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THE “GAME” OF TRAINING HUMANS FOR COMMERCIAL SUBORBITAL SPACEFLIGHT

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Game theory is the study of strategic decision making. When used as a lens through which to view the commercial suborbital human spaceflight training industry, it becomes clear that finding the right strategies to make the right decisions is key in supporting the goals of the training industry which include protection of human health and safety, managing customer and operator expectations, and facilitating an industry of education, collaboration, and growth for commercial suborbital human spaceflight. Industry structure models such as PARTS (based on game theory) suggest that gaining competitive advantages in business doesn't come from playing the game differently; it comes from changing the game itself. If we understand how to assess, challenge, and change the individual PARTS (players, added values, rules, tactics, and scope) of the game, we may discover ways to facilitate new entrants, opportunities, and outcomes. These opportunities could support training industry goals, as well as could bolster government, private, and individual long-term success of the commercial spaceflight industry as a whole.

I. INTRODUCTION

It has been noted that “U.S. policymakers, particularly at the state and local levels, have been groping toward an explicit entrepreneurship policy for at least a couple of decades. Their experiments have typically been pragmatic, inspired by immediate needs and pressures and by one another’s examples, rather than by a grand theoretical design.”[1]

Space policy and acquisition strategies of the U.S. government (USG), aimed at commercial development and stimulation of innovations, have been inspired and executed in a similar fashion. This approach, however, is not unusual. “We train managers and do research about management [with] the belief that decisions should be grounded in a solid analysis of data.”[2] But analyses that are based on data alone “rely on an implicit theory: The past is a good predictor of the future.”[2]

In fact, the basis of the emerging commercial space transportation industry is an assumption that the future will not be a repeat of the past, so an alternative to analyses based primarily on data is highly desirable. However, the role of data-based analyses should not be discounted. Although “[g]ood theory provides a robust way to understand important developments, even when data is limited. Theory is even more helpful when there is an abundance of data” and “[t]heory helps to block out the noise and to amplify the signal.”[2]

In support of the Federal Aviation Administration (FAA) Office of Commercial Space Transportation’s (AST) goal to “encourage private

sector launches, reentries, and associated services,” [Title 51 US Code Subtitle V,x50901(a)(7)] the analysis described in this article was conducted as one of a series of reports that attempt to address the lack of a “grand theoretical design” by using well-established, academically based economic theory of industry dynamics, applied to the different segments of the emerging commercial space transportation industry,[3–10] to complement data-rich analyses of similar market segments [11].

Taken together, analyses based in data and theory can be a powerful tool with which policy, business, and acquisition decision-makers should be working. An analysis of this nature is intended to be a starting point for more in-depth discussions among interested members of the industry with well-defined, baseline structure and vocabulary to facilitate a better understanding and comprehension of the observations and serve as a tool to employ tactics.

This is an analysis of the Suborbital Human Spaceflight Training (SHST) industry segment using an industry model called PARTS [12], developed in the field of game theory [13]. The SHST is tasked with human health, safety, and training-related endeavors that support commercial suborbital flights - or spaceflight which reaches space, but does not complete one orbital revolution, and the greater commercial spaceflight industry. Using the PARTS industry model, the SHST industry is broken into five components, the first letter of each designated by a letter in the acronym, including the players, added value, rules, tactics (to create, maintain and manage

perceptions), and scope. The initial industry component, players, is itself broken into five components: the industry (in this case, SHST), competitors, complementors, suppliers and customers.

The researchers performing this study were part of the third Emerging Space Industry Leaders (ESIL-03) workshop, supported by the FAA Center of Excellence for Commercial Space Transportation (COE CST).

The first section of this report provides background information of the ESIL workshops and the game theory industry structure model called PARTS.

The second section of this report is the analysis of the SHST industry segment using the PARTS model, defining the five subcomponents of the industry players, followed by the other four components of the industry model.

Finally, the paper concludes with a section of summary and results.

II. BACKGROUND

II.I ESIL Workshops

The Emerging Space Industry Leaders (ESIL) refers to a group of budding industry professionals. ESIL workshops are supported by the FAA Center of Excellence for Commercial Space Transportation (COE CST) at which outreach and education training are provided with the goal of analyzing specific segments of the emerging commercial space industry. This paper is the result of the third ESIL workshop (ESIL-03) which focused on using game theory techniques to address the training challenges within the commercial spaceflight industry, which is tasked with sending hundreds of thousands of people into space for the first time in history.

