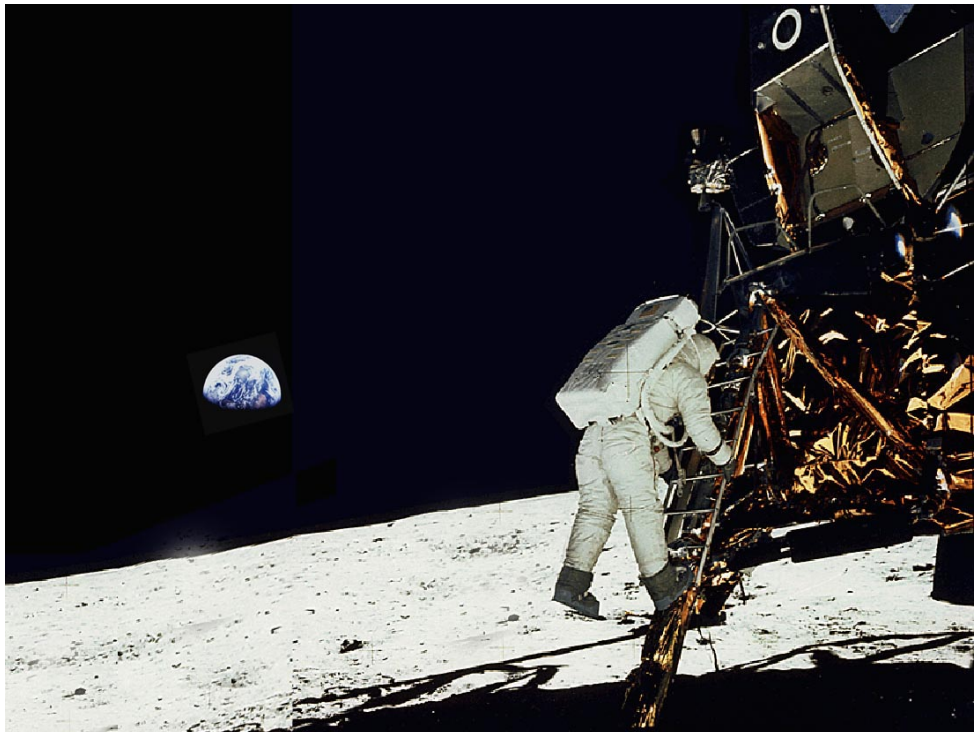
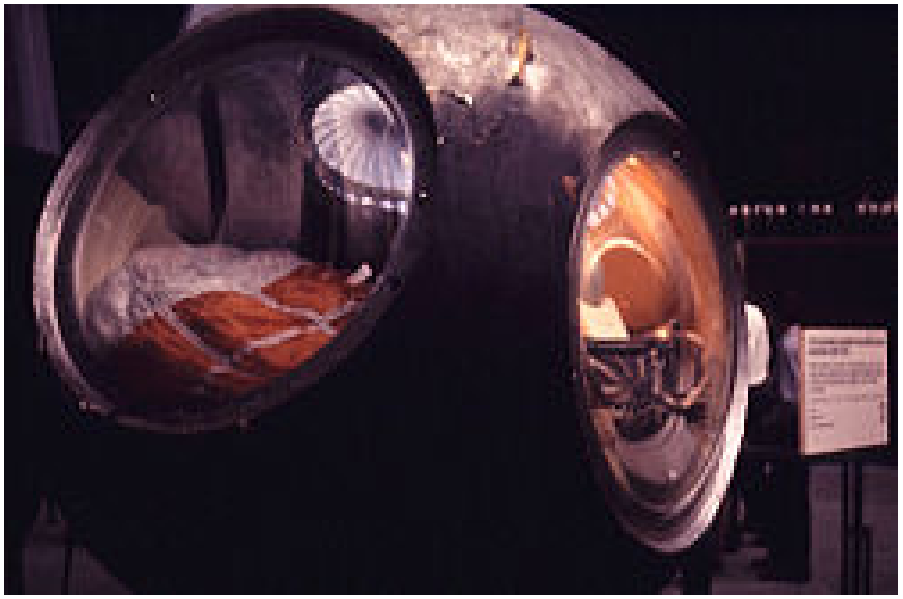


Where no man has gone before …… in economy class!!

