Medical Safety Considerations for Commercial Spaceflight Participants

Presented at: Oslo, Norway
By: Melchor J. Antuñano, M.D., M.S.
Director, Civil Aerospace Medical Institute
Date: 2011
Suborbital Commercial Space Flights
SpaceShipTwo will be capable of carrying 2 pilots and 6 passengers on a 3-hour suborbital flight (including 3-4 minutes of microgravity)
In April 2011 VG published an announcement for pilot-astronaut candidates.
Will take a pilot and a passenger up to 200,000 feet (37 miles), followed by two minutes of weightlessness for about $100,000 per passenger.
Blue Origin New Shepard

$3.7M - NASA CCDev1 2010

$22M - NASA CCDev2 2011

SPACE TOURISM

UP AND AWAY

In the latest bid to rocket tourists into orbit, the secretive Blue Origin unveils a flying pod. Is your space voyage sooner than you think?

GALACTIC GUMDROP
Goddard returns to the barn after its November launch.
Armadillo Super-MOD Vehicle

$225K NASA CRuSR Contract in 2010

**SOST**
- Based on Existing Technologies
- 200-kg to 100-km+
- Two to Three Minutes of Micro-G time
- Vehicle is True sRLV and Recovers Intact
- Emergency Capsule Cut-Away
- Platform for Space Adventures Suborbital Flights
- "Boilerplate" Unmanned Vehicle will Fly in 2011
- NASA CRuSR Platform for Payloads & People

**Sub-Orbital Space Transport**
- 2.5-m Diameter & 6.0-m Tall
- Armadillo LOX-Alcohol Propulsion Technology
- Eight Engines Canted & Opposed, in Two Banks, Differentially Throttled
- Customizable Boost Profile
- Engine Bank Out Abort Recovery Capability
- No "Black Areas"
- Ultimately Man Capable
- Two Person Capsule with Large Observation Windows
$250K NASA CRuSR Contract in 2010
Copenhagen Suborbitális
Orbital Commercial Space Flights
$278M NASA COTS 2006
$1.5B NASA CRS 2008
$75M NASA CCDev2 2011

**FALCON 9 / DRAGON:**
NASA's Choice to Resupply the Space Station
Orbital Sciences Cygnus

$278M NASA COTS 2006
$175M NASA COTS 2007
$1.9B NASA CRS 2008

Orbital Sciences is readying its new rocket and freighter for demonstration launches in 2011.

**Taurus 2 Rocket and Cygnus Spacecraft**

- **Service Module** contains avionics, power, communications, and command and control.
- **Pressurized Cargo Module** can carry up to 5,952 pounds (2,700 kg) of payload to the International Space Station.

The two-stage Taurus 2 launch vehicle burns liquid oxygen (LOX) and kerosene (RP-1).

**Rockets Compared**

- **Orbital Sciences Taurus 2**
  - Height overall: 131 ft (40 m)
  - Liftoff weight: 530,000 lb (240,000 kg)
  - Payload to Low Earth Orbit: 11,023 lb (5,000 kg)

- SpaceX Falcon 9
  - Height overall: 179 ft (54 m)
  - Liftoff weight: 735,000 lb (333,400 kg)
  - Payload to Low Earth Orbit: 23,040 lb (10,450 kg)

- Space Shuttle
  - Height overall: 184 ft (56.1 m)
  - Liftoff weight: 4,470,000 lb (2,027,600 kg)
  - Payload to Low Earth Orbit: 53,600 lb (24,400 kg)

SOURCE: ORBITAL SCIENCES
Boeing CST-100

$18M NASA CCDev1 2010

$92.3M NASA CCDev2 2011
Sierra Nevada Dream Chaser

$175M NASA COTS 2007
$80M NASA CCDev2 2011
Excalibur
Almaz
SpacePort America – New Mexico
Future Challenges in Commercial Aviation & Space Transportation
Blue Origin Private Spaceport - Texas

Future Challenges in Commercial Aviation & Space Transportation
Bigelow's Inflatable Space Modules

Internet-Era Avionics
Do we know all the Medical Risks of Flying in Space?
NO!