Two previous ESIL workshops were conducted and focused on different industry structure models including Michael Porter's Industry Structural Analysis [14] which was discussed at ESIL-01, and the appropriate role of government in the development of the emerging commercial space industry [15] discussed at ESIL-02. More details from each of the first three ESIL workshops can be found on the web¹.

² ESIL-01:

<http://commercialspace.pbworks.com/w/page/47362858/ESIL-01%20Files>

ESIL-02:

<http://commercialspace.pbworks.com/w/page/52219771/ESIL-02%20Files>

ESIL-03:

<http://commercialspace.pbworks.com/w/page/58895071/ESIL-03%20Files>

II.II Game Theory PARTS Industry Model

Game Theory is an innovation model that has been a pivotal tool, going back as far as the 1930's, for understanding the modern business world. The movie "A Beautiful Mind" in 2001 popularized game theory and modeled the character after John Nash, one of the three pioneers in game theory—John Nash, John Harsanyi, and Reinhard Selten—who were awarded a Nobel Prize for their findings in 1994.

In game theory, it is said that “what you get depends on your power in the game as well as on the power of others who have competing claims on the pie”[12]. In order to join the game or change the game in any way, you need to play the game differently. This is done by looking analytically at the game and its players, and altering one or more of its elements. One strategy used to change the game, is known as the PARTS strategy (players, added values, rules, tactics, and scope), which this paper will discuss.

This is an analysis of the Suborbital Human Spaceflight Training (SHST) industry segment using an industry model called PARTS [12] developed in the field of game theory [13]. In this model, the industry is broken into five components, the first letter of each designated by a letter in the acronym, including the players, added value, rules, tactics (to create, maintain and manage perceptions), and scope. Descriptions of each component and subcomponent is given below.

Players

The initial industry component, players, is itself broken into five components: the suborbital human spaceflight training industry (in this case, SHST), competitors, complementors, suppliers and customers (figure 1). Together, these five groups of actors are referred to as the Value Net. Each of these is described below.

The Company (or, in this case, the Industry Segment): This is the central focal point of the Value Net and typically is described as a company. In this analysis, ESIL-03 participants selected the SHST industry segment to be the central player.

Customers: The customer or “trainee” as defined by the suborbital human spaceflight training industry includes individuals that participate in an educational and physical, hands-on training program for the purposes of comprehensively understanding or preparing for a suborbital space flight. Customers may have objectives or tasks they wish to perform during the flight, and if allowed, can be trained for in the safest and most authentic manner possible.

Suppliers: Suppliers in the SHST industry include are organizations which provide support and solutions to the Company in its goal to help the spaceflight traveler maintain his or her safety and health, meet personal or mission-based objectives in space, and support overall enjoyment of the spaceflight [16]. Suppliers can be curriculum developers, equipment providers, or providers of plans, devices, and expertise. Examples of suppliers can include: Medical Health & Assessment, Pre-flight Fitness, Physical Spaceflight Training, Life Support Services & Equipment, and Operations, Procedures & Mission Specific Flight Training.

Complementors: The complementors of the SHST industry are those entities that share mutually in the benefits and costs in most circumstances. In other words, the successes enjoyed by the training industry from increased sales, publicity, etc. cause enjoyment and success by the complementors. Similarly, if the training industry experiences a major setback, the negative effects can also be experienced by its complementors. The degree to which a complementor is affected may depend on how well secured it is in the face of adversity and how interconnected it is with other economic sectors. Examples of commplementors can include: Suborbital Launch Providers, Non-Military Special Interest Groups (teachers, scientists, etc), Space Application Developers, and Space Excitement Boosters.

Competitors: Competitors to the SHST training industry include any organizations that provide competitive substitutes for the services provided by a company. Such substitutes can either be direct, meaning they provide actual spaceflight training and related services, or indirect, in which alternative services are provided which may preclude the need for such training. Therefore, the needs and motivations for each type of customer in the spaceflight training industry must be taken into account to identify a comprehensive list of competitors. Examples of competitors can include: Government Organizations, Xtreme Adventure Companies, and Space Launch Operators themselves.

Added Value

Added value refers to the measure of what the SHST industry brings to the overall value net. Since the success and safety of the commercial space industry depends on customers that return happy and healthy from spaceflights, it is expected that the SHST industry members are critical to the industry due to their ability to prepare the untrained human population for space. In fact, spaceflight participants may not be permitted to fly without training. In any

industry, it is very hard for any member or industry component to extract more value from the market than the amount of added value it contributes in the first place.

