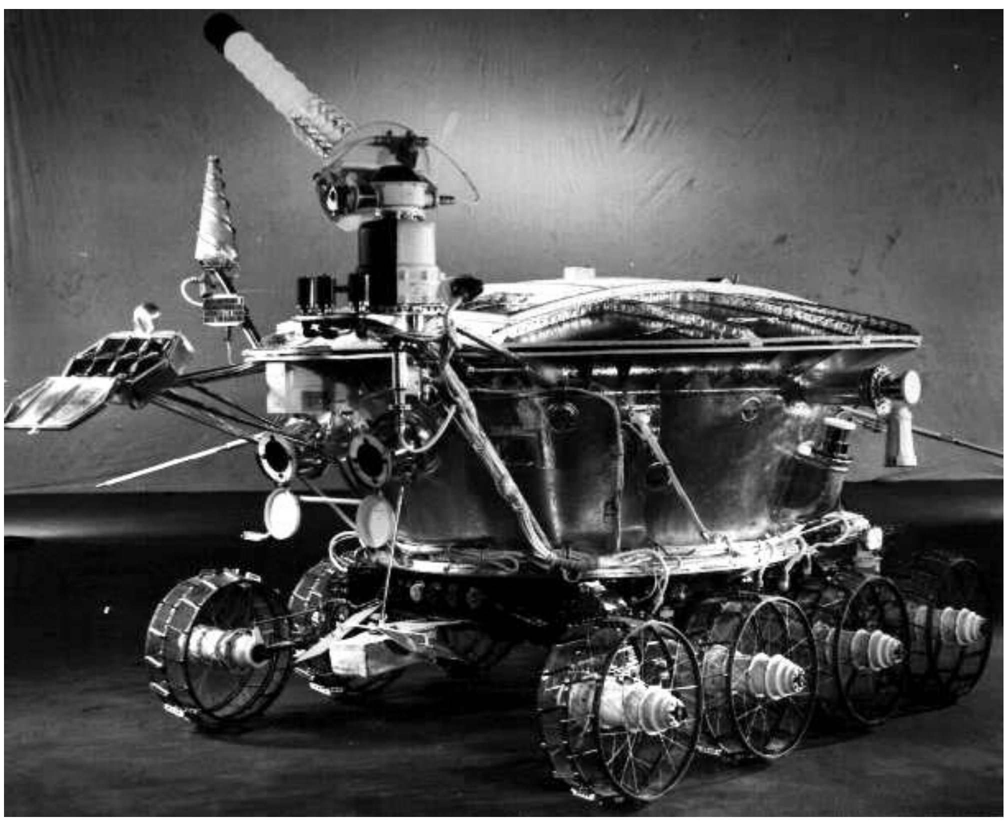

Figure 18. Lunokhod, a Soviet robotic lunar rover. A replica of *Lunokhod*-2 is on display at the Evergreen Aviation and Space Museum in Oregon. Photograph courtesy of NASA.

Soviet exploration was not exclusive to the Moon and Earth's thermosphere. In May 1961, the *Venera-1* spacecraft conducted the first flyby of the planet Venus. Five years later, the Venera program resumed exploration of Venus with *Venera-3,* which crash landed into Venus to become the first man-made object on another planet, and, later, with *Venera-7*, the first probe to successfully make a soft-landing on Venus (Wayman 2008: 22-27). Likewise, the first man-made objects to reach the surface of Mars were of Soviet origin. The *Mars-1* crash landed into Mars on November 1971 and, one month later, *Mars-2* made the first soft-landing on the Martian surface (Watt 1972: 91-93).

As with Gagarin's flight, Soviet firsts in space were not limited to unmanned spacecraft. Six Vostok missions carried cosmonauts into space, with Gherman Titov becoming the first to orbit the Earth for a full 24-hours (Greenberg 1962: 489-490), the cosmonauts aboard *Vostok 3* and *Vostok 4* accomplishing the first simultaneous spaceflight (Wilson 1962: 21-29), Valery Bykovsky setting a record of five days in space (Gauthier 1990: 20-22), and Valentina Tereshkova becoming the first woman in space, 20 years before Sally Ride became the first female American astronaut (Walcutt 2017: 25).

Later Cold War-era missions set similarly defining "firsts" in space. In 1964, *Voskhod-1* became the first spaceship to have a multi-person crew and set a new altitude record with exceeding the Kármán line by over 200 km. A year later, cosmonaut Alexey Leonov became the first to perform a spacewalk (Shelton 1993: 67-70). By the early 1970s, the Soviet Union began establishing a more permanent presence in space. On April 1971, *Salyut-1* became the first space station, signifying the Soviet Union's change of focus from attempting to travel to the Moon to instead maintaining orbital stations (Sevastiyanov and Bryukhanov 2007: 193-197).

An obsession with "firsts" is one of the characterizing aspects of the Space Race. It concedes the sociopolitical purpose of twentieth-century space exploration. For the researchers involved in the space programs of the US and USSR, spacecraft were the means to understanding the cosmos. However, for politicians and the public that they relied on for support, space exploration was instead an opportunity for one-upmanship. Though this was financially beneficial to the space scientists and rocket engineers involved in Cold War-era space programs, who relied on political and public support for funding, it meant that the Space Race's sports-like quality was generally celebrated with greater attention than its associated scientific achievements. Tragically, the result was that the safety of those involved sometimes went ignored so that space programs could avoid falling behind and injuring fragile political egos.

The *Soyuz-11* mission, which took place in June 1971, is celebrated for another "first": the first crew to enter a space station, the *Salyut-1*. Initially, the mission was remarkably successful. After nearly 24 days spent in orbit, Commander Georgi Dobrovolski, Vladislav Volkov, and Viktor Patsayev boarded the *Soyuz-11* to begin their return descent to Earth. After separating from the space station *Salyut-1*, the pyrotechnic bolts that had been holding the *Soyuz-11* descent module to its orbital module were explosively separated. A flaw in the Soyuz design caused an air valve to the *Soyuz-11* descent module to open in the process, causing rapid decompression which exposed the crew to the vacuum of space. It was not until after the module had landed that it was discovered the crew was dead (Hall and Shayler 2003: 173-176). In a harrowing twist on the notion of "firsts," the *Soyuz-11* crew became the first people to die in space, and thus far remain the only people to have suffered such a fate—other space disasters, including the fates of the space shuttles *Challenger* and *Columbia*, all occurred below the 100 km Kármán line.

This was not the Soviet Union's first fatal incident, however. In 1961, Valentin Bondarenko died horribly during training when the highly oxygenated atmosphere in an altitude chamber caught fire. Given the secretive nature of the Cold War, the circumstances of Bondarenko's demise were not revealed until long after his death (Dasch 2005). Had the US and USSR been privy, the incident might have led NASA to increase the nitrogen in the artificial atmospheres of its modules, thereby preventing the ill-fated *Apollo 1* crew from dying due to similar conditions. In another incident, the cosmonaut Vladimir Komarov was killed after his second venture into space because the parachute of the *Soyuz-1* descent module failed to open. As with many other space-related accidents, the involved engineering crew warned their superiors that the spaceship had faults that needed to be attended to, but their objections were ultimately ignored by politicians who were—quite ironically—more concerned about the affect a delay would have on public relations (Doran and Bizony 2011: 193-200).

The triumphs and tragedies of the Soviet space program are commemorated at a few Russian museums, including the Memorial Museum of Cosmonautics (2017). The museum opened 10 April 1981, exactly two decades after Yuri Gagarin's historic spaceflight. Though it is located in Moscow, its densely packed exhibit halls can be enjoyed through the museum's online virtual tour, which depict much of the museum's collections. These range from information panels on the many "firsts" of Russian spaceflight, to a variety of space-age artifacts related to the nation's space programs. Also included are glass cases containing two taxidermy dogs, Laika and Strelka, famed for being among the first animals to return safely to Earth.

For the most part, the museum is a celebration of Russia's history in space exploration, especially the achievements of its space programs, including the Soviet era CCCP space agency and the modern Roscosmos space agency. An exception to the museum's patriotic focus can be found on the first floor. Below a collection of flags representing the various nations and international agencies that have achieved spaceflight, there stands a single two-story-tall model: a Saturn V rocket, the device which propelled American astronauts to the Moon, and was, like the Soviet Union's own R-7 ICBM, a direct descendent of Nazi engineering.

Operation Paperclip: German Origins of the United States Space Program

Despite that innovation in space exploration are often touted as part of the American national identity, the origins of the US space program can also be attributed to the engineers of Nazi Germany and the slave-labor that the Nazis exploited. In July of 1945, several months before the end of the Second World War, the US Joint Chiefs of Staff created Operation Overcast. The secret operation was intended to recruit Nazi rocket experts to aid US efforts in the Pacific War. At least 350 people were recruited (Neufeld 2012: 51), and these recruiting efforts continued after the war as Operation Paperclip. The threat of Japan had ended, but a new one had taken its place: the Soviet Union (Jacobson 2014).

Under Operation Paperclip, the number of German scientists allowed entry into the United States was raised to 1,000, with this number increased as efforts to adapt Nazi technology were further carried out (Samuel 2004: 398). Among the recruits was the Nazi Dr. Hubertus Strughold, who conducted horrific medical experiments on prisoners at the Dachau concentration camp, and later found fame as the "father of space medicine" at NASA (Campbell et al. 2007: 716-719). Also among the recruits was Wernher von Braun and his engineering team, who had been responsible for using slave labor at the Peenemünde and Mittelbau-Dora concertation camps to develop the V-2 rocket (Schafft and Zeidler 2011: 43-58).

Initially, Wernher von Braun and his fellow German engineers were housed at Fort Bliss in El Paso, Texas. Wernher von Braun was assigned with teaching U.S. Army personnel how to assemble a V-2 rocket. By May 1946, Wernher von Braun's new team of German and American aerospace engineers launched the first V-2 from U.S. soil. However, the launch was only a partial success. The following month, the team accomplished their first fully successful launch: a V-2 rocket at White Sands Missile Range in New Mexico, which reached an altitude of 67 feet (Ward 2005: 63-4). Over the duration of the Army's attempt to develop a rocket program, the United States launched more than 70 of von Braun's V-2 rockets (Neufeld 2012: 59-60).

In 1950, Wernher von Braun and his fellow German engineers were relocated to Huntsville, Alabama, to work at the Redstone Arsenal U.S. Army post. Wernher von Braun worried that, having been part of the Axis powers during the war, he and his team would struggle to find acceptance in Alabama's community. His response was to encourage his workers to integrate into Huntsville through public service. Heeding von

Braun's advice, the Germans took up volunteer positions at local museums and astronomical societies, and also built a public astronomical observatory and planetarium (Ward 2005: 79; see Figure 19).

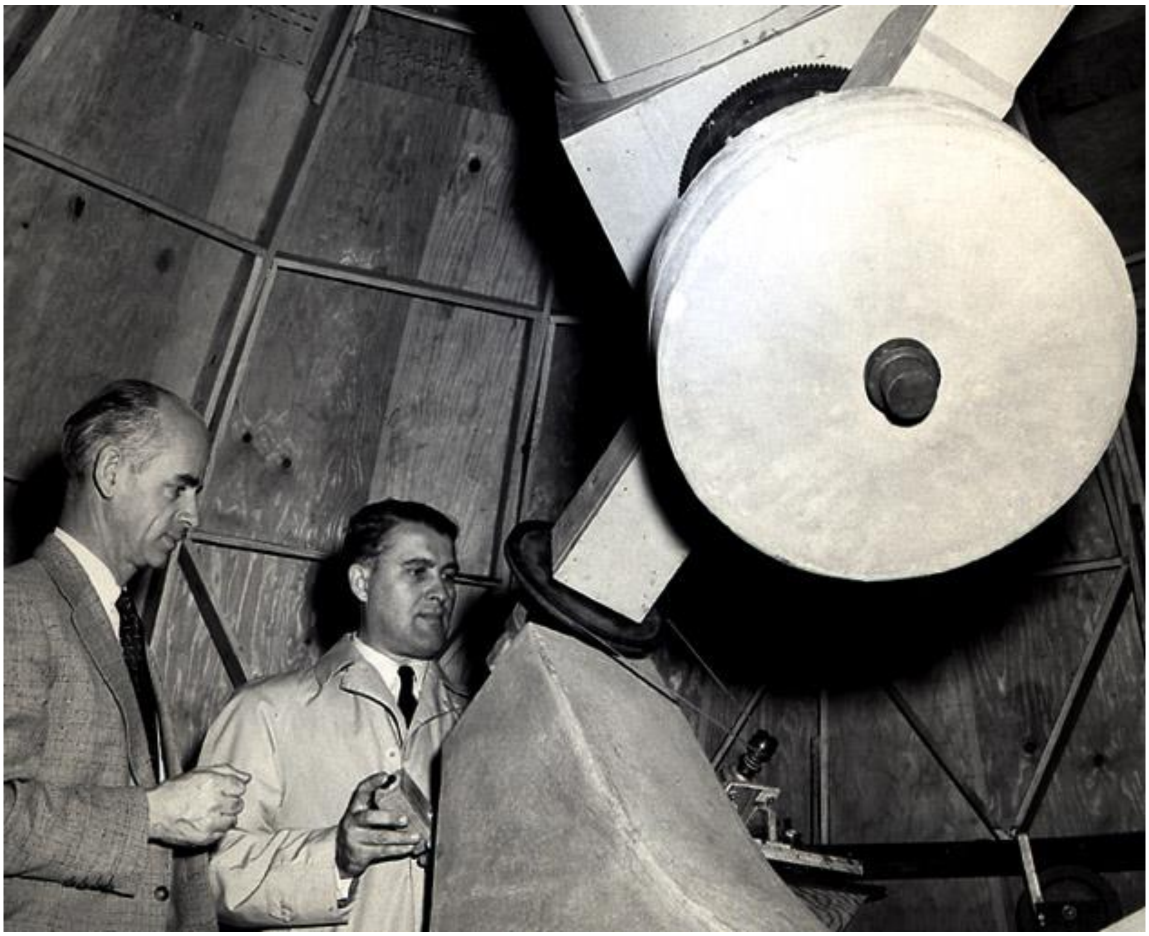

Figure 19. German rocket scientists Ernst Stuhlinger and Wernher von Braun at the Rocket City Astronomical Association public observatory in Huntsville, Alabama. Photograph courtesy of NASA.

In 1952, production of a modified V-2 rocket began via a defense contract with the Chrysler automotive corporation. After various adaptations and upgrades, the new V-2 was renamed the Redstone rocket. In 1958, a Redstone rocket became the first missile to weaponize a nuclear warhead (Simon and Robison 1997: 258-264), and on 5

May 1961, another Redstone rocket was used to carry Alan Shepherd, America's first astronaut, into space (Neal Thomson 2004). In short, German engineering and the descendent technology of Nazi war efforts had birthed the American space program.

This was not the final act of the German engineers. By the early sixties, the United States was falling behind in the so-called "Space Race." Wernher von Braun and most of his Redstone team were transferred to NASA to directly partake in the American space program, with Wernher von Braun instated as a NASA director. Over the span of two and a half decades, the German team had developed an intimate knowledge of rocketry under the command of the Nazi Party, and later under the order of the United States Army. Under NASA, they were challenged with accomplishing one of the all-time greatest feats of ingenuity: putting a person on the Moon.

After the conclusion of Project Mercury—the United States' first venture into human spaceflight—in 1963, NASA's focus switched to Project Gemini, a series of missions to develop the techniques and technology to safely send an astronaut to the Moon. Most of the missions included orbital and long-duration spaceflights. For Project Apollo, a larger, more advanced rocket was required. This was accomplished using the Saturn V, a 363-feet-tall rocket that had been designed by von Braun and built under his direction. Ultimately, it succeeded in sending the Apollo 11 spacecraft to the Moon and, along with it, the first two people to the lunar surface, Neil Armstrong and Buzz Aldrin (Kirkpatrick 2009: 119-123).

The Apollo Program continued until 1972, propelled into space by von Braun's Saturn V rocket (Cernan and Davis 1999). Wernher von Braun died an American icon three years later, and a decade before the U.S. government began investigating the scientists and engineers of Operation Paperclip for war crimes. Other members of his team did not evade this fate. For example, Arthur Rudolph, a core developer of both the V-2 and Saturn V, was successfully convicted for having taken part in the atrocities at Peenemünde and Mittelbau-Dora (Ward 2005: 155-167). By then, the connection between crimes against humanity and the origin of space exploration was indisputable.

The European Space Agency

As with the Soviet Union and the United States, both the French and British governments acted quickly to salvage Nazi technology after the war had ended. France and the United Kingdom recruited entire rocket development teams from the ruins of Germany. Incidentally, Sir Charles Darwin, grandson to the nineteenth-century naturalist of the same name, headed the British panel for reviewing some of these Nazi recruits. Had France and the United Kingdom not been depleted of their resources by the Second World War, both nations almost certainly would have proceeded with their own rocket programs to become additional Space Race contenders. Instead, the French and British government chose to concentrate their efforts on rebuilding their respective nations (Neufeld 2012: 51-52, 57-58).

Eight months after Yuri Gagarin became the first person in space, France formed its own space agency under the request of then-president Charles de Gaulle. The CNES (French *Centre national d'études spatiales*) space agency focused its initial efforts on developing systems for putting satellites into orbit, rather than on human spaceflight.

This was carried out through the creation of the Diamant rocket system. After only three years of developing its space program, France became the third nation to put a satellite, named *Astérix*, into space (Dasch 2005).

In 1962, the United Kingdom, Italy, Belgium, the Netherlands, and France began investing in the European Launcher Development Organization, or ELDO, a multinational project to create a launching system for future European satellites. In the same year, the nations banded together to form the European Space Research Organization, or ESRO, for the research and design of spacecrafts. Later, other nations such as Denmark, Spain, Sweden, and Switzerland joined in the effort. The first of their facilities, the ESRO Laboratory for Advanced Research, was built in Italy, and a year later another facility was erected in the Netherlands (Eito-Brun and Rodríguez 2016: 552).

In 1975, the same year that the United States and Soviet Union restored some of its diplomatic relations through the joint Apollo–Soyuz Test Project (Ezell and Ezell 1978), ten European nations consolidated many of their space programs to form the European Space Agency, or ESA. That year, the ESA launched its first satellite, *COS-B*, to map sources of gamma radiation within the Milky Way galaxy (Eito-Brun and Rodríguez 2016: 553). Throughout the four decades since its formation, the ESA has conducted numerous missions, ranging in focus from observing the properties of Earth (Clery 1993; Laxon et al. 2013; Frappart et al. 2016) to exploring distant planets (Langevin et al. 2005; Ingersoll 2007; Aron 2016). Although the ESA never independently put a person into space, the agency regularly collaborated with the United States and Russia to send Europeans into space by joining in their missions. As of 2017, the European Astronaut Corps, a subdivision of the ESA, has taken part in in sending 41 European astronauts beyond the Kármán line.

One of the ESA's first astronauts was Jean-Loup Chrétien. In 1982, Chrétien joined the cosmonauts Vladimir Dzhanibekov and Aleksandr Ivanchenkov in the Soyuz T-6 mission, becoming the first Western European to enter space. The crew was stationed aboard the *Salyut-7* space station in a mission lasting nearly eight days, and used that time to conduct a series of medical studies to better understand the effects of long-term spaceflight (Burnsspecial 1982: 44). The *Salyut-7* crew were tasked with conducting biomedical research on how human bodies behave in a weightless and radiation-enriched environment, including urinalysis and examinations in electrocardiography, hemodynamics, venous pressure, and the excretory functions of the salivary glands (Yegorav 1979). While aboard the space station, the *Soyuz T-6* team concerned itself especially with cardiovascular research (Astor 2002: 75-77).

Three years later, the Dutch physicist Wubbo Ockels joined the STS-61-A crew aboard the space shuttle *Challenger* as an ESA representative. STS-61-A was NASA's first multinational crew, and further included astronauts from the Federal Republic of Germany whom represented West Germany's space agency, the German Aerospace Center. During the 7-day mission, the crew conducted 77 experiments aboard the ESA-built Spacelab D1. As with many other space missions, much of the scientific research was devoted to understanding human physiology in a non-terrestrial environment. One experiment, for example, involved four of the astronauts taking turns wearing helmets designed to obstruct their vision and then strapping into a "vestibular sled" that slung them back and forth. The purpose of the experiment was intended to examine the body's physiological response to spatial disorientation and the biological mechanisms the body uses to reorient itself (Angier et al. 1985).

The International Space Station (ISS) was a boon to the European Space Agency. The first component of the space station, the Russian-built *Zarya* Functional Cargo Block, was launched 20 November 1998. Two weeks later, the American-built *Unity* module was launched and, after several days, docked with *Zarya* (Logsdon 2012).

The multinational purpose of the space station provided an opportunity for the ESA to have a greater presence in astronautics, and so the agency used the occasion to invest in the ISS to secure spots among future crew. In a joint contract through NASA and the ESA, the *Harmony* ISS module was built by the French-Italian company Thales Alenia Space, and launched on 23 October 2007 (Coppinger 2007: 33). Operating in conjunction with the ESA, Thales Alenia Space later built the *Columbus* ISS space laboratory in Turin, which was launched on 7 February 2008 (Fasano et al. 2010: 489-495; Morring and Svitak 2011: 134; see Figure 20).

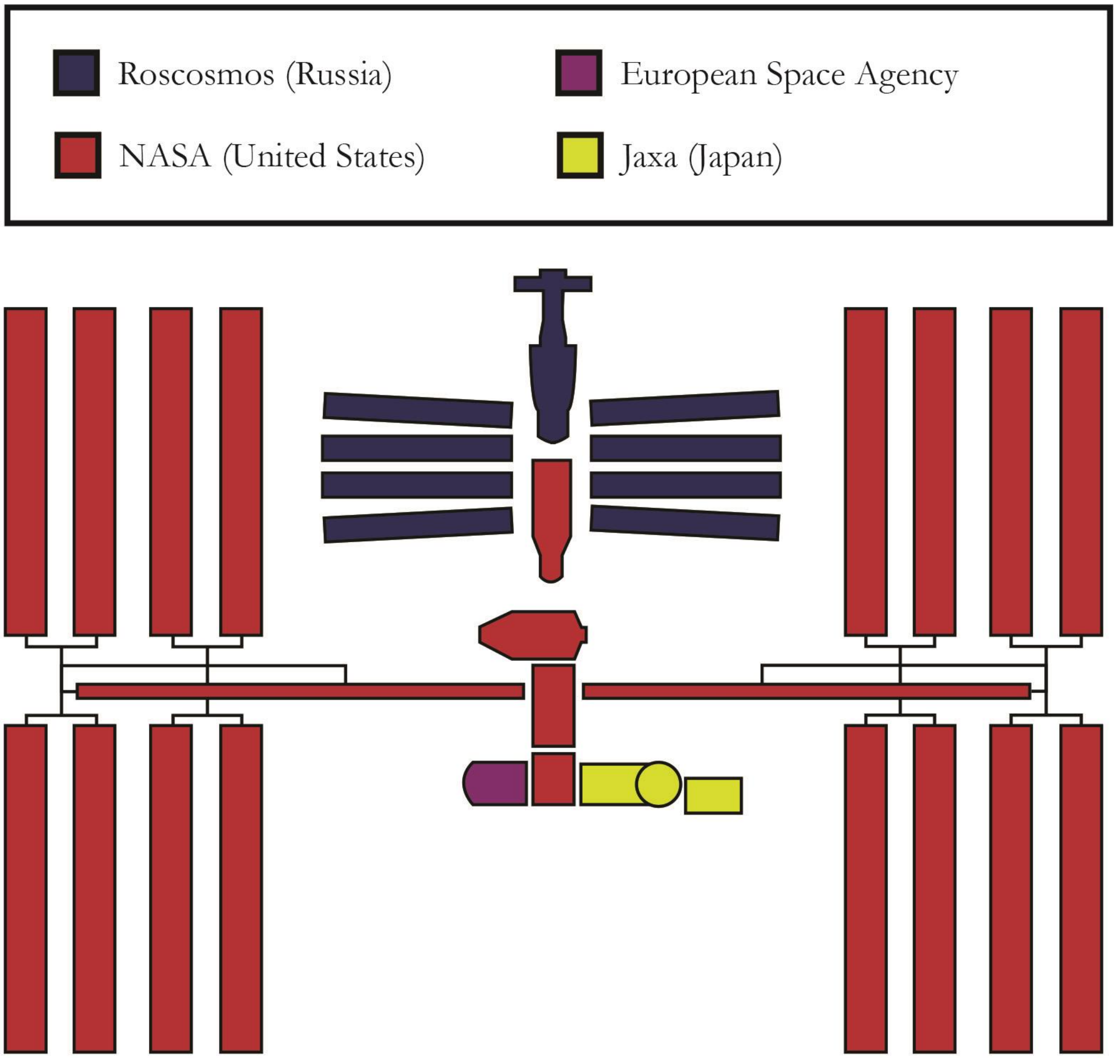

Figure 20. Simplified one-dimensional diagram showing national contributions to the International Space Station. The position of the ESA-built *Columbus* ISS Science Laboratory is visible in purple. Diagram by the author, 2017.

In collaborating with the U.S. and Russian space agencies, the ESA has put Belgian (Kaufman 2010: 7), Danish (Carreau 2015: 4), French (Covault and Sparaco 1996: 69), German (Dickman and Coles 1989: 179), Italian (Fricke 1992), Dutch (Newman 1995), Spanish (Anselmo 1998: 21), Swedish (Morring 2009: 35), Swiss

(Fricke 1992), and English (Everts 2016: 486-488) astronauts into space. France, Germany, and Italy have had a notably high presence in spaceflight, with 10 French astronauts across 18 spaceflights, 11 German astronauts across 15 spaceflights, and 7 Italian astronauts across 11 spaceflights. Other European nations have also had astronauts in space without operating through the ESA. Czechoslovakia, Hungary, Poland, and Romania each put astronauts into orbit through participation with the now defunct Interkosmos, a Soviet era space program designed to aid allies of the Soviet Union in achieving spaceflight (Dasch 2005).

Because of its rich heritage in space science, Europe has an abundance of space museums and exhibitions devoted to topics of space exploration. In France, these include the historically significant Air and Space Museum (French *Musée de l'air et de l'espace*) in Paris, and the Safran Aeronautics and Space Museum (French *Musée aéronautique et spatial Safran*) in Melun, among others; in Italy, there is the Leonardo da Vinci National Museum of Science and Technology (Italian *Museo Nazionale Scienza e Tecnologia Leonardo da Vinci*) in Milan; in Germany, the Hermann Oberth Space Travel Museum (German *Hermann-Oberth-Raumfahrt-Museum*) in Feucht, and the Speyer Technical Museum (German *Technik Museum Speyer*) in Speyer; in the Netherlands, the Space Expo in Noordwijk; in Belgium, the Euro Space Center in Libin; and in the United Kingdom, the Science Museum in London, the Winchester Science Centre in Winchester, the Life Science Centre in Newcastle upon Tyne, and the National Space Centre in Leicester.

China and Japan's Relationship with the Cosmos before the Twentieth-Century

Chinese philosophical engagement with the celestial heavens began in antiquity, and became a point of scientific relevance during a period of increased western imperialism midway into the Ming dynasty (Elman 2008). According to tradition and Confucian philosophy, each emperor ruled China by divine right bestowed through the Mandate of Heaven, legitimizing political dictatorship over their subjects (Schäfer 2011:77). The Emperor therefor possessed a direct link to *Tian*, the Chinese cosmos, and through this the ability to forecast natural events believed to be produced by the heavens, such as lunar and solar eclipses, seasonality, famine, earthquakes, and poverty. If he failed to predict these events, it indicated he had fallen out of favor with *Tian*, thereby destabilizing his control in the minds of his subjects and risking a coup d'état of his government (Morishima 2003). For this reason, it was imperative that the regime maintain a calendrical system for tracking celestial bodies and a staff of astrologers and mystics who could harbinger major events (Elman 2008: 16-18).

Not only were astrological predictions important to guiding the Emperor, but also to the decisions and sense of moral self-worth of Chinese citizenry. If a person encountered misfortune, it was attributed to celestial fate, and substantial effort was devoted to regaining favor of an otherwise impersonal cosmos. Understanding the structure of the universe was therefor of epistemological importance, and varying structures were proposed as models of the cosmos. The two most widely accepted of these were that of *gaitan*, the covering sky, and *huntian*, the enveloping sky. In *gaitan*, the sky was imagined as six belts upon which celestial bodies were fixed, with the belts rotating within seven outer circles. *Huntian* was generally described as a cosmic egg, an analogy where Earth was like the yolk, the heavens like the albumen, with a shell then holding the universe intact. As magical thinking bound the activities on Earth to the workings of the stars, the Chinese populace sought ways of predicting and interpreting *guanxiang*, or astronomical phenomena (Schäfer 2011).

Along with material trade, the arrival of European merchants in the late sixteenth-century brought science and western achievements in celestial navigation to the attention of the Chinese regime (Elman 2008: 15, 24-25). Tools used for measuring angles from the stars to make nautical decisions included the mariner's astrolabe and backstaff (Bauer 1995), which possessed great appeal for strengthening the dynasty. For the Empire, foreign astronomical systems presented lucrative opportunity to modify the problematic Chinese calendar to form one with greater predictive power. The Jesuits, a Catholic order of missionaries, seized this potential opportunity to convert China to Christendom. The Jesuit order presented a tantalizing offer to impart their mathematical and astronomical knowledge to the Chinese, allowing the Empire to strengthen its political power. This offer was far from benevolent. Instead, religious dogma was overtly mixed with otherwise irreligious scientific discoveries, which the Jesuits believed would lead China into accepting their God as a logical conclusion (Elman 2008: 15-35).

Meanwhile, European missionaries were aggressively preaching Christianity in Japan, while simultaneously undermining Japanese political order through trade manipulation and attempts to replace local culture with supposedly enlightened western thinking. In response, Tokugawa Iemitsu, a seventeenth-century shogun during the Tokugawa dynasty, outlawed all European activity from the island nation—except for trade from the Netherlands. Despite the banning of western influence, Chinese translations of European science leaked into Japan along with the goods imported from China, thereby creating a fringe intellectual black-market. Science, then, proved an appealing endeavor for the lowest order of Japan's highly stratified samurai class. Financed by taxation of the peasantry, but removed from the political activities reserved for only the elite samurai, these warriors turned to sciences like astronomy to remedy their boredom, covertly beginning Japan's future infatuation with science as a fertilizer for domestic growth (Morris-Suzuki 1994: 15-16, 23-27).

When China's Ming dynasty fell from power in 1644, and was quickly replaced by Manchu dictators, the Jesuits took no hesitation in turning their efforts to the new dynastic power. Though this allowed the Jesuit order to continue its operations well into the subsequent Qing dynasty, their provisional political allegiances marked them as untrustworthy. These events emerged as an uneasy relationship between Chinese literati and Catholic missionaries (Elman 2008: 20-21). As the sixty-year ban on European trade was ended in Japan, modern science renewed its flow into the nation, and Chinese scholars turned their attention from the Jesuits to the Japanese for scholarly material (Morris-Suzuki 1994).

In some respects, Japan proved even more adaptive than China to the in-flow of western information (Low et al. 1999). Although the behavior of both nations' citizenry was heavily guided by Confucianism, China interpreted the philosophy as preaching humanism, whereas Japanese belief had made Confucius teachings and nationalism inseparable (Morishima 2003). This Japanese nationalistic pride entailed a need to adapt and prove its superiority. While western spiritual beliefs were generally regarded with mockery, western technology did present a significant opportunity for

Japan to strengthen its industrial and military might, which would further legitimize a Japanese notion of supremacy (Morris-Suzuki 1994).

Japanese power was further affirmed by the celestial existence of the *tennō*, or heavenly emperor, the title having been derived from the Chinese *tian*. Yet unlike China, where emperors were seen as having been appointed by the heavens, the Japanese emperor was regarded as a direct embodiment of the cosmos. In accord with the indigenous Shinto belief, the *tennō* was a direct descendent of *Amaterasu*, the goddess of the universe who manifested as the sun. This elevated the *tennō* to the status of a god, who prayed to his familial universe to assure Japanese divine right over the planet. Thus, western advances in astronomy proved attractive for its potential to better engage the protectorate of Japan: the cosmos (Morishima 2003).

The Japanese Space Industry

By the twentieth-century, the Japanese populace felt increasingly self-assured in their divine right over the Earth. Japan was flourishing as it emulated western power by colonizing weaker nations and by conquering its neighbors to feed its burgeoning industrial growth (Low et al. 1999). National pride and confidence in their nation's invincibility later culminated in Japan's entry into the Second World War (Morris-Suzuki 1994). During the duration of the war, Japan's aeronautical industry continued to grow and, toward the end, the nation received the schematics for ballistic technology unmatched by anywhere else in the world—the V-2 rocket, a technology which Russia and the United States would soon modify to become the world's first space-faring nations (Brian 2000).

With the destruction of Nagasaki and Hiroshima, the faith that the Japanese had placed in their heavenly empire was reduced to little more than the rubble left by the bombing of their cities. Following the American Occupation, Japan's vast potential for aerospace development came to an abrupt halt as international sanctions banned Japan from maintaining a military (Low 1999). This injunction continued even after Japan was restored to an independent nation with the San Francisco Peace Treaty of 1952 (Nakayama and Yoshioko 2001: 144), and so, like the samurai of the early seventeenth-century, Japan's intellectual elite pursued unconventional ways to circumvent the laws that would otherwise slow the nation's scientific and militaristic progress. Less than a decade after the end of the Second World War, Hideo Itokawa began Japan's quiet contribution to the space race by launching his diminutive 23 cm *Pencil Rocket* from the grounds of Tokyo University (Low 1999: 109; see Figure 21).

Figure 21. Aeronautical engineer Hideo Itokawa holding a *Pencil Rocket*, an early step toward developing Japan’s space program. Photograph courtesy of JAXA.

The United States government soon relaxed its grip over Japan, and even began investing in its rearmament, despite that international policy forbid the nation from military spending. Consequently, Japan's aerospace industry was restored and advanced rapidly, invigorated by Japan's nationalistic effort to reinvent itself through a business and industrial focus on the international market frontier (Morris-Suzuki 1994). In February 1962, Japan constructed its ambitious Uchinoura Space Center to assert these goals. Though this was to become the launching point from which Japan would reaffirm its scientific prowess and technical sophistication, it also stood as an example of domestic bargaining dissimilar to industrial efforts seen elsewhere in the world. Uchinoura, the site of this new center, had historically served as a fishing port. The Japanese placed not only market value, but cultural value in their fishing industry, and locals feared that the cacophonous rocket launches would ruin their catch. Though Japan was determined to establish itself in space as quickly as possible, it was agreed that launches would occur only in Februaries and Septembers to accommodate the fishermen (Harvey et al. 2010: 12-14).

In February 1970, the nation launched *Ōsumi* into space aboard the Japanese-made Lambda 4S rocket, becoming the fourth nation to successfully orbit a satellite (Harvey 2000: 13). From there, Japan’s space endeavor expanded rapidly with a system of satellites, motivated in part as an investment in telecommunications, and driven in part by a public fear of North Korean aggression and a perceived need to monitor North Korea’s activity through spy satellites (Harvey et al. 2010; Low et al. 1999). Throughout the last quarter of the twentieth-century, Japan continued to assert itself in space through the presence of its astronauts and its addition of the Japanese Experiment Module to the

International Space Station. However, a growing cultural discontent—particularly among conservatives—regarding Japan's lack of independence led to some politicians portraying Japan’s space achievements as slow and even stagnant due to a bullied relationship by the United States. According to these views, Japan must break free of these shackles, regaining true cultural and social independence for the twenty-first century (Morita and Ishihara 1991).

The Japanese Experiment Module—referred to as *Kibō*, the Japanese term for “hope” (Japanese *きぼう*)—was requested by NASA in 1985, and estimated to cost Japan over one billion USD. The *Kibō* module was designed to be the largest module for the planned U.S. *Freedom* space station, and the Japanese space program completed *Kibō* without delay. However, NASA failed to adhere to its own schedule, much to the frustration of the Japanese. Ultimately, the *Freedom* space station was cancelled, but a substantial portion of its framework became the International Space Station, which included the *Kibō* module in its design. In its final form, *Kibō* included a pressurized module for carrying out science experiments, an exposed facility for conducting experiments with exposure to space, a module for storing scientific equipment, and a robotic remote manipulator arm (Harvey 2000: 89).

Before launching the *Kibō* space station module, Japan consolidated its space program into the singular Japan Aerospace Exploration Agency (Japanese *Kokuritsu-kenkyū-kaihatsu-hōjin Uchū Kōkū Kenkyū Kaihatsu Kikō*), or JAXA. Until JAXA’s foundation on 1 October 2003, the Japanese government maintained multiple space programs. Most notably, these included the Institute of Space and Astronautical Science (ISAS), the National Space Development Agency of Japan (NASDA), and the National

Aerospace Laboratory of Japan (NAL). Despite NASDA and ISAS serving similar purposes, they operated distinct launch bases, aerospace designs, and staff, without crossover occurring between the agencies. JAXA effectively brought this to an end by merging the agencies, thus creating a cohesive and collaborative environment (Harvey et al. 2010: 131).

The first section of *Kibō* was taken to the ISS on the STS-123 *Endeavor* mission on 11 March 2008. The launch included six American astronauts, but only a single JAXA astronaut, Takao Doi. Though the Japanese citizenry took pride in Takao Doi's second journey into space—in 1997, he had taken part in the STS-87 *Columbia* mission and became the first Japanese person to perform a spacewalk (Morring 2006: 13)—the absence of additional Japanese crewmen was cause for consternation. Some felt that Japan's investment in *Kibō* merited having multiple JAXA personnel among the crew rather than a singular Japanese astronaut. The subsequent STS-124 *Discovery* mission to continue installing the *Kibō* module likewise included only one JAXA astronaut, Akihiko Hoshide, among an otherwise all-American crew (Coppinger 2008: 27). Furthering this problem, the final mission to finalize *Kibō*, STS-127 *Endeavour*, did not include a single JAXA astronaut among its launch crew, although the JAXA veteran Koichi Wakata was aboard the ISS at the time after having spent four months in space (Harvey et al. 2010: 122). Although the low presence of Japanese astronauts among *Kibō*-related missions was less than ideal, Japan has proved extraordinarily successful over the duration of its space industry, with numerous rocket and satellite launches, and 11 Japanese astronauts having taken part in 19 distinct trips to outer space.

In respect to space museums, Japan celebrates the success of its aerospace industry at multiple institutions spread across the island nation. In Tokyo, the National Museum of Nature and Science devotes several of its galleries to space-related topics, which include the Global Environment Detector gallery, where satellite data and images are used to inform visitors about Earth's geophysical properties, and the "Progress in Science and Technology" gallery, with exhibitions ranging from scientific inventions made during Japan's Edo period to Japan's twentieth and twenty-first century developments in space technology. Among the displays is Hideo Itokawa's Pencil Rocket, the invention which commenced Japan's rocket development program and the nation's eventual entry into space (NMNS 2017).

Also in Tokyo, the Space Museum TeNQ displays a range of exhibits on space history and the aesthetics of outer space. Many of its exhibits incorporate projectors and LED screens to create a visually stimulating experience, including a large circular floor display where visitors can enjoy looking back on their rotating planet as if they were viewing it from the International Space Station (Rei 2014). In the Hokkaido Prefecture, the Yoichi Space Dome museum honors NASDA astronaut Mamoru Mohri, and includes a 1/20 scale model of the International Space Station and a full-scale model of the *Kibō* ISS module (JNTO 2017). Additionally, JAXA runs a museum at the Tanegashima Space Center in the Kagoshima Prefecture (JAX 2017), the historically significant site from which Japan launched many of its early rockets to become one of the foremost nations to engage in space exploration (Harvey et al. 2010: 122).

The China National Space Administration

Shortly after the Second World War, China became a communist state and therefore an immediate partner of the Soviet Union (Johnson-Freese 1998). In accord with the trending politics of the United States, this also marked China as a Cold War accomplice, and the Chinese populace grew increasingly fearful of American aggression. After all, the United States had recently decimated two cities in neighboring Japan, and was threatening its perceived enemies with further nuclear strikes. To protect themselves, China began investing in a militarized defense system, which was to include a significant presence in space (Harvey 2004: 37).

China's relationship with the Soviet Union became increasingly strained as the Soviet government neglected many of its trade agreements, sending China only its outdated technology for constructing its defense system. When China received the schematics for an R-1 rocket—little more than a modified Nazi V-2—only shortly before the Soviet Union launched Yuri Gagarin, the first astronaut, using a V-7 rocket, it became clear to the Chinese populace that their allies had mostly forsaken them. In response, the Chinese government depicted their nation's preservation as contingent on its ability to assert itself technologically and militarily. Consequently, China’s space program paralleled the development of its nuclear and ballistic missile programs (Lewis and Litai 1987: 541-554). By 1964, China achieved nuclear capabilities and, only two years later, the nation began launching animals into space as preparatory studies to ensure the safe travels of its future astronauts (Harvey 2004: 22-34, 38-44).

China's sense of isolation shaped its space investment into a mixture of defensive paranoia and a boisterous need to assert its strength (Seedhouse 2010). As a result, its activities became extremely secretive. Cover-ups and covert activity became the norm. A 1978 explosion that killed multiple aerospace engineers only gained international attention six years afterward through leaked information (Harvey 2010: 100); the explosion of a failed satellite launch, which rained down on villagers as shrapnel and lethal gas, was unapologetically denied by the Chinese government despite eye-witness accounts that it had left at least a 100 people dead; and the orbiting of China's first independently launched astronaut, Yang Liwei (Sharpe 2006: 150), was not televised to avoid embarrassment in the event that the mission failed, with the announcement of mission’s success made only afterward (Seedhouse 2010: 20).

Chinese efforts to put spacecraft and humans into orbit have been shaped by an amalgamation of their belief systems, political events, and historical foundations. For the Chinese, lively efforts by the Chinese National Space Administration (CNSA) represent a strong nationalistic belief that the twenty-first century will belong to them (Harvey 2004). Unfortunately, though China's sociopolitical policies have created a unique cultural context within their aerospace industry, the reticent nature of its social climate has made it extremely challenging to anthropologically study the nation’s space industry. Fearing incarceration or worse at the hands of their government, potential informants have been liable to provide outsiders with misinformation or to entirely decline from commenting (Seedhouse 2010: 2-7).

