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The Selection of Commercial Astronauts for Suborbital Spaceflight

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THE SELECTION OF COMMERCIAL ASTRONAUTS FOR SUBORBITAL SPACEFLIGHT

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of

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The sky is *not* the limit...

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ABSTRACT

Kozak, Brian J. M.S., Purdue University, December 2010. The Selection of Commercial Astronauts for Suborbital Spaceflight. Major Professor: Denver Lopp.

With the launch of Dennis Tito aboard a Russian Soyuz rocket in 2001 and SpaceShipOne winning the Ansari X-Prize in 2004, the commercial space tourism industry is on the verge of lifting off. In 2007 Burt Rutan spoke about the future of space tourism, “We think that 100,000 people will fly by 2020” (Rutan, 2007). With such a high frequency of suborbital spaceflights, there is a need for qualified crews to operate the spacecraft. The purpose of this qualitative, exploratory study was to investigate the possible selection criteria for suborbital commercial astronauts within the space tourism industry. Data was collected in the form of telephone and email interviews with 4 of the 5 U.S.-based suborbital space tourism companies participating. Purdue University's extensive astronaut alumni network was used to augment data gathered with five astronauts who have flown in space. In addition, Brian Binnie, the pilot who flew SpaceShipOne on its award winning Ansari X-Prize flight, participated. Grounded Theory and Truth and Reality Testing were used as the theoretical framework for data analysis. The data gathered suggests that the commercial astronaut should have at least a Bachelor's degree in engineering, have a test pilot background with thousands of hours of pilot-in-command time in high performance jet aircraft, be confident yet humble in personality, and have a fundamental understanding of their spacecraft, including spacecraft trajectories, and emergency procedures.

CHAPTER 1. INTRODUCTION

This chapter provides a brief overview of the research study. The objectives, relevant background information, scope and significance of the research project are presented. Important definitions, assumptions, limitations and delimitations are also listed.

1.1 Objectives

The purpose of this study was to expand the body of knowledge as it relates to the selection of commercial astronauts for suborbital commercial spaceflight. The research question was: “What are the possible selection criteria for suborbital commercial astronauts within the space tourism industry?”

1.2 Background

When Dennis Tito launched aboard a Russian Soyuz spacecraft to spend a week aboard the International Space Station (ISS), his flight ushered in a new era of adventure tourism. In order to lower the cost of spaceflights, the Ansari X-prize was created to award a cash prize to a non-government entity that flew a reusable spacecraft on a suborbital trajectory to an altitude greater than 100 km twice within two weeks. Burt Rutan's Scaled Composites with their SpaceShipOne was awarded the prize in 2004. Since then, several other companies have emerged with the hope to build and operate a suborbital spacecraft in order to profit from the emerging space tourism market.

1.3 Scope

This research project was designed to examine the selection criteria of commercial astronauts as crew members for suborbital vehicles used in space tourism. Currently, there are five suborbital space companies located within the United States in various stages of research and development of reusable suborbital vehicles. Of these companies, the majority plan to build and operate a fleet of suborbital vehicles with the purpose to generate income from ticket sales. Although some companies are working on both orbital and suborbital spacecraft, only suborbital vehicles were selected to be studied.

This study focused on the selection of flight crews to operate these suborbital vehicles. The study looked to contribute to the body of knowledge as it relates to the creation of selection criteria. Data was collected from the space companies through phone and email interviews and the data was analyzed using Grounded Theory. Key commonalities were discovered and augmented using Purdue's astronaut alumni network.

1.4 Significance

The commercial space industry has shown rapid growth. At the time of this writing, seven spaceflight participants have flown eight flights to the International Space Station at a cost of approximately $25 million (Space_Adventures, 2010). Furthermore, 350 individuals have purchased flights aboard SpaceShipTwo, even though it has not yet flown a test flight (Virgin_Galactic, 2010).

The Federal Aviation Administration's Office of Commercial Space Transportation (FAA/AST) stated that revenue generated from commercial launches “grew almost 100 percent between 2004 and 2008, roughly US $1 billion to nearly U.S. $2 billion” (FAA, 2008, p. 18). This rapid increase in market revenue has generated significant interest among investors. Currently, five

suborbital companies have been founded, mostly by tech savvy billionaire entrepreneurs.

Virgin Galactic, one such company founded by Sir Richard Branson of the Virgin Group, plans to launch suborbital spaceflights on a weekly basis. Once more spacecraft have been built, they plan on launching two or three times per week. With such a high frequency of launches for this one company alone, there has been a need for multiple flight crews and commercial astronauts within this one company. The expected needs of the commercial space tourism industry can be extrapolated based upon the projected launch patterns of these companies to determine the necessary number of commercial astronauts.

One significant problem that exists had been the lack of spaceflight experience by commercial pilots. Before 2004, only government funded spaceflights occurred and since 2004 only two non-government pilots have flown in space. These two test pilots have been the only examples of commercial astronauts. Furthermore, there has been a stark contrast between flying an orbital vehicle and operating a suborbital one. The latter's flight lasts mere hours while an orbital flight could last days or weeks.

The purpose of this project was to create a generalization of the data from commercial suborbital space companies to determine which characteristics a commercial astronaut might possess in such areas as educational background, flight experience, and personality. Due to their actual spaceflight experience, Purdue's astronaut alumni were also used as a source of data to validate the information gathered through interviews with the space companies. The overall goal of the project was to investigate the possible selection criteria of suborbital commercial astronauts.

1.5 Definitions

Several key words and phrases were used throughout this research paper. The Federal Aviation Administration Office of Commercial Space Transportation

(2010a). 2010 U.S. commercial space transportation developments and concepts: vehicles, technologies, and spaceports lists several of these industry specific terminology that were used. They are:

- Emergency: "Means a sudden unforeseen event where vehicle internal or external systems do not perform as planned, which may lead to or cause distress or an urgent condition" (p. 3).
- Flight Crew: "Crew that is on board a vehicle during a launch or reentry" (p. 3).
- Space Flight Participant: "An individual, who is not crew, carried onboard a launch vehicle or reentry vehicle" (p. 3).
- Suborbital Rocket: "A vehicle, rocket-propelled in whole or in part, intended for flight on a suborbital trajectory, and the thrust of which is greater than its lift for the majority of the rocket-powered portion of its ascent" (p. 3).
- Suborbital Trajectory: "The intentional flight path of a launch vehicle, reentry vehicle or any portion thereof, whose vacuum instantaneous impact point does not leave the surface of the Earth" (p. 3).

1.6 Assumptions

The assumptions of this research study include:

- Cooperation of commercial suborbital space companies.
- Cooperation of Purdue's astronaut alumni.
- The companies contacted were far enough along with research and development of their spacecraft to consider selecting a group of commercial astronauts.
- Recorded telephone and email interviews were sufficient to collect data.

- Ability to transcribe interviews in a timely manner.
- Response rates from space companies and astronauts were high enough to generate practical results from this study.
- Funding was unavailable for this study.

1.7 Delimitations

The delimitations associated with this study were:

- The project focused only on suborbital commercial companies located within the United States.
- Only the possible selection criteria of suborbital commercial astronauts was studied and not their training.
- The viability of the companies contacted was not considered.
- Only the data gathered through interviews of suborbital space company representatives and Purdue's astronaut alumni was used.
- The results of this research study were not intended to create a commercial astronaut certification or curriculum.

1.8 Limitations

The study limitations were:

- The research study was exploratory.
- Similarities between different company's spacecraft and subsequent flight crews might be nonexistent such that generalizations from this research study were irrelevant.
- Response rates from companies might be too low to formulate useful conclusions.
- Response rates from astronaut alumni might be too low to formulate useful conclusions.

1.9 Summary

The space tourism industry has been growing rapidly since its start in 2001. Several companies located within the United States have been in the process of building and/or testing privately built experimental suborbital spacecraft with the goal of launching tourists on suborbital spaceflights. The objective of this qualitative, exploratory study was to investigate the possible selection criteria of commercial astronauts for U.S.-based suborbital space tourism companies thus enhancing the knowledge base of information needed to expand safe operation of this exciting industry.

CHAPTER 2. REVIEW OF THE LITERATURE

This chapter provides background information into the space tourism industry as well as a review of literature as it pertains to the selection of government astronauts. United States government policies and regulations of the new space tourism industry are also discussed along with a list of key companies within the suborbital industry.

2.1 Space Tourism

Space and spaceflight have always captured the imagination of millions of people. The awe inspiring images of the curvature of the blue-green Earth next to vast blackness of space while floating in zero gravity has become the ultimate adventure (Cooper, 1987). With the launch of the space tourism industry in 2001, the adventure has now become a reality. The first space tourist/spaceflight participant was multimillionaire businessman Dennis Tito; he was launched on a Russian Soyuz rocket for a seven day stay at the International Space Station (ISS). Since then, seven spaceflight participants have paid roughly $25 million U.S. each for a trip to the ISS (Space_Adventures, 2010). Although space tourism has achieved a reality for private citizens, the extremely high costs of orbital spaceflight has made a flight impossible except for the extremely wealthy.

The Ansari Foundation established the Ansari X-Prize to spur innovation to create a cheaper, reusable launch system which would allow economies of scale to lower the cost of space access. The Ansari X-Prize was a prize of $10 million U.S. awarded to the first non-government entity to build and launch a private

spacecraft having the capability to fly three passengers plus a pilot into space twice within two weeks.

Burt Rutan's Scaled Composites, with financial backing of Microsoft co-founder and billionaire Paul Allen, built SpaceShipOne and their spacecraft won the X-prize in 2004 (Ansari X-Prize Foundation, 2010). SpaceShipOne brought considerable media attention to the possibility of lower cost, private access to space.

At the same time Scaled Composites was building SpaceShipOne, 26 other teams around the world were developing reusable spacecraft and launch systems. Of these teams, approximately 15 are continuing to develop suborbital spacecraft and launch systems, of which 5 are located within the United States. These U.S. based suborbital space companies were selected as participants for this study.

When he was giving a presentation about the future of space tourism, Burt Rutan said “It will be very high volume. We think that 100,000 people will fly by 2020” (Rutan, 2007). With such a high frequency of planned trips into space, there is a need for a large number of flight crews to pilot suborbital spacecraft.

British entrepreneur and billionaire from the Virgin Group, Sir Richard Branson, licensed the technology from SpaceShipOne to build SpaceShipTwo – a larger, more capable and passenger friendly version of its predecessor. Sir Branson started a company called Virgin Galactic to launch tourists on suborbital spaceflights for $200,000 U.S. The company has plans to launch the first group of tourists into space starting in mid-2011. Once the reliability and functionality of the launch system has been established, launches will be planned to take place two or three times per week (Scaled_Composites, 2010; Virgin_Galactic, 2010).

2.2 The First Commercial Astronauts

Scaled Composites' test pilot Mike Melvill became the first commercial astronaut when he flew SpaceShipOne into space at an altitude of 100 km in

2004. Melvill had 23 years of test pilot experience and flown 10 first flights of Burt Rutan's aircraft. Brian Binnie, another Scaled Composites test pilot, flew SpaceShipOne on its historic flight to win the X-Prize in 2004. His flight reached an altitude of 112 km. Binnie flew for the United States Navy for 21 years and graduated from the U.S. Naval Test Pilot School. These two men have been the only current commercial astronauts at the time of this writing (Scaled_Composites, 2010).

The first call for commercial astronauts was in 2006. However, the selection was only open to commercial pilots from the Virgin Atlantic airline. Both Virgin Galactic and Virgin Atlantic are part of the larger Virgin Group which has made the selection faster because the flight records, performance, and medical data were already known within the Virgin Group (Virgin_Group, 2010). Turner wrote, “Four Virgin Atlantic pilots have already been handpicked on the basis of their experience and skills” (Turner, 2006, p. 1). Three of these pilots were former military and aerobatic pilots and all were captains for the Virgin Atlantic airline. These individuals have interdisciplinary piloting experience with emphasis on aerobatic flight. Additionally, they earned Bachelor's degrees in science and/or engineering. These individuals have been planned to be the first commercial astronauts to fly passenger suborbital spaceflights for Virgin Galactic, although the initial testing of SpaceShipTwo will be handled by Scaled Composites' test pilots (Scaled_Composites, 2010; Turner, 2006; Virgin_Galactic, 2010). Once the launch system has become fully operational with biweekly launches, Virgin Galactic expects to have around 30 commercial astronauts, with the future selection criteria is unknown as of this writing (Turner, 2006).

2.3 Review of Government Astronaut Selection

Deke Slayton, one of National Aeronautics and Space Administration's (NASA) first astronauts and head of astronaut selection from 1963 – 1972 said the selection of an astronaut is a complex task that may take up to two years to

complete. Before application, the astronaut candidate must meet certain educational and pilot performance minimums. After the first round of selections, the candidate is interviewed to determine character and motivational values (Slayton, 1994). Once the interviews have been conducted, the candidates are tested on their ability to learn new skills associated with the spacecraft/mission, their work ethic in a high stress environment, and their ability to be a team player. Once the candidates have been selected as astronauts, they are ready to begin training for a mission. The training will last two to seven years depending on the type of mission to be flown (Gargain, 2008; Slayton, 1994).

Slayton wrote, “I had already developed a point system that we used in making the final evaluations on astronaut candidates. There were three parts: academic, pilot performance, and character/motivation” (Slayton, 1994, p. 133). Each has been a separate, independent skill that intertwines with the others to create a well-rounded candidate. These three parts were used to develop the research questions used in this study.

2.3.1 Academic Performance

Spaceflight is a cutting edge, state-of-the-art industry requiring highly educated people because of the interdisciplinary nature of designing, flying and operating a vehicle both inside and outside of the atmosphere. Academic performance and preparedness were a preferred characteristics because flying in space has required a new set of skills mostly unknown to average pilots. Airspeed, lift, drag, thrust and navigation take on new meanings when the vehicle is at 100km in altitude and traveling at Mach 3.
(Godwin, 2006; Scaled_Composites, 2010).

Early astronauts from NASA had to have at least a Bachelor's degree in a related engineering field such as aeronautical or astronautical engineering (Smith, 2005). NASA also wanted professionals who were stable and who had been screened for security because the early space program was a national

security interest (Shepard, 1994). For subsequent astronaut groups, the selection criteria was relaxed slightly to a Bachelor's degree in a physical science or engineering field (Cernan, 1999). Currently, NASA requires a minimum of a Bachelor's degree in science or related engineering for astronaut applicants with more emphasis placed on a Master's degree or Doctorate degree (Cernan, 1999).

Similarly, Soviet/Russian Federal Space Agency (RKA) astronauts[1] were required to have a technical engineering degree (Gagarin, 2008). However, the RKA was less interested than NASA in the particular type of degree that their astronauts earned. They accepted various types of engineering degree as long as it could be somehow related to the space program (Linenger, 2000). Currently, the RKA only accepts astronaut applicants who have a technical engineering degree; a science degree does not qualify (Gagarin, 2008). The desire for highly educated people has also been common to the European Space Agency (ESA). Their astronaut candidates should have a minimum of a Bachelor's degree in a technical, scientific or engineering field. A Master's degree's with several years of related experience prior to application has also been preferred (Messerschmid et al., 2003).

The spaceflight industry has been highly competitive and as a result the quality of academic preparedness has been important. Gene Cernan, a Purdue University graduate who walked on the Moon during Apollo 17, wrote “Receiving a B instead of a B+ in some college course years earlier might be reason enough to pick the other guy” (Cernan, 1999, p.58). The emphasis on educational history was also apparent with the RKA. Most of their astronauts attend university classes during their early years of training to make them more well-rounded astronauts. (Gargain, 2008).

The importance of a science or engineering degree has also been evident when an astronaut has not actually been flying the vehicle because they could

1 Russian astronauts are known as cosmonauts. The author uses the term astronauts throughout the paper to avoid confusion.

assist with flight testing, mission control and program development (Slayton, 1994). The astronaut was able to contribute to improvements in spacecraft design and operation. During Project Apollo, Slayton assigned astronauts to spacecraft development in specific areas in which they had experience. Astronaut Bill Anders was put in charge of radiation shielding for the Apollo spacecraft because he had a degree in nuclear engineering (Slayton, 1994). Likewise in the RKA, astronaut Alexey Leonov worked with the development of the global tracking network because of his experience with military communications (Stafford, 2002).

2.3.2 Pilot Experience

The RKA was the first agency to launch an astronaut into space in 1961; NASA followed with a suborbital spaceflight a few weeks later (NASA, 1963; RKA, 2009). The early astronauts from both agencies were explorers in the brand new field of spaceflight. Both agencies decided to select military test pilots for the first group of astronauts because of their considerable piloting experiences in experimental vehicles (Clark, 1988). Early spacecraft were highly experimental and fraught with danger because the challenges of flying in space were relativity unknown and the technology to travel in space was in its infancy (Harvey, 2004).

NASA wrote, “The astronauts were first and foremost test pilots, men accustomed to flying along in the newest, most advanced, and most powerful vehicles this civilization had produced. They were talented specialists who loved to fly high-performance aircraft and who had survived the natural selection process in their profession” (NASA, 1963, p. 1). Flying experimental vehicles was dangerous and approximately six test pilots died each year testing them (Slayton, 1994). The pilots who did survive were ideal for the space program because they were well-rounded pilots with experience related to the interdisciplinary aspects of flying (Borman, 1988)

The first of the RKA astronauts from the Soviet Union were also test pilots. Alexey Leonov was a MiG 15 pilot with a Bachelor's degree in aeronautics and training in high altitude flight test (Stafford, 2002). Leonov would go on to become the 'chief astronaut' from 1976 – 1982. During his tenure, Leonov was responsible for the selection and training of astronauts for the Buran Program – a reusable space shuttle similar to the NASA's orbiter (Stafford, 2002). Due to the fact the Buran was an experimental vehicle, Leonov selected military test pilots to train as astronauts for the initial flights.

Likewise, during the first few flights of the Space Shuttle / Orbiter, Slayton selected test pilots for the crew. It was an experimental vehicle, with a new concept of landing a spacecraft on a runway, something that had never been tried before. Additionally, the entire vehicle was never launch tested unmanned because there was no way to recover the spacecraft. The first flight of Columbia in 1981 was consequently the first test of the Space Shuttle System. (Slayton, 1994).

Both ESA and RKA have more automated launch processes and more computer controlled spaceflights than NASA. Currently, NASA astronauts land the Orbiter on a runway after a mission while ESA and RKA employ a parachute landing for spacecraft recovery for their Soyuz capsule (RKA, 2009). The astronauts of SpaceShipTwo will need to manually land the vehicle after a flight much like NASA’s astronauts. It is a high performance glider which is similar to the Orbiter. Hence, it could be reasoned the required flight experience for commercial astronauts should be somewhat similar to what NASA requires for their astronauts. Currently, NASA requires astronauts to have a minimum of 1500 hours total flying time in turbine aircraft, with military test pilot experience preferred (Linenger, 2000).

In the early 1980s, the ESA selected test pilots with experience in high performance vehicles as astronauts to fly missions aboard the Space Shuttle and Soyuz (Harvey, 2003). Although the ESA astronauts were not actually piloting their respective vehicles, they had training in their operation should an

emergency occur. Although they were pilots, ESA's astronauts were closer to scientists or researchers because they conducted scientific experiments aboard the Orbiter or Soyuz (Messerschmid, et al., 2003).

Unforeseen problems could occur that might require an astronaut to think quickly in unfamiliar situations. Test pilots regularly work and operate in such environments (Freeman, 2000). On the first flight of suborbital flight of SpaceShipOne there were several anomalies. After engine ignition, the vehicle experienced a failure of an electric trim tab which caused it to roll a total of 29 times at speeds from ranging from Mach 1 to Mach 3 at altitudes in excess of 200,000ft (Scaled_Composites, 2010). SpaceShipTwo, though built on existing technology, it has been a highly experimental vehicle.

2.3.3 Character / Motivation

The quality and type of person selected as a commercial astronaut has also been very important. The astronauts are flying high performance vehicles in extremely hostile environments with little room for error. The physical and physiological stresses are immense (NASA, 1963). An astronaut needs to be calm under pressure and quick thinking (Freeman, 2000). The qualities of test pilots were also very similar. Shepard wrote, “Esprit de corps, pride, honor, dedication, skill, and courage were all qualities required of the men who would become astronauts” (Shepard, 1994, p. 50).

Once a person had been selected as an astronaut, there are years of training before they have been assigned a flight. The astronaut must have the dedication to stay motivated during this time. The astronauts should be patient, as delays with the program are very likely (Harvey, 2007). For example, the first flight of SpaceShipTwo has been delayed for at least three years (Scaled_Composites, 2010). Also, an astronaut with the RKA may wait up to 10 years before a spaceflight (Gagarin, 2008).

Additionally, the commercial astronaut should expect to spend a significant amount of time in simulator training for an upcoming flight. Before a typical ESA mission, the astronaut will train for two to three years in spacecraft operations and mission objectives (Messerschmid et al., 2003). In Russia, the astronauts spend two years learning about their spacecraft and its systems before they train for a specific mission (Gagarin, 2008; RKA, 2009).

The spaceflight will be simulated hundreds of times in order to prepare the astronaut for any emergencies that may occur. The flight simulations have been very similar to aircraft training for pilots. Before his first spaceflight, Alan Shepard made several hundred simulated flights (Wendt, 2001). The astronaut must be able to stay motivated and focused on the task even after hundreds of simulations.

The astronaut must be personally interested in spaceflight. When asked about spaceflight, John Glenn said "How could anyone turn down a chance to be a part of something like this?" (NASA, 1963, p. 1). In addition to a personal interest in spaceflight, the commercial astronaut should be personable and friendly to the passengers. Virgin Galactic is selling tickets on SpaceShipTwo for two hundred thousand dollars. (Scaled_Composites, 2010). It would be expected passengers paying such a large amount of money for a spaceflight would want that their flight crew be friendly and hospitable (Space_Adventures, 2010).

2.4 United States Government Regulations

The regulation of airspace and aircraft within the United States falls under the jurisdiction of the Federal Aviation Administration (FAA). Any vehicle that operates from ground level up to 60,000 ft is subject to FAA inspection and certification. Although suborbital spacecraft operate at altitudes reaching 400,000 ft, they pass through the FAA's jurisdiction and consequently, the flight crews of the spacecraft are subject to FAA certification (FAA, 2010). It is the

understanding of the FAA Office of Commercial Space Transportation (FAA/AST) to limit involvement in the regulation of flight crews. Only current FAA pilot certification requirements would be enforced as to allow the new space tourism industry to grow independently. A spokesman for the FAA said, “If we had imposed all the current regulations on the Wright brothers' aircraft, they never would have gotten in the air” (Nguyen, 2010, p. 1). If SpaceShipOne were operated as a public vehicle, the pilots would need to be certified as commercial glider pilots due to the fact the vehicle lands unpowered as a glider even though it is operated at speeds in excess of Mach 2 and at altitudes higher than 300,000ft (FAA, 2005; FAA, 2008). The FAA/AST office regulates the space tourism industry although it is under direction to encourage commercial growth. In the introduction of FAA/AST reports, the following paragraph describes the function and goal of the Office of Commercial Space Transportation:

> **About the Office Of Commercial Space Transportation**
>
> The Federal Aviation Administration's Office of Commercial Space Transportation (FAA/AST) licenses and regulates U.S. commercial space launch and reentry activity, as well as the operation of non-federal launch and reentry sites, as authorized by Executive Order 12465 and Title 49 Unites States Code, Subtitle IX, Chapter 701 (formerly the Commercial Space Launch Act). FAA/AST's missions is to ensure public health and safety and the safety of property while protecting the national security and foreign policy interests of the United States during launch and reentry operations. In addition, FAA/AST is directed to encourage, facilitate, and promote commercial space launches and reentries. Additional information concerning commercial

> space transportation can be found on FAA/AST's web site at http://www.faa.gov/about/office_org/headquarters_offices/ast (FAA, 2010a, p. i)

2.5 Suborbital Companies within Space Tourism

Currently, there exist several suborbital space companies within the United States. They are, as described in the Federal Aviation Administration's *2008 U.S. Commercial Space Transportation Developments and Concepts: Vehicles, Technologies, and Spaceports:*

- Armadillo Aerospace: “Armadillo Aerospace, a former competitor for the Ansari X-Prize, is developing a family of vehicles designed for suborbital and, eventually orbital flight operations” (p. 21).
- Blue Origin: “Blue Origin is developing the New Shepard Reusable Launch System, a suborbital, vertical-takeoff, vertical landing RLV [reusable launch vehicle] for commercial passenger spaceflights” (p. 22).
- Scaled Composites/The Spaceship Company/Virgin Galactic: “Scaled Composites, LLC, and Virgin Galactic, LLC a subsidiary of the Virgin Group of Companies, announced the formation of a joint venture, called The Spaceship Company (TSC), LLC, in July 2005. The purpose of the TSC is to oversee the development and production of SpaceShipTwo, a commercial suborbital spacecraft based on the technology developed for SpaceShipOne. TSC will produce the first five SpaceShipTwo vehicles for Virgin Galactic, which plans to put them into commercial service once test flights are completed, offering suborbital space flights for private individuals, science research, and payload” (p. 27).

- SpaceDev – DreamChaser suborbital spacecraft: “Dream Chaser is a RLV under development by SpaceDev to serve suborbital and orbital applications” (pp. 27-28).
- XCOR Aerospace – Lynx: “The Xerus [Lynx] would take off horizontally from a runway under rocket power and fly to an altitude of 100 kilometers before returning for a runway landing. XCOR plans to use Xerus [Lynx] for a variety of suborbital missions including microgravity research, suborbital tourism, and even the launch of very small satellites into orbit” (p. 31).

2.6 Summary

From a review of the literature of government astronaut selection from the United States, Soviet Union/Russia and the European Union, the three main themes for astronaut selection were: academic performance, flight experience and character/motivation. For this study, the six suborbital space companies in the United States were contacted and representatives were interviewed with questions stemming from these three key points of astronaut selection. Purdue's astronaut alumni were used to add depth to the study because of their personal spaceflight experience and their relationship with Purdue University, which was determined to possibly increase the voluntary participation in this study. The Federal Aviation Administration's regulation of the new commercial spaceflight industry is solely based upon current policies. No further regulations are planned as to allow the industry to grow rapidly.

CHAPTER 3. METHODOLOGY

This chapter introduces the type of research used and the process used to collect and analyze data for the research project. The purpose, theoretical framework, sample and data collection techniques, analysis procedures, and researcher bias are presented.

3.1 Purpose

The space tourism industry is less than 10 years old. Rapidly growing, it has attracted several wealthy, successful entrepreneurs looking to profit from this new form of adventure tourism. In order to achieve profitability, these young companies will need to develop, test and operate a fleet of suborbital spacecraft to launch tourists into space. Although test pilots will handle the initial flight tests, a new breed of pilots – the commercial astronaut – will fly the actual suborbital tourist flights. The purpose of this research project is to explore the possible selection criteria of these new commercial astronauts.

3.2 Qualitative Research

This research project was a qualitative study conducted to contribute to the body of knowledge as it relates to the selection of commercial astronauts for suborbital spaceflight. The study was exploratory because the space tourism industry is less than 10 years old and there are presently only two commercial astronauts. Sekaran (2003) wrote, “An exploratory study is undertaken when not much is known about the situation at hand, or no information is available on how similar problems or research issues have been solved in the past” (p. 119).

Wiggins (1999) said, “Qualitative research techniques are typically applied in situations where little is known about a particular domain” (p. 164). Furthermore, qualitative research methods are useful for “new fields of study where little work has been done, few definitive hypotheses exist and little is known about the nature of the phenomenon” (Patton, 2002, p.193).

Since data were collected through interviews, a qualitative research method was chosen. Interviews allowed for the most open-ended questions and responses as compared to a survey. Furthermore, the interview allowed for additional data to be collected that was not foreseen by the researcher (Sediman, 1998).

3.3 Theoretical Framework

The theoretical framework describes and defines the gathering and interpretation of data in this study as it relates to qualitative research and it is a key aspect of such research (Sekaran, 2002). The qualitative research technique called Grounded Theory was used as a theoretical framework for the study. It was developed by Barney Glaser and Anselm Strauss as a research method to create a theory from the generalization of recorded data rather than test an established theory (Patton, 2002; Strauss & Corbin, 1990). It has been a useful exploratory technique to use when not much is known about a particular subject.

> Grounded Theory focuses on the process of generating theory rather than a particular theoretical content. It emphasizes steps and procedures for connecting induction and deduction through the constant comparative method, comparing research sites, doing theoretical sampling, and testing emergent concepts with additional fieldwork (Patton, 2002, p. 125).

Furthermore, Grounded Theory allowed for opened-ended interviews which are useful to gather as much data about a certain process as possible

without being constrained to set answers. One of the fundamental questions of Grounded Theory is to answer “What theory emerges from systematic comparative analysis and is grounded in fieldwork so as to explain what has been and is observed?” said Patton (2002, p. 125).

A key aspect of Grounded Theory is the bias and credibility of the researcher because the researcher gathered, analyzed and interpreted data based upon his experience and knowledge of the subject. These important key points have been discussed further in this study in sections 3.8 and 3.9.

The strength of Grounded Theory is based upon the quality and integrity of recorded data. As a result, all interviews were transcribed as recorded including stalls, stutters, and any audible sounds like “uh” and “um”. This accurate transcription of the interviews is a key qualitative technique to preserve the data collected. Patton wrote, “The raw data of interviews are the actual quotations spoken by the interviewees” (Patton, 2002, p. 380). The transcripts of the interviews have been included in Appendices C and D.

