

Your Personal Spaceflight Adventure – Have You Got What it Takes?

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1. INTRODUCTION

This paper provides a framework for answering the question put forth in its title, ie what requirements will you, as a future public space traveler, have to meet in order to take your personal spaceflight. Some of these requirements are already clear; others are still being formulated because the personal spaceflight business is still in its formative stages.

The future public space traveler will have financial, medical and training hurdles to clear, and the paper brings these together. An argument is made for a simplification of the medical and training requirements of future space tourists, when compared with the regime that was developed historically for government astronauts.

It is worth a moment discussing semantics. From the point of view of this paper, there is no distinction made between the terms: Space Tourist, Public Space Traveler, or Space Flight Participant, although it is accepted that for some purposes beyond those of this paper, distinctions could be drawn.

2. REGULATORY VIEW

There has been a gradual recognition in the US that public spaceflight is here to stay, and furthermore that it represents a significant future business opportunity. A succession of blue ribbon reports (starting with the President’s Commission on the Future of the US Aerospace Industry in November 2002) have pointed out that public space travel represents an enabling market opportunity. It is the only sector with enough demand to justify the operation of reusable launch vehicles, and therefore it makes possible the next step in spaceflight of moving to more airline-like operations.

Even terrestrially, there has been the recognition of a changing role for spaceports (see eg Ref 28), and many States (such as Texas and Oklahoma) are vying for the right to attract the new space tourism companies, and their potential employment and tax base, into their midst. The “traditional” space state of Florida is having to fight a rear guard action to preserve the benefits of its own space heritage at Kennedy Space Center against the newcomers.

The general public was captivated by the X-Prize activities in the Mojave desert during 2004, and they have noted that a significant change is taking place. The US Congress has recognized this change, and the Office of Commercial Space Transportation within the Federal Aviation Authority (FAA-AST) has been very effective in producing guidelines, certification and legislation to enable the new industry to develop (see Ref 1, 2, 3, 4, 5, 6, 16), while protecting the uninvolved public.

The next stage of the legislative process will involve finalizing the rules for medical and training requirements for future space tourists, so this paper is intended to trigger some timely discussions on these topics.

3. DEFINING THE FIELD OF INTEREST

It is important to be clear about the area of discussion in this paper. As we have seen from the Regulatory perspective, there will be very different considerations for crew and passengers. There will even be different requirements for different kinds of crew. This paper will focus on those folks who are only in space because of the space tourism business, and this might therefore include a new kind of astronaut, a “Cruise Chief” who is a kind of steward, a specialist in looking after the needs of the paying passengers, as well of course as the public space travelers themselves (see Ref 19 for discussion of the “Cruise Chief” role). The paper will not focus on training of the prime flight command crew, but for reference Virgin Galactic intends to use existing airline pilots with an additional 27 months of training to become pilot astronauts (see Ref 31).

We are concentrating also on the early years of this business. Twenty years from now, the training regime might be relaxed significantly, but at the stage that we are describing in this paper, there is sufficient uncertainty to require that passengers undergo a fairly stringent set of training requirements, particularly for orbital space flight. Passengers will not be allowed to fly with the astronaut crew during the early test phase which relies upon experimental permits to operate, so we are therefore only going to describe the requirements that will prevail once the service is operational and is offering seats to paying passengers.

4. FINANCIAL REQUIREMENTS

To have what it takes for personal spaceflight, if you are not a lucky winner of a game prize, you need to be wealthy. Suborbital flights are likely to cost up to \$200,000 initially, and orbital missions cost about \$20M. Prices for both types of experience will come down as the companies offering the flights recover their investment and begin to develop economies of operation (eg Virgin Galactic believes that a ticket price of \$75,000 should be possible for its suborbital experiences), but for now we need to be realistic about the wealth levels implied by these prices. Reference 27 indicates that wealthy people will generally not spend more than 10% of their net

worth on a major item of expense, and other work suggests a maximum between 1.5% and 7%. Therefore for planning purposes we should assume 5%. Table 1 shows how wealthy you have to be in general so that you can afford to fly into space as a space flight participant.

TABLE 1 Probable Net Worth of Spaceflight Participants (\$US) in order to be able to Afford the Ticket Price.

	Ticket Price \$	Proportion of Net Worth spent on Ticket		
		10%	5%	1.50%
Suborbital	200,000	\$2M	\$4M	\$13.3M
	100,000	\$1M	\$2M	\$6.6M
	75,000	\$750K	\$1.5M	\$5M
Orbital	20M	\$200M	\$400M	\$1.3B
	5M	\$50M	\$100M	\$333.3M
	1M	\$10M	\$20M	\$66.6M

Note: Net worth proportion data from Reference 27, quoting Futron/Zogby survey.