Despite—or perhaps because of—the isolation of its space program, China is one of only three nations to have independently put its own citizens into space. From 2003 to 2016, the CNSA’s Shenzhou program has put 11 Chinese astronauts into orbit through 14 distinct missions (Jones 2011; Jones 2012; Preu and Braun 2014: 584-591; Li et al. 2017: 17-22), while NASA has not independently put an astronaut into space since the conclusion of the Space Shuttle program on 21 July 2011 (Witze 2011: 262; Marris 2011: 908). China has also demonstrated its potential for dominating twenty-first century space exploration by launching two space stations, *Tiangong-1* on 29 September 2011 (Morring 2012a: 18) and *Tiangong-2* on 2 October 2016 (Perrett and Morring 2016: 22). Additionally, the Chang'e space program, titled after the Chinese lunar goddess of the same name, successfully placed the *Chang'e-1* and *Chang'e-2* probes into lunar orbit in 2007 and 2010, respectively (Zuo et al. 2014: 24-44), and the *Chang'e-3* lander and rover onto the Moon in 2011 (Sun et al. 2013: 2702-2708).

The Canadian Space Agency

Much like other Allied powers, Canada acquired 41 Nazi aerospace personnel at the end of the Second World War (Neufeld 2012: 53). The nation's space program was slow to develop due to inadequate funding, however. Political disinterest in defense spending was made especially apparent when the Canadian Prime Minister John Diefenbaker unexpectedly cancelled the Avro Arrow program just six months after the Soviet Union launched *Sputnik-1* into orbit. The aeronautical program had spent five years developing the Avro Canada CF-105 Arrow, one of the world's most sophisticated fighter planes of the late 1950s. Inexplicably, Diefenbaker ordered the half-dozen aircraft that had been produced to be destroyed, effectively putting the Avro Canada manufacturing company out of business, which at that time was one of Canada's largest employers. The effect was a partial exodus of Canada's most accomplished engineers to the United States, with many of them finding work in the developing U.S. space program at NASA (Melady 2009: 44-45).

Like the United States, Canada had emerged from the Second World War without the damaged infrastructure that stymied industrial growth in Europe, yet Canada's economic policies prevented the nation from experiencing the same unprecedented productivity as the United States. Despite such setbacks, Canada managed some admirable feats of engineering ingenuity by collaborating directly with NASA. On 29 September 1962, the *Alouette-1* satellite was launched into orbit aboard a U.S. Thor-Agena rocket, becoming Canada's first satellite, while additionally making Canada one of the earliest nations to operate an instrument in outer space. It was also unusually successful. Not only did *Alouette-1* gather an unprecedented amount of usable data, but it also exceeded its life expectancy of six month by remaining operational until 1972, a full decade after its initial orbit (Godefroy 2011: 95-96).

Thereafter, most of Canada's aerospace ventures were done in conjunction with NASA. On 21 July 1969, the *Apollo 11* lunar module descended onto the Sea of Tranquility, an expansive area of basaltic mare on the Moon's surface, using landing gear that had been built and developed by the Canadian company Heroux Aerospace of Longueil in Quebec. On 13 November 1981, another piece of Canadian technology flew into space, this time aboard the space shuttle *Columbia*: the remote manipulator system, affectionately referred to as Canadarm. The robotic Canadarm was successfully used to deploy and manipulate payloads, and became an enduring icon of Canada's contribution to orbital space exploration (Melady 2009: 45, 47).

Three years later, Canadian Marc Garneau took part in the STS-41-G *Challenger* mission and became the nation's first astronaut. Among Garneau's equipment was a Canadian IMAX camera, with its film later used to create a high-definition documentary about the space shuttle program. *Challenger* orbited for eight days, including on Canadian Thanksgiving Day, whereupon the American crew surprised Garneau with a celebratory tinfoil packet of turkey and gravy. In another instance of solidarity, the residents of Kingston, Ontario turned on and off their lights as a greeting to the *Challenger* crew, a nighttime spectacle that was visible from space (Melady 2009: 49-60).

Despite that Canada had been actively developing space technology since 1958, the nation lacked a central space agency for over three decades. Until the Canadian Space Agency (CSA) was founded on 1 March 1989, interdepartmental committees were tasked with coordinating most of Canada's space-related projects. Although Canada effectively used this time to develop technologies related to communication satellites and remote sensing, the disunity of Canada's space program created inefficiencies which otherwise slowed the nation's progress (Gainor 2007: 132-139).

Prior to 1989, only one astronaut had been Canadian. After the CSA's founding, investments in astronautics increased dramatically. On 22 January 1992, Dr. Roberta Bondar joined the STS-42 *Discovery* mission and became Canada's second astronaut. Dr. Bondar had distinguished herself from other applicants to the CSA astronautics program with an impressive list of achievements that included a bachelor's degree in zoology and agriculture, a master's degree in experimental pathology, a doctorate in neuroscience from the University of Toronto, and a doctorate of medicine from McMaster University, in addition to a pilot's license. Because of her conspicuous achievements, Dr. Bondar had been selected as the ideal candidate for the STS-42 *Discovery* mission's focus on biological research. During her eight-day spaceflight, Dr. Bondar and her crewmates operated in Skylab to conduct research on biological specimens which ranged from fruit flies to mouse cells, and on biomedical research related to human eyes, lungs, legs, spine, heart, and the auricular system (Melady 2009: 61-71).

Between 1992 and the CSA's final astronautics mission in 2012, eight Canadians were launched into space on 13 separate missions. Of these CSA astronauts, Colonel Chris Hadfield was one of the most distinguished. On 12 November 1995, Hadfield joined the STS-74 *Atlantis* crew in constructing a docking module for the Russian space station *Mir*, and became the only Canadian to board the space station before *Mir* was deorbited on 23 March 2001 (Hadfield 2013: 26-27). Hadfield returned to space again in 2001 with the STS-100 *Endeavour* mission to install the robotic Canadarm2 into the ISS (Melady 2009: 163-174), and flew to space a third time in 2012 aboard a Soyuz-TMA spacecraft, whereupon Colonel Hadfield became the first Canadian commander of the ISS (Hadfield 2013: 247-259).

The popularity of astronauts has been of great benefit to space and science museums, and Colonel Hadfield is no exception. During Colonel Hadfield's final spaceflight mission, the Canada Aviation and Space Museum in Ottawa (French *Musée de l'Aviation et de l'Espace du Canada*) ran special programming to draw in additional visitors. The museum's content on astronautics has similarly enticed visitors, such as its

"Life in Orbit: The International Space Station" exhibit, which includes displays and interactives related to the journeys of Colonel Hadfield and other space adventurers. Above all, visiting astronauts pull the biggest crowds. Through public outreach programs, Hadfield and other astronauts have made themselves available to the museum-going public to inspire congregations of children and adults alike (Howell 2013).

Other Canadian space museums have been similarly popular. The Canadian Air and Space Museum in Toronto chronicles Canada's history in both aviation and spaceflight, with exhibit content such as a replica *Alouette-1* satellite (CASM 2017). Museums in other provinces similarly split content between collections of aircraft with exhibits on space history, such as at The Hangar Flight Museum in Calgary (HFM 2016). Other museums split their exhibition content on Earth's natural history with content on space-related topics, such as at Science World at Telus World of Science in Vancouver, which on July 2017 began bringing attention to women in space as a celebration of the former CSA astronaut Julie Payette's recent appointment as Governor General of Canada (ScienceWorld 2017). At the H.R. MacMillan Space Center in Vancouver, the museum distinguishes itself by devoting its content solely to topics on space science, including Canada's role in the development of space exploration and, to a lesser extent, the role of other emerging international space powers (MacMillan 2015).

Other Developing International Space Programs

As with the United States and the Soviet Union, other nations also benefited from the technology brought to their nation by fleeing Nazi engineers, including Argentina, Australia, Brazil, Egypt, and India. Some of these nations also acquired smuggled objects from German aircraft and rockets, which were coveted for their use in developing domestic military capabilities (Neufeld 2012: 49-50). Other nations have only engaged in space research in recent decades, motivated by a desire for technological independence and the prestige that space programs bring. As of 2017, 46 nations have had at least one astronaut in space, with this number likely to increase in the twenty-first century as space tourism becomes more prevalent. According to SpaceX founder Elon Musk, growth in space exploration is not necessarily inevitable (TED 2017), but trends in technological progress do indicate that space tourism will only increase public interest in space (Forganni 2017).

Regarding international space powers, India has shown great potential. In 1966, Vikram Sarabhai, who was to become the father of India's space program, met Hideo Itokawa, father of the Japanese program, while attending an international astronautical conference (Harvey 200: 127-128). Inspired, Vikram Sarabhai directed a team of engineers to build and launch India's first rocket, *Rohini-75*, in 1967. Two years later, the Indian Space Research Organisation (ISRO) was founded (Vasant and Suresh 2009: 1515-1519).

For Sarabhai, developing a rocket program was not a matter of prestige, but of practicality. He envisioned that satellite networks might provide India with a network for monitoring its agriculture and forestry, and for bringing education to remote villages. Over the following decades, India built and launched dozens of satellites. The viability of these satellites was quickly proved as they helped to predict and track various dangers such as droughts, pests, floods, and storms (Harvey 2000: 128-153). Not all endeavors were as immediately practical as India's satellite network. The prestige of India having its own astronaut became too alluring to ignore, and on 2 April 1984, the nation paid the Soviet Union to let Rakesh Sharma aboard the Soyuz T-11 spaceflight mission, whereupon he became India's first astronaut (Rao 2008: 25).

In Brazil, the end of its military dictatorship in 1985 shifted the nation's space efforts from having a militant purpose to becoming a comparatively benign civilian and science focused industry. This culminated in a series of programs devoted to meteorology and telecommunications. In 1994, the Brazilian Space Agency (Portuguese *Agência Espacial Brasileira*) was established to manage these projects, and to guarantee Brazil autonomous capability in building its own rockets (Harvey et al. 2010: 311-369). Though successful in launching its own rockets and satellites, Brazil was unable to safely develop a means of putting an astronaut of its own into space. In 2006, the Brazilian government paid Russia to send Marcos Pontes into space on the Soyuz TMA-8 mission, making Pontes the first South American to reach the Kármán line (Canes 2006).

For Israel, developments in space technology were motivated by a desire for higher security. On 19 September 1988, Israel became the eighth nation to independently launch a satellite using its own launch system, which it named Shavit (Hebrew שביט), the Hebrew term for comet. Most of the missions of the Israeli Space Agency have been in collaboration with partners and allies of Israel (Harvey et al. 2010: 385-435), such as on 1 February 2003, when Ilan Ramon (Hebrew אילן רמון) joined NASA's STS-107 *Columbia* mission with the intention of becoming Israel's first astronaut. Tragically, Ilan Ramon was killed when a piece of *Columbia*'s insulation foam broke loose and struck the external fuel tank and shuttle wing, later causing catastrophic damage during re-entry (Brown and Sin-David 2007: 731-737; CAIB 2012; NASA 2012). Though the Israeli

Space Agency has remained active since then, Israel has yet to put another astronaut into orbit.

South Korea's space developments have likewise been related to defense and security. Beginning in the 1970s, North Korea and the People's Republic of China entered an agreement to collaborate in developing and producing liquid-fueled ballistic missiles. By 1990, North Korea began test launching its Nodong missiles, putting Japan and South Korea in range of North Korea's ballistic program. In an attempt to secure international respect, North Korea began further launches in the early 2000s, claiming that it was establishing an independent network of orbital satellites. The claim appears to have been dubious. Russian and U.S. spacecraft-tracking programs did not detect an orbital payload, and so the supposed North Korean network has been disparagingly referred to as "ghost-satellites" (Harvey et al. 2010: 439-482).

Many of North Korea's boisterous claims have been ill-founded, but the threat behind the nation's rhetoric has had legitimacy. In 2006, North Korea began conducting tests in developing a weaponized nuclear missile, and on 12 April 2012, the nation amended its constitution to declare itself a nuclear weapons state (Choi and Bae 2014: 53-76). In 2009, North Korea also launched a satellite via an Iranian rocket (Harvey et al. 2010: 439), and on 4 July 2017, North Korea achieved ICBM capabilities with the launch of its *Hwasong-14* missile (BBC 2017).

On 10 October 1989, South Korea established the Korea Aerospace Research Institute (KARI), its space agency to improve national security in response to North Korea and other threats, and to develop technical capabilities related to areas of public interest. The development of KARI's rocket program began shortly afterward. On 10

August 1992, KARI collaborated with France and the United States to launch South Korea's first satellite, with further satellite programs following throughout the 1990s and early 2000s. (Harvey et al. 2010: 487-542). Unlike North Korea, South Korea also successfully funded putting one of its own citizens into orbit. On 8 April 2008, Yi So-yeon represented South Korea as an astronaut on the Soyuz TMA-12 mission (Sang-Hun 2008: A5).

As of 2017, no African nation has independently put an astronaut into space, nor funded an astronaut through a foreign space agency. A few African nations have established modest space agencies, primarily with the desire of establishing independent satellite networks. The Nigerian government has launched multiple satellites through its National Space Research and Development Agency (NASRDA), beginning with *NigerSAT-1* on 13 May 2007 (McLymont 2004: 36; Bakare et al. 2016: 104-109). On 9 December 2010, South Africa also established an agency of its own. The South African National Space Agency (SANSA) was founded to develop infrastructure for remote sensing, with an intent to monitor and prevent agricultural and environmental disasters (Morring 2012b: 18).

Alternatively, space tourism has created a means through which wealthy citizens can seek out a ride to space, regardless of whether a domestic space agency exists and without the requirement of having the extensive training normally expected of astronauts. Notably, South African entrepreneur Mark Shuttleworth became the second space tourist in 2002 after purchasing a ride on the Soyuz TM-34 mission, and is thus the only African-born person to go to space (Covault 2002: 26). To date, seven people have taken up tourism in space, including the Iranian-born Anousheh Ansari—founder of the

Ansari X Prize—in 2006 on the Soyuz TMA-9 mission (Kleszewski 2006: 3), and the British-born Richard Garriot—creator of Ultima Online, the first successful massively multiplayer online role-playing game (MMORPG)—in 2008 on the Soyuz TMA-13 mission (Oberg 2009: 70).

Currently, there are no museums devoted exclusively to space tourism, nor have there been any well-publicized exhibitions with a sole focus on the topic of space tourism. Nonetheless, some museums have dedicated smaller exhibit spaces to content on space tourism, with the most notable example being the *SpaceShipOne* at the Smithsonian National Air and Space Museum (Collins 2005: 42). In 2004, the creators of the *SpacesShipOne* suborbital aircraft earned the coveted Ansari X Prize after becoming the first non-government organization to independently launch a person into space twice within a two-week period (Byko 2004: 24-28), thus turning *SpacesShipOne* into a historically and culturally important object.

Thereafter, the *SpacesShipOne* suborbital aircraft was moved to the Smithsonian National Air and Space Museum via the White Night aircraft, which had previously been used to launch *SpaceShipOne* into its suborbital flight the previous year. As a testament to the historic importance of *SpaceShipOne*, the Smithsonian decided to hang it alongside Charles Lindbergh's *Spirit of St. Louis*, the first aircraft to make a continuous flight across the Atlantic (Bryson 2013: 146, 426-427; Welch and Lamport 2013: 1-30), and Chuck Yeager's *Bell X-1*, the first aircraft to break the sound barrier (Collins 2005: 42). Public interest in space tourism has reached new heights following *SpaceShipOne*'s rise to fame, as has the likelihood that privatized suborbital space programs will increase in the coming decades (Chang 2015: 79-91). However, it remains to be seen how the 31 October 2014 fatal crash of Virgin Galactic's *SpaceShipTwo* will affect the future of privatized spaceflight (Witze 2014a: 15-16; Witze 2014b; Wilkinson 2015: 1-8).

With the development of privatized spaceflight in mind, along with the rising prevalence of international space agencies, it is likely that the general public will look to museums in the future for engaging, educational exhibit content on the multi-national growth and history of space exploration. In this regard, curators and exhibit designers can adapt museum and anthropological theory to consider exhibit narratives and, importantly, establish exhibit content that is politically balanced and culturally inclusive.

CHAPTER IV

THEORETICAL FRAMEWORK

Introduction

No theoretical framework has been firmly established for examining and discussing the objects used within space exhibits despite that considerable literature has been written about the curatorial collections of space museums, including spacesuits (Kozloski 1994; Lantry 2001; Young 2009), space shuttle insulation tiles (Szczepanowska 2015), V-2 rockets (DeVorkin and Neufeld 2011), space capsules (Gouyon 2014; Neufeld 2014), lunar artifacts (NASA 2011; Hollins and Needell 2014), and so forth. Nor has a theoretical framework been developed for the specific purpose of analyzing interpretive exhibit panels and labels, despite that museum texts play a critical role in visitor understanding (Serrell 1996: 9). To supplement this situation, my thesis applies a framework combining some aspects of new museum theory, applied linguistics, and semiotics to analyze and interpret my data.

New museum theory posits that the cultural experiences and belief systems of museum professionals are, intentionally or unintentionally, conveyed through the narratives of the museum exhibits they produce (Marstine 2006: 5). The central purpose of my thesis research is to explore how various national identities are presented in space museum exhibits, and consider why some narratives might have been chosen over others. Although I try to maintain some objectivity in acquiring this information by analyzing museum texts and labels, rather than relying on interview narratives of museum personnel, my interpretations of the results are subjective nonetheless. New museum theory is useful to this interpretative process in that it is intended to consider how other groups of people are represented within museum narratives (Bryan 2008: 1-48).

Applied linguistics deals with the cultural conceptualizing of schemas, categories, models, metaphors and myths (Palmer and Sharifan 2007: 7, 12) in order to help solve real-world problems (Malcolm 2007; Occhi 2007). For this reason, applied linguistics is useful to assessing the narratives used in contemporary museum exhibitions, including panels, labels, auditory media, and visual media. Museum objects likewise convey narratives based on how their presentations have been arranged, their relationships with the other objects on display around them (Kockelman 2013: 42-43), and the symbolic sociocultural meanings of those objects (Anyfandi et al. 2014: 231). In this capacity, semiotics provides the theoretical framework for assessing and interpreting the use of exhibit objects at the museums I investigated.

There exists a variety of additional theoretical approaches, some of them particular to museum studies, which might offer alternatives to studying space museums. Foucauldian, constructivist, and other theoretical approaches to sociocultural topics might be useful to studying aspects of space museums not explored at depth by my research, such as visitor perspectives, tour-group dynamics, or the use of museum-hosted classes and summer-camps. Many alternative theories offer valid approaches to anthropological and museum research, and it is my hope that future researchers will use other methods to study space museums in the future. However, for the purpose of this thesis, I have chosen new museum theory, semiotics, and applied linguistics as ideal conceptual tools for understanding the content of exhibit panels and labels.

New Museum Theory

New museum theory, also known as critical museum theory and new museology, posits that the cultural experiences and belief systems of museum professionals are, intentionally or unintentionally, conveyed through the narratives of the museum exhibits they produce (Marstine 2006: 5). New museum theory has been used to consider how visitors think critically about the veiled perspectives and values within museum narratives, and has also, to some extent, been used to encourage visitors to actively engage in this activity (Lindauer 2006: 203-223; Beaujot 2015: 17-26). Although an in-depth study of visitor perspectives is beyond the scope of this thesis, the basic premise of new museum theory is still applicable: to understand the purpose of a museum, research should consider both the explicit and the implicit—that is, the stated and unstated textual content within exhibits (Marstine 2006: 1-31).

In one example where new museum theory has been considered, the Smithsonian National Air and Space Museum infamously chose to display the *Enola Gay*, a Boeing B-29 Superfortress that dropped the first atomic bomb. Given the sensitivity of the subject, the associated exhibit text narrative conflicted with varying visitor values and differing visitor perspectives about world history. Consequently, this led to an enormous uproar among politicians and the public (Kohn 1995: 1036-1063; Mayr 1998: 462-473; Hubbard and Marouf 1998: 363-385; Marstine 2006: 1-31). Visitor emotions are less likely to be as volatile for museum content on space history as they are for an object like *Enola Gay*, which was involved in the death and serious injury of hundreds of thousands of Japanese civilians. However, historical perspectives on the developments in space technology, especially those related to the Cold War, are still likely to rouse politically-driven emotions. For this reason, it is important to be mindful that some exhibit creators will have chosen to omit certain discussions so as to avoid controversy.

In the words of Janet Marstine (2006: 4), the academic director of museum studies at the University of Leicester and editor for the *New Museum Theory and Practice* textbook, "museums don't just represent cultural identity, they produce it through framing." That is, context dictates the meaning of objects. As an example, a sculpture memorializing the *Challenger* disaster will convey aesthetic value within an art museum, whereas the same sculpture will convey historic value if placed within a history museum. Similarly, a Soyuz descent module is more likely to stir political sentiments if placed within an exhibit on the Cold War than it is if placed within an exhibit on the biophysical challenges of surviving in space.

Contrary to the notion that museums are objective places of learning, museums are places where versions of history are amalgamated and arranged to craft specific stories through texts, images, and artifacts (Gable 2006: 110). Ambitiously, Janet Marstine (2006: x) states that new museum theorists, “call for the transformation of the museum from a site of worship and awe to one of critical inquiry; they look to a museum that is transparent in its decision-making, willing to share power, and activist in promoting human rights.” New museum theory advocates giving a voice to individuals other than just the museum staff, thereby making contemporary museums more inclusive through collaborative efforts. Whether this vision is fully achievable is debatable, but the basic premise of new museum theory is valid. Museums are better understood when considering the intent behind the arrangement of their displayed collections, the choice words in their texts, and the content left unseen or unsaid.

Material Culture and Semiotics

All objects, whether they are mundanely common or distinguishably rare, have cultural meaning. These meanings are subjective, and depend largely on the background experiences of the individuals interacting with the object. If the object is used regularly, its users are likely to be blinded by the cultural value of the object—something which only becomes apparent when the object is absent during a time it is perceived as needed. For objects used on rarer occasions, the cultural value of the object is likely to be more obvious, especially if that object is tied to some socially sacred event. This can be as true of the artifacts born from space exploration as it is for objects more traditionally viewed as ceremonial and sacred, such as ankhs, crosses, totems, or other objects with symbolic meaning and historic affiliations. This is not to imply that an exhibited space-related object, such as those of the first lunar landing, have religious connotations, but rather that museum visitors are likely to draw upon their own values and experiences when viewing an object they perceive as having deep cultural significance. Knowing this, museum exhibitors exploit the symbolic value of their collections when designing exhibits to convey specific narratives.

Some museum objects require descriptive texts to convey the importance of the object on display (Serrell 1996: 9-19), but in some cases the objects speak for themselves (Conn 1998: 4). Museum curators and exhibit designers are aware of the ways specific objects can evoke thoughts, emotions, or both, and use these in conjunction with other objects to form larger narratives. Such narratives are not dependent on verbal or written modes of conveying ideas to visitors because, presumably, visitors arrive with some preconceived idea of what the object means. This concept of interpretative bias has been explored within the frameworks of constructivist learning theory which, within the context of museums, considers the subjective views of visitors and how such views affect visitor interactions with exhibit content (Falk and Dierking 1992; Hein 1998: 155-179; Falk et al. 2006: 821-829).

Semiotics explores the attribute of non-verbal communication through which museum objects are used to “speak” to the visitor (Anyfandi et al. 2014). A semiotics theoretical approach is useful to assessing the intended subjective meaning of material culture within the museum context. Moreover, this theoretical framework is helpful when considering the correlation between museum objects on display and adjacent exhibit panels and labels. Because this thesis takes a content-focused approach, wherein the narratives produced by exhibit designers are considered, rather than a visitor-focused approach, wherein visitor interpretations of those narratives are investigated, semiotics is more applicable than constructivist learning theory. Nonetheless, it is still worthwhile to muse on how museum content might affect visitors, albeit in brief.

Due to the renown of some objects, museums stand as destination points for modern pilgrimages, where visitors engage in a form of material worship. For technology and science museums, this typically involves some object that has been bestowed special attention for being the “first” of its kind (Crouch 2007: 20). At the Smithsonian National Air and Space Museum, for example, the *Friendship 7* space capsule is given special attention for having been used by John Glenn, the first American to orbit the Earth

(Neufeld 2014: 7); the A7-L spacesuit, for keeping Neil Armstrong, the first man on the Moon, alive (Lewis 2014: 81); the *North American X-15* aerospace vehicle, for becoming the first spaceplane (Joiner 2014: 68-72); and the *SpaceShipOne* suborbital spaceplane, for completing the first privatized human spaceflight (Collins 2005: 42). Such exhibits are intended to stimulate the cultural value of pride, wherein visitors are expected to find themselves proud of human achievements, and also to find awe in the technological prowess—and presumed superiority—of the United States.

The connotative semiotic meaning of objects demonstrate their potential use in communicating specific ideas to museum visitors. In this respect, science exhibits can be looked at and studied as socio-semiotic resources with "social value" and "communicative potential" (Anyfandi et al. 2014: 231). Museum curators and exhibit designers then collaboratively use the communicative potential of exhibits to convey emotions, ideas, and stories by recognizing the symbolic meaning of objects and arranging them in specific ways. This involves a process of semiotic segregation, semiotic separation, and semiotic contrast.

Semiotic segregation relates to the museum's architectural arrangement and how a floor-space can be used to arrange exhibitions and the exhibits they are composed of in the arrangement. This entails set boundaries where walls, dividers, or other structures are used to separate exhibits from one another. Exhibit designers use these structures to segregate objects and, in doing so, ideas. For example, if exhibit designers decide to create exhibits using a collection of objects from the Canadian Space Agency (CSA) and another collection of objects from the Japan Aerospace Exploration Agency (JAXA), they can choose to either display the entirety of the collection together, or the designers can instead use physical barriers to separate the collections from one another. The latter case demonstrates semiotic separation, whereupon visitors will not view the objects together and will therefore dissociate the objects without having to be explicitly told to do so.

The extent of semiotic segregation can vary by permanence or permeability. An architectural feature with full semiotic permanence is intended to fully segregate one exhibit space from another. This typically involves walls that were included in the original architectural layout of the museum, with later exhibitions planned around these spaces. Permanence can also involve later additions of walls included solely for the purpose of creating semiotic segregation within a new exhibition. Semiotic permeability, by contrast, leaves segregated exhibits in view of one another. Permeability may be achieved through the use of windows, glass walls, glass exhibit cases, roping off exhibit areas, or any other form of physical barrier intended to control visitor movement while also allowing them visibility.

Contrast is another important semiotic component of museum exhibitions. Establishing semiotic contrast involves separating objects within adjacent exhibits into different socio-cultural groups. This is accomplished through assessing the physical characteristics which distinguish objects by social categories and then displaying them accordingly. Such characteristics might include the varying shapes and sizes of the objects, their color, the material they were crafted with, or any other physical properties which museum visitors can observe as differentiating the objects from one another. For example, an exhibit on rocketry may establish semiotic contrast by using visually dissimilar objects, such as by placing models of Russian Vostok rockets with the model of American Saturn V rockets, rather than using visually similar and therefore culturally ambiguous rocket models. In this system of categorization, the greater the dissimilarity between the objects, the stronger the semiotic contrast.

Finally, semiotic separation is another important way of conveying the meaning of objects. In this process, objects are separated in terms of space. For example, two objects can be placed in a glass display case side by side, but with an open space between them to signify their similarities and relationship while also indicating that some distinction still exists between the objects. This visually apparent separation notifies museum visitors that the material culture on display has shared symbolic meaning, even though the objects might not share the same material categories. For example, a display case might include distinctly different objects such as a Japanese sun-marked flag (Japanese *Nisshōki*), a painting of the heavenly Shinto goddess Amaterasu-ōmikami, and a patch with the JAXA logo, but in this circumstance, all of these objects have been unified in a common space to thematize national identity and affiliation. These categories of semiotic properties are encapsulated in Table 1.

Table 1. Summary of semiotic properties of material objects used in museum exhibitions.

Semiotic Properties	High	Low
Segregation	Physical partitions such as walls (permanence), glass dividers (permeability), or rope barriers (permeability).	Floor-plans which lack partitioning.
Contrast	Apparent differences in object shape, size, color, material constituents, or other physical properties.	Strong similarities in object shape, size, color, material constituents, or other physical properties.
Separation	Objects may be placed in proximity, but with some space allowed between them.	Objects are physically attached, or the space between objects is too great to indicate their relationship.

As a theoretical framework, semiotics can be used to assess the way signs are structured and sequenced to communicate scientific ideas (Jamani 2011: 199), as well as socio-historic concepts. The sociocultural potential of inanimate objects to embody myths, ideas, and ideologies is an important component of the museum visitor experience (Dimopoulos 2011: 5). Because the arrangements of exhibit objects involve the conscious planning of museum exhibit designers and curators, the narratives these form can be anthropologically studied and assessed. However, although this is a useful construct for discussing museum content and exhibitor intentions, its subjectivity does pose limitations. Museum visitors each arrive with their own experiences, beliefs, and perspectives which affect their interpretations of museum displays (Roberts 1997: 74-75; Falk et al. 2006: 821-829). This is no less true for anthropologists using semiotics to assess the symbolic meanings of objects.

Applied Linguistics

While many social theories rely on subjective and qualitative assessments, applied linguistics uses both qualitative and quantitative measures for assessing the conveyance of narratives through language (Hashemi and Babaii 2013). Few studies have used social theories to consider the use of objects as expressions of language in science and technology museums, and even fewer have considered the content of museum texts such as panels and labels. This poses a substantial academic oversight. Many museums are reliant on panels and labels and other media to aid visitors in interpreting their exhibits (Serrell 1996: 9-19), and the prevalence of this reliance is only likely to increase as science and technology museums make sparser use of their collections (Conn 2010: 22). The utilization of applied linguistics as a theoretical framework can ameliorate some of this by providing a means of assessing how language is used in exhibit panels and labels, and to what ends. In the context of this thesis, applied linguistics can reveal some of the underlying linguistic indicators of state, society, and culture within exhibit narratives.

Historically, applied linguistics has been predominantly used in sociocultural and sociolinguistic studies (Palmer and Sharifan 2007: 1-4), although it has been increasingly used in multidisciplinary settings. The applied linguistics paradigm involves identifying the linguistic components of a given subject undergoing academic scrutiny, which can involve topically broad projects such as looking at interview narratives (Parkinson 1993: 96-109; Dieltjens et al. 2014: 324-311; Montes et al. 2014: 101-16; Kasper and Prior 2015: 226-255) or specific projects such assessing the presence of language barriers in a certain setting (Dahm et al. 2015: 828-837). Once linguistic components have been identified, the research findings are not intended to be left as knowledge for knowledge's sake. Instead, applied linguistics involves considering the social implications of the research findings and offering socially progressive solutions.

Brian Parkinson (1993: 96-109) outlined one method of applied linguistics which involves using code to assess ethnographic narratives. In this method, narrative components are assigned specific codes which can later be analyzed for frequency. This first involves establishing categories and assigning alphabetical coding. For example, in an ethnographic interview, any instance where the person being interviewed mentions something about food can be labeled as "A," instances where the interviewee mentions the person conducting the interview can be labeled as "B," any instance where the interviewee references themselves can be labeled as "C," and so on. Numerical subcategories can then be assigned. For example, self-disparaging comments can be marked "1," any expression of personal aspirations can be marked as "2," and so on.

The process of assigning labels produces a codified interview narrative which can appear as something like, "A2, A5, C2, A2, D4, B1, A3…" and so forth. From there, categories can be tallied to assess frequency between categories and, if desired, the frequency at which categories appear in adjacency can be tallied to assess contextual frequency. This creates an output of data which the researcher can then assess with greater objectivity, although some subjectivity is inevitably involved in these assessments. This method of applied linguistics can similarly be applied to textualized museum content.

Any research into sociocultural mediums will lose some objectivity in the process of trying to interpret human creations, whether the medium is in speech or literature. Because applied linguistics can involve both quantitative and qualitative assessment of verbally or textually expressed human thoughts, some subjectivity will occur during the process of research and analysis (Parkinson 1993: 99; Davies 2007:6-7). In this capacity, applied linguistics is merely a means of acquiring greater objectivity than would be achieved without using a quantitative method. This does require the presence of some variables which can be measured and a social hypothesis which can be tested (Purpura et al. 2015: 38-42). In this theoretical approach, the researcher discusses their subjective interpretation of research results only after numerically tracking the words, sentences, phrases, or paragraphs in which sociocultural topics were discussed by the interviewee (Parkinson 1993: 98). This does not suggest that researchers are free from their own cultural biases in defining the research categories, however.

Although this theoretical approach is not the only viable framework for studying the narratives presented within space museums, it is notably useful to developing both qualitative and quantitative methods for studying space exhibitions. When supplemented with new museum theory and semiotics, applied linguistics serves as a particularly useful approach for developing anthropologically sound methods for considering the textual and material content of space museums.

CHAPTER V

METHODOLOGY

Internship at the Chabot Space and Science Center

During the summer of 2014, I worked as an exhibits intern for the Chabot Space and Science Center in Oakland, California, to gain more experience in museum practices and for the purpose of producing a case study for this thesis. The internship itself was diverse, involving learning how to operate the Chabot's planetarium, designing graphic layouts for planetarium shows, creating exhibit panels and labels on space history and cosmology, delivering science demonstrations to visitors, partaking in discussion groups to brainstorm for future exhibits, and working with the Chabot's collections of cosmonaut and astronomy artifacts. Each of these experiences gave me a greater sense of the behind-the-scenes activities of a space museum, and how these activities affect the exhibit design process. In addition to giving me full access to the museum so that I could collect my own data for this thesis, the Chabot generously provided me with 11 scripts from its *Cosmos 360* planetarium shows, a catalogue listing the collections stored in the Chabot's archive, and files containing the design work for the Chabot's exhibit panels and labels.

All *Cosmos 360* planetarium shows were designed in-house by staff at the Chabot, and are used during both live narrations and for pre-recorded shows. Although planetarium shows are not the exclusive focus of this thesis, the planetarium in itself was intended as an exhibit when it was first invented for the German Museum in Munich (Chant 1935: 144-146), and today the narratives of planetarium shows provide a notable portion of museum visitors' exposure to topics of state, society, and culture. This is apparent in many of the *Cosmos 360* scripts. Each *Cosmos 360* script varies by theme, with many discussing cultural and socio-historic events ranging from Greek mythology to Sputnik.

The *Cosmos 360* scripts provided an opportunity to use applied linguistics to investigate how the Chabot's planetarium narratives express cultural content. This involved assessing some of the variables present within the narratives, such as whether one culture or another is discussed and within what context. These variables are then codified using the theoretical method described by Brian Parkinson (1993: 96-109) in the Applied Linguistics section of *Chapter IV: Theoretical Framework*. The final codified narrative allowed me to determine the frequency at which certain topics were discussed in a given script, provided a quantitative means of comparing the scripts, and also allowed for the aggregation of all eleven scripts for the purpose of looking at their overall usage of content related states, societies, and cultures. Figure 22 provides a sample segment of a script from the planetarium show that was analyzed using the applied linguistic method.

> Despite the costs, risks, and politics surrounding the only human trips to the Moon, Apollo was one of the greatest episodes in the drama of space exploration--and literally provided us a 100 billion dollar view of the Moon and our own home planet.

Figure 22. Sample script segment of the Chabot Space and Science Center's *Cosmos 360 – Fast and Curious: Humans in Space* planetarium show. Courtesy of the Chabot Space and Science Center.

The application of this method requires developing code segments to represent the themes which commonly appear in planetarium scripts, exhibit panels, and exhibit labels. An example of this can be understood by looking at the previous figure, which presents several common exhibit themes: the Moon and the U.S. Apollo space program. In this case, the script segment can be coded as "+US2/Mo," where "+" indicates praiseful speech such as "...was one of the greatest episodes…," the use of "US" signifies that an American event is under discussion, the "2" signifies that a space vessel or space program was discussed, and "Mo" provides context that this occurred within a discussion of the Moon. For a sample catalogue of code categories, as well as samples of codified exhibits, please refer to Appendix A.

Unfortunately, linguistic codification does have some serious limitations; this point will be elaborated upon in the discussion sections of *Chapter VI: Results and Discussion*. To compensate for some of the limitations while still maintaining an applied linguistics approach when examining museum texts and labels, socioculturally affiliated nouns were tallied and statistically analyzed. For example, terms appearing in exhibit texts such "JAXA," "China," "cosmonaut," individuals discussed in cultural mythologies, and other similarly societally affiliated terms were recorded and tracked for distribution and frequency of their occurrence. Statistical analysis was carried out using the IBM SPSS Modeler data mining software, which I discuss at greater depth in the final section of this chapter.

Regarding museum objects, the Chabot exhibits team expressed that museum collections are playing a decreasingly important role in the exhibit design and installation process at their institution. This trend has been common to many modern science museums, and has been discussed at length by Steven Conn (2010: 22) in *Do Museums Still Need Objects?* Despite this, the Chabot Space and Science Center still has an abundance of collections on display within some of the older exhibits, and many of the newer exhibits incorporate objects as well, albeit to a lesser extent. Furthermore, the Chabot does devote limited storage space to its collections, such as cosmonautic paraphernalia and astronomy artifacts, which I was able to work with while interning at the Chabot. Because many of these objects have some cultural affiliation and are therefore relevant to this thesis, they have been documented and are included in further discussions where relevant.

The Chabot Space and Science Center used the PastPerfect Museum Software to archive its collections of artifacts, photographs, and periodicals. Unfortunately, the low prioritization of the Chabot's collections led to the archival catalogue not being updated since 2007. Consequently, the archival catalogue is of limited use; it does provide insight into the Chabot's collections as of ten years ago, but these do not necessarily reflect the current state of the Chabot's collections. It is probable that some objects have been deaccessioned, and new objects have been added through recent acquisitions, but these changes are difficult to assess since the collections catalogue has not been updated with these changes. The catalogue also includes listings on where each object is kept, such as within storage areas or within specific exhibits, but these listings have not been updated either. Because many of the exhibits have been modified or replaced over the past ten years, the catalogue is only minimally helpful to assessing the relationship between the Chabot's current exhibits and its collections.

As has been discussed, museums use objects in their exhibits as a means of communicating ideas and narratives to visitors in a nonverbal manner (Anyfandi et al. 2014: 231). To compensate for the Chabot's outdated archival catalogue, I created an updated catalogue of the collections which were being exhibited as of the summer of 2015. This entailed photographing each of the displayed collections *in situ* to maintain their context within the exhibit narrative. Documenting each of these objects on display, along with their related exhibit panels and labels, was important in evaluating the extent at which exhibit narratives were dictated by collections. These objects were then assessed in terms of their semiotic properties (refer to Table 1 in *Chapter IV: Theoretical Framework*) so that their sociocultural relevance could be discussed in *Chapter VI: Results*.

Field Research Methods

Initially, this thesis was intended to analyze representations of states, societies, and cultures at space exhibits across North America. Budgetary constraints meant that the geographic scope of this study had to be scaled down to the West Coast, with Canada included. This involved traveling to museums across British Columbia, Washington, Oregon, and California to directly collect information on the museums' space exhibit objects, panels, and labels. This field research involved meticulously documenting exhibit displays for later qualitative and quantitative analysis.

A total of 19 museums were selected for this study, and these museums represented a diverse range in terms of their exhibit floor space sizes, budgetary constraints, collection sizes, and styles of exhibit presentations. Institutions without notable visitor centers were excluded from the study, most of which were private or exclusive research observatories. The 19 institutions included in this study represent nearly all the publicly accessible museums in California, Oregon, Washington, and British Columbia that have one or more exhibit spaces devoted predominantly to space-related topics.

Thirteen, or 72 percent, of these museums are located in California. The abundance of space museums in California in comparison to Oregon, Washington, and British Columbia does have the consequence of skewing results toward heavier representation of California, and is likely a consequence of California's leading role in space science and aerospace industries (Bugos 1997: 97-104; Cendes 2011: 50-53; Ehrlich 2013: 21-34; Hunter 2014: 373-404). Given that California museums are concentrated in the Bay Area and the Los Angeles area, which are geographically distant, California can be considered in two parts: Southern California and Northern California (see Table 2).

Table 2. List of the 19 space museums included for field research in this study.

Museum	Country	State or Province	City
H.R. MacMillan Space Center	Canada	British Columbia	Vancouver
Science World at Telus World of Science	Canada	British Columbia	Vancouver
The Museum of Flight	U.S.A.	Washington	Tukwila
Evergreen Aviation and Space Museum	U.S.A.	Oregon	Eugene
The Oregon Air and Space Museum	U.S.A.	Oregon	McMinnville
Chico Air Museum	U.S.A.	Northern California	Chico
Aerospace Museum of California	U.S.A.	Northern California	Sacramento
The Discovery Museum Science & Space Center	U.S.A.	Northern California	Sacramento
Chabot Space and Science Center	U.S.A.	Northern California	Oakland
Oakland Aviation Museum	U.S.A.	Northern California	Oakland
Space Station Museum	U.S.A.	Northern California	Novato
USS Hornet Museum	U.S.A.	Northern California	Alameda
NASA Ames Exploration Center	U.S.A.	Northern California	Mountain View
Rosicrucian Egyptian Museum	U.S.A.	Northern California	San Jose
California Academy of Sciences	U.S.A.	Northern California	San Francisco
California Science Center	U.S.A.	Southern California	Los Angeles
Griffith Observatory	U.S.A.	Southern California	Los Angeles
The March Field Air Museum	U.S.A.	Southern California	Moreno Valley
San Diego Air and Space Museum	U.S.A.	Southern California	San Diego

All 19 space museums were contacted via email and notified of their inclusion in this study. Each email was distributed with a letter informing each institution of the purpose of this MA Thesis research and requested permission to directly discuss exhibition content (see Appendix B). Exhibit titles, photographs, and quotations are not included for non-profit institutions which declined or were unresponsive to the letter requesting permission to directly discuss their exhibit content.

One of the primary objectives of this research is to assess trends of cultural representation in space exhibition content across the West Coast, although looking at museums on an individual basis is an integral part of this research as well. To collect the data necessary for assessing trends in exhibit content, scrupulous notes were recorded during each field study and over 7,000 photographs were taken of exhibit objects, panels, labels, interactives, and other exhibit components. Content at each institution ranged from having a historical focus to having a purely academic discussion on astronomical topics, so not all exhibit content proved relevant to this study. Except for cases in which exhibit content was explicitly sociocultural, exhibit presentations on technical topics of astronomy, aerospace engineering, and other space sciences were excluded from this study.

As with the case study of the Chabot Space and Science Center, analyzing the texts of exhibit panels and labels was an important component of this research. The frequency at which certain socioculturally affiliated words are used in exhibit narratives is useful to assessing their perceived value and importance within a narrative (Parkinson 1993: 98). Ultimately, the decisions of exhibit designers and curators in what to include in panels and labels affects visitor interpretation of not only the exhibit, but also visitor interpretations of the sociocultural history under discussion (Marstine 2006: 1-31). Exhibit panels and labels were quantitatively assessed to achieve greater objectivity in assessing such exhibit representations of society and culture.