Although Grounded theory was the fundamental framework used in this study, Truth and Reality Testing was used as a secondary framework to 'backup' data gathered with Grounded Theory. Truth and Reality Testing was useful to determine how data gathered related to what is going on in the real world. Patton (2002, p. 93) wrote about the theory:

> In short, you incorporate the language and principles of 21st-century science into naturalistic inquiry and qualitative analysis to convey a sense that you are dedicated to getting as close as possible to what is really going on in whatever setting you are studying. Realizing that absolute objectivity of the pure positivist variety is impossible to attain, you are prepared to admit and deal with imperfections in a phenomenologically messy and methodologically imperfect world, but you still believe that objectivity is worth striving for.

The researcher planned to use the objectivity of the Truth and Reality Testing Theory when analyzing the data collected through the interviews.

3.4 Sampling

Qualitative studies differ substantially from quantitative studies because of their smaller sample sizes. Patton wrote, “There are no rules for sample size in qualitative inquiry” (Patton, 2002, p. 244). Qualitative studies rely heavily on targeted subjects with high levels of experience within a certain field.

The targeted interviewees for this study were individuals with experience working in the space tourism industry and government astronauts with actual spaceflight experience. During the literature review process, the researcher identified these individuals as a critical part of study.

Currently, there exists five suborbital space tourism companies developing suborbital spacecraft located within the United States. They were identified using the FAA/AST 2009 report. They include:

- Armadillo Aerospace
- Blue Origin
- Scaled Composites, LLC/The Spaceship Company/Virgin Galactic
- SpaceDev
- XCOR Aerospace

These companies were selected because they were the front runners within the space tourism industry and their active research and development of suborbital spacecraft at the time of this study. Although these five companies represented a small sample size, these were the only examples within the confines of the study representing the target population.

3.5 Data Collection

The researcher used recorded phone interviews and email correspondence to collect data. The interview process was divided into two separate categories: commercial space companies and astronauts.

For the space companies, the researcher 'cold called' the company, asked for the person in charge of flight testing, crew selection, and/or crew training. The researcher identified himself as a Master's degree student at Purdue University seeking information about commercial astronaut selection. The researcher asked for the person's title, the mailing address to send out a research brief, and when an interview could be conducted. The researcher was able a establish a rapport with the individual prior to the actual interview. The individuals representing the suborbital space companies were co-founders, vice presidents of engineer/research, former NASA astronauts, or test pilots with actual suborbital spaceflight experience. The interviewees were receptive to the researcher's inquires and provided valuable information about the suborbital industry's needs as they related to commercial astronaut selection.

For Purdue's astronaut alumni, the only contact information that the researcher had were mailing addresses. A letter asking for their participation in the study and a research brief detailing the study was sent out with information of how to contact the researcher. These documents have been attached in Appendix A and Appendix B, respectively. The astronaut alumni were receptive to the researcher's request for information. Time constraints of the study allowed for only one interview per participant.

During the interviews, opened-ended questions were used so that the interviewee would be able to respond at whatever length they felt was appropriate. Sekaran wrote, "Open-ended questions allow respondents to answer them in any way they choose" while a closed-ended question "would ask the respondents to make choices among a set of alternates given by the researcher" (Sekaran, 2003, p. 329). Furthermore, the researcher was able to

'follow the data' with follow-up questions about interesting and unique points described by the interviewees.

All contact with the interviewees was documented and stored according to Purdue's Institutional Review Board's (IRB) requirements. In order to strengthen the data collected, the researcher asked if he could associate the interviewees' name with their interview answers. The interviewees who waived their right to anonymity were asked once at the beginning of the interview and again at the end of the interview if they wished to waive the anonymity right.

According the IRB requirements, the following interview protocol was read before each recorded phone interview:

Opening Statement:

Please understand that your participation in this study is voluntary, and you must be 18 years old to participate. Participation or non-participation in this study will not affect your employment. Your responses will be kept confidential, and any quotations used in the final report will be attributed to "Participant 1, 2, 3…etc." to maintain anonymity. If you wish to waive your right to anonymity, please let me know now. At the end of the interview, if you waived your right to anonymity I will ask again if wish to waive your right to anonymity. The interview itself should last between 20 and 25 minutes. The interview will be recorded via audio recordings and all original recordings will be destroyed by 31-December-2010.

The risks involved are minimal, no greater than everyday life. The purpose of this study is to determine the selection criteria of flight crews for suborbital spaceflight within the space tourism industry. I am conducting this study for my Master's Thesis. As such, I will be conducting and recording the interviews, transcribing the audio recordings, analyzing the data, and writing the final report.

Insights generated as a result of this study could benefit the companies in the commercial space industry, institutions of aviation and aerospace education, as well as the Federal Aviation Administration's Office of Commercial Space

Transportation. Please answer the following questions based on your knowledge and experience with suborbital spacecraft.

The Principal Investigator for this study is Professor Denver Lopp. He can be reached at 765-494-6387. If you have concerns about your treatment during this interview, you can contact the Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114. The phone number for the Board is 765-494-5942. The email address is irb@purdue.edu. Do you have any questions?

Interview Questions:

1) What kind of educational and/or technical background should a commercial astronaut possess?

2) What type and how much flight experience should a commercial astronaut have?

3) In terms of personality and character, what would make a desirable commercial astronaut?

4) If training a person to become a commercial astronaut, what are the most important subjects and/or flight areas in which to be familiar?

5) When selecting a commercial astronaut, is there anything that you believe is important to consider that we have not discussed?

3.6 Study Participants

The study participants have been listed below. Prior to and after each interview, the interviewee was asked if he/she wished to waive his/her right to anonymity and if he/she wished to be associated with his/her answers to the questions asked. The interviewees whose name's are listed gave their approval[2] to be mentioned in this study.

2 The interviewee's approval to be mentioned by name within this study can be read within the transcript of the interviews in Appendix C. Some interviewees gave their approval via email correspondence and such records are stored according to IRB protocol.

A brief biography of the interviewees has been listed below:

- Brian Binnie: Commercial astronaut and pilot of Scaled Composites' SpaceShipOne which won the X-Prize in 2004. Flew 59 different aircraft and former Navy test pilot with 4600 hours of flight time (Scaled, 2010).
- Mark Brown: NASA astronaut who flew on two Shuttle missions as a mission specialist. Retired Air Force colonel (NASA, 2010).
- Dan DeLong: Co-founder, Vice President and Chief Engineer of XCOR Aerospace (XCOR Aerospace, 2010).
- Andrew Feustel: NASA astronaut who flew in space on a Shuttle mission to repair the Hubble Space Telescope. Currently training for a second spaceflight (NASA, 2010).
- Neil Milburn: Co-founder, Vice President and Program Manager for Armadillo Aerospace (Armadillo Aerospace, 2010).
- Participant 9: NASA astronaut who has flown on several Shuttle missions (NASA, 2010)
- Gary Payton: NASA astronaut who flew in space as part of a Space Shuttle Department of Defense mission. Currently the Deputy Undersecretary for Space Programs in the United States Air Force (Defense_news, 2010; NASA, 2010).
- Tom Shelley: President of Space Adventures. Partnered with the Russian Space Agency to launch seven spaceflight participants on eight separate missions aboard Soyuz rockets for week-long stays aboard the International Space Station (Space_adventures, 2010).
- Loren Shriver: NASA astronaut who commanded two of the three Shuttle flights he flew on. He also commanded the deployment of the Hubble Space Telescope on STS-31. Retired Air Force colonel. Former F-15 test pilot (NASA, 2010).

- James Voss: Vice President of Engineering at SpaceDev. Flew in space five times and lived on the International Space Station for five and a half months. Former Deputy for Flight Operations in the Space Station Program Mission Integration and Operations Office at NASA (NASA, 2010; SpaceDev, 2010).

3.7 Data Analysis

Data analysis of qualitative studies was unique to the study and theoretical framework being used conducted. Patton wrote, “Qualitative analysis transforms data into findings. No formula exists for that transformation” (2002, p. 433). The analysis of data associated with the study is heavily dependent upon the theoretical framework used within the study and with the bias and credibility of the researcher himself. (Patton, 2002). This is one major way that qualitative studies differ from quantitative research. Like quantitative research, however, there exists a set of tools to allow the researcher to conduct his/her data analysis with credibility (Glaser & Strauss, 1967).

Grounded Theory is one such tool which is based upon the ability of the researcher to fundamentally understand the data gathered and transform the data into meaningful information. The resulting assertions and/or theory generated from the data is the result of the data analysis process. There are several distinct steps in the Grounded Theory process in which the data/interview transcripts were read and analyzed a total of seven times.

During the first pass, the interview transcript was read completely without any comments or notes being made. This was to re-familiarize the reader with the data. During the second pass, short notes about key points being made by the interviewee were written. Some questions were asked internally such as, 'What is the interviewee really saying? What points are made with this topic? What words are emphasized?' (Strauss & Corbin, 1990).

The third reading of the data occurred at a much slower rate to allow the researcher to make additional notes about the context of key points raised by the interviewee. The third reading allowed the researcher to fully understand what the data were saying.

During the fourth reading of the data, the interviews were coded. The interview transcripts were coded via Grounded Theory's open coding. The coding scheme allowed for informative descriptors to be assigned to key phrases in the transcripts.

> "This is where most names come from – YOU!. The name you choose is usually the one that seems most logically related to the data it represents, and should be graphic enough to remind you quickly of its referent" (Strauss & Corbin, 1990, p. 67).

For example, the following sentence would be coded, 'Brian graduated with an Applied Physics degree **[science degree]** and is a private pilot **[pilot]**.' The format of transcript **[code]** transcript was used. The uncoded interview transcripts have been located in Appendices C and D and coded interview transcripts have been located in Appendices E and F (Sediman, 1998; Strauss & Corbin, 1990).

In the fifth pass of data analysis, each of the codes were placed into a matrix which had the code, the frequency and the data line number(s) associated with the code. The total of all data collected was easily seen within the matrix. Also, during this pass of data analysis, categories for the codes were created using axial coding. Categories reflect the relationships among codes according to the research purpose. Each of the codes were assigned to a matrix according to the research question asked and the interviewee. There were two different matrices for each research question: one for suborbital space companies and the other for Purdue's astronaut alumni. The matrices have been included in Appendix G. Once the codes were assigned to their respective matrices, common themes were found among interviewees. For example, most of the

participants answered that at least a Bachelor's degree was required for commercial astronauts.

During the sixth step, any outlier codes from the previous step were followed up by re-reading the interview transcripts to determine the causation of the deviation. Common codes, themes and assertions began to emerge from the data. For extremely divergent cases, the researcher was able to follow up with correspondence to the interviewee asking for additional information. The matrix created in the previous step was used to find possible answers to the research questions.

The seventh and final step of data analysis was to make assertions based upon the data gathered. The assertions made with regard to the research questions were compiled to create a strength of the data chart. For example, one assertion was that a commercial astronaut should have a test pilot background. A continuum was constructed about the concept of importance. The continuum of the code went from 'Not Important' to 'Important'. The strength of the code was determined by the researcher using the code's location within the transcript, relations to the context in which the code was mentioned, the emphasis placed upon the code itself by the interviewee and via the researcher listening to the audio recording of the interviewee's tone and inflection when the particular code was said. The chart shows which interviewee's transcript yielded the data support, which line number from the interview the code appeared, and a brief explanation of the strength of the code. The Strength of Data Continua charts have been included in Appendix H (Strauss & Corbin, 1990).

In order to gain a better visualization of the data analysis process, the flowchart below summarizes the steps used.

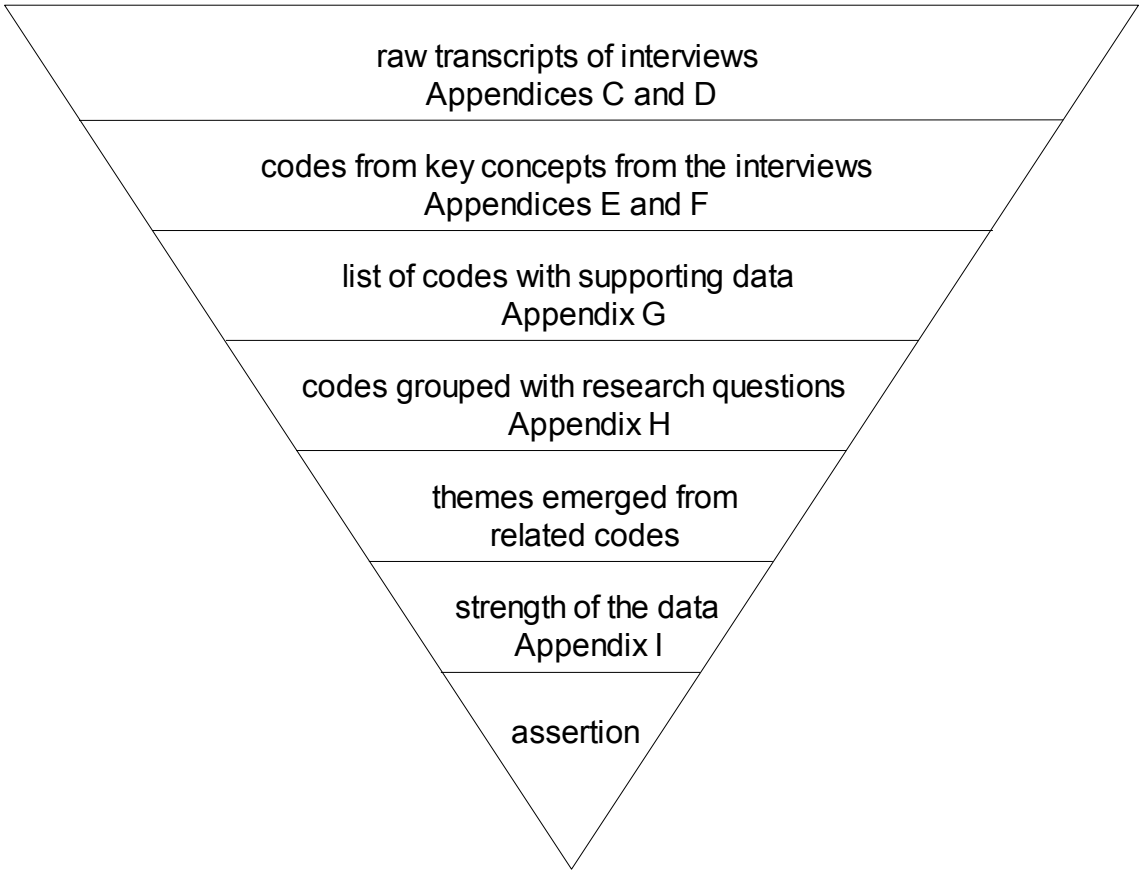

Figure 1. Flowchart of Data Analysis

3.8 Researcher Bias

I am a graduate of Purdue's College of Science with Bachelor of Science degrees in Applied Physics (December 2007) and Interdisciplinary Science (May 2008). I changed to Aviation Technology for my Master's Degree because I have strong interests in spaceflight, particularly the areas of commercial spaceflight and space tourism. I chose the selection of flight crews for suborbital spaceflight because I have always been interested in piloting aircraft. Growing up, I built countless Lego aircraft and flew them around the house. During the summer of

2004, I earned my private pilot license in a Cessna 150. Since then, I have flown eight different aircraft types, including gliders, with over 200 hours of flight experience during which 175 have been pilot-in-command. I have several thousand hours of flight simulator time, mostly in X-Plane and Microsoft Flight Simulator with approximately 200 hours in FAA approved flight training devices.

Additionally, I have a passion for learning about the space program, particularly the Lunar missions of the late 1960s and early 1970s. I have read the biographies and autobiographies of most of the 24 astronauts who journeyed to the Moon as well as those key personnel within NASA during the Apollo Program. The most influential book that I have read for this research project was Deke!, written by Deke Slayton, who was one of NASA's first astronauts. During his tenure at NASA, Slayton was responsible for the selection of new astronauts from the mid 1960s to the late 1970s. He personally selected the crews for all of the Gemini and Apollo missions which included the decision to select Neil Armstrong as the first man on the Moon.

3.9 Researcher Credibility

Although I have had significant experience in quantitative research, qualitative research is relativity new to me. In order to gain a better understanding of the techniques and processes used in qualitative research, I enrolled in EDCI 615 Qualitative Research Methods during the Fall 2010 semester. Furthermore, I made an active effort to leave any preconceived notions about commercial astronaut selection 'at the door' when I conducted the interviews. I also transcribed the interviews personally and used Grounded Theory to determine which themes and characteristics emerged from the data gathered.

I believe, due to my interdisciplinary background, I was able to conduct interviews of space company representatives and Purdue's astronaut alumni with minimal bias. I was able to expand my knowledge of qualitative research techniques as well as establish a rapport within the suborbital space tourism industry.

3.10 Summary

This study was a qualitative, exploratory study designed to look into the selection criteria of suborbital commercial astronauts. Grounded Theory was used to generate a theory based upon the needs of commercial suborbital space companies. Data gathered from U.S.-based suborbital space companies were supported and augmented through the personal spaceflight experiences of Purdue's astronaut alumni. Due to the researcher's interdisciplinary background, the researcher was able to conduct the study with limited researcher bias.

CHAPTER 4. DATA ANALYSIS AND FINDINGS

This chapter introduces the sample attrition and data analysis of the study. The results and assertions have been presented as well as the findings of the research questions into the selection of commercial astronauts for suborbital spaceflight.

4.1 Sample Attrition

Before the data are presented, attrition of the targeted sample needs to be addressed. The US-based suborbital space tourism companies targeted were:

- Armadillo Aerospace
- Blue Origin
- Scaled Composites, LLC/The Spaceship Company/Virgin Galactic
- SpaceDev
- XCOR Aerospace

One of the suborbital space tourism companies did not respond to repeated interview requests. The researcher learned their spacecraft was recently changed to fly autonomously and their participation in the study would have been limited.

In addition, 18 of Purdue's astronaut alumni were contacted seeking their participation in this study and 6 were able to participate. However, one 20 minute interview was not recorded due to the dual failure of the researcher's primary and backup recording devices. Some data, however, were recovered from two pages of notes taken during the interview. The data were not included in the study. The interview was not conducted a second time due to time constraints of the

interviewee. One participant expressed interest in the study, but responded too late to be included. A total of 10 interviews were conduced with 4 of the 5 suborbital space companies and 5 of Purdue University's astronaut alumni.

4.2 Data Analysis and Reduction

This research project was a qualitative study conducted to contribute to body of knowledge as it relates to the commercial astronaut selection. The procedure used for data analysis was: multiple readings of the raw interview transcripts, open coding, creation of concepts, testing the strength of the data and making assertions to answer the research questions. The data collected and the organized data can be found in the Appendices.

4.3 Findings

The final part of data analysis was to make assertions based upon the data collected. The assertions were presented in the following way: assertion, definition of the the assertion, transcript quotations supporting the assertion and the researchers comments and interpretation of the data. The definition of the assertion was created by the researcher based upon his experience with the data gathered and his knowledge of the industry from the review of the literature. Furthermore, any pauses, stutters or 'ahs' were eliminated from supporting quotations for ease of reading. The assertions were presented based upon the research questions asked with the question being included for clarity. The strength of the data continua on which the assertions were based can be found in Appendix H.

4.3.1 Assertions

Research Question 1: What kind of educational and/or technical background should a commercial astronaut possess?

Assertion: A commercial astronaut should have an engineering degree at the Bachelor's level or higher.

Definition: an engineering degree is a broad term that could be any sub discipline of engineering as it relates to aerospace such as aeronautical, astronautical, electrical, mechanical or materials engineering. A bachelor's degree is minimal amount of educational knowledge required with preference given to advanced degrees.

> "As it comes to educational requirements, I would say an engineering degree at least as a Bachelor's"
> (Gary Payton, personal communication, 2010)

> "So you are still going looking for people that are, for the lack of a better word, aerospace engineers and test pilots"
> (Mark Brown, personal communication, 2010)

> "So for educational and technical background whatever the requirements are for, military pilots along the lines of engineering training or possibility some classes either undergraduate or master degree level" (Andrew Feustel, personal communication, 2010)

An engineering degree was mentioned and discussed by the majority of the participants in the study. Some participants specifically stated an aeronautical engineering degree while others only stated an engineering degree that could be applied to aerospace. The underlying notion that was expressed was that an

engineering degree trains a person to think with an engineering and technical point of view and provides the ability to understand the vehicle that they are operating.

Research Question 2: What type and how much flight experience should a commercial astronaut have?

Assertion: A commercial astronaut should have a test pilot background.

Definition: A test pilot is someone who flies new and experimental aircraft during the first few flights to verify the design specifications of the vehicle. Furthermore, they 'push the limits' of the vehicle to determine the margins of safety for commercial or military use. A test pilot is also familiar and conformable with high stress situations associated with testing new, unproven vehicles.

> “Generally those type of vehicles are not going to have enough experience behind them to be routine so people with flight test experience [would] probably be more appropriate for piloting those vehicles” (Jim Voss, personal communication, 2010).

> “Because of the big unknowns right now, you are going to want test pilots” (Participant 9, personal communication, 2010)

> “Initially they will all be taken from the pool of experimental test pilots” (Brian Binnie, personal communication, 2010).

The majority of the participants mentioned test pilots and having a test pilot background for the initial groups of commercial astronauts. Since commercial suborbital rockets are relatively new and unproven, having experienced pilots

with flight backgrounds in testing and flying experimental aircraft would be beneficial. Furthermore, test pilots have a keen understanding and 'feel' for the vehicle which is a result of tremendous cockpit experience.

Assertion: A commercial astronaut should have thousands of hours as Pilot-in-Command[3] (PIC) of high performance jet aircraft.

Definition: a high performance jet aircraft is a single or multi turbine engine aircraft similar in performance and maneuverability to state-of-the-art military fighters. PIC time is actual pilot control of the aircraft with no autopilot use.

> "I think commercial astronauts, the ones actually flying the vehicle, should have to have the same requirements that NASA astronauts have. And that would a minimum of 1000 hours pilot in command time" (Mark Brown, personal communication, 2010).

> "Somewhere around the order of several thousand hours, probably around two thousand hours in a high performance jet aircraft or a thousand minimum that you would need to have before you had somebody climb into a rocket expecting them to fly passengers to space" (Andrew Feustel, personal communication, 2010).

The more hours that a pilot has, generally the more experienced he/she is. There is, however, a distinction between having a thousand hours in a commercial airliner with the autopilot engaged and a thousand hours in a high performance military jet conducting combat maneuvers. The military pilot would have more flight experience due to their actual control of the aircraft. When operating a commercial suborbital spacecraft, the commercial astronaut needs to

3 Although the FAA and the airline industry uses the term PIC as time accumulated by a pilot in command of the aircraft even though the autopilot may be used for the majority of the flight. In this definition, PIC time refers to only hand flown time.

have as much experience as they can. Military pilots with thousands of hours of PIC time in highly maneuverable jet aircraft would be preferred.

Research Question 3: In terms of personality and character, what would make a desirable commercial astronaut?

Assertion: A commercial astronaut should have strong communication skills.

Definition: communication skills are the ability to document and transmit information verbally or via writing. The ability of a pilot to relate a wrong 'feel' of an aircraft to a technician who can fix the problem is extremely important.

> “You've got to be able to work with the engineers and technicians who are developing the spacecraft to be able to, when they find something that needs to be fixed, they need to be able to communicate why it needs to be fixed and work with the people involved to get it fixed” (Participant 9, personal communication, 2010).

> “The ability to communicate phases of flight and the willingness to communicate all of the phases of flight and explain to them what to expect and give them [the passengers] a couple of updates about the way things are going”
> (Andrew Feustel, personal communication, 2010).

During the design and flight test of the spacecraft, the crew needs to identify and document any problems that they uncover. They need to be able to thoroughly explain how and what went wrong to the engineers and technician working on the vehicle in order to solve the problem. Furthermore, during the passenger flights,

the crew needs to explain the different flight phases to the passengers so that they are not surprised during the spaceflight.

Assertion: A commercial astronaut should have enormous confidence in their vehicle and training and should inspire confidence in their passengers.

Definition: the space tourism industry is an emerging market with cutting edge technology and experimental vehicles. In order to successfully operate a spacecraft for passenger revenue flights, commercial astronauts need to to be confident in his/her vehicle's design and testing as well as in his/her own abilities to fly the spacecraft safely.

> "[It is a] brand new industry and it is a brand new experience for these folks and so that level of confidence of the flight crew would be critical and so to me that would say being able explain the engineering of the vehicle in the flight, the propulsion, the electrical systems and the ascent environment and the technical perspectives and should be able to explain it and comment everything about it would be an absolutely critical part of the experience that these folks would have" (Gary Payton, personal communication, 2010).

> "That is because they are flying people in space who are probably paying per seat in that sense the crew needs to be like a boat captain or cruise director" (Andrew Feustel, personal communication, 2010).

Since the space tourism industry is based upon tourist flights generating income for the companies involved, the safety of the passengers and their enjoyment of the flight is a key concern. The commercial astronaut needs to instill a confidence in their passengers that the vehicle is safe, space-worthy and the crew is well trained for the flight.

Assertion: The commercial astronaut should be humble as it pertains to his/her personality and work.

Definition: being humble means having the ability to admit mistakes and learn from them, the ability to take constructive criticism well and the ability to 'check your ego' before piloting a suborbital spacecraft.

> “Throw away the scarf” (Gary Payton, personal communication, 2010).

> “I think they ultimately want someone that can check their ego at the door and work effectively in a team environment”
> (Brian Binnie, personal communication, 2010).

> “I tend to recommend to stay away from the flashy, 'devil may care' personality, or one who thinks rules are for others, and go instead for the 'steady in any situation'”
> (Loren Shriver, personal communication, 2010).

Being humble is a critical part of any safety culture. The purpose of the space tourism industry is to provide an adventurous flight safely. Although the first group of commercial astronauts will most likely be former military test pilots, the 'fighter pilot' ego needs to be limited. Also, the ability to work as a team player is key.

Research Question 4: If training a person to become a commercial astronaut, what are the most important subjects and/or flight areas in which to be familiar?

Assertion: The commercial astronauts should have a fundamental understanding of their spacecraft's engineering, performance characteristics and limitations.

Definition: information about the specific handling characteristics of the spacecraft as it pertains to G limitations, aerial maneuvers, landing speed, maximum bank angle, etc.

> “They have to understand their vehicle so training would have to revolve around the vehicle that they are going to be piloting”
> (Jim Voss, personal communication, 2010).

> “It would be more of a familiarization with the vehicle. That's important”
> (Mark Brown, personal communication, 2010).

> “Things like engine operation/thrust, flight trajectory (up and down), flight path angle, "zero g" characteristics, heating, flight control response throughout the flight regime, and of course, landing procedures, would be topics of interest”
> (Loren Shriver, personal communication, 2010).

Being familiar with the engineering, performance, and limitations of the spacecraft is one of the most important subjects for a commercial astronaut to learn because it enables the pilot to fully understand and 'feel' his/her vehicle. In the event of an emergency, the crew knows how far they can 'push' the vehicle.

Assertion: The commercial astronaut should be familiar with emergency procedures of the vehicle.

Definition: an emergency procedure is an event that is off-nominal, unplanned or otherwise dangerous to the safety of the vehicle.

> “Also the flight simulation and emergency procedures that would have to be taught and learned”
> (Mark Brown, personal communication, 2010).

> “But for the spacecraft it would be some kind of really dangerous spin or a pressurization, something like that. Which you really wouldn't want the real person to go through because they have to learn. You don't want them to kill themselves”
> (Participant 9, personal communication, 2010).

Although the spacecraft are designed to minimize the risks involved, accidents can happen and the crew needs to be trained for this. During a SpaceShipOne flight, the spacecraft rolled 33 times at speeds in excess of Mach 1. The pilot was able to maintain control of the vehicle during this off-nominal situation. Furthermore, an airline pilot trains for several major emergencies such as engine failure, engine fire and loss of power and has procedures for these situations practiced to a point so he/she can remember the procedure almost from memory. A commercial astronaut needs similar training.

Assertion: The commercial astronaut should be trained in spacecraft trajectories during launch, ascent, cruise, entry and landing.

Definition: suborbital spaceflight is unique when compared to traditional aircraft due to the high speeds, altitudes, maneuvers performed and power of the vehicle. Key parts of understanding the new kind of flight environment are astronautics, physics and aeronautic engineering.

> "So most of the training will have to revolve around the trajectories itself and the attitudes, G loads of those trajectories and then the handling the flight control systems during ascent and entry and then the off-nominal, potential off-nominal scenarios around all that" (Gary Payton, personal communication, 2010).

> "Flying rockets is a completely unique environment" (Brian Binnie, personal communication, 2010).

> "Ascent and entry. Because it is just like an airplane, those are the most critical phases of flight" (Andrew Feustel, personal communication, 2010).

Due to the difference between suborbital spacecraft and traditional aircraft, emphasis needs to be placed upon the critical phases of flight. The spacecraft are designed and built to operate at much higher speeds and altitudes than aircraft, and a dedicated training program needs to be developed to train pilots to operate in such environments.

Research Question 5: When selecting a commercial astronaut, is there anything that you believe is important to consider that we have not discussed?

Assertion: A commercial astronaut is not needed for some spacecraft operations.

Definition: Armadillo Aerospace is designing and building their *Black Armadillo* suborbital spacecraft to operate as a fully automated vehicle. There would be no flight crew members aboard the vehicle during tourist flights.