So, at least for the present, only millionaires need apply! Even for sub-orbital flight, the table shows that, on average, you need to have a million dollars or more to be able to afford to buy a ticket, assuming your previous spending habits remain relatively unchanged. For the orbital spaceflight experience, at current prices, you need to have a net worth of hundreds of millions of dollars.

5. MEDICAL REQUIREMENTS

A number of sources (eg Ref 11, 12) discuss the likely needs for medical screening for space tourism candidates. Table 2 shows the range of likely medical requirements that a future public space traveler will be expected to meet. Much work has still to be done to finalize the requirements, and the British tabloid newspaper “The Sun” even reported (Ref 14) that the Virgin Galactic team has indicated that it might be necessary to screen out candidates who have had breast enhancement surgery! Theme park rides, such as “Mission: Space” at Disney’s Epcot Center in Orlando, carry warning signs that declare:

For safety, you should be in good health and free from high blood pressure, heart, back or neck problems, motion sickness, or other conditions that could be aggravated by this adventure.”

TABLE 2 MEDICAL SCREENING REQUIREMENTS FOR SPACE TOURISM

CLASS	ORIGINAL MERCURY TESTS	SUBSEQUENT NASA FLIGHT CREW	MISSION PAYLOAD SPECIALISTS	RUSSIAN TOURISTS SCREEN (Shuttleworth, Ref 25)	FAA GUIDELINES	COMMENTS
Orbital	<p><u>Medical(Lovelace)</u></p> <p>Medical Histories Fitness Chemical Encephalographic Cardiographic X-Ray Barium Opthamology Otolaryngology Physiological Total body radiation Total body water</p> <p>Total 7 1/2 days</p> <p><u>Stress(Wright Aero)</u></p> <p>Psychological Acceleration Vibration Heat Noise Sensory Deprivation Isolation/Confinement Motion Sickness Treadmills Tilt Tables Ice Water Lung Capacity Pressure Suit depress Total 7 days</p>	<p><u>Detection of Abnormalities</u></p> <p>peptic ulcers diabetes gall stones varicose veins inguinal hernia</p> <p><u>Predisposition to Limited Performance</u></p> <p>obesity glucose tolerance</p> <p><u>Psychological</u></p> <p>motivation learning aptitude emotional adaptability maturity</p> <p><u>Performance under Stress</u></p> <p>maximum exertion autonomic control hyperventilation and breath holding</p>	<p>"Not more restrictive than a Class II flight physical (USAF) or Service Group III (USN)"</p> <p>Blood pressure not to exceed 140/90</p> <p>Vision 20/70 or better correctable to 20/20</p> <p>Hearing</p>	<p>Disorders</p> <p>vestibular nervous cardiovascular psychological X-Ray</p> <p>Team Interactions</p> <p>Anechoic Chamber</p> <p>Heat Chamber</p> <p>Spacesuit</p> <p>Total 3 weeks</p>	<p><u>Medical History</u></p> <ol style="list-style-type: none"> 1) Respiratory disorders 2) Allergies 3) Dizziness or vertigo 4) Motion sickness 5) Fainting 6) Epilepsy/paralysis 7) TB/AIDS, other chronic infect 8) Surgery 9) Recent trauma 10) Anemia and blood disorders 11) heart/circulatory/pacemaker 12) High or low blood pressure 13) Mental disorders 14) Attempted suicide 15) Medications 16) Alcohol/Drug dependency 17) Pregnancy/Menstrual 18) Hay fever 19) Pneumothorax 20) Kidney stones 21) Gallstones 22) Dabetes 23) Cancer 24) Radiation 25) Rejection for life/health insur 26) Decompression syndrome 27) Previous spaceflights <p><u>Medical Testing</u></p> <p>hematology/chemistry urinalysis EKG Chest X-Rays Visual and Hearing</p>	<p>Possible need for centrifuge runs as part of screening process.</p> <p>Duration One Week objective</p>
Sub-Orbital	same as orbital	N/A	N/A	N/A	Physical Exam not required, but Medical History (as above, but without items 2,4,12,18,19,20,21,24,27)	no exam. modelled on extreme theme park adventure rides.

Sources: References 1, 2, 3, 4, 5, 7, 8, 10, 11, 12, 15, 18, 19, 25, 30

Note: Reference 15 lists the following disqualifying conditions:

Minors, Pregnant women, Heart abnormalities, Severe vertigo, Claustrophobia

Note that at this stage there is no provision for the needs of very long duration missions, where radiation, psychological and other effects could be more severe. The FAA has not, at this stage, imposed any significant requirements on the operators. For sub-orbital flight, the FAA proposes that no exam is necessary. It is proposed here that the overall duration of the medical testing that is required for orbital flights be kept down to one week or less, because potential travelers need an early decision before committing their time, money and resources to an upcoming flight. This should be possible, since even the original Mercury astronauts with their extensive battery of tests took only two weeks.