The aeromedical challenges of space tourism

Lt.Col. Francesco Torchia

April 1961



April 1971

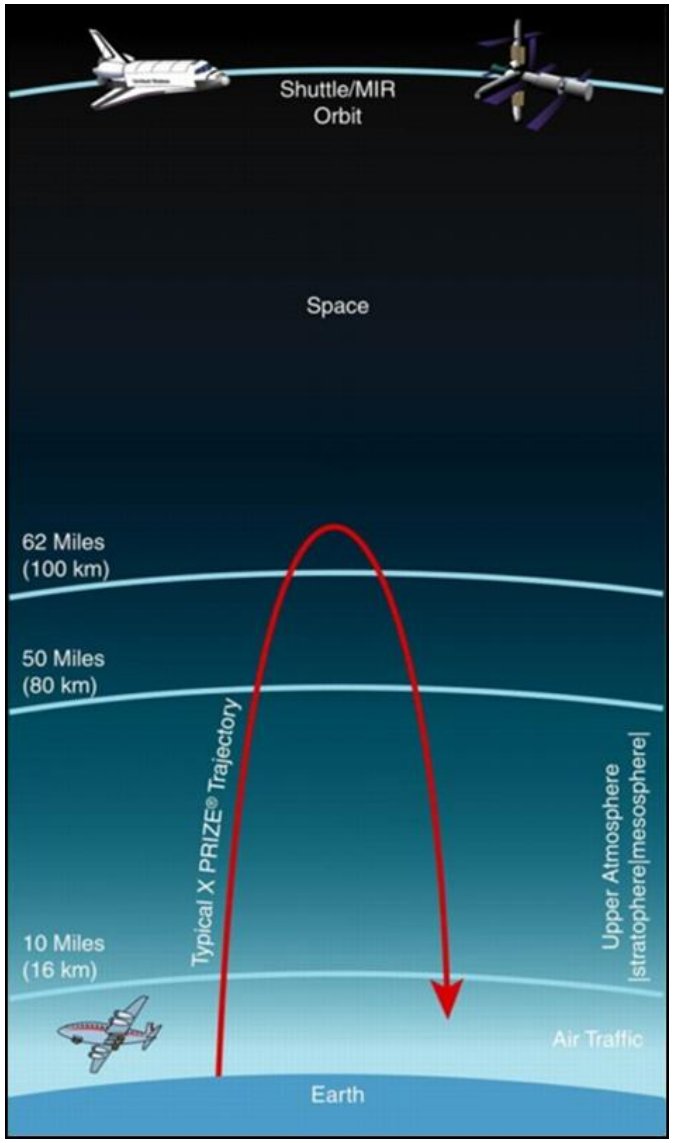
April 1981

1° Shuttle test flight

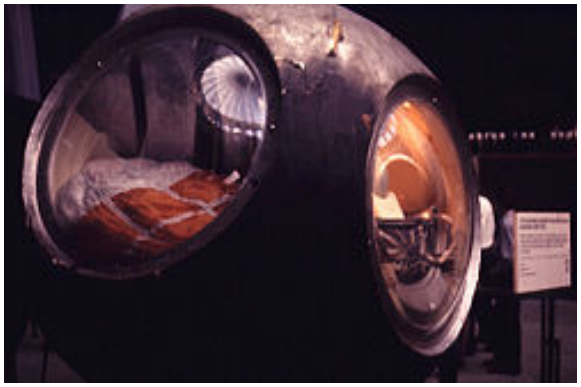
April 2001

Dennis Tito –
1° space tourist

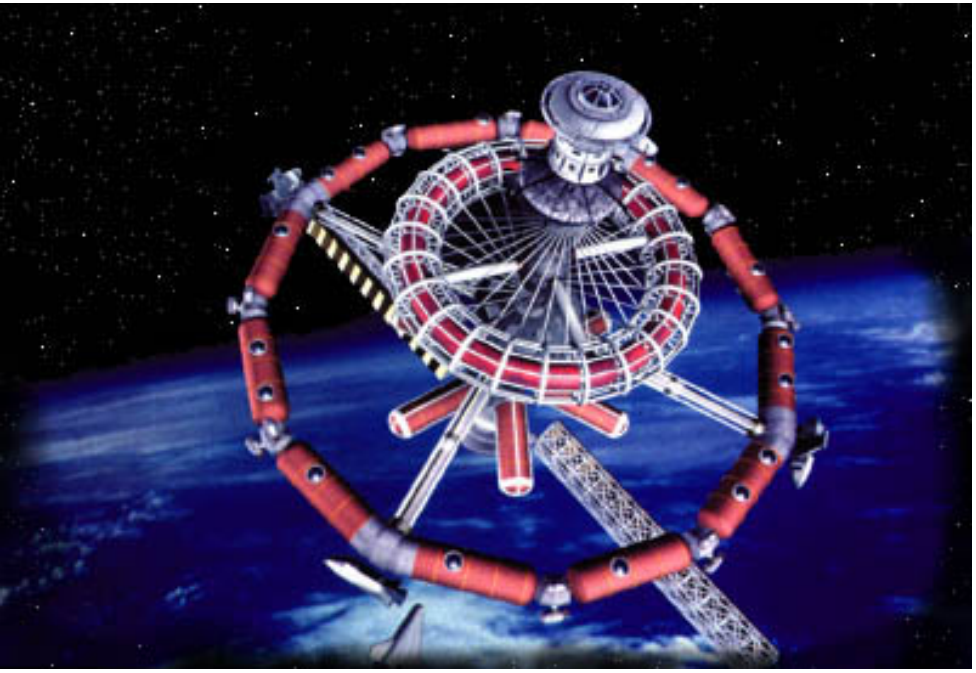
2011: Space Ship 2 - test flights



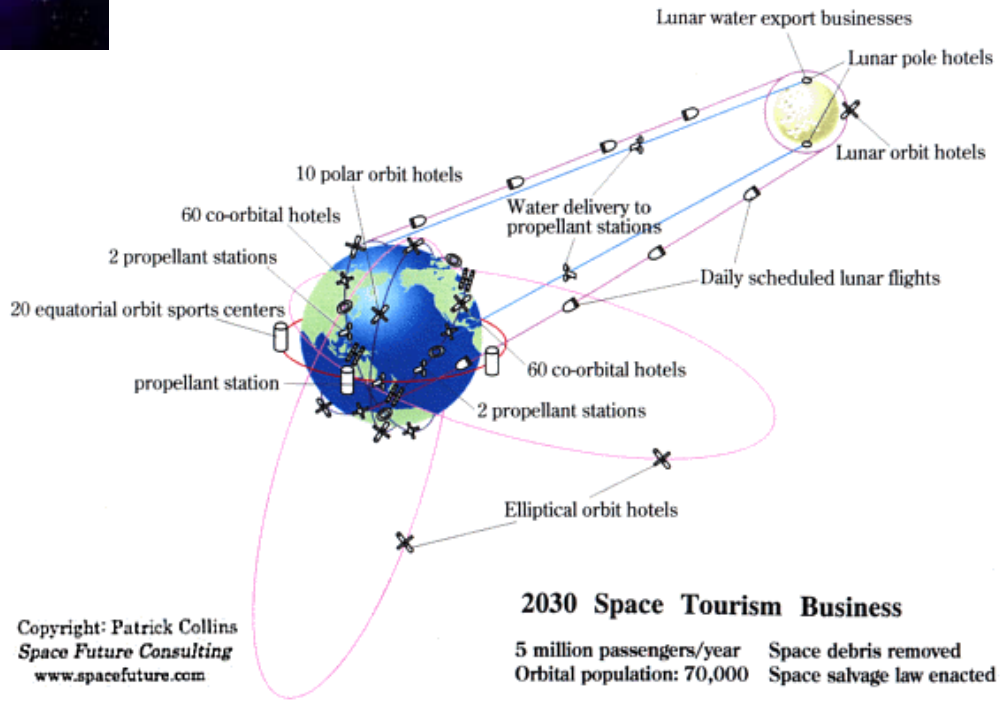
What has NOT changed since 1961…..