Using photographs from the 19 museums as a reference, all exhibit panels and labels were typed into a word processor. These were then entered into a digital spreadsheet and organized to include the text from each panel and label, the name of the museum they were from, and the name of the exhibition the panel or label was used in. Afterward, this information was entered into the IBM SPSS Modeler data mining software program, the specifics of which will be discussed at greater depth in the final section of this chapter. This process of text mining was useful for assessing word frequencies across museums and at individual museums.

Survey Methods

Although the focus of this thesis is on exhibit representations of states, societies, and cultures at museums of the West Coast, the question must be posed as to whether or not these institutions have any resemblance to other institutions throughout the United States and Canada. As was mentioned in the previous section, budgetary constrictions meant that field research could not be conducted beyond the research area; surveys, however, provide a means of some amelioration. Additionally, surveys allow for questions to be asked that provide information about exhibits not otherwise apparent at face-value. For these reasons, surveys were incorporated into this study as an additional means of gathering data for quantitative and qualitative analysis.

The survey questions were designed, among other things, to make assessments about the importance of exhibit texts and objects at each institution. All survey questions were made intentionally simplistic to maintain brevity and minimize the potential for ambiguity, as is the standard in surveying (Rea and Parker 2014: 27). The survey was designed to include 25 questions, plus an optional open-ended twenty-sixth question allowing survey-takers to voice any questions, comments, or concerns. The primary 25 questions varied in format, such as by asking multiple choice or fill-in-the-blank questions, and were divided into five separate pages.

The first page of the survey included questions designed to acquire some insight into how individual surveys were influenced by where they were taken, such as geographic location or institution. The first of these questions was optional to allow for privacy, and asked the name of the institution where the survey-taker worked. The second question, also optional, asked survey-takers to enter their occupational title. This question was important for assessing how occupational titles might influence survey answers. For example, an exhibit designer might have greater knowledge of the museum's panels and labels than a museum director, and a curator might have greater insight into the nuances of the museum's collections than other staff members.

Question three asked survey-takers to list the approximate size of their institution in terms of budget, staff size, and square-footage as either small, medium, or large. These factors all have a number of influences on collections and exhibits, and presumably would affect survey results. Budgetary constraints, for example, can heavily influence exhibits because they determine whether acquisitions of new objects can be carried out, whether current collections can be maintained, and whether renovations or expansions can occur for the addition of further exhibits (Genoways and Ireland 2003: 91-117). The first survey page then concluded by asking survey-takers to select where their museum was located from a list of the ten Canadian provinces, three territories, or 50 U.S. states.

The second survey page focused primarily on asking questions related to planetariums, as well as exhibits that might be associated with planetariums. The first question opened by asking whether the institution operated a planetarium. Those that did were asked to select if planetarium shows were made in-house, were purchased or on loan, or both. The next question served as a follow-up, asking the frequency at which new planetarium shows were added. Both questions were asked to assess the level of independence maintained by planetariums in determining their own shows and, potentially, associated exhibit content. If, for example, a given planetarium primarily designed their own shows rather than purchasing pre-recorded ones, any inclusion of cultural narratives can be attributed directly to the institution's own decision-making. Conversely, an institution that purchases pre-recorded shows plays a role in deciding which shows to acquire, but has no creative control over the content within the show itself.

The three questions which followed were posed to collect data on which ancient cultures the institutions included in their exhibit and planetarium narratives. Thirteen different cultural groups, each of which were anticipated to be predominant in their narratives, were listed as possible options, and survey-takers were encouraged to select all that applied. These included groups such as ancient Egypt, Greece, Rome, and so on, and survey-takers were also given the option to write in any additional groups.

They were also given the option to check off “none” in the event that no ancient cultural group has been discussed within their exhibit or planetarium narratives. The final question of the second survey page then asked what sort of resources were used in designing content on ancient cultures. Among other things, this latter question was intended to assess the possibility that certain resources, such as pop-culture magazines or astronomy textbooks, might dictate exhibit content.

The third survey page began by asking how frequently exhibit content, such as panels and labels, was designed in-house or outsourced. Survey-takers were presented with a range of options, from “always in-house” to “never in house.” This question was vital to understanding whether space museum staff primarily take initiative in designing exhibit content, and are therefore responsible for how cultures are represented within exhibit narratives, or if external companies control this process. This was also posed to see how answers correlate with responses to other survey questions, such as budgetary constraints or what cultures are discussed within exhibits.

Historically, exhibits were heavily determined by a given museum’s collections. As noted by Steven Conn (2010: 22), this has become decreasingly the case, especially for science and technology museums. To investigate the importance of museum collections at space museums, survey-takers were asked a set of questions to rate their institution’s dependence on objects, such as when brainstorming for upcoming exhibits. Heavy reliance on collections would indicate that exhibit narratives are likely to be determined by what objects are available for the exhibit designers to use. In this event, exhibit designers with a collection consisting almost exclusively of artifacts from Russia and the United States would be more inclined to create exhibit panels and labels only discussing those groups, and would therefore be significantly less inclined to create content on cultural groups for which they have no collections. Conversely, little reliance on collection would suggest that exhibit designers are not dependent on their collections when creating exhibit narratives, and might feel comparatively free to create narratives with cultural content despite an absence of relevant cultural objects.

The fourth and fifth pages of the survey covered exhibit representation of government space agencies. Survey-takers were given a list of 15 of the most successful space agencies and were asked if they had collections originating from any of them. Survey-takers were then asked if the institution has had experience receiving acquisitions or loans from any privatized space companies. The final questions then proceeded to ask survey-takers to estimate their institution's willingness to create future exhibits using narratives on foreign space agencies, whether the institution might be interested in working with foreign space agencies to acquire new objects for exhibiting, and if the institution might be willing to create exhibit content on foreign space agencies even in the absence of relevant collections.

Each of the 25 survey questions was aimed at gathering information on museum representation of states, societies, and cultures, and how museum practices affect the decision-making process. The sequence at which questions appear can substantially influence survey results (Rea and Parker 2014: 18); although questions about cultural representation existed throughout the survey, questions which explicitly conveyed the purpose of the survey were left until the end. This was done to avoid the possibility of survey-takers exaggerating some of their answers out of a desire to represent their museum as having greater balance in cultural representation than is actually the case. That is, had the purposes of the data-gathering survey been made unnecessarily explicit, survey-takers might have worried about their institution appearing prejudiced or politically incorrect, and adjusted their answers accordingly.

Distributing the surveys initially entailed conducting an online search to compile a list of the active space museums existing throughout Canada and all 50 U.S. states. These included planetariums, astronomy observatories, aerospace museums, and science museums with space exhibits. College and university planetariums were excluded unless they were regularly open to the public. Astronomy observatories with a predominant focus on research and an absence of publicly accessible exhibits were likewise excluded.

The surveys were approved by the Human Subjects in Research Committee of California State University, Chico (see Appendix C) and a message of informed consent was sent with every email to potential survey-takers, which then linked to the survey (see Appendix D). Survey questions were hosted on SurveyMonkey, a cloud-based software service. All surveys were distributed via email or directly through the museum's website services with a request letter (see Appendix E) allowing anonymity and providing a link to the survey. Survey-takers were allowed the option to keep their institution anonymous; surveys that identified their institution were used for data analysis, but, to protect the individual survey-taker and the associated institution, individual respondent answers are not published in this thesis. Instead, the results were aggregated into a table which can be viewed in Appendix F.

In total, 244 surveys were distributed across 109 institutions, of which 121 individuals responded to the survey. The institutions contacted were also encouraged to distribute the survey internally among appropriate staff so that differences in staff perspectives could be assessed, such as those potentially existing between museum directors, curators, planetarium specialists, and exhibit designers. The accessibility of contact information varied from institution to institution. Some museums made their relevant staff contact information readily available, whereas others required relying on surveys being distributed internally to appropriate staff. This will have affected the number of surveys taken, as it is doubtful that all surveys were forwarded to the appropriate staff members.

Statistical Analysis

Because this thesis takes an applied linguistics approach to assessing potential issues in museum representation, statistical analysis is used extensively in this research. This is done to reduce some of the personal biases involved in assessing exhibit narratives, with a data-driven approach allowing for comparatively greater objectivity than a purely qualitative approach. The Statistical Package for the Social Sciences (SPSS) developed by the International Business Machines Corporation (IBM) was used for each instance of statistical analysis on data gathered from the Chabot Space and Science Center case study, and the field research at West Coast space museums. The IBM SPSS software program is useful for data exploration, verification, and description (Xiao 2015: 606), and has been widely used to produce socioculutral studies with quantifiable assessments (Greasley 2008:3; Martin and Bridgmon 2012: 2), and is equally applicable to assessing the use of language in museum exhibit narratives.

Given that the data of exhibit panels and labels exist as textual components, a method is necessary for converting narrative texts into numbers which can be quantitatively measured and compared. For this, the techniques developed for data mining—and, more specifically, text analytics—are applicable. Text analytics is useful when dealing with unstructured data, such as the words, paragraphs, or phrases which together form a body of text that cannot be organized into a spreadsheet with the ease of many other data types (Struhl 2015: 7). In the case of exhibit narratives, data mining can be used to sift through a panel or label and separate out key terms or phrases. This process can then be continued for multiple exhibit panels and labels to aggregate key words or phrases from a single exhibition, or to aggregate words and phrases from numerous museums.

In the case of this thesis, IBM SPSS Modeler was used in the data mining process. This involved using photographs taken of space exhibit panels and labels at 19 museums in California, Oregon, Washington, and British Columbia as references for digitally transcribing exhibit texts, which were then compiled and entered into IBM SPSS Modeler. This allowed for information extraction, the process in which useful information is extracted from textual data so that it can be entered into organized tables for further analysis (Polig et. al. 2014: 6). From there, it became possible not only to look at prevalence of certain culturally-affiliated terms, but also to look at their relationship with other terms that were commonly used in the same context. Afterward, sociocultural terms are compared to assess which ones occurred in greater abundance.

At its core, text analytics is about posing and testing hypotheses related to textual information. This methodological approach is beneficial to social science research because it acts as a safeguard against researchers proceeding into their research while unwittingly assuming that their presumptions are correct. Text analytics, instead, encourages researchers to pose questions related to their research, then test the possibility that their questions are wrong through a null hypothesis, before coming to a quantitatively-reached conclusion (Struhl 2015: 8). In the case of this thesis, the text of exhibit labels and panels can be “mined” to test the hypotheses that certain cultural groups are over- or underrepresented at space-themed exhibits, rather than intuitively assuming this to be true.

The first hypothesis posed by this thesis is that space history exhibits in California, Oregon, Washington, and British Columbia lionize domestic events while neglecting to talk about foreign activities in space. This was tested by comparing the frequency in which certain terms were used within exhibit narratives. Identifier terms were those associated with nationality, domestic technology, citizen astronauts or cosmonauts, and historic events tied to national history. IBM SPSS Modeler was then used to generate a concept map, a tool which creates a visualized web linking together terms which occur together in high frequency. This can reveal trends in the data, for example that the term “astronaut” is highly associated with terms like “American,” “achievement,” “Apollo,” and so forth. In terms of testing the hypothesis, this is useful to looking at what nationalities are being discussed and in what context.

The second hypothesis posed by this thesis is that space exhibits will often overlook the inclusion of non-Russian, non-American events and people in their narratives. It became important to take into consideration the reasonability that both Russia and the United States would occur in higher abundance than discussions of space organizations such as JAXA, CSA, ESA, and CNSA. Each of these four organizations have had substantial contributions to space exploration, but not at quite the same extreme as the two Cold War powers, the United States and Soviet-era Russia. This does pose some issues because there is no simple way of measuring the proportional contributions of a given nation. Assigning percentages to national contributions in developing space technology is problematic to the point of almost being useless; no study exists to show how much each nation has contributed to making the individual parts of probes, satellites, telescopes, aerospace vehicles, and space stations, nor the quantifiable extant at which various nations have conducted research in space science.

To avoid this pitfall, this thesis uses astronauts as a measure for national contributions to space exploration. Over 500 people have been in space, a little less than two-thirds of whom were United States citizens. Approximately 22 percent of space explorers were of Russian nationality and 16 percent were of some other nationality, such as Japanese, Canadian, French, German, Italian, or Chinese (NASA 2013: 4-13). If exhibit representations of nationality were to perfectly reflect the national affiliations of the people who have been to space, a little over a third of exhibit narratives would discuss nations other than the United States, with somewhere around 16 percent of the narratives discussing nationalities other than those belonging to the two Cold War space powers. Herein, a Z-test was used to compare the aggregated data on exhibit texts with the distribution of nations that partook in spaceflight.

It is, of course, unreasonable to expect exhibit designers and curators to conform perfectly to proportionally depicting national groups of space explorers. Narrative-writing is in part a creative process, and it would be inane to force panel and label writers to conform to a rigid guideline wherein different nationalities must be distributed percentage-wise. The use of percentages in this study is intended only to assess if the aggregated museum narratives across the West Coast deviate substantially from these numbers. This creates a standard of measurement against which the accumulated data can be measured and the hypotheses can be tested. If this hypothesis is correct, the percentage at which non-American, non-Russians are discussed should be dramatically lower than 16 percent. Conversely, this hypothesis will be refuted if the exhibit narratives correlate with these percentages, or if representation exceeds 16 percent by a statistically noteworthy extent.

The third and final hypothesis was posed to consider the possibility that when space museums do discuss cultural histories beyond the activities of the United States and Russia in spaceflight, they will predominantly discuss ancient cultural groups. That is, modern foreign space programs will be neglected in favor of presenting narratives on cultural histories which significantly predate spaceflight. In some cases, this is easy to assess in the data because obvious terms are used. For example, these terms can include words that are used in a context to unambiguously refer to historically older groups, like "Roman" rather than "Italian," or terms related to earlier belief systems, such as the names of mythological heroes or deities.

Other terms, such as "European" or "Chinese" can be more ambiguous and cannot be looked at in terms of word frequency alone. This is another instance in which the IBM SPSS Modeler concept mapping system becomes useful. By using this tool, terms can be assessed according to the context in which they are used, and then separated according to whether they are intended to discuss topics of modern spaceflight or topics on pre-spaceflight. Although there remains some subjectivity to this process, research results with greater objectivity can be achieved by using statistical analysis to produce quantified data on exhibit content, thereby allowing for a more thoughtful discussion of cultural representation within space museums.

CHAPTER VI

RESULTS AND DISCUSSION

Introduction

This chapter presents and discusses the research findings of the thesis. The first section, Space Museum Exhibition Types, builds on the discussion of the history of space museums covered in *Chapter III: Literature Review*. In the Space Museum Exhibition Types section, I discuss my observation that many modern space museums are more like mosaics than some of their earlier counterparts; whereas many institutions of the past were distinct as aerospace museums, observatories, or planetariums, the space museums of today often contain each of these components and split them between their exhibitions. The discussion section is included to provide some of the conceptual frameworks that will be helpful in the sections that follow.

The sections following that discussion provide a case study of the Chabot Space and Science Center in Oakland, California, where I spent the 2014 summer interning as a component of this thesis. The Chabot Space and Science Center will serve as a particularly interesting case study because it is the oldest American observatory to focus solely on public access and education (Burckhalter 1984: 85-86), and because it is a strong representative of some of the trends that twenty-first century space museums are undergoing. Following this discussion, the next section provides a broader discussion of space museums across California, Oregon, Washington, and British Columbia. This includes the analysis of their exhibit content, including labels and artifacts, and the extent of their cultural representation.

In the final section, I analyze the survey results, using them for greater insight into the exhibition content observed at space museums along the West Coast. Additionally, these surveys are used to compare and, where possible, to contrast the space museums studied in California, Oregon, Washington, and British Columbia to the other institutions surveyed in the United States and Canada. Although surveys cannot provide the same level of detail as research conducted directly at these locations, the survey results will nonetheless allow for the brief discussion of institutions which otherwise could not be included in this study. In all, these sections provide an analysis of the extent at which states, societies, and cultures are represented in modern space museums. Additionally, this chapter critiques the educational implications of what content space museums have decided to—and decided *not* to—exhibit.

Space Museum Exhibition Types

Museums have been categorized in multiple ways by different scholars, with their usefulness depending heavily on what questions a scholar has been asking. Such categorizations suffer some limitations when extended beyond the scope of their contextual research, thus posing some issues for this study. While conducting research on space exhibits at institutions along the West Coast, I observed four primary exhibition types which are useful to understanding the question of cultural representation in space museums and space-themed exhibitions. This topic is explored here, and will provide a discussion point for later sections of this chapter.

An example of museum categorization can be found in the introductory museums studies book *Museum Administration*, in which authors Hugh H. Genoways and Lynne M. Ireland (2003: 18-19) adapted a list of museum categories from the 2002 *Official Museum Directory* to call attention to the great variety of museum types. In this, art, history, science, and other similarly generalized groupings were listed as distinct categories, effectively separating the art museum from the history museum or science museum. Each category then contained subcategories, wherein science museums could be further differentiated into smaller subgroupings like arboretums, anthropology museums, entomology museums, and so forth. Rather than devoting a single subcategory to space museums, the authors included three separate subcategories. These categories were the aeronautics and space museums; planetariums, observatories, and astronomy museums; and, lastly, science museums and science centers.

Categorizing in this way can be useful, but it is important to remain aware that these categories are also somewhat arbitrary. For example, though the history museum category used by Genoways and Ireland included a subcategory for military museums and another for maritime museums, it could easily be argued that these subcategories would fit equally well into the science museum category. The decision to include aeronautics and space museums as a subcategory of science museums, rather than a subcategory of history museums, is similarly arbitrary. Though many aeronautics and space museums do incorporate a discussion of science into their panels and labels, they also frequently include discussions of history as well. For example, it is not unusual for an exhibition on the Space Race to have panels or interactives devoted to teaching relevant scientific concepts, such as explaining why astronauts like Neil Armstrong or Eugene Cernan experienced less gravitational pull during their stays on the Moon, however, much of the exhibition's content will be devoted to the historic events which occurred during the Cold War.

Using sieves as an analogy for the process of categorizing, linguistic anthropologist Paul Kockelman (2013: 37) stated quite bluntly that "sieves are essential to information processing." That is, categorizing is necessary to understanding the similarities and differences of things. Despite that any system of categorization will have its limitations, and that any new or modified system of categorization will also have some arbitrariness and limitations of its own, breaking observations into separately defined categories is essential to discussing them. In the case of this thesis, regarding the space museum as its own category, which can then be further divided into subcategories, will be an important tool for revealing some of the patterns of content and narrative used by different space museums and their exhibitions.

While conducting research on space museums between 2013 and 2017, I observed that exhibitions at West Coast institutions can be identified by four discernible subcategories, or areas of topical interest and styles of presentation. These four exhibition subcategories are: 1.) the astronomical observatory exhibition, 2.) the aerospace and astronautics exhibition, 3.) the science center exhibition, and 4.) the planetarium exhibition. Although these subcategories are not strictly discrete—overlap does occur between subcategories and between institutions—an awareness of these subcategories yield some insight into the similarities and differences across space museums (see Figure 23). Overlaps in these subgroups are also of great importance to understanding the choices of museum faculty on what to include and exclude in their exhibit narratives.

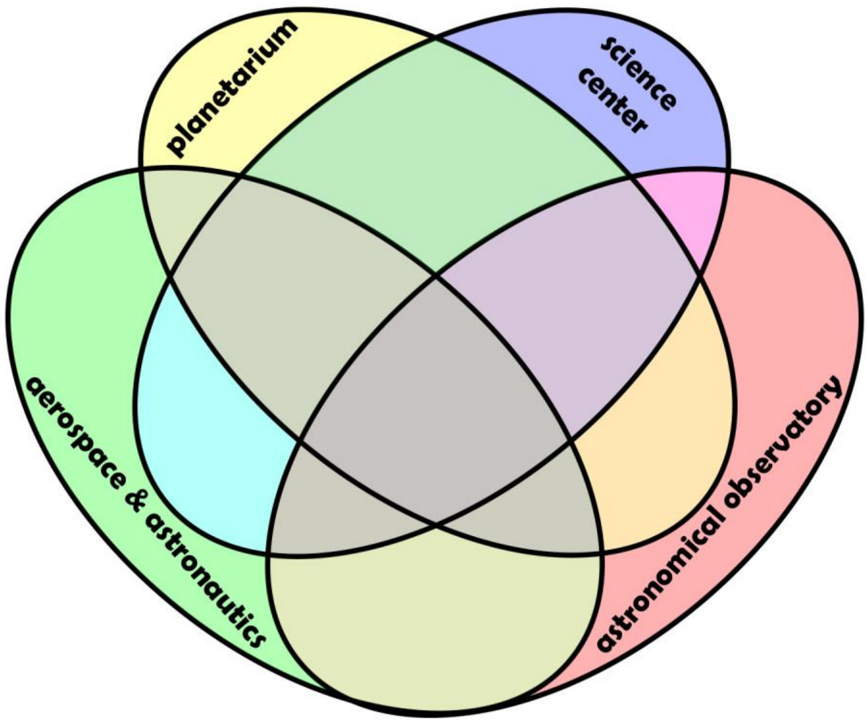

Figure 23. Exhibitions can be broken down into four distinct categories, with crossover occurring at some space museums. Venn four-set diagram by the author, 2017.

Broadly defined, an observatory is a place intended for visitors or academics to observe astronomical phenomena. In terms of chronology, the observatory predates planetariums, aerospace museums, and science centers. The Marāgha Observatory, for example, was built in Persia as an Islamic astronomical vantage point during the midthirteenth-century by Hülegü Khan, founder of the Ilkhanate dynasty and a grandson of Genghis Khan (Mozaffari and Zotti 2012: 395-397). The Royal Greenwich Observatory was founded in 1675 (Lovell 1994: 283), arguably becoming the most famous observatory in modern times because of its dual roles as prime meridian and for its many contributions to the development of modern astronomy.

As was discussed in *Chapter III: Literature Review*, historic observatories differ from modern museums in that they were generally open only to the academic elite, rather than the general public. To some extent, this does remain true for many observatories today; while some astronomical observatories have limited visitor centers available to the public, their telescopes and other technical equipment are generally out of public reach unless the instruments have become sufficiently obsolete. Nonetheless, publicly available discourses on astronomy have been made possible, in part, because of the existence of observatories, and many of today's science centers can trace their origins to a former sole role as an observatory (Aitken 1919: 198-199; Fortmeyer 2007).

For the purposes of this thesis, an observatory can be described more narrowly as an institution built around its use of telescopes and made available to the general public. My experience has been that staff at such institutions are unlikely to identify observatories as museums and, having a more traditional idea of what a museum is, are even likely to disparage the idea. Resistance to this label is valid when discussing observatories reserved strictly for professional research, but when discussing non-profit observatories that have been opened to encourage public engagement in science, public observatories bear many similarities to the historic houses preserved at state parks.

Borrowing from the language of archaeology, large telescopes and the structures that shelter them can be regarded as features. Optical lenses, small and moderately sized telescopes, astronomical slides, and other objects which can similarly be moved with ease are akin to artifacts. Finally, the astronomers in charge of maintaining the telescopes and other instruments are the museum's curators. If observatories are conceptualized as sites where historic structures and artifacts are preserved for the sake of public appreciation, observatories are barely distinguishable from the many historic houses which similarly preserve national heritage for the purpose of educating the public.

Astronomical observatories might not have some of the more familiar attributes of a museum, such as a display case filled with historical objects, but it is common for public observatories to have one of the other hallmarks of museums: the informational panel. Such panels typically present on topics of astronomy, but may also provide historical information about the observatory and its telescopes. Panels on the observatory deck of the Chabot Space and Science Center, for example, inform visitors of the history of two of their telescopes, dubbed “Rachel” and “Leah” and named after the two sisters in the biblical story of Jacob. Inside the metal dome that houses Rachel, all available wall space is covered with diagrams explaining the geographic features of other planets and satellites, panels explaining how the Chabot's refracting telescopes work, and, importantly, informational displays on the observatory's history.

This contrasts with planetariums despite that planetariums and observatories serve nearly identical functions. While some of the focus in observatory exhibition spaces is devoted to the grandeur of the telescopes themselves, this is atypical for planetariums. The projectors and their associated equipment are not made into a focal point for visitors. In most other museum types, the structure of the room, placement of its collections, and the room's use of lighting are used to guide visitors' attention to an important object that has been put on display and convey its importance (Moser 2010: 24-28). This is not done in planetariums even though projectors are vital to making planetariums work and, in some cases, the planetariums may use projectors of historic importance such as a Zeiss projector. Despite their uniqueness, planetarium projectors are regarded merely as a means to an end rather than a relic worthy of visitor attention.

Planetariums also contrast with observatories in another marked way. During daylight hours at astronomical observatories, visitors are not only expected to view sunspots or other cosmic events through the observatory's telescopes, but they are also expected to wander the exhibition floor-space. During this time, observatory visitors read informational panels, use interactives when they are available, and even converse among themselves about astronomy. At planetariums, visitors are expected to make their way directly to their seats, where they are to remain until the end of the show. As with movie theaters, carrying out conversations among themselves is taboo with one notable exception: if the planetarium show is not pre-recorded, but is instead conducted live, the host will sometimes interact directly with the audience, especially if the audience consists mostly of children. After the show has ended and the lights are restored, guests are expected to leave the room rather than wander. The consequence of this routine has led to a static pedagogical paradigm wherein planetarium domes are not equipped with stationary educational displays like those of most other museums, but instead more closely resemble theaters.

To supplement the theatre aspect of the planetarium, many planetariums have exhibition areas external to their domes. Panels, interactives, and, in some cases, display cases with artifacts are arranged around these outer areas. Their content may vary, but usually complement the educational themes of the planetarium's shows. Because many of these shows are likely to focus on Solar System astronomy, display panels commonly present on topics like the Sun, terrestrial and Jovian planets, and other cosmologically domestic objects. As will be discussed in further depth within this chapter, the astronomical systems and astrological beliefs of indigenous and ancient cultures are also popular planetarium themes; consequently, planetarium exhibition areas are sometimes used to elaborate on topics of cultural heritage and belief.

While observatory exhibition spaces are generally devoted to the history of the observatory and what visitors are likely to see when peering through their telescopes, and planetarium exhibition spaces are generally used as a means of reinforcing the learning objectives of shows occurring within the planetariums, science center exhibitions may cover similar topics, but are likely to be more broad in doing so. Science center exhibition topics range from the Big Bang Theory, to how black holes work, to the danger of meteors wiping out the human species. What distinguishes science center exhibit spaces is that they do not revolve around the function of a specific piece of equipment, such as a telescope or projector, to formulate their exhibition narratives. They are also far less reliant on the presence of staff astronomers to guide visitors in their educational experience. In doing so, science centers free the role of educator to school teachers, parents, or to an individual's own volition.

Science center exhibition spaces also draw heavily from the pedagogy of modern science classrooms. Reading material—in this case, exhibit panels and labels—are an important component in creating science literacy, but acquiring hands-on experience is considered critical. In school, these activities occur through the use of practicums and science experiments (Jung and Tonso 2006: 15-16). In science centers, this learning objective is mimicked and met through the use of interactives. Although an interactive like rolling a ball down the side of a black funnel is insufficient for visitors to master the concept of how planets interact with black holes, nor are visitors likely to fully grasp the physics of gravitation when stepping on a scale that informs them of their weight on other planets, both interactives create tangible conceptual foundations that are necessary for further learning.

In terms of the traditional idea of museums where large relics are roped off and smaller artifacts are protected behind glass barriers, aerospace and astronautics exhibition spaces are the most in line with the standard museum model. They make heavy use of informational panels and labels to explain their collections on display, with an educational emphasis that strays between history and engineering. In the words of Dr. Tom Crouch (2007: 20), a senior curator for Smithsonian's National Air and Space Museum, such exhibitions are also "shrines to progress." Individual labels make frequent use of terms like "first" and "most" to convey the importance of their collections, and also to unify their collections through stories of human ambition, ingenuity and achievement.

Because aerospace and astronautics exhibitions tend to be more firmly rooted in deliberating the history of astronauts and spacecraft, they are less likely emphasize topics of astronomy. Astronomy plays a secondary role instead, and only when it is relevant to the historical narrative. For example, exhibits may lightly touch on a scientific understanding of the Moon within a larger context of discussing the Apollo missions, and an exhibit with a replica of a space telescope may briefly discuss stars, nebulae, galaxies, or some of the space telescope's other findings. In each of these instances, however, greater emphasis is placed on history than on science. Although there are exceptions, aerospace and astronautics exhibitions also appear less likely to incorporate interactives than other exhibition types, preferring instead to let their collections and informative texts to stand alone in enticing and educating their visitors.

The four exhibition types—observatory, planetarium, science center, and aeronautics / astronautics—should be viewed as common trends rather than exact rules. There is nothing preventing one subcategory from blending into another, and this *does* occur to varying degrees. An individual space museum may maintain only one of these exhibition types, or it may devote various sections of the institution to having some or all of these exhibition types. For this reason, many modern space museums are like mosaics; discrete exhibitions work side-by-side to form a larger whole, giving a museum thematic purpose. One room may be devoted to an exhibition on the history of astronautics, whereas an adjacent room is devoted to an exhibition on basic astronomy. In tandem, these exhibitions serve the institution's central objective of stimulating visitor interest in space.

When these four subgroupings are looked at separately, it becomes easier to assess the choices made by museum staff in designing their exhibits. This is important when investigating an exhibit's use—or absence of—cultural and historical content. As this chapter will explore, narratives on modern culture could viably be interwoven into a planetarium exhibition, but this is uncommon. Similarly, the use of linear historical narratives within aerospace and astronautics exhibitions does have some benefits, but at the cost of greater cultural inclusion and international representation. Finally, the system of categorization described in this section is intended to provide a distinct vocabulary for discussing and critiquing exhibition trends at space museums.

Case Study: The Chabot Space and Science Center

The Chabot Space and Science Center resides between the Joaquin Miller Park and Redwood Regional Park in Oakland, and provides residents of the California Bay Area with access to educational material on topics of astronomy and spaceflight. As was discussed in *Chapter V: Methodology*, I spent the summer of 2014 working as an exhibits intern at the Chabot for the purposes of including it as a case study in this thesis. The Chabot Space and Science Center is useful as a case study for a few reasons: it is perhaps the oldest publicly accessible astronomy observatory in the world (Burckhalter 1984: 85); it has expanded and is highly modernized, while acknowledging its own foundation by including historic artifacts from its late-nineteenth-century origin; and it is a good representative of the mosaic of exhibition types discussed in the previous section of this chapter, with its various exhibitions including a planetarium, an observatory, science center exhibition areas, and exhibition spaces devoted to astronautics. In these respects, the Chabot Space and Science Center can be regarded as one of the most important and historically iconic space museums of the West Coast.

The Chabot Space and Science Center maintains multiple diverse museum exhibitions, which include *Beyond Blastoff*, *UnEarthed*, *Destination Universe*, *Tales of the Maya Skies*, *A View of the Stars, Bill Nye's Climate Lab*, *One Giant Leap*, *Touch the Sun*, the *Ask Jeeves Planetarium*, an observatory with three large telescopes, the *Tien MegaDome Theater*, and the *Challenger Learning Center*. With the exception of *Bill Nye's Climate Lab*, which focuses more exclusively on the Earthly matters of climate change, all of Chabot's exhibitions discuss topics related to space science or space history. To maintain simplicity and avoid tangentially straying away from focusing on content with cultural narratives, exhibitions which focus on topics of astronomy and astrophysics rather than space history are excluded from this investigation. Thus, this case study will only discuss the exhibitions *Beyond Blastoff*, *Tales of the Maya Skies*, *One Giant Leap*, the observatory, and custom shows developed for use in the *Ask Jeeves Planetarium*.

The exhibition *Beyond Blastoff: Surviving in Space* makes for an especially interesting case study because it integrates a multi-million-dollar collection of artifacts from the Soviet-era space program into its design, including a Soyuz descent module, tools and food with Russian labels, space suits worn by French cosmonauts, and even a backup toilet for the Mir space station. Although the *Beyond Blastoff* exhibition was designed to discuss survival in space in terms of human physiological responses and technology-driven adaptations, the extensive use of historic artifacts led to the inclusion of numerous descriptive panels and labels with cultural content. Similarly, the *One Giant Leap: A Moon Odyssey* exhibition has content focused on space science, but its inclusion of historic artifacts, replicas, and models result in an exhibition that is largely focused on space history.

Tales of the Maya Skies is a companion exhibition to an outsourced planetarium show of the same name, and consists of panels and interactives which engage and inform visitors with educational material on Mayan cosmology. The *Ask Jeeves Planetarium* also plays other shows throughout the day, some of which were purchased from external vendors, and others of which were developed in-house. Because of copyright issues, planetarium shows that were developed outside the Chabot are not included in the thesis' analysis or discussion. However, the *Cosmos 360* shows, which were all written and developed by staff astronomers at the Chabot, were included in the analysis and will be discussed within this chapter.

In the following sections, I will discuss the results of the exhibit analysis outlined in *Chapter V: Methodology* and my observations of the Chabot's exhibit content on states, societies, and cultures. These discussions are distributed between separate sections which individually discuss the *Beyond Blastoff* exhibition, the *One Giant Leap* exhibition, the *Cosmos 360* planetarium shows, and *Tales of the Maya Skies* companion exhibition. From there, this thesis will proceed with a discussion section tying these exhibitions together to examine the overall inclusion of socio-historical narratives at the Chabot Space and Science Center. Afterward, this chapter will move beyond this case study by investigating and discussing sociocultural exhibit content throughout the West Coast, with the findings at the Chabot Space and Science Center incorporated into those discussions.

Case Study: The Chabot's *Beyond Blastoff* Exhibition

Of all the exhibitions at the Chabot Space and Science Center, the *Beyond Blastoff: Surviving in Space* exhibition has the highest concentration of space-related artifacts and text-based narratives with sociocultural content. The objects on display almost exclusively consist of the Chabot's collection of cosmonautic artifacts. These are arranged between two large rooms that are joined by a break in the wall, with the overall exhibition intended as a testament to the challenges of living in space. These challenges are conveyed through interactives which demonstrate the physical strain of working in space, exhibit panels which describe the protective suits space travelers must wear to survive, and by giving museum visitors a view into a cramped Soyuz descent module in which cosmonauts would have resided during their return journeys to Earth (Wise 2008: 14; see Figure 24).

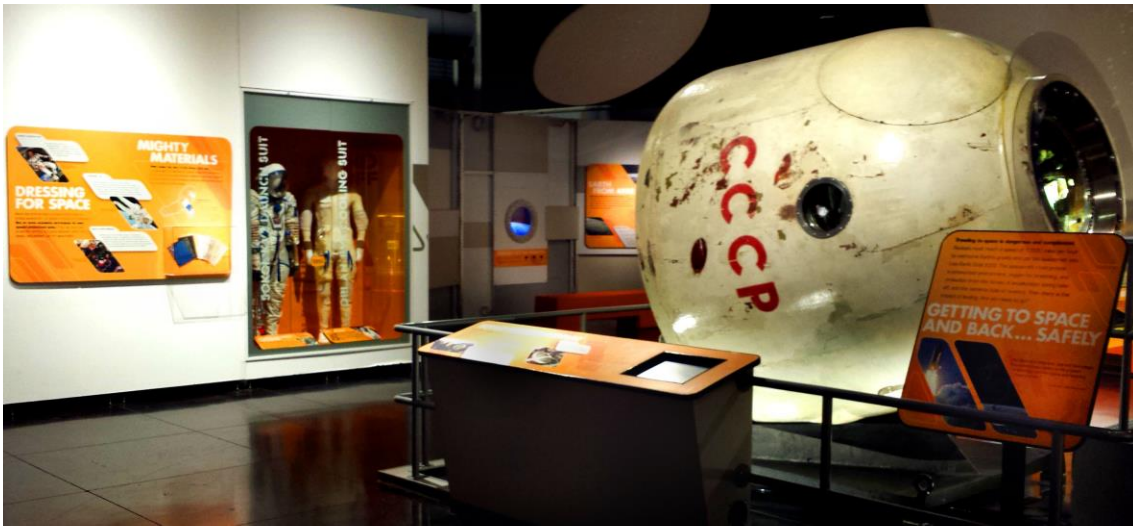

Figure 24. Soyuz descent module and other exhibits in the *Beyond Blastoff: Surviving in Space* exhibition. Photograph by the author, 2014.

The collection is distinctly Soviet rather than modern Russian. Emblazoned across the Soyuz descent module in red lettering is the initialism CCCP, which stands for the "Union of Soviet Socialist Republics" (Russian *Сою́з Сове́тских Социалисти́ческих Респу́блик*). The choice of the red-colored lettering is also iconic of the orbital module's origins in Communist Russia, with red having historically been symbolic of the blood spilled over the fight for universal (Latin *communis*) equality (Platoff 2009: 14). It is surprising then that an analysis of the exhibit panels and labels show a complete absence of terms like "Soviet Russia," "Soviet Union," or "Communist Russia" to indicate that the collection's history links to the Soviet space program rather than modern Russia's Roscosmos space agency.

Museum objects have semiotic value, communicating ideas about society and culture to museum visitors (Dimopoulos 2011: 5), with visitor interpretations shaped by a mixture of the personal knowledge and belief they arrive with (Roberts 1997: 74-75; Falk and Dierking 1992; Falk et al. 2006: 821-829) and the spatial arrangements in which exhibit designers have placed objects on display (Anyfandi et al. 2014: 231). The choice made by exhibit designers and curators on where to place museum objects is especially important to understanding how material culture fits into the narrative of an exhibition. Objects placed with ample lighting and generous amounts of floorspace enable visitors to view the objects with a sense of grandeur to emphasize the objects' unambiguous importance and to lure visitors (Moser 2010: 24-28). In these respects, the Soyuz descent module has substantial semiotic value, having been placed in a central point within the *Beyond Blastoff* exhibition and allowed enough floor-space for visitors to walk unimpeded around the full body of the artifact.

In semiotic terms, the Soyuz descent module has high segregated permeability, separation, and moderate contrast. The use of exhibit panels and metal barriers around the spacecraft prevent the passage of visitor traffic while still maintaining high visibility. The placement of the object in a room with other cosmonaut artifacts conveys their relationship, but substantial separation is maintained around the spacecraft to maintain its specialness. In terms of contrast, the cultural nature of the Soviet artifact means that it has enough visual similarities to demonstrate its association with the other objects on display, while the engineering attributes that have led to its substantial size and material composition are distinctly unlike the objects used throughout the rest of the exhibit. The exhibit designers used these collective properties to make the Soyuz descent module a central piece of the visitor experience.

The historical importance of this artifact cannot be understated. Soyuz, meaning "Union" in Russian, was the Soviet answer to competing with America's mission to place men on the Moon, and may have even been modeled after an unused Apollo design that had been drafted by the General Electric Company (Doran and Bizony 2011: 170). The Soyuz spacecraft has led to numerous impressive accomplishments in space science and human spaceflight (Office of Technology Assessment 1983: 5-34), and played an active role in ferrying cosmonauts to and from the Salyut space station (Golden and Hannifin 1981: 117), the Mir space station (Covault 1992: 24), and, more recently, the International Space Station (Hodson 2013: 34). The informational panels which flank the Chabot's Soyuz descent module provide visitors with a glimpse of some of this rich heritage, explaining its historic role in cosmonautics and its current importance to the ISS program.

In addition to the use of companion exhibit objects, such as a nearby model showing the full structure of a Soyuz spacecraft, a touch-screen interactive lets curious visitors learn more about the Soyuz launching system. These, along with the exhibit texts, act to bring visitor attention back to the displayed descent module. An analysis of the exhibition panels and labels reveal that the term "Soyuz" is used 29 times throughout *Beyond Blastoff: Surviving in Space*. The prevalence of this noun further demonstrates its importance within the exhibition context, at times even overshadowing the comparatively less prevalent content on actual survival and adaptation to space. In these texts, the noun

“Soyuz” is highly associated with terms such as “Russian,” “cosmonaut,” “astronaut,” “International Space Station,” and also “Kazakhstan.” The prevalent use of “International Space Station” is interesting because the actual artifact on display would have predated the creation of the International Space Station, possibly even by decades; here, again, the Chabot exhibit designers chose not to associate the artifact with terms like the “USSR” and “communism.”

Given the importance that the exhibit designers placed on the Soyuz descent module, the inclusion of a defamatory quote (see Figure 25) to describe the spacecraft is surprising. The quote, taken from a book authored by pop-science writer Chris Jones (2007), has the effect within the exhibit of either hinting at the utilitarian practicality of the Russian engineers, or disparaging the spacecraft as minimalistically non-innovative, depending on one’s perspective. This contrasts with the admiring tone generally given to describing spacecraft, particularly those important to domestic history, that are otherwise made at space exhibits.

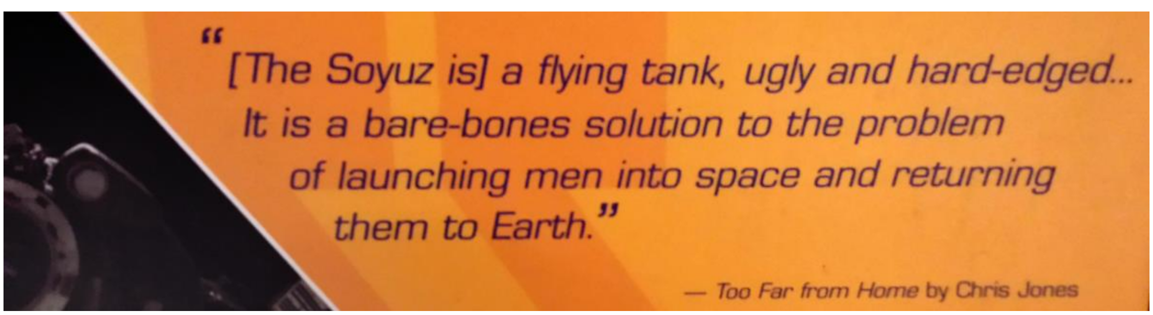

Figure 25. Panel text describing the Soyuz as an ugly, hard-edged flying tank. Photograph by the author, 2014.