We have very limited medical experience and knowledge on individuals with significant medical problems who have flown in space.
Most of the medical and physiological data collected to date are based on the effects of space flight on generally normal and healthy individuals (career astronauts and cosmonauts).
Until now most people who have flown in space are healthy career astronauts aged 35 to 50 years old (only exception is John Glenn).

Due to medical privacy regulations and career considerations individual medical data from career astronauts is not available for study by the scientific community.
What Medical Data is Available to the Public?
U.S. Government Space Program
Experience with Medical Pathology
## Ground Medical Events Among U.S. Astronauts

<table>
<thead>
<tr>
<th>Medical Event</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allergic reaction (severe)</td>
<td>1</td>
</tr>
<tr>
<td>Choledocholithiasis</td>
<td>3</td>
</tr>
<tr>
<td>Retinal detachment</td>
<td>2</td>
</tr>
<tr>
<td>Pancreatitis</td>
<td>2</td>
</tr>
<tr>
<td>Appendicitis</td>
<td>2</td>
</tr>
<tr>
<td>Diverticulitis</td>
<td>1</td>
</tr>
<tr>
<td>Ventricular tachycardia</td>
<td>1</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>1</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>1</td>
</tr>
<tr>
<td>Hemorrhagic cyst</td>
<td>1</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>1</td>
</tr>
<tr>
<td>Duodenal ulcer</td>
<td>1</td>
</tr>
</tbody>
</table>

**Source:** Jon Clark, MD, Space Medicine Liaison, National Space Biomedical Research Institute, Baylor College of Medicine, Personal Communication, 2007
<table>
<thead>
<tr>
<th>Condition</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inguinal hernia</td>
<td>4</td>
</tr>
<tr>
<td>Ureteral calculus</td>
<td>3</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>2</td>
</tr>
<tr>
<td>Sudden hearing loss</td>
<td>2</td>
</tr>
<tr>
<td>Cervical disk herniation with impingement on spinal cord</td>
<td>1</td>
</tr>
<tr>
<td>Corneal ulcer</td>
<td>1</td>
</tr>
<tr>
<td>Malignant melanoma</td>
<td>1</td>
</tr>
<tr>
<td>Severe epistaxis</td>
<td>1</td>
</tr>
<tr>
<td>Right ovarian cyst</td>
<td>1</td>
</tr>
<tr>
<td>Olecranon bursitis r/o septic joint</td>
<td>1</td>
</tr>
<tr>
<td>Clostridium difficile infection</td>
<td>1</td>
</tr>
<tr>
<td>Gastroenteritis/colitis</td>
<td>1</td>
</tr>
<tr>
<td>Dysmenorrhea</td>
<td>1</td>
</tr>
</tbody>
</table>