…… is the economy class!!!!



Space tourism business: Fiction or fact?



Commercial Spaceflight Federation

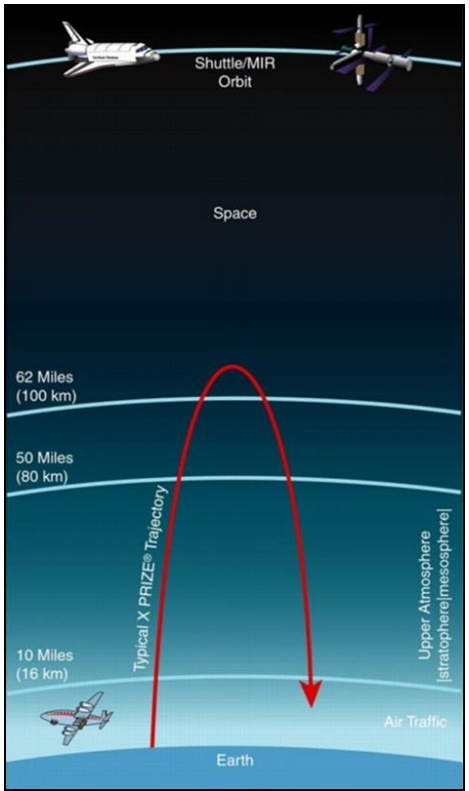
Space Adventures

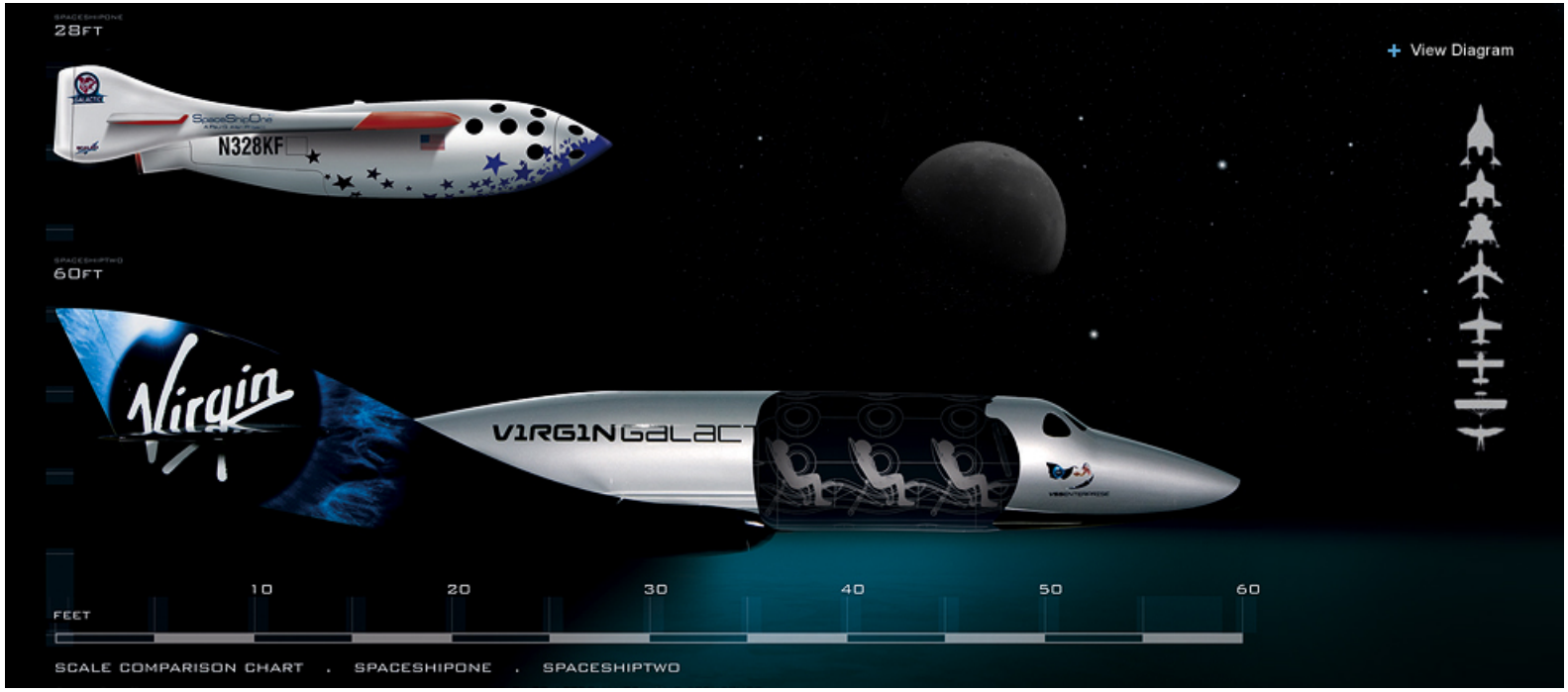
Commercial suborbital space flight

Virgin Galactic Spaceship 2

- will fly over 100 km
- 2 pilots + 6 passengers
- 3-hours suborbital flight

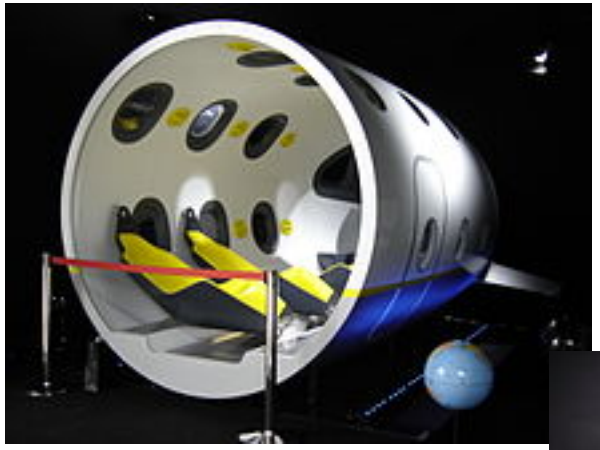
(3-4 minutes of microgravity)