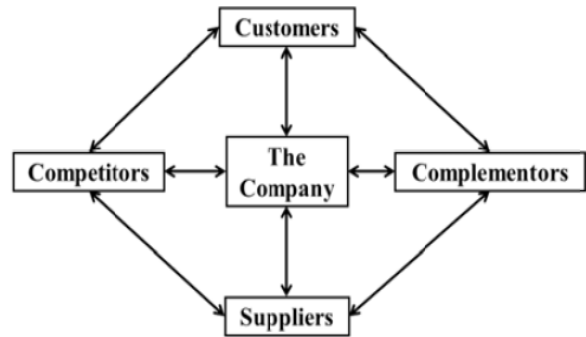


Fig. I: The PARTS Value Net [12]

Tactics

This portion of the PARTS construct primarily concentrates on the tactics required to create, maintain, and manage perceptions of the industry. Since an industry is perceived differently by different people, their perceptions will influence the decisions they make and the actions they take (their “moves”) with respect to the industry. Tactics are especially important during negotiations, any good game strategy will take account the perceptions of all parties.

Scope

The scope refers to how the SHST industry is relevant. In evaluating the scope, it can be helpful to draw boundaries around the market or industry being analyzed in order to simplify its analysis. Sometimes this requires looking at the situation as distinct, separate games rather than parts of a more complex system. In fact, it is recognized that boundaries between segments of industries and between industries themselves (including boundaries of products, geography, time, etc.) are largely simplifications solely for the purpose of analysis despite the dangers and inaccuracies introduced in the process.

III. INDUSTRY ANALYSIS

III.I Players – The SHST Industry Segment

The Suborbital Human Spaceflight Training (SHST) industry provides knowledge and hands-on skill training to maximize personal health and safety related to suborbital spaceflights, or spaceflight which reaches space but does not complete one orbital revolution, and to other customers of the commercial spaceflight industry. Spaceflight training is important in extreme environments such as space.

Training helps to communicate and execute individual's roles and responsibilities in case of emergency, aids in the reduction of anxiety, and can help build group moral and teamwork during the flight. The general goals of training are to protect personal human health and safety, to build confidence and ability to perform any objectives and/or tasks efficiently during flight, and to facilitate a successful mission and enjoyable spaceflight experience.

The mission of the SHST industry is operationally different than that of the NASA Space Shuttle, commercial airliners, or any other training industry for transportation such as cars or trains. One difference is that spaceflight participants are not physically separated from the crew. Another is the extreme exposure to acceleration G-forces beyond the Space Shuttle or any commercial aircraft flight as well as potential exposure to off-nominal cabin environmental parameters for a considerable time period. Participants may also have to integrate into life support or flight crew equipment including restraint systems and vehicle egress systems [17].

Spaceflight training companies have developed methodologies to evaluate human tolerance, control and operation, and personal enjoyment during nominal and off-nominal (emergency) flight scenarios. In several cases, academic curriculum is combined with flight exposures to prepare pilots, crew, and spaceflight participants for the rigors of space, as well as facilitate personal and commercial suborbital spaceflight mission objectives.

The suborbital training industry interfaces with multiple players in the broader commercial space industry including: space launch operators, the spaceflight participant or "customer", and the government Federal Aviation Administration Office of Commercial Space Transportation (FAA AST) regulating agency. Education-only courseware providers can play a role in the training industry; however, this segment will not be discussed for the purposes of this paper.

III.II Players – Customers

The customer or "trainee" in the suborbital human spaceflight training industry includes on-board spaceflight participants, researchers or mission-specialists, pilots and crew, and space experience customers such as students, teachers, educators, media, etc. interested in the education, experience, and entertainment value of the training program, but may not be able to make the financial commitment for an actual spaceflight.

Once commercial suborbital spaceflights begin, it is probable that the "customer" category could expand to include on-ground personnel training

customers such as medical physicians, operators, and emergency responders, as well as other members with a vested interest in the health, safety, and wellbeing of the commercial spaceflight industry.

Training customers participate in a physical, hands-on training program for the purposes of comprehensively understanding and preparing for a suborbital space flight. Understanding how to recognize and manage both the physiologic and psychological stresses induced by high gravitational accelerations common to commercial space flight trajectories is important for their personal health and safety. In addition, each customer may have objectives or tasks to perform during the flight. These tasks, if allowed, can be practiced in a training program regime, in order to execute the objectives in the safest and most authentic manner possible.

This paper intends to focus on the three most common types of trainees found in this industry to date. Those customers include: (1) Spaceflight Participants, (2) Professional Users; (3) Crew/Pilots, and; (4) Space Experience Customers.