> "The Armadillo Aerospace vehicle concepts require no crew as such. They are designed to be autonomous in virtually all respects except for the launch controllers and pad ops team. There will be no pilot, commander...or beverage service when we reach cruising altitude :-)" (Neil Miburn, personal communication, 2010)

> "The only area I can see professional astronauts being needed is to tend scientific payload, as they would be familiar with operating in the weightless environment" (Tom Shelley, personal communication, 2010)

Interpretation: The Armadillo Aerospace concept of a fully automated reusable suborbital spacecraft is unique in the space tourism industry. During the launch, ascent, cruise, entry and landing the vehicle would be controlled via on board computers. Although this approach is risky due to the extensive programming and testing of the computer code to operate the vehicle, it could save on weight due to the absence of flight crews and could allow for additional passenger revenue from additional seats aboard the spacecraft.

4.4 Summary

In this study, 5 participants representing 4 of the U.S.-based suborbital space tourism companies and 5 of Purdue's astronaut alumni were interviewed concerning their ideas about commercial astronaut selection. Grounded Theory was the basis of the analysis of the data collected in this study. The assertions made about a commercial astronaut are that they: should have at least a bachelor's degree in engineering, have a test pilot background with thousands of hours of PIC time in high performance jet aircraft, be confident yet humble in personality and have an in-depth knowledge of their spacecraft, including emergency procedures and spacecraft trajectories.

CHAPTER 5. CONCLUSIONS, DISCUCCSION, AND RECOMMENDATIONS

This chapter reviews the study and discusses the results generated. This chapter includes a discussion of the results and the researcher's recommendations about further study into the area of commercial astronaut selection.

5.1 Conclusions

This research project was a qualitative, exploratory study conducted to investigate the possible selection criteria commercial astronaut selection for suborbital spaceflight. An extensive literature review was conducted on astronaut selection, and the research questions were formulated based upon government astronaut selection criteria of the United States and Russia/Soviet Union.

Grounded Theory was used as the theoretical framework to create a theory from data gathered in which the results from this study contributed to the growing theory about suborbital commercial spaceflight. Furthermore, Truth and Reality Testing was used as a secondary theoretical framework to cross reference data collected to 'what was going on in the real world'. Participants of the study were selected from two highly targeted populations: U.S.-based suborbital space companies and Purdue's astronaut alumni. Telephone and e-mail interviews were conducted with the participants and the transcripts recorded were by the researcher.

The assertions made, with the data collected, about the possible commercial astronaut selection were that the commercial astronaut: should have at least a Bachelor's degree in engineering; extensive test pilot flight experience

in high performance jet aircraft; fundamentally understand the engineering and performance characteristics of their spacecraft; and have an aura of humble confidence.

5.2 Discussion

The results of this study may be hard to generalize to the commercial space tourism industry due to the uniqueness of each company's' spacecraft design. Also, the participants of this study, n=11, represent a small portion of the individuals who have flown in space and who are actively working to develop suborbital spacecraft. Time constraints of the study allowed only one interview with the interviewees. A second round of interviews could have allowed the participants to either confirm or oppose the assertions made.

In addition, the space tourism industry is yet unproven and highly experimental. The only U.S.-based suborbital space company to operate a suborbital spacecraft was Scaled Composites with three spaceflights of SpaceShipOne in 2004. The spacecraft being developed have been experimental vehicles with little or no previous experience in actual suborbital spaceflight. This could cause the initial selection criteria of suborbital commercial astronauts to be much higher right now as opposed to when the industry becomes more established. Several of the interviewees shared these thoughts.

> “I believe the initial requirements will differ from the later ones when (if) the business becomes established”
> (Brian Binnie, personal communication, 2010).

> “The qualifications right now will be much higher than they will be in say 10 years...Right now, there are very few slots and the competition is very fierce and there are huge number of unknowns. So all of those are going to drive all of these requirements very high right now”
> (Participant 9, personal communication, 2010).

> “As commercial spaceflight matures, it will be more of a comfort and service offering in the vehicle so degrees of any kind will probably to start to erode” (Mark Brown, personal communication, 2010).

Furthermore, some of the data collected seem to suggest that the commercial astronaut selection criteria will vary between companies due to the unique nature of each company's spacecraft. Although general selection criteria of educational backgrounds and flight experience may be similar, the actual criteria may be vastly different.

During the course of data collection, two different targeted samples were interviewed: suborbital space companies and Purdue's astronaut alumni. Each group was asked the same research questions and the responses compiled into a table in Appendix H. There was some variance between the two groups with regard to educational and/or technical background. The suborbital space companies placed less emphasis on the type of degree earned as long as it could be applied to the company's specific spacecraft design. However, Purdue astronaut alumni focused more on engineering degrees. Both groups placed emphasis on advanced degrees at the Master's level.

When asked about the flight experience required for suborbital spaceflight, the companies placed emphasis on flight test, high performance vehicles and a high amount of flight time. The astronauts similarly addressed the same ideas. They delved deeper into the subject when they mentioned specific topics associated with flight test scenarios, such as aircraft control, disorientating and stressful situations, and complex aerobatics.

The questions about personality and character for a suborbital commercial astronaut were weak from the perspective of the space companies. The only data gathered mentioned that the commercial astronaut should be enthusiastic about their work and have a fighter pilot

and/or test pilot attitude. Purdue's astronauts provided additional information citing examples of confidence and the ability to be humble when faced with a demanding work routine. Also, strong verbal and written communication skills were emphasized. The ability to relay information to the passengers before, during and after the flight to provide a sense of calm and confidence was also suggested. Furthermore, the alumni stressed teamwork as an important topic.

Both groups placed considerable emphasis on stick and rudder skills and which is the inherent and fundamental ability to fly an aircraft. Also, the ability to 'feel' an aircraft when flying it was considered important. Again, the astronaut alumni provided more in-depth information and discussed details of the most important subjects and/or flight areas in which the commercial astronaut should be familiar. Both groups also mentioned the training for emergencies during a suborbital spaceflight and the ability to perform the required procedures to recovery from such an emergency quickly and efficiently.

The thoughts and views of Purdue's astronaut alumni provided additional and valuable data to support the data gathered from the U.S.-based suborbital space companies. Furthermore, the alumni with their personal spaceflight experience and the use of their names associated with their answers to the research questions added credibility to the research project.

5.3 Recommendations

Although the results of this exploratory study suggest that the suborbital commercial astronauts should have a strong background in engineering, flight test experience and have strong personable skills, further studies may be conducted to strengthen the results. A larger sample of participants for the next study may be needed. It is the researcher's recommendation to use this study as

a basis for further research into the area of commercial astronaut selection. In addition to verification of the results generated with a larger sample size, the research should investigate the commercial astronaut as a possible career path for individuals interested in spaceflight.

Future research should also investigate a possible training guide for commercial astronauts to prepare themselves at the university level for a career as a commercial astronaut. Many of these research topics and questions can only be answered once the space tourism industry is established. There is need for additional research into this emerging industry and this study provides the basis for it with regard to commercial astronaut selection.

5.4 Summary

This chapter provided the conclusion that the commercial astronaut should be highly educated in engineering, have flight test experience and have strong communication skills. The selection criteria of commercial astronauts may change once the industry becomes established and it is the researcher's recommendation to continue research into this exciting new field.

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APPENDICES

Appendix A. Research Letter

The research letter was sent out to Purdue's astronaut alumni seeking their participation in this study.

PURDUE
UNIVERSITY

COLLEGE OF TECHNOLOGY
Aviation TECHNOLOGY

Brian Kozak
1401 Aviation Drive
West Lafayette IN 47907-2015

24-August-2010

Mr. [NAME]
321 Space Way
Blastoff, IN 54321

Dear Mr. [NAME],

My name is Brian Kozak, a Master's Degree student in Aviation Technology at Purdue University. I am conducing thesis research evaluating selection criteria of flight crews for suborbital spaceflight within the space tourism industry. Part of my data gathering strategy is in the form of personal phone interviews. I am seeking your participation because of your experience in spaceflight and your relationship with Purdue University. An overview of this research is attached to give you a better idea of my study design.

Your input and expertise would lend significant depth to this study. If you would like to help, your response is needed by 30-September-2010. Please contact me via email at bkozak@purdue.edu or via phone at 219-781-3180 to arrange a time where we could talk. If you are unable to find time for a phone interview, you could also mail your written responses to me using the self addressed stamped enveloped enclosed.

Thank you for your time and consideration helping me advance the body of knowledge of this emerging industry.

Sincerely,

Brian Kozak

Enclosed: 2 page research brief, self addressed stamped envelope

Appendix B. Research Brief

The research brief was included in the research letter that was sent out to Purdue's astronaut alumni. The research brief contains the five research questions, the interview protocol required by the Institutional Review Board, a brief biography of the researcher and contact information of the researcher.

PURDUE UNIVERSITY

COLLEGE OF TECHNOLOGY
Aviation TECHNOLOGY

THE SELECTION OF FLIGHT CREWS FOR SUBORBITAL SPACEFLIGHT WITHIN THE SPACE TOURISM INDUSTRY

Brian Kozak
Department of Aviation Technology
Purdue University

Questions:

1) What kind of educational and/or technical background should a commercial astronaut possess?
2) What type and how much flight experience should a commercial astronaut have?
3) In terms of personality and character, what would make a desirable commercial astronaut?
4) If training a person to become a commercial astronaut, what are the most important subjects and/or flight areas in which to be familiar?
5) When selecting a commercial astronaut, is there anything that you believe is important to consider that we have not discussed?

Interview Protocol

Opening Statement

Please understand that your participation in this study is voluntary, and you must be 18 years old to participate. Participation or non-participation in this study will not affect your employment. Your responses will be kept confidential, and any quotations used in the final report will be attributed to "Participant 1, 2, 3…etc." to maintain anonymity. If you wish to waive your right to anonymity, please let me know now. At the end of the interview, if you waived your right to anonymity I will ask again if wish to waive your right to anonymity. The interview itself should last between 20 and 25 minutes. The interview will be recorded via audio recordings and all original recordings will be destroyed by 31-December-2010.

The risks involved are minimal, no greater than everyday life. The purpose of this study is to determine the selection criteria of flight crews for suborbital spaceflight within the space tourism industry. I am conducting this study for my Master's Thesis. As such, I will be conducting and recording the interviews, transcribing the audio recordings, analyzing the data, and writing the final report.

Insights generated as a result of this study could benefit the companies in the commercial space industry, institutions of aviation and aerospace education, as well as the Federal Aviation Administration's Office of Commercial Space Transportation. Please answer the following questions based on your knowledge and experience with suborbital spacecraft.

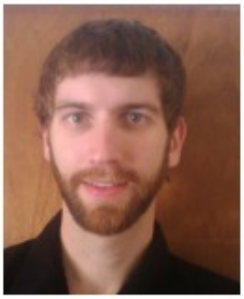
The Principal Investigator for this study is Professor Denver Lopp. He can be reached at 765-494-6387. If you have concerns about your treatment during this interview, you can contact the Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114. The phone number for the Board is 765-494-5942. The email address is irb@purdue.edu. Do you have any questions?

PURDUE
UNIVERSITY

COLLEGE OF TECHNOLOGY
Aviation TECHNOLOGY

The researcher who is conducting the study is Mr. Brian Kozak. A short introduction is given below:

Brian Kozak is a second year Master's Degree student in the College of Technology at Purdue University. His research interests are in emerging high technology markets in aviation and commercial spacecraft operations with a focus on flight crew selection for suborbital spaceflight. Brian graduated from Purdue University with a Bachelor of Science in Applied Physics in 2007 and a Bachelor of Science in Interdisciplinary Science in 2008. Brian is an FAA licensed private pilot, a student instrument pilot and student commercial glider pilot. He is also working toward his FAA Airframe and Powerplant license.



E-mail: bkozak@purdue.edu
Phone: 219-781-3180

A research paper may be published once the study has been completed with a copy being sent to you.

If you wish to participate in this study, your response is needed by 30-September-2010.

Please contact Brian Kozak at one of the following:

- **bkozak@purdue.edu**
- **219 – 781 – 3180**
- **1401 Aviation Drive, West Lafayette IN 47907-2015**

Appendix C. Telephone Interview Transcripts

The raw telephone interviews transcripts are listed.

Date:	2-September-2010
Interviewer:	Brian Kozak
Interviewee:	Dan DeLong (DD)

Brian: I can record this conversation?

DD: Sure.

Brian: Alright, Please understand that your participation in this study is voluntary, and you must be 18 years old to participate. Participation or non-participation in this study will not affect your employment. Your responses will be kept confidential, and any quotations used in the final report will be attributed to "Participant 1, 2, 3…etc." to maintain anonymity. If you wish to waive your right to anonymity, please let me know now. At the end of the interview, if you waived your right to anonymity I will ask again if wish to waive your right to anonymity. The interview itself should last between 20 and 25 minutes. The interview will be recorded via audio recordings and all original recordings will be destroyed by 31-December-2010. The risks involved are minimal, no greater than everyday life. The purpose of this study is to determine the selection criteria of flight crews for suborbital spaceflight within the space tourism industry. I am conducting this study for my Master's Thesis. As such, I will be conducting and recording the interviews, transcribing the audio recordings, analyzing the data, and writing the final report. Insights generated as a result of this study could benefit the companies in the commercial space industry, institutions of aviation and aerospace education, as well as the Federal Aviation Administration's Office of Commercial Space Transportation. Please answer the following questions based on your knowledge and experience with suborbital spacecraft. The Principal Investigator for this study is Professor Denver Lopp. He can be reached at 765-494-6387. If you have concerns about your treatment during this interview, you can contact the

Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114. The phone number for the Board is 765-494-5942. The email address is irb@purdue.edu. Do you have any questions?

DD: No. You can use my name and title.

Brian: Ok, what kind of educational and/or technical background should a commercial astronaut possess?

DD: They should be a pilot with high performance vehicle.

Brian: Ok, any particular type of educational background?

DD: Um, not necessarily. An engineering degree would be nice. Not required.

Brian: Ok, um, then, what kind, what type and how much flight experience should a commercial astronaut have?

DD: Well, you are using the term astronaut, we probably won't. It is either pilot or, um, during development flight test engineer.

Brian: Ok.

DD: And flight test engineer is primarily an engineer who is also familiar with, um, the qualities of the vehicle but primarily an engineer monitoring the vehicle systems. Um, that won't exist on an operational flights but will on flight test And the pilot is mostly a pilot. He is flying a high performance vehicle atleast XCOR vehicles takeoff and landing like airplanes.

Brian: Right.

DD: The answers to that question from other organizations that, things like vertical takeoff vehicles will be very different.

Brian: Right, and just from like the point of this conversation right now I'm just talking about XCOR Lynx aircraft or spacecraft.

DD: Sure.

Brian: And I'm, um, actually looking toward more of the, um, functionality of the spacecraft. So maybe more...

DD: It is really launch vehicle**.**

Brian: Ok, launch vehicle.

DD: That is the current term. Hold on a second.

Brian: Sure.

DD: Yeah, we are going to need to cut this short.

Brian: Ok. Any time you have I be really appreciative of it.

DD: Go ahead.

Brian: The next question is, um, if training a person to be, again, a commercial astronaut what are the most important subject and/or flight areas in which to be familiar?

DD: I think that really has the same answer, a degree in engineering of some type because, ah, it trains you how to think or how to react to problems.

And, um, experience flying high performance airplanes, particularly turbojet powered airplanes. It would be a big help if you have experience flying something supersonic.

Brian: Un huh, Any set number of hours as a minimum or any type of, um, multiengine, single engine turbojets or supersonic aircraft.

DD: Not really.

Brian: Ok. And, and then, the last question is when selecting a commercial astronaut that believe you is important to consider that we, um, have not talked about already?

DD: Well, the medical screen of participants, which is, um, the person buying a ticket rather than flight crew, a, we plan to test for tenancies for claustrophobia, um, ability to take high g as well as 0g and thats going to be administered by a ride in a Pitts aerobatic airplane as well as just general good health , including passing an equivalent of a 3rd class FAA medical.

Brian: Ok, um...

DD: In going commercial, we really trying to minimize the need requirements in order to fly because we want to carry anybody who can buy a ticket.

Brian: Uh huh.

DD: Obviously we can't but we are trying real hard to make the physical requirements and mental requirements easy to meet as well.

Brian: Ok. In terms of the pilots that operate the vehicle, would they, um, would they need a certain number of rest days between each flight or would they be able to fly like a flight morning and another one in the afternoon?

DD: You know, it will probably similar be to air transport pilots in that respect. In other words, they'll take the FAA's crew rest criteria and apply them.

Brian: Ok.

DD: Although, um, we'll be more strict than that because the demands bigger than standard air transport pilot.

Brian: Ok.

DD: A lot more like driving a race car than a bus.

Brian: Right, haha, ok.

DD: Now I do need to goto a meeting.

Brian: Ok, one quick...

DD: Can I have your name again?

Brian: Brian Kozak and I'm from Purdue University.

DD: Ok.

Brian: And, one quick final question, would I be able to use your name and title in study or would like to remain anonymous?

DD: Go ahead, you can use my name. I really do need to go so have a good day.

Brian: Ok, thank you.

END OF RECORDED INTERVIEW

Date:	3-September-2010
Interviewer:	Brian Kozak
Interviewee:	James Voss (JV)

Brian: First off, can I record this conversation?

JV: Sure.

Brian: Please understand that your participation in this study is voluntary, and you must be 18 years old to participate. Participation or non-participation in this study will not affect your employment. Your responses will be kept confidential, and any quotations used in the final report will be attributed to "Participant 1, 2, 3…etc." to maintain anonymity. If you wish to waive your right to anonymity, please let me know now. At the end of the interview, if you waived your right to anonymity I will ask again if wish to waive your right to anonymity.

JV: You can use my name.

Brian: Ok, the interview itself should last between 20 and 25 minutes.

JV: Ah, I'm on my way somewhere, so I have maybe five minutes.

Brian: Alright, the interview will be recorded via audio recordings and all original recordings will be destroyed by 31-December-2010.The risks involved are minimal, no greater than everyday life. The purpose of this study is to determine the selection criteria of flight crews for suborbital spaceflight within the space tourism industry. I am conducting this study for my Master's Thesis. As such, I will be conducting and recording the interviews, transcribing the audio recordings, analyzing the data, and

writing the final report. Insights generated as a result of this study could benefit the companies in the commercial space industry, institutions of aviation and aerospace education, as well as the Federal Aviation Administration's Office of Commercial Space Transportation. Please answer the following questions based on your knowledge and experience with suborbital spacecraft. The Principal Investigator for this study is Professor Denver Lopp. He can be reached at 765-494-6387. If you have concerns about your treatment during this interview, you can contact the Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114. The phone number for the Board is 765-494-5942. The email address is irb@purdue.edu. Do you have any questions?

JV: No.

Brian: Ok, um, the first question is what kind of educational and or technical background should a commercial posses?

JV: It doesn't matter. Ah, it doesn't really have that much to do with...with the skills a person needs to fly in a commercial human spacecraft. So background isn't that important, its..ah, more of the technical skills person has. So I don't think education is...is a particularly linked to the kinds of things a person has to do with the spacecraft. They are more piloting skills or, ah, their ability to operate equipment, ah, it is just generally finding people, who...who have technical educations are the kind of people inclined to do that type of thing.

Brian: Ok, ah, the second question is what type and how much flight experience should a commercial astronaut have?

JV: Well, they're going to have piloting skills so they should have a lot of flight experience. Ah, NASA has generally required a thousand hours of high performance jet time for, ah, Shuttle pilots. So for a, um, a spacecraft that requires a high degree of piloting skills something similar to that would probably be appropriate. If it flying a capsule, then that is much...it is very different kind of task and the actual flying skills are probably not that...that critical.

Brian: Ok.

JV: They would have to have, ah, the ability to work in the cockpit type environment that often times comes from experienced people working in the vehi...aircraft of some kind. But you probably would get the same value from a commercial or transport type pilot that you would from someone with high performance jet time.

Brian: Ok, ah, um, may, for this study I'm focusing primarily on suborbital spacecraft or launch vehicles...

JV: Suborbital, ah, um, but what type of suborbital do you hope to...

Brian: Um, reusable...

JV: That require piloting skills of landing on a runway or just, ah, capsule, where do don't have to pilot the vehicle?

Brian: Um, I was primarily gearing towards, ah, takeoff and landing on a runway or atleast landing on a runway but, um...

JV: Ok.

Brian: Capsules as well. Ah...

JV: In that case they require piloting skills that could be anything learned from any type piloting experience and extensive pilot experience is probably necessary for type of, ah, vehicle.

Brian: Would civilian or military, ah, flight time be more applicable?

JV: No, ah, it is just flight time.

Brian: Ok.

JV: It doesn't matter if you are flying a military airplane or civilian airplane, both require the same kind of skills.

Brian: Ok.

JV: Ah, and it depends on the flight regime of the vehicle that you talking about, a suborbital vehicle with it...that has very high landing speeds then, ah, flying that type of a aircraft with it military or civilian be more appropriate. Suborbital links, ah, things that are common and are similar would be performance characteristics of a suborbital spacecraft that you are talking about.

Brian: Ok, the next question is if training a person to be a commercial astronaut what are the most important subject and/or flight areas in which to be familiar?

JV: Well, they have to understand their vehicle so, ah, training would have to revolve around the vehicle that they are going to be piloting and then, ah, practicing piloting tasks that need to be done and that could be done

somewhat in a simulator or in a flying simulator like the Shuttle Training Aircraft, ah, the closer to the real thing the better the training.

Brian: Right.

JV: For the person. So its mostly for the pilots and the flying skills.

Brian: Ok, and the last question is when selecting a commercial astronaut is there anything you believe is important that, to consider that we have not already talked about?

JV: Could you say that one more time?

Brian: Ah, um, when selecting a commercial astronaut is there anything that you believe is important to consider that we have not discussed?

JV: Ah, I think, the...personality types, ah, that you would want for something like that are the, the kind you would typically find in, ah...ah...kind of community that does flight test work because generally those type of vehicles are not going to have enough experience behind them to be routine...so a people with flight test, ah, experience probably be more appropriate for,ah, for piloting those vehicles.

Brian: Ah, do you see a need, um, like a minimum of days or hours between each suborbital spaceflight in terms of flight crew rest?

JV: No, no, there can be multiple piloting days just, ah, generally a short flight so no I don't think there would be any need for any, um, period of rest time between flights.

Brian: Ok, and one quick, um, final question,

JV: Sure.

Brian: Can I use your name in my thesis?

JV: Ah, as long as it is just associated with the responses to the questions that I had, sure.

Brian: Right, exactly, I will be transcribing this interview, um, and then using quotations as appropriate in my work.

JV: Ok, sure thats fine.

Brian: Ok, um, thank you very much.

JV: Thank you, bye.

Brian: Bye.

END OF RECORDED INTERVIEW

Date:	14-September-2010
Interviewer:	Brian Kozak
Interviewee:	Gary Payton (GP)

Brian: First off, can I record this conversation?

GP: Sure.

Brian: Ok, let me get it started here. Ok. Please understand that your participation in this study is voluntary, and you must be 18 years old to participate. Participation or non-participation in this study will not affect your employment. Your responses will be kept confidential, and any quotations used in the final report will be attributed to Participant 1, 2, 3… etc. to maintain anonymity. If you...if you wish to waive your right to anonymity, please let me know now. At the end of the interview, if you waived your right to anonymity I will ask again if wish to waive your right to anonymity. The interview itself should last between 20 and 25 minutes. The interview will be...will be recorded via...via audio recordings and all original recordings will be destroyed by 31-December-2010. The risks involved are minimal, no greater than everyday life. The purpose of this study is to determine the selection criteria of flight crews for suborbital spaceflight within the space tourism industry. I am conducting this study for my Master's Thesis. As such, I will be conducting and recording the interviews, transcribing the audio recordings, analyzing the data, and writing the final report. Insights generated as a result of this study could benefit the companies in...in the commercial space industry, institutions of aviation and aerospace education, as well as the Federal Aviation Administration's Office of Commercial of...Commercial Space Transportation. Please answer the following questions based on your knowledge and experience with suborbital spacecraft. The Principal

Investigator for this study is Professor Denver Lopp. He can be reached at 765-494-6387. If you have concerns about your treatment during this interview, you can contact the Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 South Grant St., West Lafayette, Indiana 47907-2114. The phone number for the Board is 765-494-5942. And the email address is irb@purdue.edu. Do you have any questions?

GP: No, sounds good!

Brian: Ok. And like I said in the email I will send you a copy of this transcripts and you can look it over and tell me what you think about it.

GP: Ok.

Brian: Ok, and the first question is, what kind of educational and/or technical background should a commercial astronaut posses?

GP: Ah, I would think for these kinds of suborbital spaceflights like, um, Virgin Galactic and anybody else in there, ah, I would think that the passengers want to have a very high confidence in their flight crew. Because this is a brand new industry and it is a brand new experience for these folks and so that level of confidence of the flight crew would be critical and so to me that would say, ah, being able explain the engineering of the vehicle in the flight, ah, the propulsion, the electrical systems and the ascent environment and the technical perspectives and should be able to explain it and comment everything about it would be an absolutely critical part of the experience that these folks would have. To me, that says an engineer degree at a minimum plus all sorts of flight experience. As it comes to educational requirements, I would say an engineering degree at least as a Bachelor's.

Brian: Ok. And what type of how much flight experience should a commercial astronaut have?

GP: Ah, because the flight will be dramatically different than just takeoff, cruise and landing I honestly don't think, ah, commercial airline type qualifications, ah, would be adequate. Certification, airline transport rating or airline transport pilot, you know, so many thousands of hours as an airline pilot , I don't think that would be very beneficial in this sort of flight. Because it is going to be a very steep ascent and then pushing over toward the end of powered flight and a coast period, 0g, and then the reentry, its a parabolic flight not a takeoff, cruise and land kind of flight...so how would you describe that, some sort of a test pilot like curriculum, jeez, I remember the Air Force Test Pilot School used to have a F-104 with a rocket up underneath tail in addition to the J79 in the F-104 itself and so, ah, and that was specifically designed to get guys ready for the X-15 flights. It would be that kind thing, um, I think which is the kind of flight training you need to have, varying G load environments, varying pitch attitudes, dramatically varying pitch attitudes environments during the flight and you would have to be watching the flight performance which is dramatically different than the flight performance of a 787 or a 777 or some airplane like that.

Brian: Ok.

GP: I'm thinking some sort of a, um, a course similar to a test pilot school kind of course would be the flight training that would be necessary for these kinds of commercial pilots.

Brian: What about aerobatic flight experience and, um, like the military or civilian aerobatic demonstration team?

GP: Yeah, aerobatics that, um, weather its military or not, aerobatics is that kind training that puts you upside down, in a high G environment, low G environment, or horizontal Gs going left and right not necessary forward and aft Gs. So its, ah, yeah, aerobatic training would have to be part of because again you have keep your head about you, upside down, negative 1G, positive 3Gs or whatever.

Brian: Ok.

GP: Aerobatic training would cover that.

Brian: Do you think there is a set number of minimum hours of aerobatic flight that, ah, would properly a person for a suborbital spaceflight?

GP: No, just, ah, complex aerobatics, let's phrase it that way.

Brian: Ok. And in terms of personality and character, would make a desirable commercial astronaut?

GP: Ah, throw away the scarf. Haha.

Brian: Haha.

GP: Again, the main and most important job I would think for the commercial crew, commercial astronaut crew, would be an image of confidence in this very different kind of flight environment. The, um, passengers have to have a lot of confidence in the flight crew. Well that means they would, um, kind of throw away the fighter pilot classic, test pilot, silk scarf mentality. And you have to be, have this attitude...well, for ever flight for these folks, the passengers, would be similar to a Young Eagles flight for someone who is 14 or 17 years old.

Brian: Right.

GP: It is an introduction to a new environment so there has to be an aura of competency and experience that the crew has to have.

Brian: Do you foresee any need for the crew, ah, for a certain, like, um, rest hours or days between each suborbital flight?

GP: Ah, between each one?

Brian: Yes.

GP: No, I would think, from what I know about the flight the longest part of the flight is the climb up to the, ah, altitude....That's the longest part of the flight. So I would think, 2 a day would no problem, um, and then maybe 3 a day, something like that because the flights are really really short.

Brian: Ok. How much experience with weightlessness or 0G should these flight crews have?

GP: Probably not much because the 0g exposure relativity short. Ah, their main job is making sure the vehicle has the right attitude at the start of reentry back into the atmosphere for flight control authority purposes. Ah, and then reentry trajectories purposes, so, ah, I would think 0g experience isn't that important personally because they are going to be strapped into the front seats monitoring the attitude of the bird as it starts to get back into the atmosphere.

Brian: Ok.

GP: Now, the passengers, running around probably would have to have enough discipline in the passenger compartment to get everybody strapped back down before the G loads get too high, nonetheless the flight crews main responsibility will be, ah, maintaining, achieving the right kind of attitude for reentry.

Brian: Ok. And if training a person to become a commercial astronaut what are the most important subject and/or flight areas in which to be familiar?

GP: Ok, yeah, you're assuming somebody a FAA pilot, commercial pilot, got all the necessary credentials, actually training for the flight itself, probably have to include, um, again ascent off nominal, unrecoverable off nominal trajectories both going up hill and coming back down and of course system malfunctions during the flight. So most of the training will have to revolve around, um, again the trajectories itself and the attitudes, G loads of that trajectories and then, um, handling the flight control systems during ascent and entry and then the off nominal, potential off nominal scenarios around all that.