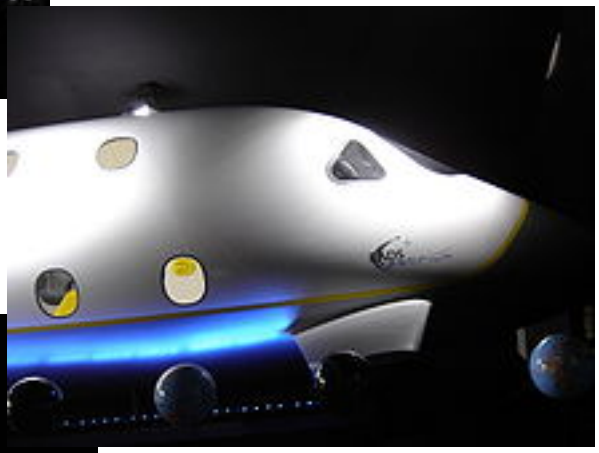


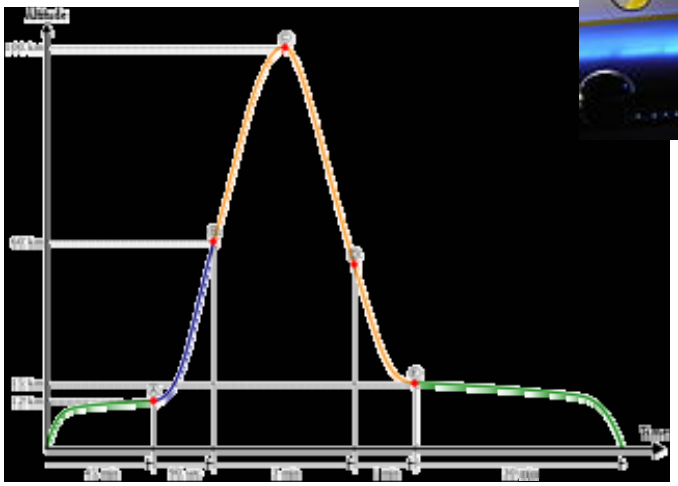
- About 250 people from 30 countries have signed into fly as passengers for about $200,000 per person
- Down payments have reached about $35million

Commercial suborbital space flight



EADS Astrium Spaceplane





X-COR Lynx:

1 pilot + 1 pax + payload

Commercial orbital spaceflight

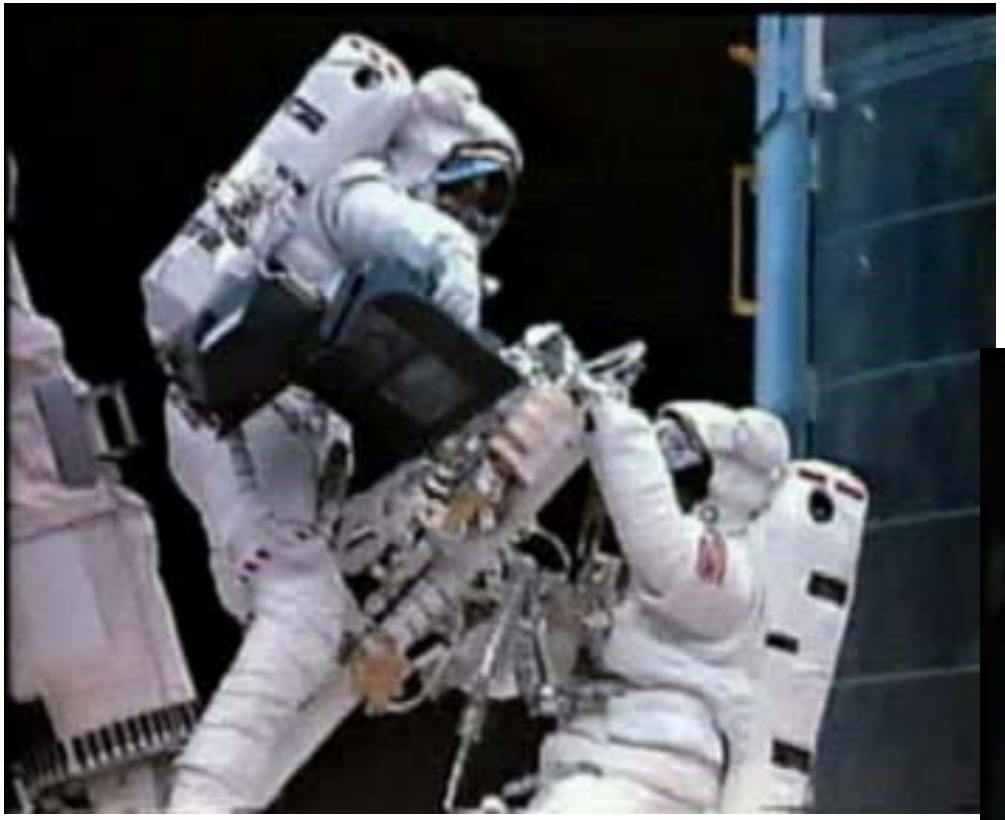
- ***Private companies involved in the development of the manned orbital commercial space industry,***
- **SpaceX**
- **Benson Space**
- **Energia Kliper**
- **Excalibur Almaz**
- **Interorbital Systems**
- **Shenzhou**
- **SpaceDev**

Commercial space stations

Nautilus Module

Genesis I and II

Is it Risky to Fly in Space?