Spaceflight Participants: Spaceflight participants are non crewmembers that participate in a suborbital spaceflight. They comprise both passive and active roles on board based on their mission goals and objectives. Common spaceflight participant subcategories include: "tourist", "researcher", "educator", and "media".

Professional Users: A professional user is a spaceflight participant that is additionally involved in performing a complex task or specific assignment during their spaceflight. Professional users can include scientists or researchers, grad students, and participants tasked with conducting microgravity research, providing medical care, or monitoring other spaceflight participants.

Pilots and Crew: Pilots and crew are crewmembers charged with overall vehicle operation and mission success of the spaceflight. This can include preflight to post flight preparations and procedures, spacecraft operation and flight, care of safety of passengers and crew, and handling any safety related issues such as science or payload stowage and security. Common positions include: commander or pilot.

Space Experience Customers: These customers participate in space flight training for the experience, education, or entertainment value, independent of or in advance of making any plans for actual spaceflight. Typical customers today are spaceflight enthusiasts or adventure travelers not yet willing or

able to make the financial or physical commitment for actual spaceflight, or those who want a spaceflight experience now before the actual spaceflights are generally available (may include retired astronauts and aviators as well as future space tourists), or educators or researchers who want a better understanding of spaceflight training, or those who are preparing themselves to participate in research when space flights are available. These customers might also participate in zero gravity flights, skydiving, gliding and soaring, scuba, Space Camp, or space simulation experiences on Earth. Some customers may pay with personal funds, while educators and researchers may take advantage of educational outreach or research grants to fund their space training experience.

III.III Players - Suppliers

Suppliers in the SHST industry include are organizations which provide support and solutions to the Company in its goal to help the spaceflight traveler maintain his or her safety and health, meet personal or mission-based objectives in space, and support overall enjoyment of the spaceflight. Suppliers can be curriculum developers, equipment providers, or providers of plans, devices, and expertise. Examples of suppliers can include: Medical Health & Assessment, Pre-flight Fitness, Physical Spaceflight Training, Life Support Services & Equipment, and Operations, Procedures & Mission Specific Flight Training.

The growth and demand of the greater commercial human spaceflight industry and its growing customer base, will affect the diversity and volume of training services, and may also impact the value net and service supply chain. We categorize suppliers into the following main categories: Suborbital Launch Providers, Spaceflight Equipment Providers & Facilities, and Support Services. A representative list of companies is shown below, however there may be additional companies either unknown or missed during the data collection for this paper.

Suborbital Launch Providers(passenger-carrying)

- Virgin Galactic, Mojave, CA
- Space Expedition Corporation/XCOR, Mojave, CA
- Blue Origin, Seattle, WA
- Booster, Brussels, Belgium

Spaceflight Training Providers & Facilities

- Weightlessness Training: Aurora Aerospace, Tampa Bay, FL; Zero G Corporation, Arlington, VA

- Land/Water Survival Training: Survival Systems USA, Groton, CT
- Launch/Reentry High G Spaceflight Simulator Training: ETC's The NASTAR Center, Philadelphia, PA
- In-air G-Force Flight Training: Starfighters, Cape Canaveral, FL; Black Sky Training, Oviedo, FL
- Spatial Disorientation & Motion Sickness: ETC's The NASTAR Center, Philadelphia, PA; Ashton Graybiel Spatial Orientation Lab, Brandeis University, Waltham, MA
- Altitude Physiology Training: ETC's The NASTAR Center, Philadelphia, PA; FAA Civil Aerospace Medical Institute, Oklahoma City, OK
- Mental Awareness & Group Dynamics: Inner Space Training, Netherlands
- Pre-flight Fitness Training: Astrowright, Las Vegas, NV; Qualtec, Tempe, AZ
- Life Support System Training Services: David Clark, Worcester, MA; ILC Dover, Frederica, DE; Final Frontier Design, Brooklyn, NY; Oceaneering, Houston, TX; Orbital Outfitters, North Hollywood, CA

Support Services

- Space Ticket Sales & Support: Space Adventures, Vienna, VA; Suborbital Training Services and Solutions, Canada; Space Expedition Corporation (SXC), Netherlands; Virgin Galactic Accredited Space Agents (ASAs), worldwide
- Human Health and Medical: Wyle Laboratories, Houston, TX; NASA JSC, Houston, TX; USAF Academy, Colorado Springs, CO; Barrios Technology, Houston, TX; Individual Aerospace Physicists
- Training Plans and Support: Qualtec, Tempe, AZ