Brian: How well can you adequately simulate that in a simulator, like ground based...

GP: How well what?

Brian: How well can you simulate a off nominal trajectory in a simulator, either ground based or aerial.

GP: Well, its very easy. In fact I wouldn't worry so much about a flight simulator, the Shuttle Training Aircraft...

Brian: Right.

GP: Yeah, its nice to get into a sim and point the nose straight down like the STA where you would get 40,000 feet per minute sink rates. The real learning goes on inside simulators and they really don't need to be motion based simulators. In my experience, a motion based simulator is good, but it doesn't replicate the rocket powered ascent and the, ah, motion range at entry are not that great so you don't need motion based. Especially with modern, high definition visuals I wouldn't even think the, a motion based simulator on the ground would be necessary.

Brian: Ok, um, the final question: when selecting a commercial astronaut, is there anything that you believe is important to consider that we have not discussed?

GP: For this kind of flight, again, the image of confidence in their attitude and in the way can explain the flight, explain trajectories, and in the way they can describe the engineering of the vehicle. Again you are dealing with, ah, a relativity rich customers who are in it for the experience and if you could use them as somebody who says yes, these are very very confident, very professional, very skilled, they become advertisers for other customers. So the competency in flight with the crew is going to be the dominate feature that the customers walk away with. And establishing the image and establishing the actuality of confidence in the vehicle is essentials to the entire success of the company and in this case, maybe the entire market place.

Brian: Ok, alrighty, thats all I had.

GP: Ok.

Brian: Thank you very much.

GP: And now whats interesting is if you are describing your thesis notion of commercial space transportation for orbital flight, where the people would be on orbit for a week or two weeks or something like that, the flight crews would have a different set of skills for flight. Maybe an additional set of skills. And thats a different thesis you can work on later.

Brian: Haha, Exactly. I originally considered working on both suborbital and orbital flight but time constraints and my thesis committee kinda narrowed it down a bit to primarily...only suborbital spaceflight.

GP: Yeah.

Brian: It is definitely an interesting area to explore and to talk to people about.

GP: How many people are you talking to?

Brian: You are the 6th participant so far.

GP: Ok. You are going to need a big group aren't you?

Brian: Going to need what? I missed that last past.

GP: You are going to need a large number of interviews right?

Brian: Yes.

GP: Ok.

Brian: I'm hoping to get a couple more here.

GP: Ok, good.

Brian: So...

GP: Well, alright, excellent!

Brian: Well, alright, thank you very much for your help and your assistance with this.

GP: You bet. Ok, bye.

Brian: Ok, thanks, bye.

END OF RECORDED INTERVIEW

Date:	22-September-2010
Interviewer:	Brian Kozak
Interviewee:	Mark Brown (MB)

Brian: Can I record this conversation?

MB: Sure.

Brian: Ok, please understand that your participation in this study is voluntary, and you must be 18 years old to participate. Participation or non-participation will not affect your employment. Your responses will be kept confidential, and any quotations used in the final report will be attributed to “Participant 1, 2, 3…etc.” to maintain anonymity. If you...if you wish to waive your right to anonymity, please let me know now. At the end of the interview, if you waived your right to anonymity I will ask again if wish to waive your right to anonymity. The interview itself should last between 20 and 25 minutes. The interview will be recorded via audio recordings and all original recordings will be destroyed by 31-December-2010. The risks involved are minimal, no greater than everyday life. The purpose of this study is to determine the selection criteria of flight crews for suborbital spaceflight within the space tourism industry. I am conducting this study for my Master’s Thesis. As such, I will be conducting and recording the interviews, transcribing the audio recordings, and analyzing the data, and writing the final report. The Principal Investigator for this study is Professor Denver Lopp. He can be reached at 765-494-6387. If you have concerns about your treatment during this interview, you can contact the Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 South Grant St., West Lafayette, Indiana 47907. And the phone number for the Board is 765-494-5942. Do you have any questions?

MB. No sir!

Brian: Ok, let's begin. What kind of educational and/or technical background should a commercial astronaut have?

MB: Well, there is a fundamental philosophy of the issue here that we have to deal with first. The issue here is the level of fidelity that the vehicles themselves have and the people who are part of the flight crews have that are supplying the service. The manned spaceflight program that NASA has, managed and supervised over the last half of century, there have been specific requirements that determine what is acceptable, quote unquote from systems engineering standpoint and what is also acceptable quote unquote to certify a crew a member to operate one their vehicles as either pilot, mission specialist or whatever function they might, um, perform on the vehicle. So the fundamental question here, do those same safety requirements translate into commercial space or are we going relax the safety requirements to do something different. And my personal opinion is that the safety should not change. They should be the same because the passengers, just like with Christa McAuliffe the school teacher who was killed on *Challenger,* anybody who flies on a spacecraft, either government supplied through NASA or commercially should have the comfort knowing there are adequate safety standards in place both from a hardware standpoint and from a human standpoint to guarantee them some level of safety as they fly the flight. So the bottom line answer to your question is that, yes, I think that the same training and certification, um, methodologies used for professional astronauts at NASA should be applied to commercial spaceflight, and that in turn implies that there needs to be high percentage of people that have degrees in either technical science or engineering and also have fairly high level experience in flying . So you are still are going looking for people that are, for the lack of a better word, aerospace engineers and test pilots.

Brian: Ok. Any particular type of engineering degree or, um...

MB: Well, NASA's experience has shown that...even though aero degrees are naturally what people would assume to be best is not necessarily the case. Any technical degree that is present helps you with some fairly solid flying experience is adequate. The requirements that NASA uses for pilots and missions specialists is very well defined. You know, Bachelor's Degree like we've talked about for the pilots plus 1000 hours pilot in command time or Master's Degree for the mission specialist with 3 years of experience. For the pilots themselves, there is nothing really more required beyond a Bachelor's degree. The flying experience is actually more important. For the crew members that will operate the vehicle, effectively be the crew chiefs of the vehicle. There is probably still is a good argument to be had for them to have Master's level experience to start with. As commercial spaceflight matures, it will be more of a comfort and service offering in the vehicle so degrees of any kind will probably to start to erode.

Brian: What type and how much flight experience should a commercial astronaut have?

MB: Well, I think commercial astronauts, the ones actually flying the vehicle, should have to have the same requirements that NASA astronauts have. And that would a minimum of 1000 hours pilot in command time.

Brian: What about, like, aerobatic flight experience or, um, military flight, is any of that time more proffered than a normal airline pilot flight time?

MB: Aerobatic, no. Military flying, yes. And that only reason military flying has higher marks is because military officers generally are giving more responsibility and put in more stressful situations earlier in their life than a typical commercial pilot. But when you have a military pilot with a 1000

hours command time you have a more seasoned professional pilot with an equivalent number of hours in the air.

Brian: Ok. In terms of, um, personality and character, what would make a desirable commercial astronaut?

MB: That would be the same questions that would applied to, um, a commercial airline captain or ,ah, a current astronaut at NASA. I would take a look NASA's own selection criteria. The real fundamental question, is one of duration. If these people are simply going to haul people up to a orbiting hotel or something like that where there total exposure to the passengers community is going to be 1 to 3 days, they don't required, say, significant interpersonal skills as opposed to technical flying skills and experience. If you talking about longer duration exposure to the passengers than the needs for more social skills becomes important.

Brian: Ok. Right now, I'm only looking at suborbital spaceflights. Ones that last half an hour, 15 minutes or so. So it is just short little hop into space and back.

MB: Yep. If you are looking at that, then the social aspect of this is not applicable. Technical skills would be more important.

Brian: And, do you see like a need for a mi mum number of days or like, um, rest days between suborbital spaceflight?

MB: In order to answer that questions, lets talk about it from the passenger prospective first.

Brian: Ok.

MB: In the flight that you are modeling, what is the total...exposure to zero gravity going to be?

Brian: Um, 10 minutes, 15 minutes or so maximum.

MB: With that exposure, it is basically a pop up flight.

Brian: Right.

MB: From a pilot's standpoint, I think normal crew rest, um, rules would apply....where you can't fly for more than 10 to 12 hours depending on what the function is. I don't have a problem with that. The reality of spaceflight and also weightlessness is that there is a tremendous adjustment that the body goes through in the first 24 hours. And a large number of your passengers are going to be losing their lunch in the 10 or 15 minutes. They paid all that money for to experience weightlessness and some of my commercial buddies down at Cape Kennedy have thought about this because they finally realized they need to talk about the mission profiles that are 3 or 4 days because the first day and half these people are going to feel like they have spacesickness. And it will only be on second and third days that they will be able to really enjoy the experience. Now with the 10 or 15 minute exposure to zero G, yeah, you get to float around and look out the window and do all of the rest of it but probably a good percentage of people are going to suffer from fair, fairly immediate affects of zero gravity which would throwing up, headache, nausea disorientation, vertigo, all of those other fun things.

Brian: And how much experience with weightlessness should these, um, the pilots of suborbital spacecraft have?

MB: Well, they have to have some minimal amount of training so that they understand not only what it means but how is affects the operation of the vehicle itself. And, for, for a 10 or 15 minute it is a relativity easy process other than the fact that everything that isn't nailed down will float and there can be special concerns that they need to mindful of, of with not only the passengers but what is going on in the cabin . For example, serving coffee is a really bad idea in weightlessness.

Brian: Haha. Right.

MB: It will be things like that they to train for. Training in a zero G aircraft would be more than adequate. It would be more of a familiarization with the vehicle. That's important.

Brian: And then, when selecting a commercial astronaut, is there anything that you believe is important to consider that we have not already talked about?

MB: That is a good question. Let me ponder that for a quick second.

Brian: Sure.

MB: I don't think so. I think that in terms of the flight crew itself I think we've covered it. From the vehicle side of it, I have a number of concerns but I think thats a different thesis topic. And let me just expand on the one area that would affect the crew. I think there is a lot of work that needs to be done in terms of human factors, cockpit design layout, um, that would relate to how you would want the crewmen operate the vehicle and maintain their own orientation. Yeah, I don't spent enough time on that.

Brian: And, how well can you adequately simulate a spaceflight in, ah, simulator either ground based or aerial.

MB: Oh, can you simulate it pretty well with three degree of motion simulators even though things won't literally float in the cockpit you definitely get the sensation of getting zero G and going through those transitions with the vehicle. You can do that with a combination of visual cues and audio cues and so you get, you get simulate very well but the simulator training would be an important ingredient for these suborbital flights.

Brian: And, how long of a, of a training period you think would be required to train a person for a suborbital spaceflight?

MB: As a pilot?

Brian: Yes, going from a military pilot 1000 hours PIC time to a suborbital commercial astronaut.

MB: Probably 6 months to a year. And the reasons for that is that there will be a fair amount of classroom activity that would have to be conducted in addition to the physical vehicle training and then also the flight simulation and emergency procedures that would have to be taught and learned. Things like that. For example, if you are going to be doing suborbital flight, everybody thats going to have to basic training in land survival, water survival, Arctic survival etcetera etcetera etcetera. So it is a lot more than just putting somebody in a simulator for 3 hours and turning them loose.

Brian: Ok. Do you have anything else that you want to ,ah, add to this conversation?

MB: Yes, I would like to get a copy of your paper when you get it done.

Brian: Ok.

MB: I'm very proud that you're doing all this.

Brian: Thank you! Um, would you want a copy of the entire thesis or just a article length or journal length paper?

MB: Oh, I would like the whole thing!

Brian: Ok!

MB: And just so you know, one of the things I encouraged our university friends to do was to host a national dialogue on what the U.S. spaceflight plan should be. So right now we don't have a manned spaceflight program. We are kind of lost.

Brian: Right.

MB: I think very appropriate we have a national dialogue. You know, what do we want to do? It is commercial, military, NASA standpoint? Where are we going to invested our funds? What are our strategic goals? It is Moon, Mars, a Lagrange point? What do we really want get out of this? A Marriott in low Earth orbit? And I think now is the time to have that debate nationally and decide what level of international participation we want to have before the Chinese go to the Moon and start selling everything from Tranquility Base on eBay.

Brian: Right, haha, ok. Yeah, it is definitely an interesting time for the, like you said, the U.S. space program or the lack thereof.

MB: Yeah, you got it!

Brian: Hopefully some of these commercial companies will be able to kinda step up and, you know, lead the U.S. and make some money off of it too.

MB: Yeah, that right. And they send guys like you and me to go do that.

Brian: Right. Haha. Ok. One more quick thing. Can I use your name associated with these answers?

MB: Absolutely!

Brian: Ok. And thats all I had.

MB: And its a great pleasure and I wish you the best of luck

Brian: Thank you very much.

MB: Take care.

Brian: Ok, bye.

MB: Bye.

END OF RECORDED INTERVIEW

Date:	22-September-2010
Interviewer:	Brian Kozak
Interviewee:	Participant (P9)

Brian: Can I record this interview?

P9: Sure.

Brian: Ok, please understand that your participation in this study is voluntary, and you must be 18 years old to participate. Participation or non-participation in this study will not affect your employment. Your responses will be kept confidential, and any quotations used in the final report will be attributed to Participant 1, 2, 3 to maintain anonymity. If you...if you wish to waive your right to anonymity, please let me know now.

P9: No.

Brian: Ok. At the end of the interview, if you waived your right to anonymity I will ask again if wish to waive your right to anonymity. The interview itself should last between 20 and 25 minutes. The interview will be recorded via audio recordings and all original recordings will be destroyed by 31-December-2010. The risks involved are minimal, no greater than everyday life. The purpose of this study is to determine the selection criteria of commercial astronauts for suborbital spaceflight within the space tourism industry. I am conducting this study for my Master's Thesis. As such, I will be conducting and recording the interviews, transcribing the audio recordings, and analyzing the data, and writing the final report. Insights generated as a result of this study could benefit the companies in the commercial space industry, institutions of aviation and aerospace education, as well as the Federal Aviation Administration's Office of

Commercial Space Transportation. Please answer the following questions based on your knowledge and experience with suborbital spacecraft. The Principal Investigator for this study is Professor Denver Lopp. He can be reached at 765-494-6387. If you have concerns about your treatment during this interview, you can contact the Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 South Grant Street, West Lafayette, Indiana 47907. And the phone number for the Board is 765-494-5942. And the email address is irb@purdue.edu. Do you have any questions?

P9: No.

Brian: Ok. And the first question, what kind of educational and/or technical background should a commercial astronaut possess?

P9: Let me give you kind of a top level responses to all of your questions with some minor variations.

Brian: Sure.

P9: Which is by definition, the backgrounds of the ones that we have...which is the two that flew for SpaceShipOne, Brian Binnie and Mike Melvill, um, the reason being that a lot of this will change with time. I can only really give you an answer right now and the qualifications right now will much higher than they will be in say 10 years.

Brian: Ok.

P9: And the only way to really predict what their qualifications will be is to work with the ones they have right now. Right now, there are very few slots and the competition is very fierce and there are huge number of unknowns. So

all of those are going to drive all of these requirement very high right now. So you are asking me right now.

Brian: Yes.

P9: So the answer is going to be high. If you look, example at Mike Mevill and Brian Binnie, both of them participated in the design process. They've been with the company for a long time and they knew a lot about the vehicle in case of, um, Mike Mevill he actually built his own aircraft...that was one of Dick Rutan's planes, um, sorry, one of Scaled Composites' planes. He helped design the release mechanism for SpaceShipOne, he was VP of general management at Scaled Composites. Brian Binnie, um, had just been with the company for a long time. He was more of, I would have guess what they were looking for, he came from a military flying background. He has a Master's degree, a Bachelor's from Brown in aerospace engineering, a Master's from Princeton in aeronautics and he was a graduate of the U.S. Navy Test Pilot School. 21 years in the Navy flying aircraft. 4600 hours of flight time . That is the kind of thing I would expect, a graduate degree , and the military flight background with several thousand hours of flight time. Mike Melvill was more of a surprise to me. It gives you the range you might see. He was one of those who was much more involved in the design process. So his qualifications came from building the aircraft. He doesn't have a military background and consequently he has much more hours of flight time although he has a comparable level of experience with 7600 hours of flight time. And both of them had flown many of the Scaled Composites' planes before they flew the spacecraft. So that is kind of the big picture. So back to your first question.

Brian: Ok. Sure.

P9: What kind of technical background...I would expect you might get a military pilot with at least a graduate degree and several thousand hours of flight time or a civilian pilot who has either graduate degree or who has been heavily involved in the design process...with also several thousand hours of flight time probably as you saw in military guy to be competitive.

Brian: So like a specific graduate degree in science or engineering then?

P9: Not necessary. If you look at what astronauts have, for example, some them have management graduate degrees. It depends on where they were in their military career when astronaut opportunity came open to them. It really depends on what the organization needed at the time. So...I would say first choice would be engineering with second choice either management or science.

Brian: Ok. And then with the flight experience would aerobatic flight, um, either civilian or military would be more preferred than general military time or like any specific type military time?

P9: You can't avoid aerobatic flying when you have high flight hours in either military or...certainly military because the military guys do, you know, combat maneuvers which is aerobatics.

Brian: Right.

P9: You aren't going to get a high flight time military pilot who doesn't have aerobatic flight time. In terms of the commercial guys, um, don't know that as well as the high flight time so I could guess it is the same thing for safety. I would expect it is true for the Scaled guys. Both of them will be test pilots. Both are members of the Society of Test Pilots and they have test pilot backgrounds so...Mike Melvill flew commercial planes as a test pilot capacity

and Brian Binnie flew military planes but if you a test pilot, again, you are going to have aerobatic training because that is what you need to have to be safe. You need to be able to recover from spins. You need to know...if you get into some high angle maneuvers you need know how to recover from them and how to spot them. So I wouldn't put it as a separate requirement. I think that comes with...a test pilot background like we've previously talked about.

Brian: And would a graduate from a government run test pilot school or the civilian nation test pilot school out in California be preferred or would they be equally valid?

P9: I don't know enough...I'm not pilot so I don't know enough about the various test pilot schools.

Brian: Ok. In terms of personality and character, what would make a desirable commercial astronaut?

P9: I would say, that is probably the same as a military astronaut or rather a government astronaut which is...you want someone who has performed well in high speed life threating situations which comes kind of for free with a test pilot background. They get that as part of technical training. You want someone who is good speaking to the public again at least initially eventually that won't be true. In the early years, right now, they are going to get a lot of public attention. You want someone who is comfortable being in front of crowds and going out promoting the company and spacecraft. And you want someone who is a good team player. You've got to be able to work with the engineers and technicians who are developing the spacecraft to be able to...when they find something needs to be fixed they need to be able to do a good communicating why it needs to be fixed and working with the people involved to get it fixed. Giving them good feedback all of that kind of stuff.

Brian: And do you foresee a certain number of years in the military or a certain number of hours like you said before?

P9: I would expect hours of flight time to meet the criteria.

Brian: Ok.

P9: And the variety of planes flown. Again that comes with hours.

Brian: And that would be, mostly turbojet or, um, turbofan time?

P9: I don't think that would be an issue. I would expect it doesn't matter. Spacecraft are none of the above.

Brian: Ok. If training a commercial...a person to become a commercial astronaut, what are the most important subject and/or flight areas in which to be familiar?

P9: Again we are back to the ones that we have. Because of the big unknowns right now, you are going to want test pilots**.** There is a standard test pilot curriculum that they will go through and they will have to know all of that stuff. And I expect their going to want, they are going to want someone with a graduate degree not because it is particularly necessarily but because the competition is so fierce why wouldn't you?

Brian: Right. Exactly.

P9: It is important in the picking, it is important in the job. You see the same thing in government astronaut programs. Two aspects. One is you want people who are self starters and confident and have high general analysis goings. All that is demonstrated for you by getting an advanced degree even

potential a PhD. Although test pilots because they spend so much flying would unlikely to have a PhD but it is not impossible. Scott Horowitz, one of our NASA astronauts, had a PhD. So it has been done. Um, but thats a way of getting the evaluation done for you by the universities and not by NASA itself. So it is not the education per se, it is the technical stuff. It is the fact that they made the effort to complete a graduate program and have the skills and abilities to do. And those skills and abilities become helpful because there are so many unknowns you want people who know how to handle problems and do some of their own leg work and not just have to fed by other people. And that is A, the abilities to deal with knowns. And the second is, you are going to be dealing with very qualified people. The more qualifications you have the more credibility you have in the eyes of those people.

Brian: Ok.

P9: For example, on my first flight I flew with someone who was a military helicopter pilot. She had just a Bachelor's degree at that point. To tell you how skilled she is, she eventually got a PhD going to night school while she was a single mom with, ah, like a 10 year old.

Brian: Oh wow!

P9: So is obviously is extremely capable. But at the time she flew with me, she didn't have a PhD and I did. When we would go into meetings with payload team members and they would just ignore what she said and they would listen to me. So I would basically repeat what she said they would listen to me simply because I had a PhD. Nobody could say to me, which they did her, if you had actually done your own research you would understand why this is important.

Brian: Right.

P9: So having those kind of credentials can be useful in with working with people who like credentials.

Brian: To do think it is possible to be overqualified for the, like, a commercial astronaut or work...

P9: No.

Brian: Ok.

P9: No, at least not right now because the competition is so stiff. And there are unknowns about the job. Overqualified is generally what happens when people people get bored. So at times of high unemployment so like when a PhD in chemistry takes a job at McDonalds. Right? And their not going to stay. As soon as the economy turns around, they are going to leave. And they're not paid as well. The commercial astronaut thing is so cool right now.

Brian: Right.

P9: There are some many different opportunities, international travel, meeting all kinds of different people, all kinds of interesting stuff. People aren't going to get bored so overqualified isn't an issue. Like what we just talked about, overqualified has so many different benefits that they will see for themselves. They will see how nice it is to have those qualifications...that they're not going to feel overqualified. Thats another problem overqualified is. Working those people who don't understand or aren't interested in what you do. The material is boring and the people are boring. Its not going to happen with commercial astronauts at this point.

Brian: Right. And how long of a, ah, like, going back to the training question. How long of a training program do you think is adequate to prepare someone for a 15 or 20 minute suborbital spaceflight?

P9: Right now. Again we are back to the people we know. The training program per se is not a separate program. They are an integral part of the company and they sort of train as they go.

Brian: Right...

P9: And a huge amount of training was done before they got there with all of that test pilot stuff. So a specific training program is probably pretty short. You can probably find those records as to how long they spent kind of dedicated to the flight aspect. Brian Binnie and Mike Melvill. But it is probably up to a year.

Brian: Ok. How well can you adequately simulate, like, a spaceflight in a simulator in terms of visuals, the actual feel for it, the performance characteristics of the vehicle that you are operating?

P9: Well, you can do it pretty well after you have had a few flights under your belts. You can do it well enough even when you don't because we have so experience now that it is not a huge unknown. But there is a huge difference between a simulator...the real advantage of a simulator from my perspective is training for things that are too dangerous to attempt to do in real life, like blown tires for the Shuttle. But for the spacecraft it would be some kind of really dangerous spin or a pressurization, something like that. Which you really wouldn't want the real person through because they have to learn. You don't want them to kill themselves. So the real value of a simulator is in the heavily off nominal situations. You can also use it to train for routine operations to develop your patterns so they are very consistent. One thing you just don't get from a simulator is this knowledge that if you make a

mistake you will kill yourself. And you need that regular exposure to keep yourself efficient at focusing situation like that.

Brian: Right because no one is really afraid of dying in a simulator.

P9: Right. So you get a little causal about it. One of the big advantages of having everybody in the astronaut corps who is on flight status fly T-38s is that it keeps you in that environment where you have to have be efficient and it really and truly only happens in the cockpit. You can't just say, oh wait I forgot my notebook I'll run over next door and get it. You don't have it in the plane you are out of luck and it forces you maintain the habit pattern. Simulators are great. When I flew in space the first time, I spent so many hours in the simulator that it honestly didn't feel like my first flight. It felt like I was there before. They did a great job at making the switches the same, the skills the same so you weren't distracted by developing any new habit patterns. All of the habits patterns you developed in the simulator were perfectly useful.

Brian: How much experience with weightlessness should these commercial crews have?

P9: You honestly don't need much. The weightless part you don't spend much time at because you are restrained. The people in the space station, who have been up there for a month or two, get really good at working without being restrained. If you are only up there for a couple of days, you are going to be restrained all of the time. So the weightless part isn't something you really need know much about.

Brian: What about the issue spacesickness from a exposure to weightlessness for 15 minutes, 10 minutes or so? Do you think...

P9: As far as we know, there is no way adapt to that expect for being in space. As far I know, every time you fly it is easier than the time before. But...I know of many people who, not me because I did really well on my first flight, did many flights in the parabolic airplanes but its really not the same because there is too much of the low G high G oscillation your body adaptation process to that and it doesn't carry over to space. And they tried those chairs, multi direction motional chairs for the early astronauts...I had, um, they recommend...some people recommend doing a lot of aerobatics to get used to odd positions but I don't think that helps. I did that before my first flight. I don't think it made any difference. Again that process is so different.

Brian: So the only real way to do it is to fly a flight and see what happens with the...the crew?

P9: There are meds you can take...

Brian: Ok.

P9: They work pretty well.

Brian: And how much down time do thing these crews should have before each suborbital flight? Like crew rest time?

P9: Right now it is going to be months so it isn't something you wouldn't have to worry about. Flying in space, going up and down as a carrier pilot who isn't going to stay up in space, it really isn't that much harder than flying an airplane. You could do it everyday if you had that many spacecraft. It is different if you are up there for an amount of time because of the whole adaption thing but up and down is pretty easy. I think that the G level will be pretty light with a easy recovery. You aren't going to land in the ocean with you being out in the water for 24 hours.

Brian: When selecting a commercial astronaut is there anything else important to consider that we have not already discussed?

P9: Not that I can think of.

Brian: Ok. Thank you very much for talking with me.

P9: Sure. Good luck in your report!

Brian: Thank you.

END OF RECORDED INTERVIEW

Date:	1-October-2010
Interviewer:	Brian Kozak
Interviewee:	Andrew Feustel (AF)

Brian: First off, can I record this conversation?

AF: Yeah, sure.

Brian: Ok, let's begin. Please understand that your participation in this study is voluntary, and you must be 18 years old to participate. Participation or non-participation in this study will not affect your employment. Your responses will be kept confidential, and any quotations used in the final report will be attributed to participant 1, 2, 3 to maintain anonymity. If you wish to waive your right to anony....anonymity, please let me know now.

AF: You can use my name.

Brian: Ok. At the end of the interview, if you waived your right to anonymity I will ask again if wish to continue to waive your right to anonymity. The interview itself should last between 20 and 25 minutes. It will be recorded via audio recordings and all original recordings will be destroyed by 31-December-2010. The risks involved are minimal, no greater than everyday life. The purpose of this study is to determine the selection criteria for commercial astronauts for suborbital spaceflight within the space tourism industry. I am conducting this study for my Master's Thesis. As such, I will be conducting and recording the interviews, transcribing the audio recordings, analyzing the data, and writing the final report. The Principal Investigator for this study is Professor Denver Lopp. He can be reached at 765-494-6387. If you have concerns about your treatment during this interview, you can contact the Institutional Review Board at Prud...Purdue

University, Ernest C. Young Hall, Room 1032, 155 South Grant Street, West Lafayette, Indiana 47907. And the phone number for the Board is 765-494-5942. Do you have any questions?

AF. No.

Brian: Ok, and the first question. What kind of educational and/or technical background should a commercial astronaut posses?

AF: You want me to answer that one first?

Brian: Yes please.

AF: Ok, and just to clarify, I sent you an email about this, so from the title of your study is suborbital spaceflight within the tourism industry...

Brian: Yes.

AF: And you are talking specifically about the crew rather than the passengers...

Brian: Right. For this study, I'm only looking at the pilots or the commander of the vehicle, um, the personnel that will actually be piloting and operating the suborbital spacecraft.

AF: Right. Ok. And so, I guess there are some assumptions made about weather or not the vehicle is fully tested or is considered fully operational or has functional crew participation on it.

Brian: Right, um, I'm looking at fully operational vehicles flying 15 to 20 minute suborbital spaceflights, um, assuming that the vehicle is fully operational at this time.

AF: OK, so I guess my answer to question number one is going to be that, um, they should have a similar background to what a lot of the military test pilots have, there is probably some possibility for commercial, strictly commercial airline pilots to be able to participate in those flights but I think there are advantages to having somebody trained in high performance jet aircraft military test program and also obviously test flight experience would be beneficial but I think that is question two. So for educational and technical background whatever the requirements are for, um, military pilots along the lines of engineering training or possibility some classes either undergraduate or master degree level courses in avionics or astronautics or aeronautics would be beneficial.

Brian: You said high performance aircraft. What would your definition of a high performance aircraft be?

AF: My definition would be small military jet fighters type aircraft, so single or dual engine, um, with thrust capabilities and maneuvering capabilities similar to a military training or operational fighter aircraft.

Brian: Ok.