Risk factors vary

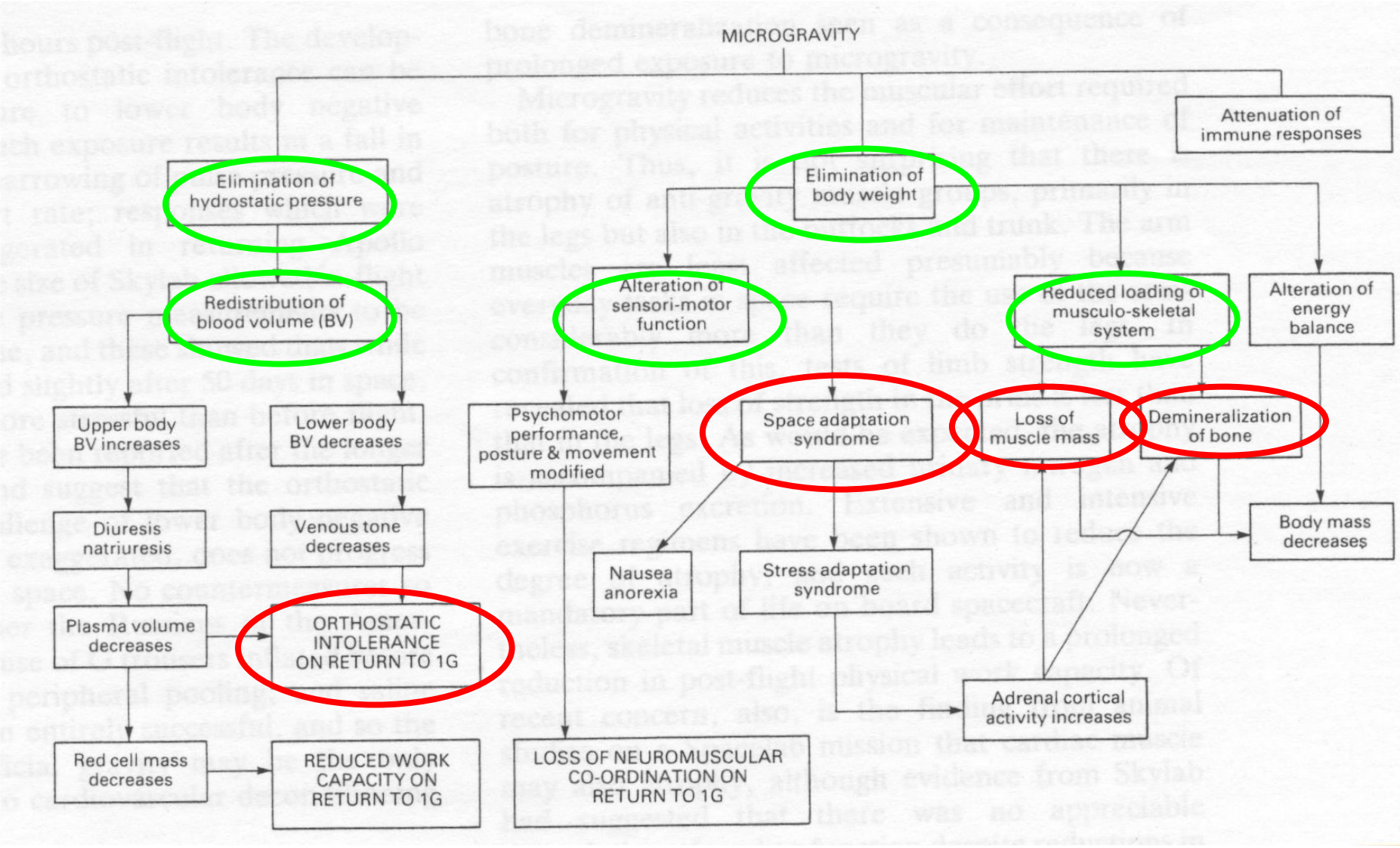
- *Suborbital vs Orbital*
- *Short Flights (hrs-days) vs Long Flights (weeks)*

- *EXTERNAL ENVIRONMENTAL FACTORS (Microgravity, Radiation, Acceleration)*

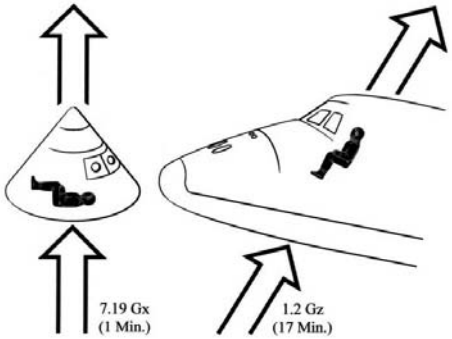
- *INDIVIDUAL FACTORS*

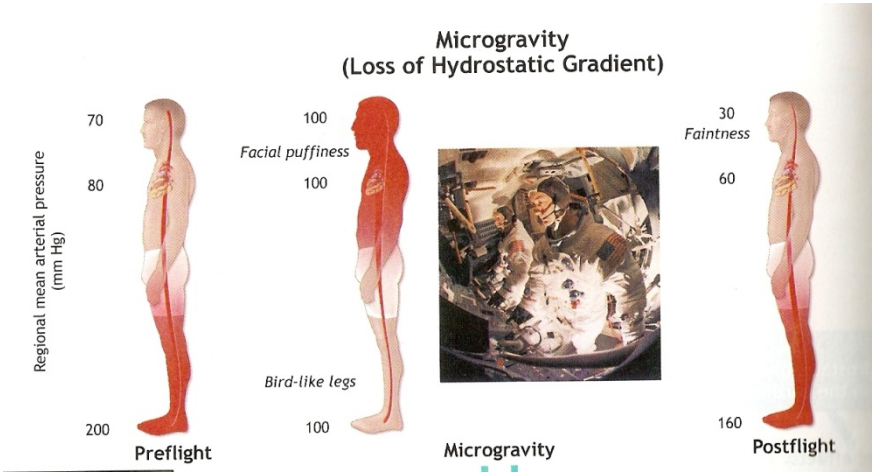
- *OPERATIONAL FACTORS (Vehicle and Flight Operations, i.e. EVA)*