III.IV Players – Complementors

The complementors of the SHST industry are those entities that share mutually in the benefits and costs in most circumstances. In other words, the successes enjoyed by the training industry from increased sales, publicity, etc. cause enjoyment and success by the complementors. Similarly, if the training industry experiences a major setback, the negative effects can also be experienced by its complementors. The degree to which a complementor is affected may depend on how well secured it is in the face of adversity and how interconnected it is with other economic sectors. We categorize complementors into the following main categories:

Suborbital Launch Providers, Non-Military Special Interest Groups (teachers, scientists, etc), Space Application Developers, and Space Excitement Boosters. Subsets of the companies are represented below.

Suborbital Launch Providers

The most obvious complementor is the company that will provide flights for which the participants are being trained for by the training industry. There is a clear 'industrial symbiosis' between these two entities whereby the risks, successes and failures are shared evenly. An increase in popularity of suborbital space tourism will lead to a similar increase for the training industry.

Non-Military Special Interest Groups

This category of complementors includes people like teachers and scientists that benefit from suborbital spaceflight through inspiring students to pursue STEM careers or through direct research in fields such as biology and fluid physics. As non-military personnel, these groups of people typically do not have exposure to the rigor of spaceflight and thus are in need of training for their suborbital spaceflights. Therefore, not only are these people customers, but complementors too. If the training industry is negatively impacted, then so is the work done by these professionals, and vice versa.

Space Application Developers

Similar to special interest groups are developers of space applications. These are people or companies who are in the business of product development and require suborbital spaceflight training for a basic flight as well as additional training to meet their personal or professional space objectives.

Space Excitement Boosters

This category refers to all entities that provide goods or services in order to stimulate interest in space exploration amongst the general public. They may include merchandise providers, popular science media, educational institutions, theme parks, and many more. A customer of the training industry will have additional value when one of these complementors provides its good or service to the customer.

III.V Players – Competitors

Competitors to the SHST training industry include any organizations that provide competitive substitutes for the services provided by the Company. Such substitutes can either be direct, meaning they provide actual spaceflight training and related services; or indirect, in which alternative services are

provided which may preclude the need for such training. Therefore, the needs and motivations for each type of customer in the spaceflight training industry must be taken into account to identify a comprehensive list of competitors. We categorize competitors into the following main categories: Government Organizations, Xtreme Adventure, and Space Launch Providers. Subsets of the companies are represented below.

Government Organizations

Various government organizations have extensive experience in spaceflight training and related areas and therefore present competition to commercial spaceflight training providers. In one case, if a government organization is the customer to the flight provider, the government may elect to train the employees and researchers it will be sending on the flight. In another case, the flight providers may opt to contract with the government for training and related services for its crew and customers. Government competitors can be either domestic or international; domestic competitors include the National Air and Space Administration (NASA), the Federal Aviation Administration's Civil Aerospace Medical Institute (FAA CAMI), and the U.S. Military, while international competitors include Star City in Russia and the European Space Agency.

Xtreme Adventure

Because a significant aspect of the attraction of the human spaceflight experience is the thrill and adrenaline rush, providers of related Xtreme Adventure activities can be categorized as competitors because of the potential for their services act as a substitute for space tourism. If thrill seekers decide to pursue cliff diving or hang gliding, for example, as a substitute for feeling weightless like a ZeroG space flight training experience, the individual may not see the need for additional spaceflight training unless mandated or motivated for personal or professional gain.

Space Launch Providers

Finally, the flight providers themselves have the option to provide their own training for the pilots and crew, professional users, and spaceflight participants flying on their vehicles. Companies such as Virgin Galactic have stated there will be three days of pre-flight training included in the ticket price. What will be included as part of individual Space Launch Providers training program is still largely unknown. It is expected that while some aspects of training might overlap and therefore be competitive, other aspects of training might be complimentary – such as is seen in the commercial aviation industry today.

III.VI Value Net for Suborbital Human Spaceflight Training Industry

Based on the game theory, we ask if the suborbital human spaceflight training (SHST) industry is a game, who are the players and what are their roles? Understanding who the players are in the game and their interdependencies to one another can be visualized in a basic schematic called a value net. Each value net includes the traditional customers, suppliers, and competitors, as well as features those who provide complements to the industry, called “complementors” [12].

Based on Barry J. Nalebuff and Adam M. Brandenburger’s definitions in the book *Co-Opetition*;

- A player is your complementor if customers value your product more when they have the other player’s product than when they have your product alone.
- A player is your competitor if customers value your product less when they have the other player’s product than when they have your product alone.