SOURCE: Jon Clark, MD, Space Medicine Liaison, National Space Biomedical Research Institute, Baylor College of Medicine, Personal Communication, 2007
<table>
<thead>
<tr>
<th>Name</th>
<th>Nation</th>
<th>Date</th>
<th>In-flight Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Komarov, Vladimir</td>
<td>USSR</td>
<td>04/24/67</td>
<td>Soyuz 1 parachute failure</td>
</tr>
<tr>
<td>Dobrovolsky, Georgy</td>
<td>USSR</td>
<td>06/29/71</td>
<td>Soyuz 11 depressurized during entry</td>
</tr>
<tr>
<td>Patsayev, Victor</td>
<td>USSR</td>
<td>06/29/71</td>
<td>Soyuz 11 depressurized during entry</td>
</tr>
<tr>
<td>Volkov, Vladislav</td>
<td>USSR</td>
<td>06/29/71</td>
<td>Soyuz 11 depressurized during entry</td>
</tr>
<tr>
<td>Scobee, Francis</td>
<td>US</td>
<td>01/28/86</td>
<td>SRB failure; Challenger, STS-51L</td>
</tr>
<tr>
<td>Smith, Michael</td>
<td>US</td>
<td>01/28/86</td>
<td>SRB failure; Challenger, STS-51L</td>
</tr>
<tr>
<td>Resnik, Judith</td>
<td>US</td>
<td>01/28/86</td>
<td>SRB failure; Challenger, STS-51L</td>
</tr>
<tr>
<td>Onizuka, Ellison</td>
<td>US</td>
<td>01/28/86</td>
<td>SRB failure; Challenger, STS-51L</td>
</tr>
<tr>
<td>McNair, Ronald</td>
<td>US</td>
<td>01/28/86</td>
<td>SRB failure; Challenger, STS-51L</td>
</tr>
<tr>
<td>Jarvis, Gregory</td>
<td>US</td>
<td>01/28/86</td>
<td>SRB failure; Challenger, STS-51L</td>
</tr>
<tr>
<td>McAuliffe, Christa</td>
<td>US</td>
<td>01/28/86</td>
<td>SRB failure; Challenger, STS-51L</td>
</tr>
<tr>
<td>Husband, Rick</td>
<td>US</td>
<td>02/01/03</td>
<td>Entry breakup; Columbia, STS-107</td>
</tr>
<tr>
<td>McCool, William</td>
<td>US</td>
<td>02/01/03</td>
<td>Entry breakup; Columbia, STS-107</td>
</tr>
<tr>
<td>Chawla, Kalpana</td>
<td>US</td>
<td>02/01/03</td>
<td>Entry breakup; Columbia, STS-107</td>
</tr>
<tr>
<td>Anderson, Michael</td>
<td>US</td>
<td>02/01/03</td>
<td>Entry breakup; Columbia, STS-107</td>
</tr>
<tr>
<td>Brown, David</td>
<td>US</td>
<td>02/01/03</td>
<td>Entry breakup; Columbia, STS-107</td>
</tr>
<tr>
<td>Clark, Laurel</td>
<td>US</td>
<td>02/01/03</td>
<td>Entry breakup; Columbia, STS-107</td>
</tr>
<tr>
<td>Ramon, Ilan</td>
<td>Israel</td>
<td>02/01/03</td>
<td>Entry breakup; Columbia, STS-107</td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td></td>
<td></td>
<td><strong>18</strong></td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Other Active-Duty Fatalities</th>
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<tbody>
<tr>
<td><strong>Freeman, Theodore</strong></td>
</tr>
<tr>
<td><strong>Bassett, Charles</strong></td>
</tr>
<tr>
<td>Name</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>See, Elliott</td>
</tr>
<tr>
<td>Grissom, Virgil</td>
</tr>
<tr>
<td>White, Edward</td>
</tr>
<tr>
<td>Chaffee, Roger</td>
</tr>
<tr>
<td>Givens, Edward</td>
</tr>
<tr>
<td>Williams, Clifton</td>
</tr>
<tr>
<td>Robert Lawrence</td>
</tr>
<tr>
<td>Gagariin, Yuri</td>
</tr>
<tr>
<td>Belyayev, Pavel</td>
</tr>
<tr>
<td>Thorne, Stephen</td>
</tr>
<tr>
<td>Levchenko, Anatoly</td>
</tr>
<tr>
<td>Shchukin, Alexander</td>
</tr>
<tr>
<td>Griggs, David</td>
</tr>
<tr>
<td>Carter, Manley</td>
</tr>
<tr>
<td>Veach, Lacy</td>
</tr>
<tr>
<td>Robertson, Patricia</td>
</tr>
</tbody>
</table>

Compiled by William Harwood
Short-Duration Orbital Flights
Inflight Medical Events Among U.S. Astronauts

607 Astronauts (521 men and 86 women)
5,496 Flight Days

- 98.1% of men and 94.2% of women reported 2,207 medical events or symptoms during flight:
  - Space adaptation syndrome (39.6%)
  - Nervous system and sensory organs (16.7%)
  - Digestive system (9.2%)
  - Injuries and trauma (8.8%)
  - Musculoskeletal system and connective tissues (8.2%)
- Skin and subcutaneous tissue (8%)
- Respiratory system (4.5%)
- Behavioral signs and symptoms (1.8%)
- Infectious diseases (1.3%)
- Genitorurinary system (1.5%)
- Circulatory system (0.3%)
- Endocrine, nutritional, metabolic & immunity disorders (0.1%)

194 events due to injury (including 14 fatalities)