Consequences of microgravity

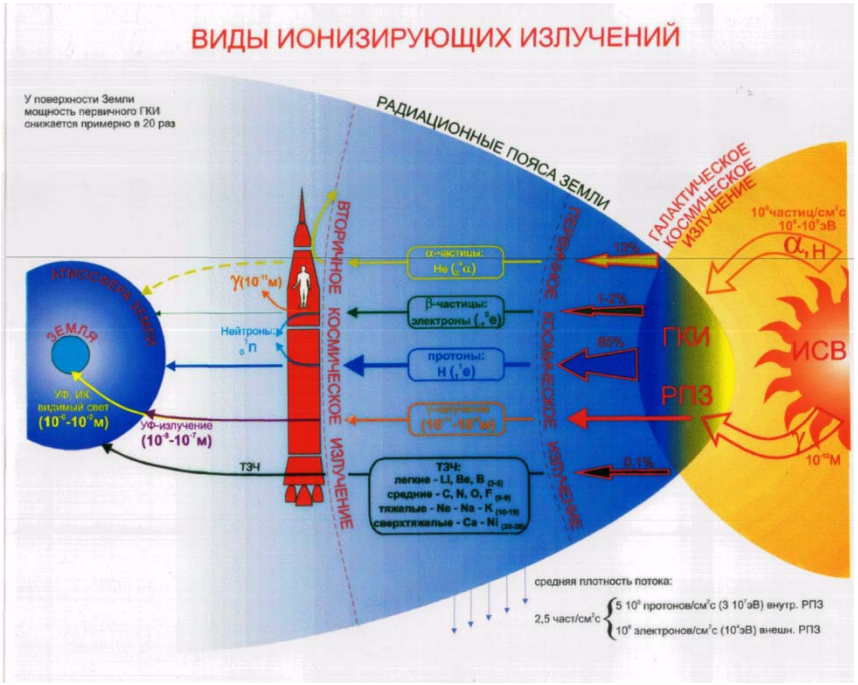


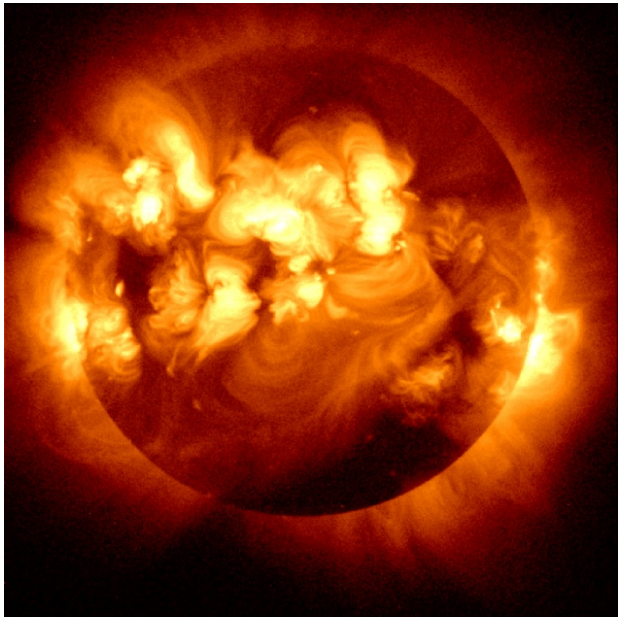
Reentry

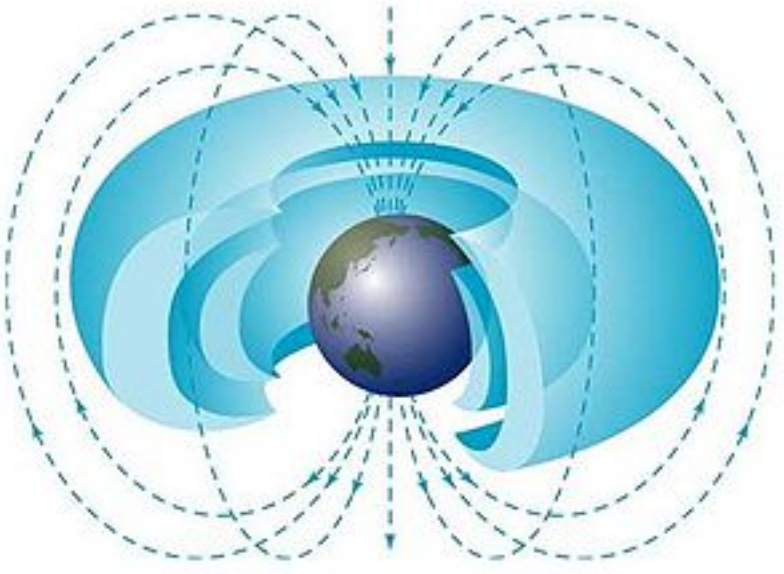

7.19 Gx
(1 Min.)
1.2 Gz
(17 Min.)


Microgravity
(Loss of Hydrostatic Gradient)
Regional mean arterial pressure (mm Hg)
70
80
200
Preflight
100
Facial puffiness
100
Bird-like legs
100
Microgravity
30
Faintness
60
160
Postflight

Radiations


ВИДЫ ИОНИЗИРУЮЩИХ ИЗЛУЧЕНИЙ
У поверхности Земли мощность первичного ГКИ снижается примерно в 20 раз
РАДИАЦИОННЫЕ ПОЯСА ЗЕМЛИ
ГАЛАКТИЧЕСКОЕ КОСМИЧЕСКОЕ ИЗЛУЧЕНИЕ
ВТОРИЧНОЕ КОСМИЧЕСКОЕ ИЗЛУЧЕНИЕ
ГКИ
РПЗ
ИСВ
ЗЕМЛЯ
АТМОСФЕРА ЗЕМЛИ
γ(10⁻¹¹м)
Нейтроны
УФ, ИК, видимый свет (10⁻⁶-10⁻²м)
УФ-излучение (10⁻⁸-10⁻⁷м)
ТЯЧ
α-частицы: He (2 4 α)
β-частицы: электроны (-1 0 e)
протоны: H (1 1 e)
ТЯЧ: легкие - Li, Be, B (6-9) средние - C, N, O, F (12-19) тяжелые - Ne - Na - K (20-39) сверхтяжелые - Ca - Ni (40-59)
13%
1-3%
85%
0,1%
средняя плотность потока:
2,5 част/см²с
5 10³ протонов/см²с (3 10⁷эВ) внутр. РПЗ
10⁶ электронов/см²с (10⁷эВ) внешн. РПЗ