AF: I guess my personal opinion and obviously none of these are based on a specific NASA position or professional position, so my opinion is after one spaceflight and training for another one here at the end of the Shuttle Program and only having the Space Shuttle for a vehicle. So my general opinion is that for these types of vehicles that are doing suborbital spaceflight, it is still a rocket, it is still a very high performance vehicle and a crew should whatever background they needed to gain that insight or expertize or actual experience of, ah, a rocket and typically the way folks do that is either to have flown on a Shuttle, you know, or a Soyuz rocket or trained with the military and done a lot of test pilot work on high performance

vehicles that performance in extremely dynamic environments, very different from what a commercial airliner would experience, you now flying passengers commercially around the country. So although the level of training required to those commercial airplane...aircraft is similar between a former military pilot and a person who is just gone straight through commercial train alone I would think that overall the military pilots would have been exposed more dynamics environments in, um, more potentially risky environments and aircraft. And many of those have gone on to fly Shuttles. The challenge with, um, flying a non pilot or commander who has spaceflight experience is, you probably would have to look at somebody who is a scientist who has flown a Soyuz rocket because that person may have been trained as...an ascent and entry flight officer who is actually operating the vehicle more so than a mission specialist who are on the Space Shuttle where the commander and pilot are in charge. You do have two flight engineers on the flight deck although they don't have the level of control of the vehicle.

Brian: Do you think there is a certain number flight hours to, ah, qualify someone for a commercial astronaut position?

AF: You know, the challenge is that we don't have many rockets and space vehicles around that people can ride on to get experience so in terms of high performance jet aircraft hours...I think it would be a standard that would required for somebody to go on to test pilot school I don't know if there is actually a number. Somewhere around the order of several thousand hours, probably around two thousand hours in a high performance jet aircraft or a thousand minimum that you would before you had somebody climb into a rocket expecting them to fly passengers to space. A lot of this of course has to do with the capabilities of vehicle, is it that something that a crew could even fly or is it is so automated is that their job is to really monitor vehicle performance and know whatever or not they are going to make a landing or

so, maybe not having anything they could about that, depending on what the vehicle's design, and ideally you would want a vehicle to designed so that whoever your crew is, your qualified crew is, there is some capability for them to recover an ascent or do an abort or actually perform a landing if the vehicle's systems, the automated systems, were not functioning properly.

Brian: What do you think about aerobatic flight experience for a civilian pilot? Do you think it would be beneficial or kind of neutral...

AF: Beneficial. You are a pilot as well so as you know the more exposure you give yourself in those environments and operating in those environments more capable become. It is true, whatever anybody does the more they practice a specific, the situational awareness they have of those tasks and objectives that exists outside of the primary objectives so what aerobatics does for the pilots, I think, is it exposes them to disorientating scenarios where they are focusing on controlling the aircraft for a specific task and if they do that more and more and more it allows them to expand their awareness of the other aspects of the flight , you know, whatever its specifically altitude or awareness of their regional position over the flight test area, whatever it is. Or the subsystems of aircraft when they initially start those maneuvers, they have the ability to focus on anything except aircraft attitude.

Brian: Ok.

AF: So I would say yes, it is beneficial.

Brian: Haha. Question three, in terms of personality and character what would make a desi, desirable commercial astronaut?

AF: You know, that gets into...my thoughts are focused more on the flying of the commercial crew. That is because they are flying people in space who are probably paying per seat...in that sense the crew needs to be like a boat captain or cruise director, um, so I think some to degree, whatever the crews are commercial flights, the paying customers who are tourists and that person have to been quite personable with good interpersonal skills. The ability to communicate phases of flight and the willingness to communicate all of the phases of flight and explain to them what to expect and give them a couple of updates about the way things are going. A lot of times when you get on a commercial airlines, you get the pilot...captain come on over the overhead and try to talk to the people. Some of those individuals are better at giving that 'here we go' speech than others and many of them don't do it at all. So I think so willingness on part of the crew to be able to share the experiences and what the expectations of the mission are is desirable. So in that sense, um, character is important, the ability to get along with others with many different backgrounds and experience level and be patient, have the patience to deal with all those levels of possibility anxiety , or you know, whatever their faced with in terms of the commercial crew and paying customer.

Brian: And do you foresee any need for a like a certain number of rest days or hours between each suborbital flight?

AF: You are talking about 30 minute flights?

Brian: Yes.

AF: I would say that there is probably going to be some level of preparations involved for each flight so I can't image flights would be going up on daily basis but I would expect for a commercial crew they would want some normalcy to their work requirements. A Monday through Friday workweek.

And yes, probably some days in between for rest. And it would depend on the G load of vehicle, how much stress it is under. You need to look at military pilots and training, ah, flying sorties everyday so there are some requirements for on and off hours so I think a model similar to that would be appropriate when those guys go up for combat missions they of course put their bodies under significant loads and sort of max out their performance each time they are up with the aircraft. There are conditions on flying a certain number of hours and a certain number of rest hours. We have the same thing, our duty day can only last 14 hours max with 8 to 10 hours of rest time before we start up our day again. So it will probably follow a model similar to that.

Brian: Ok. How much, um, experience with weightlessness should these crew have?

AF: I would say as much as practical and specifically they need experience in weightlessness for the...it would hard to perform something that sitting down in a seat. So they should be flying either 0G flights with parabolic flights in aircraft or they should have actual spaceflight experience. You know, when these commercial rockets start flying, there are only a limited number of people who have that experience.

Brian: What about the issue of spacesickness with the flight crew? Do you think that will be an issues on a short 30 minute flight with about 15 minutes of weightlessness?

AF: Most definitely. Yeah. It is very common...in my work experience and the experience of the people in the astronaut office so it is definitely something that would have to be addressed. Ideally, you would want the crew to be less susceptible to that and that would probably be restrictions medication that they could use because of their requirement to operate the vehicle.

Technically spacesickness isn't an issue until someone unstraps from their seat and starts floating about the cabin . There can be an upset once weightlessness has been experience so that is something to be deal with. It can be extremely debilitating and incapability so you definitely want crew members who are not susceptible to spacesickness or have some countermeasures in place in the form of medication so they can operate the vehicle.

Brian: And then on to question four. If training a commercial, what are the most important subject and/or flight areas in which to be familiar?

AF: Ascent and entry. Because it is just like an airplane, those are the most critical phases of flight. So whatever simulators, you would have to make simulator available that would model those phases of flight to allow the crew to, on multiple occasions, to go through training runs that would simulate both nominal and off nominal conditions that would exist. So it would give them some training to operate the vehicle.

Brian: And how well....

AF: Not so much on orbital flight except to...for passenger care taking.

Brian: How well can you adequately simulate a spaceflight in a simulator? And how well can it...can you translate those skills from a simulator environment to actual space?

AF: You can simulate it quite well. We use motion based systems here and out in the aircraft as well. The carry over is quite significant. In my experience, difference between a simulated ascent and a real ascent to space is level of noise and the fact in your mind you know that you are blasting off the Earth. The expectations, the layout, the controls, all those things are all identical to

the simulator. So I think that the carryover is excellent and in fact...because all of those phases of flight are under loads, G loads, there is really no issue of weightlessness. You are under load the whole time. It is similar to working in a 1 G environment. You can emulate the angle motion based simulators, you can sort of emulate what senses might feel in space.

Brian: How long of a training program do you think is adequate to train someone going from a military or commercial pilot to a suborbital commercial astronaut?

AF: How long of a training program?

Brian: Yes

AF: I would say that would depend on the complexity of the vehicle but I would say the training program should last be...no more than 24 months . From whatever starting point the person is at to the complexity of the vehicle, it might be shorting than that.

Brian: Ok. And the last question. When selecting a commercial astronaut, do you believe there is anything important to consider that we have not already discussed?

AF: Not really. I guess my opinion overall is that you probably want the most amount of experience you can in the cockpit. At least for somebody to have the ability, to work within the larger framework of situational awareness while operating the vehicle. You don't want to have the commercial crew to be just as surprised as the commercial passengers on those initial flights. You want somebody who knows what to expect. So think my impression is, my opinion, is that initially commercial crews should be limited to individuals with actual spaceflight experience or something similar to the pilot who flew

SpaceShipOne. He certainly has some experience now with flying a vehicle up in space, close to space. Those types of experience are important. You don't want whoever is trained in the program to be...have their first flight as a actual paying customer flight. You want them to have some experience with the vehicle and some actual spaceflight experience.

Brian: Right. Ok. Could I use your name in my Thesis?

AF: You can use it if you think it will be helpful or want some credibility. Or you might not want to use it if you think it will distract from the to the end result.

Brian: Haha.

AF: You are certainly welcome to use it

Brian: Ok. Thank you.

END OF RECORDED INTERVIEW

Appendix D. Email Interview Transcripts

The raw email interviews transcripts are listed.

Date:	1-September-2010
Interviewer:	Brian Kozak - email
Interviewee:	Neil Milburn - email

Brian: I have forwarded your inquiry to Tom Shelley at Space Adventures, our partner in the suborbital space industry. They are much more familiar with the participant side of the business than us and, for that matter, just about anyone else on the planet!

I can respond to one question though re space crew. The Armadillo Aerospace vehicle concepts require no crew as such. They are designed to be autonomous in virtually all respects except for the launch controllers and pad ops team. There will be no pilot, commander ... or beverage service when we reach cruising altitude :-)

Tom: Don't know if you can help this young man or if the information he is requesting is considered SA privileged / confidential. Just as a footnote, we are working with Professor Steve Collicott at Purdue to launch student payloads (SPEAR Project) to low altitudes here at Caddo Mills and possibly at Oklahoma.

Date:	1-September-2010
Interviewer:	Brian Kozak - email
Interviewee:	Tom Shelley - email

Neil is right in the context of tourist flights. The only area I can see professional astronauts being needed is to tend scientific payload, as they would be familiar with operating in the weightless environment. Not my area of specialism but happy to talk - call me if you want to discuss on *[X]*.

Date:	24-September-2010
Interviewer:	Brian Kozak - email
Interviewee:	Loren Shriver - email

1) What kind of educational and/or technical background should a commercial astronaut possess?

The kind or type of education or technical background that a commercial suborbital astronaut should have I think might be dependent on what amount of control or input the astronaut will have over the specific vehicle being used, and the magnitude of expected control or input the astronaut may have to exercise in an emergency situation. As a basis, a good solid technical background (engineering, science, math, etc.) would seem to me to offer a good start point. If the spacecraft will have no ability for crew control or intervention (in my opinion not a good plan for human occupied vehicles), then not much else would be needed. If the crew would be able to only move switches from one position to another, still not much else would be required. But if the intent is for the crew to perform system reconfigurations, or fly the spacecraft to maintain or correct trajectory, orientation, then one should be thinking about considerable flying experience and training, and quite a healthy amount of specific launch/ascent and entry/descent/landing training using spacecraft simulators and possibly appropriate aircraft.

2) What type and how much flight experience should a commercial astronaut have?

If normal flight or emergency response were to require considerable flight knowledge or experience, then that should be a requirement, along with specific spacecraft simulator experience.

3) In terms of personality and character, what would make a desirable commercial astronaut?

I tend to recommend to stay away from the flashy, "devil may care" personality, or one who thinks rules are for others, and go instead for the "steady in any situation," team player who can get along with anyone almost anytime, is patient, logical, and can think on their feet. There are a few other characteristics that contribute also, but one more important one is the ability to admit mistakes, learn from the situation, and be better from it. Those who cannot accept criticism would probably be a misfit in an integrated crew.

4) If training a person to become a commercial astronaut, what are the most important subjects and/or flight areas in which to be familiar?

One has to be a little careful, I think, when recommending specific subjects or flight areas for training or background. Some of the statements up in answer 1 apply here as well. I think a good technical base is good, although some of the best AIRCRAFT PILOTS in history have been liberal arts majors! But as you start into the realm of space, the ability to understand the technical aspects of what is going on in any flight phase is very important, and there are some phases of a mission (I think, even a suborbital mission) that are not like regular aircraft flight, and the speeds are not comparable either. This is where a good ability to understand the characteristics of each segment of the flight profile is a must, especially if a considerable amount of manual flying or emergency response would be needed. Things like engine operation/thrust, flight trajectory (up and down), flight path angle, "zero g" characteristics, heating, flight control response throughout the flight regime, and of course, landing procedures, would be topics of interest. Some of those are also dependent on the specific spacecraft design.

5) When selecting a commercial astronaut, is there anything that you believe is important to consider that we have not discussed?

I would refer you back to answer 3 above for the main thoughts here. For a suborbital flight, perhaps the question of personality traits is not quite such a big deal, because the missions will be short. But as the length of missions increases the compatibility of the crew members is very important, and personality traits must be considered.

Date:	2-October-2010
Interviewer:	Brian Kozak - email
Interviewee:	Brian Binnie - email

1) What kind of educational and/or technical background should a commercial astronaut possess?

Initially they will all be taken from the pool of experimental test pilots . They in turn typically have engineering degrees and more often these days Master's . Long term, I don't really see why these need be hard requirements . A Boeing or Airbus are sophisticated machines yet pilots aren't requirement to be technical geniuses to fly them.

2) What type and how much flight experience should a commercial astronaut have?

The only requirement to fly SS1 was a commercial glider rating. I got the first powered flight because of my carrier experience. Flying rockets is a completely unique environment. I liken it to bull riding. You need that kind of attitude going into it. Only a centrifuge/simulator can come anywhere near the dynamics involved.

3) In terms of personality and character, what would make a desirable commercial astronaut?

I bet it's not too different from what makes a good fighter pilot. Their common denominator is participation in sports. I've seen all types, so eventually it's the individual's interest and enthusiasm that will make or break him or her.

4) If training a person to become a commercial astronaut, what are the most important subjects and/or flight areas in which to be familiar?

Aeronautical engineering and good stick and rudder skills are still the basis for everything else.

5) When selecting a commercial astronaut, is there anything that you believe is important to consider that we have not discussed?

NASA spends a lot of time screening their astronaut candidates . I think they ultimately want someone that can check their ego at the door and work effectively in a team environment.

Appendix E. Coded Telephone Interviews

The coded telephone interview transcripts are listed.
The keyword or key phrase **[code]** format was used.

Date:	2-September-2010
Interviewer:	Brian Kozak
Interviewee:	Dan DeLong (DD)

Brian: I can record this conversation?

DD: Sure.

Brian: Alright, Please understand that your participation in this study is voluntary, and you must be 18 years old to participate. Participation or non-participation in this study will not affect your employment. Your responses will be kept confidential, and any quotations used in the final report will be attributed to “Participant 1, 2, 3…etc.” to maintain anonymity. If you wish to waive your right to anonymity, please let me know now. At the end of the interview, if you waived your right to anonymity I will ask again if wish to waive your right to anonymity. The interview itself should last between 20 and 25 minutes. The interview will be recorded via audio recordings and all original recordings will be destroyed by 31-December-2010. The risks involved are minimal, no greater than everyday life. The purpose of this study is to determine the selection criteria of flight crews for suborbital spaceflight within the space tourism industry. I am conducting this study for my Master’s Thesis. As such, I will be conducting and recording the interviews, transcribing the audio recordings, analyzing the data, and writing the final report. Insights generated as a result of this study could benefit the companies in the commercial space industry, institutions of aviation and aerospace education, as well as the Federal Aviation Administration’s Office of Commercial Space Transportation. Please answer the following questions based on your knowledge and experience with suborbital spacecraft. The Principal Investigator for this study is Professor Denver Lopp. He can be reached at 765-494-6387. If you have concerns about

your treatment during this interview, you can contact the Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114. The phone number for the Board is 765-494-5942. The email address is irb@purdue.edu. Do you have any questions?

DD: No. You can use my name and title.

Brian: Ok, what kind of educational and/or technical background should a commercial astronaut possess?

DD: They should be a pilot with high performance vehicle [**high performance vehicle]**

Brian: Ok, any particular type of educational background?

DD: Um, not necessarily. An engineering degree **[engineering degree]** would be nice. Not required **[no required degree]**

Brian: Ok, um, then, what kind, what type and how much flight experience should a commercial astronaut have?

DD: Well, you are using the term astronaut, we probably won't. It is either pilot or, um, during development **[flight test]** flight test engineer.

Brian: Ok.

DD: And flight test engineer is primarily an engineer **[engineer]** who is also familiar with, um, the qualities of the vehicle **[unique to vehicle]** but primarily an engineer monitoring the vehicle systems **[monitoring vehicle]**. Um, that won't exist on an operational flights but will on flight test **[flight**

test] And the pilot is mostly a pilot **[pilot]**. He is flying a high performance vehicle **[high performance vehicle]** atleast XCOR vehicles takeoff and landing like airplanes.

Brian: Right.

DD: The answers to that question from other organizations that, things like vertical takeoff vehicles will be very different **[unique to vehicle]**.

Brian: Right, and just from like the point of this conversation right now I'm just talking about XCOR Lynx aircraft or spacecraft.

DD: Sure.

Brian: And I'm, um, actually looking toward more of the, um, functionality of the spacecraft. So maybe more...

DD: It is really launch vehicle **[proper terminology]**

Brian: Ok, launch vehicle.

DD: That is the current term. Hold on a second.

Brian: Sure.

DD: Yeah, we are going to need to cut this short.

Brian: Ok. Any time you have I be really appreciative of it.

DD: Go ahead.

Brian: The next question is, um, if training a person to be, again, a commercial astronaut what are the most important subject and/or flight areas in which to be familiar?

DD: I think that really has the same answer, a degree in engineering **[engineering degree]** of some type because, ah, it trains you how to think **[technical thinking]** or how to react to problems **[reacting to problems]**. And, um, experience flying high performance airplanes **[high performance vehicle]**, particularly turbojet powered airplanes **[turbojet]**. It would be a big help if you have experience flying something supersonic **[high performance vehicle]**.

Brian: Un huh, Any set number of hours as a minimum or any type of, um, multiengine single engine turbojets or supersonic aircraft.

DD: Not really **[no set hours]**

Brian: Ok. And, and then, the last question is when selecting a commercial astronaut that believe you is important to consider that we, um, have not talked about already?

DD: Well, the medical screen of participants **[medical evaluation]**, which is, um, the person buying a ticket rather than flight crew, a, we plan to test for tenancies for claustrophobia, um, ability to take high g **[high g exposure]**as well as 0g **[weightlessness]** and thats going to be administered by a ride in a Pitts aerobatic airplane **[aerobatics]** as well as just general good health **[good health]**, including passing an equivalent of a 3rd class FAA medical.

Brian: Ok, um...

DD: In going commercial, we really trying to minimize the need requirements in order to fly because we want to carry anybody who can buy a ticket.

Brian: Uh huh.

DD: Obviously we can't but we trying real hard to make the physical requirements and mental requirements easy to meet as well.

Brian: Ok. In terms of the pilots that operate the vehicle, would they, um, would they need a certain number of rest days between each flight or would they be able to fly like a flight morning and another one in the afternoon?

DD: You know, it will probably similar be to air transport pilots in that respect **[FAA standards]**. In other words, they'll take the FAA's crew rest criteria and apply them **[limited duty days]**.

Brian: Ok.

DD: Although, um, we'll be more strict than that because the demands bigger than standard air transport pilot **[great pilot demands]**

Brian: Ok.

DD: A lot more like driving a race car than a bus **[high performance vehicles]** **[great pilot demands]**

Brian: Right, hehe, ok.

DD: Now I do need to goto a meeting.

Brian: Ok, one quick...

DD: Can I have your name again?

Brian: Brian Kozak and I'm from Purdue University.

DD: Ok.

Brian: And, one quick final question, would I be able to use your name and title in study or would like to remain anonymous?

DD: Go ahead, you can use my name. I really do need to go so have a good day.

Brian: Ok, thank you.

END OF RECORDED INTERVIEW

Date:	3-September-2010
Interviewer:	Brian Kozak
Interviewee:	James Voss (JV)

Brian: First off, can I record this conversation?

JV: Sure.

Brian: Please understand that your participation in this study is voluntary, and you must be 18 years old to participate. Participation or non-participation in this study will not affect your employment. Your responses will be kept confidential, and any quotations used in the final report will be attributed to “Participant 1, 2, 3…etc.” to maintain anonymity. If you wish to waive your right to anonymity, please let me know now. At the end of the interview, if you waived your right to anonymity I will ask again if wish to waive your right to anonymity.

JV: You can use my name.

Brian: Ok, the interview itself should last between 20 and 25 minutes.

JV: Ah, I'm on my way somewhere, so I have maybe five minutes.

Brian: Alright, the interview will be recorded via audio recordings and all original recordings will be destroyed by 31-December-2010.The risks involved are minimal, no greater than everyday life. The purpose of this study is to determine the selection criteria of flight crews for suborbital spaceflight within the space tourism industry. I am conducting this study for my Master’s Thesis. As such, I will be conducting and recording the interviews, transcribing the audio recordings, analyzing the data, and

writing the final report. Insights generated as a result of this study could benefit the companies in the commercial space industry, institutions of aviation and aerospace education, as well as the Federal Aviation Administration's Office of Commercial Space Transportation. Please answer the following questions based on your knowledge and experience with suborbital spacecraft. The Principal Investigator for this study is Professor Denver Lopp. He can be reached at 765-494-6387. If you have concerns about your treatment during this interview, you can contact the Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 S. Grant St., West Lafayette, IN 47907-2114. The phone number for the Board is 765-494-5942. The email address is irb@purdue.edu. Do you have any questions?

JV: No.

Brian: Ok, um, the first question is what kind of educational and or technical background should a commercial posses?

JV: It doesn't matter **[no set degree]**. Ah, it doesn't really have that much to do with...with the skills a person needs to fly **[flying skills]** in a commercial human spacecraft. So background isn't that important, its..ah, more of the technical skills person has **[technical skills]**. So I don't think education is...is a particularly linked to the kinds of things a person has to do with the spacecraft. They are more piloting skills **[flying skills]** or, ah, their ability to operate equipment **[aircraft operation]**, ah, it is just generally finding people, who...who have technical educations **[technical educations]** are the kind of people inclined to do that type of thing **[adventurous]**.

Brian: Ok, ah, the second question is what type and how much flight experience should a commercial astronaut have?

JV: Well, they're going to have piloting skills **[flying skills]** so they should have a lot of flight experience. Ah, NASA has generally required a thousand hours of high performance jet time for **[thousands of hours][high performance vehicle]**, ah, Shuttle pilots **[NASA requirements]**. So for a, um, a spacecraft that requires a high degree of piloting skills **[flying skills]** something similar to that would probably be appropriate. If it flying a capsule, then that is much...it is very different kind of task and the actual flying skills are probably not that...that critical **[unique to vehicle]**.

Brian: Ok

JV: They would have to have, ah, the ability to work in the cockpit type environment that often times comes from experienced people working in the vehi...aircraft of some kind. But you probably would get the same value from a commercial or transport type pilot **[commercial pilot]** that you would from someone with high performance jet time **[high performance vehicle]**.

Brian: Ok, ah, um, may, for this study I'm focusing primarily on suborbital spacecraft or launch vehicles...

JV: Suborbital, ah, um, but what type of suborbital do you hope to...

Brian: Um, reusable...

JV: That require piloting skills of landing on a runway or just, ah, capsule, where do don't have to pilot the vehicle? **[unique to vehicle]**

Brian: Um, I was primarily gearing towards, ah, takeoff and landing on a runway or atleast landing on a runway but, um...

JV: Ok.

Brian: Capsules as well. Ah...

JV: In that case they require piloting skills that could be anything learned from any type piloting experience and extensive pilot experience **[pilot experience]**is probably necessary for type of, ah, vehicle.

Brian: Would civilian or military, ah, flight time be more applicable?

JV: No, ah, it is just flight time **[flight time]**.

Brian: Ok.

JV: It doesn't matter if you are flying a military airplane or civilian airplane, both require the same kind of skills **[flying skills]**.

Brian: Ok.

JV: Ah, and it depends on the flight regime of the vehicle that you talking about, a suborbital vehicle with it...that has very high landing speeds then, ah, flying that type of a aircraft with it military or civilian be more appropriate **[unique to vehicle]**. Suborbital links, ah, things that are common and are similar would be performance characteristics of a suborbital spacecraft that you are talking about **[unique to vehicle]**.

Brian: Ok, the next question is if training a person to be a commercial astronaut what are the most important subject and/or flight areas in which to be familiar?

JV: Well, they have to understand their vehicle **[vehicle understanding]** so, ah, training would have to revolve around the vehicle that they are going to be piloting **[unique to vehicle]** and then, ah, practicing piloting tasks **[pilot experience]** that need to be done and that could be done somewhat in a simulator or in a flying simulator like the Shuttle Training Aircraft, ah, the closer to the real thing the better the training **[realism]**.

Brian: Right.

JV: For the person. So its mostly for the pilots and the flying skills **[flying skills]**.

Brian: Ok, and the last question is when selecting a commercial astronaut is there anything you believe is important that, to consider that we have not already talked about?

JV: Could you say that one more time?

Brian: Ah, um, when selecting a commercial astronaut is there anything that you believe is important to consider that we have not discussed?

JV: Ah, I think, the...personality types, ah, that you would want for something like that are the, the kind you would typically find in, ah...ah...kind of community that does flight test work **[flight test]** because generally those type of vehicles are not going to have enough experience behind them to be routine...so a people with flight test **[flight test]**, ah, experience probably be more appropriate for,ah, for piloting those vehicles.

Brian: Ah, do you see a need, um, like a minimum of days or hours between each suborbital spaceflight in terms of flight crew rest?

JV: No, no, there can be multiple piloting days just, ah, generally a short flight so no I don't think there would be any need for any, um, period of rest time between flights **[limited down time]**.

Brian: Ok, and one quick, um, final question,

JV: Sure.

Brian: Can I use your name in my thesis?

JV: Ah, as long as it is just associated with the responses to the questions that I had, sure.

Brian: Right, exactly, I will be transcribing this interview, um, and then using quotations as appropriate in my work.

JV: Ok, sure thats fine.

Brian: Ok, um, thank you very much.

JV: Thank you, bye.

Brian: Bye.

END OF RECORDED INTERVIEW

Date:	14-September-2010
Interviewer:	Brian Kozak
Interviewee:	Gary Payton (GP)

Brian: First off, can I record this conversation?

GP: Sure.

Brian: Ok, let me get it started here. Ok. Please understand that your participation in this study is voluntary, and you must be 18 years old to participate. Participation or non-participation in this study will not affect your employment. Your responses will be kept confidential, and any quotations used in the final report will be attributed to Participant 1, 2, 3…etc. to maintain anonymity. If you...if you wish to waive your right to anonymity, please let me know now. At the end of the interview, if you waived your right to anonymity I will ask again if wish to waive your right to anonymity. The interview itself should last between 20 and 25 minutes. The interview will be...will be recorded via...via audio recordings and all original recordings will be destroyed by 31-December-2010. The risks involved are minimal, no greater than everyday life. The purpose of this study is to determine the selection criteria of flight crews for suborbital spaceflight within the space tourism industry. I am conducting this study for my Master's Thesis. As such, I will be conducting and recording the interviews, transcribing the audio recordings, analyzing the data, and writing the final report. Insights generated as a result of this study could benefit the companies in...in the commercial space industry, institutions of aviation and aerospace education, as well as the Federal Aviation Administration's Office of Commercial of...Commercial Space Transportation. Please answer the following questions based on your

knowledge and experience with suborbital spacecraft. The Principal Investigator for this study is Professor Denver Lopp. He can be reached at 765-494-6387. If you have concerns about your treatment during this interview, you can contact the Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 South Grant St., West Lafayette, Indiana 47907-2114. The phone number for the Board is 765-494-5942. And the email address is irb@purdue.edu. Do you have any questions?

GP: No, sounds good!

Brian: Ok. And like I said in the email I will send you a copy of this transcripts and you can look it over and tell me what you think about it.

GP: Ok.

Brian: Ok, and the first question is, what kind of educational and/or technical background should a commercial astronaut posses?

GP: Ah, I would think for these kinds of suborbital spaceflights like, um, Virgin Galactic and anybody else in there, ah, I would think that the passengers want to have a very high confidence **[confidence]** in their flight crew. Because this is a brand new industry and it is a brand new experience **[new experiences]** for these folks and so that level of confidence of the flight crew would be critical and so to me that would say, ah, being able explain the engineering of the vehicle in the flight **[communication skills]**, ah, the propulsion **[rocket power]**, the electrical systems and the ascent environment and the technical perspectives and should be able to explain it and comment everything about it would be an absolutely critical part of the experience that these folks would have. To me, that says an engineer degree **[engineering degree]** at a minimum plus all sorts of flight

experience **[flight experience]**. As it comes to educational requirements, I would say an engineering degree **[engineer degree]**at least as a Bachelor's **[Bachelor's degree]**.

Brian: Ok. And what type of how much flight experience should a commercial astronaut have?

GP: Ah, because the flight will be dramatically different than just takeoff, cruise and landing I honestly don't think, ah, commercial airline type qualifications, ah, would be adequate **[new flight experience]**. Certification, airline transport rating or airline transport pilot, you know, so many thousands of hours as an airline pilot **[thousands of hours]**, I don't think that would be very beneficial in this sort of flight. Because it is going to be a very steep ascent **[steep ascent]** and then pushing over toward the end of powered flight and a coast period **[coast period]**, 0g **[0 G]**, and then the reentry **[reentry]**, its a parabolic flight not a takeoff, cruise and land kind of flight **[rapid flight]**...so how would you describe that, some sort of a test pilot like curriculum, jeez, I remember the Air Force Test Pilot School used to have a F-104 with a rocket up underneath tail in addition to the J79 in the F-104 itself **[rocket power]** and so, ah, and that was specifically designed to get guys ready for the X-15 flights. It would be that kind thing, um, I think which is the kind of flight training you need to have, varying G load environments **[G forces]**, varying pitch attitudes, dramatically varying pitch attitudes **[dramatic flight]** environments during the flight and you would have to be watching the flight performance which is dramatically different than the flight performance of a 787 or a 777 or some airplane like that **[new type of flight]**.