Only a partial amount of the Chabot’s cosmonautic artifacts are on display. The collection itself was purchased as a package, which included artifacts the exhibit designers intended to use in the Chabot's exhibits, like the Soyuz descent module, and artifacts destined for the storage rooms nearby. Some of these objects are not on display because they are redundant with already existing exhibits, such as the packages of Russian space food in the *Eating Out... Way Out* exhibit. Others remain in storage so as to avoid crowding the exhibition space with an excess of objects, such as Soviet Space Race propaganda posters (see Figure 26), a Soviet-era ejector seat, and a TZK-14 thermal suit worn by the German Hans Schlegel, a veteran ESA cosmonaut (Triplett 2003: 22; Morring 2008: 168). Understandably, the exhibit designers chose to be selective about their collections, aiming to only use those they deemed fit to depict the living conditions experienced by astronauts and cosmonauts.

Figure 26. Soviet propaganda posters in the Chabot's collections storage area, with the first poster stating “Glory [to the Soviet Union]” at the base in orange lettering, and the second depicting a Lunokhod lunar rover. Photograph by the author, 2014.

The consequence is that the exhibition panels and labels waver somewhat uncomfortably between only lightly commenting on the apparent foreignness of some of the artifacts, sticking to the exhibition's intended topic of discussing life in space, and giving a full-fledged effort to describing the Russian origins of some of the other artifacts. The use of the historic collections, and exhibit texts that accompany them, sway *Beyond Blastoff* toward being an astronautics and aeronautics exhibit type. But the majority of the interactives and many of the exhibit panels and labels do not discuss sociocultural histories, and instead focus more on science without any blatant cultural ties. This latter tendency, which is typical of the science center exhibition type, likely has a lot to do with the decreasingly object-oriented direction many space museums seem to be headed (Conn 2010: 22). During my internship with the exhibits team in the summer of 2014, it was made clear that the Chabot Space and Science Center planned to move away from prioritizing collections in its exhibitions; in this, *Beyond Blastoff* appears to represent an early step toward that direction.

With respect to cultural narratives, it is interesting to note that the exhibition draws a distinction between astronauts and cosmonauts, defining cosmonauts as "Russian" and astronauts as being from the United States (see Figure 27). This distinction is commonly used throughout literature on space history, causing occasional confusion about what non-Russian, non-American space travelers should be called (Triplet 2003: 44). As for the contextual use and defining of these terms within the exhibition, it makes for an interesting case of cultural inclusion and exclusion. An analysis of all the panels and labels used within *Beyond Blastoff* reveal that the term "astronaut" is used a total of 110 times, whereas the term "cosmonaut" is used a mere 14 times. This represents a nearly 8:1 ratio of discussions of astronauts being favored over discussions of cosmonauts. If "astronaut" is assumed to equate only with American nationality, and "cosmonaut" with Russian nationality, this means that the exhibition guides visitors more toward considering an American presence in space than a Russian one.

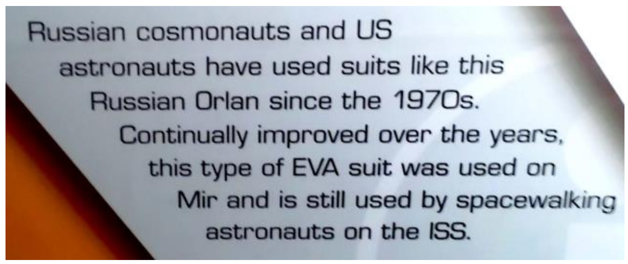

Figure 27. Descriptive label which defines the cultural affiliations of cosmonauts as Russian and astronauts as American. Photograph by the author, 2014.

However, the use of the terms "U.S.," "America," and "American" are used only 11 times in total within the exhibition, whereas "Russia" and Russian" are used 36 times in total. This represents about a 3:1 ratio of favoring the national identifier "Russia/n" over "America/n." There are a few ways of interpreting this reversal from the 8:1 inclusion of "astronaut" over "cosmonaut." A likely one is that the label writers felt inclined to use "Russian" to discuss content that was vividly foreign, whereas American nationality would be assumed elsewhere because that is both what they, and presumably their visitors, were most likely to identify with. This would make sense given the high correlation of the term "Russian" with "Soyuz." Meanwhile, "American" is correlated with the term "first," indicating its use is intended to call visitor attention to domestic achievements (see Figure 28). Another possibility is that the use of the term "Russian" was intended to garner visitor attention on the subject of a Russian presence in space, with this cultural aspect of the narrative aligning well with the collections on display, although this would indicate that the insubstantial use of the term "cosmonaut" was an unintentional oversight.

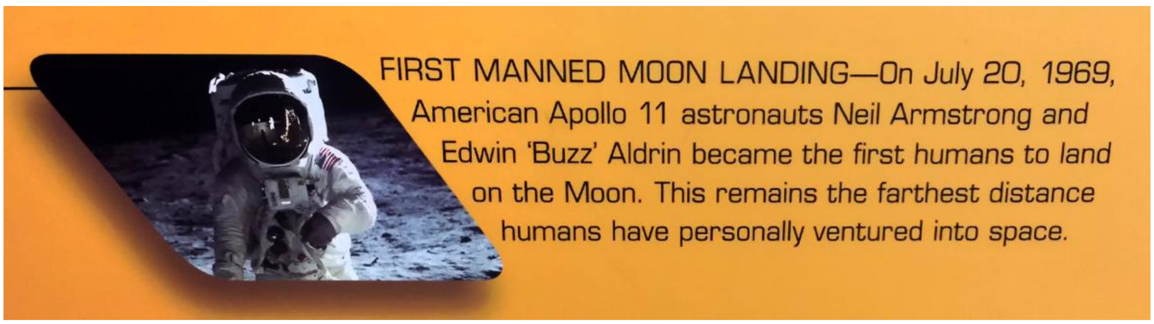

Figure 28. Panel text listing Americans Neil Armstrong and "Buzz" Aldrin as the first humans on the Moon. Photograph by the author, 2014.

When filtering the panel texts for the names of space travelers, 83 names appear throughout the exhibition, of which 70 include distinct individuals. Of these, 81 percent are American citizens and, with the exception of three space tourists, which are mentioned by name, all were employed by NASA. Four of these people, including two of the space tourists, held dual-citizenship, and so can be regarded as representatives of multiple nations. When taking dual-citizenship into account, 20 of the named space travelers represented foreign nations, 10 of whom were Russian. These are surprising numbers because they represent about a 7:1 ratio of representing nations other than

Russia in an exhibit that uses exclusively Russian artifacts, with a notable bias toward including American names.

Given that Russian cosmonauts are mentioned by name only 10 times, their inclusion appears underwhelming considering the substantial incorporation of Russian artifacts in the exhibition. It is therefore surprising that space travelers with citizenships beyond Russia and the United States are included in equal numbers. These include people with either sole or dual citizenship in South Africa, Sweden, Switzerland, England, France, Germany, Canada, Hungary, or Iran. Their inclusion within an exhibition brimming with Russian artifacts becomes substantially less surprising when taking into account that many of these people received some of their training from Roscosmos and entered space aboard a Soyuz spacecraft. For example, Canadian Chris Hadfield (2013: 34) served as a flight engineer aboard Soyuz TMA-07M (Spiteri 2013: 94-97), the German ESA engineer Thomas Reiter partook in the Soyuz TM-22 mission and was part of the joint Russian-European EuroMir program (Covault 1995: 30; Hoffmann et. al. 1998: 313-319; Sellevag 1995: 17), the French ESA engineer Léopold Eyharts traveled to Mir on the Soyuz TM-26 mission (Covault 1997: 30) and Soyuz TM-27 mission (Covault 1998: 26), and all of the tourists achieved spaceflight by paying for a ticket aboard a Soyuz spacecraft (Hadfield 2013: 28).

Throughout the exhibition, eight space travelers are mentioned more than once. Seven of these people are of American nationality, and one, Yury Usachov, is of Russian nationality. The only names which appear on exhibit panels or labels more than twice are American astronauts Shannon Lucid and Sunita Williams. Shannon Lucid, who lived aboard Mir (Begley and Carroll 1996: 68) and formerly held the record for having lived in space longer than any other American (Jerome and Calkins 1996: 36), is mentioned by name three times throughout the exhibition. Sunita Williams is mentioned six times, and is famous for having accumulated more time spacewalking time than any other female astronaut (Shea 2013: 124-126) and recently served as commander of the International Space Station during Expedition 33 (Spiteri 2012: 454; see Figure 29).

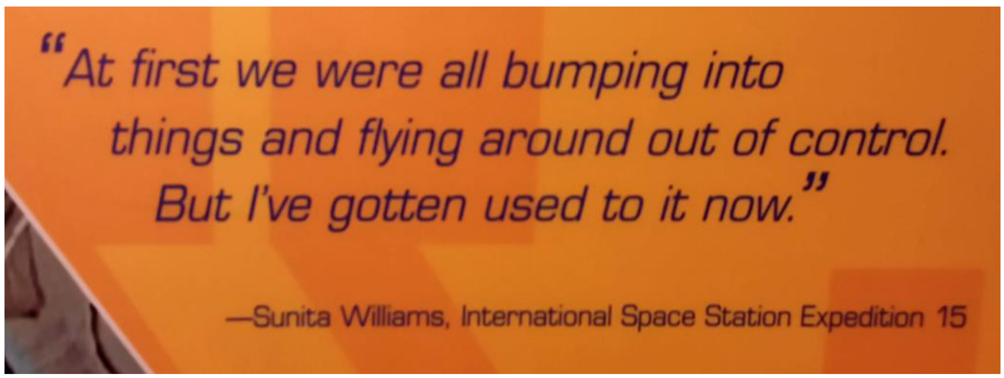

Figure 29. American astronaut Sunita Williams is quoted or referenced six times throughout the *Beyond Blastoff* exhibition. Photograph by the author, 2014.

When considering space museum representations of foreign nations, one of the Chabot's most impressive exhibit pieces is a large panel which displays a chronology of human spaceflight (see Figure 30). The mission duration of each individual is depicted with colored bars which stretch across the timeline to mark the length of time spent in space. These bars are color coordinated, with blue representing the United States, red for Russia and the Soviet Union, purple for France, green for Germany, yellow for Canada, light blue for Japan, and black for "Other." The key then lists abbreviations for the 26 other nations, from Afghanistan to Vietnam, which have put their citizens into space. The abbreviations are then listed alongside any of the black bars appearing within the chronology.

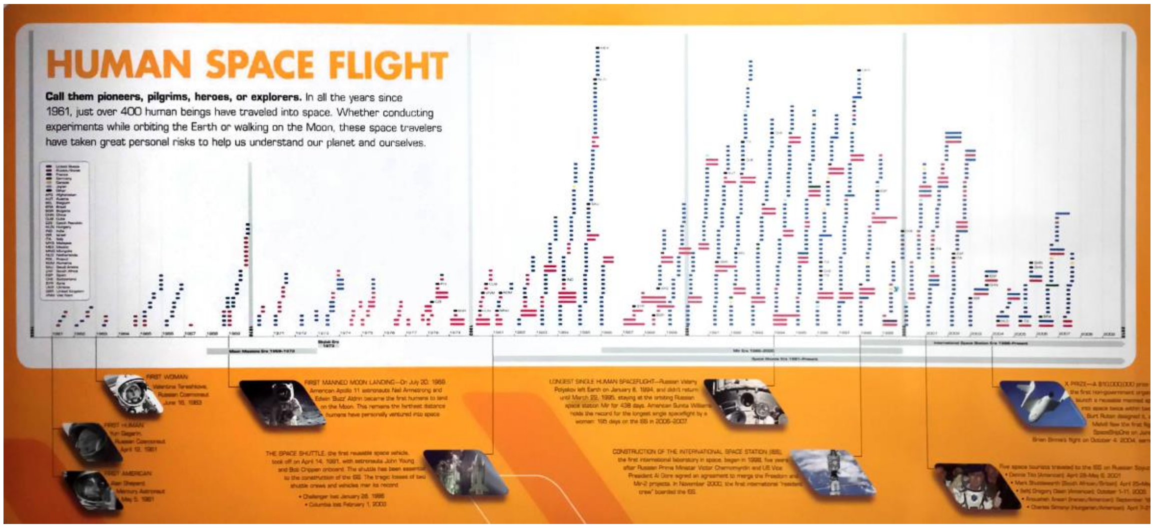

Figure 30. Exhibit panel providing a chronology of human spaceflight with a key that lists contributors by nationality. Photograph by the author, 2014.

The timeline begins in 1961, when cosmonaut Yuri Gagarin became the first person to venture into space, and ends in 2007 because the *Beyond Blastoff: Surviving in Space* exhibition has not been updated since that year. With the exception of the accomplishments of the three Russian cosmonauts and six American astronauts who are described at the base of the panel, the informational panel does not explicitly describe the majority of these national endeavors. There is nothing throughout the exhibit to discuss Canadian, Japanese, or German space history. Nonetheless, the panel is a distinguished example of inclusiveness, informing visitors that more than just Russia and the United States have been to space.

Using text analytics to assess all the panels and label texts used throughout *Beyond Blastoff: Surviving in Space* shows that the United States has the highest representation of any nationality. This includes aggregating the names of space explorers, space vehicles such as Mir and Soyuz, terms such as “cosmonaut,” and the mentioning of individual nations by name. If “astronaut” is included as a term that is synonymous with being American, as many of the exhibit panels and labels imply, then 61 percent of the exhibit’s national representation consists of an American identity. Using this system of analysis, 29 percent of the exhibit content uses terms referring to Russia, with the remaining 10 percent representing other nationalities. This is reasonably close to the actual distribution of human spaceflight, in which about 62 percent of space explorers have been American, 22 percent Russian, and 16 percent of other nationalities (NASA 2013: 4-13; see Figure 31).

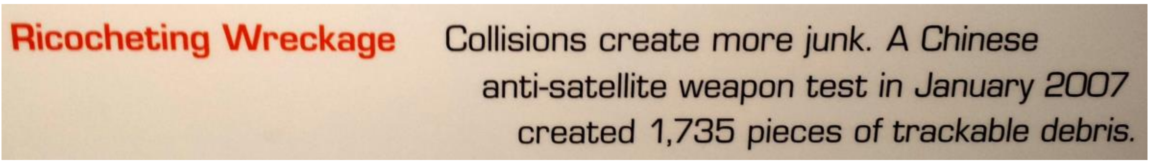

Figure 31. One of two instances in which China is mentioned in the *Beyond Blastoff* exhibition. Photograph by the author, 2014.

If, however, the terms “astronaut” and “cosmonaut” are categorized as terms with ambiguous nationality because they can be used interchangeably for space travelers affiliated with organizations like JAXA and the ESA, the terms can be removed from the study. The figures then change dramatically. American representation then drops to 45.3

percent, Russian representation rises to 37.1 percent, and other nationalities to 17.6 percent. Aside from the United States and Russia, the only nations represented more than once in the exhibition are China, France, Canada, Germany, and Kazakhstan, with Kazakhstan being discussed only as a launch site location for Russia's space program. If, however, the analysis is adjusted to remove the key appearing on the Human Spaceflight exhibit panel, then representation of nations other than Russia and the United States drop to 6 percent.

This demonstrates one of the limitations of text analytics. Statistical distributions on space museum representation of states, societies, and cultures are dependent on how specific terms are categorized, and whether certain terms are included or excluded. Because Russian space travelers are only referred to as "cosmonauts" and U.S. space travelers only as "astronauts," some difficulty can arise when considering space travelers from other nations because they may use the terms interchangeably depending on the mission or contextual setting. To maintain analytical simplicity, the terms "cosmonaut" and "astronaut" are excluded in future instances of text analysis conducted in this thesis, but it is worth discussing the context here. Within the context of the *Beyond Blastoff* exhibition, use of these terms generally appear to represent a Russian / American duality. The consequence is that visitors are most commonly confronted with these two national identities in the exhibition.

Case Study: The Chabot's *One Giant Leap* Exhibition

One of the Chabot Space and Science Center's other exhibitions, *One Giant Leap: A Moon Odyssey*, was designed and constructed to give museum visitors appreciation and knowledge of humanity's journey to the Moon. The exhibition includes multiple artifacts, interactives, and exhibit panels related to lunar travel, as well as content on some of the early steps in spaceflight that made trekking to the Moon possible. Interactives vary from teaching scientific to historical information, such as with a pivoting chair next to a beam of light to demonstrates how and why the Moon has multiple phases, an interactive conveying the comparative ease with which objects on the Moon can be lifted, a simulator which lets visitors make an attempt at the arduous effort of landing an Apollo Lunar Module on the Moon, and an interactive discussing NASA's selectivity with height requirements and encouraging visitors to see how they measure up. Categorically, the exhibition can be classified as a hybrid between aerospace and science center, with one end of the exhibition devoted more to the history of spaceflight and the other end devoted to discussing lunar physics.

The few artifacts found in the science center half of the *One Giant Leap* are minimalistic in providing visitors with historical information about the objects, and instead devote panel and label space to explaining the objects' physical properties. A good example of this is an exhibit case containing a fragment of mare basalt (see Figure 32). In semiotic terms, the extrusive igneous lunar rock is segregated with substantial permeability; the object has been placed in a triangular glass case, allowing visitors to walk around the exhibit and see it from all angles. This conveys the importance of the object as historically significant, and also protects it from visitors' touch. Yet no historical information is given other than stating that astronauts collected it during the Apollo 15 mission in 1971. Nothing is said of the crew, James Irwin and Davis Scott, that gathered the lunar samples (Time 1971: 52; Schaber et. al 1972: 1573-1577), nor of NASA's scientific justifications for having lunar rock gathered and brought back to Earth in this first place (Fagan et. al. 2014: 97-127; Kaneko et. al. 2014; Liu et al. 2015: 122-153).

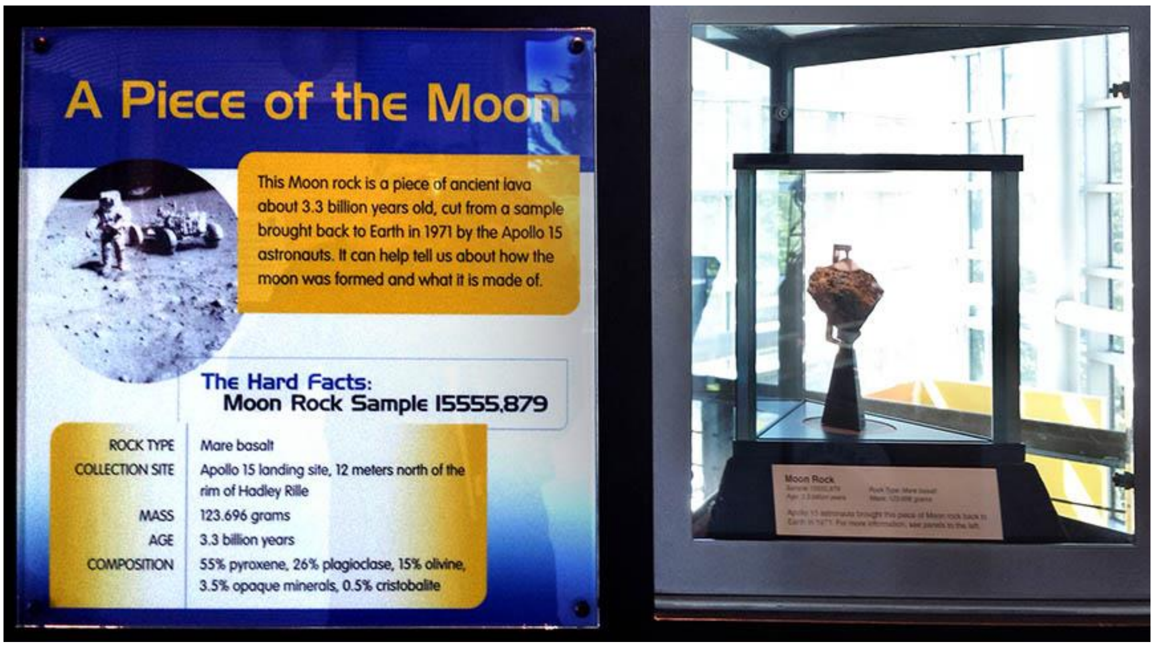

Figure 32. Panel and label describing a fragment of mare basalt sampled from the Moon by the Apollo 15 crew. Photograph by the author, 2014.

By contrast, the other half of the *One Giant Leap* exhibition includes numerous panels and labels devoted less to scientific details and more to historic information, wherein all exhibit artifacts fit into an overall socio-historic narrative about lunar travel. This includes content on the two original space powers, the United States and the Soviet Union, but does not exert effort into discussing the competitive contextual circumstance of the Cold War and the Space Race. In this, the exhibition frees itself from a sociopolitical narrative, instead focusing more on topics of astronautics and lunar exploration. This is accomplished, in part, through exhibit panels that present on the science fiction which predated spaceflight and inspired later scientists and engineers to develop a method for reaching the Moon, and also with replica artifacts of important spacecraft that made such a long journey possible.

Science fiction was hugely influential on some of the original aerospace engineers such as Hermann Oberth, Wernher von Braun, and Robert Goddard (Bainbridge 1983: 29-30), thus it is not surprising that the Chabot chose to include a timeline of early science fiction in *One Giant Leap*. The panels which compose the timeline provide a notable example of cultural inclusion; although they predominantly discuss the United States and topics related to American spaceflight, figures of other nationalities are mentioned. For example, one panel text (see Figure 33) mentions a particularly influential novel, *From the Earth to the Moon* (French *De la Terre à la Lune*) by the nineteenth-century French author Jules Gabriel Verne (1867). Verne's novel succeeded in stimulating widespread cultural interest in space exploration throughout Europe and North America (Unwin 2005: 5-17), has been cited by many key historical figures as having inspired their pursuits in space exploration (Bainbridge 1983: 29-30), and remains famous for its uncanny prediction of some of the activities of the Apollo space program that took place a century after its publication (Regas 2015: 32-37).

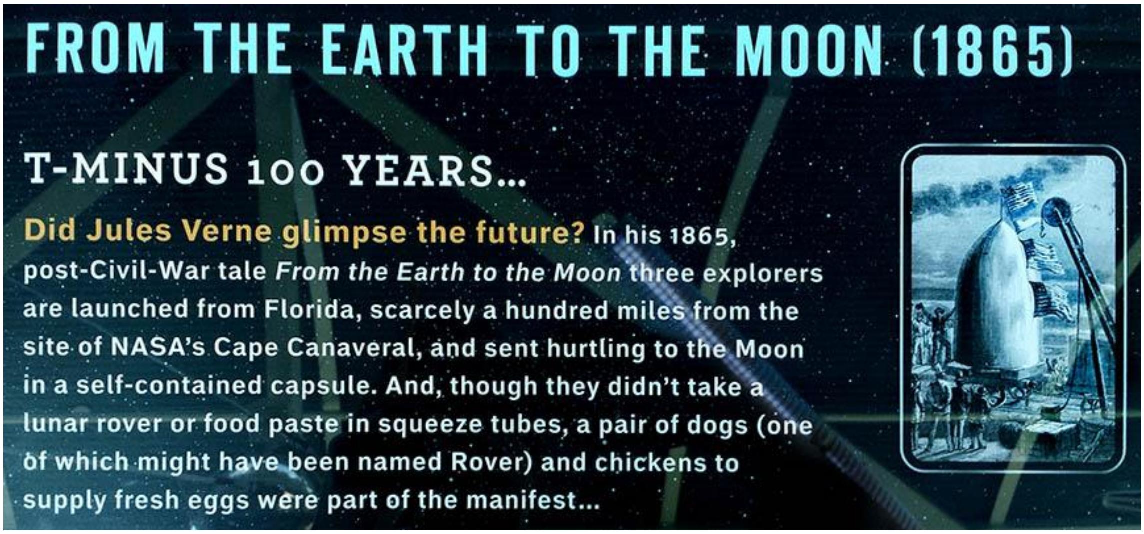

Figure 33. Part of a timeline on the science fiction that predated spaceflight and inspired later space explorers. Photograph by the author, 2014.

With the exception of a panel discussion on Project Daedalus, a hypothetical interstellar spacecraft designed by the British Interplanetary Society (Long et. al. 2011: 1820-1829), the timeline does not present on contemporary efforts in space beyond the United States. Nor is Project Daedalus' British origin explicitly stated, meaning that museum visitors must already have some familiarity with the project to recognize it as more than just American. Furthermore, the surrounding texts risk giving visitors the impression that Project Daedalus has strictly American roots. This is unfortunate in that the exhibit designers overlooked an easy opportunity to inform visitors that nations other than the United States and Russia contribute to space exploration.

The skybridge hallway, which connects the exhibition's science center section to the aerospace section, displays replica artifacts of spacecraft in a timeline which begins with *Sputnik-1*, the first artificial space satellite (DeGroot 2007: 34-39), and concludes with Apollo 8, the first manned spacecraft to circulate the Moon (Rabinowitch 1969: 2-12). Labels are mounted on the floor along the walkway and provide visitors with brief insights about *Sputnik-1*, *Explorer-1*, Project Gemini, and Project Apollo (see Figure 34). These labels direct visitor attention to relevant replica artifacts hanging from the ceiling above them (see Figure 35). Halfway into the timeline, museum visitors encounter a full-size replica of a spaceship, the Project Mercury space capsule (see Figure 36).

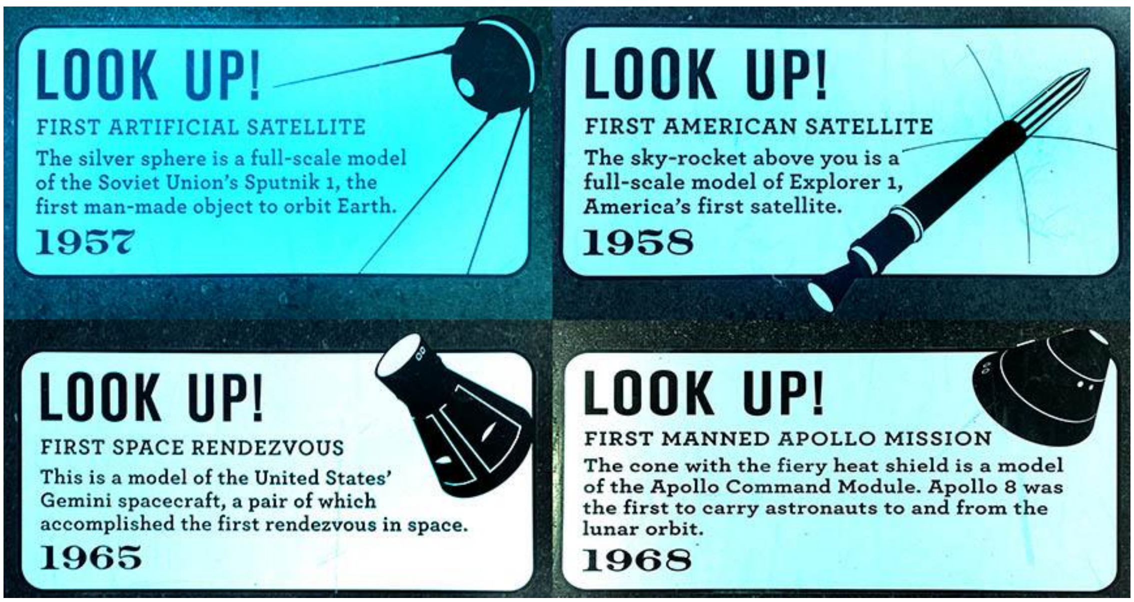

Figure 34. Labels on the Chabot's *One Giant Leap* exhibition floor encourage visitors to take notice of replica spacecraft hanging from the ceiling. Photograph by the author, 2014.

Figure 35. A hallway in *One Giant Leap: A Moon Odyssey* with floor labels and model spacecraft attached to the ceiling. Photograph by the author, 2014.

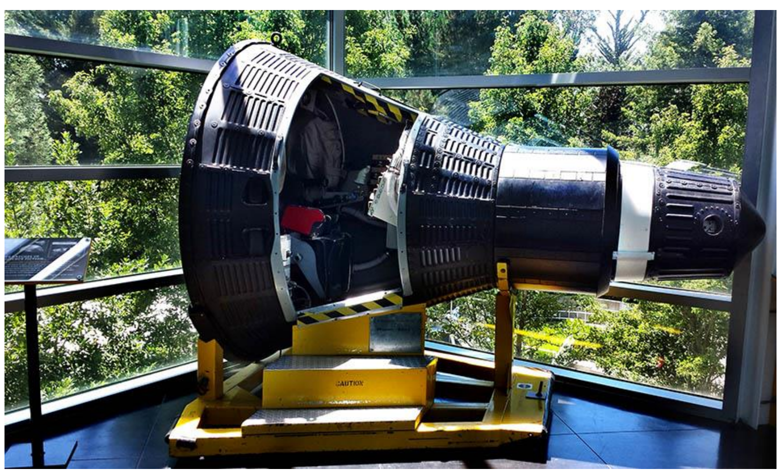

Figure 36. Replica Mercury spacecraft. Visitors are encouraged to climb inside to gain a sense of what space travel was like for the first astronauts. Photograph by the author, 2014.

At its beginning, the timeline gives tribute to the Soviet origins of spaceflight with a scale model of *Sputnik-1*, but gives an overall impression that the United States had a domineering role in space travel from there on. This is subtly—and likely unintentionally—conveyed through a lack of balanced representation; nothing was added to represent Soviet spacecraft beyond *Sputnik-1*, though replicas for the Vostok,Voskhod, or Luna space programs would have accomplished this. Although the exhibition is very successful in avoiding many of the nationalistic pitfalls that can arise when exhibits discuss Space Race era competition, the lack of content on Soviet efforts toward lunar navigation risks giving visitors a false impression that only the United States played a noticeable role in the expedition to the Moon, or can reinforce this assumption if visitors arrive with it already. In actuality, Soviet spacecraft reached the Moon before the spacecraft of any other nation (McLean 2009: 14).

The panel “Mythical Moon” is one of the few instances in which foreign cultures are explicitly named and discussed (see Figure 37). In it, the panel indicates that werewolf mythology and its association with the Moon started with the Greeks, although it is not clear that either of these points are correct. The panel also mentions that seeing a rabbit in the patterned shadows and lighting of the Moon is a widespread cultural phenomenon, and that folktales about the cosmic rabbit can be found in China, India, Mexico, Korea, and Japan. This is an interesting example of cultural inclusion and exclusion because it does present on space culture beyond the United States, but it is an isolated case, and does so without any accompanying exhibit content discussing how these nations have contributed to space exploration in modernity. When considering the panel's placement in the overall exhibition, it has the unintended effect of contrasting the technological achievements of the United States with cultures and nations which seemingly have not progressed beyond their ancient folkloric beliefs.

Figure 37. An exhibit panel discussing ancient cultural mythologies about the Moon is one of the few instances where foreign cultures are discussed. Photograph by the author, 2014.

An analysis of all the exhibit panels and labels within the *One Giant Leap: A Moon Odyssey* exhibition reveal 68 instances in which key terms unambiguously affiliated with the United States are named. Instances of American lunar exploration, such as the Apollo space program, are mention throughout the exhibit (see Figure 38). By contrast, the Soviet Union is only mentioned in seven instances, meaning that museum visitors are almost ten times as likely to encounter terms on the United States than on the

Soviet Union when browsing the exhibition's texts, despite that the Soviet Union also engaged in lunar exploration.

Figure 38. Panel text stating that human space exploration began with *Apollo 11* landing on the Moon. The *One Giant Leap: A Moon Odyssey* exhibition is dominated by content on the American space program. Photograph by the author, 2014.

Content on cultures and societies other than these two space powers are mentioned 22 times. However, only four of these instances relate to spaceflight, and in none of these four instances is a nation explicitly named. Thus, while key terms affiliated with nationalities other than the United States are included in exhibit panels and labels approximately 30 percent of the time, only about 11 percent of all instances of national representation actually discuss space travel conducted outside of the United States.

Overall, the exhibition gives museum visitors an interesting, albeit limited and outdated, glimpse of lunar travel. Herein, the Chabot missed a worthwhile opportunity to present museum visitors with displays and texts about Russia's many historic accomplishments on exploring the Moon, like the Luna Program in which, beginning in 1966, the Soviet Union became the first nation to begin successfully sending satellites to the Moon (Sipiera 2015: 2), and the Zond Program of the late 1960s, in which the Soviet Union orbited the Moon with a number of robots sent to gather scientific information (Portree 2002: 235-237). Although no person has set foot on the Moon since the American Eugene Cernan (1999) returned to Earth after the success of Apollo 17 in 1972, other nations have succeeded in reaching the Moon by means of unmanned spacecraft. Examples of these lunar spacecraft include Japan's *Hiten* (Eberhart 1990: 198) and *SELENE* (Gusev et. al. 2003: 579), the European Space Agency's *SMART-1* (Foing and Racca 1999: 1865-1870), India's *Chandrayaan-1* (Vighnesam et. al. 2010: 784-792), and China's *Chang'e 3* (Liu et. al. 2015: 1074-1084).

Case Study: The Chabot's *Tales of the Maya Skies* Companion Exhibition

The *Ask Jeeves Planetarium* is one of the Chabot Space and Science Center's main attractions, providing museum visitors with the choice of a variety of live and pre-recorded shows which play at various times throughout the day. The original planetariums were intended as visually awe-inspiring exhibits which would give visitors a full view of the night sky, even during the day (Fox 1932: 128; Chant 1935: 144-146). Encouraged by the success of the planetarium exhibit in Germany, museums around the world began building their own planetariums to accompany their astronomy and science exhibitions. Over the past century, planetariums and their adjacent exhibits have sometimes taken up the role of raconteurs to bring visitors tales of ancient cultural beliefs about the cosmos. The Chabot's planetarium is a continuation of this legacy; in addition to its other planetarium shows, visitors are given the opportunity to watch *Tales of the*

Maya Skies, a digital full-dome show about ancient Mayan cosmic beliefs, and can then tour the companion exhibition in the rotunda outside the planetarium.

The cultural importance of the sky, both of day and night, to Maya culture was profound. They believed that the universe was born and reborn in a series of cycles, and that the bright heavenly bodies of the celestial sphere were gods (Rice 2004: 19-21). The Sun God of Chichén Itzá, for example, was revered by the Maya and appears in stela carving accompanied by other cosmic deities and star warriors (Milbrath 1999: 82-83). The planetarium show *Tales of the Maya Skies* offer some of their stories, with its companion exhibition providing further learning opportunities with interactives and informational panels. This includes content such as a chronology of Maya events and where they fit in a timeline of other cultural events around the world, a touch-screen interactive whereupon visitors can learn more about the meaning of various stela figures, an interactive booth at which visitors are taught how to write Maya script, and an informational panel explaining that the Maya people still exist today and that a large population resides in the San Francisco Bay Area in modern times.

Though confined to only one room, the exhibition panels make up a substantial amount of the Chabot's exhibit content on pre-spaceflight culture. The majority of the *Tales of the Maya Skies* consists of literature discussing Maya civilization and beliefs, but other civilizations are acknowledged as well. Spain, for example, is mentioned several times because of the brutal history of Spanish conquest in Mesoamerica during which indigenous religious practices were suppressed and countless people were murdered or died from European-born pestilence (Adams 1989: 119-136;

Stutz 2006: 44-51; Graham et. al. 2013: 161-179). The exhibition, in sum, compliments the Chabot's planetarium show while also demonstrating an effort at multicultural inclusion within the parameters of limited floor-space.

Case Study: The Chabot's *Cosmos 360* Planetarium Shows

"Over thousands of years and all human cultures, we've searched for familiar shapes and composed stories about animals and monsters, god and goddesses among the stars." This quote, taken from the Chabot's winter 2012 script, *Cosmos 360: Seeing Stars*, exemplifies one of the unique aspects of planetarium shows. Unlike most object-oriented space exhibits, planetarium narratives frequently indulge in cultural cosmologies. At the Chabot, where new shows are seasonally released under the titular name *Cosmos 360*, anecdotes about foreign and ancient cultures are interwoven into the planetarium scripts to give warmth to otherwise impersonal narratives about the cosmos. By including tales derived from oral lore, narrators strive to captivate their audience while also embracing the ancientness of human intrigue in the night sky.

During my time interning at the Chabot Space and Science Center, I worked under the guidance of Ben Buress, a content developer and staff astronomer. In addition to brainstorming and developing new exhibit displays, Ben oversees the creation of new planetarium content. This entails researching recent discoveries in astronomy and space exploration, choosing a thematic topic for a new planetarium show, finding relevant cultural tales to include, writing and testing a script, digitally manipulating photographs to fit on the lens-shaped planetarium screen, programming the planetarium to progress to various astronomical points of interest in conjunction with the script, and, finally, training select personnel on how to narrate the new show. Beginning in 2014, Ben also began experimenting with creating pre-recorded planetarium shows, which have the advantage of not requiring that a narrator be present for audiences to watch a planetarium show.

Ben familiarized me with each of the stages that go into developing a planetarium show, and also collaborated with me in creating some of the content for the upcoming winter 2014 *Cosmos 360* show. Most of my efforts were spent finding high resolution photographs of interesting skylines, such as the Roman Theatre at Palmyra, that were in the public domain, and then using Adobe Photoshop to manipulate and layer these images so that they could be integrated with the starscapes produced by the planetarium's projector. Ben also taught me the basics of planetarium operation and generously provided me with reading material for programming the planetarium's DigitalSky 2 Full Dome software. Additionally, Ben took the time with me to share his thoughts on the nuances of developing a script, and provided me with three years' worth of *Cosmos 360* planetarium shows.

As with planetarium shows I experienced at other West Coast institutions, Greek mythology is a common talking point within the Chabot's planetarium. This is hardly surprising since Greek and Roman terms have been assigned to many of the celestial bodies, such as the planet Uranus, a Latin word derived from the Greek term for sky-heaven (Greek *οὐρανός*), or to North American ventures in space, such as the Apollo space program, named after the Olympian deity found in both Greek and Roman mythology. The popularity of referencing Greek mythology also casually displays a link to Greek astrology, an origin point for much of western astronomy. Though astrology has been rejected by modern science, Greek constellations and asterism are still popularly taught within college astronomy classes and textbooks. Such patterns in the sky give astronomers convenient reference points in the sky, and help astronomers guide the gazes of other onlookers toward celestial points of interest (Dickinson and Ferris 2006; Palen 2012: 22-45).

Cultural references within *Cosmos 360* scripts are not exclusively ancient Greek and Roman. Although this is dominantly the case, other cosmologies are also discussed at varying levels of detail, including cosmological mythologies from Ireland, England, Egypt, India, China, Japan, Thailand, the Māori of New Zealand, the Maya, the Aztec, the Mono of California, the Iroquois, and the Greenlandic Inuit. In some instances, cultural references are presented as anecdotes. For example, the *Cosmos 360* script for the fall of 2011 show discussed the Pleiades open star cluster, and mentions that in Thailand the points of light were seven "baby chickens." In other instances, the script provides narrators with lengthy stories derived from oral traditions. In further discussing the Pleiades, the *Cosmos 360* script presents lore from the Western Mono Native American tribe, wherein the asterism represents six women moving across the night sky.

According to this latter story, which gives a humorous twist on the significance of Pleiades, the six women were out foraging when they found and ate some wild onions. After the women returned home, their husbands—disgusted by the foulness of their onion-breath—unscrupulously decided to cast out them out. The women climbed the night sky looking for sanctuary. Their husbands, who had by then grown lonely, went out in search of their wives. In their remorse, the band of husbands—perhaps more familiar to western stargazers as the body of the Constellation Taurus—then endlessly followed their wives in their journey across the starlit sky.

For the Chabot's planetarium visitors, many of whom have never seen the true brilliance of the night sky because of the extensive light pollution in Southern California, such narratives help them to understand and appreciate the dynamic nature of the Earth's celestial sphere. Stories give planetarium guides an entertaining way of narrating the movement of the stars, and are also intended as homages to earlier stargazers. In this way, planetariums seek to convey cultural history and astronomy that is interesting, engaging, and memorable.

Chabot's planetarium narratives also markedly contrast with most of the museum's exhibits. Aside from *Tales of the Maya Skies,* a companion exhibition used in conjunction with a pre-recorded planetarium show of the same name, most of the Chabot's exhibit panels and labels do not consider cultural histories that predate the scientific revolution. Both planetarium shows and exhibits do incorporate content from recent history, however. Through quotes and anecdotes, the planetarium scripts mention scientists from the United States, the Soviet Union, Russia, Italy, Japan, Germany, and China. The same is true of exhibit texts, albeit more focused on the United States and Russia.

This represents an interesting distinction between what content creators expect for museum exhibits and what they expect for planetarium shows. In the case of Ben

Burress, he has been involved in both at the Chabot. Despite Ben's affinity for finding and adding cultural lore to his planetarium scripts, most of the exhibitions he worked on rarely discuss such topics. In the *Beyond Blastoff* and *One Giant Leap* exhibitions, discussions about cultural events or beliefs rarely stray from topics pertaining to modern space programs. At the *Touch the Sun: Heart of the Solar System* exhibition, which contains interactives pertaining to the Sun, culturally-affiliated content is virtually absent. The same is true of the *Destination Universe* exhibition, where visitors engage a variety of astronomical topics through interactives and exhibit panels.

There is certainly nothing wrong with choosing to only exhibit scientific concepts, as is the case with *Destination Universe*, or with exclusively discussing modern space programs in an exhibition displaying cosmonautic artifacts, as is the case with *Beyond Blastoff: Surviving in Space*. Nonetheless, the high prevalence of cultural stories and references within the *Cosmos 360* shows, contrasted with the anecdote-free *Touch the Sun* exhibition, is demonstrative of the different paradigms for planetarium versus exhibit design. Had the visual content and descriptive texts for *Touch the Sun* been a planetarium show instead, it appears likely that cultural references would have been made liberally, perhaps to the Greek god Helios, or to lore found in other cultural traditions. By contrast, had a given *Cosmos 360* show been made into an exhibition instead, it would have been all-or-nothing in terms of its cultural narratives; that is, either content such as ancient Chinese astrology would be the exclusive focus of the exhibition, or the exhibition would instead focus nearly exclusively on topics pertaining to modern astronomy.

Case Study: Data Mining of the Chabot's Exhibit Panels and Labels

Despite that exhibit panels and labels at the Chabot predominantly discuss American astronauts, text analytics demonstrates that other national groups are also represented when filtering for culturally and socially affiliated nouns. This was accomplished by programming the IBM SPSS Modeler software to filter for terms like "Soyuz," "Mir," "Russian," and the names of specific astronauts and cosmonauts, and aggregate them into distinct clusters which were then used to demonstrate the overall text-based distribution of their usage throughout the Chabot Space and Science Center. This revealed that, when strictly looking at spacefaring societies, visitors to the Chabot will encounter key terms affiliated with the United States 54.8 percent of the time and will encounter terms affiliated with the Soviet Union or Russia 30.8 percent of the time. Representation of space powers other than the United States and the Soviet Union or Russia appear in exhibit panels and texts at a 14.4 percent frequency, with a little over half of those texts devoted to discussions of European nations or Europe in general (see Figure 39).