The Value Net is a helpful tool in that it reveals two fundamental symmetries in the game of business. Vertically we see that suppliers and customers play symmetric roles and contribute as partners in creating value, while horizontally we see competitors and complementors play nearly mirror-image roles in creating value to the industry (figure 2).

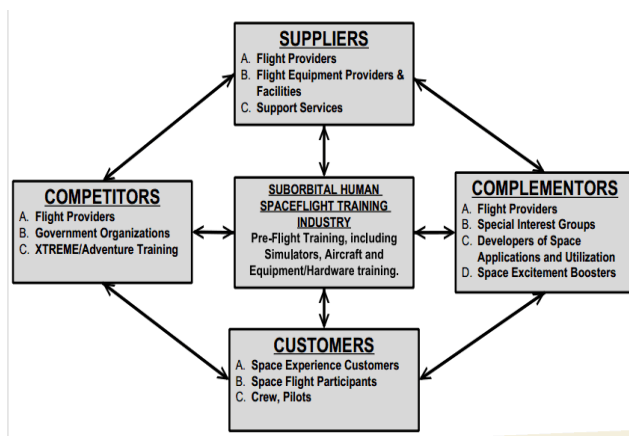


Fig II: Suborbital Human Spaceflight Training (SHST) Industry PLAYERS – Value Net

III.VII Added Value

The SHST industry adds value for the cadre of customers, competitors, suppliers and complementors within its value net. The predominant areas of value have been identified as those that create (1)

performance and experience enhancement, (2) outreach and market expansion, (3) supplier prosperity, (4) medical understanding, (5) increase of public awareness and approval, (6) risk mitigation, (7) job creation, and (8) innovation from lead users.

Performance and Experience Enhancement

Performance and experience enhancement is one of the foremost factors of this industry’s added value. By participating in pre-flight training, participants, professionals, and crew members will each be able to take advantage of increased familiarity to the unusual environment they will be experiencing in addition to the spacecraft hardware with which they will be interacting. This familiarity will provide reduced anxiety and enhanced safety to these individuals, as well as management of their expectations during the flight. Each of these factors will in turn optimize the individuals’ time usage while on the spacecraft, allowing them to fully enjoy their flight or ensure their project is performed properly. This overall enhancement of the spaceflight experience will not only benefit the customers, but also the suppliers and the complementors, since the short time available will be utilized to its fullest extent.

Outreach and Market Expansion

Outreach and market expansion will affect each of the four groups within the value net. As outreach and awareness of the industry increases, the public will generate increased excitement about suborbital space travel and the training that is required for such flights. The increased expansion of the market will also bring in more spaceflight training participants. This larger pool of trainees will provide more customer feedback of the experiences involved in the training, which will allow the providers to improve their training for future groups.

Supplier Prosperity

Supplier prosperity is the successful flourishing or good fortune of business success. Often this is related to financial growth and market share. The impact of success on suppliers on the value net will result in success for everyone in the commercial spaceflight industry. Training is heavily dependent upon actual spaceflight, thus the increased ability for supplier growth will directly influence the success of the suborbital human spaceflight training industry.

Medical Understanding

Medical understanding will also increase as the suborbital human spaceflight training industry grows. Throughout the courses of training, tracking the overall health and wellbeing of each participating trainee will increase the amount of data aerospace

medical researchers have. These increased metrics will allow researchers to analyze the effects spaceflight has on the human body to a greater extent than ever before, due to the large increase of the data pool. Not only will these data provide the suppliers and complementors with better information to improve their services, but it will also allow the customers to have a greater awareness of what their body will experience when put under such conditions.

Increase of Public Awareness and Approval

Increased public awareness and public approval of the industry is required in order to reduce the litigation involved in the operations of the training programs. This will allow the providers more freedom in their operations, which will enhance the trainees' experiences. This will in turn increase the operational stability of the overall space industry, benefiting all four value net groups.

Risk Mitigation

Risk mitigation also comes into play concerning increasing value of the industry. As mentioned, by participating in the training courses, trainees will increase their familiarity with the unusual environment of spaceflight in addition to the spacecraft itself. By doing so, they will each substantially decrease the amount of risk they impose on themselves, the other crew members, the spacecraft, and the success of the mission as a whole. Mitigating risks as much as possible is also advantageous as far as insurance providers are concerned, as they are likely to be much more benevolent if the participating individuals have been trained before their flights.