SOURCE: Jon Clark, MD, Space Medicine Liaison, National Space Biomedical Research Institute, Baylor College of Medicine, Personal Communication, 2007
Long-Duration Orbital Flights
Inflight Medical Events among U.S. Astronauts
NASA/MIR Program
(Mar 95 – Jun 98)

Inflight Medical Events among Cosmonauts
MIR Program
(Feb 87 – Feb 96)
## Inflight Medical Events Among U.S. Astronauts during the NASA/MIR Program (Mar 95 – Jun 98)

<table>
<thead>
<tr>
<th>Medical Event</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Musculoskeletal</td>
<td>7</td>
</tr>
<tr>
<td>Skin</td>
<td>6</td>
</tr>
<tr>
<td>Nasal congestion, irritation</td>
<td>4</td>
</tr>
<tr>
<td>Bruise</td>
<td>2</td>
</tr>
<tr>
<td>Eyes</td>
<td>2</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>2</td>
</tr>
<tr>
<td>Hemorrhoids</td>
<td>1</td>
</tr>
<tr>
<td>Psychiatric</td>
<td>2</td>
</tr>
<tr>
<td>Headaches</td>
<td>1</td>
</tr>
<tr>
<td>Sleep disorders</td>
<td>1</td>
</tr>
</tbody>
</table>
Inflight Medical Events Among Cosmonauts during the MIR Program (Feb 87 – Feb 96)

<table>
<thead>
<tr>
<th>MEDICAL EVENT</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrhythmia/conduction disorder</td>
<td>128</td>
</tr>
<tr>
<td>Superficial Injury</td>
<td>36</td>
</tr>
<tr>
<td>Musculoskeletal</td>
<td>29</td>
</tr>
<tr>
<td>Headache</td>
<td>24</td>
</tr>
<tr>
<td>Sleeplessness</td>
<td>19</td>
</tr>
<tr>
<td>Tiredness</td>
<td>14</td>
</tr>
<tr>
<td>Contact dermatitis</td>
<td>7</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Condition</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conjunctivitis</td>
<td>6</td>
</tr>
<tr>
<td>Laryngitis</td>
<td>6</td>
</tr>
<tr>
<td>Asthenia</td>
<td>5</td>
</tr>
<tr>
<td>Erythema of face, hands</td>
<td>4</td>
</tr>
<tr>
<td>Acute respiratory infection</td>
<td>3</td>
</tr>
<tr>
<td>Surface burn, hands</td>
<td>3</td>
</tr>
<tr>
<td>Glossitis</td>
<td>3</td>
</tr>
<tr>
<td>Dry nose</td>
<td>2</td>
</tr>
<tr>
<td>Heartburn /gas</td>
<td>2</td>
</tr>
<tr>
<td>Foreign body in eye</td>
<td>2</td>
</tr>
<tr>
<td>Dry skin</td>
<td>2</td>
</tr>
<tr>
<td>Hematoma</td>
<td>1</td>
</tr>
<tr>
<td>Constipation</td>
<td>1</td>
</tr>
<tr>
<td>Eye contusion</td>
<td>1</td>
</tr>
<tr>
<td>Dental caries</td>
<td>1</td>
</tr>
<tr>
<td>Wax in ear</td>
<td>1</td>
</tr>
</tbody>
</table>
October 11-22, 1968

- Apollo-VII
- Walter Schirra, Jr, Donn Eisele & Walt Cunningham
- Schirra develops common cold 15 hrs into the flight. Others follow later
- 7/8 onboard Kleenex® boxes used up
- Refusal to don helmets during reentry*
- Schirra announces retirement before reentry
- Crew takes Actifed® before reentry
- Eisele and Cunningham were making their first flight and felt they had to follow their commander but, because of their actions, neither one would ever fly in space again
Medical Findings Among Commercial Orbital Space Flight Participants
COMMERCIAL ORBITAL FLIGHTS
(Soyuz TMA Launch Vehicles)

Space Adventures

Russian Aviation Space Agency (Rosaviakosmos)
Rocket Space Corporation Energia (RSC Energia)