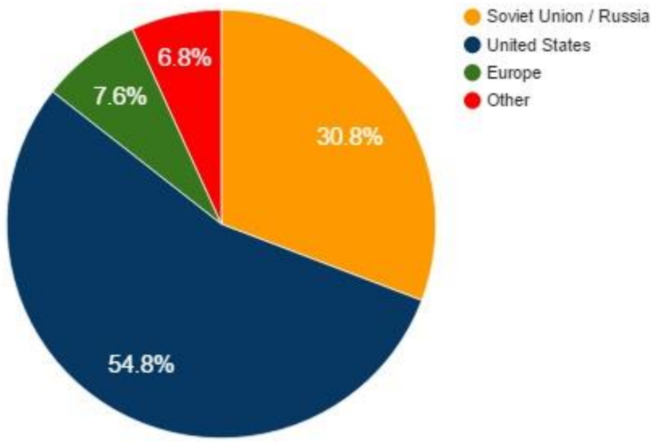

Figure 39. Proportion of exhibit panel and label representation of spaceflight era nations at the Chabot Space and Science Center. Pie chart by the author, 2015.

These distributions are relatively similar to the actual distribution of space travelers by nationality, of which approximately two-thirds have been United States citizens, 22 percent of whom were from the Soviet Union or Russia, and 16 percent of whom were of nationalities other than the two Cold War-era space powers (NASA 2013: 4-13). The Chabot's representation of the United States is somewhat lower, and their representation of Russia slightly higher, than these values. This can be attributed to the Chabot's large collection of cosmonautic artifacts, some of which are on display and discussed within exhibit labels and panels in the *Beyond Blastoff* exhibition. Though American astronauts are named at a greater extent in that exhibition than are Russian and Soviet cosmonauts, and although Soviet and Russian history is only minimally discussed in the *One Giant Leap: A Moon Odyssey* exhibition, the references to the Soyuz descent module and other artifacts on display skew the Chabot's overall text-based representation toward a greater inclusion of the Russian space programs.

The Chabot also includes some informational panels and labels that discuss pre-spaceflight cultural practices and beliefs related to the cosmos. Some of these discuss mythologies in brief, such as a panel which appears twice outside the planetarium, both on its upper and lower level entrances, recounting multiple cultural stories about the Sun (see Figure 40). However, the majority of these narratives present content only on pre-spaceflight Mesoamerica, most of which can be found in the *Tales of the Maya Skies* planetarium-companion exhibition. When aggregating all panel and labels at the Chabot Space and Science Center, including both pre- and post-spaceflight texts, the IBM SPSS Modeler program reveals that about 29.1 percent of Chabot's text include terms affiliated with cultures and societies that predated spaceflight (see Figure 41). Interestingly, content on these earlier cultural groups appear at three times the frequency of non-Russian, non-U.S. spaceflight-era nations.

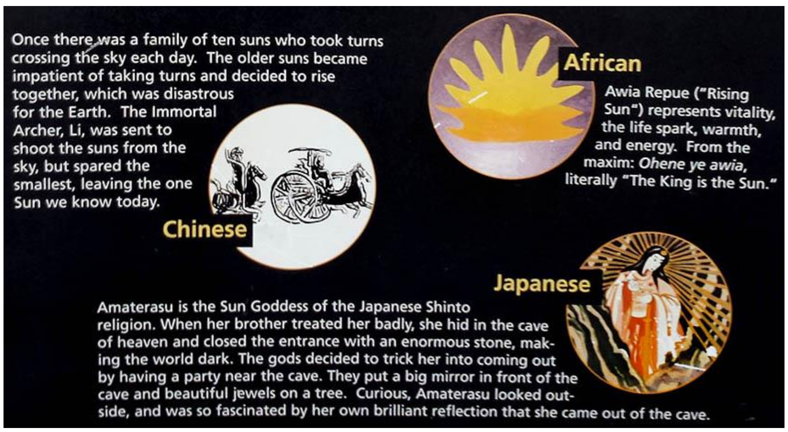

Figure 40. Some exhibit panels at the Chabot Space and Science Center discuss pre-spaceflight cultural beliefs about the cosmos. Photograph by the author, 2014.

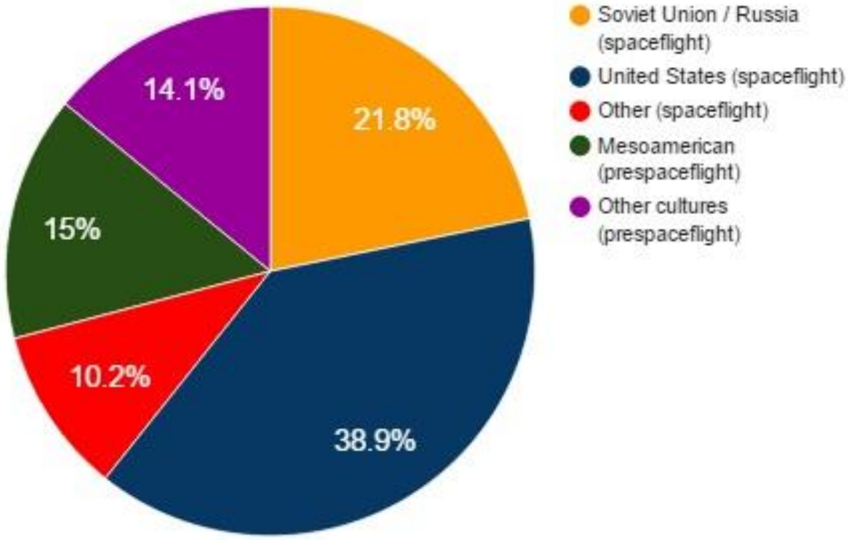

Figure 41. Overall proportion of cultural representation within exhibit texts and labels at the Chabot Space and Science Center. Pie chart by the author, 2015.

Field Research Results

This thesis set out to test three hypotheses on West Coast museum representation of states, societies, and cultures by aggregating panel and label texts from institutions in California, Oregon, Washington, and British Columbia. This involved entering the text of several thousand panels into the IBM SPSS Modeler data mining program to, among other things, look at word frequencies across the 19 institutions. This revealed multiple trends on the extent at which space museums include narratives on the United States, Russia, and other spacefaring societies like Japan, Canada, China, Germany, and so on. Additionally, text analytics revealed the extent at which these exhibitions provide visitors with narratives on cultures predating the development of spaceflight. The data results from this research are presented in this section.

Programming the IBM SPSS Modeler to filter for culturally affiliated terms, including those specifically related to the history of spaceflight, showed that there were 15,041 instances across all exhibit panels and labels in which culturally specific terms were used. These included terms with obvious cultural affiliations like “Greek,” “American,” “Soviet,” “Japanese,” “French,” “Aztec,” and so on. These instances also included terms in which nationally specific technology or companies were mentioned in exhibit texts, such as “Roscosmos,” Japan’s “Kibo” module for the International Space Station, or the European Space Agency’s “Ariane” expendable launch vehicles. Further, these include instances in which specific astronauts and cosmonauts are named. As has previously been stated, socially ambiguous terms which cannot be associated with a specific geographic area, like “astronaut” or “International Space Station,” were excluded from this analysis and thus are not represented in the 15,041 instances in which exhibit panels and texts used culturally affiliated terms.

The overall distribution of culturally affiliated terms across all West Coast museums show that content on the United States dominates all exhibit labels and panels (see Figure 42). Over two-thirds of the content is focused on the United States, 17.4 percent on the Soviet Union or post-communist Russia, 10.3 percent on other spacefaring nations or generalized geographic regions like Europe, with the remaining 3 percent on cultures which predated the development of spaceflight. Though it is difficult to assess how well these percentages match the actual distribution of international presence and contributions to space exploration, it does appear conclusive that museum are skewed, overall, toward over-representation the United States and under-representing foreign nations in their exhibition narratives. The results also demonstrate that space museums make sparse discussion of societies and cultures which existed prior to the development of spaceflight.

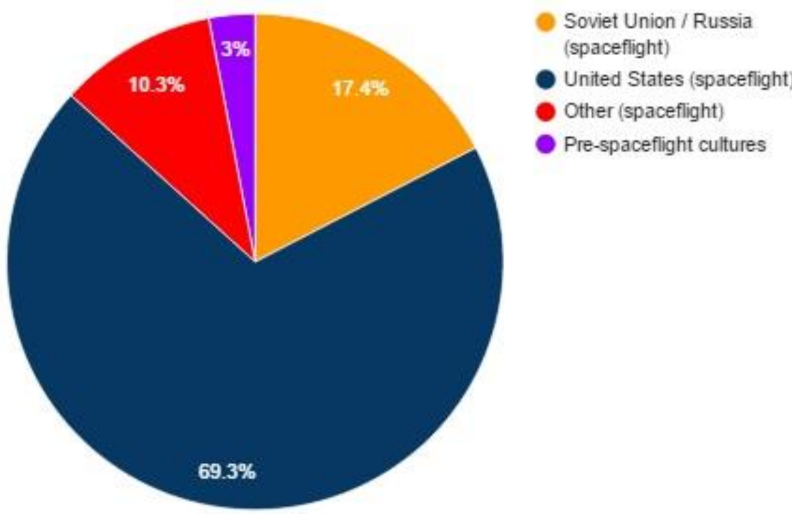

Figure 42. Overall exhibit panel and label text distribution of states, societies, and cultures throughout the West Coast. Pie chart by the author, 2015.

When looking at the regional distribution of national representation in exhibit panels and labels, Southern California shows the greatest tendency toward over-representing the United States compared to representing other nations (see Figure 43). When strictly looking at the frequency at which culturally affiliated terms were used, only 15.4 percent of exhibit panels and labels discussed topics on foreign cultures, states, and societies. Perhaps the biggest surprise in this data is that Southern Californian space museums were, overall, twice as likely to discuss non-Cold War space powers than discuss the Soviet Union or Russia. This is partially due to the exhibition design at the California Science Center in Los Angeles, which has panels with information on every space shuttle mission, including the names of both national and international crew members. These missions included 97 international passengers, of which only a third were Russian (NASA 2013: 4-13).

Compared to Southern Californian space exhibitions, Northern California exhibitions show greater representation of both Russia and of cultures which existed before the development of modern space travel (see Figures 44 and 45). After assessing exhibit texts strictly by their use of culturally affiliated terms, it became apparent that 26.9 percent of overall space exhibition content in Northern California is spent discussing states, societies, and cultures other than the twentieth-century United States. Compared to Southern California, institutions in Northern California show a much greater tendency toward creating exhibit content on Russia and pre-spaceflight cultures. At 4.6 percent to Southern California's 8.2 percent, representation of foreign spacefaring nations other than Russia is comparatively low, however.

The reasons for these regional differences are not immediately clear. One possibility is that conservative politics in Southern California have led to greater representation of American interests, whereas comparatively liberal politics in Northern California have resulted in more inclusive narratives. This question would be worth exploring through future research using means such as further museum case studies, interviews of museum staff, and the assessment of ideological views of each museum’s board of trustees and their influence on which exhibits are approved. Likewise, future studies should investigate these questions at museums in other states.

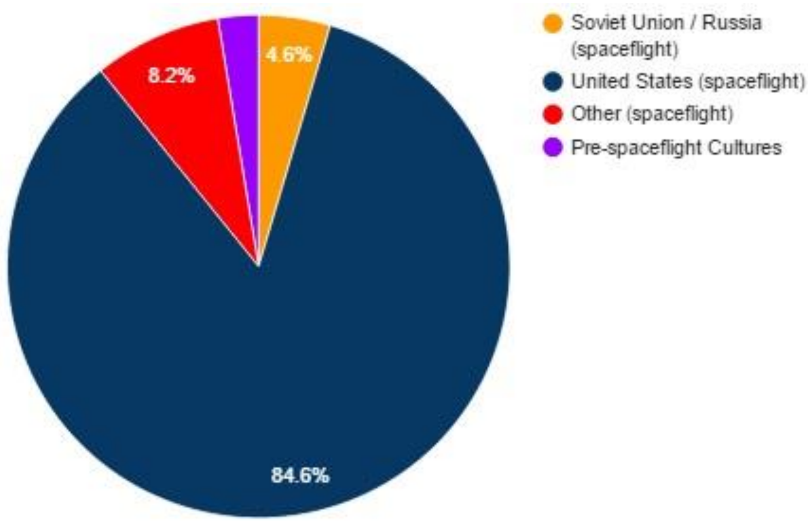

Figure 43. Exhibit panel and label text distribution of states, societies, and cultures at museums in Southern California. Pie chart by the author, 2015.

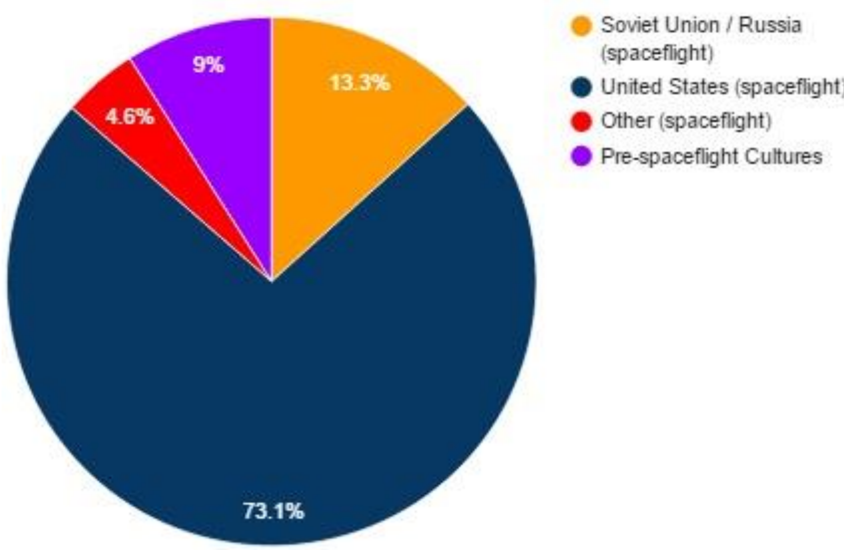

Figure 44. Exhibit panel and label text distribution of states, societies, and cultures at museums in Northern California. Pie chart by the author, 2015.

Exhibition texts from only two institutions in Oregon were collected for this study, which is substantially less than the ten Northern Californian and five Southern California institutions which are included in this study. At face-value, this may give the impression that exhibit panels and labels are less represented in this study than are those from California, skewing results toward reflecting Californian institutions than those elsewhere. Looking at the data contradicts this notion by showing that 3,845 in 15,041, or 25.6 percent, of the culturally affiliated terms used throughout exhibitions of the West Coast were from Oregon. The majority of these came from exhibit panels and labels at the Evergreen Aviation and Space Museum, a large-scale museum which houses a massive collection of aerospace artifacts, replicas, and informational panels to accompany their collections.

Space museums in Oregon also discuss Russian space history at a significantly higher frequency than do institutions across both southern and Northern California (see Figure 45). Nations other than the United States and Russia are also better represented. By contrast, a mere 2.4 percent of exhibit texts cover topics related to cultural histories prior to spaceflight. As with other institutions, content on spaceflight in the United States does make up a majority of exhibition narratives, but the greater distribution of narratives on foreign cultures indicates the desire of Oregon museums to maintain some balance in content.

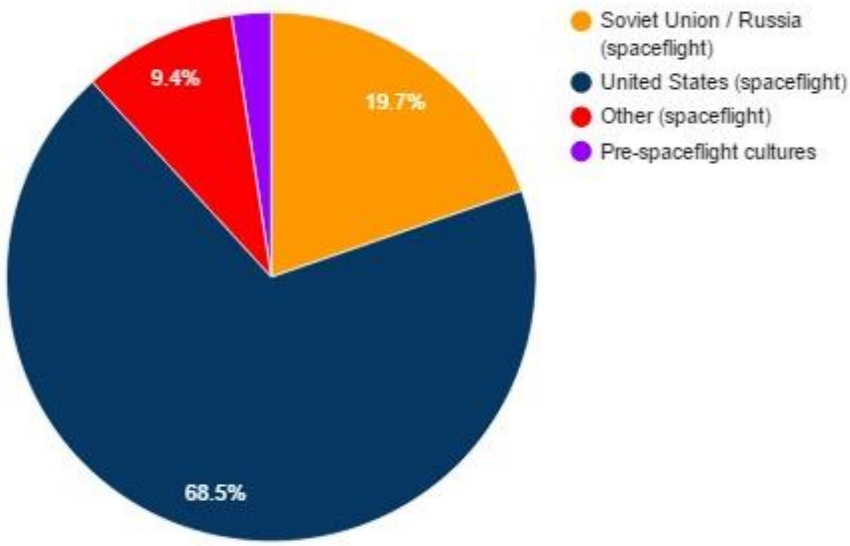

Figure 45. Exhibit panel and label text distribution of states, societies, and cultures at museums in Oregon. Pie chart by the author, 2015.

The Museum of Flight, a large aerospace museum near Seattle, is Washington’s only institution with notable space exhibitions. For this reason, it is the only museum in Washington that was included in this study. Despite that the data used in this thesis only includes one institution from Washington, the enormous size of the museum and its extensive use of panels and labels meant that slightly over a third of all exhibit texts used in this study were from the Museum of Flight. Even though the Museum of Flight represents only one of the 19 museums used in this study, the amount of text-based content from Washington is approximately equivalent to that of all 14 Californian institutions that were included. Consequently, Washington is well represented in this research.

Washington had, by far, the largest representation of the Soviet Union and Russia (see Figure 46). In this museum, 26.5 percent of exhibition content used cultural terms associated with Russia and Russian technology, compared to 19.7 percent in Oregon, 13.3 percent in Northern California, and 4.6 percent in Southern California. This represents a trend in which there is lower inclusion of Russian content in Southern California with increased inclusion the further one travels north. At 9.1 percent, Washington's content on spacefaring nations other than the two Cold War-era space powers is only slightly lower than the use of similar content in Oregon. Unlike elsewhere, Washington has virtually no narratives on societies which predated the development of spaceflight.

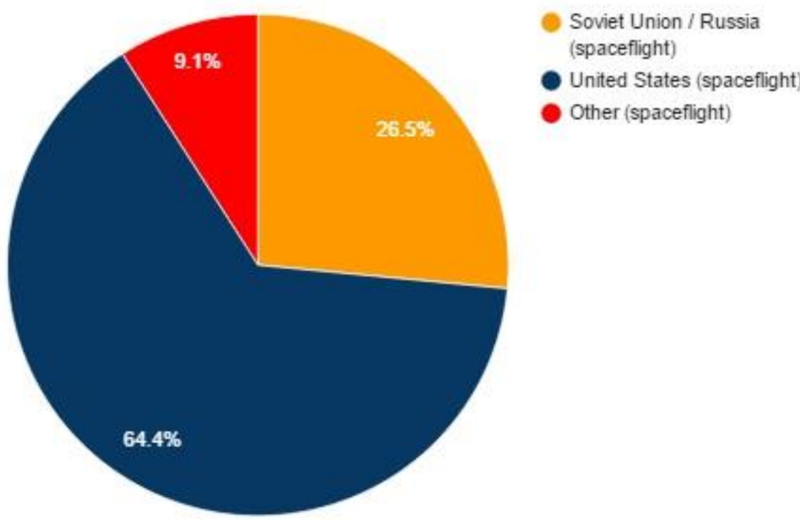

Figure 46. Exhibit panel and label text distribution of States, societies, and cultures at museums in Washington. Pie chart by the author, 2015.

At 59.9 percent, British Columbia had the greatest distribution of text on states, societies, and cultures other than the United States and Russia (see Figure 47). As was the case with California, Oregon, and Washington's extensive use of content on United States history, British Columbia heavily integrated their own domestic history into their exhibit panels and labels. Yet text-based content on Canadian history only appeared at a slightly higher frequency than did content on the United States. In part, this is an issue of necessity; all of the Canadian Space Agency's nine astronauts achieved spaceflight aboard a U.S. Space Shuttle, making it impossible to fully discuss Canadian space history without some discussion of U.S. technology. However, despite that CSA astronauts Chris Hadfield (2013: 34) and Bob Thirsk (Melady 2009: 211) later flew aboard Russian Soyuz spacecraft, only 6 percent of the culturally affiliated terms within British Columbian exhibit panels and labels mention content related to Russia.

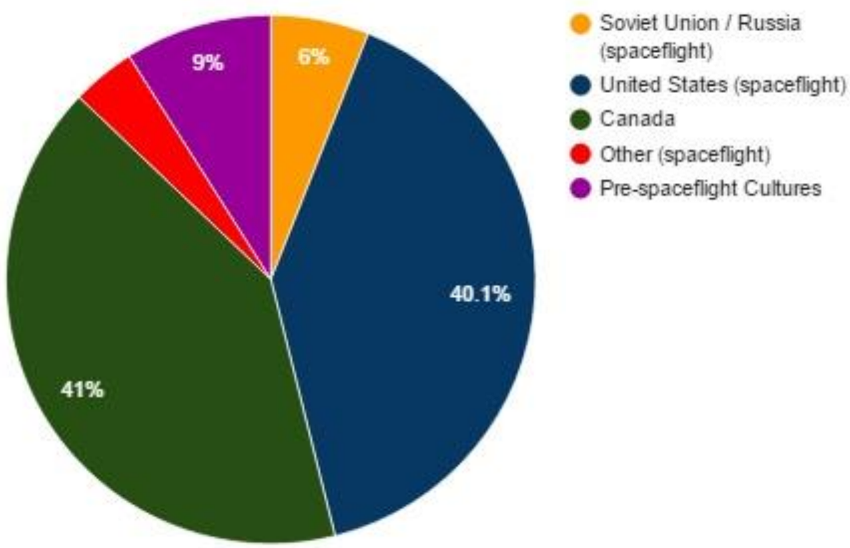

Figure 47. Exhibit panel and label text distribution of States, societies and cultures at museums in British Columbia, Canada. Pie graph by the author, 2015.

Returning to the three hypotheses that were posed before the research phase of this thesis began, the first hypothesis does appear correct. That is, it was proposed that the narratives used in museums of the West Coast will have more exhibit content on domestic achievements and events than on foreign ones. The result of running exhibit panel and label texts through IBM SPSS Modeler demonstrates that space museums in California, Oregon, and Washington do prioritize exposing visitors to national accomplishments in spaceflight. In this respect, Washington has the greatest balance of any West Coast region when it comes to including foreign narratives, devoting only 64.4 percent of culturally affiliated terms appearing in exhibit panels and labels to domestic interests. Whereas Southern Californian museums show the highest propensity to prioritizing domestic interests, devoting 84.6 percent of culturally affiliated terms to domestic interests. British Columbia also shows a tendency to choose domestic exhibit content over foreign content, although content on Canada and the United States is split almost evenly.

The second hypothesis was posed to consider the possibility that museums of the West Coast will almost exclusively choose exhibit content on the two Cold War-era space powers, the United States and Russia, while almost entirely neglecting the cultural histories of other nations. The results invalidate this hypothesis, showing instead that representation appears to vary regionally. Unsurprisingly, museum content in British Columbia discusses more than just the United States and Russia, and uses considerable exhibit space to glorify the activities of the Canadian Space Agency. Additionally, 9 percent of cultural terms were marked as representing societies predating the development of spaceflight. However, over half of these terms relate to some discussion of the eighteenth-century United States ship *Columbia Rediviva* after which the province British Columbia (Hayes 1967: 100) and the U.S. *Columbia* space shuttle were named (West and Kling 1989: 46). As for British Columbia's exhibit representation of spacefaring nations other than Canada, the United States, and Russia, only 3.9 percent of their culturally affiliated exhibit terms were related to States other than these three nations.

Overall, West Coast museums had a 10.3 percent inclusion of information on nations other than the United States and Russia. Had the second hypothesis been correct, this figure should have been significantly lower. Although 10.3 percent does indicate that some under-representation of foreign nations occurs, especially when taking into account the similarly low percentage of representing Russia, it also proves that exhibit designers at West Coast space museums do not, collectively, disregard the notion of including narratives on foreign cultures. Merely that exhibit designers and curators consider these narratives as being of secondary or tertiary importance to using informational panels to describe domestic history in addition to the science of space exploration.

In further regard to the second hypothesis, a closer examination of West Coast museums' cultural content shows that, when terms related to the United States and Russia are excluded, narratives on Europe or European nations dominate (see Figure 48). These include text-based discussions of the European Space Agency and its projects, as well as national space efforts like France's National Center for Space Studies (French *Centre National D'études Spatiales*) and historical narratives on the development of spaceflight in places like Germany. Canada has the second largest representation after Europe, and the largest overall representation of any individual nation other than the United States and Russia. This is due, in part, to the abundance of content on Canadian space history at museums in British Columbia, and also because of the inclusion of content on Canada at museums in Oregon and Washington.

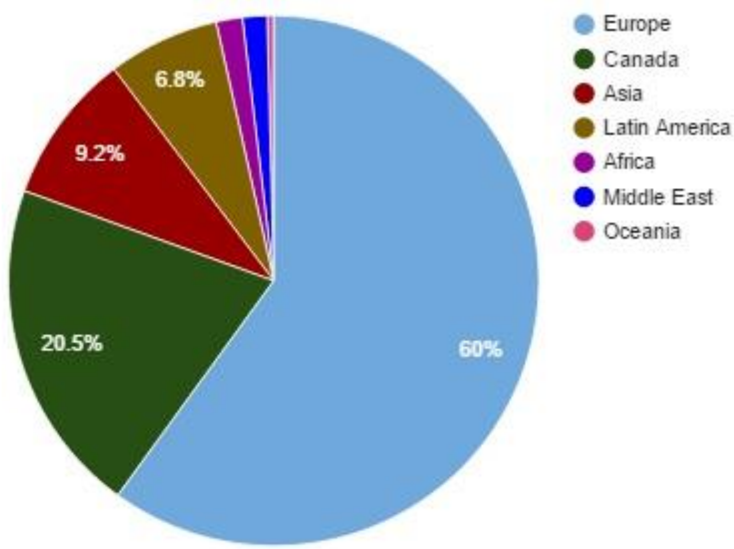

Figure 48. Overall West Coast exhibit panel and label text distribution of spacefaring geographic regions when excluding the United States, the Soviet Union, and modern Russia. Pie graph by the author, 2015.

The third hypothesis posed by this thesis was an extension of the second hypothesis. It was put forward to explore the possibility that when West Coast space museums incorporate cultural content on nations other than the United States and Russia, such narratives will generally only present on ancient societies rather than modern spacefaring nations. The analysis of thousands of museum panels and labels indicates the opposite to be true. Not only are the space industries of foreign societies other than Russia discussed, but ancient societies are only rarely touched upon within space museum exhibitions. Of all the culturally affiliated terms that were identified across exhibit text-based content, only 3 percent discussed history and prehistory prior to the development of spaceflight. A few exceptions, such as the Chabot Space and Science Center, put greater effort toward incorporating societal cosmologies beyond strict discussions of twentieth and twenty-first century technological history, but the majority of museums made sparse or no discussion of such topics.

With the first hypothesis confirmed and the second and third refuted, it does appear that many exhibit designers seek to integrate foreign cultural histories into their museum exhibitions. However, when this does occur it is rarely intended as the focal point of informational panels and labels. Instead, such narratives are usually added as part of overall discussions on American space history, with foreign cultural histories discussed only to give these stories greater depth. This is indicative of one of the limitations of using data in this way. Nearly a third of the culturally affiliated terms within exhibit texts at West Coast space museums relate to cultures and industries other than those of the contemporary United States, but though looking at the data strictly in terms of frequencies is useful for producing quantifiable data and greater analytical objectivity, it also has the consequence of neglecting context. Outside of the exhibit content on Canadian history and interests at space museums in British Columbia, very few museums made exhibits available to visitors which purely discuss other national histories in space exploration without inevitably tying them to American history.

Survey Results

Scope posed a major limitation to this study, which had to be confined to only investigating museums of the West Coast due to budgetary constraints that prevented the inclusion of more geographically dispersed institutions. Time was also a major limitation in terms of when the exhibitions were analyzed. Museum exhibits are ever changing, and it is possible that current trends do not perfectly reflect exhibit content of the past, nor will they perfectly reflect content in the future. Surveys were distributed to space museums across the United States and Canada as an amelioration of some of these issues, and to gain some insight into how museum directors, curators, and exhibit designers consider content on foreign states, societies, and cultures. The full survey results are included in Appendices E and F.

In total, 244 surveys were distributed across 109 institutions. A total of 121 individuals took the survey, though less completed the survey in its entirety. Because respondents had been given the option to skip past questions or submit their survey answers without reaching the survey's end, the completeness of surveys varied between respondents. Of the 121 people that did partake in the survey, only 90 opted to identify their place of employment. Staff from at least 69 distinct institutions partook in the survey, though this number is likely higher given that survey-takers were allowed the option to opt out of identifying their place of work.

All 121 survey takers identified their state, territory, or province. California was disproportionately represented, with 14 survey-takers making up 11 percent of the total respondents. Washington was also well represented via seven respondents, whereas only two survey-takers identified their institution's location as Oregon. Only five respondents marked their institution as being in Canada, none of which included British Columbia. Of these, only three Canadian respondents filled out the survey in its entirety. Thus, respondents at museums of the West Coast account for 19 percent of the total survey-takers, with no representation from British Columbia, and only 4 percent of the surveys represent Canada, with this value lowered when taking the incomplete surveys into account.

Additionally, 17 individuals responded from museums located in other parts of the Western United States, including from Alaska, Arizona, Colorado, New Mexico, and Utah. There were also 17 respondents from museums located in the Midwestern United States, including from Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, Ohio, and Wisconsin. Surveys taken at museums in the Northeastern United States included respondents from Maryland, Massachusetts, New Jersey, New York, and Pennsylvania. A further 37 respondents from museums in the Southern United States also took the survey, which included institutions in Alabama, District of Columbia, Florida, Georgia, Kentucky, Louisiana, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. Thus, survey respondents represented 32 US states plus the District of Columbia.

One of the advantages of having multiple people take the survey at a single institution, rather than request that only one survey be submitted per institution, is that it increases the likelihood of the surveys being filled out. It also allows for survey results to be compared between staff at the same institution. For example, two respondents identified their place of work as Griffith Observatory in Los Angeles, and their results were mostly identical. There were some notable differences, however. When asked, "Using your best judgment, what is the approximate size of your institution in terms of budget, staff size, square footage, etc?," one staff member marked "Large" whereas the other marked "Medium."

By contrast, all staff at the Smithsonian National Air and Space Museum marked "Large." The variation of this response is due, in part, to the inexactness of the question, which was posed to acquire a rough idea of how museum content might relate to the approximate scale of the institution. The varied answers to the question are also a reminder that each respondent possesses subjective perspectives on their place of work, and therefore quantitative results should not be regarded as inherently objective.

It should be noted that variation between survey responses, coupled with the option for anonymity, posed some limitations to this study. Firstly, some institutions may have been represented multiple times, but because of the anonymity option, it is not possible to assess which institutions are overrepresented. That is, of the 31 respondents that opted out of identifying their place of work, it is probable that at least some of them are co-workers with respondents that did identify their place of employment in their surveys. Because of this, the resulting over-representation means that any quantitative analysis of the aggregated data may be erroneously skewed.

Secondly, even if it were possible to assess which institutions are overrepresented, and by how much, there is no objective means of removing overrepresented institutions from the data. Overrepresented surveys cannot simply be thrown out to create even survey numbers between institutions. This is because surveys taken by multiple staff members at the same institution are not, in most cases, perfectly identical; subjective variation occurred between respondents based on different possible factors that influenced their survey results, such as their occupational experience at the institution, their time working there, the amount of thought and time they chose to put into the survey, their unique world view, and so on.

Being mindful of these problems, it is still worthwhile to consider the implications of the survey results. Ninety-two respondents answered the question, “Planetarium shows at your institution currently discuss, or have previously discussed, the astronomy of which ancient cultures? (Please select all that apply).” This yielded an interesting find: 53 respondents selected “Native North Americans,” marking that group as the most widespread cultural topic at planetariums. Even if this value was inflated by multiple respondents selecting “Native North Americans” at the same institution, the implication is unchanged: indigenous groups are a widespread planetarium topic. When looking at individual survey answers, it is apparent that those marking “Native North Americans” were geographically disperse, with these respondents representing planetariums in twenty-eight different U.S. states and two Canadian provinces

Nearly 60 percent of survey-takers stated that their planetarium shows, past or present, have had at least some discussion on Native North American cosmology. A further 40 percent stated that Native North American cosmology has been included in exhibits at their institution (see Figure 49). Content on ancient Greece was only slightly less common at planetariums, and 29 percent of survey-takers included ancient Greece among the societies which have been represented within exhibits at their museum. Egyptian, Roman, Mayan, Aztec, and European megalithic cultures were also common subjects. This data further suggests that the low levels of content on pre-spaceflight cosmologies that were observed at institutions of the West Coast may not necessarily be representative of space museum content elsewhere.

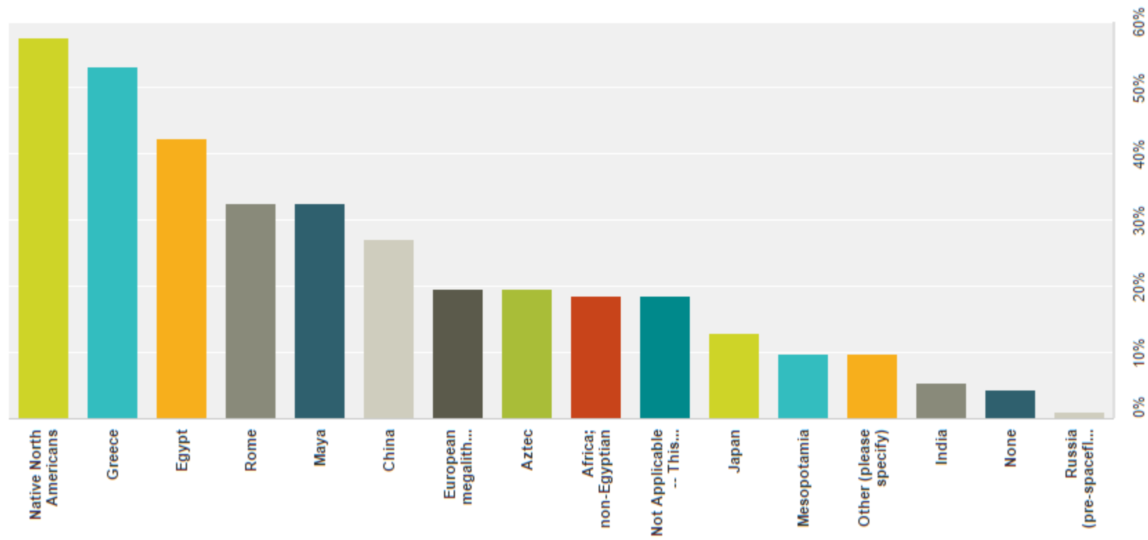

Figure 49. Survey results on ancient cultures discussed by planetariums. “Native North Americans” was the most selected topic. Chart by SurveyMonkey, 2016.

When asked about the prevalence of content on ancient cultures within exhibits, “Native North Americans” and “Greece” were similarly common selections (see Figure 50). What these survey results do not convey, however, is the extent at which these cultures are discussed, nor the quality of these discussions. For example, respondents from Griffith Observatory marked that their institution has exhibit content on “Native North Americans.” While this is true, a visit to Griffith reveals that it only has a diorama devoted to this topic, with the diorama about the size of a computer monitor and a narrative that does not go into much depth. Thus, the respondents are correct into their response, and such representations of Native Americans in this manner does signify an interesting topic that can be explored by later research, but it does reveal another area wherein survey results can be misleading. A visitor to the *Tales of the Maya Skies* exhibition at Griffith Observatory will have far more exposure to the topic of Mayan cosmology than a visitor to a museum that only mentions the Maya once or twice, but this is indistinguishable when look at the survey results.

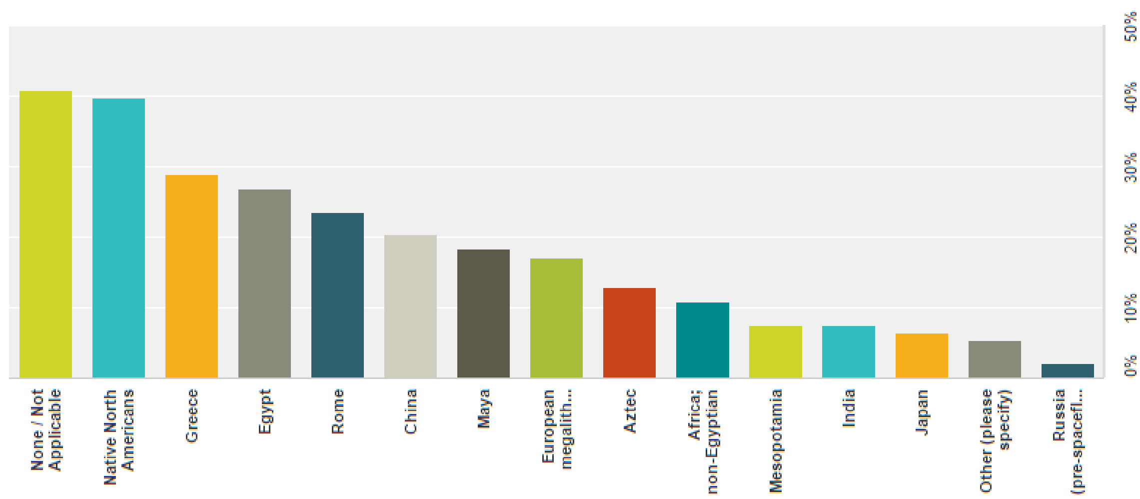

Figure 50. Survey results on ancient cultures discussed in space museum exhibits. Chart by SurveyMonkey, 2016.

The prevalence of Native North American planetarium and exhibit content at Canadian and U.S. museums also brings up ethical questions. It must be admitted that referring to indigenous people as “ancient culture” is a shortcoming of the survey questions. Although many of these cultures are indeed ancient, many of the groups listed exist contemporarily, as do their cultural practices. Because the survey only used the term "ancient" to refer to these societies, it is not possible to assess whether these cultural groups are recognized within the exhibits as having active modern communities, or if planetariums and exhibit content present them in such a way as to imply that they no longer exist. As stated by socioanthropologist John R. Sosa (1988: 131), traditional Maya cosmology remains "Every bit as important, vibrant and essential for life as [it was for] their ancestors." Unfortunately, this is not always conveyed by exhibit content on the Maya and other sociocultural groups.

Most survey-takers at institutions with planetariums expressed a moderate to high turnover rate for planetarium show content (see Figure 51). The range of responses for turnover on exhibit content was comparatively more varied, with 20 percent responding that exhibits and exhibitions are "often" switched out at their institutions, 47 percent responding "sometimes," and 29 percent responding "rarely" (see Figure 52). These responses demonstrate that museums are generally not static, but change in content over time, and may thus also change overtime in terms of the cultural narratives that are incorporated into exhibits and exhibitions. This is an important consideration, especially when considering the research results on West Coast museums that were considered in this thesis. The distribution of textualized content on cultures are likely to change in California, Oregon, Washington, and British Columbia due to exhibit turnover in the future. Similarly, distribution of content in the present may not represent past distributions.

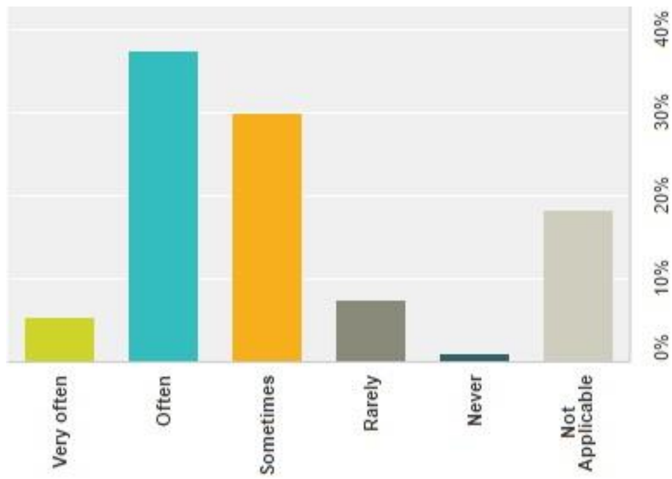

Figure 51. Survey results showing the frequency at which planetariums add shows with new content. Chart by SurveyMonkey, 2016.

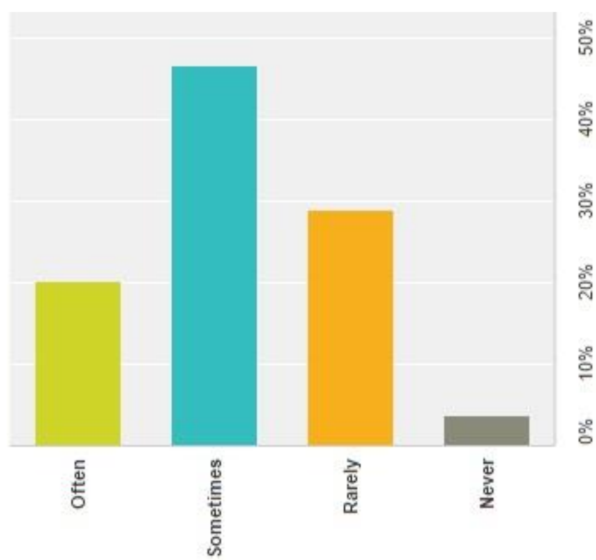

Figure 52. Survey results showing the frequency at which institutions rotate their exhibits and exhibitions. Chart by SurveyMonkey, 2016.

Another consideration was whether exhibit content is designed "in-house" or if that process is generally outsourced. If exhibit panels and labels are outsourced, the responsibility for their content may be attributed to an external organization rather than the museum itself. However, the survey results overwhelmingly showed that at least some of the design process is carried out by the museums rather than an external design firm (see Figure 53). Of the 88 respondents that answered this question, only 3 stated that exhibit design is “never” in-house and 4 stated that it is “rarely” in-house, whereas 20 stated that design work is “sometimes” in-house, 40 that it is “often” in-house, and 21 that it is “always” in-house.