Brian: Ok.

GP: I'm thinking some sort of a, um, a course similar to a test pilot school **[test pilot school]** kind of course would be the flight training that would be necessary for these kinds of commercial pilots.

Brian: What about aerobatic flight experience and, um, like the military or civilian aerobatic demonstration team?

GP: Yeah, aerobatics that, um, weather its military or not, aerobatics **[aerobatics]** is that kind training that puts you upside down, in a high G environment, low G environment, or horizontal Gs **[G forces]** going left and right not necessary forward and aft Gs. So its, ah, yeah, aerobatic training **[aerobatic training]** would have to be part of because again you have keep your head about you, upside down, negative 1G, positive 3Gs or whatever.

Brian: Ok.

GP: Aerobatic training would cover that **[aerobatic training].**

Brian: Do you think there is a set number of minimum hours of aerobatic flight that, ah, would properly a person for a suborbital spaceflight?

GP: No, just, ah, complex aerobatics **[complex aerobatics]**, let's phrase it that way.

Brian: Ok. And in terms of personality and character, would make a desirable commercial astronaut?

GP: Ah, throw away the scarf. Haha. **[humble]**

Brian: Haha.

GP: Again, the main and most important job I would think for the commercial crew, commercial astronaut crew, would be an image of confidence **[confidence]** in this very different kind of flight environment **[new flight experience]**. The, um, passengers have to have a lot of confidence in the flight crew **[confidence]**. Well that means they would, um, kind of throw away the fighter pilot classic, test pilot, silk scarf mentality **[humble]**. And you have to be, have this attitude...well, for ever flight for these folks, the passengers, would be similar to a Young Eagles flight for someone who is 14 or 17 years old **[new type of flight]**.

Brian: Right.

GP: It is an introduction to a new environment so there has to be an aura of competency **[competency]** and experience that the crew has to have.

Brian: Do you foresee any need for the crew, ah, for a certain, like, um, rest hours or days between each suborbital flight?

GP: Ah, between each one?

Brian: Yes.

GP: No, I would think, from what I know about the flight the longest part of the flight is the climb up to the, ah, altitude....That's the longest part of the flight. So I would think, 2 a day would no problem, um, and then maybe 3 a day, something like that because the flights are really really short **[limited rest time]**.

Brian: Ok. How much experience with weightlessness or 0G should these flight crews have?

GP: Probably not much because the 0g exposure relativity short **[little weightlessness]**. Ah, their main job is making sure the vehicle has the right attitude at the start of reentry back into the atmosphere for flight control authority purposes **[vehicle control]**. Ah, and then reentry trajectories purposes, so, ah, I would think 0g experience isn't that important personally because they are going to be strapped into the front seats monitoring the attitude of the bird as it starts to get back into the atmosphere **[monitoring vehicle]**.

Brian: Ok.

GP: Now, the passengers, running around probably would have to have enough discipline in the passenger compartment to get everybody strapped back down before the G loads get too high **[responsibility]**, nonetheless the flight crews main responsibility will be, ah, maintaining, achieving the right kind of attitude for reentry **[vehicle control]**.

Brian: Ok. And if training a person to become a commercial astronaut what are the most important subject and/or flight areas in which to be familiar?

GP: Ok, yeah, you're assuming somebody a FAA pilot, commercial pilot, got all the necessary credentials **[FAA credentials]**, actually training for the flight itself, probably have to include, um, again ascent off nominal, unrecoverable off nominal trajectories **[off nominal]** both going up hill **[trajectories]** and coming back down **[trajectories]** and of course system malfunctions **[system failure]** during the flight. So most of the training will have to revolve around, um, again the trajectories **[trajectories]** itself and the attitudes, G loads of that trajectories **[G loads]** and then, um, handling the flight control systems **[vehicle control]** during ascent and entry and then the off nominal, potential off nominal scenarios around all that.

Brian: How well can you adequately simulate that in a simulator, like ground based...

GP: How well what?

Brian: How well can you simulate a off nominal trajectory in a simulator, either ground based or aerial.

GP: Well, its very easy. In fact I wouldn't worry so much about a flight simulator, the Shuttle Training Aircraft...

Brian: Right.

GP: Yeah, its nice to get into a sim and point the nose straight down like the STA where you would get 40,000 feet per minute sink rates. The real learning goes on inside simulators and they really don't need to be motion based simulators **[simulator learning]**. In my experience, a motion based simulator is good, but it doesn't replicate the rocket powered ascent **[limited realism]** and the, ah, motion range at entry are not that great so you don't need motion based. Especially with modern, high definition visuals I wouldn't even think the, a motion based simulator on the ground would be necessary**.**

Brian: Ok, um, the final question: when selecting a commercial astronaut, is there anything that you believe is important to consider that we have not discussed?

GP: For this kind of flight, again, the image of confidence **[confidence]** in their attitude and in the way can explain the flight, explain trajectories **[explaining flight]**, and in the way they can describe the engineering of the vehicle **[vehicle expertise]**, again you are dealing with, ah, a relativity rich

customers who are in it for the experience and if you could use them as somebody who says yes, these are very very confident, very professional, very skilled, they become advertisers for other customers **[public relations]**. So the competency in flight with the crew is going to be the dominate feature that the customers walk away with **[customer relations]**. And establishing the image and establishing the actuality of confidence in the vehicle is essentials to the entire success of the company and in this case, maybe the entire market place **[public relations]**.

Brian: Ok, alrighty, thats all I had.

GP: Ok.

Brian: Thank you very much.

GP: And now whats interesting is if you are describing your thesis notion of commercial space transportation for orbital flight, where the people would be on orbit for a week or two weeks or something like that, the flight crews would have a different set of skills for flight. Maybe an additional set of skills. And thats a different thesis you can work on later.

Brian: Haha, Exactly. I originally considered working on both suborbital and orbital flight but time constraints and my thesis committee kinda narrowed it down a bit to primarily...only suborbital spaceflight.

GP: Yeah.

Brian: It is definitely an interesting area to explore and to talk to people about.

GP: How many people are you talking to?

Brian: You are the 6th participant so far.

GP: Ok. You are going to need a big group aren't you?

Brian: Going to need what? I missed that last past.

GP: You are going to need a large number of interviews right?

Brian: Yes.

GP: Ok.

Brian: I'm hoping to get a couple more here.

GP: Ok, good.

Brian: So...

GP: Well, alright, excellent!

Brian: Well, alright, thank you very much for your help and your assistance with this.

GP: You bet. Ok, bye.

Brian: Ok, thanks, bye.

END OF RECORDED INTERVIEW

Date:	22-September-2010
Interviewer:	Brian Kozak
Interviewee:	Mark Brown (MB)

Brian: Can I record this conversation?

MB: Sure.

Brian: Ok, please understand that your participation in this study is voluntary, and you must be 18 years old to participate. Participation or non-participation will not affect your employment. Your responses will be kept confidential, and any quotations used in the final report will be attributed to “Participant 1, 2, 3…etc.” to maintain anonymity. If you...if you wish to waive your right to anonymity, please let me know now. At the end of the interview, if you waived your right to anonymity I will ask again if wish to waive your right to anonymity. The interview itself should last between 20 and 25 minutes. The interview will be recorded via audio recordings and all original recordings will be destroyed by 31-December-2010. The risks involved are minimal, no greater than everyday life. The purpose of this study is to determine the selection criteria of flight crews for suborbital spaceflight within the space tourism industry. I am conducting this study for my Master’s Thesis. As such, I will be conducting and recording the interviews, transcribing the audio recordings, and analyzing the data, and writing the final report. The Principal Investigator for this study is Professor Denver Lopp. He can be reached at 765-494-6387. If you have concerns about your treatment during this interview, you can contact the Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 South Grant St., West Lafayette, Indiana 47907. And the phone number for the Board is 765-494-5942. Do you have any questions?

MB. No sir!

Brian: Ok, let's begin. What kind of educational and/or technical background should a commercial astronaut have?

MB: Well, there is a fundamental philosophy of the issue here that we have to deal with first. The issue here is the level of fidelity that the vehicles themselves have and the people who are part of the flight crews have that are supplying the service. The manned spaceflight program that NASA has, managed and supervised over the last half of century **[NASA requirements]**, there have been specific requirements that determine what is acceptable, quote unquote from systems engineering standpoint and what is also acceptable quote unquote to certify a crew a member to operate one their vehicles as either pilot, mission specialist or whatever function they might, um, perform on the vehicle. So the fundamental question here, do those same safety requirements **[safety requirements]** translate into commercial space or are we going relax the safety requirements to do something different. And my personal opinion is that the safety should not change **[NASA requirements]**. They should be the same because the passengers, just like with Christa McAuliffe the school teacher who was killed on *Challenger,* anybody who flies on a spacecraft, either government supplied through NASA or commercially should have the comfort knowing there are adequate safety standards in place both from a hardware standpoint **[safe hardware]** and from a human standpoint **[crew training]** to guarantee them some level of safety as they fly the flight **[NASA requirements]**. So the bottom line answer to your question is that, yes, I think that the same training and certification, um, methodologies used for professional astronauts at NASA should be applied to commercial spaceflight **[NASA requirements]**, and that in turn implies that there needs to be high percentage of people that have degrees in either technical science **[technical science]** or engineering **[engineering]** and also have

fairly high level experience in flying **[flying experience]**. So you are still are going looking for people that are, for the lack of a better word, aerospace engineers **[aerospace engineering]** and test pilots **[test pilots]**.

Brian: Ok. Any particular type of engineering degree or, um...

MB: Well, NASA's experience has shown that...even though aero degrees are naturally what people would assume to be best is not necessarily the case. Any technical degree **[technical degree]** that is present helps you with some fairly solid flying experience is adequate **[flying experience]**. The requirements that NASA **[NASA requirements]** uses for pilots and missions specialists is very well defined. You know, Bachelor's Degree **[Bachelor's Degree]** like we've talked about for the pilots plus 1000 hours pilot in command time **[1000 hours PIC]** or Master's Degree **[Master's degree]** for the mission specialist with 3 years of experience. For the pilots themselves, there is nothing really more required beyond a Bachelor's degree **[Bachelor's degree]**. The flying experience **[flying experience]** is actually more important. For the crew members that will operate the vehicle, effectively be the crew chiefs of the vehicle. There is probably still is a good argument to be had for them to have Master's level experience to start with **[Master's Degree]**. As commercial spaceflight matures, it will be more of a comfort and service offering in the vehicle so degrees of any kind will probably to start to erode **[high requirements now]**.

Brian: What type and how much flight experience should a commercial astronaut have?

MB: Well, I think commercial astronauts, the ones actually flying the vehicle, should have to have the same requirements that NASA astronauts have

[NASA requirements]. And that would a minimum of 1000 hours pilot in command time **[1000 hours PIC]**.

Brian: What about, like, aerobatic flight experience or, um, military flight, is any of that time more proffered than a normal airline pilot flight time?

MB: Aerobatic, no. Military flying, yes **[military flying]**. And that only reason military flying has higher marks is because military officers generally are giving more responsibility **[responsibility]** and put in more stressful situations **[stressful situations]** earlier in their life than a typical commercial pilot. But when you have a military pilot **[military pilot]** with a 1000 hours command time **[1000 hours PIC]** you have a more seasoned professional pilot with an equivalent number of hours in the air.

Brian: Ok. In terms of, um, personality and character, what would make a desirable commercial astronaut?

MB: That would be the same questions that would applied to, um, a commercial airline captain or ,ah, a current astronaut at NASA. I would take a look NASA's own selection criteria **[NASA requirements]**. The real fundamental question, is one of duration **[mission unique]**. If these people are simply going to haul people up to a orbiting hotel or something like that where there total exposure to the passengers community is going to be 1 to 3 days, they don't required, say, significant interpersonal skills as opposed to technical flying skills and experience **[flying skills]**. If you talking about longer duration exposure to the passengers than the needs for more social skills becomes important **[communication skills]**.

Brian: Ok. Right now, I'm only looking at suborbital spaceflights. Ones that last half an hour, 15 minutes or so. So it is just short little hop into space and back.

MB: Yep. If you are looking at that, then the social aspect of this is not applicable. Technical skills would be more important **[technical skills]**.

Brian: And, do you see like a need for a minimum number of days or like, um, rest days between suborbital spaceflight?

MB: In order to answer that questions, lets talk about it from the passenger prospective first

Brian: Ok

MB: In the flight that you are modeling, what is the total...exposure to zero gravity going to be?

Brian: Um, 10 minutes, 15 minutes or so maximum.

MB: With that exposure, it is basically a pop up flight **[short flight]**.

Brian: Right.

MB: From a pilot's standpoint, I think normal crew rest, um, rules would apply....where you can't fly for more than 10 to 12 hours depending on what the function is **[FAA requirements]**. I don't have a problem with that. The reality of spaceflight and also weightlessness is that there is a tremendous adjustment that the body goes through in the first 24 hours **[spacesickness]**. And a large number of your passengers are going to be losing their lunch in the 10 or 15 minutes. They paid all that money for to experience weightlessness and some of my commercial buddies down at Cape Kennedy have thought about this because they finally realized they need to talk about the mission profiles that are 3 or 4 days because the first day and half these people are going to feel like they have

spacesickness **[spacesickness]**. And it will only be on second and third days that they will be able to really enjoy the experience **[longer flights]**. Now with the 10 or 15 minute exposure to zero G, yeah, you get to float around and look out the window and do all of the rest of it but probably a good percentage of people are going to suffer from fair, fairly immediate affects of zero gravity which would throwing up, headache, nausea disorientation, vertigo, all of those other fun things **[spacesickness]**.

Brian: And how much experience with weightlessness should these, um, the pilots of suborbital spacecraft have?

MB: Well, they have to have some minimal amount of training so that they understand not only what it means but how is affects the operation of the vehicle itself **[limited weightlessness]**. And, for, for a 10 or 15 minute it is a relativity easy process other than the fact that everything that isn't nailed down will float and there can be special concerns that they need to mindful of, of with not only the passengers but what is going on in the cabin **[situational awareness]**. For example, serving coffee is a really bad idea in weightlessness.

Brian: Haha. Right.

MB: It will be things like that they to train for. Training in a zero G aircraft would be more than adequate **[simulated weightlessness]**. It would be more of a familiarization with the vehicle **[vehicle familiarization]**. That's important.

Brian: And then, when selecting a commercial astronaut, is there anything that you believe is important to consider that we have not already talked about?

MB: That is a good question. Let me ponder that for a quick second.

Brian: Sure.

MB: I don't think so. I think that in terms of the flight crew itself I think we've covered it. From the vehicle side of it, I have a number of concerns but I think thats a different thesis topic. And let me just expand on the one area that would affect the crew. I think there is a lot of work that needs to be done in terms of human factors **[human factors]**, cockpit design layout **[cockpit design]**, um, that would relate to how you would want the crewmen operate the vehicle and maintain their own orientation **[situational awareness]**. Yeah, I don't spent enough time on that.

Brian: And, how well can you adequately simulate a spaceflight in, ah, simulator either ground based or aerial.

MB: Oh, can you simulate it pretty well with three degree of motion simulators even though things won't literally float in the cockpit you definitely get the sensation of getting zero G **[realism]** and going through those transitions with the vehicle **[simulate space]**. You can do that with a combination of visual cues and audio cues and so you get, you get simulate very well but the simulator training would be an important ingredient for these suborbital flights.

Brian: And, how long of a, of a training period you think would be required to train a person for a suborbital spaceflight?

MB: As a pilot?

Brian: Yes, going from a military pilot 1000 hours PIC time to a suborbital commercial astronaut.

MB: Probably 6 months to a year **[commitment]**. And the reasons for that is that there will be a fair amount of classroom activity that would have to be conducted in addition to the physical vehicle training **[vehicle training]** and then also the flight simulation and emergency procedures **[emergency procedures]** that would have to be taught and learned. Things like that. For example, if you are going to be doing suborbital flight, everybody thats going to have to basic training **[survival training]** in land survival, water survival, Arctic survival etcetera etcetera etcetera. So it is a lot more than just putting somebody in a simulator for 3 hours and turning them loose.

Brian: Ok. Do you have anything else that you want to ,ah, add to this conversation?

MB: Yes, I would like to get a copy of your paper when you get it done

Brian: Ok.

MB: I'm very proud that you're doing all this.

Brian: Thank you! Um, would you want a copy of the entire thesis or just a article length or journal length paper?

MB: Oh, I would like the whole thing!

Brian: Ok!

MB: And just so you know, one of the things I encouraged our university friends to do was to host a national dialogue on what the U.S. spaceflight plan should be. So right now we don't have a manned spaceflight program. We are kind of lost.

Brian: Right.

MB: I think very appropriate we have a national dialogue. You know, what do we want to do? It is commercial, military, NASA standpoint? Where are we going to invested our funds? What are our strategic goals? It is Moon, Mars, a Lagrange point? What do we really want get out of this? A Marriott in low Earth orbit? And I think now is the time to have that debate nationally and decide what level of international participation we want to have before the Chinese go to the Moon and start selling everything from Tranquility Base on eBay.

Brian: Right, haha, ok. Yeah, it is definitely an interesting time for the, like you said, the U.S. space program or the lack thereof.

MB: Yeah, you got it!

Brian: Hopefully some of these commercial companies will be able to kinda step up and, you know, lead the U.S. and make some money off of it too.

MB: Yeah, that right. And they send guys like you and me to go do that.

Brian: Right. Haha. Ok. One more quick thing. Can I use your name associated with these answers?

MB: Absolutely!

Brian: Ok. And thats all I had.

MB: And its a great pleasure and I wish you the best of luck

224 Brian: Thank you very much.

225 MB: Take care.

226 Brian: Ok, bye.

227 MB: Bye.

END OF RECORDED INTERVIEW

Date:	22-September-2010
Interviewer:	Brian Kozak
Interviewee:	Participant (P9)

Brian: Can I record this interview?

P9: Sure.

Brian: Ok, please understand that your participation in this study is voluntary, and you must be 18 years old to participate. Participation or non-participation in this study will not affect your employment. Your responses will be kept confidential, and any quotations used in the final report will be attributed to Participant 1, 2, 3 to maintain anonymity. If you...if you wish to waive your right to anonymity, please let me know now.

P9: No.

Brian: Ok. At the end of the interview, if you waived your right to anonymity I will ask again if wish to waive your right to anonymity. The interview itself should last between 20 and 25 minutes. The interview will be recorded via audio recordings and all original recordings will be destroyed by 31-December-2010. The risks involved are minimal, no greater than everyday life. The purpose of this study is to determine the selection criteria of commercial astronauts for suborbital spaceflight within the space tourism industry. I am conducting this study for my Master's Thesis. As such, I will be conducting and recording the interviews, transcribing the audio recordings, and analyzing the data, and writing the final report. Insights generated as a result of this study could benefit the companies in the commercial space industry, institutions of aviation and aerospace education, as well as the Federal Aviation Administration's

Office of Commercial Space Transportation. Please answer the following questions based on your knowledge and experience with suborbital spacecraft. The Principal Investigator for this study is Professor Denver Lopp. He can be reached at 765-494-6387. If you have concerns about your treatment during this interview, you can contact the Institutional Review Board at Purdue University, Ernest C. Young Hall, Room 1032, 155 South Grant Street, West Lafayette, Indiana 47907. And the phone number for the Board is 765-494-5942. And the email address is irb@purdue.edu. Do you have any questions?

P9: No.

Brian: Ok. And the first question, what kind of educational and/or technical background should a commercial astronaut possess?

P9: Let me give you kind of a top level responses to all of your questions with some minor variations.

Brian: Sure.

P9: Which is by definition, the backgrounds of the ones that we have...which is the two that flew for SpaceShipOne, Brian Binnie and Mike Melvill, um, the reason being that a lot of this will change with time **[current astronauts]**. I can only really give you an answer right now and the qualifications right now will much higher than they will be in say 10 years **[high requirements now]**

Brian: Ok.

P9: And the only way to really predict what their qualifications will be is to work with the ones they have right now. Right now, there are very few slots and

the competition is very fierce **[competitive]** and there are huge number of unknowns **[unknowns]**. So all of those are going to drive all of these requirement very high right now **[high requirements now]**. So you are asking me right now.

Brian: Yes.

P9: So the answer is going to be high **[high requirements now]**. If you look, example at Mike Mevill and Brian Binnie, both of them participated in the design process **[designing vehicle]**. They've been with the company for a long time and they knew a lot about the vehicle in case of, um, Mike Mevill he actually built his own aircraft...that was one of Dick Rutan's planes, um, sorry, one of Scaled Composites' planes. He helped design the release mechanism for SpaceShipOne **[designing vehicle]**, he was VP of general management at Scaled Composites. Brian Binnie, um, had just been with the company for a long time. He was more of, I would have guess what they were looking for, he came from a military flying background **[military flying]**. He has a Master's degree, a Bachelor's from Brown in aerospace engineering **[aerospace engineering]**, a Master's from Princeton in aeronautics **[aeronautics]** and he was a graduate of the U.S. Navy Test Pilot School **[test pilot school]**. 21 years in the Navy flying aircraft. 4600 hours of flight time **[thousands hours]**. That is the kind of thing I would expect, a graduate degree **[graduate degree]**, and the military flight background with several thousand hours of flight time. Mike Melvill was more of a surprise to me. It gives you the range you might see. He was one of those who was much more involved in the design process. So his qualifications came from building the aircraft **[designing vehicle]**. He doesn't have a military background and consequently he has much more hours of flight time although he has a comparable level of experience with 7600 hours of flight time **[several thousand hours]**. And both of them had flown many of the Scaled Composites' planes before **[variety of aircraft]**

they flew the spacecraft. So that is kind of the big picture. So back to your first question.

Brian: Ok. Sure.

P9: What kind of technical background...I would expect you might get a military pilot with at least a graduate degree **[graduate degree]** and several thousand hours of flight time **[thousands of hours]** or a civilian pilot who has either graduate degree **[graduate degree]** or who has been heavily involved in the design process **[designing vehicle]**...with also several thousand hours of flight time **[thousands of hours]** probably as you saw in military guy to be competitive.

Brian: So like a specific graduate degree in science or engineering then?

P9: Not necessary. If you look at what astronauts have, for example, some them have management graduate degrees **[management degree]**. It depends on where they were in their military career when astronaut opportunity came open to them. It really depends on what the organization needed at the time. So...I would say first choice would be engineering **[engineering degree]** with second choice either management **[management degree]** or science **[science degree].**

Brian: Ok. And then with the flight experience would aerobatic flight, um, either civilian or military would be more preferred than general military time or like any specific type military time?

P9: You can't avoid aerobatic flying **[aerobatics]** when you have high flight hours in either military or...certainly military because the military guys do, you know, combat maneuvers which is aerobatics **[aerobatics]**.

Brian: Right.

P9: You aren't going to get a high flight time military pilot **[military pilot]** who doesn't have aerobatic flight time. In terms of the commercial guys, um, don't know that as well as the high flight time so I could guess it is the same thing for safety. I would expect it is true for the Scaled guys. Both of them will be test pilots. Both are members of the Society of Test Pilots and they have test pilot backgrounds so...Mike Melvill flew commercial planes as a test pilot capacity and Brian Binnie flew military planes but if you a test pilot **[test pilot]**, again, you are going to have aerobatic training **[aerobatic training]** because that is what you need to have to be safe. You need to be able to recover from spins **[aerobatics]**. You need to know...if you get into some high angle maneuvers **[aerobatics]** you need know how to recover from them and how to spot them. So I wouldn't put it as a separate requirement. I think that comes with...a test pilot background like we've previously talked about.

Brian: And would a graduate from a government run test pilot school or the civilian nation test pilot school out in California be preferred or would they be equally valid?

P9: I don't know enough...I'm not pilot so I don't know enough about the various test pilot schools.

Brian: Ok. In terms of personality and character, what would make a desirable commercial astronaut?

P9: I would say, that is probably the same as a military astronaut or rather a government astronaut which is **[NASA requirements]**...you want someone who has performed well in high speed life threating situations **[life threating situations]** which comes kind of for free with a test pilot

background **[test pilot background].** They get that as part of technical training **[technical training]**. You want someone who is good speaking to the public **[public speaking]** again at least initially eventually that won't be true. In the early years, right now, they are going to get a lot of public attention **[public attention]**. You want someone who is comfortable being in front of crowds **[public attention]** and going out promoting the company and spacecraft **[public speaking]**. And you want someone who is a good team player **[team player]** You've got to be able to work with the engineers and technicians **[team player]** who are developing the spacecraft to be able to...when they find something needs to be fixed they need to be able to do a good communicating **[communication skills]** why it needs to be fixed and working with the people involved to get it fixed **[team player]**. Giving them good feedback all of that kind of stuff **[communication skills].**

Brian: And do you foresee a certain number of years in the military or a certain number of hours like you said before?

P9: I would expect hours of flight time **[high flight hours]** to meet the criteria.

Brian: Ok.

P9: And the variety of planes flown **[variety of aircraft flown]**. Again that comes with hours **[high flight hours]**.

Brian: And that would be, mostly turbojet or, um, turbofan time?

P9: I don't think that would be an issue. I would expect it doesn't matter. Spacecraft are none of the above **[spacecraft unique]**.

Brian: Ok. If training a commercial...a person to become a commercial

astronaut, what are the most important subject and/or flight areas in which to be familiar?

P9: Again we are back to the ones that we have. Because of the big unknowns **[unknowns]** right now, you are going to want test pilots **[test pilot].** There is a standard test pilot curriculum that they will go through and they will have to know all of that stuff. And I expect their going to want, they are going to want someone with a graduate degree **[graduate degree]** not because it is particularly necessarily but because the competition is so fierce why wouldn't you? **[competitive]**

Brian: Right. Exactly.

P9: It is important in the picking, it is important in the job. You see the same thing in government astronaut programs. Two aspects. One is you want people who are self starters **[self starter]** and confident **[confident]** and have high general analysis goings **[problem solving]**. All that is demonstrated for you by getting an advanced degree **[graduate degree]** even potential a PhD **[PhD]**. Although test pilots **[test pilot]** because they spend so much flying **[flying time]** would unlikely to have a PhD but it is not impossible. Scott Horowitz, one of our NASA astronauts, had a PhD. So it has been done. Um, but thats a way of getting the evaluation done for you by the universities and not by NASA itself. So it is not the education per se, it is the technical stuff **[technical skills].** It is the fact that they made the effort to complete a graduate program **[graduate degree]** **[commitment]** and have the skills and abilities to do. And those skills and abilities become helpful because there are so many unknowns **[unknowns]** you want people who know how to handle problems **[problem solving]** and do some of their own leg work and not just have to fed by other people **[independent solving]**. And that is A, the abilities to deal with knowns **[deal with unknowns]**. And the second is, you are going to be dealing

with very qualified people **[team player]**. The more qualifications **[many qualifications]** you have the more credibility you have in the eyes of those people.

Brian: Ok.

P9: For example, on my first flight I flew with someone who was a military helicopter pilot. She had just a Bachelor's degree at that point. To tell you how skilled she is, she eventually got a PhD going to night school while she was a single mom with, ah, like a 10 year old **[commitment].**

Brian: Oh wow!

P9: So is obviously is extremely capable. But at the time she flew with me, she didn't have a PhD and I did. When we would go into meetings with payload team members and they would just ignore what she said and they would listen to me. So I would basically repeat what she said they would listen to me simply because I had a PhD **[credibility]** Nobody could say to me, which they did her, if you had actually done your own research you would understand why this is important **[credibility].**

Brian: Right.

P9: So having those kind of credentials can be useful in with working with people who like credentials **[credibility]**.

Brian: To do think it is possible to be overqualified for the, like, a commercial astronaut or work...

P6: No.

Brian: Ok.

P9: No, at least not right now because the competition **[competitive]** is so stiff. And there are unknowns about the job **[unknowns]**. Overqualified is generally what happens when people people get bored. So at times of high unemployment so like when a PhD in chemistry takes a job at McDonalds. Right? And their not going to stay. As soon as the economy turns around, they are going to leave. And they're not paid as well. The commercial astronaut thing is so cool right now **[interesting experiences].**

Brian: Right.

P9: There are some many different opportunities, international travel, meeting all kinds of different people, all kinds of interesting stuff **[interesting experiences]**. People aren't going to get bored so overqualified isn't an issue. Like what we just talked about, overqualified has so many different benefits that they will see for themselves. They will see how nice it is to have those qualifications...that they're not going to feel overqualified. Thats another problem overqualified is. Working those people who don't understand or aren't interested in what you do. The material is boring and the people are boring. Its not going to happen with commercial astronauts at this point **[exciting]**.

Brian: Right. And how long of a, ah, like, going back to the training question. How long of a training program do you think is adequate to prepare someone for a 15 or 20 minute suborbital spaceflight?

P9: Right now. Again we are back to the people we know. The training program per se is not a separate program. They are an integral part of the company and they sort of train as they go **[training on the job].**

Brian: Right...

P9: And a huge amount of training was done before they got there with all of that test pilot stuff **[test pilot background]**. So a specific training program is probably pretty short. You can probably find those records as to how long they spent kind of dedicated to the flight aspect. Brian Binnie and Mike Melvill. But it is probably up to a year **[commitment].**

Brian: Ok. How well can you adequately simulate, like, a spaceflight in a simulator in terms of visuals, the actual feel for it, the performance characteristics of the vehicle that you are operating?