• Dennis Tito (April 2001)
• Mark Shuttleworth (April 2002)
• Greg Olsen (October 2005)
• Anousheh Ansari (September 2006)
• Charles Simony (April 2007)
• Richard Garriott (October 2008)
• Charles Simony (March 2009)
• Guy LaLiberte (September 2009)
Dennis Tito (61)
Mark Shuttleworth (29)
Gregory Olsen (60)
Anoush Ansari (40)
Charles Simony (59 & 61)
Richard Garriott (47)
Guy LaLiberte (40)
Dr. Gregory Olsen

- 57 year-old man with a history of pneumothorax, moderately severe emphysema, bilateral parenchymal bullae, pulmonary and mediastinal masses, and ventricular and atrial ectopy

- Received preventive treatment of these conditions, including surgery before being cleared to fly in space

- Completed medical evaluation in analog environments (altitude chamber, high altitude mixed-gas simulation, zero-G flight, and high-G centrifuge)

Dr. Gregory Olsen

- Had no difficulties during the training and performed well during space flight
- Post-flight medical testing showed that he was in excellent condition and unchanged medically by the flight

What is the impact of Dr. Olsen’s decision to openly share his medical case?
• Provides the space medicine community with an opportunity to gain critical experience with non-career astronauts who have certain abnormalities to demonstrate that they could fly safely

• Enables the revision of medical screening criteria used by operators to accommodate individuals with certain abnormalities, optimize their pre-flight treatment and observe their performance during space flight

• Provides an opportunity for controlled study of adverse medical conditions in analog and space flight environments
• Provides medical knowledge that will prove extremely valuable for future human space exploration

• Benefits other individuals who may have similar medical conditions and wish to fly in space

• Demonstrates that space flight participants and their physicians can evaluate and accept some medical risks for performance testing in hazardous environments, pre-flight training, and space flight
What is the minimum “Right Stuff” for passengers in commercial space flights?
Flying in space is not like taking a roller coaster ride.
February 11, 2005

- The “Guidance for Medical Screening of Commercial Aerospace Passengers” was released to the public during the 8th FAA Commercial Space Transportation Forecast Conference.

- This was the culmination of a team effort that started in July 1998.
“FAA Recommended Guidelines for Medical Screening of Commercial Space Passengers”
How conservative should medical screening guidelines be for space passengers in order to:

Promote the preservation of life and the safety of the flight?

and at the same time

Avoid imposing an obstacle to the successful establishment and growth of the manned commercial space transportation industry?
Main Risk Factors Relevant to the Development of Guidelines for Medical Screening of Commercial Space Passengers

- Exposure to acceleration/deceleration
- Exposure to decreased barometric pressure
- Exposure to microgravity
- Exposure to radiation (solar and cosmic)
This medical screening guidance is based on the following assumptions:

- An in-flight cabin environment with a barometric pressure not exceeding 8,000 ft (10.91 psi), where passengers will not be required to use a pressurized suit.

- Passengers will be able to perform an emergency evacuation without assistance.
Medical Aspects of Manned Commercial Space Flights
Dryden Flight Research Center  E-9543  Photographed 1959
X-15 after a hard landing by pilot Scott Crossfield.
NASA photo
After orbital insertion of Soyuz 1 one of the solar panels failed to deploy. Although only receiving half of the planned solar power, an attempt was made to maneuver the spacecraft but it failed. The decision was made to bring Komarov back. Re-entry was successful and the drag chute deployed. However due to a failure of a pressure sensor, the main parachute would not deploy. Komarov released the reserve chute, but it became tangled with the drag chute. The descent module crashed.
HUMAN TOLERANCE TO DECELERATION (250 G/sec)

+ Gz: 25 Gs for 0.1 sec  
- Gz: 15 Gs for 0.1 sec

+ Gx: 83 Gs for 0.04 sec  
   45 Gs for 0.1 sec  
   25 Gs for 0.2 sec
- Gx: 45 Gs for 0.1 sec (full harness)  
   25 Gs for 0.2 sec (full harness)