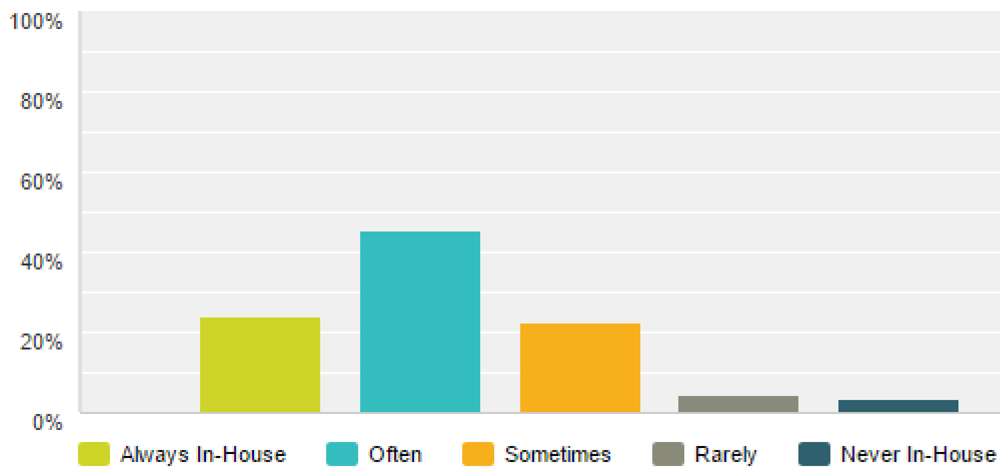

Figure 53. Survey results showing that exhibit design ranges from “sometimes” to “always” happening in-house. Chart by SurveyMonkey, 2016.

Respondents were also asked whether, when designing new exhibits, their institutions place greater focus on designing exhibits that use objects already in their collection rather than exhibits which require acquiring new collections. For a museum that is dependent on its existing collections when making the decision to expand their exhibits, they are unlikely to create an exhibit on a topic such as foreign space agencies unless they already possess relevant objects. Given that many museums are becoming less object-oriented (Conn 2010: 22), exhibit designers at institutions that are less bound by their collections should have less reservations about creating new exhibits such as on foreign space agencies regardless of whether they possess relevant collections.

The survey results showed that approximately 11 percent of respondents felt their institutions are always reliant on their existing collections, 47 percent that they often rely on existing collections, 32 percent that they are sometimes reliant, and 8 percent that they are rarely reliant (see Figure 54). This shows that there is some variation in this respect between space museums, and indicated that some space museums may be less inclined to create content on foreign states, societies, and cultures unless the museum already has collections pertaining to those groups. Thus said, many seemingly "American" or "Russian" space artifacts do have historic connections to foreign cultures, such as to that of Nazi Germany (Neufeld 2012), so these results are not enough to fully explain why some institutions choose not to discuss societies other than the United States and Russia.

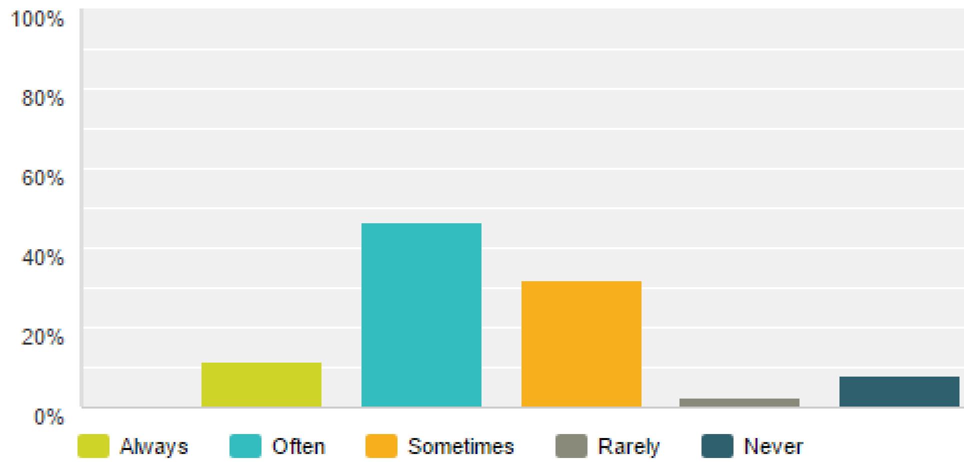

Figure 54. Survey results for a question asking whether, when designing new exhibits, the institution places greater focus on designing exhibits that use objects already in the institution's collection rather than exhibits which require acquiring new collections. Chart by SurveyMonkey, 2016.

When asked, "The institution has experience acquiring or being loaned objects from which of the following government space agencies," six respondents selected the Canadian Space Agency (CSA), nine selected the European Space Agency (ESA), 60 respondents selected NASA, and 10 respondents selected "Russian Federal Space Agency / Roscosmos (RKA/FKA)." All other foreign space agencies were never selected or were selected only once. Asked the same question for domestic agencies, the survey results showed that many of the institutions had experience acquiring loans from domestic space agencies (see Figure 55). Thus, the inexperience of many institutions with acquiring loans from foreign space agencies may be a partial explanation for the infrequency of such exhibit content at some space museums.

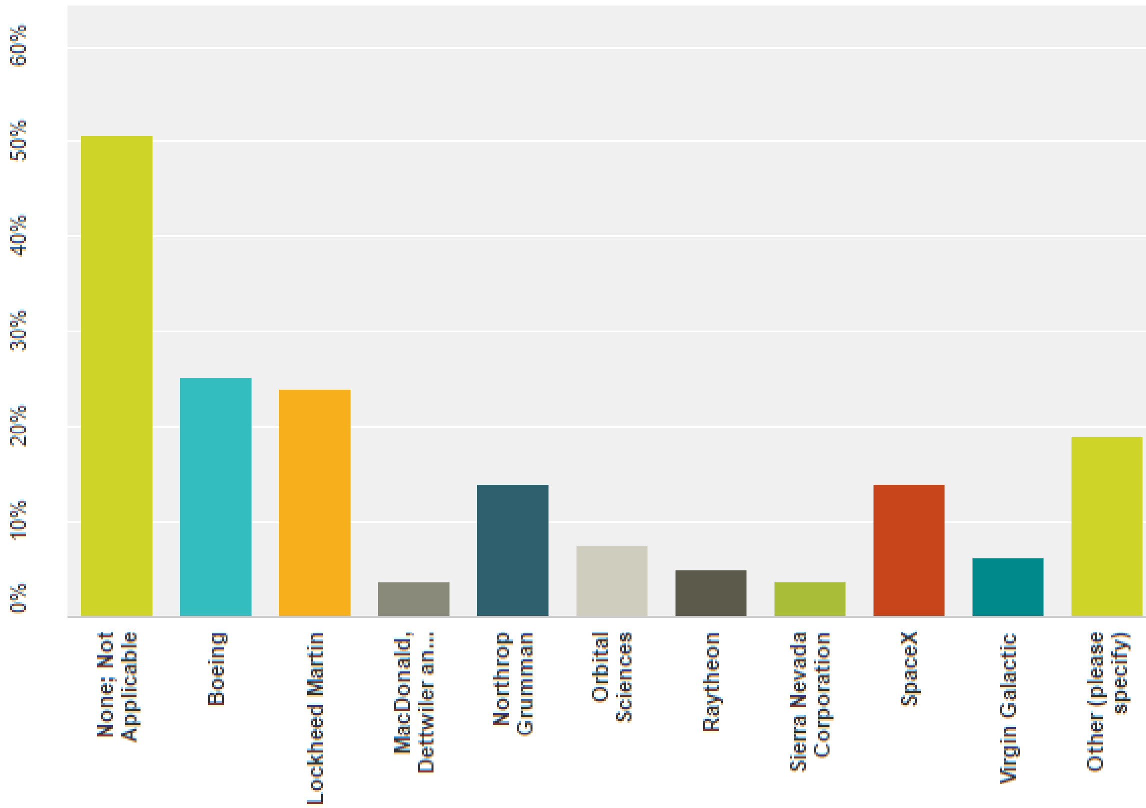

Figure 55. Survey results after being asked to select which major domestic space agencies the institution has loan-acquisition experience with. Chart by SurveyMonkey, 2016.

Asked whether the institution would consider creating future exhibit content on foreign space agencies even without relevant objects in its collection, 63 percent of respondents marked "yes." In a follow-up question, 73 percent stated their institution would be interested in working with foreign space agencies to acquire or receive loaned objects in the future. Furthermore, 65 percent stated their institution would consider creating exhibit content on non-Russian, non-American space agencies in the future. Many of the respondents that marked “no” to this latter question also replied with valid reasons for their response, such as not wanting to stray too far from their museum's purpose of discussing local history, or because the museum already has space limitations.

For the most part, the survey results do show a widespread and overall interest in having more culturally inclusive exhibit content. The reason that a given space museums does not have exhibit content on foreign states, societies, and cultures should be considered on a case-by-case basis, and is best examined through a case study at that particular institution. These survey results, when considered in conjunction with the Chabot case study and West Coast field research discussed within this thesis, indicates that there are likely multiple reasons that cultural representation varies between institutions in terms of their exhibit narratives. For some institutions, doing so might conflict with the scope of their mission statement, whereas for others, it may have simply been an oversight. Nonetheless, the survey results suggest that many space museums are likely to be receptive to the idea of greater inclusion as they proceed with designing new exhibit content in the future.

CHAPTER VII

CONCLUSION

The narratives conveyed through exhibit panels and labels at West Coast space museums generally favor discussions of domestic achievements over discussions of foreign ones. Exhibits do contain content on space agencies and cultures belonging to nations other than the two Cold War powers—the United States and Soviet Russia—but such discussions are limited. Space museums also present content on other sociocultural groups, such as Native North Americans and the Maya, but content on non-spacefaring societies are generally presented within planetarium shows rather than exhibit texts. The relative infrequency of diverse exhibit narratives about foreign states, societies, and cultures is demonstrative of a widespread oversight in exhibit design. By drawing upon the wealth of historical information on how other peoples have engaged with the cosmos, future space museums can create exhibits that have richer, more inclusive, and more balanced accounts of space history.

Through researching a variety of academic and literary sources, I have provided examples of some of the socio-historic events that content creators can consider when designing new exhibits. Roughly 20 percent of astronauts have come from nations other than the United States and Russia. Space agencies in Europe, China, Japan, and Canada have played very active roles in space exploration, and emerging space powers such as India, Israel, and South Korea are equally worthy of attention, especially when the intrigue of each nation's unique, culturally-driven endeavor into space exploration is considered. Yet exhibit content on such histories are generally superficial. Even for exhibits intended to focus exclusively on the U.S. or Russian space programs, there exists considerable room for related discussions of other nations, particularly in terms of new museum theory, which advocates an inclusive exhibit planning process.

I have also traced the origins of space museums, from their antecedents in the sixteenth-century, wherein museums of natural history were private collections made available mostly for noblemen, to the West Coast space museums of today, most of which were founded throughout the twentieth-century. By using multiple methods to examine these museums in the twentieth-first century, including a case study at the Chabot Space and Science Center, field research at 18 other West Coast space museums, the data mining of exhibits and labels, and through the distribution of surveys, I have demonstrated the marginalized but meaningful role of exhibit narratives on multinational engagements with the cosmos. Through this, I contribute to the burgeoning subfield of using an anthropological approach to consider topics on space science and exploration, while also showing that theory established within museum studies and anthropology can be used to examine modern space museums. In this, my intention is not that this thesis will be the definitive investigation into this subject, but that it will instead serve as a starting point from which other research projects can emerge.

Contributions

For the most part, historians have been the ones to assess the sociocultural aspects of space exploration. The drawback is that such research is only carried out long after events have passed, leaving historians to rely on technical documents and superficial journalism to piece together the socially-motivated context through which the events transpired. Anthropologists are uniquely qualified to investigate the socially nuanced aspects of contemporary space culture as they happen. Using the Boasian four-field approach, anthropologists are well equipped to consider topics such as the biological content of astronautic research, the linguistic aspects of international space agencies, the artifact-oriented components of space exploration, and, of course, both historical and contemporaneous cultures. Space museums are a medium through which all these areas merge, and my research advances this fledgling topic by anthropologically studying multiple aspects of space museums.

Only a few publications have considered the historical development of space museums, and those that do typically only do so as a tangential point rather than as a primary point of discussion. I have added to the otherwise sparse literature on the history of space museums by using early to mid-twentieth-century science publications, news articles, and magazines to demonstrate the historic significance of West Coast space museums. Additionally, my research expands on museum studies by exploring the potential that data mining has for critically examining modern museum texts and labels. Because of the relative newness of using anthropology to study space-related topics, and the infrequency of publications that consider space museums other than the Smithsonian’s National Air and Space Museum, the biggest contribution of my research is showing that space museums are a viable and fruitful topic for future researchers to consider.

Future Research

The dearth of anthropological research on the cultural histories of space exploration is unfortunate, but also means that there are plentiful areas for future researchers to delve into. I chose to focus on space museums after noticing that the topic is disappointingly understudied despite that museums are a popular medium for public learning. Given that cultural inclusion has been a trending topic in museum studies, I decided to further narrow my research to investigating how West Coast space museums handle representing foreign nations within their exhibit panels and labels. Though narrowing the scope allowed me to explore this topic at greater depth, I was only able to consider other topics in moderation. My hope is that future researchers will take interest in these limitations and expand on my research with related investigations of their own.

The two greatest limitations of my thesis were temporal and geographical. Budgetary constraints made it difficult for me to expand the scope of my research beyond the West Coast of the United States. To ameliorate this, I briefly discussed foreign space museums in the literature review chapter, and contacted other museums in the United States and Canada by means of survey. However, far more would be gained by directly assessing panels and labels at museums outside the West Coast. It would also be worthwhile to visit space museums on other continents to see if their respective nations predominantly include exhibit content on domestic accomplishments in space, or if they balance out their exhibits with content on foreign space programs.

Regarding the temporal limitation of this study, it would also be useful to revisit West Coast museums in the future for comparison. The permanency of museum exhibits varies, with some undergoing regular turnover, while others may not change over the course of a decade or longer. For example, during my internship at the Chabot Space and Science Center, the exhibition design staff were considering reducing the size of its *Beyond Blastoff* exhibition of cosmonautic artifacts, which had otherwise undergone little change over the past decade. Had I conducted my research before or after the installment of *Beyond Blastoff*, my research results for the Chabot would have differed. Because of the impermanence of most exhibits, it would be interesting to conduct this research again at multiple intervals in the future to observe how cultural representation at West Coast space museums changes over time.

As for cultural representation, I chose to focus mostly on social groups defined by some form of nationality. However, it would be equally viable to conduct the same study on space museum representations of other groups, such as how space exhibit panels and labels represent ethnic minorities, or the extent at exhibits include content on women. The same could be done for less well-defined subjects of multicultural relevance, such as science fiction. As I discussed to a moderate extent in the literature review, science fiction greatly influenced the development of spaceflight. Unsurprisingly, science fiction is also a topic found within some museum exhibits, and because some of the most popular writers, such as Jules Verne and H.G. Wells, were not from the United States, there is room to research how the socio-historical context of their writing affected their stories and, in turn, affected developments in spaceflight and content within space museums.

Originally, I had also intended to include a section on representations of indigenous peoples. Several West Coast space museums include small exhibits on Native American astronomy. For example, Griffith Observatory in Southern California has a small diorama titled “California Indian Horizon Calendar.” Further, many planetariums present shows with cultural and archaeoastronomical subject matter on indigenous people, which I was only able to address briefly. Given the sensitive nature of discussing indigenous cultures, I tried to find an experienced consultant to guide me in avoiding some of the pitfalls of writing about underrepresented peoples. Unfortunately, this did not happen, and I chose to save this topic for a later research endeavor. Both anthropology and history museums have improved by undergoing some scrutiny of their content on indigenous peoples, and I hope that future researchers will similarly consider the content of space museums.

It would also be useful to expand on the history and role of planetariums. During the research process, I sifted through some early twentieth-century documents to understand the origins and development of planetariums, some of which I included in the literature review. There is far more to be said, however. Planetariums have thus far been inadequately researched from a socio-historical perspective. Even fewer studies have considered how planetariums facilitate knowledge of cultural histories, or their role within increasingly multicultural communities.

Although I did not include a study on visitor perspectives in this thesis, visitor studies would also be a good area for future research. Museum visitors arrive with a range of demographic differences and varying perspective that influence their museum-going experience. Such differences can also affect their interpretations of exhibit content and what information they retain (Falk et al. 2006: 821-829). It would be interesting to research this topic within the context of space museums. At what extent do visitors understand various cultural cosmologies, how do such perspectives vary by demographics, and at what extent are visitors influenced by space museums after a visit? Do most visitors arrive with an awareness that efforts in space exploration are multinational, and how do various space museums affect these understandings? These questions, and others like them, might best be answered through directly surveying and interviewing visitors.

Moving beyond a museum studies focus, there exists tremendous room for anthropological research on spacefaring societies. Most of the English language literature on space history has been written about the United States and, to a lesser but still conspicuous extent, the Soviet Union and Russia. The scarce literature on foreign space programs, especially those outside of Europe, rarely delve into thoughtful discussions on the relationship between a foreign nation's space program and its culture. Instead, literature on international efforts in space exploration are most often written with an engineering perspective—they predominantly focus on technical attributes of space programs, without much association to socio-historical contexts. By using an anthropological approach, future researchers can further develop an understanding of international space agencies by considering the interplay between human biology, language, sociocultural perspectives and trends, and material culture.

REFERENCES CITED

Adam, Thomas Ritchie
1939 *The Museum and Popular Culture*. New York: American Association for Adult Education.

Adams, John Quincy
1825 First Annual Message. Washington, D.C.: National Archives.

Adams, Richard N.
1989 The Conquest Tradition of Mesoamerica. *Americas* 46(2): 119-136.

Aitken, Robert G.
1919 The 20-inch Telescope for The Chabot Observatory. *Publications of the Astronomical Society of the Pacific* 26(152): 53-54.

Aitken, Robert G.
1919 The New Chabot Observatory. *Publications of the Astronomical Society of the Pacific* 31(181): 198-199.

Angier, Natalie, Jerry Hannifin, and John Kohan
1985 Guten Tag, Houston Control! *Time* 126(20): 94.

Anselmo, Joseph
1998 Space Cadets. *Aviation Week & Space Technology* 149(2): 21.

Anyfandi, Glykeria, Vasilis Koulaidis, and Kostas Dimopoulos
2014 A Socio-Semiotic Framework for the Analysis of Exhibits in a Science Museum. *Semiotica* 2014(200): p229-254

Argerich, Luis
2011 *Meteor at the Pleiades*. 11/27/2011. Flickr. Accessed 10/18/2015. https://www.flickr.com/photos/lrargerich/6521870167

Arny, Thomas
2004 *Explorations: An Introduction to Astronomy.* New York City: McGraw-Hill.

Aron, Jacob
2016 Off to Sniff Out Life on Mars: Europe's ExoMars Trace Gas Orbiter. *New Scientist* 229(3064): 10.

Astor, J.L.
2002 Activities Relating to Space Technology. *Acta Astronautica* 50(2): 75-77.

Atkins, Leslie, Lisanne Velez, David Goudy, and Kevin Dunbar
2010 The Unintended Effects of Interactive Objects and Labels in the Science Museum. *Science Education* 93(1): 161-184.

Aubin, David
2003 The Fading Star of the Paris Observatory in the Nineteenth Century: Astronomer's Urban Culture of Circulation and Observation. *Osiris* 18(2): 79-100.

Aubin, David Charlotte Bigg, H. Otto Sibum
2010 *The Heavens on Earth: Observatories and Astronomy in the Nineteenth Century.* Durham: Duke University Press.

Aveni, Anthony F., Sharon L. Gibbs, and Horst Hartung
1975 The Caracol Tower at Chichen Itza: An Ancient Astronomical Observatory? *Science* 188(4192): 977-985.

Aviation Week & Space Technology
1959 Soviets Hoped to Impact Mechta on Moon. *Aviation Week & Space Technology* 70: 26-29.

Bainbridge, William Sims
1983 *The Spaceflight Revolution: A Sociological Study.* Malabar: Robert E. Krieger Publishing Company.

Bakare, B.I., E.V. Odu, and T. Ngeri
2016 Satellite Communication in Nigera: Prospects and Challenges. *American Journal of Engineering Research* 5(11): 104-109.

Balloffet, Pierre, François H. Courvoisier, and Joëlle Lagier
2014 From Museum to Amusement Park: The Opportunities and Risks of Edutainment. *International Journal of Arts Management* 16(2): 4-18.

Banks, Henry S.
1995 Museum Traces History of Flight. *Air Force Times* 55(32): 38.

Baraga, Victoria
2013 Mythical Language in Mayan Epic Popol Vuh. *Studii de Stiinta si Cultura 9(2): 99-107.*

Barnum's American Museum
1860 *An Illustrated Catalogue and Guide Book to Barnum's American Museum.* New York: Published by the Proprietor.

Bauer, Bruce
1995 *The Sextant Handbook: Adjustment, Repair, Use and History.* Camden: International Marine.

BBC
2017 North Korea Agency Carries Kim Remarks on ICBM "Gift" to U.S. *BBC Monitoring Asia Pacific* 5 July 2017.

Beaujot, Ariel
2015 Balade Blanche: Putting New Museum Theory into Practice. *Curator: The Museum Journal* 58(1): 17-26.

Begley, Sharon, and Ginny Carroll
1996 Lucid's Long Road Home. *Newsweek* 128(14): 68.

Belcher, Nancy Hoyt
2002 California's Carrier. *American History* 37(2): 12-14.

Bell, Trudy E.
2011 The Great Telescope Race: In the 19th Century, the United States Transformed Itself from a Scientific Backwater into an Astronomical Juggernaut. *Sky & Telescope* 121(6): 28.

Bergaust, Erik
1976 *Wernher Von Braun.* District of Columbia: National Space Institute.

Berlo, Janet Catharine
2011 Navajo Cosmoscapes—Up, Down, Within. *American Art* 25(1): 10-13.

Bernardini 2014, F.
2014 Meeting Endeavour. *Spaceflight* 56(3): 102-104.

Bertucci, Paola
2013 Designing the House of Knowledge in Eigteenth-Century Naples: The Ephemeral Museum of Ferdinando Spinelli, Prince of Tarsia. *Cabinets of Experimental Philosophy in Eighteenth-Century Europe.* Giorgio Strano, ed. Cambridge: Cambridge University Press. Leiden: Brill.

Biesbroek, R., and G. Janin
2000 Ways to the Moon? *ESA Bulletin* 103: 92-99.

Blatchford, Ian, and Natalia Sidlina
2015 The Cosmonauts Challenge. *Science Museum Group Journal* 4.

Bošković, Aleksandar
1989 The Meaning of Maya Myths. *Anthropos* 84: 203-212.

Bostwick, Todd W.
2010 Exploring the Frontiers of Hohokam Astronomy: Tracking Seasons and Orienting Ritual Space in the Sonoran Desert. *Archaeoastronomy* 23: 165-189.

Boutsikas, Efrosyni, and Clive Ruggles
2011 Temples, Stars, and Ritual Landscapes: The Potential for Archaeoastronomy in Ancient Greece. *American Journal of Archaeology* 115(1): 55-68.

Bowers, Ken
2004 Moon Pilot. *The Science Fiction Film Reader*. Gregg Rickman, ed. New York City: Proscenium Publishers, Inc.

Braakhuis, Hyacinthus Edwinus Maria
2010 Xbalanque's Marriage: a Commentary on the Q'eqchi' Myth of Sun and Moon. Ph.D. dissertation, Faculty of Social and Behavioral Sciences, Leiden University.

Brady, James E., and Jeremy D. Coltman
2016 Bats and the Camazotz: Correcting a Century of Mistaken Identity. *Latin American Antiquity* 27(2): 227-237.

Bricker, Victoria R., and Harvey M. Bricker
1988 Exploring Some Anthropological Theoretical Foundations for Archaeoastronomy. *World Archaeoastronomy: Selected Papers from the 2nd Oxford International Conference on Archaeoastronomy, Held at Merida, Yucatan, Mexico, 13-17 January 1986*. Anthony F. Aveni, ed. Cambridge: Cambridge University Press.

Brotherston, Gordon
1988 Zodiac Signs, Number Sets, and Astronomical Cycles in Mesoamerica. *World Archaeoastronomy: Selected Papers from the 2nd Oxford International Conference on Archaeoastronomy, Held at Merida, Yucatan, Mexico, 13-17 January 1986*. Anthony F. Aveni, ed. Cambridge: Cambridge University Press.

Brown, Sharon, Laser Sin-David
2007 Diary of an Astronaut: Examination of the Remains of the Late Israeli Astronaut Colonel Ilan Ramon's Crew Notebook Recovered After the Loss of NASA's Space Shuttle *Columbia*. *Journal of Forensic Sciences* 52(3): 731-737.

Brysac, Shareen
2002 Reliving the Nightmare. *Archaeology* 55(3).

Bryan, Amanda
2008 New Museum Theory in Practice: A Case Study of the American Visionary Art Museum and the Representation of Disability. Master’s thesis, Department of Arts and Humanities, Virginia Commonwealth University.

Bryson, Bill
2013 *One Summer: America, 1927*. New York: Anchor Books.

Bugos, Glenn E.
1997 The Aerospace Impetus to Silicon Valley. *Journal of the West* 36(3): 97-104.

Burnsspecial, John F.
1982 French and Soviet Astronauts End 9-Day Mission. *New York Times* July-3: 44.

Burckhalter, Charles
1894a The Chabot Observatory. *Publications of the Astronomical Society of the Pacific* 5(6): 85-88.
1894b Observations of the Transit of Mercury, November 10, 1894, at the Chabot Observatory. *Publications of the Astronomical Society of the Pacific* 6(38): 271-272.

Burgess, Colin, and Chris Dubbs
2007 *Animals in Space: From Research Rockets to the Space Shuttle*. New York: Springer Praxis Books.

Burl, Aubrey
1999 *Great Stone Circles.* New Haven: Yale University Press.

Campbell, M.R., S.R. Mohler, V.A. Harsch, and D. Baisden
2007 Hubertus Strughold: the "Father of Space Medicine". *Aviation, Space, and Environmental Medicine* 78(7): 716-719.

Campion, Nicholas
2012 *Astrology and Cosmology in the World's Religions.* New York City: New York University Press.

Canes, Michlle
2006 O astronauta brasileiro Marcos Pontes fara tres contatos com a Terra. *Jornal do Commercio.*

Carreau, Mark
2015 Roscosmos Picks Kazakh Aydin Aimbetov For ISS Flight. *Aerospace Daily & Defense Report* 252(61): 4.

CAIB
2012 *Columbia Accident Investigation Board Report*. US Independent Agencies and Commissions.

CASM
2017 Toronto International Aerospace. *Canadian Air & Space Museum.* Accessed 4/15/2017. http://www.casmuseum.org/Welcome.html

Caulton, Tim
1998 *Hands-on exhibitions: Managing Interactive Museums and Science Centres*. London: Routledge.

Cendes, Yvette
2011 Visit Southern California's Top Astronomy Sites. *Astronomy* 39(12): 64-67.

Cernan, Eugene, and Don Davis
1999 *The Last Man on the Moon: Astronaut Eugene Cernan and America's Race in Space.* New York: St. Martin's Griffin.

Chang, Yi-Wei
2014 The First Decade of Commercial Space Tourism. *Acta Astronautica* 108: 79-91.

Chant, C.A.
1935 The Story of the Zeiss Planetarium. *Journal of the Royal Astronomical Society of Canada* 29: 143-156.

Chaumier, Serge
2005 "Introduction." *Du musée au parc d'attractions, S. Chaumier, ed. Culture et Musées*. Arles: Actes Sud.
2011 *Expoland: Ce que le parc fait au musée: ambivalence des formes de l'exposition.* Paris: Complicités

Ciotti, Joseph E.
2010 Museums and Planetariums: Bridging the Gap between Hawaiian Culture and Astronomy Through Informal Education--A Case Study. *Forum on Public Policy Online* 2010(2): 1-14.

Clarke, Philip A.
2008 An Overview of Australian Aboriginal Ethnoastronomy. *Archaeoastronomy* 21: 39-58.

Clément, Gilles
2011 *Fundamentals of Space Medicine.* New York City: Springer Publishing.

Clery, Daniel

1993 ERS-1 Gives Europeans New Views of the Oceans. *Science* 260(5115): 1742-1743.

Coggins, Clemency Chase

1988 A New Sun at Chichen Itza. *World Archaeoastronomy: Selected Papers from the 2nd Oxford International Conference on Archaeoastronomy, Held at Merida, Yucatan, Mexico, 13-17 January 1986.* Anthony F. Aveni, ed. Cambridge: Cambridge University Press.

Collins, Mary

2005 Flying High: The Winner of an Out-Of-This-World Race, SpaceShipOne Will Land This Summer at the National Air and Space Museum. *Smithsonian* 36(2): 42.

Conn, Steven

1998 *Museums and American Intellectual Life, 1876-1926.* Chicago: University of Chicago Press.

2010 *Do Museums Still Need Objects?* Philadelphia: University of Pennsylvania Press.

Coppinger, Rob

2007 Last call for NASA's Shuttle. *Flight International* 172(5112): 33.

2008 Japan Has High Hopes for Kibo. Flight International 173(5143): 27.

Cornell, James

1981 *The First Stargazers: An Introduction to the Origins of Astronomy*. New York City: Charles Scribner’s Sons Publishing.

Covault, Craig

1992 Mir Cosmonauts Prepare for Reentry as NASA Holds Soyuz Talks in Moscow. *Aviation Week & Space Technology* 136(12): 24.

1995 ESA begins EuroMir science operations. *Aviation Week & Space Technology* 143(11): 30.

1997 New Shuttle, Soyuz Crews Work Diverse Flight Plans. *Aviation Week & Space Technology* 147(6): 30.

1998 New Russian / French Flight Launched to Mir. *Aviation Week & Space Technology* 148(5): 26.

2002 ISS Tourist Launch Set as Astronauts Depart. Aviation *Week & Space Technology* 156(16): 26.

Covault, Craig, and Pierre Sparaco

1996 French Astronaut Joins Russian/U.S. Mir Crew. Aviation Week & Space Technology 145(9): 69.

Crawford, Russell Tracy
1915 Astronomy of the Pacific Coast. *Popular Science* 86(15): 209-222.

Crouch, Tom D.
2007 Aerospace Museums: A Question of Balance. *Curator* 50(1): 19-32.

Cunningham, Clifford J.
2005 The First Planetarium. *Mercury* 34(5): 10.

Curry, Andrew
2001 The King of Humbug. *U.S. News & World Report* 131(9): 48.

Dahm, Maria R., Lynda Yates, Kathryn Ogden, Kim Rooney, Brooke Sheldon
2015 Enhancing International Medical Graduates' Communication: the Contribution of Applied Linguistics. *Medical Education* 49(8): 828-837.

Darrin, M. Ann Garrison
2015 *The Impact of the Space Environment on Material Remains. In Archaeology and Heritage of the Human Movement into Space.* P.J. Capelotti and Beth Laura O'Leary, eds. New York City: Springer Publishing.

Dasch, E. Julius
2005 *A Dictionary of Space Exploration*. Oxford: Oxford University Press.

Davies, Alan
2007 *Introduction to Applied Linguistics: From Practice to Study.* Edinburgh: Edinburgh University Press.

DeAlba, Victoria
2014 Splashdown 45. *Wings of Gold* 39(2): 38-39.

DeGroot, Gerard J.
2007 Sputnik 1957. *American History* 42(5): 34-39.

DeVorkin, David H., and Michael J. Neufeld
2011 Space Artifact or Nazi Weapon? Displaying the Smithsonian's V-2 missile, 1976–2011. *Beyond the Limits of Latitude: Reappraising the Race to the South Pole.* Endeavour: 35(4):187-195

Dickinson, Terence, and Timothy Ferris
2006 *Nightwatch: A Practical Guide to Viewing the Universe.* Ontario: Firefly Books.

Dickman, Steven, and Peter Coles
1989 Cap on German Space Budget (European Space Programme). *Nature* 340(6230): 179.

Dieltjens, Sylvain, Priscilla Heynderickx, Priscilla, Marianne Dees, and Kris Vissers
2014 Linguistic Analysis of Face-to-Face Interviews with Patients with An Explicit Request for Euthanasia, their Closest Relatives, and their Attending Physicians: the Use of Modal Verbs in Dutch. *Pain Practice* 14(4): 324-331.

Dimopoulos, Kostas
2011 Signifying the Transition from Modern to Post-Modern Schooling Through Analyzing Changes in the Material Culture of Schools. *Semiotics: Theory and Applications.* Steven C. Hamel, ed. Hauppauge: Nova Science Publisher, Inc.

Doran, Jamie, and Piers Bizony
2011 *Starman: The Truth Behind the Legend of Yuri Gagarin.* New York: Walker & Company.

Eberhart, J.
1990 Japanese Satellite Begins Orbiting Moon. *Science News* 137(13): 198.

Editorial
2014a Fleet Week in San Francisco and USS Hornet Museum Update. *Wings of Gold* 39(2): 34-36.
2014b Hornet Museum Celebrates 45th Anniversary of First Walk on the Moon. *Wings of Gold* 39(2): 14.
2015 Restoring Hornet's Flight Deck and Aircraft Elevators. *Wings of Gold* 40(1): 32-33.

Ehrlich, Susan
2013 How Aerospace Built Southern California. *Real Estate Review* 42(3): 21-34.

Eicher, David J.
2015 History and Future Meet at Lowell Observatory. *Astronomy* 43(11): 62-67.

Eito-Brun, Ricardo, and María Ledesma Rodríguez
2016 50 years of Space Research in Europe: a Bibliometric Profile of the European Space Agency (ESA). *Scientometrics* 109(1): 551-576.

Elman, Benjamin A.
2008 *A Cultural History of Modern Science in China.* Cambridge: Harvard University Press.

Esteban, Cesar
2000 Astronomy in Island Cultures. *Archaeoastronomy* 15: 64-77.

Everts, Sarah
2016 A Conversation with Helen Sharman. *ACS Central Science* 2(8): 486-488.

Ezell, Clinton Edward, and Linda Neuman Ezell
1978 *The Partnership: A History of the Apollo-Soyuz Test Project.* Washington: U.S. Govermnent Printing Office.

Fagan, Timothy J., Daiju Kashima, Yuki Wakabayashi, and Akiko Suginohara.
2014 Case Study of Magmatic Differentiation Trends on the Moon Based on Lunar Meteorite Northwest Africa 773 and Comparison with Apollo 15 Quartz Monzodiorite. *Geochimica et Cosmochimica Acta* 133: 97-127.

Falk, John H., and Lynn D. Dierking
1992 *The Museum Experience*. Kittery Point: Howells House.

Falk, John H., Lynn D. Dierking, Léonie J. Rennie, and Gina F. Williams
2006 Forum: Communication About Science in a Traditional Museum—Visitors' and Staff's Perceptions. *Cultural Studies of Science Education* 1(4): 821-829.

Fasano, G., D. Saia, and A. Piras
2010 Columbus Stowage Optimization by Cast (Cargo Accommodation Support Tool). *Acta Astronautica* 67(3/4): 489-495.

Fairbrass, Sheila
2013 The Conservation of a V2 Rocket. *Studies in Conservation* 45(S1): 70-72.

Findlen, Paula
1996 *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy*. Berkeley: University of California Press.

Fletcher, Valerie
2013 Museums around the World that Enliven Our Souls: Inclusion through Rich Experience. *Curator* 56(3): 297-305.

Foing, B.H., and G.R. Racca
1999 The ESA SMART-1 Mission to the Moon with Solar Electric Propulsion. *The Moon and Mars, Advances in Space Research* 23(11): 1865-1870.

Forganni, Antonella
2017 The Potential of Space Tourism for Space Popularisation: An Opportunity for the EU Space Policy? *Space Policy* 11(1).

Fortmeyer, Russell
2007 Griffith Observatory: Los Angeles, California. *Architectural Record* 195(6): 154-158.

Fox, Philip
1932 The Adler Planetarium and Astronomical Museum of Chicago. *Popular Astronomy* 40(3): 125-155.

Frappart, F., B. Legrésy, F. Niño, F. Blarel, N. Fuller, S. Fleury, F. Birol, and S. Calmant
2016 An ERS-2 Altimetry Reprocessing Compatible with ENVISAT for Long-Term Land and Ice Sheet Studies. *Remote Sensing of Environment* 184: 558-581.

Fricke, Robert W.
1992 STS-46 Space Shuttle Mission Report: NASA-CR-193058. *Lockheed Engineering and Sciences Co.*

Gable, Eric
2006 How We Study History Museums: Or Cultural Studies at Monticello. *New Museum Theory and Practice: An Introduction.* Janet Marstine, ed. Hoboken: Blackwell.

Gail, Otto Willi
2013 *The Stone from the Moon.* Ron Miller, ed. Wake Forest: Baen Books.

Gainor, Christopher
2007 Canada's Space Program, 1958-1989: A Program without an Agency. *Acta Astronautica* 60(2): 132-139.

Ganswindt, Heinz
1956 *The Men Behind the Space Rockets*. New York City: David McKay Company, Inc.

Gauthier, Daniel James
1990 A Bold Plan That Was Not To Be. *Ad Astra* 2(2): 20-22.

Genoways, Hugh, and Lynne Ireland
2003 *Museum Administration: An Introduction.* Walnut Creek: AltaMira Press.

Gillette, Robert
1972 The Soviet Space Program: Effort Said to Surpass Peak U.S. Level. *Science* 175(4023): 731-736.

Giffard, Hermione.
2014 The Politics of Donating Technological Artifacts: Techno-Nationalism and the Donations of the World's First Jet Engines. *History & Technology* 30(1/2): 61-82.

Gleason, Sterling
1936 Push-Button Museum Shows Secrets of Science. *Popular Science* 128(4): 14-15.

Goddard, Cliff, and Anna Wierzbicka
2007 Semantic Primes and Cultural Scripts in Language Learning and Intercultural Communication. *Applied Cultural Linguistics: Applications for Second Language Learning and Intercultural Communication.* Gary B. Plamer and Farzad Sharifan, eds. Amsterdam: John Benjamins Publishing Company.

Godefroy, Andrew B.
2011 *Defence and Discovery: Canada's Military Space Program, 1945-1975.* Vancouver: University of British Columbia Press.

Golden, Frederic, and Jerry Hannifin
1981 A Final Salute to Salyut 6. *Time* 117(25): 58.

Gorman, Alice
2005 A Cultural Landscape of Interplanetary Space. *Journal of Social Archaeology* 5(1): 85-107.

Gouyon, Jean-Baptiste
2014 Making science at home: visual displays of space science and nuclear physics at the Science Museum and on television in postwar Britain. *History and Technology* 30(1-2): 37-60.

Graham, Elizabeth, Scott E. Simmons, and Christine D. White
2013 The Spanish Conquest and the Maya Collapse: How 'Religious' Is Change? *World Archaeology* 45(1): 161–185.

Greasley, Pete
2008 *Quantitative Data Analysis Using SPSS: An Introduction for Health & Social Science.* New York: Open University Press.

Greenberg, D.
1962 Titov in Washington: The Soviet Cosmonaut Was Talkative, But He Managed to Say Nothing. *Science* 136(3515): 489-490.

Gusev, A., N. Kawano, and N. Petrova
2003 Gravitational Investigations on the SELENE Mission (Japan) and the Existence of a Lunar Core. *Astronomical & Astrophysical Transactions* 22(4/5): 579.

Haas, W.H.
1939 Observations of Saturn, 1936-1938. *Journal of the Royal Astronomical Society of Canada* 33: 274-250.

Hadfield, Chris
2013 *An Astronaut's Guide To Earth: What Going to Space Taught Me About Ingenuity, Determination, and Being Prepared for Anything*. New York: Little, Brown and Company.
2016 Canada's Astronaut. *Royal Ontario Museum Magazine* 48(4): 30-31.

Hall, Rex, and David Shayler
2003 *Soyuz: A Universal Spacecraft*. New York: Springer Praxis Books.

HFM
2016 The Hanger Flight Museum: A Museum with Altitude. *The Hanger Flight Museum.* Accessed 8/5/2016. http://www.thehangarmuseum.ca/

Harford, James
2013 *Korolev: How One Man Masterminded the Soviet Drive to Beat America to the Moon.* Hoboken: Wiley.

Harvey, Brian
2000 *The Japanese and Indian Space Programmes: Two Roads Into Space.* Chichester: Springer-Praxis Books.
2004 *China's Space Program – From Conception to Manned Spaceflight.* Chichester: Springer-Praxis Books.

Hashemi, Mohammad R., and Esmat Babaii
2013 Mixed Methods Research: Toward New Research Designs in Applied Linguistics. *Modern Language Journal* 97(4): 828-852.

Hayes, Edmund
1967 Gray's Adventure Cove. *Oregon Historical Quarterly* 68(2): 100.

Heindel, Max
1911 *The Rosicrucian Cosmo-Conception Or Mystic Christianity: An Elementary Treatise Upon Man's Past Evolution, Present Constitution and Future Development.* Oceanside: Rosicrucian Fellowship.

Hein, George E.
1998 *Learning in the Museum*. Abingdon: Routledge.

Hodson, Hal
2013 ISS Reached in Record Time. *New Scientist* 217(2911): 34.

Hoffman, A. Kellig, H.U. Hoffmann, and G. Ruyters
1998 DARA vestibular equipment onboard MIR. *Acta Astronautica* 43 (3-6): 313-319.

Hollins, Hunter, and Alan Needell
2014 Lunar Module LM-2. *Milestones of Space: Eleven iconic objects from the Smithsonian National Air and Space Museum.* Michael J. Neufeld, ed. Minneapolis: Zenith Press.

Howell, Elizabeth
2013 Space Rock Star: Astronaut Chris Hadfield Becoming Canadian Celebrity. *Space.com*. Accessed 4/26/2017. https://www.space.com/19212-astronaut-hadfield-celebrity-canada.html

Hubbard, Bryan, and Marouf A. Hasian
1998 Atomic Memories of the Enola Gay: Strategies of Remembrance at the National Air and Space Museum. *Rhetoric & Public Affairs* 1(3): 363-385.

Hunter, Hollins
2014 Science and Military Influences on the Influences on the Ascent of Aerospace Development in Southern California. *Southern California Quarterly* 96(4): 373-404.

Huntington, Tom
1997 One Good Year. *Air & Space Smithsonian* 11(6): 74.

Ingersoll, Andrew P.
2007 Venus Express. *Nature* 450(7170): 617.

Iwaniszewski, Stanislaw
1988 Exploring Some Anthropological Theoretical Foundations for Archaeoastronomy. *World Archaeoastronomy: Selected Papers from the 2nd Oxford International Conference on Archaeoastronomy, Held at Merida, Yucatan, Mexico, 13-17 January 1986*. Anthony F. Aveni, ed. Cambridge: Cambridge University Press.

Jacobson, Annie
2014 *Operation Paperclip: The Secret Intelligence Program that Brought Nazi Scientists to America.* Boston: Little, Brown and Company.