Individual factors

- Generally normal and healthy individuals (career astronauts and cosmonauts) aged 35 to 50 years old

- Individual medical data from career astronauts is not available for study by the scientific community

Condition	Frequency	Percent
Facial fullness	226	81.0%
Headache	212	76.0%
Sinus congestion	173	62.0%
Dry skin, irritation, rash	110	39.4%
Eye irritation, dryness, redness	64	22.9%
Foreign body in eye	56	20.1%
Sneezing/coughing	31	11.1%
Sensory changes (e.g., tingly, numbness)	26	9.3%
URI (common cold, sore throat, hay fever)	24	8.6%
Back muscle pain	21	7.5%
Leg/foot muscle pain	21	7.5%
Cuts	19	6.8%
Shoulder/trunk muscle pain	18	6.5%
Hand/arm muscle pain	15	5.4%
Anxiety/annoyance	10	3.6%
Contusions	10	3.6%
Ear problems (predominantly earaches)	8	2.9%
Neck muscle pain	8	2.9%
Stress/tension	8	2.9%
Muscle cramp	7	2.5%
Abrasions	6	2.2%
Fever, chills	6	2.2%
Nosebleed	6	2.2%
Psoriasis, folliculitis, seborrhea	6	2.2%
Low heart rate	5	1.8%
Myoclonic jerks (associated with sleep)	5	1.8%
General muscle pain, fatigue	4	1.4%
Subconjunctival hemorrhage	4	1.4%
Allergic reaction	3	1.1%
Fungal infection	3	1.1%
Hoarseness	3	1.1%
Concentrated or "dark" urine	2	0.7%
Decreased concentration	2	0.7%
Dehydration	2	0.7%
Inhalation of foreign body	2	0.7%
Subcutaneous skin infection	2	0.7%
Chemical in eye (buffer solution)	1	0.4%
Mood elevation	1	0.4%
Phlebitis	1	0.4%
Viral gastrointestinal disease	1	0.4%

Table 7.04. Medical events in the Space Shuttle program reported by frequency from postfli medical debriefings with the cre members. This Table include the data compiled for all Shu missions from 1988 to 1995 (STS-26 to STS-74). (Source NASA)

Medical events

Medical Event	Initial Events (n=169)	Recurrences (n=135)
Superficial injury	34	2
Arrhythmia/conduction disorder	30	98
Musculoskeletal	29	NR
Headache	16	8
Sleeplessness	10	9
Tiredness	10	4
Conjunctivitis	4	2
Contact dermatitis	4	3
Erythema of face, hands	4	NR
Stool contents (preflight)	4	NR
Acute respiratory infection	3	NR
Asthenia	3	2
Surface burn, hands	3	NR
Dry nasal mucous	2	NR
Glossitis	2	1
Heartburn/gas	2	NR
Foreign body in eye	2	NR
Constipation	1	NR
Contusion of eyeball	1	NR
Dental caries	1	NR
Dry skin	1	1
Hematoma	1	NR
Laryngitis	1	5
Wax in ear	1	NR

Table 7.05. In-flight medical events for cosmonauts in the Mir program from February 7, 1987 to February 29, 1996. NR = None Reported. (Source NASA)

International Space Station

Human research facility rack # 1

European physiology module

Selection as primary prevention

to exclude medical and psychological risk factors, impossible to treat onboard a spacecraft

Medical Evaluation Documents (MED) Volume A

Medical Standards for ISS Crewmembers (AMERD 2A)

ISS Multilateral Medical Operations Panel

Shuttle Medical standards

Item	Pilots (Class I)	Mission Specialist (Class II)	Payload Specialist (Class III)	Participants to Spaceflight (Class IV)
Distant vision	20/50 or better uncorrected; correctable to 20/20 each eye	20/150 uncorrected; correctable to 20/20 each eye	Correctable to best eye	Same as Class III
Near vision	Uncorrected <20/20 each eye	Uncorrected <20/20 each eye	Not specified	Not specified
Hearing	Each ear: 30 dBA @ 500 Hz 25 dBA @ 1,000 Hz 25 dBA @ 2,000 Hz 50 dBA @ 4,000 Hz	Same as Class I	Better ear: 35 dBA @ 500 Hz 30 dBA @ 1,000 Hz 30 dBA @ 2,000 Hz	Must hear whispered voice at 1 m (hearing aid allowed)
Height	162—191 cm	152-191 cm	Not specified	150-190 cm (Soyuz)
Refraction/ astigmatism	Specified	Specified	Not specified	Not specified
Contraction visual field	15 deg	15 deg	30 deg	Not specified
Phorias	eso>15; exo>8 hyper>2	eso>15; exo>8	Not specified	Not specified hyper>2
Depth perception	No errors in 16 presentations of the Verhoeff stereopter Test	Same as Class I	Not specified	Not specified
Color vision	Pass Farnsworth lantern Test	Pass Farnsworth lantern Test	Not specified	Not specified
Blood pressure	140/90	140/90	150/90 allowed	150/90 allowed
Radiation exposure	<0.05Sv/year	<0.05 Sv/year	Not specified	Not specified

Table 7-01. Medical requirements for NASA Class I, II, III and IV astronaut applicants.