± Gy: 11-20 Gs for 0.1 sec (full harness)
"You want me to do what?"
All 157 passengers and eight crew members safely evacuated the China Airlines Boeing 737-800 that caught fire after landing at Okinawa Naha Airport.
Apollo 1 Astronauts Gus Grissom, Edward White and Roger Chaffee died when a fire blazed their command module during a ground test at KSC.
March 18, 1965

- Voskhod-2 “Sunrise”
- Pavel Belyayev and Aleksei Leonov (1st EVA)
- EVA suit failure with suit ballooning
- Unable to squeeze through narrow hatch without bleeding air from suit
- Primary hatch reseal failure
- Environmental control systems compensated by flooding cabin with 100% O2
- Service module failed to separate completely
- Wild gyrations on re-entry
- Crash landed in deep woods, 1,200 miles off target & spent the night surrounded by wolves

Leonov A and Scott D. *Two Sides of the Moon*. Thomas Dunne Books, St. Martin’s Press LLC, 2004
In view of the wide variety of possible approaches to design, produce and operate manned commercial RLVs the guidance for medical screening applies differently to two categories of space passengers:

Passengers on suborbital space flights or exposed to a G-load of up to +3Gz during any phase of the flight.

Passengers on orbital space flights or exposed to a G-load exceeding +3Gz during any phase of the flight.
Guidance for Medical Screening of Passengers on Suborbital Flights or Exposed to a G-Load of up to +3Gz During any Phase of the Flight.
1. Passengers complete a **medical history questionnaire** prior to every flight (single or multiple)

2. A **company physician** who is experienced or trained in the concepts of aerospace medicine **reviews the completed questionnaire**

3. Passengers **may need to undergo a physical examination and complete medical laboratory testing** if deemed necessary by the company physician upon review of the completed questionnaire
Medical History Assessments of Passengers in Suborbital Space Flights

- Otitis, sinusitis, bronchitis, asthma, or other respiratory disorders
- Dizziness or vertigo
- Fainting spells, or any other loss of consciousness
- Seizures
- Tuberculosis
- Surgery and other hospital admissions
- Visits to physicians in the last 3 years
- Recent significant trauma
- History of decompression syndrome (DCS)
- Anemia or other blood disorders
Medical History Assessments of Passengers in Suborbital Space Flights

- Heart or circulatory disorders, including implanted pacemaker or defibrillator
- Mental disorders
- Claustrophobia
- Attempted suicide
- Use of medications
- Alcohol or drug dependence or abuse
- Date of last menstrual period, current pregnancy, recent post-partum (less than 6 weeks), or recent spontaneous or voluntary termination of pregnancy
- Diabetes
- Cancer
- Rejection for life or health insurance
Guidance for Medical Screening of Passengers on Orbital Flights or Exposed to a G-Load exceeding +3Gz during any Phase of the Flight.
A Common Sense Approach

1. Passengers complete a comprehensive medical history questionnaire prior to the flight.

2. Passengers undergo a physical examination with laboratory testing.

3. The medical history, physical examination, and medical tests should be valid for a period of one (1) year.
Recommended Medical History
Physical Examination Standards
Medical Tests
Medical Testing of Passengers in Orbital Space Flights

- Routine hematology
- Clinical chemistry (serum)
- Urinalysis
- Resting EKG
- Chest X-rays (PA & lateral)
- Visual acuity (corrected)
- Pregnancy testing (optional)
- Hearing (conversational voice at 6 ft)
- Tympanometry and/or tonometry (if clinically indicated)
- Pulmonary function testing (if clinically indicated)
Pre-flight Medical Interview and Physical Examination for Passengers in **Orbital Space Flights**
One to two weeks prior to each flight it is recommended that passengers should have their medical history updated and undergo an abbreviated physical examination.