Job Creation

Job creation will increase residually not only in the suborbital human spaceflight training industry, but in the entire space industry. As more trainees seek to perform the regimen set out by providers, the providers will require more staff to operate the training facilities. Additionally, as more people become certified to work in the suborbital environment, jobs will become available to them as researchers, test subjects, etc.

Innovation from Lead Users

Innovation from lead users will increase from the growth of the industry as well. Each time a lead user utilizes training services, they become increasingly familiar with the environment, allowing them to broaden their scope of thinking regarding the flight. Instead of merely focusing on a singular experiment or given experience, they will become more aware of

possibilities regarding the platform they are utilizing. This will provide great feedback in the use of space within the various spacecrafts, in addition to increasing overall knowledge of what a person can possibly accomplish within a given time constraint for a mission.

III.VIII Rules

The rules of the game refer to the external and internal constructs of the training industry which allows the game to be played. External rules can involve overall funding mechanisms (i.e. such as government contracts, corporate contracts, and individual sale of goods/services), as well as commercial suborbital human spaceflight training industry guidelines such as safety or training, government regulations, protection of sensitive information, and standard rules of business.

Safety and training rules include government regulation such as the Federal Aviation Administration (FAA) Office of Space Transportation regulations. The FAA FAR part 460.5 illustrates the "Crew Qualification and Training Requirements" to be adhered to by commercial spaceflight providers. In addition, a FAA Medical Class 3 certificate issued by an AeroMedical Examiner (AME) may also be required by some training providers (i.e. such as NASTAR Center which is FAA approved) as a guideline to keep its trainees safe.

Other safety and training rules may include signed documentation such as a waiver or release of liability by each trainee prior to training, and the "right of refusal" not to train anyone who may be at risk to him/herself or the training provider. Typically, full safety disclosure is provided to the trainee along with a customer code of conduct to follow and adhere to while training to ensure safe and effective training practices.

Government regulations may include the FAA legal and safety guidelines specific to each activity (if listed or known), as well as ITAR restrictions for foreigners nationals, and contract methods where applicable. Other government regulations may be applied to the training providers in time as the industry matures with greater volumes of "at risk" situations.

The protection of sensitive information such as Nondisclosure Agreements (NDA's) that protect proprietary information may help confirm the rules between launch providers and training suppliers and their clients., such as the confidentiality of an item of information (i.e. such as a flight profile or specific protocol) used in a training program. From the customers prospective, customers or trainees, may find it helpful to have rules regarding the protection

of their medical information if it is taken during training.

Standard rules of business also always apply and should be considered. These can include an ethics policy, contracting vehicles, and legal and liability considerations or constraints.

III.IX Tactics

Tactics of the industry focus on both the current perceptions and future outlook of the industry and its survival. Fundamentally, tactics that anticipate and overcome personal and safety risk aspects of spaceflight such as preparing humans for the harsh environment, flight profile, technology or vehicle constraints, or individual limitations or restrictions are critical for training success. Factors impacting training industry growth can include the promotion, marketing, sales, and public relations generated by previous trainees touting their positive reactions to the training, or by the training industry itself in generating public awareness. An additional factor in tactics for the SHST industry would be the imposition of government licensing on the commercial space training industry. Currently, governmental training licensing does not yet exist creating freedom for space launch providers, but no enforcement that training or types of training is essential prior to flight. The few training companies that exist today may continue to grow and expand, despite policy or other challenges, or may collapse waiting for the space training industry to mature to a steady customer level. Growth is hindered on commercial spaceflight success.

Market Expansion

It is foreseeable that as the entire commercial space industry matures, multiple training companies and competitors will emerge which may cause conflict over market share. With demand and capital growth, it is often the case that only the “top” companies survive. This can be due to a company’s heritage, prestige, or customer loyalty. In this scenario, often the remaining companies either shut down or are absorbed by the “top” succeeding company or companies.

Commercial Association Formation

An alternate tactic and potential outcome is for an association group of member training organizations to form whereby each share in marketing, messaging, and delivery of training services to the industry. Commercial associations benefit typically from a large (fee-paying) participant membership community and a comprehensive skill-set of assets from the partner member training companies. In any outcome, the arrival of

government imposed training standards may also alter the landscape. Government regulations may benefit the industry by demonstrating increased safety standards, however may limit the number of persons able to go to space onboard a space launch operators spacecraft. Examples of regulations include imposing spacecraft system safety compliance, imposing human health and fitness level flight restrictions, opposing certain anthropometric or medical conditions for flight, etc.