6. TRAINING REQUIREMENTS

The objective of this paper is to propose a regime that will ensure the safety and enjoyment of prospective space tourists, while avoiding excessively long training periods that, while appropriate for government astronauts, will be a discouragement to future public space travelers. These spaceflight participants are paying significant ticket prices for what is probably a once-in-a-lifetime experience, but they are likely to have only limited time available to spend in preparation.

Table 3 shows, purely as an initial point of reference, the training regimen that was used by early government command crew astronauts in US and Russia/USSR. Data in Ref 10 indicates that, starting with the original Mercury seven, the US astronaut corps reached 57 as Apollo began, declined to 28 over the next decade, then climbed to around 100 during the Shuttle era, and the training for all these candidates has remained generally the same, taking about two years in total. The process takes somewhat longer in Russia, but covers the same general topic areas.

TABLE 3 GOVERNMENT COMMAND CREW ASTRONAUT TRAINING PROCEDURES FOR ORBITAL MISSIONS (for Reference)

TRAINING ELEMENT	US	Russia/USSR
Fitness (Bicycle Ergonometer)	Y	Y
Sports (Water, Mountain, etc)	N	Y
Flying and Combat Skills (assumed)	Y	Y
Helicopter training (during Apollo)	Y	N
Parachute Jumping Training	N	Y
High-g Training -Aerobatics	Y	N
High-g Training Centrifuge	Y	Y (up to 10g)
Zero-g Training - Neutral Buoyancy	Y	Y
Zero-g Training - Parabolic flights	Y	Y
Theoretical/Academic classes (Space science, Nav, etc)	Y	Y
Systems Management (Single Systems Trainers)		
-Attitude Control Simulator	Y	Y
- Cockpit Mission Simulator	Y	Y
- Full Spacecraft Simulator	Y	Y
- Docking and Rendezvous Simulator	Y	Y
- Robotic Arm Simulator	Y	N
-Lander Simulator (during Apollo)	Y	N
- Special Training Aircraft	Y	N
- Life Support/ Suit Training (Hyperbaric)	Y	Y
Mission Specific and Experiment Training	Y	Y
Radio and Comms Gear and Procedure Drills	Y	Y
Stowage Drills	Y	Y
Geology Training Field Trips (during Apollo)	Y	N
Emergency, Rescue Drills, Procedures and Simulations	Y	Y
- Pad escapes and aborts	Y	Y
-Water egress and scuba qualif	Y	Y
- Wilderness Survival (Arctic, Desert, Jungle, Mountain)	Y	Y
Team Training (incl language, culture for int'l missions)	Y	Y
TOTAL TRAINING PERIOD	1 Year basic and 1 Year advanced	2 Years basic and 6-18 mths mission specific

Source: References 7, 8, 11, 30

The time periods involved in such comprehensive training regimes are, however, not going to be acceptable to potential personal spaceflight participants in future. Table 4 (source Ref 27, quoting Futron/Zogby survey results) shows the relatively small amounts of time that millionaires allocate annually for recreational activities. And they will be going into space for recreation, after all, and not to follow the active construction work regime that is the case for the government astronauts.

TABLE 4 **Millionaires - Time Availability for R&R**

	Duration of Vacation	Proportion
Millionaire R&R data	More than 6 months	2%
	3 months or more	6%
	1 month or more	26%
Impact of reduction of training period	Training period reduced from 6 months to 1 month	"30% Much more likely to accept"

Source: Reference 27, quoting Futron/Zogby study data.

Reflecting this realization, Table 5 shows the training that was undertaken by those public space travelers who have so far flown into orbit, with an indication by the author of how this might be further amended to bring the training regime down to one-three months, more in line with the general level of time availability of the millionaires as reported in the survey of Ref 27. Also included is a suggested “Cruise Chief” training regime for the non-command astronaut flight crew member, whose duties are looking after the needs and health of the public spaceflight participants. The Cruise Chief will be fully trained to supervise the space flight participants in emergencies and this will enable the tourist training schedule to be reduced accordingly.