Jamani, Kamini
2011 A Semiotics Discourse Analysis Framework: Understanding Meaning Making in Science Education Contexts. *Semiotics: Theory and Applications.* Steven C. Hamel, ed. Hauppauge: Nova Science Publisher, Inc.

JAXA
2003 Pencil Rocket Story. *Japan Aerospace Exploration Agency.* Accessed 4/4/2017. http://global.jaxa.jp/article/interview/sp1/prologue_p1_e.html
2017 Tanegashima Space Center. *Japan Aeorspace Exploration Agency*. Accessed 5/25/2017. http://global.jaxa.jp/about/centers/tnsc/

Jensen, Richard
2016 The First Space Race: During the 1930s, the U.S. and Soviet Union Competed in Gas Balloons to See Who Could Fly the Highest. *Aviation History* 26(5): 50-55.

Jerome, Richard, and Laurel Brubaker Calkins
2013 Above and Beyond. *People* 46(4): 36.

JNTO
2017 Yoichi Space Museum. *Jnto Japan: the Official Guide of the Japan National Tourism Organization.* Accessed 4/8/2017. https://www.jnto.go.jp/eng/spot/museum/yoichispacedome.html

Joiner, Stephen
2013 The X-15 Rocket Plane: Flying the First Wings into Space. *Air & Space Smithsonian* 28(6): 68-72.

Jones, Chris
2007 *Too Far from Home: A Story of Life and Death in Space*. New York City: Doubleday.

Jones, Chris
2011 Rendezvous for Shenzhou. *Science Daily* 11(11).
2012 Is Shenzhou Unsafe? *Science Daily* 5(1).

Johnson-Freese, Joan
1998 *The Chinese Space Program: A Mystery within a Maze*. New York City: Krieger Publishing.

Jung, Maura Lobos, and Karen L. Tonso
2006 Elementary Preservice Teachers Learning to Teach Science in Science Museums and Nature Centers: A Novel Program's Impact on Science, Knowledge, Science Pedagogy, and Confidence Teaching. *Journal of Elementary Science Education* 18(1): 15-31.

Justeson, John S.
1988 Ancient Maya Ethnoastronomy: An Overview of Hieroglyphic Sources. *World Archaeoastronomy: Selected Papers from the 2nd Oxford International Conference on Archaeoastronomy, Held at Merida, Yucatan, Mexico, 13-17 January 1986.* Anthony F. Aveni, ed. Cambridge: Cambridge University Press.

Kaneko, Shohei, Eiji Ohtani, Masaaki Miyahara, Shin Ozawa, and Tomoko Arai
2014 *Discovery of Stishovite in an Apollo 15 Sample and Impact Record on the Moon*. Tokyo: Japan Geoscience Union.

Kasper, Gabriele, and Matthew T. Prior.
2015 Analyzing Storytelling In TESOL Interview Research. *TESOL Quarterly* 49(2): 226-255.

Kaufman, Joanne
2010 A Cultural Conversation with Patrick Steward: Spacecraft to Stage Craft. *Wall Street Journal* 10(6): D7.

Keeler, James E.
1900 The Crossley Reflector of the Lick Observatory. *Publications of the Astronomical Society of the Pacific* 12(75): 146-167.

Keenan, P.C.
1991 The Earliest National Observatories in Latin America. *Journal for the History of Astronomy* 22(1): 21-30.

Kemp, Martin
2007 Russian science: A dog's Life. *Nature* 449(7162): 541.

Kirkpatrick, Rob
2009 *1969: The Year Everything Changed.* New York City: Skyhorse Publishing.

Kleszewski, Adam
2006 First female space tourist boards ISS (Anousheh Ansari, International Space Station). *Moscow News* 4240(36): 3.

Kissinger, Sam
2009 Unearthing the Mayan Creation Myth. *Discover* 30(6): 18.

Knudsen, Toke
2014 Astronomy and Mathematics in Ancient India. *Critical Reviews in the History of Science* 11: 223-226.

Kockelman, Paul
2013 The Anthropology of an Equation: Sieves, Spam Filters, Agentive Algorithms, and Ontologies of Transformation. *HAU: Journal of Ethnographic Theory* 3(3): 33-61.

Kohn, Richard H.
1995 History and the Culture Wars: The Case of the Smithsonian Institution's Enola Gay Exhibition. *The Journal of American History* 82(3): 1036-1063.

Kohonen, Iina
2009 The Space Race and Soviet Utopian Thinking. *Sociological Review Monograph* 57(1): 114-131.

Kozloski, Lillian D.
1994 *U.S. Space Gear: Outfitting the Astronaut*. Washington: Smithsonian Institution Press.

Kress, G. and T. Van Leeuwen
1996 *The Grammar of Visual Design*. London: Routledge.

Krug, Linda T.
1991 *Presidential Perspectives on Space Exploration: Guiding Metaphors from Eisenhower to Bush*. Santa Barbara: Praeger.

Krupp, Edwin C.
2001 Rambling Through the Skies, Los Angeles's Griffith Has Become a Star of Film, Television, and Even the Comics. *Sky and Telescope* 102(2): 92-97.
2010 2012: Is the Fear Justified? *Hinduism Today* 32(4): 60-63.

Kuzmin, A.V.
1999 Ethno-Astronomical Testimonies, Written and Architectural, from Ancient Egypt: Evidence for the Discovery of the Solar Year. *Astronomical & Astrophysical Transactions* 17(6): 515-527.

Langevin, Yves, François Poulet, Jean-Pierre Bibring, and Brigitte Gondet
2005 Sulfates in the North Polar Region of Mars Detected by OMEGA/Mars Express. *Science* 307(5715): 1584-1586.

Lantry, Douglas N.
2001 Dress for Egress: The Smithsonian National Air and Space Museum's Apollo Spacesuit Collection. *Journal of Design History* 14(4): 343-359.

Laouli, Amanda
2006 The Greek Myth of Pleiades in the Archaeology of Natural Disasters: Decoding, Dating and Environmental Interpretation. *Mediterranean Archaeology and Archaeometry* 6(9): 5-22.

Latson, Jennifer
2014 The Sad Story of Laika, the First Dog Launched into Orbit. *Time Magazine*.

Lawson, Richard
1999 Company Lands Simulator in Seattle Flight Museum. *Nashville Business Journal* 15(3): 2.

Laxon, Seymour W., Katharine A. Giles, Andy L. Ridout, Duncan J. Wingham, Rosemary Willat, Robert Cullen, Ron Kwok, Axel Schweiger, Jinlun Zhang, Christian Haas, Stefan Hendricks, Richard Krishfield, Nathan Kurts, Sinear Farrell, and Malcolm Davidson
2013 CryoSat-2 Estimates of Arctic Sea Ice Thickness and Volume. *Geophysical Research Letters* 40(4): 732-737.

Lee, Paula Young
1997 The Museum of Alexandria and the Formation of the Muséum in Eighteenth-Century France. College Art Association of America. *The Art Bulletin* 79(3): 385-412.

Leonard, Frederick
1934 Popularizing Astronomy. *Publication for the Astronomical Society of the Pacific* 46(272): 191-193.

Levin
2008 Griffith Observatory. *Architectural Record* 196(5): 62.

Lewis, Cathleen S.
2014 Neil Armstrong's A7-L Spacesuit. *Milestones of Space: Eleven iconic objects from the Smithsonian National Air and Space Museum*. Michael J. Neufeld, ed. Minneapolis: Zenith Press.

Lewis, Cathleen S., Valerie Neal, and Frank H. Winter
1995 *Spaceflight: A Smithsonian Guide*. New York City: Macmillan Publishing Company.

Lewis, H. Spencer
1929 *Complete History of the Rosicrucian Order*. San Jose: Rosicrucian Press.

Li, Xiaoyan, Peter R. Richter, Zongjie Hao, Yanjun An, Gaohong Wang, Dunhai Li, Yongding Liu, Sebastian M. Strauch, Martin Schuster, Ferdinand W. Haag, Michael Lebert
2017 Operation of An Enclosed Aquatic Ecosystem in the Shenzhou-8 Mission. *Acta Astronautica* 134: 17-22.

Lindauer, Margaret
2006 The Critical Museum Visitor. *New Museum Theory and Practice: An Introduction.* Janet Marstine, ed. Hoboken: Blackwell.

Liu, Jingao, Miriam Sharp, Richard D. Ash, David A. Kring, and Richard J. Walker
2015 Diverse Impactors in Apollo 15 and 16 Impact Melt Rocks; Evidence From Osmium Isotopes and Highly Siderophile Elements. *Geochimica et Cosmochimica Acta* 155: 122-153.

Liu, Lei, Jian-feng Cao, Yong Liu, Song-jie Hu, Ge-shi Tang, and Jian-feng Xie
2015 CHANG'E-3 contingency scheme and trajectory. *Advances in Research* 55(4): 1074-1084.

Logsdon, John M.
2012 *Together in Orbit: The Origins of International Participation in the Space Station*. North Charleston: Createspace Independent Publishing.

Long, K. F., R. K. Obousy, and A. Hein
2011 Project Icarus: Optimisation of Nuclear Fusion Propulsion for Interstellar Missions. *Acta Astronautica* 68(11): 1820-1829.

Lounsbury, Floyd G.
1988 A Palenque King and the Planet Jupiter. *World Archaeoastronomy: Selected Papers from the 2nd Oxford International Conference on Archaeoastronomy, Held at Merida, Yucatan, Mexico, 13-17 January 1986*. Anthony F. Aveni, ed. Cambridge: Cambridge University Press.

Lovell, Bernard
1994 The Royal Society, The Royal Greenwich Observatory and the Astronomer Royal. *Notes & Records of the Royal Society* 48(2): 283-297.

Low, Denise
2016 *Native American Astronomy.* Salem Press Encyclopedia.

Low, Morris
2005 Building a Modern Japan: Science, Technology, and Medicine in the Meiji Era and Beyond. New York City: Palgrave Macmillan.

Low, Morris, Shigeru Nakayama, and Hitoshi Yoshioka
1999 *Science, Technology, and Society in Ancient Japan*. Cambridge: Cambridge University Press.

MacMillan
2015 *H.R. MacMillan Space Center.* Accessed 6/8/2015. http://www.spacecentre.ca

Malcolm, Ian
2007 Cultural Linguistics in Biadialactic Education. *Applied Cultural Linguistics: Applications for Second Language Learning and Intercultural Communication.* Gary B. Plamer and Farzad Sharifan, eds. Amsterdam: John Benjamins Publishing Company.

Mathews, Jennifer P.
2016 *Building of Chichén Itzá.* Ipswich: Salem Press Encyclopedia.

Marris, Emma
2011 Shuttle's End Could Spell a Bumpy Ride for Biomedicine in Space. *Nature Medicine* 17(8): 908.

Marstine, Janet
2006 Introduction. *New Museum Theory and Practice: An Introduction.* Janet Marstine, ed. Hoboken: Blackwell.

Martin, William E., and Krista D. Bridgmon
2007 *Quantitative and Statistical Research Methods: From Hypothesis to Results*. Hoboken: John Wiley & Sons.

Marx, Karl
1867 *Capital*, *Volume I: The Process of Production of Capital*.

Mauro, Stephen
2006 A Museum of Flight art exhibit offers an exciting look into the development of World War I aircraft. *Aviation History* 16(4): 72.

Mayr, Otto
1998 The 'Enola Gay' Fiasco: History, Politics, and the Museum. *Technology and Culture* 39(3): 462-473.

McAleer, John
2013 ‘Stargazers at the World’s End’: Telescopes, Observatories and ‘Views’ of Empire in the Nineteenth-Century British Empire. *British Journal for the History of Science* 46(3): 389-413.

McConville, David
2007 Cosmological Cinema: Pedagogy, Propaganda, and Perturbation in Early Dome Theaters. *Technoetic Arts: A Journal of Speculative Research* 5(2): 69-85.

McCormick, Keith, Dean Abbott, and Meta S. Brown
2013 *IBM SPSS Modeler Cookbook.* Birmingham: Packt Publishing.

McDonald, Robert L. and Walter H. Hesse
1970 *Space Science.* Columbus: Charles E. Merrill Publishing Company.

McGee, R. Jon, and Richard L. Warms
2008 *Anthropological Theory: An Introductory History.* Jon R. McGee and Richard L. Warms, eds. New York City: McGraw-Hill.

McLean, Alison
2009 This Month in History. *Smithsonian* 40(6): 14.

McMahon, Michal
1981 The Romance of Technological Progress: A Critical Review of the National Air and Space Museum. *Technology and Culture* 22(2): 281-296.

McLymont, Rosalind
2004 Nigeria's Satellite Launch; Whose Victory is it? *Network Journal* 11(3): 36.

Meladay, John
2009 *Canadians in Space: The Forever Frontier.* Toronto: Dundurn Press.

Messeri, Lisa
2011 Placing Outer Space: An Earthly Ethnograph of Other Worlds. Doctoral dissertation. HASTS (History, Anthropology, Science, Technology, and Society). *Massachusetts Institute of Technology.*

Milbrath, Susan
1999 *Star Gods of the Maya: Astronomy in Art, Folklore, and Calendars*. Austin: University of Texas Press.
2004 The Maya Katun Cycle and the Retrograde Periods of Jupiter and Saturn. *Archaeoastronomy* 18: 81-97.

Mieczkowski, Yanek

1999 *Eisenhower's Sputnik: The Race for Space and World Prestige.* Ithaca: Cornell University Press.

Milham, Willis I.

1937a Early American Observatories. *Popular Astronomy* 45(10): 465-539.

1937b *The History of Astronomy in Williams College and the Founding of the Hopkins Observatory.* Williamstown: Williams College Press.

Miller, Roy

1988 Pleiades Perceived: MUL.MUL to Subaru. *Journal of the American Oriental Society* 108(1): 1-25

Moen, Margaret

2004 The Seattle Museum of Flight's Stearman C-3B carries a load of history on its cotton-covered wings. *Aviation History* 15(1): 62-65.

Montes, Garcia, Paula Andrea, Sagre Barboza, Ana Maria, Lacharme Olascoaga, and Alba Isabel

2014 Systemic Functional Linguistics and Discourse Analysis as Alternatives When Dealing with Texts (La lingüística sistémica funcional y el análisis del discurso como alternativas para trabajar con textos). *Teachers' Professional Development* 16(2): 101-116.

Morishima, Michio

2003 *Why has Japan 'Succeeded'?: Western Technology and the Japanese Ethos.* Cambridge: Cambridge University Press.

Morring, Frank

2006 International Astronauts. *Aviation Week & Space Technology* 164(23): 13.

2008 European ISS. *Aviation Week & Space Technology* 169(2): 168.

2009 Orbital Outfitting. *Aviation Week & Space Technology* 171(8): 35.

2012a Space Stations—Plural. *Aviation Week & Space Technology* 174(22): 18.

2012b Space for Africa. *Aviation Week & Space Technology* 174(4): 18.

Morring, Frank, and Amy Svitak

2011 European Continuity. *Aviation Week & Space* Technology 173(22): 134.

Morring, Frank, and Bradley Perrett

2016 By Degrees: China's Space Program Takes Next Well-Planned Steps for Ambitious Orbital Laboratory (Tiangong-2). *Aviation Week & Space Technology* 178(22): 22.

Morris-Suzuki, Tessa
1994 *The Technological Transformation of Japan: From the Seventeenth to the Twenty- first Century.* Cambridge: Cambridge University Press.

Moser, Stephanie
2010 The Devil is in the Detail: Museum Displays and the Creation of Knowledge. *Museum Anthropology* 22(1): 22-32.

Mozaffari, S. Mohammad, and Georg Zotti
2012 Ghāzān Khān's Astronomical Innovations at Marāgha Observatory. *Journal of American Oriental Society* 132(3): 395-425.

Museum of Cosmonautics
2017 Virtual Tour. Accessed 4/18/2017. http://www.kosmo-museum.ru/?locale=en

NASA
2011 NASA's Recommendations to Space-Faring Entities: How to Protect and Preserve the Historic and Scientific Value of U.S. Government Lunar Artifacts. National Air and Space Museum.
2012 *Columbia Crew Survival Investigation Report.* National Aeronautics and Space Administration.
2013 *Informational Summaries: Astronaut Fact Book.* National Aeronautics and Space Administration.
2016 *Close-up of the far side of the Moon from Luna 3*. 3/31/2016. NSSDC. Accessed 4/4/2017. https://nssdc.gsfc.nasa.gov/imgcat/html/object_page/lu3_27.html

Natural History
2012 Around the Country. *Natural History* 120(9): 44-47.

Neufeld, Michael J.
1990 Weimar Culture and Futuristic Technology: The Rocketry and Spaceflight Fad in Germany, 1923-1933. *Technology and Culture* 31(4): 725-752.
1993a *The Rocket and the Reich: Peenemünde and the Coming of the Ballistic Missile Era*. District of Columbia: Smithsonian Books.
1993b Hitler, the V-2, and the Battle for Priority, 1939-1943. *The Journal of Military History* 57(3): 511-538.
2012 The Nazi Aerospace Exodus: Towards a Global, Transnational History. *History and Technology* 28(1): 49-67.
2014 Mercury Capsule Friendship 7. *Milestones of Space: Eleven iconic objects from the Smithsonian National Air and Space Museum*. Michael J. Neufeld, ed. Minneapolis: Zenith Press.

Newman, Ronald
1995 STS-61 Mission Director's Post-Mission Report: NASA-TM-104803. *NASA Johnson Space Center.*

NMNS
2017 Global Gallery. *National Museum of Nature and Science.* Accessed 4/4/2017. http://shinkan.kahaku.go.jp/floor/2f_en.html.

Oberg, James
2009 The amazing orbiting Garriotts: Owen and Richard Garriot, the second father-and-son pair to have traveled in space (Interview). *IEEE Spectrum* 46(6): 70.

Oberth, Hermann
1929 *Ways to Spaceflight.* Berlin: Oldenbourg Verlag.

Occhi, Debra
2007 Using Cultural Linguistics to Teach English Language Inferential Schemas Used in Archaeology to Japanese University Students. *Applied Cultural Linguistics: Applications for Second Language Learning and Intercultural Communication*. Gary B. Plamer and Farzad Sharifan, eds. Amsterdam: John Benjamins Publishing Company.

Office of Technology Assessment
1983 *Fundamentals of Space Medicine. New York City: Springer Publishing. Salyut: Soviet Steps Toward Permanent Human Presence in Space (a Technical Memorandum).* Washington, D.C.: The Library of Congress.

O'Leary, Beth Laura
2015 "To Boldy Go Where No Man [sic] Has Gone Before:" Approaches in Space Archaeology and Heritage. *Archaeology and Heritage of the Human Movement into Space.* P.J. Capelotti and Beth Laura O'Leary, eds. New York City: Springer Publishing.

Olson, Valerie
2010 American Extreme: An Ethnography of Astronautical Visions and Ecologies. Ph.D. dissertation, Anthropology, Rice University.

Ordway, Frederick, Werner K. Dahm, Konrad Dannenberg, Walter Haeussermann, Gerhard Reisig, Ernst Stuhlinger, Georg von Tiesenhausen, Irene Willhite.
2006 A memoir: From Peenemünde to USA: A Classic Case of Technology Transfer. *Acta Astronautica* 113(60): 212-220.

Painter, George
1982 James Smithson's Bequest to the United States: the Smithsonian Institution. *American History Illustrated* 16(9): 30-35.

Palen, Stacy, Laura Kay, Brad Smith, and George Blumenthal
2012 *Understanding Our Universe.* New York City: W.W. Norton & Company, Inc.

Palmer, Edwina
2010 "Slit Belly Swamp": A Japanese Myth of the Origin of the Pleiades? *Asian Ethnology* 69(2): 311-331.

Palmer, Gray B., and Farzad Sharifan
2007 Applied Cultural Linguistics. *Applied Cultural Linguistics: Applications for Second Language Learning and Intercultural Communication*. Gary B. Plamer and Farzad Sharifan, eds. Amsterdam: John Benjamins Publishing Company.

Pankenier, David
1988 The Mandate of Heaven. *Archaeology* 51(2): 26-34.

Parkinson, Brian
1993 Can Applied Linguists Do Ethnographic Interviews? *Edinburgh Working Papers in Applied Linguistics* 4: 96-109.

Piszkiewicz, Dennis
1998 *Wernher von Braun: The Man Who Sold the Moon.* Westport: Praeger Publishing.

Pittman, Bonnie
1999 Museums, Museums, and Memories. *Daedalus* 128(3): 1-31.

Platoff, Anne M.
2008 Colors Used in the Flags. *Raven: A Journal of Vexillology* 16: 12-17.

Polig, Raphael, Kubilay Atasu, Laura Chiticariu, Christoph Hagleitner, H. Peter Hofstee, Frederick Reiss, Huaiyu Zhu, and Eva Sitaridi
2014 Giving Text Analytics a Boost. *IEEE Micro* 34(4): 6-14.

Portree, David S. F
2002 Zond. *Space Sciences* 3: 235-237.

Preu, Peter, and Markus Braun
2014 German SIMBOX on Chinese Mission Shenzhou-8: Europe's First Bilateral Cooperation Utilizing China's Shenzhou Programme. *Acta Astronautica* 94(2): 584-591.

Price, Charles
2008 Travel Trip: Seattle's Museum of Flight. *Oklahoma City Journal Record*.

PR Newswire
2012 Begin the Baktun at Chabot Space & Science Center. *PR Newswire*.

Purcell, Rosamond
2004 A Room Revisited. *Natural History* 113(7): 46-48.

Rabinowitch, Eugene
1969 Reflections on Apollo 8. *Bulletin of the Atomic Scientists* 25(3): 2-12.

Raloff, Janet
1992 Instrumental Changes in Astronomy. *Science News* 142(25/26): 424-426.

Rao, Radhakrishna
2008 India's Manned Mission Studies Get $31 Million. *Flight International* 173(5129): 25.

Rea, Louis M., and Richard A. Parker
2014 *Designing and Conducting Survey Research: A Comprehensive Guide*. San Francisco: Jossey-Bass.

Rebekah, Higgitt
2015 A British National Observatory: The Building of the New Physical Observatory at Greenwich, 1889-1898. *British Journal for the History of Science* 47(4): 609-635.

Regas, Dean
2004 *Maya Political Science: Time, Astronomy, and the Cosmos*. Austin: University of Texas Press.

Reid
2014 A Trip Into Space From Japan’s TeNQ Space Museum. *Tadaima Japan.* Accessed 12/5/2017. http://tadaimajp.com/2014/07/tenq-space-museum/

Reid, R.L.
2013 A Stellar Move Transporting the retired space shuttle Endeavour from Los Angeles International Airport to the California Science Center involved a twisting, turning, 12 mi odyssey through the streets of Los Angeles and Inglewood, California. *American Society of Civil Engineers* 83: 72-81.

Reynolds, Joseph
2015 Legal Implications of Protecting Historic Sites in Space. *Archaeology and Heritage of the Human Movement into Space*. P.J. Capelotti and Beth Laura O'Leary, eds. New York City: Springer Publishing.

Rice, Prudence M.
2015 The Science of Jules Verne's Fiction. *Sky & Telescope* 129(6): 32-37.

Ricketson, Oliver.
1928 Notes on Two Maya Astronomic Observatories. *American Anthropologist* 30(3): 434-444.

Roach, Mary
2010 *Packing for Mars: The curious Science of Life in the Void*. New York City: W.W. Norton & Company, Inc.

Roberts, Lisa C.
1997 *From Knowledge to Narrative: Educators and the Changing Museum*. Washington, D.C.: Smithsonian Institute Press.

Rosta, Paul B.
2002 L.A.'s Griffith Park Observatory Closes for Three-Year Overhaul. *Engineering News-Record* 248(3): 17.

Roys, Ralph L.
1965 *Ritual of the Bacabs*. Norman: University of Oklahoma Press.

Ruggles, Clive L.N., and Nicholas J. Saunders, eds.
1993 *Astronomies and Cultures.* Niwot: University Press of Colorado.

Rupert, Karl
1935 *The Caracol at Chichen Itza, Yucatan, Mexico.* District of Columbia: Carnegie Institution of Washington.

Salkeld, Robert, Donald W. Patterson, Walter B. Olstad, and Christopher J. Cohan
1978 *Space Transportation Systems: 1980-2000.* New York City: American Institute of Aeronautics and Astronautics.

Samuel, Wolfgang
2004 From Overcast to Paperclip. *American Raiders: The Race to Capture the Luftwaffe's Secrets*. Jackson: University Press of Mississippi.

Sang-Hun, Chloe
2008 Woman Replaces Colleague for South Korea's First Space Mission. *The New York Times* 157(54246): A5.

Schaber, Gerald G., David R Scott, and James B. Irwin
1972 Glass in the Bottom of Small Lunar Craters; An Observation from Apollo 15. *Geological Society of America Bulletin* 83(6): 1573-1577.

Schäfer, Dagmar
2011 *The Crafting of 10,000 Things: Knowledge and Technology in the Seventeenth-Century China.* Chicago: The University of Chicago Press.

Schafft, Gretchen, and Gerhard Zeidler
2011 *Commemorating Hell: The Public Memory of Mittelbau-Dora.* Urbana–Champaign: University of Illinois Press.

ScienceWorld
2017 Let's Talk About Canadian Women In Space! *Science World at Telus World of Science.* Accessed 7/15/2017. https://www.scienceworld.ca/blog/lets-talk-about-canadian-women-space

Scientific American
1960 The Soviet Space Ship. *Scientific American* 203(5): 98-100.

Seedhouse, Erik
2010 *The New Space Race: China vs. USA*. Chichester: Springer-Praxis Books.

Sellers, Charles Coleman
1969 *Charles Wilson Peale.* New York: Charles Scribner's Sons.
1980 Peale's Museum and "The New Museum Idea". *Proceedings of the American Philosophical Society* 124(1): 25-34.

Selleveg, Inge
1995 Euromir 95. *Ad Astra* 7(6): 17.

Serrell, Beverly
1996 *Exhibit Labels: An Interpretive Approach*. Walnut Creek: AltaMira Press.

Sevastiyanov, Nikolay, and Nikolay Bryukhanov
2007 Space stations: Evolution and New Programs. *Bringing Space Closer to People, Selected Proceedings of the 57th IAF Congress.* Valencia: Acta Astronautica.

Shackelford, Jole
1999 Documenting the Factual and the Artifactual: Ole Worm and Public Knowledge. *Endeavour* 23(2): 65-71.

Shapley, Harlow
1943 Notes on Thomas Jefferson as a Natural Philosopher. *Proceedings of the American Philosophical Society* 87(3): 234-237.

Sharpe, Mike
2006 *Space: The Ultimate Frontier*. Chichester: Taj Books.

Shea, Rachel Hartigan
2013 Space Walker. *National Geographic* 224(2): 124-126.

Shelton, William
1993 Free Space: An Account of the First Soviet Space Walk, Performed by Alexei Leonov on March 18, 1965, during the Voskhod 2 Mission. *Parabola* 18(20: 67-70.

Simon, Nina
2010 *The Participatory Museum.* Santa Cruz: Museum 2.0.

Simon, S.L., and W.L. Robison
1997 A compilation of Nuclear Weapons Test Detonation Data for US Pacific Ocean Tests. *Health Physics Society* 73(1): 258-264.

Sipiera, Paul P.
2015 *Lunar Prospector Mission.* Salem: Salem Press Encyclopedia.

Sivin, Nathan
1988 Chinese Archaeoastronomy: Between Two Worlds. *World Archaeoastronomy: Selected Papers from the 2nd Oxford International Conference on Archaeoastronomy, Held at Merida, Yucatan, Mexico, 13-17 January 1986*. Anthony F. Aveni, ed. Cambridge: Cambridge University Press.

Smiley, Charles H.
1938 The History of the Lick Observatory. *The Scientific Monthly* 47(2): 128-135.

Smithsonian
2009 *Official Guide to the Smithsonian National Air and Space Museum*: D.C.: Smithsonian Institute.

Snedgar, K.V.
1995 Stars and Seasons in Southern Africa. *Vistas in Astronomy* 39: 529-538.

Socha, Mabel V.
1935 Address at the Formal Opening of the Griffith Observatory and Planetarium. *Publications of the Astronomical Society of the Pacific* 47(277): 157-159.

Sosa, John R.
1988 Cosmological, Symbolic, and Cultural Complexity Among the Contemporary Maya of Yucatan. *World Archaeoastronomy: Selected Papers from the 2nd Oxford International Conference on Archaeoastronomy, Held at Merida, Yucatan, Mexico, 13-17 January 1986.* Anthony F. Aveni, ed. Cambridge: Cambridge University Press.

Spence, Lewis
1908 *Popol Vuh; the Mythic and Heroic Sagas of the Kiches of Central America.* London: AMS Press.

Spiteri, George
2012 Operations Summary. *Spaceflight* 54(12): 454-456.
2013 Operations Summary. *Spaceflight* 55(3): 94-97.

Stagnargo, Frank
1999 Take a Step Back in Time at the Rosicrucian Museum. *Business Journal Serving San Jose & Silicon Valley* 17(21).

Stephens, John Lloyd
1843 *Incidents of Travel in Yucatan.* New York: Harper & Brothers.

Stokley, James
1934 The Fels Planetarium of the Franklin Institute. *The Scientific Monthly* 38(2): 194-198.

Struhl, Steven
2015 *Practical Text Analytics: Interpreting Text and Unstructured Data for Business Intelligence.* London: Kogan Page.

Sun, ZeZhou, Yang Jia, and He Zhang
2013 Technological Advancements and Promotion Roles of Chang'e-3 Lunar Probe Mission. *Science China Technological Sciences* 56(11): 2702-2708.

Svoboda, Elizabeth
2004 Dragon Skies: Astronomy of Imperial China. *Discover* 25(10): 82.

Szczepanowska, Hanna M.
2015 The Space Shuttle Discovery: Its Scientific Legacy in a Museum Context. *Archaeology and Heritage of the Human Movement into Space*. P.J. Capelotti and Beth Laura O'Leary, eds. New York City: Springer Publishing.

TED
2017 The Future We're Building—and Boring (Elon Musk). *Ted Talks*. Accessed 5/4/2017. https://www.ted.com/talks/elon_musk_the_future_we_re_building_and_boring

Teale, Edwin W.
1929 Greatest Telescope to Enlarge the Universe Eight Times, and Marvelous "Sky-Theater" Promise Untold Thrills in Astronomy. *Popular Science* 114(1): 20-32, 129-130.

Thom, Alexander
1967 *Megalithic Sites in Britain.* Oxford: Clarendon Press.

Thomas, Cyrus
1898 *Introduction to the Study of North American Archaeology. Cincinnati*: The Robert Clark Company.

Thompson, Neal
2004 *Light This Candle: The Life & Times of Alan Shepard, America's First Spaceman*. Crown Publishing.

Time
1971 Roving the Moon. *Time* 98(4): 52.

Todd, David
1925 A New Optical Projection Planetarium for Visualizing the Motions of the Celestial Bodies. *Popular Astronomy* 33: 446-456.

Trejo, Jesús Galindo
2000 Recent Advances in Mesoamerican Archaeoastronomy. *Archaeoastronomy* 15: 32-42.

Triplet, William
2003 Astronaut, Cosmonaut...Euronaut? *Air & Space Smithsonian* 18(3): 44

Unwin, Timothy
2005 Jules Verne: Negotiating Change in the Nineteenth Century. *Science Fiction Studies* 32(1): 5-17.

Updike, Robin
2008 Style in the Aisle: The History of Fashion in Flight. *Ornament* 31(4): 28-29.

Valier, Max
2013 *A Daring Trip to Mars*. Ron Miller, ed. Wake Forest: Baen Books.

Vasant, Gowarikar, and B.N. Suresh
2009 History of Rocketry in India. *Acta Astronautica* 65(11): 1515-1519.

Verne, Jules Gabriel
1867 *From the Earth to the Moon*. Paris: Pierre-Jules Hetzel.

Vighnesam, N.V., Anatta Sonney, and N.S. Gopinath
2010 India's First Lunar Mission Chandrayaan-1 Initial Phase Orbit Determination. *Acta Astronautica* 67(7): 784-792.

Volz, Peter
2013 Tracing Paths of History. *Planetarian* 42(4): 50-83.

Walcutt, Leif
2017 The First Woman In Space Turns 80, And You've Probably Never Heard Of Her. *Forbes* 25.

Walsh, Megan
2011 The Politics of Vision: Charles Willson Peale in Print. *Early American Literature* 46(1): 69-92.

Wang, Zuoyue
2008 *In Sputnik's Shadow: The President's Science Advisory Committee and Cold War.* New Brunswick: Rutgers University Press.

Ward, Bob
2005 *Dr. Space: The Life of Wernher von Braun.* Annapolis: Naval Institute Press.

Watts, R.
1972 Soviet Exploration of Mars. *Sky and Telescope* 43(2): 91-93.

Wayman, Erin
2008 Venturing to Venus. *Geotimes* 53(5): 22-27.

Weeks, John M.
2009 *Maya Daykeeping: Three Calendars from Highland Guatemala*. Boulder: University Press of Colorado.

Welch, John, and Ann Hammittee
2013 Inside the Issue. Allen's Trademark Digest 27(1): 1-64.

Weingardt, Richard G.
2012 Wernher von Braun and the Race to the Moon. *Leadership & Management in Engineering* 12(1): 26-36.

Werrett, Simon
2010 The Astronomical Capital of the World: Pulkovo Observatory in the Russia of Tsar Nicholas I. *The Heavens on Earth: Observatories and Astronomy in the Nineteenth Century.* David Aubin, Charlotte Bigg, H. Otto Sibum, eds. Durham: Duke University Press.

West, Delno C., and August Kling
1989 Columbus and Columbia: A Brief Survey of the Early Creation of the Columbus Symbol in American History. *Studies in Popular Culture* 12(2): 45-60.

Westwood, Lisa D.
2015 Historic Preservation on the Fringe: A Human Lunar Exploration Heritage Cultural Landscape. *Archaeology and Heritage of the Human Movement into Space*. P.J. Capelotti and Beth Laura O'Leary, eds. New York City: Springer Publishing.

Williams, Bina, and Kathy Ishizuka
2005 Ancient Observatories: Chichén Itzá. *School Library Journal* 51(7): 48.

Wilkinson, Lydia
2015 Charting a Course for Effective Scientific Communication: Balancing Accuracy and Promotion around the Virgin Galactic Crash. *2015 IEEE International Professional Communication Conference*.

Wilson, Cecile
2014 Is AMORC Rosicrucian? *Aries Journal for the Study of Western Esotericism* 14: 73-94.

Wilson, H.
1962 Vostoks 3 and 4 Rendezvous, Dock in Orbit. *Aviation Week & Space Technology* 77: 21-29.

Wilson, John, and Xue Litai
1987 Strategic Weapons and Chinese Power: The Formative Years. *The China Quarterly* 112: 541-554.

Wise, Jeff
2008 The Hard Way Back to Earth. *Popular Mechanics* 185(8): 14.

Witze, Alexandra
2011 Shuttle's End Spells Change at NASA. *Nature* 473(7347): 262-263.
2014a Fledgling Space Industry Resolute after Fatal Crash. *Nature* 515(7525): 15-16.
2014b Investigation begins after Fatal Virgin Galactic Crash. *Nature* 10(1038).

Wood, John Edwin
1978 *Sun, Moon and Standing Stones.* Oxford: Oxford University Press.

Woodruff, John M.
2011 Ma(r)king the Popol Vuh. *Romance Notes* 51(1): 97-106.

Worm, Olaus
1655 *Museum Wormianum.*

Xiao, Xiang, Honglei Xu, and Shouzhi Xu
2015 Using IBM SPSS Modeler to Improve Undergraduate Mathematical Modeling Competence. *Computer Applications in Engineering Education* 23 (4): 603–609.

Yegorov, A.D.
1979 *Results of Medical Studies During Long-Term Manned Flights on the Orbital Salyut-6 and Soyuz Complex.* D.C.: NASA.

Young, Amanda
2009 *Spacesuits: The Smithsonian National Air and Space Museum Collection.* Brooklyn: Powerhouse Books

Zimmerman, Larry J.
2010 "WHITE PEOPLE WILL BELIEVE ANYTHING!" Worrying about Authenticity, Museum Audiences, and Working in Native American–Focused Museums. *Museum Anthropology* 33(1): 33-36.

Zorich, Zach
2010 Popol Vuh Relief. *Archaeology* 63(1): 23.

Zou, Wei, Chunlai Li, and Zhoubin Zhang
2014 Scientific Data and Their Release of Chang'E-1 and Chang'E-2. *Chinese Journal of Geochemistry* 33(1): 24-44.

Zytaruk, Maria
2011 Cabinets of Curiosities and the Organization of Knowledge. *Letters in Canada* 80(1): 1-23.

APPENDIX A

SAMPLE EXHIBIT CODIFICATIONS

Location: The Chabot Space and Science Center's

Title: *Cosmos 360: The Home Galaxy*

Exhibit type: Planetarium show (6/6/14 script)

preMao, preMao, preMao, preMao, preMao, preMao, preMao/Astr/Gk4, preMao/Astr, Astr, Hu/Astr, Hu/Astr, preHu/Astr, preRm/Astr, Gk5, Gk5, Astr, Astr, P*preEuro, P*preEuro/Astr, preGer, P*preGer/Euro, P*preGer, P*preGer, P*preGer, P*preGer, P*preGer/Euro, Astr, Astr, Astr,, Astr, Astr, Astr, P*preGer, Astr, Astr, Sol, Astr/Sol, Astr, Astr, Sol, Astr, preInd5, preInd5, preInd5, preInd5, Astr, Astr, Sci, Sci/Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, preMaya, preMaya, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Asr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Astr, Hu, P*preGer/Euro, Astr, Astr, Gk4, Gk4, Gk5

Location: The Chabot Space and Science Center's

Title: *Cosmos 360: Fast and Curious* -- *Humans in Space*

Exhibit type: Planetarium show (6/28/13 script)

Astr, Hum/Astr, Hum/Mo, +preHum, preHum, Hum/Astr, Hum/Astr, preHum, Int1, +preUS1, +preP*US1, -preP*US1, Sci, Sci, Sci, +preP*US1, +preUS1/Sci, Sci, -preP*US1, +Rus2/Mo, Rus2/Sci/preP*Euro, Sci, preP*Euro/Sci, P*Rus3/Rus2, P*Rus3, +P*Rus3, Mo, Sci/Mo, US3/Mo, +US2/Mo, Sci, US3/Mo/US2, US2/Mo, Mo, +US2, P*US3, US2/Mo, US1/Int1, US1/US2/IS1, IS1/Mo/Ma/US1, IS1, IS1/Mo, Hum, +US2/Ma, Ma, Hum/Sci, Hum/Ma, Ma, US2/Ma, US2/Ma, Rus3/Am3, P*US3/Plu, +P*US3/Plu, US2/Ju, US2/US1, Plu, P*US3/US2Plu, US2/Astr, Astr, US2, Sci, Brt2, Brt2/US2, Brt2/Astr, +Brt/US, US/Brt2, Fi, Fi, +Fi, Hu, Hu/Sci, Fi, P*Am/Gr, P*Am/Gr, Fi, Sci, P*Am/Gr, Sci, Astr, Ju, US2, Astr, Astr, Hum, Gk4, Gk4/Gk5, Gk4/Sa, Gk4, Gk4

APPENDIX B

REQUEST TO DISCUSS INSTITUTION

Hello,

My name is Liam Townsend, and I am conducting research for my Master's thesis in anthropology, with an emphasis in museum studies, at California State University, Chico. This thesis, which I intend to publish, will primarily examine how space and science museums present exhibits with cultural and international content.

With your permission, I would like to include the [NAME OF INSTITUTION HERE] in this study. This will include the use of your institution's name, exhibition titles, and a discussion of your institution's exhibit content. This might also include sample quotes of informational labels and panels, and example photographs of exhibit content; if you prefer that these be omitted from the study, but are otherwise fine with my discussing your museum in the thesis and in future publications, please notify me in your response to this email.

Should you agree to participate in this study, you will be notified of my results upon completion of the thesis, as well as any follow-up publications in which your institution is discussed thereafter. I will also provide access to a digital copy of my thesis.

The participation of your institution in this research project would be greatly appreciated. Thank you for your consideration.

Please do not hesitate to contact me with any questions or comments at wtownsend1@mail.csuchico.edu or (530) 559-1570.

Sincerely,

William "Liam" Townsend

APPENDIX C

California State University, Chico
Chico, California 95929-0875

Office of Graduate Studies
530-898-6880
Fax: 530-898-3342
www.csuchico.edu/graduatestudies

October 28, 2015

William R. Townsend
600 N. Harbor Blvd, Unit #24
La Habra, CA 90631

Dear William,

As the Chair of the Campus Institutional Review Board, I have determined that your proposal entitled: "Representation of International States, Societies, and Cultures in 21st Century Space-Themed Exhibits: An Anthropological Inquiry into the Pacific Northwest" is exempt from full committee review and given the "After-the Fact" Approval.

Now that your data collection is complete, you will need to turn in the attached Post Data Collection Report for final approval. Students should be aware that failure to comply with any HSRC requirements will delay graduation. If you should have any questions regarding this clearance, please do not hesitate to contact me.

Sincerely,

John Mahoney, Ph.D., Chair
Human Subjects in Research Committee

Cc: Georgia Fox, zip 400

The California State University

HUMAN SUBJECTS IN REVIEW COMMITTEE

Post Data Collection Questionnaire

Under Federal law relating to the protection of Human Subjects, this report is to be completed by each Principal Investigator at the end of data collection.

Please return to: Marsha Osborne, HSRC Assistant
Office of Graduate Studies
Student Services Center (SSC), Room 460
CSU, Chico
Chico, CA 95929-0875

Or Fax to: Marsha Osborne, 530-898-3342

Name: William R. Townsend Chico State Portal ID# 006522374

Phone(s) 530-559-1570 Email: LiamTown1958@gmail.com

Faculty Advisor name (if student): Dr. Georgia Fox Phone 530-898-5583

College/Department: Anthropology

Title of Project: Representation of International States, Societies, and Cultures in 21st Century Space-Themed Exhibits: An Anthropological Inquiry into the Pacific Northwest (Now titled: "The Representation of International States, Societies, and Cultures in Twenty-First Century Space-Themed Exhibits: An Anthropological Inquiry of Museums in California, Oregon, Washington, and British Columbia."