III.X Scope

The scope refers to how the commercial human suborbital training industry is relevant. Currently in its infancy with test flights and rocket powered suborbital flights underway, but without the first paying passengers onboard spacecraft [as of August 2013], the commercial spaceflight training industry is primarily relevant in its research and development work performed to date. As the industry matures, growing in spaceflight and spaceflight training demand, it is foreseeable that safety, training, and human health standards will develop to both safeguard and promote future commercial spaceflight activities.

Research

Concerns over the health effects and restrictions for upcoming commercial space travelers have prompted many questions resulting in several research studies. One of the largest studies ever conducted probes this question. Funded by the Federal Aviation Administration’s Office of Commercial Spaceflight’s Center of Excellence (FAA COE) and conducted by the University of Texas Medical Branch (UTMB) at the spaceflight simulation facilities at The National AeroSpace Training and Research Center, NASTAR Center, the study [April to October 2013][18] follows on preliminary data collected from 2007 which determined that individuals with well-controlled medical conditions were able to endure acceleration forces and reentry profiles of spacecrafts with training. Based on this finding, four health conditions were selected to be specifically addressed in the research protocol. These include (1) hypertension, (2) diabetes mellitus, (3) coronary artery disease, (4) hyperlipidemia, and a fifth control group. Results are expected in summer-fall 2014. The data resulting from this study is significant to better understand the limitations or non-limitations of upcoming commercial space travelers.

Training

Training for space travel is known to include high launch and reentry acceleration (G) forces,

vibrations, microgravity, altitude, spatial disorientation, and other physiological and psychological effects. In order to better educate and prepare the vast majority of commercial space travelers without prior spaceflight experience for the rigors of space, training becomes an important element. Training can help understand how the stresses of spaceflight will affect your performance and enjoyment ability. In addition, training aids in controlling and decreasing anxiety, tension, and risk of injury. Companies that perform commercial space training and training related activities are an important contributor that should have both short term and long term scope strategies.

Education

Training helps to increase topic understanding and knowledge of a specific skill or activity. Education imparts a better awareness of the activity being learned and often leads to greater inspiration, motivation, and contribution in that skill or activity. In commercial spaceflight, training can help educate more people, and more people can encourage and promote engagement in training and actual commercial human spaceflight.

IV. SUMMARY & RESULTS

Applying the game theory innovation model to the emerging commercial human suborbital training industry provides new perspectives to evaluate the growth of the industry tasked with supporting the health, safety, and preparedness of the greater commercial space industry. We see that by adjusting the parts of the game, game theory can be used to provide a comprehensive and structured method to assess ways to grow, change, and mature over time to meet the needs of commercial human spaceflight.

FAA COE CST Disclaimer Statement: Although the FAA has sponsored this project, it neither endorses nor rejects the findings of this research. The presentation of this information is in the interest of invoking technical community comment on the results and conclusions of the research.

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Spanish. Brienna has a degree in Biology and maintains current First Aid, CPR, and AED certifications. Her professional memberships include Explorers Club, WIA, CSF, WAI, IAF, AIAA, IEEE, NSS, IAE, DAN, PADI and NAUI.

VI. BIOGRAPHY

Brienna Henwood is an accomplished Marine Biologist, Astronaut Trainer, Certified Fitness Instructor, Published Researcher, Student Pilot, Master SCUBA Diver, and PR & Communications Executive. Ms. Henwood currently serves as the Executive Director of Space Training and Research at the National AeroSpace Training and Research (NASTAR) Center in Philadelphia, PA, where she has lead the company from infancy into an internationally recognized, FAA approved, global center for commercial astronaut training.

Brienna has developed, managed, and conducted over four (4) dozen courses and trained over 275 future astronauts for space to date; including passengers for Sir Richard Branson's Virgin Galactic SpaceShipTwo, and Space Expedition Corporation's XCor Lynx, in addition to scientists, teachers, and students.

In her years as a PR Communications Executive, she has orchestrated congressional VIP events, created hands-on experiential adventure campaigns, and has secured global media coverage on ABC, NBC, Good Morning America, Discovery Channel, History Channel, BBC, NHK, and others generating over 25 million impressions.

Brienna has a lifelong passion for exploration, travel, and health/fitness. She is a published author currently working on two books, and is a leading industry spokeswoman, featured at events such as the National Suborbital Researcher Conference (NSRC), International Symposium for Personal and Commercial Spaceflight (ISPCS), and Sea Space Symposium (S3).

Brienna has a multi-cultural background with family located in four continents. She is fluent in French and English; currently studying Italian and