		SOYUZ "TAXI" MISSIONS				FAA Guidelines	Comments
TRAINING	Akiyama and Sharman	Tito	Shuttleworth	Olsen			
TOURIST	Suitability Training						
	Learning Russian	Y	Y	Y	Y		Not needed
	Physical Fitness	Y	Y	Y(vestib chair)	Y(vestib chair)		
	Academic (Orb Dynamics, etc)	Y	Y	Y	Y		Not needed
	Practical Training						
	Centrifuge high-g training	N/K	Y	Y	Y(8g)	"Safety Training is required,	
	Parachute Training	Y(2 jumps)	N	N	N	including	Not needed
	Parabolic Zero-g training	Y	Y	N/K	Y(3 times)	Emergency,	
	Survival Training	Y (Black Sea)	Y	Y(des,mtn,arct)	Y(Hydrolab)	Fire,	Not needed
	Emergency Drills	Y	Y	Y(water 2wks)	Y	Smoke,	
	Suit Training	Y	Y	Y	Y	Cabin press failure"	
	Crew Training						
	Spacecraft simulator	Y (30 hours)	Y	Y(one third)	Y		
	Space Station Simulator	Y (24 hours)	Y	Y(one third)	Y		
Experiment training	Y 2mths	N	Y	Y		Not needed	
Housekeeping training	Y	Y	Y	Y			
Team Training						Suggested	
TOTAL TOURIST TRAINING	18 Months	8 months	8 months	1 1/2 yr (due interrupt)	not specified	one-three months	
"CRUISE CHIEF" (Ref 19)	Survival Leadership Medical Training Tourist Activity Leadership Regulatory Requirements Trg	N/A	N/A	N/A	N/A	not clear	V.impt V.Impt V.Impt Necessary

Sources: References 1, 2, 3, 5, 6, 7, 19, 22, 23, 24, 25, 26

TABLE 5 TRAINING REGIMES FOR ORBITAL PUBLIC SPACE TRAVEL

Suborbital spaceflight will not in any case require nearly as much preparation for the space tourist, and this has been recognized already by the leading future providers of the experience, viz Virgin Galactic and Rocketplane. Both these organizations have proposed a training process that takes less than a week, as shown in Table 6. Jane Reifert, CEO of the adventure travel agency Incredible Adventures, has suggested (Ref 32) that it may be preferable to include some g-force and zero-g training *before* the actual week of the experience, because this will establish whether 4 g's is tolerable, before \$200,000 is spent, and in any event will make the actual spaceflight experience so much more satisfactory and enjoyable.

TABLE 6 PROPOSED SUB-ORBITAL PUBLIC SPACE TRAVELER TRAINING

VIRGIN GALACTIC	ROCKETPLANE	FAA GUIDELINES	COMMENTS
<p><u>Day One</u></p> <p>Medical Tests incl CT Scan</p> <p>Trip briefing</p> <p>Simulators</p> <p>Light Aircraft flights</p> <p><u>Day Two</u></p> <p>Mothership ride</p> <p>Cabin familiarity</p> <p>Communications console trg</p> <p><u>Day Three</u></p> <p>2 hour mission</p>	<p><u>Days One and Two</u> (Aeromedical Module)</p> <p>Aviation physiology</p> <p>Flight trajectory</p> <p>Simulators</p> <p>Altitude chamber</p> <p>Disorientation</p> <p>Emergency simulation</p> <p><u>Days Three and Four</u> (Spaceport Module)</p> <p>Tour Spaceplane</p> <p>Tour Spaceport</p> <p>Tour mission control</p> <p>Study Development, Maintenance, and Flight Coordination.</p> <p>Meet Crew</p> <p>Study Procedures</p> <p><u>Day Five</u></p> <p>Mission</p>	<p>Valid for initial Period of 8 years</p> <p>"Safety Training to include:</p> <p>Emergency egress drills</p> <p>Fire</p> <p>Smoke</p> <p>Cabin Pressure failure etc."</p>	<p>Preliminary high-g jet and zero-g parabolic flights recommended</p> <p>(Ref 32)</p>
<p>TOTAL 3 days incl flight or 6 days (Ref 15)</p>	<p>TOTAL 5 days incl flight</p>	<p>not specified</p>	<p>Recommend from 3 to 6 days</p>

Source: References 1, 2, 3, 5, 6, 13, 15, 21, 32

Note that the FAA has not imposed any onerous requirements at this stage.

7. CONCLUSIONS

We have seen what it takes to be able to join the band of future personal spaceflight adventurers, so that the reader can assess if they possess the necessary credentials. The future space tourist will need to be wealthy, healthy, and wise (in the case of the orbital mission being able to devote a fair amount of time to skills training).

The FAA is working to establish a regulatory framework that is supportive of these early ventures, and this paper has suggested some targets for making the medical selection and training of future public space travelers appropriate yet not discouraging. For sub-orbital tourist flights, the framework is already in place and seems to be well balanced between safety and entertainment. For **orbital tourism**, more work needs to be done, and **this paper proposes targets of no more than a week for medical screening, and a training regime of less than 3 months, ideally aiming ultimately for 1 month, in order to maximize the opportunities of finding the future customers for the experience.**

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