The purpose is to ensure that no significant medical changes have occurred since the completion of the initial medical screening examination.
Medical Conditions that may Preclude Passenger Participation in Commercial Space Flights
Medical Conditions that may Contraindicate Passenger Participation in Suborbital or Orbital Space Flights

Any deformities (congenital or acquired), diseases, illnesses, injuries, infections, tumors, treatments (pharmacological, surgical, prosthetic, or other), or other physiological or pathological conditions that may:

1) Result in an in-flight death
2) Result in an in-flight medical emergency
3) Interfere with the proper use (don and doff) and operation of personal protective equipment
4) Interfere with in-flight emergency procedures or emergency evacuation
5) Compromise the health and safety of the passenger or other space vehicle occupants, and/or the safety of the flight
An established clinical diagnosis or finding of any of the following conditions may contraindicate participation in suborbital or orbital space flight and should be evaluated on a case-by-case basis:

- Acute or chronic use of any medication (prescription and/or non-prescription), drug, or substance
- Severe trauma or invasive medical procedures (diagnostic or therapeutic) associated with significant functional deficit
- Severe acute or chronic infections or communicable/contagious diseases (including blood borne infectious diseases)
- Cancer
• Any psychiatric, psychological, mental, or behavioral disorder that would cause an individual to become a potential hazard to him/herself or to others.

• Current pregnancy, recent post-partum (less than 6 weeks), or recent spontaneous or voluntary termination of pregnancy

• History of individual exposure to ionizing radiation (single dose or cumulative) that exceeds the maximum exposure limit of 5 mSv in 5 years recommended by the International Commission on Radiological Protection.

• Any other medical conditions that may result in significant functional impairment or that may be aggravated by exposure to the environmental or operational stress factors of space flight.
Some medical conditions may be cleared for space flight following special medical assessments in simulated spaceflight environments including the use of a zero-G aircraft, a high performance aircraft, a hypobaric (altitude) chamber, or a human centrifuge.

Using a flexible approach that applies aerospace medicine knowledge and experience-based medical risk analysis, it may be possible to permit special medical accommodations for prospective participants who have certain pathologies (including disabilities).
Example

• Professor Stephen Hawking suffers advanced amyotrophic lateral sclerosis with significant mobility impairment and he was able to safely participate in a zero-G flight.

• He was accompanied by a medical team (including an aerospace medicine specialist) who were involved in providing inflight medical support as needed.
The aeromedical preparation for this very unique flight included:

1) A training flight carrying a healthy volunteer on the day before Professor Hawking’s flight

2) The use of non-invasive biomedical monitoring equipment for blood pressure, heart rate, electrocardiography, respiratory rate, oxygen saturation and carbon dioxide saturation

3) A practical simulation of possible inflight medical emergencies
This zero-G flight demonstrated that it is feasible to allow selected individuals with severe disabilities (or other pathologies) to participate in short-duration space flights, but this may require:

1) A comprehensive preflight aeromedical preparation

2) Appropriate in-flight biomedical monitoring (including medical equipment and supplies)

3) It may even require a special flight dedicated to carry such an individual with real-time support provided by a medical team to ensure his/her health and safety
Other Guidance

- No conclusive data exist concerning the potential adverse physiologic and pathologic effects of space flight on infants or young children.

- Operators may wish to establish a minimum age for passengers participating in space flights.
• Because of the potential hazards of space flight (including exposure to solar and cosmic galactic radiation, acceleration, and microgravity), it is highly recommended that a female of child-bearing age be offered a pregnancy test.

• Operators may wish to consider excluding pregnant women from participating in space flights, until more medical information becomes available to assess the actual risks of space flight for pregnant women and their unborn children.
There may be some individuals suffering **terminal medical conditions** who may wish to participate in a space flight before they pass away.

Operators will have to decide whether or not such individuals will be allowed to participate in a space flight.

This will be a very difficult decision to make due to a number of significant ethical and legal implications.
IAA Study Group 2.6
“Medical Safety Considerations for Passengers on Short-Duration Commercial Orbital Space Flights”
Objective

To identify and prioritize medical screening considerations in order to preserve the health and promote the safety of paying passengers who intend to participate in short-duration flights onboard commercial orbital space vehicles.
Final Product

An IAA report entitled “Medical Safety Considerations for Passengers on Short-Duration Commercial Orbital Space Flights” that will be made available to the manned commercial space transportation industry for voluntary implementation.
The final report contains a list of medical conditions that could be adversely impacted by exposure to operational and environmental risk factors in orbital space flights.
LIMITED MEDICAL INTERVENTION CAPABILITIES DURING FLIGHT