P9: Well, you can do it pretty well after you have had a few flights under your belts. You can do it well enough even when you don't because we have so experience now that it is not a huge unknown. But there is a huge difference between a simulator...the real advantage of a simulator from my perspective is training for things that are too dangerous to attempt to do in real life **[emergency training]**, like blown tires for the Shuttle. But for the spacecraft it would be some kind of really dangerous spin or a pressurization, something like that **[emergency training]**. Which you really wouldn't want the real person through because they have to learn. You don't want them to kill themselves. So the real value of a simulator is in the heavily off nominal situations **[emergency training]**. You can also use it to train for routine operations to develop your patterns so they are very consistent **[habit patterns]**. One thing you just don't get from a simulator is this knowledge that if you make a mistake you will kill yourself. And you need that regular exposure to keep yourself efficient at focusing situation like that **[efficiency]**.

Brian: Right because no one is really afraid of dying in a simulator.

P9: Right. So you get a little causal about it. One of the big advantages of having everybody in the astronaut corps who is on flight status fly T-38s is

that it keeps you in that environment where you have to have be efficient and it really and truly only happens in the cockpit **[efficiency]**. You can't just say, oh wait I forgot my notebook I'll run over next door and get it. You don't have it in the plane you are out of luck and it forces you maintain the habit pattern. Simulators are great. When I flew in space the first time, I spent so many hours in the simulator that it honestly didn't feel like my first flight **[habits]**. It felt like I was there before. They did a great job at making the switches the same, the skills the same so you weren't distracted by developing any new habit patterns **[habit patterns]**. All of the habits patterns you developed in the simulator were perfectly useful.

Brian: How much experience with weightlessness should these commercial crews have?

P9: You honestly don't need much **[little weightlessness]**. The weightless part you don't spend much time at because you are restrained. The people in the space station, who have been up there for a month or two, get really good at working without being restrained. If you are only up there for a couple of days, you are going to be restrained all of the time. So the weightless part isn't something you really need know much about **[little weightlessness]**

Brian: What about the issue spacesickness from a exposure to weightlessness for 15 minutes, 10 minutes or so? Do you think...

P9: As far as we know, there is no way adapt to that expect for being in space. As far I know, every time you fly it is easier than the time before. But...I know of many people who, not me because I did really well on my first flight, did many flights in the parabolic airplanes but its really not the same because there is too much of the low G high G oscillation your body adaptation process to that and it doesn't carry over to space

[spacesickness]. And they tried those chairs, multi direction motional chairs for the early astronauts...I had, um, they recommend...some people recommend doing a lot of aerobatics to get used to odd positions but I don't think that helps. I did that before my first flight. I don't think it made any difference. Again that process is so different **[spaceflight experience]**.

Brian: So the only real way to do it is to fly a flight and see what happens with the...the crew?

P9: There are meds you can take...

Brian: Ok.

P9: They work pretty well.

Brian: And how much down time do thing these crews should have before each suborbital flight? Like crew rest time?

P9: Right now it is going to be months so it isn't something you wouldn't have to worry about. Flying in space, going up and down as a carrier pilot who isn't going to stay up in space, it really isn't that much harder than flying an airplane **[mission unique]**. You could do it everyday if you had that many spacecraft **[routine spaceflights]**. It is different if you are up there for an amount of time because of the whole adaption thing but up and down is pretty easy. I think that the G level will be pretty light with a easy recovery **[limited G loads]**. You aren't going to land in the ocean with you being out in the water for 24 hours.

Brian: When selecting a commercial astronaut is there anything else important to consider that we have not already discussed?

300 P9: Not that I can think of.

301 Brian: Ok. Thank you very much for talking with me.

302 P9: Sure. Good luck in your report!

303 Brian: Thank you.

END OF RECORDED INTERVIEW

Date:	1-October-2010
Interviewer:	Brian Kozak
Interviewee:	Andrew Feustel (AF)

Brian: First off, can I record this conversation?

AF: Yeah, sure.

Brian: Ok, let's begin. Please understand that your participation in this study is voluntary, and you must be 18 years old to participate. Participation or non-participation in this study will not affect your employment. Your responses will be kept confidential, and any quotations used in the final report will be attributed to participant 1, 2, 3 to maintain anonymity. If you wish to waive your right to anony....anonymity, please let me know now.

AF: You can use my name.

Brian: Ok. At the end of the interview, if you waived your right to anonymity I will ask again if wish to continue to waive your right to anonymity. The interview itself should last between 20 and 25 minutes. It will be recorded via audio recordings and all original recordings will be destroyed by 31-December-2010. The risks involved are minimal, no greater than everyday life. The purpose of this study is to determine the selection criteria for commercial astronauts for suborbital spaceflight within the space tourism industry. I am conducting this study for my Master's Thesis. As such, I will be conducting and recording the interviews, transcribing the audio recordings, analyzing the data, and writing the final report. The Principal Investigator for this study is Professor Denver Lopp. He can be reached at 765-494-6387. If you have concerns about your treatment during this interview, you can

contact the Institutional Review Board at Prud...Purdue University, Ernest C. Young Hall, Room 1032, 155 South Grant Street, West Lafayette, Indiana 47907. And the phone number for the Board is 765-494-5942. Do you have any questions?

AF. No.

Brian: Ok, and the first question. What kind of educational and/or technical background should a commercial astronaut posses?

AF: You want me to answer that one first?

Brian: Yes please.

AF: Ok, and just to clarify, I sent you an email about this, so from the title of your study is suborbital spaceflight within the tourism industry...

Brian: Yes.

AF: And you are talking specifically about the crew rather than the passengers...

Brian: Right. For this study, I'm only looking at the pilots or the commander of the vehicle, um, the personnel that will actually be piloting and operating the suborbital spacecraft.

AF: Right. Ok. And so, I guess there are some assumptions made about weather or not the vehicle is fully tested or is considered fully operational or has functional crew participation on it.

Brian: Right, um, I'm looking at fully operational vehicles flying 15 to 20 minute suborbital spaceflights, um, assuming that the vehicle is fully operational at this time.

AF: OK, so I guess my answer to question number one is going to be that, um, they should have a similar background to what a lot of the military test pilots **[test pilot background]** have, there is probably some possibility for commercial, strictly commercial airline pilots to be able to participate in those flights but I think there are advantages to having somebody trained in high performance jet aircraft **[high performance aircraft]** military test program and also obviously test flight experience **[flight test]** would be beneficial but I think that is question two. So for educational and technical background whatever the requirements are for, um, military pilots **[military pilots]** along the lines of engineering training **[engineering training]** or possibility some classes either undergraduate **[undergraduate training]** or master degree level **[graduate training]** courses in avionics **[avionics]** or astronautics **[astronautics]** or aeronautics **[aeronautics]** would be beneficial.

Brian: You said high performance aircraft. What would your definition of a high performance aircraft be?

AF: My definition would be small military jet fighters type aircraft, so single or dual engine, um, with thrust capabilities and maneuvering capabilities similar to a military training or operational fighter aircraft **[jet fighter time]**.

Brian: Ok.

AF: I guess my personal opinion and obviously none of these are based on a specific NASA position or professional position, so my opinion is after one spaceflight and training for another one here at the end of the Shuttle

Program and only having the Space Shuttle for a vehicle. So my general opinion is that for these types of vehicles that are doing suborbital spaceflight, it is still a rocket **[rocketry]**, it is still a very high performance vehicle **[high performance vehicle]** and a crew should whatever background they needed to gain that insight or expertize or actual experience of, ah, a rocket **[rocket flight experience]** and typically the way folks do that is either to have flown on a Shuttle, you know, or a Soyuz rocket **[spaceflight experience]** or trained with the military and done a lot of test pilot work **[test pilot background]** on high performance vehicles **[high performance vehicle]** that performance in extremely dynamic environments **[dynamic environments]**, very different from what a commercial airliner would experience, you now flying passengers commercially around the country **[new flight experiences]**. So although the level of training required to those commercial airplane...aircraft is similar between a former military pilot and a person who is just gone straight through commercial train alone I would think that overall the military pilots would have been exposed more dynamics environments **[dynamic environments]** in, um, more potentially risky environments and aircraft **[risky situations]**. And many of those have gone on to fly Shuttles. The challenge with, um, flying a non pilot or commander who has spaceflight experience **[spaceflight experience]** is, you probably would have to look at somebody who is a scientist who has flown a Soyuz rocket because that person may have been trained as...an ascent and entry **[ascent][entry]** flight officer who is actually operating the vehicle **[spacecraft control]** more so than a mission specialist who are on the Space Shuttle where the commander and pilot are in charge. You do have two flight engineers on the flight deck although they don't have the level of control of the vehicle.

Brian: Do you think there is a certain number flight hours to, ah, qualify someone for a commercial astronaut position?

AF: You know, the challenge is that we don't have many rockets and space vehicles **[new flight experience]** around that people can ride on to get experience so in terms of high performance jet aircraft hours **[high performance vehicle][jet time]**...I think it would be a standard that would required for somebody to go on to test pilot school **[test pilot background]**, I don't know if there is actually a number. Somewhere around the order of several thousand hours **[several thousand hours]**, probably around two thousand hours in a high performance jet aircraft **[2000 hours][jet time][high performance vehicle]** or a thousand minimum that you would before you had somebody climb into a rocket expecting them to fly passengers to space. A lot of this of course has to do with the capabilities of vehicle **[unique to vehicle]**, is it that something that a crew could even fly or is it is so automated **[vehicle control]** is that their job is to really monitor vehicle performance and know whatever or not they are going to make a landing or so, maybe not having anything they could about that, depending on what the vehicle's design **[unique to vehicle]**, and ideally you would want a vehicle to designed so that whoever your crew is, your qualified crew is, there is some capability for them to recover an ascent or do an abort or actually perform a landing if the vehicle's systems, the automated systems, were not functioning properly **[vehicle control]**

Brian: What do you think about aerobatic flight experience for a civilian pilot? Do you think it would be beneficial or kind of neutral...

AF: Beneficial. You are a pilot as well so as you know the more exposure you give yourself in those environments and operating in those environments more capable become **[habit patterns]**. It is true, whatever anybody does the more they practice a specific, the situational awareness **[situational awareness]** they have of those tasks and objectives that exists outside of the primary objectives so what aerobatics **[aerobatics]** does for the pilots, I

think, is it exposes them to disorientating scenarios **[disorientating situations]** where they are focusing on controlling the aircraft **[vehicle control]** for a specific task and if they do that more and more and more it allows them to expand their awareness of the other aspects of the flight **[situational awareness]**, you know, whatever its specifically altitude or awareness of their regional position over the flight test area **[situational awareness]**, whatever it is. Or the subsystems of aircraft when they initially start those maneuvers, they have the ability to focus on anything except aircraft attitude.

Brian: Ok.

AF: So I would say yes, it is beneficial.

Brian: Haha. Question three, in terms of personality and character what would make a desi, desirable commercial astronaut?

AF: You know, that gets into...my thoughts are focused more on the flying of the commercial crew. That is because they are flying people in space who are probably paying per seat...in that sense the crew needs to be like a boat captain or cruise director **[confidence][calm]**, um, so I think some to degree, whatever the crews are commercial flights, the paying customers who are tourists and that person have to been quite personable with good interpersonal skills **[interpersonal skills]**. The ability to communicate phases of flight and the willingness to communicate all of the phases of flight **[communication skills]** and explain to them what to expect and give them a couple of updates about the way things are going **[communication skills]**. A lot of times when you get on a commercial airlines, you get the pilot...captain come on over the overhead and try to talk to the people. Some of those individuals are better at giving that 'here we go' speech than others and many of them don't do it at all. So I think so willingness on part

of the crew to be able to share the experiences and what the expectations of the mission are is desirable **[personable]**. So in that sense, um, character is important, the ability to get along with others with many different backgrounds and experience level and be patient **[patience]**, have the patience to deal with all those levels of possibility anxiety **[unknown situations]**, or you know, whatever their faced with in terms of the commercial crew and paying customer.

Brian: And do you foresee any need for a like a certain number of rest days or hours between each suborbital flight?

AF: You are talking about 30 minute flights?

Brian: Yes.

AF: I would say that there is probably going to be some level of preparations involved for each flight so I can't image flights would be going up on daily basis but I would expect for a commercial crew they would want some normalcy to their work requirements **[work normalcy]**. A Monday through Friday workweek. And yes, probably some days in between for rest. And it would depend on the G load of vehicle, how much stress it is under. You need to look at military pilots and training, ah, flying sorties everyday so there are some requirements for on and off hours so I think a model similar to that would be appropriate **[limited work day]** when those guys go up for combat missions they of course put their bodies under significant loads and sort of max out their performance each time they are up with the aircraft. There are conditions on flying a certain number of hours and a certain number of rest hours. We have the same thing, our duty day can only last 14 hours max with 8 to 10 hours of rest time before we start up our day again **[NASA requirements]**. So it will probably follow a model similar to that **[limited work day]**.

Brian: Ok. How much, um, experience with weightlessness should these crew have?

AF: I would say as much as practical **[weightlessness experience]** and specifically they need experience in weightlessness for the...it would hard to perform something that sitting down in a seat. So they should be flying either 0G flights with parabolic flights in aircraft or they should have actual spaceflight experience **[spaceflight experience]**. You know, when these commercial rockets start flying, there are only a limited number of people who have that experience.

Brian: What about the issue of spacesickness with the flight crew? Do you think that will be an issues on a short 30 minute flight with about 15 minutes of weightlessness?

AF: Most definitely. Yeah. It is very common...in my work experience and the experience of the people in the astronaut office so it is definitely something that would have to be addressed **[spacesickness]**. Ideally, you would want the crew to be less susceptible to that and that would probably be restrictions medication that they could use because of their requirement to operate the vehicle. Technically spacesickness isn't an issue until someone unstraps from their seat and starts floating about the cabin **[weightlessness experience]**. There can be an upset once weightlessness has been experience so that is something to be deal with. It can be extremely debilitating and incapability so you definitely want crew members who are not susceptible to spacesickness **[spacesickness]** or have some countermeasures in place in the form of medication so they can operate the vehicle.

Brian: And then on to question four. If training a commercial, what are the most important subject and/or flight areas in which to be familiar?

AF: Ascent and entry. **[ascent][entry]** Because it is just like an airplane, those are the most critical phases of flight. So whatever simulators, you would have to make simulator available that would model those phases of flight to allow the crew to, on multiple occasions, to go through training runs that would simulate both nominal **[nominal flight training]** and off nominal conditions **[off nominal flight training]** that would exist. So it would give them some training to operate the vehicle **[vehicle control]**

Brian: And how well....

AF: Not so much on orbital flight except to...for passenger care taking.

Brian: How well can you adequately simulate a spaceflight in a simulator? And how well can it...can you translate those skills from a simulator environment to actual space?

AF: You can simulate it quite well. We use motion based systems here and out in the aircraft as well. The carry over is quite significant. In my experience, difference between a simulated ascent and a real ascent to space is level of noise and the fact in your mind you know that you are blasting off the Earth **[realism]**. The expectations, the layout, the controls, all those things are all identical to the simulator **[habit patterns]**. So I think that the carryover is excellent and in fact...because all of those phases of flight are under loads, G loads, there is really no issue of weightlessness. You are under load the whole time. It is similar to working in a 1 G environment. You can emulate the angle motion based simulators, you can sort of emulate what senses might feel in space **[simulate space]**.

Brian: How long of a training program do you think is adequate to train someone going from a military or commercial pilot to a suborbital commercial astronaut?

AF: How long of a training program?

Brian: Yes

AF: I would say that would depend on the complexity of the vehicle but I would say the training program should last be...no more than 24 months **[commitment]**. From whatever starting point the person is at to the complexity of the vehicle, it might be shorting than that **[unique to vehicle]**.

Brian: Ok. And the last question. When selecting a commercial astronaut, do you believe there is anything important to consider that we have not already discussed?

AF: Not really. I guess my opinion overall is that you probably want the most amount of experience you can in the cockpit **[high experience level]**. At least for somebody to have the ability, to work within the larger frame work of situational awareness while operating the vehicle **[situational awareness]**. You don't want to have the commercial crew to be just as surprised as the commercial passengers on those initial flights. You want somebody who knows what to expect **[well-trained]**. So think my impression is, my opinion, is that initially commercial crews should be limited to individuals with actual spaceflight experience **[spaceflight experience]** or something similar to the pilot who flew SpaceShipOne. He certainly has some experience now with flying a vehicle up in space, close to space. Those types of experience are important **[spaceflight experience]**. You don't want whoever is trained in the program to be...have their first flight as a actual paying customer flight. You want them to have some experience with the vehicle and some actual spaceflight experience **[spaceflight experience]**.

Brian: Right. Ok. Could I use your name in my Thesis?

AF: You can use it if you think it will be helpful or want some credibility. Or you might not want to use it if you think it will distract from the to the end result **[comedy]**.

Brian: Haha.

AF: You are certainly welcome to use it

Brian: Ok. Thank you.

END OF RECORDED INTERVIEW

Appendix F. Coded Email Interviews

The coded email interview transcripts are listed.
The keyword or key phrase **[code]** format was used.

Date:	1-September-2010
Interviewer:	Brian Kozak - email
Interviewee:	Neil Milburn - email

Brian: I have forwarded your inquiry to Tom Shelley at Space Adventures, our partner in the suborbital space industry. They are much more familiar with the participant side of the business than us and, for that matter, just about anyone else on the planet!

I can respond to one question though re space crew. The Armadillo Aerospace vehicle concepts require no crew as such **[no flight crews]**. They are designed to be autonomous in virtually all respects except for the launch controllers and pad ops team **[computer controlled]**. There will be no pilot, commander ... or beverage service when we
reach cruising altitude :-)

Tom: Don't know if you can help this young man or if the information he is requesting is considered SA privileged / confidential. Just as a footnote, we are working with Professor Steve Collicott at Purdue to launch student payloads (SPEAR Project) to low altitudes here at Caddo Mills and possiblyat Oklahoma.

Date:	1-September-2010
Interviewer:	Brian Kozak - email
Interviewee:	Tom Shelley - email

Neil is right in the context of tourist flights. The only area I can see professional astronauts being needed is to tend scientific payload **[payload specialist]**, as they would be familiar with operating in the weightless environment **[weightlessness]**. Not my area of specialism but happy to talk - call me if you want to discuss on X.

Date:	24-September-2010
Interviewer:	Brian Kozak - email
Interviewee:	Loren Shriver - email

1) What kind of educational and/or technical background should a commercial astronaut possess?

The kind or type of education or technical background that a commercial suborbital astronaut should have I think might be dependent on what amount of control or input the astronaut will have over the specific vehicle being used **[vehicle unique]**, and the magnitude of expected control or input the astronaut may have to exercise in an emergency situation. As a basis, a good solid technical background **[technical skills][engineering][science][math]** (engineering, science, math, etc.) would seem to me to offer a good start point. If the spacecraft will have no ability for crew control or intervention (in my opinion not a good plan for human occupied vehicles), then not much else would be needed. If the crew would be able to only move switches from one position to another, still not much else would be required **[unique to vehicle]**. But if the intent is for the crew to perform system reconfigurations, or fly the spacecraft to maintain or correct trajectory, orientation, then one should be thinking about considerable flying experience **[flying experience]** and training, and quite a healthy amount of specific launch/ascent **[launch][ascent]** and entry/descent/landing **[entry][descent][landing]** training using spacecraft simulators and possibly appropriate aircraft.

2) What type and how much flight experience should a commercial astronaut have?

If normal flight or emergency response were to require considerable flight knowledge or experience **[high experience level]**, then that should be a requirement, along with specific spacecraft simulator experience.

3) In terms of personality and character, what would make a desirable commercial astronaut?

I tend to recommend to stay away from the flashy, "devil may care" personality, or one who thinks rules are for others, and go instead for the "steady in any situation," team player **[team player]**who can get along with anyone almost anytime, is patient **[patient]**, logical,**[logical]** and can think on their feet **[quick thinking]**. There are a few other characteristics that contribute also, but one more important one is the ability to admit mistakes, learn from the situation, and be better from it **[learning from mistakes][humble]**. Those who cannot accept criticism would probably be a misfit in an integrated crew.

4) If training a person to become a commercial astronaut, what are the most important subjects and/or flight areas in which to be familiar?

One has to be a little careful, I think, when recommending specific subjects or flight areas for training or background. Some of the statements up in answer 1 apply here as well. I think a good technical base is good **[technical skills]**, although some of the best AIRCRAFT PILOTS in history have been liberal arts majors! But as you start into the realm of space, the ability to understand the technical aspects **[technical skills]** of what is going on in any flight phase is very important, and there are some phases of a mission (I think, even a suborbital mission) that are not like regular aircraft flight, and the speeds are not comparable either **[new environment]** . This is where a good ability to understand the characteristics of each segment of the flight profile is a must, especially if a considerable amount of manual flying or emergency response would be needed **[high performance flying]**. Things like engine operation/thrust, flight trajectory (up and down), flight path angle, "zero g" characteristics, heating, flight control response throughout the flight regime, and of course, landing procedures, would be topics of interest **[aeronautics]**

[astronautics]. Some of those are also dependent on the specific spacecraft design **[unique to vehicle]**.

5) When selecting a commercial astronaut, is there anything that you believe is important to consider that we have not discussed?

I would refer you back to answer 3 above for the main thoughts here. For a suborbital flight, perhaps the question of personality traits is not quite such a big deal **[no set personality]**, because the missions will be short **[mission unique]**. But as the length of missions increases the compatibility of the crew members is very important, and personality traits must be considered.

Date:	2-October-2010
Interviewer:	Brian Kozak - email
Interviewee:	Brian Binnie - email

1) What kind of educational and/or technical background should a commercial astronaut possess?

Initially they will all be taken from the pool of experimental test pilots **[test pilot background]**. They in turn typically have engineering degrees **[engineering degree]** and more often these days Master's **[Master's degree]**. Long term, I don't really see why these need be hard requirements **[soft requirements**. A Boeing or Airbus are sophisticated machines yet pilots aren't requirement to be technical geniuses to fly them.

2) What type and how much flight experience should a commercial astronaut have?

The only requirement to fly SS1 was a commercial glider rating **[commercial glider]**. I got the first powered flight because of my carrier experience **[carrier experience]**. Flying rockets is a completely unique environment **[unique experience]**. I liken it to bull riding **[extreme personality]**. You need that kind of attitude going into it **[new attitude]**. Only a centrifuge/simulator can come anywhere near the dynamics involved **[complex dynamics]**.

3) In terms of personality and character, what would make a desirable commercial astronaut?

I bet it's not too different from what makes a good fighter pilot **[fighter pilot]**. Their common denominator is participation in sports **[sports]**. I've seen all

types, so eventually it's the individual's interest **[interest]** and enthusiasm **[enthusiasm]** that will make or break him or her.

4) If training a person to become a commercial astronaut, what are the most important subjects and/or flight areas in which to be familiar?

Aeronautical engineering **[aeronautical engineering]** and good stick and rudder skills **[stick and rudder skills]** are still the basis for everything else.

5) When selecting a commercial astronaut, is there anything that you believe is important to consider that we have not discussed?

NASA spends a lot of time screening their astronaut candidates **[NASA requirements]**. I think they ultimately want someone that can check their ego **[humble]** at the door and work effectively in a team environment **[team player]**.

Appendix G. Code Frequencies

The list of all codes from the interviews are listed along with the frequency of the code and the line number(s) from the interview where the code could be found.

Table G.1

Codes and Frequencies from Dan DeLong

Codes	Frequency	Line Number
high performance vehicle	5	34, 49, 72, 74, 105
engineering degree	2	37, 70
no required degree	1	38
flight test	2	42, 47
engineer	1	44
unique to vehicle	2	45, 53
monitoring vehicle	1	46
pilot	1	48
proper terminology	1	59
technical thinking	1	71
reacting to problems	1	71
turbojet	1	73
no set hours	1	78
medical evaluation	1	82
high g exposure	1	84
weightlessness	1	85
aerobatics	1	86
good health	1	87
FAA standards	1	99
limited duty day	1	100
great pilot demands	2	103, 106

Table G.2

Codes and Frequencies from Jim Voss

Codes	Frequency	Line Number
not set degree	1	36
flying skills	6	37, 41, 47, 51, 79, 97
technical skills	1	39
aircraft operation	1	42
technical education	1	43
adventurous	1	44
thousands of hours	1	49
high performance vehicle	2	50, 60
NASA requirements	1	50
unique to vehicle	5	54, 67, 85, 86, 92
flight time	2	76, 59
commercial pilot	1	59
pilot experience	2	73, 92
vehicle understanding	1	90
realism	1	95
flight test	2	107, 109
limited down time	1	115

Table G.3

Codes and Frequencies from Gary Payton

Codes	Frequency	Line Number
confidence	4	40, 99, 101, 166
new experiences	1	41
communication skills	1	44
rocket power	2	45, 67
engineering degree	2	49, 51
flight experience	1	50
Bachelor's degree	1	52
new flight experience	2	57, 100
thousands of hours	1	59
steep ascent	1	61
coast period	1	62
0 G	1	62
reentry	1	63
rapid flight	1	64
G forces	2	70, 83
dramatic flight	1	71
new type of flight	2	73, 105
test pilot school	1	76
aerobatics	1	82
aerobatic training	2	85, 88
complex aerobatics	1	91
humble	2	95, 102
competency	1	108
limited rest time	1	116
little weightlessness	1	120
vehicle control	3	123, 133, 145
monitoring vehicle	1	126
responsibility	1	131

Table G.3 (continued).

Codes and Frequencies from Gary Payton

FAA credentials	1	137
off nominal	1	139
system failure	1	141
trajectories	3	139, 140, 142
G loads	1	143
simulator learning	1	157
limited realism	1	158
explaining flight	1	167
vehicle expertise	1	169
public relations	2	172, 177
customer relations	1	174

Table G.4

Codes and Frequencies from Mark Brown

Codes	Frequency	Line Number
NASA requirements	7	32, 41, 48, 51, 63, 80, 95
safety requirements	1	38
safe hardware	1	46
crew training	1	47
technical science	1	53
engineering	1	53
flying experience	3	54, 62, 69
aerospace engineering	1	56
test pilots	1	56
technical degree	1	61
1000 hours PIC	3	66, 81, 89
Master's degree	2	66, 73
Bachelor's degree	1	69
high requirements now	1	75
military flying	1	84
responsibility	1	86
stressful situations	1	87
military pilot	1	88
mission unique	1	96
flying skills	1	100
communication skills	1	102
technical skills	1	107
short flight	1	116
FAA requirements	1	120
spacesickness	3	123, 129, 135
longer flights	2	130, 187
limited weightlessness	1	140
situational awareness	2	144, 163
simulated weightlessness	1	148

Table G.4 (continued).

Table G.4 (continued).

Codes and Frequencies from Mark Brown

vehicle familiarization	1	149
human factors	1	160
cockpit design	1	161
realism	1	168
simulate space	1	169
commitment	1	178
vehicle training	1	180
emergency procedures	1	181
survival training	1	184

Table G.5

Codes and Frequencies from Participant 9

Codes	Frequency	Line Number
current astronauts	1	40
high requirements now	3	42, 49, 52
competitive	3	47, 157, 200
unknowns	4	48, 152, 172, 201
designing vehicle	4	54, 58, 71, 83
military flying	1	61
aerospace engineering	1	63
aeronautics	1	64
test pilot school	1	65
thousands of hours	3	66, 81, 84
graduate degree	6	67, 80, 82, 155, 164, 171
several thousand hours	1	74
variety of aircraft	2	75, 143
management degree	2	88, 93
engineering degree	1	92
science degree	1	93
aerobatics	4	97, 99, 110, 111
military pilot	1	101
test pilot	3	108, 152, 165
test pilot background	2	126, 226
aerobatic training	1	108
NASA requirements	1	123
life threatening situations	1	124
technical training	1	127
public speaking	2	128, 132
public attention	2	130, 131
team player	4	133, 134, 137, 177
communication skills	2	136, 138
high flight hours	2	141, 144

Table G.5 (continued).

Codes and Frequencies from Participant 9		
spacecraft unique	1	147
self starter	1	161
confident	1	161
problem solving	2	162, 173
PhD	1	164
flying time	1	165
technical skills	1	169
commitment	3	171, 185, 229
independent solving	1	175
deal with unknowns	1	177
many qualifications	1	177
credibility	3	190, 192, 195
interesting experiences	2	206, 209
exciting	1	217
training on the job	1	223
emergency training	3	238, 240, 243
habit patterns	2	245, 260
efficiency	2	248, 253
habits	1	258
little weightlessness	2	264, 269
spacesickness	1	279
spaceflight experience	1	283
mission unique	1	294
routine spaceflight	1	295
limited G loads	1	298

Table G.6

Codes and Frequencies from Andrew Feustel

Codes	Frequency	Line Number
test pilot background	3	47, 76, 101
high performance aircraft	1	50
flight test	1	51
military pilots	1	53
engineering training	1	54
undergraduate training	1	55
graduate training	1	56
avionics	1	56
astronautics	1	57
aeronautics	1	57
jet fighter time	1	63
rocketry	1	70
high performance vehicle	4	71, 77, 99, 105
rocket flight experience	1	73
spaceflight experience	6	75, 88, 186, 251, 254, 258
dynamic environments	2	78, 84
new flight experience	2	80, 98
risky situations	1	86
ascent	2	90, 207
entry	2	90, 207
spacecraft control	1	91
jet time	2	100, 105
several thousand hours	1	103
2000 hours	1	105
unique to vehicle	2	108, 112
vehicle control	4	109, 116, 127, 213
habit patterns	2	122, 224
situational awareness	4	123, 130, 131, 246
aerobatics	1	125

Table G.6 (continued).