Date application was approved (mo/yr.): 10/2015 Date collection complete (mo/yr.): 11/2016

How many subjects were recruited? 244 How many subjects actually completed the project? 121

***HARM**--Did subjects have severe reactions or extreme emotional response? No

If yes, please attach a detailed explanation:

Your signature: Date: April 1st, 2017

***Final clearance will not be granted without a complete answer to this question.**

Approved By: Date: 4/13/17
John Mahoney, Chair

****

VERY IMPORTANT: If you will or have used this research in your project or thesis you are required to provide a copy of this form (with John Mahoney's signature in place) to your graduate committee.

Do you want a photo copy of this form emailed to you? Yes
If yes, provide email address: LiamTown1958@gmail.com

APPENDIX D

INFORMED CONSENT

Hello,

I am conducting a research survey as a component of my museum studies Master's thesis at California State University, Chico. This thesis will explore topics related to space and science centers, planetariums, and aerospace museums. Your institution's participation in this survey will greatly benefit this study.

https://www.surveymonkey.com/s/spacemuseumsurvey

This survey consists of 25 questions, and should take approximately **3 - 10 minutes** to complete. The use of your institution's name is not required, but is encouraged. The survey will only be available until **August 1st**.

Please also consider forwarding this survey to anyone at your institution that is involved in designing exhibits, planetarium shows, and/or curating space-related objects.

Thank you for your time, and please do not hesitate to email me with questions.

Sincerely,
William "Liam" Townsend

APPENDIX E

SURVEY RESULTS

1.) What is the name of your institution? (optional)

Answered question: 90
Skipped question: 31

Answer	Number of Survey Takers
Aerospace Museum of California	1
Air Zoo	1
Arizona Science Center	1
Astronomical Society of the Pacific	1
Bays Mountain Park & Planetarium	1
Berkeley County Planetarium	1
Buhl Planetarium at Carnegie Science Center	1
California Science Center	1
Canada Aviation and Space Museum	1
Canada Science and Technology Museum Corporation	1
Carnegie Science Center / Buhl Planetarium	1
Charles W. Brown Planetarium	1
Chico Air Museum	1
Clark Planetarium	3
Cradle of Aviation Museum	3
Cranbrook Institute of Science	1
Diablo Valley College	1
East Kentucky Science Center and Planetarium	1
Evergreen Aviation & Space Museum	1
Fort Worth Museum of Science and History	1
Gallery of Scientific Exploration, Arizona State University	1
George Mason University	1
Griffith Observatory	2
Hudson River Museum	1
James H. Lynn Planetarium/Schiele Museum of Natural History	1
Jefferson High School Planetarium	1
Leander McCormick Observatory at the University of Virginia	1
Link Observatory Space Science Institute	1
Louisiana Art & Science Museum	1

March Field Air Museum	2
McKinley Presidential Library & Museum Patricia and Phillip Frost Museum of Science	1
Milwaukee Public Museum	1
Morehead Planetarium and Science Center	1
Mt. San Antonio College Randall Planetarium	1
Museum of Science and History	1
Museum of Science and Industry, Chicago	1
Museum of Science, Boston	1
Museum of Science, Charles Hayden Planetarium	1
Museum of York County	1
Neag Planetarium at the Reading Public Museum	1
New Jersey State Museum	1
New Mexico Museum of Natural History and Science	1
New Mexico Museum of Space History	3
Pace University	1
Palouse Discovery Science Center	1
Peterson Air and Space Museum	1
Pima Air & Space Museum	2
Pink Palace Museum	1
Ralph Mueller Planetarium	1
Red Rocks Community College	1
Reuben H. Fleet Science Center	1
Robeson Planetarium and Science Center	1
Rochester Museum & Science Center / Strasenburgh Planetarium	3
Saint Louis Science Center	1
Schiele Museum of Natural History	1
Science Museum Oklahoma	1
Smithsonian National Air and Space Museum	5
Sudekum Planetarium at the Adventure Science Center	1
TELUS World of Science – Edmonton	1
The Manitoba Museum	1
The Museum of Flight	4
The New Mexico Museum of Natural History & Science	1
The Schiele Museum of Natural History and Planetarium	1
The Space Station Museum	1
Tulsa Air and Space Museum and Planetarium	1

University of Maryland	1
US Space & Rocket Center	1
Virginia Living Museum	3
Wm. McKinley Presidential Library & Museum	1

2.) What is your occupational title at the institution? (optional)

Answered question: 118
Skipped question: 3

Director of Education	Director
Planetarium Director	Observatory Manager
Postdoctoral Fellow	Curator
Curator of Collections	Director of Exhibits
Assistant Director of Space Science	Museum curator
Teacher of Earth/Space Science and Planetarium Director	Astronomy Curator
Director of Education	Head Librarian
Exhibit Designer, Space Artist & Public Show Producer	Curator of Aviation
Outreach Coordinator	Corporate Secretary, Member of Board of Directors.
Exhibit Project Manager	Deputy Director
Events Coordinator/Discovery Dome Facilitator	Exhibit Designer
Board Member and one of the Founders	Collections Manager
Astronomy educator	Archivist
Curator	Senior Exhibits Fabricator
Manager of Planetarium and Science Programs	Manager of the Planetarium
Director of Exhibits and Curation	Collections Specialist
Exhibition Design Chair	Exhibits Assistant Graphic Artist
Planetarium Director	Museum Curator
Exhibition Project Manager	Director of Collections and Aircraft Restoration
Associate Professor	Assistant Curator
Science Visualizer and Presenter, Charles Hayden Planetarium	Planetarium Director
Head of Interpretation	Education Manager
Astronomy Professor	Planetarium Director
Former planetarium director	Planetarium Director
Officer, Exhibition Interpretataion	Planetarium Manager

Museum Specialist	Planetarium Producer
Curator of Education	Museum Curator, Space History (Human Spaceflight)
School Coordinator	Curator Supervisor
Planetarium Educator (we don't have a planetarium director, I am the only designated planetarium staff person)	Education/Exhibits Manager
Faculty Lead - Astronomy	Curator
Professor	Curator/Scientist
Senior Scientist	Technical Director
Graduate student	Deputy Director
Chief Science Officer ans Senior Astronomer	Production Manager
Associate Professor	Educator
Senior Educator, Planetarium	Planetarium Director
Planetarium Manager	Astronomer & Exhibition Developer
Planetarium Manager	Deputy Director
Curator	Executive Assistant
Planetarium Director	Creative Manager
Director	Executive Director
President	IT Manager
Planetarium Supervisor	Director
Planetarium Director	Director, Exhibitions and Theaters
Panetarium Director	Planetarium Director
Star Trekker	Collections Manager
Instructor	Science Curator
Planetarium Manager	Community Engagement Manager
Planetarium Program Manager	Assistant Director, Advancement
Planetarium Producer	Planetarium Director
Science Visualizer	Assistant Director / CFO
Planetarium Supervisor	Curator
Producer	Art and Collection Manager
VP Science and Director, Planetarium and Space Sciences	Planetarium Director
Director, Exhibit Design and Development	Administrator
Assistant Planetarium Director	Marketing Director
President and CEO	Director
Head of Astronomy/Exhibits	Executive Director
Planetarium/Science Gallery Programs Supervisor	Director

3.) Using your best judgment, what is the approximate size of your institution in terms of budget, staff size, square footage, etc?

Answered question: 120
Skipped question: 1

Answer Options	Response Percent	Response Count
Small	21.70%	26
Medium	45.80%	55
Large	32.50%	39

4.) In what state, territory, or province is your institution located?

Answered question: 121
Skipped question: 0

Answer Options	Response Percent	Response Count
Alabama	1.70%	2
Alaska	0.80%	1
Alberta	0.80%	1
Arizona	4.10%	5
California	11.60%	14
Colorado	1.70%	2
District of Columbia (DC)	5.80%	7
Florida	3.30%	4
Georgia	0.80%	1
Illinois	0.80%	1
Indiana	2.50%	3
Kansas	0.80%	1
Kentucky	0.80%	1
Louisiana	3.30%	4
Manitoba	0.80%	1
Maryland	1.70%	2
Massachusetts	3.30%	4
Michigan	2.50%	3
Minnesota	0.80%	1
Missouri	0.80%	1
Nebraska	0.80%	1

New Jersey	1.70%	2
New Mexico	4.15%	5
New York	9.10%	11
Newfoundland and Labrador	0.80%	1
North Carolina	4.10%	5
Ohio	3.30%	4
Oklahama	1.70%	2
Ontario	1.70%	2
Oregon	1.70%	2
Pennsylvania	2.50%	3
South Carolina	0.80%	1
Tennessee	2.50%	3
Texas	0.80%	1
Utah	3.30%	4
Virginia	4.10%	5
Washington	5.80%	7
West Virginia	0.80%	1
Wisconsin	1.70%	2

5.) Please select all that apply:

Answered question: 99
Skipped question: 22

Answer Options	Response Percent	Response Count
This institution does not have a planetarium	24.20%	24
Custom planetarium shows are made by the institution's staff	61.60%	61
The planetarium includes show not made by the institution (e.g., loaned or purchased from another company)	62.60%	62

6.) How often does your planetarium add shows with new content?

Answered question: 93
Skipped question: 28

Answer Options	Response Percent	Response Count
Very often	5.40%	5
Often	37.60%	35
Sometimes	30.10%	28
Rarely	7.50%	7
Never	1.10%	17
Not Applicable	18.30%	1

7.) Planetarium shows at your institution currently discuss, or have previously discussed, the astronomy of which ancient cultures? (Please select all that apply)

Answered question: 92
Skipped question: 29

Answer Options	Response Percent	Response Count
Not Applicable -- This institution does not have a planetarium	18.50%	17
None	4.30%	4
Africa; non-Egyptian	18.50%	17
Aztec	19.60%	18.00%
China	27.20%	25
European megalith cultures (e.g., Stonehenge)	19.60%	18
Egypt	42.40%	39
Greece	53.30%	49
India	5.40%	5
Japan	13.00%	12
Maya	32.60%	30
Mesopotamia	9.80%	9
Native North Americans	57.60%	53
Rome	32.60%	30
Russia (pre-spaceflight)	1.10%	1
Other (please specify)	9.80%	9

Written responses to “Other (please specify)”	Response Count
Polynesia	3
Norse	1
Scandinavia	1
Hawai'ian	1
Inca	1

8.) What ancient societies does your institution’s current or former exhibits mention when discussing how ancient cultures used astronomy? (Please select all that apply)

Answered question: 93
Skipped question: 28

Answer Options	Response Percent	Response Count
None / Not Applicable	40.95%	38
Africa; non-Egyptian	10.80%	10
Aztec	12.90%	12.00%
China	20.40%	19
European megalith cultures (e.g., Stonehenge)	17.20%	16
Egypt	26.90%	25
Greece	29.00%	27
India	7.50%	7
Japan	6.50%	7
Maya	18.30%	17
Mesopotamia	7.50%	7
Native North Americans	39.80%	37
Rome	23.70%	22
Russia (pre-spaceflight)	2.20%	2
Other (please specify)	5.40%	5

Written responses to “Other (please specify)”
Middle Ages Arabic
Polynesia (navigators); by Mesopotamia, I'm including Persia, Babylon, and the Islamic centers of learning

9.) **When planning for exhibits or exhibitions on how ancient cultures used astronomy (e.g., Aztec, Mayan, Egyptian, etc), what resources do you and other researchers at your institution use? (Please select all that apply)**

Answered question: 95
Skipped question: 26

Answer Options	Response Percent	Response Count
Not Applicable	36.80%	35
Academic journals	24.20%	23
Astronomy textbooks	41.10%	39.00%
Academic books	43.20%	41
Non-acedemic books	20.00%	19
Exhibits at other museums are referenced	26.30%	25
Magazines	12.60%	12
Television programs / Films	12.60%	12
Government websites	18.90%	18
YouTube	5.30%	5
Wikipedia	15.80%	15
Other internet sites	29.50%	28
Advice from professionals and experts outside the institution	38.90%	37
Memory / former personal research	22.10%	21
Other (please specify)	12.60%	12

Written responses to "Other (please specify)"
NASA websites and University workshops
Our director is a leader in historical astronomy
We have limited exhibit space.
The Observatory Director is one of the world's foremost archeoastronomers
Local Astronomy Organizations and Colleges
We have an archaeologist on staff who has worked several local sites in NM such as Wizard's Roost, Three Rivers, and others. We also work closely with local astronomers. We are fortunate to have living nearby Alan Hale of comet Hale-Bopp fame.
Internal experts on staff

10.) Exhibits, including labels and panels, are designed in-house (your institution does not use external exhibit design firms.)

Answered question: 88
Skipped question: 33

Answer Options	Response Percent	Response Count
Always In-House	23.86%	21
Often	45.45%	40
Sometimes	22.73%	20
Rarely	4.55%	4
Never In-House	3.41%	3

11.) When designing new exhibits, the institution places greater focus on designing exhibits that use objects already in the institution's collection rather than exhibits which require acquiring new collections.

Answered question: 88
Skipped question: 33

Answer Options	Response Percent	Response Count
Always	11.36%	10
Often	46.59%	41
Sometimes	31.82%	28
Rarely	2.27%	2
Never	7.95%	7

12.) Your institution is reliant on collections of objects or artifacts (whether already acquired or to be acquired) when brainstorming for future exhibits or exhibitions.

Answered question: 87
Skipped question: 34

Answer Options	Response Percent	Response Count
Always	12.64%	11
Often	29.89%	29
Sometimes	35.63%	31
Rarely	16.09%	14
Never	5.75%	5

13.) When new collections are donated to your institution, new exhibits are designed and installed to include them.

Answered question: 89
Skipped question: 32

Answer Options	Response Percent	Response Count
Always	0.00%	0
Often	12.36%	11
Sometimes	59.55%	53
Rarely	21.35%	19
Never	6.74%	6

14.) When designing a new exhibit, more consideration goes into acquiring new collections than using collections already in the institution's possession.

Answered question: 89
Skipped question: 32

Answer Options	Response Percent	Response Count
Always	1.12%	1
Often	7.87%	7
Sometimes	23.60%	21
Rarely	53.93%	48
Never	13.48%	12

15.) Your institution creates informational panels or other exhibit content on foreign space agencies for which it has no collections.

Answered question: 89
Skipped question: 32

Answer Options	Response Percent	Response Count
Always	1.12%	1
Often	5.62%	5
Sometimes	30.34%	27
Rarely	30.34%	27
Never	32.58%	29

16.) The institution has experience acquiring or being loaned objects from other museums (If yes, please specify which museums).

Answered question: 81
Skipped question: 40

Answer Options	Response Percent	Response Count
No	32.10%	26
Yes (please specify)	67.90%	55

Answers to "Yes (please specify)"
National Air and Space Museum, National Museum of the United States Air Force, National Museum of Naval Aviation, Royal Air Force Museum, Imperial War Museum, National Museum of the Marine Corps, United States Army Aviation Museum
Smithsonian, New Mexico Museum of Space History, etc
Smithsonian museums
Metropolitan Museum of Art, South Street Seaport, many others
National Air and Space Museum, Kansas Cosmosphere, Huntsville Museum of Art
NASA Langley, Smithsonian Air and Space Museum
We have worked with many museums across Canada and internationally to coordinate object and aircraft loans. Most of our loans have, to date, involved the aircraft side of our mandate.
120 year history - many many loaned objects but not currently on a regular basis
Smithsonian, NASA
Smithsonian
Schiele Museum in Gastonia, NC, Carnegie Museum in Pittsburgh, we are a Smithsonian affiliate so objects from there aw well. American Museum of Natural History - NY
Morehead planetarium and science center
We often seek out and book traveling exhibits, many of which were designed and built at other museums.
Details unknown
I don't know the details
Exploratorium
Not sure, these are questions for the Exhibits team, not the Planetarium staff
University of Alberta (meteorites), NASA (Moon rock)
Many
Smithsonian, National Naval Aviation Museum, Museum of the Air Force, etc.
We loan our artifacts out all over the country.
Canadian Museum of History, Canadian Museum of Nature, Canadian Science and Tech Museum, Canadian Aviation and Space Museum
Smithsonian National Air & Space Museum, Kansas Cosmosphere & Space Center, National Museum of the USAF, National Museum of Naval Aviation, National Museum of the Marine Corps, NASA, Hiller Avaiton Museum, National Soaring Museum

NASM, Air force Museum, Smithsonian, Lemay Car Museum
The Smithsonian has deep and longstanding relationships with museums all over the world: too many to list.
State Museum of Virginia
Several but I do not know the names off the top of my head.
NASA Moonrocks
Burke Museum
Smithsonian, NASA, Field, Regional and Local University collections.
Smithsonian
National Museum of Naval Aviation, Museum of History and Industry, National Air and Space Museum, National Museum of the US Air Force,
Other Smithsonian Museums, NASA, National Maritime Museum (London), Boorhaave Museum (Netherlands), and others.
National Museum of the United States Air Force, National Naval Aviation Museum, Smithsonian Institution
National Air and Space Museum (we are a Smithsonian affiliate), National Museum of the USAF, Insights Museum, NM Museum of Natural History
We work with a variety of industry and cultural organizations
Smithsonian
Carngie Museum of Natural History (Mars Meteorite)
Smithsonian, NASA, National Museum of the Air Force, Meteoritic Museum, National Museum of Nuclear Science and History, US Army TACOM,Kansas Cosmosphere and Space Center, Holloman AFB Museum, NM Museum of Natural History and Science, Insights, Los Alamos Bradbury Museum
Smithsonian
List is too long to include
NASM, NASA, Air Force,
Private collections
uncertain
Multiple but mostly for non-astronomy exhibits
Members of the NISE Network
NASM; USAFM; NASA
Too numerous to mention
Smithsonian Afflitiate, NASA Loan Program, NC Grassroots Science Museums members, York Co. Museum
The Smithsonian
Several
The planetarium has received loans from NASA. The museum has rented traveling exhibits and borrowed vehicles from others all over the US.
NASA
Smithsonian, National Museum of the USAF, US Navy & US Coast Guard & NASA.

17.) The institution has experience acquiring or being loaned objects from which of the following government space agencies (Please select all that apply):

Answered question: 78
Skipped question: 43

Answer Options	Response Percent	Response Count
None; Not Applicable	20.51%	16
Brazilian Space Agency (AEB)	0.00%	0
Canadian Space Agency (CSA)	7.69%	6
China National Space Administration (CNSA)	0.00%	0
European Space Agency (ESA)	11.54%	9
French Space Agency (CNES)	0.00%	0
German Aerospace Center (DLR)	1.28%	1
Indian Space Research Organization (ISRO)	1.28%	1
Italian Space Agency (ASI)	0.00%	0
Japan Aerospace eXploration Agency (JAXA)	0.00%	0
Korea Aerospace Research Institute (KARI)	0.00%	0
Mexican Space Agency (AEM)	0.00%	0
National Aeronautics and Space Administration (NASA)	76.92%	60
Russian Federal Space Agency / Roscosmos (RKA/FKA)	12.82%	10
Ukrainian Space Agency (SSAU)	0.00%	0
UK Space Agency (UKSA)	1.28%	1

18.) The institution has experience acquiring or being loaned objects from major space companies (Please select all that apply).

Answered question: 79
Skipped question: 42

Answer Options	Response Percent	Response Count
None; Not Applicable	50.63%	40
Boeing	25.32%	20
Lockheed Martin	24.05%	19
MacDonald, Dettwiler and Associates Ltd. (MDA)	3.80%	3
Northrop Grumman	13.92%	11
Orbital Sciences	7.59%	6
Raytheon	5.06%	4
Sierra Nevada Corporation	3.80%	3
SpaceX	13.92%	11
Virgin Galactic	6.33%	5
Other (please specify)	17.72%	14

Answers to "Other (please specify)"
ILC Dover
ATK
Others (i.e. Boeing and Lockheed Martin may apply, but I am not certain).
X-Prize
Magellan
SpaceX, Planetary Resources, Blue Origin, Aerojet Rocketdyne
Too many to name; all the large aerospace firms and many of the smaller ones. Also McDonnell Douglas, the airlines, makers of aircraft and rocket engines, manufacturers of aircraft/spacecraft components, flight apparel, etc.
ILC Dover (Apollo space suit)
DCX
Orbital ATK (formerly ATK)
Timkin
ATK
Aerojet Rocketdyne

19.) Your institution would consider creating future exhibit content on foreign space agencies even without relevant objects in its collections.

Answered question: 81
Skipped question: 40

Answer Options	Response Percent	Response Count
Yes	62.96%	51
No (Please explain)	37.04%	30

Answers to "No (Please explain)"
We would be extremely unlikely to consider an exhibit about an agency.
we are an United States Air Force Heritage Program museum and our story line sticks to US heritage objects
We do not have an exhibit space. The planetarium is just used for classes.
Planetarium closed June 10, 2015.
A check-box for "yes" would have been helpful here. We have a close relationship with the CSA, but we strive to present an internationally-balanced view of space science. This past June, we opened and exhibition titled Life in Orbit: The International Space Station. Acquiring authentic items was a challenge. We brought in the international focus through image and media choices, but our artifacts were largely Canadian (CSA and Canadian astronauts' private collections). So in essence, the answer is yes and no ... we want to profile the work of foreign space agencies, but we know that visitors are attracted to and expect authentic objects. Our interpretation needs to be focused on what visitors can see in the exhibition.
limited exhibit space in the Planetarium and we are a State institutuion so we focus on New Jersey and the US
As a government-owned museum dedicated to local objects, exhibit content on foreign space agencies doesn't make much sense to us.
We don't plan any new exhibits in the forseeable future
Limited space for exhibits. Our exhibits are about astronomy content not space programs.
Space is not currently a major focus of our exhibits. However our permanent exhibits will undergo a major renovation in the coming years, and will include a new focus area on space.
Planetarium shows could be considered.
Not as an institution, but in the planetarium we would consider this.
Not sure, these are questions for the Exhibits team, not the Planetarium staff
Exhibits are built around artifacts
Our museum is focused on the natural environment of Virginia - we have never done an exhibit on foreign space agencies.
Hard to make a Tulsa connection, which is the basis for the museum.
Our entire exhibit program is permanent.
We might include content within a larger exhibition, but without supporting/illustrative artifacts we probably would not do a discrete exhibit on this topic.
Not in current plans. Change of philosophy.

Not my area of expertise or responsibility but... current exhibit space has become limited and a major amount of soace has been dedicated to NASA.
If an exhibit was created, it would be based off the relevant object(s).
Our exhibit program is like that of a science center, we are not collections based at all. This negates much of your survey questions for us. Since we are not collections based, the answer to #20 is no.
we're a local history museum
While Planetarium staff is very interested in these topics and believe such exhibits or programs could be well done and engage visitors, senior management does not.
The focus of the Museum is the Virginia environment
I would say this isn't a definite "no", more like a "probably not". We may mention a foreign space agency in an exhibit, but it would not be a whole exhibit about the agency without some artifacts to show.
This topic is not particularly relevant to our audience. Having no collection to back up the panels is difficult. We would consider as a secondary option, but not as a featured option.
Text panels and videos can only go so far and are often contain material accessible via the Internet. In order to attract visitors, we have to have something they can't experience at home.
We focus exhibits on hands-on interactive experiences that teach science pricipals. Nothing kills audience interest quite as fast an exhibit that communicates a history lesson. We are not a museum - we're a planetarium with an exhibits area.
While we might mention a contribution unless you have visual or interactively not relevant for guests.

20.) Would your institution be interested in working with foreign space agencies to acquire or receive loaned objects in the future?

Answered question: 79
Skipped question: 42

Answer Options	Response Percent	Response Count
Yes	73.40%	58
No	26.60%	21

21.) How frequently does your institution rotate its exhibits and exhibitions?

Answered question: 79
Skipped question: 42

Answer Options	Response Percent	Response Count
Often	20.25%	16
Sometimes	46.84%	37
Rarely	29.11%	23
Never	3.80%	3

22.) Has your institution created past exhibits or exhibitions on non-Russian, non-American space agencies which are no longer on display? If yes, please discuss.

Answered question: 77
Skipped question: 44

Answer Options	Response Percent	Response Count
No	94.81%	73
Yes (please list)	5.19%	4

Answers to “Yes (please list)”
I assembled the ESA Gaia Space Telescope from scratch which was part of a six space telescopes Exhibit from Past to Future
Yes, but in Canada the CSA is our main ally and focus in interpreting space science. Our current exhibition replaces a previous ISS-focussed exhibition that profiled key aspects of "living in space" and highlighted Canadian contributions to the ISS project.
Information boards on ESA
Brief inclusion of Ariane (ESA) launch vehicle in an exhibit.

23.) Does your institution currently have exhibits or exhibitions on non-Russian, non-American space agencies? If yes, please discuss.

Answered question: 79
Skipped question: 42

Answer Options	Response Percent	Response Count
No	84.81%	67
Yes (please list)	15.19%	12

Answers to "Yes (please list)"
Indian Space Research Organisation China National Space Administration European Space Agency
We have a Space Telescope Exhibit on display at the Strasenburgh Planetarium that is part of the Rochester Museum
Images and posters from the Hubble Space Telescope.
Our main focus so far has been on Canadian space science. That said, we strive to keep an international "lens" as we interpret - showcasing Canada in the broader context of international projects.
To some extent we have content from our Canadian Space Agency but that is primarily photo based.
Our exhibits related to the International Space Station include information on the various partner space agencies and their programs.
ISS-related
European, Japanese, some Canadian, pretty much agencies associated with the Space Shuttle and ISS.
We have exhibits on non-space aviation, including WWI, WWII, Birth of Flight, etc.
Soviet/Russian Space Agency content and objects in our Space Race exhibition hall.
Models provided by European and Indian Space Agencies
Many ESA objects

24.) Would your institution consider creating exhibit content on non-Russian, non-American space agencies in the future?

Answered question: 78
Skipped question: 43

Answer Options	Response Percent	Response Count
Yes	65.38%	51
No (please list)	34.62%	27

Answers to "No (please list)"
We present findings and results from space missions in current-events planetarium shows and in large photos for our lobby. That gives us more than enough to keep up with. I detect no interest from our audience in an exhibit about an agency.
Unlikely
Our museum on discusses US Air Force heritage
This is not a museum, there is no staff to do exhibits or place to put them.
Planetarium still exists, but closed June 10, 2015
Again, as a State Museum we focus on NJ and the US not on foreign content unless it relates to our collection or NJ in some way.
Maybe if we were loaned an object or objects, but it would have to have a connection to the Carolinas, and that seems unlikely.
No new exhibits in the forseeable future
There simply doesn't seem to be a logical motivating factor, like a local connection to a foreign space agency or program.
Not as an institution, but the planetarium itself would be interested.
The planetarium, yes, the insitution, not so much.
We are refurbishing our current space gallery in 2016 and would like to include more information and interactive exhibits on various space programs.
We are a natural history museum focused on the state of Virginia and do not generally do exhibits on foreign space agencies.
See question 19.
Our exhibit program is permanent.
For this response, I wish I had a maybe option. I am not in charge of designing exhibitions, and I cannot tell if the curator would include such an exhibit.
Probably not, Somewhat outside the scope of our mission, which focuses on the natural history, and relevant science, of New Mexico.
Unless it was impacting overall exploration of the Solar System or the Universe, we'd probably stay away from it
My institution would consider the creation but would need appropriate funding
We are not collections based.
Only local history

Planetarium staff would be enthusiastic, but senior management is not.
Our focus is the Virginia Environment
Not within our master plan.
This is not particularly interesting to our audience as a natural history museum. I could see the topic discussed as a part of a larger exhibit on the future of space flight or a historical perspective on man reaching toward space as a new frontier.
Only if they had a hands-on exhibit that was educationally valuable and that was unavailable from other, less complicated sources.
We are space limited.

25.) When planning for exhibits or exhibitions on 20th and 21st century space history, what resources do you and other researchers at your institution use? (Please select all that apply)

Answered question: 77
Skipped question: 44

Answer Options	Response Percent	Response Count
Not Applicable	19.48%	15
Academic journals	49.35%	38
Astronomy textbooks	50.65%	39
Academic books	62.34%	48
Non-acedemic books	44.16%	34
Exhibits at other museums are referenced	51.95%	40
Magazines	37.66%	29
Television programs / Films	35.06%	27
Government websites	61.04%	47
YouTube	16.88%	13
Wikipedia	24.68%	19
Other internet sites	40.26%	31
Advice from professionals and experts outside the institution	62.34%	48
Memory / former personal research	37.66%	29
Other (please specify)	9.09%	7

26. Do you have any other comments, questions, or concerns? (optional)

Answered question: 20
Skipped question: 101

Written Answers
To clarify, the Starlab is a portable planetarium which uses premade cylinders, but in house created shows to present to schools and the public.
I object to the Survey Monkey format, in which I cannot see the next question until I have answered the present one. As I proceeded through your survey, I got the idea that you are trying to make the case for an exhibit about foreign space agencies -- or maybe about ancient cultures. I'm not sure what your point is. I wish you had made a statement of your general purpose at the start, then allowed me to see all the questions before beginning.
I plan on designing and building more Space Exhibits for Planetariums and space companys
Didn't know if I should fill out the survey since our planetarium just closed.
Sounds like an interesting topic of study - best of luck with your paper. A thought - by only offering the comment box for some answers and not others, you might miss some of the context (i.e. you will know why people said know, but not why they said yes). Also, there is a different nuance for Canadian institutions answering these questions. While US and Russia have been the main players in space science, our mandate and partners mean that we focus largely on the CSA as the entry point to the larger "story." We don't approach space as a "two character story" (or presume that visitors will) and can't classify the CSA as an "other" agency. We address the CSA with a similar centrality that an American institution would place on NASA. Hope this is helpful.
We would be interested in exhibiting space flight from other agencies around the world.
Our institution does not focus on anything space related except in the planetarium. In the planetarium, we are open to creating content various content, U.S. focused or not. In the planetarium, we rotate our show schedule every 3 months and often include content made in house. We use a variety of resources to produce content from academic and astronomy books to astronomy professionals.
In future surveys, it may be helpful to disassociate planetarium and institution. For many what's occurring the the dome is vastly different than what's occurring in the institution itself.
I would love to see the results of this study!
Our exhibits are fairly new, having been developed over the 8 years. As we go forward with revisions in the future, we will be adding more information about both foreign governmental space programs and private commercial programs. We have some information available on these and are planning to expand that coverage. Accompanying artifacts certainly make the exhibits more interesting to the public, however they are not necessary to tell the story. They're just icing on the cake as it were
Survey does not easily encompass experience at the National Air and Space Museum.
Good luck with your thesis!
We currently do not have a space science curator, and much of the State's exhibit resources, regarding space programs, are invested in the the NM Space History Museum, in Alamogordo, or in the, currently unfinished, NM Space Port Interpretive Center, near Truth or Consequences, NM.
Our museum is very behind in the management and cataloging of the collection, which makes things very difficult for our exhibits department. They have often bought ephemera and photos for our space exhibits when we may have actually been able to support some of it with things that have been donated to us. Hopefully we can change that in the future.
We are a branch of the New Mexico State Government, part of the Department of Cultural Affairs

Cheers!
Your survey assumed too much. You could have built it so that an answer up front that dealt with "Are you collections based" or simiilar could have skipped you through to the end if the answer was no. Any more, most planetariums and science centers are not collections based, especially where it comes to space artifacts.
Your research sounds very interesting, and I would like to see the results when complete if you are willing and able to share them.
The planetarium is newly renovated. We plan to change shows 4x a year. There are exhibits in the planetarium as well as in the museum.
The question on size of museum was not clear. What is considered small, medium or large? Attendance...sq footage, budget?

APPENDIX F

QUANTIFIED INDIVIDUAL SURVEYS

Author’s note: The answers to questions 1 and 2 are omitted to maintain respondent privacy. Completed surveys are included in the data tables below, followed by incomplete surveys. For question 5, the scaling is adjusted so that 0 = no planetarium, 1 = outsourced, 2 = in-house, and 3 = both outsource and in-house. For more information, please refer to the Survey section of *Chapter V: Methodology*.

Q3	Scale: 1-3	2	2	2	1	2	2	1	1	2	3	2	2	2	2	2	1	2	1	3	1	2
Q4	Location	CA	UT	MI	GA	NC	NC	NY	OH	KS	PA	NC	UT	VA	NY	TN	NM	NY	LA	DC	UT	LA
Q5	0-3*	0	3	3	1	3	1	3	2	1	3	2	3	3	3	3	1	1	3	3	3	3
Q6	0-5	0	4	4	4	2	4	2	4	2	4	4	3	2	4	3	2	2	4	2	4	1
Q7	#	0	8	2	8	1	3	7	7	0	10	5	6	4	4	5	0	3	6	11	3	2
Q8	#	0	0	1	7	3	3	7	7	0	6	7	0	1	4	5	1	0	0	1	0	1
Q9	#	0	0	13	7	4	6	6	5	4	6	8	0	2	8	6	1	0	3	8	0	0
Q10	0-4	3	2	4	3	3	4	4	4	3	4	1	3	2	3	2	2	4	2	3	3	2
Q11	0-4	3	2	3	2	2	3	2	4	3	2	2	2	3	2	0	2	4	2	3	1	0
Q12	0-4	2	1	3	2	3	3	1	3	4	2	1	1	2	2	0	2	4	2	2	1	2
Q13	0-4	1	1	2	2	2	2	2	2	2	3	2	2	2	2	0	3	3	2	2	1	1
Q14	0-4	1	2	1	1	1	3	2	1	1	3	3	1	1	1	0	2	0	2	1	1	1
Q15	0-4	1	1	0	0	1	0	1	1	1	2	1	0	1	1	0	2	0	0	2	0	0
Q16	0 or 1	1	1	1	1	1	1	1	0	3	0	1	0	1	1	0	1	3	0	1	1	0
Q17	#	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	2	3	0	1
Q18	#	1	1	0	1	0	0	0	2	0	0	0	2	0	3	0	1	0	0	4	1	0
Q19	0 or 1	0	0	1	1	0	0	1	1	0	1	1	1	0	1	0	1	0	1	1	0	0
Q20	0 or 1	0	0	1	1	1	1	1	1	1	0	1	1	0	1	0	1	0	1	1	0	1
Q21	0 - 3	2	2	2	2	2	3	3	1	2	3	2	1	2	1	1	1	2	3	2	0	1
Q22	0 or 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q23	0 or 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Q24	0 or 1	0	0	1	1	1	0	1	1	1	0	1	1	0	1	0	1	0	1	1	0	1
Q25	#	3	0	13	10	8	9	6	6	4	6	7	1	0	11	9	4	4	2	7	0	0

Q3	3	2	2	2	3	2	3	2	3	3	2	3	2	2	2	2	3	2	3	3	3	2	2
Q4	PA	NM	PA	NE	OK	NY	AZ	NM	DC	WA	TX	WA	NM	CA	CA	OK	WA	VA	DC	WA	OR	KY	MB
Q5	3	3	3	3	1	3	0	2	3	0	2	0	3	1	2	3	0	3	3	0	0	1	1
Q6	2	1	2	4	2	4	0	1	4	0	2	0	4	1	2	2	0	4	4	0	0	4	1
Q7	2	3	3	2	3	3	0	1	1	0	8	0	3	0	3	4	0	10		0	0	6	3
Q8	0	4	7	1	2	2	1	8	10	0	2	0	8	0	2	4	0	5	0	3	5	0	3
Q9	0	6	5	2	4	6	4	5	7	0	10	0	11	0	2	5	0	11	0	0	5	0	5
Q10	4	3	1	2	2	3		3	4	3	4	3	3	4	2	3	3	3	3	4	3	1	3
Q11	2	3	0	2	3	3	4	3	3	2	3	2	3	3	2	3	3	4	4	4	3	3	3
Q12	2	2	4	2	3	1	3	3	4	3	4	1	3	3	1	3	2	3	4	3	3	3	3
Q13	1	2	1	3	3	3	3	2	2	2	2	1	2	2	1	2	2	2	2	3	2	2	2
Q14	1	1	0	2	1	2	2	2	1	3	2	3	1	1	1	1	2	1	1	1	1	1	1
Q15	2	4	2	1	0	2	1	2	2	1	1	2	1	2	1	0	2	0	1	2	3	2	0
Q16	1	1	0	1	0	1	3	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	1
Q17	1	3	0	1	1	2	1	4	2	1	2	1	1	1	1	1	4	1	4	4	1	1	2
Q18	0	7	1	0	3	3	1	4	8	2	1	1	0	0	1	0	2	0	5	10	2	0	2
Q19	0	1	1	1	0	1	1	1	0	1	1	1	1	1	0	0	1	0	0	1	1	1	1
Q20	0	1	1	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1
Q21	2	2	2	2	1	2	2	1	2	2	2	1	2	2	0	2	0	2	2	3	1	2	1
Q22	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Q23	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	1	1	0	0
Q24	0	1	1	1	1	0	1	1	1	1	1	1	0	0	0	0	1	0	1	1	1	1	1
Q25	0	11	4	7	0	7	6	9	5	0	6	8	12	4	0	0	9	11	9	13	11	3	10

Q3	3	1	3	2	2	3	2	3	1	3	3	3	2	1	1	2	3	2	1	2	3	1	1	2
Q4	ON	WV	CA	MI	MI	IL	AB	MA	CA	CA	AZ	AZ	TN	CA	NC	NJ	CA	SC	AL	FL	MO	VA	WA	NJ
Q5	0	3	2	3	0	0	3	3	3	2	3	3	1	0	3	3	2	1	0	3	2	0	2	1
Q6	0	4	2	4	0	0	1	4	4	3	2	2	2	0	4	4	2	4	0	2	5	0	2	4
Q7	0	5	2	2	0	0	5	7	7	4	7	6	5	0	6	9	4	4	0	1	9	0	4	1
Q8	0	0	0	0	3	0	5	3	7	0	0	0	6	0	6	0	0	0	0	0	1	0	0	1
Q9	0	0	3	0	3	0	7	1	7	0	4	2	5	0	4	8	1	0	0	4	2	0	0	0
Q10	2	0	4	3	2	3	3	2	4	2	2	2	2	3	2	0	2	2	0	3	3	4	4	3
Q11	3	0	0	3	3	2	2	2	2	0	3	3	3	3	3	3	2	3	0	3	3	4	3	3
Q12	3	3	0	3	2	2	1	2	2	0	2	2	2	4	2	1	2	3	0	2	2	1	2	4
Q13	2	0	1	2	2	1	2	2	2	0	1	1	2	2	3	2	1	2	0	2	2	2	1	2
Q14	1	0	0	1	1	2	1	2	1	0	1	1	2	1	1	1	1	1	0	2	2	1	0	1
Q15	2	0	0	1	2	2	2	2	2	1	1	0	1	2	2	1	1	0	0	1	1	1	0	1
Q16	1	0	0	1	1	1	1	2	0	1	1	1	1	0	1	1	0	1	0	1	1	0	0	1
Q17	2	1	0	4	1	1	2	1	0	1	1	1	1	0	2	1	1	1	0	0	1	1	0	1
Q18	3	0	0	3	0	5	0	1	0	0	1	1	0	2	1	0	2	0	0	0	2	0	0	0
Q19	0	0	0	1	1	1	1	1	1	1	0	0	0	1	1	0	0	0	1	1	1	1	1	0
Q20	1	0	0	1	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	0
Q21	1	0	1	3	2	3	2	1	1	3	1	1	3	3	2	1	1	3	0	3	1	1	1	3
Q22	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Q23	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q24	1	0	0	1	1	1	0	0	1	1	0	0	0	1	1	1	0	0	0	1	1	1	1	0
Q25	10	1	0	13	5	4	11	0	9	0	0	0	6	8	10	0	4	3	0	6	13	0	7	0

Q3	2	3	1	2	1	1	3	1	1	1	2	3	1	2	3	2	3	2	2	2	2	2	3	3	2	3	3
Q4	NC	VA	AL	NY	CO	CA	CA	CA	NY	IN	NM	AZ	AZ	NY	FL	OH	DC	LA	FL	TN	VA	NY	FL	UT	LA	DC	WA
Q5	2	3	0	2	0	0	2	2	1	2	3	0	2	3						3		3			3		
Q6	3	2	0	2	0	0	1	0	1	2	4	0	2	5						4		4			4		
Q7	4	1	1	10	0	0	2	0	3	7	4	0	5	5						4					2		
Q8	1	1	4	3	0	0	0	0	0	6	1	0	5	0						0					1		
Q9	3	6	0	6	0	0	0	0	1	5	5	0	4	0						9					4		
Q10	4	4	3	4	4	4	3	3	3	3	3	3	3	3								3			2		
Q11	2	3	3	3	3	3	1	2	2	3	2	3	3	4								2			2		
Q12	3	1	2	3	3	2	3	2	2	2	1	4	3	2								3			4		
Q13	3	1	2	2	2	2	3	1	1	2	2	1	3	0								2			2		
Q14	3	1	1	1	1	2	3	0	3	0	1	1	2	0								2			1		
Q15	2	0	1	2	0	1	3	0	2	0	2	3	1	0								1					
Q16	1	0	1	1	0	0	1	0	0	0	1	1	0	0													
Q17	0	1	2	0	0	0	0	0	0	1	1	1	0	1													
Q18	0	3	6	0	0	0	2	0	0	0	0	1	0	0													
Q19	1	1	1	1	0	1	0	1	1	1	1	1	1	0													
Q20	1	1	1	1	0	1	1	1	1	1	0	1	1	0													
Q21	3	0	2	2	1	2	1	0	2	2	2	2	2	2													
Q22	0	0	0	0	0	0	0	0	1	0	0	0	0	0													
Q23	0	0	0	0	0	0	0	0	1	0	0	1	0	0													
Q24	1	1	1	1	0	1	1	0	1	1	0	1	1	0													
Q25	6	6	10	7	6	0	4	0	8	5	6	8	9	12													

Q3	3	3	2	2	3	2	1	2	1	1	2	1	1	3	3	3	3	3	2	3	1	3	2	2	1	3
Q4	WA	NY	MD	IN	MA	MN	OH	CA	OR	NL	AK	WI	IN	MD	MA	DC	MA	ON	WI	DC	CA	CA	NT	OH	AL	MA
Q5				3	3				3		0	3	1	0	3		3		3		1				0	3
Q6				4	4				4		1	5	0	0	2		4		4		0				0	4
Q7				4	2				5		1	2	0	0	5		3		7		6				0	7
Q8				0	3				6		1	5	0	0	4		2				8				0	3
Q9				0	8				3		1	4	4	0	4		0								0	1
Q10				3	0				2		2				3										0	2
Q11				2	0				2		2				3										0	2
Q12				2	0				3		2				1										0	2
Q13				0	0				2		2				1										0	2
Q14					0				1		2				2										0	2
Q15					0										2										0	2
Q16																									0	2
Q17																									0	1
Q18																									0	1
Q19																									1	1
Q20																									0	0
Q21																										1
Q22																										
Q23																										
Q24																										
Q25																										