Codes and Frequencies from Andrew Feustel

disorientating situations	1	126
confidence	1	142
calm	1	142
interpersonal skills	1	145
communication skills	2	147, 148
personable	1	154
patience	1	156
unknown situations	1	157
work normalcy	1	167
limited work day	2	172, 179
NASA requirements	1	178
weightlessness experience	2	182, 199
spacesickness	2	194, 202
nominal flight training	1	211
off nominal flight training	1	212
realism	1	223
simulate space	1	229
commitment	1	237
unique to vehicle	1	238
high experience level	1	244
well-trained	1	249
comedy	1	262

Table G.7

Codes and Frequencies from Neil Milburn

Codes	Frequency	Line Number
no flight crews	1	6
computer controlled	1	8

Table G.8

Codes and Frequencies from Tom Shelley

Codes	Frequency	Line Number
payload specialist	1	2
weightlessness	1	4

Table G.9

Codes and Frequencies from Loren Shriver

Codes	Frequency	Line Number
unique to vehicle	3	6, 13, 53
technical skills	3	8, 39, 42
engineering	1	8
science	1	8
math	1	8
flying experience	1	16
launch	1	17
ascent	1	17
entry	1	18
decent	1	18
landing	1	18
high experience level	1	23
team player	1	29
patient	1	30
logical	1	30
quick thinking	1	30
learning from mistakes	1	33
humble	1	33
technical skills	2	39, 42
new environment	1	45
high performance flying	1	48
aeronautics	1	51
astronautics	1	52
unique to vehicle	1	53
no set personality	1	58
mission unique	1	58

Table G.10

Codes and Frequencies from Brian Binnie

Codes	Frequency	Line Number
test pilot background	1	3
engineering degree	1	4
Master's degree	1	5
soft requirements	1	6
commercial glider	1	11
carrier experience	1	12
unique experience	1	13
extreme personality	1	14
new attitude	1	15
complex dynamics	1	16
fighter pilot	1	19
sports	1	20
interest	1	21
enthusiasm	1	22
aeronautical engineering	1	25
stick and rudder skills	1	26
NASA requirements	1	29
humble	1	31
team player	1	31

Appendix H. Code Frequencies

The codes from each interviewee are associated with the research question asked in matrix form. Two different matrices representing the answers to each research question from the U.S.-based suborbital space companies and Purdue's astronaut alumni are presented.

Table H.1.
Codes from Question 1 from Suborbital Space Companies
What kind of educational and/or technical background should a commercial astronaut possess?

Neil Milburn	Tom Shelley	Dan DeLong	Jim Voss	Brian Binnie
No flight crews	*none*	high performance vehicle engineering degree no required degree	doesn't matter technical skills engineering degree piloting skills technical education	test pilot background engineering degree Master's degree soft requirements

Table H.1.A
Codes from Question 1 from Purdue's Astronauts
What kind of educational and/or technical background should a commercial astronaut possess?

Gary Payton	Mark Brown	Participant 9	Loren Shriver	Andrew Feustel
confidence	NASA requirements	high requirements	technical skills	test pilot background
rocket power	technical science	competitive	engineering	high performance
engineering degree	engineering	unknowns	science	aircraft
	flying experience	designing vehicle	math	flight test
	aerospace engineering	military flying	unique to vehicle	flight test experience
	test pilot	aerospace	flying experience	engineering training
	technical degree	engineering	launch	undergraduate training
	Bachelor's degree	aeronautics	ascent	graduate training
	1000 hours PIC	graduate degree	descent landing	avionics
	Master's degree	management degree		astronautics
		science degree		aeronautics
		engineering degree		jet fighter time

Table H.2.
Codes from Question 2 from Suborbital Space Companies
What type and how much flight experience should a commercial astronaut have?

Neil Milburn	Tom Shelley	Dan DeLong	Jim Voss	Brian Binnie
none	*none*	flight test	NASA requirements high performance vehicle turbojet high flight time	commercial glider carrier experience unique environment extreme personality new attitude complex dynamics

Table H.2.A
Codes from Question 2 from Purdue's Astronauts
What type and how much flight experience should a commercial astronaut have?

Gary Payton	Mark Brown	Participant 9	Loren Shriver	Andrew Feustel
thousands of hours	military flying	test pilot school	high experience level	high performance vehicle
rapid flight	stressful situations	thousands of hours		rocket flight experience
rocket power	1000 hours PIC	variety of aircraft		spaceflight experience
dramatic flight		aerobatics		test pilot background
new type of flight		military pilot		dynamic flight experience
test pilot school		test pilot		new flight experiences
aerobatics		test pilot background		risky situations
aerobatic training		aerobatic training		ascent
complex aerobatics		high flight hours		entry
				spacecraft control
				jet time
				several thousand hours
				2000 hours
				unique to vehicle
				habit patterns
				situational awareness
				aerobatics
				disorientating situations
				aircraft control

Table H.3.
Codes from Question 3 from Suborbital Space Companies
In terms of personality and character, what would make a desirable commercial astronaut?

Neil Milburn	Tom Shelley	Dan DeLong	Jim Voss	Brian Binnie
none	*none*	*none*	*none*	fighter pilot sports interest enthusiasm

Table H.3.A
Codes from Question 3 from Purdue's Astronauts
In terms of personality and character, what would make a desirable commercial astronaut?

Gary Payton	Mark Brown	Participant 9	Loren Shriver	Andrew Feustel
humble	NASA requirements	test pilot background	team player	confidence
confidence	flying skills	life threatening situations	patient	calm
new type of flight	communication skills	technical training	logical	interpersonal skills
competency	technical skills	public speaking	quick thinking	communication skills
		public attention	learning from	personable
		team player	mistakes	patience
		communication skills	humble	unknown situations

Table H.4.
Codes from Question 4 from Suborbital Space Companies
If training a person to become a commercial astronaut, what are the most important subjects and/or flight areas in which to be familiar?

Neil Milburn	Tom Shelley	Dan DeLong	Jim Voss	Brian Binnie
none	weightlessness	high performance vehicle turbojet no set hours	flight test piloting skills test pilot background	aeronautical engineering stick and rudder skills

Table H.4.A
Codes from Question 4 from Purdue's Astronauts
If training a person to become a commercial astronaut, what are the most important subjects and/or flight areas in which to be familiar?

Gary Payton	Mark Brown	Participant 9	Loren Shriver	Andrew Feustel
FAA credentials	Short flight	unknowns	technical skills	weightlessness
off nominal	spacesickness	test pilot	new environment	spaceflight experience
system failure	longer flights	graduate degree	high performance	spacesickness
G loads	limited weightlessness	competitive	flying	ascent
vehicle control	vehicle familiarization	self starter	aeronautics	entry
		confident	astronautics	nominal training
		problem solving	unique to vehicle	off nominal training
		PhD		vehicle operations
		flying time		realism
		technical skills		habit patterns
		commitment		simulate space
		handle problems		commitment
		team player		unique to vehicle
		interesting experiences		
		emergency training		
		efficiency		
		habits		
		little weightlessness		
		spaceflight experience		
		off nominal training		

Table H.5.
Codes from Question 5 from Suborbital Space Companies
When selecting a commercial astronaut, is there anything that you believe is important to consider that we have not discussed?

Neil Milburn	Tom Shelley	Dan DeLong	Jim Voss	Brian Binnie
none	*none*	weightlessness aerobatics high performance vehicle	*none*	humble team player

Table H.5.A
Codes from Question 5 from Purdue's Astronauts
When selecting a commercial astronaut, is there anything that you believe is important to consider that we have not discussed?

Gary Payton	Mark Brown	Participant 9	Loren Shriver	Andrew Feustel
confidence vehicle expertise public relations	human factors simulate space commitment vehicle training emergency training survival training	*none*	mission unique	high level of experience situational awareness well-trained suborbital experience spaceflight experience comedy

Appendix I. Strength of Data Continua

The assertions made were based upon the strength of the data. The continua were constructed using each data point that referred to the assertion being tested. The participant who said the code, the code, the line from the interview where the code occurred and a brief explanation of the strength of the data point are presented for each continua.

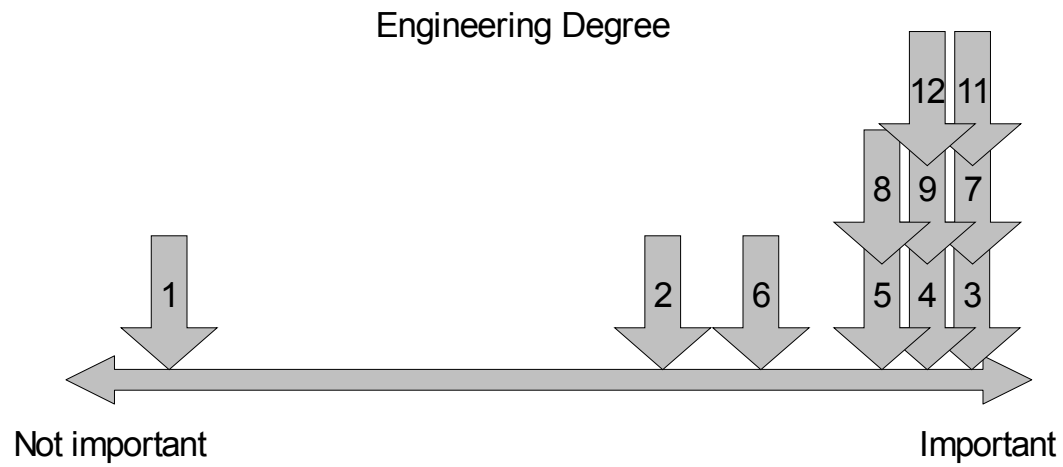


Figure I.1 Engineering Degree Continuum

#	Participant	Code	Line	Comment
1	Dan DeLong	engineering degree	37	casually mentioned, not required degree
2	Dan DeLong	engineering degree	70	trains how to think, related background
3	Gary Payton	engineering degree	49	critical educational experience
4	Gary Payton	engineering degree	51	minimum education
5	Mark Brown	engineering	53	required for NASA and commercial space
6	Mark Brown	aerospace engineering	56	key educational background
7	Participant 9	aerospace engineering	63	current commercial astronaut background
8	Participant 9	engineering degree	92	first educational choice for astronauts/pilots
9	Andrew Feustel	engineering training	55	military requirements similar to engineering
10	Loren Shriver	engineering	8	solid background experience
11	Brian Binnie	engineering degree	4	education for test pilots, first hand knowledge
12	Brian Binnie	aeronautical engineering	25	basis for pilots, commercial astronauts

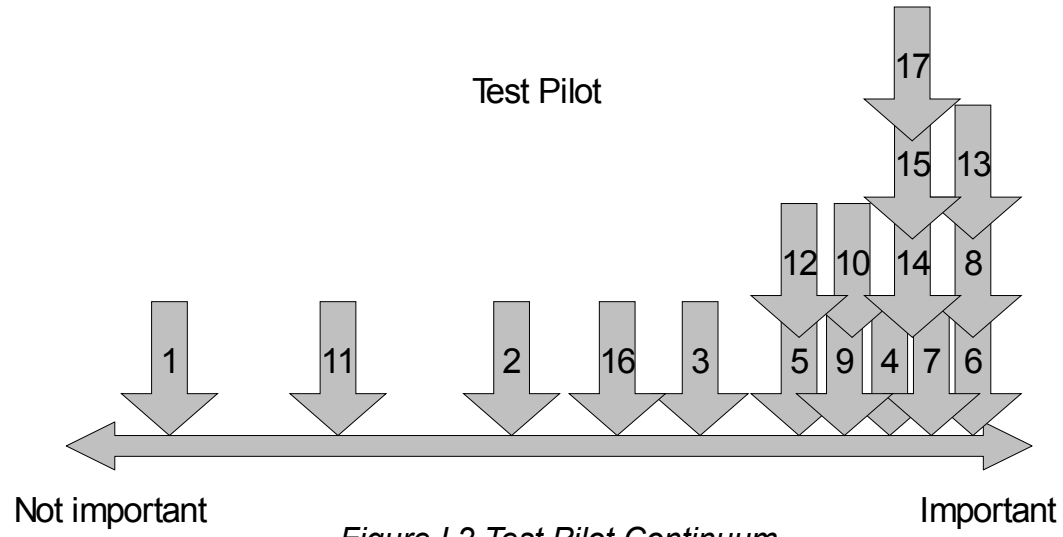


Figure I.2 Test Pilot Continuum

#	Participant	Code	Line	Comment
1	Dan DeLong	flight test	42	causally mentioned, title
2	Dan DeLong	flight test	47	development work only
3	Jim Voss	flight test	108	personality
4	Jim Voss	flight test	110	experience with unknown vehicles
5	Gary Payton	test pilot school	76	training course for crew
6	Mark Brown	test pilots	56	Skilled pilots, strong background experience
7	Participant 9	test pilot school	65	commercial astronaut background
8	Participant 9	test pilot	108	commercial astronaut background
9	Participant 9	test pilot background	126	experience with stressful situations
10	Participant 9	test pilot	153	experience with unknown
11	Participant 9	test pilot	165	casually mentioned
12	Participant 9	test pilot background	227	background from training program
13	Andrew Feustel	test pilot background	47	background experience
14	Andrew Feustel	flight test	51	key background
15	Andrew Feustel	test pilot background	77	NASA astronauts
16	Andrew Feustel	test pilot background	101	training for crews
17	Brian Binnie	test pilot background	3	initial crew selections

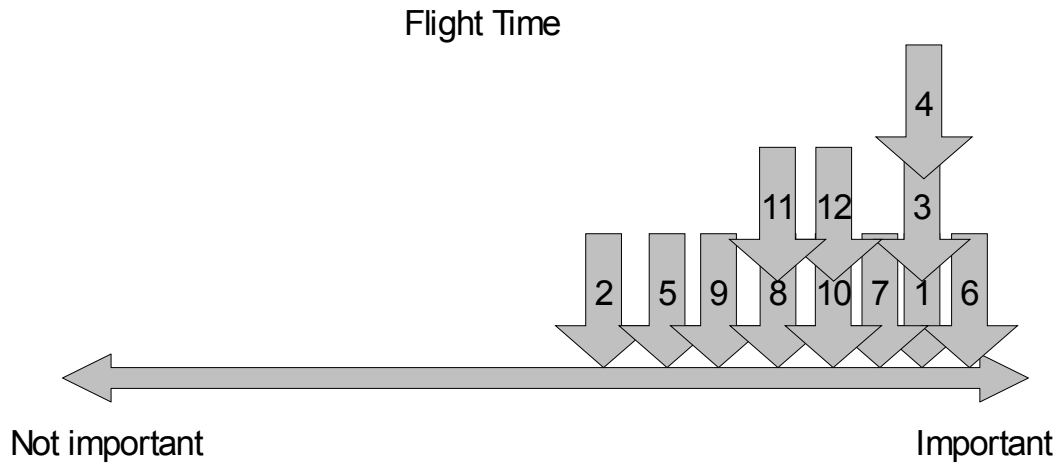


Figure I.3 Flight Time Continuum

#	Participant	Code	Line	Comment
1	Jim Voss	thousands of hours	49	NASA requirement
2	Gary Payton	thousands of hours	59	certification similar to airline captain
3	Mark Brown	1000 hours PIC	66	NASA requirement
4	Mark Brown	1000 hours PIC	81	NASA requirement
5	Mark Brown	1000 hours PIC	89	military time compared to civilian time
6	Participant 9	thousands of hours	66	commercial astronaut background
7	Participant 9	thousands of hours	81	military background, technical flying
8	Participant 9	thousands of hours	84	pilot who assisted with design of vehicle
9	Participant 9	high flight hours	141	related experience
10	Andrew Feustel	several thousand hours	103	important for crew
11	Andrew Feustel	2000 hours	105	test pilot experience
12	Loren Shriver	high experience level	23	experience for emergencies

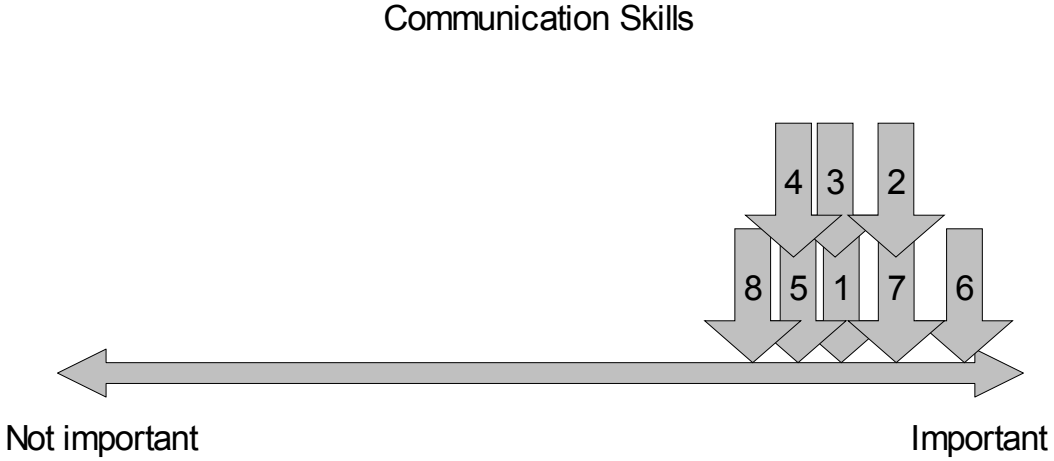


Figure I.4 Communication Skills Continuum

#	Participant	Code	Line	Comment
1	Gary Payton	communication skills	44	explaining engineering to passengers
2	Gary Payton	explaining flight	168	explaining flight dynamics to passengers
3	Mark Brown	communication skills	102	passenger relations on flight
4	Participant 9	public speaking	129	media relations, interviews
5	Participant 9	public speaking	132	promoting company
6	Participant 9	communication skills	138	working with engineers to fix problems with vehicle
7	Andrew Feustel	communication skills	147	explaining flight dynamics to passengers
8	Andrew Feustel	communication skills	148	customer relations

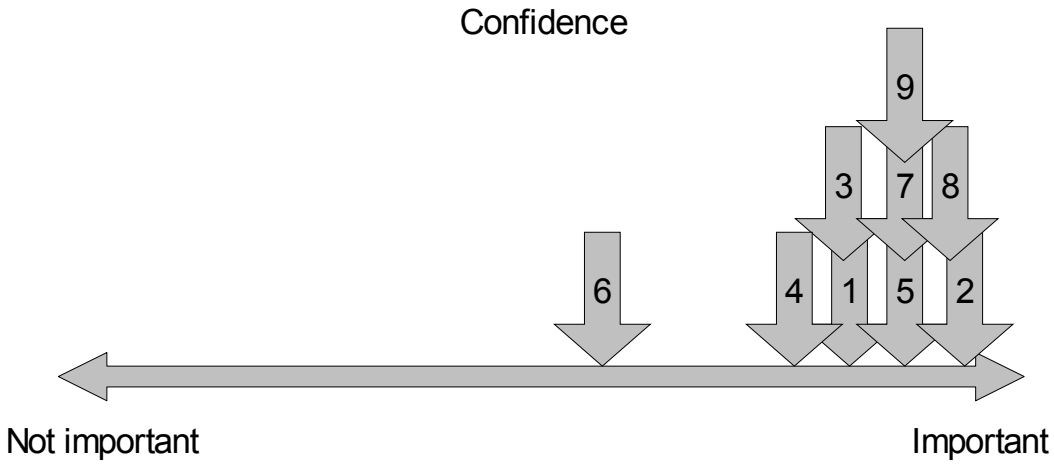


Figure I.5 Confidence Continuum

#	Participant	Code	Line	Comment
1	Gary Payton	confidence	40	passenger confidence with flight crew
2	Gary Payton	confidence	99	new type of flight environment
3	Gary Payton	confidence	101	passenger trusting crew
4	Gary Payton	confidence	166	explaining flight dynamics to passengers
5	Participant 9	confident	161	NASA requirement
6	Participant 9	credibility	190	educational basis
7	Participant 9	credibility	192	intimate understanding of engineering
8	Participant 9	credibility	195	teamwork and knowledge of vehicle
9	Andrew Feustel	confident	142	customer relations, explaining flight dynamics to passengers

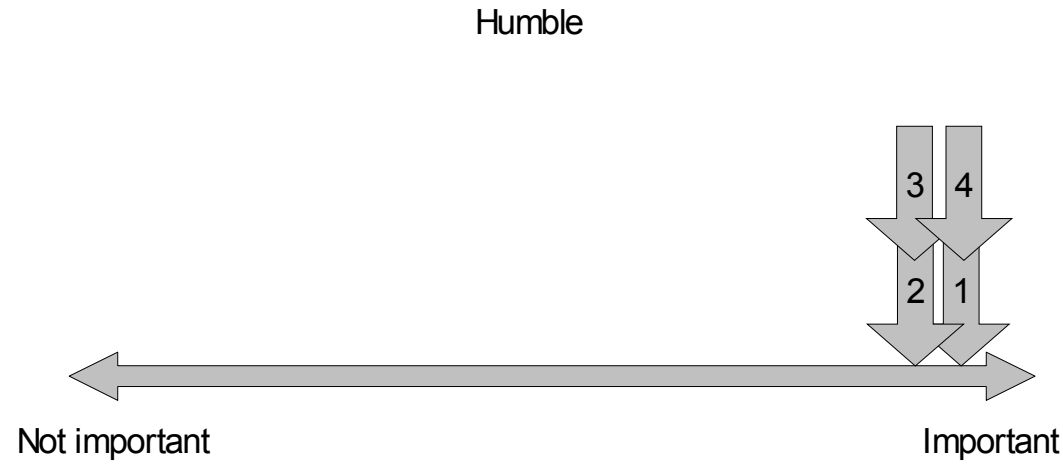


Figure I.6 Humble Continuum

#	Participant	Code	Line	Comment
1	Gary Payton	humble	95	remove test pilot ego
2	Gary Payton	humble	103	humble when operating in a dangerous and adventurous environment
3	Loren Shriver	humble	33	ability to admit, learn and improve from mistakes
4	Brian Binnie	humble	31	ability to work as a team player and check their ego before working/flying

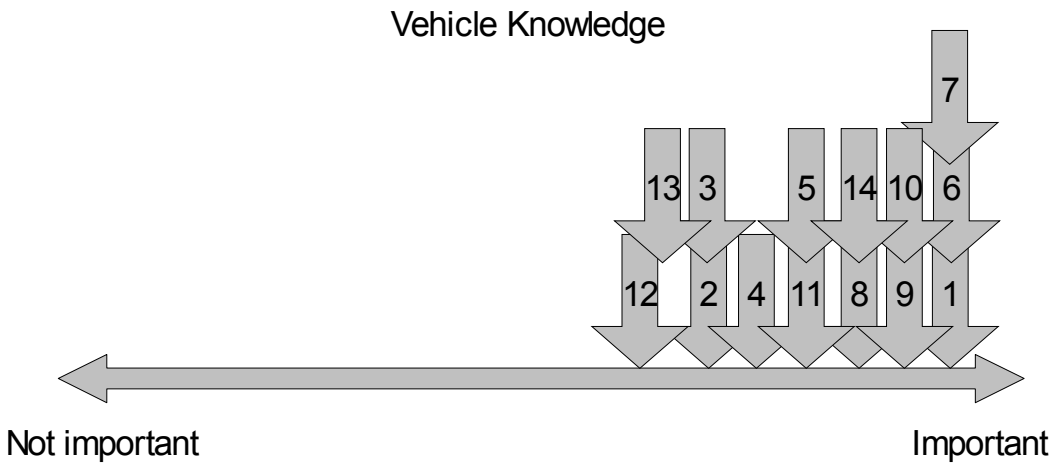


Figure I.7 Vehicle Knowledge Continuum

#	Participant	Code	Line	Comment
1	Dan DeLong	unique to vehicle	45	familiar with vehicle characteristics
2	Dan DeLong	unique to vehicle	53	company unique spacecraft
3	Jim Voss	unique to vehicle	54	type of spacecraft flown
4	Jim Voss	unique to vehicle	67	pilot control of spacecraft
5	Jim Voss	unique to vehicle	84	dependent on flight type
6	Jim Voss	unique to vehicle	86	similar knowledge areas for all spacecraft
7	Jim Voss	vehicle understanding	90	intimate understand of vehicle
8	Jim Voss	unique to vehicle	92	vehicle specific training
9	Gary Payton	vehicle expertise	169	explaining flight dynamics to passengers
10	Mark Brown	vehicle familiarization	149	understanding of vehicle performance
11	Andrew Feustel	unique to vehicle	238	complexity of vehicle
12	Loren Shriver	unique to vehicle	6	crew control of vehicle
13	Loren Shriver	unique to vehicle	13	level of crew control
14	Loren Shriver	unique to vehicle	53	type of spacecraft flown

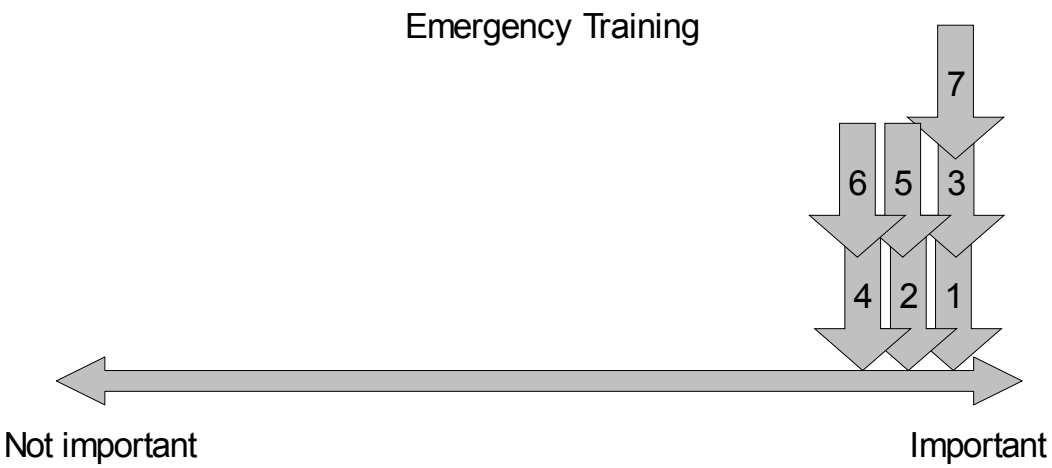


Figure I.8 Emergency Training Continuum

#	Participant	Code	Line	Comment
1	Dan DeLong	reacting to problems	71	core part of training
2	Gary Payton	off nominal	139	abnormal flight parameters
3	Gary Payton	system failure	141	training to recover from failures
4	Mark Brown	emergency procedures	181	core part of training
5	Participant 9	emergency training	240	training for dangerous situations in a sim
6	Participant 9	emergency training	243	preparing for highly unusual situations
7	Andrew Feustel	off nominal flight training	212	essence part of vehicle familiarization and training

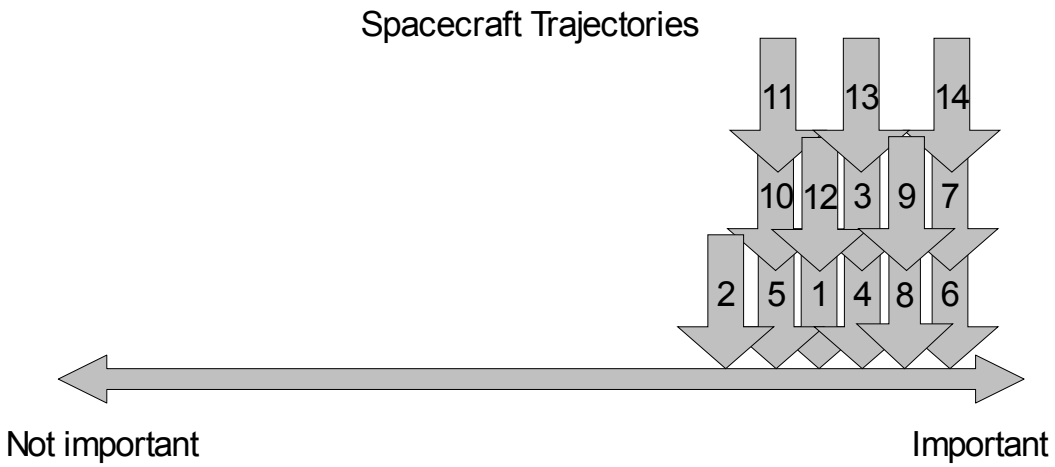


Figure I.9 Spacecraft Trajectories Continuum

#	Participant	Code	Line	Comment
1	Gary Payton	steep ascent	61	new type of flight environment
2	Gary Payton	reentry	63	rapid change of flight profiles during spaceflight
3	Gary Payton	trajectories	139	understanding of launch profile
4	Gary Payton	trajectories	140	understanding of entry profile
5	Gary Payton	trajectories	142	understanding of maneuvers
6	Andrew Feustel	ascent	90	Soyuz rocket experience
7	Andrew Feustel	entry	90	Soyuz rocket experience
8	Andrew Feustel	ascent	207	critical phase of flight
9	Andrew Feustel	entry	207	critical phase of flight
10	Loren Shriver	launch	17	key part of training
11	Loren Shirver	ascent	17	key part of training
12	Loren Shriver	entry	18	key part of training
13	Loren Shriver	decent	18	key part of training
14	Brian Binnie	complex dynamics	16	spaceflights are complex