4 classes based on Astronaut position

Class IV for participants to spaceflight

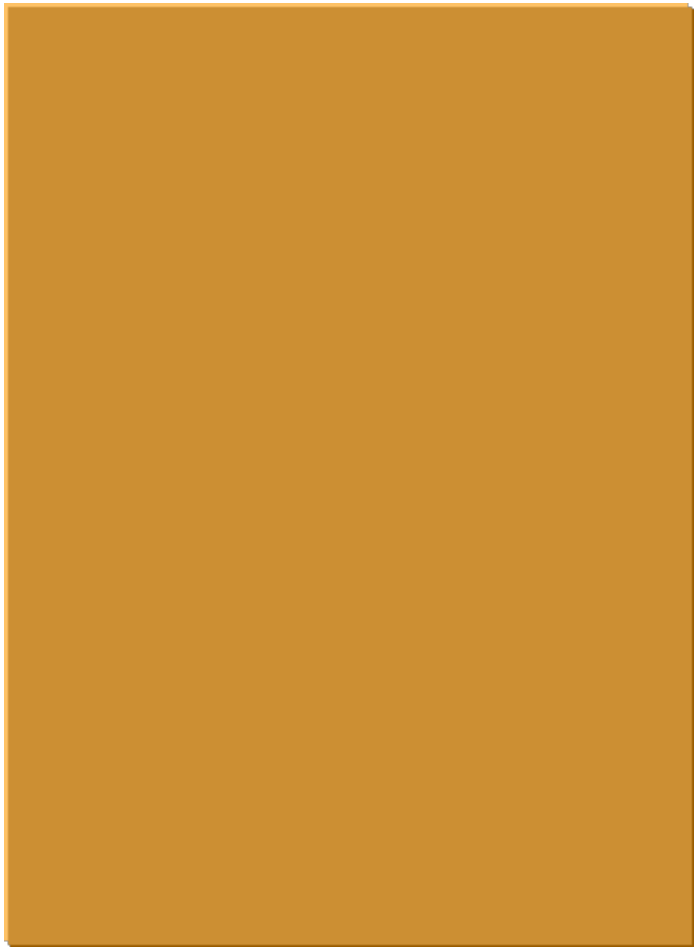
The space passenger ….
is not your average astronaut!

Dr. Eng. Gregory Olsen

- 57ys old: history of pneumothorax, moderately severe emphysema, bilateral parenchymal bullae, mediastinal mass, ventricular and atrial ectopy

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

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



Jennings RT et al. "Medical Qualification of a Commercial Spaceflight Participant: Not Your Average Astronaut." Aviat Space & Env Med Journal, Vol 77, No. 5, May 2006. (Dr. Olsen released his medical data)

Future space voyager acceptance criteria

- A good compromise between:
  - Safety of passengers and of the flight
  - Avoiding imposing an obstacle to the successfull establishment of the manned space transportation industry
- 1-time medical clearance for 1-flight passenger

Risk Disclosure is important !

- **But the public has the right to take some personal risk !**

Enomoto

SPECIAL TASK FORCE REPORT

Medical Guidelines for Space Passengers

AEROSPACE MEDICAL ASSOCIATION TASK FORCE ON SPACE TRAVEL

AEROSPACE MEDICAL ASSOCIATION TASK FORCE ON SPACE TRAVEL. *Medical guidelines for space passengers.* Aviat Space Environ Med 2001; 72:948–50.

Aerospace Medical Association

Task Force on Space Travel 2001

CARDIOVASCULAR

- Coronary Artery Disease
  Symptomatic = DQ
  Asymptomatic = Evaluate for exception
- Arrhythmias/Conduction Defects
  Hemodynamically significant = DQ
  Nonhemodynamically significant = Evaluate for exception
- Pacemaker/Implantable Defibrillators = DQ
- Pericarditis/Myocarditis
  DQ
  Evaluate 6 months post-recovery
- Heart Transplant/Replacement
  DQ
- Hypertension
  Severe or poorly controlled = DQ
  Well Controlled = Qualified with possible exceptions
- Structural/Valvular Defects
  Symptomatic = DQ
  Asymptomatic = Evaluate for exception
- Cardiomyopathy
  Symptomatic = DQ
  Asymptomatic = Evaluate for qualification

2002 “assumptions”

SPACE PASSENGER TASK FORCE: RAYMAN RB, ANTUÑANO MJ, GARBER MA, HASTINGS JD, ILLIG PA, JORDAN JL, LANDRY RF, MCMEEKIN RR, NORTHRUP SE, RUEHLE C, SAENGER A, SCHNEIDER VS. *Position Paper: Medical guidelines for space passengers–II.* Aviat Space Environ Med 2002; 73:1132–4.

- Space vehicle interior small and confining
- Suborbital flight 1 to 3 hr including x min. microgravity
- Cabin pressurized to sea level
- No life support equipment required
- Acceleration will range between 2 – 4.5 +Gz or Gx (depending on the space vehicle)
- Different emergency procedure (depending on the space vehicle)
- Few or no medical capabilities onboard

Future space voyager

- **Commercial Space Launch Amendment Act (2004):** US is the only country that established licensing requirements

  “Passengers to be fully informed about the potential risks but allowing to fly at their own risk”

- **FAA 2005 “Guidance for Medical Screening of Commercial Aerospace Passengers”**

Suborbital: medical history and physical assessment decided by the space Flight Surgeon

Orbital: medical history and physical assessment

IAA Study Group 2.6

- General guidance for medical assessment of prospective passengers of orbital commercial space vehicles
- To identify medical screening considerations for short-duration commercial orbital space flights
- Guidelines based on the assumption that passengers will be capable of performing an emergency evacuation without assistance

Medical Safety and Liability Issues for Short-Duration Commercial Orbital Space Flights

International Academy of Astronautics

Contraindications

- *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

IAA Study Group

- 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
- **ACCELERATIONS**
- **NON – IONIZING RADIATION**:

- Implanted medical devices such as pacemakers and cardiac defibrillators

For a more comprehensive review of reference information on human exposure limits to acceleration it is recommended to consult "NASA Bioastronautics Data Book" (Ref [8] – Chapter 4, Pages 149-190), "Fundamentals of Aerospace Medicine" (Ref [9] - Chapter 4, Pages 86-98), and "Human Space Flight Mission Analysis and Design" (Ref [9] - Chapter 5, Pages 115-116).

The following are some medical conditions that could be adversely impacted by exposure to acceleration:

- *Cardiovascular pathologies such as congenital heart diseases, valvular heart diseases, cardiomyopathies, pericarditis, myocarditis, endocarditis, ischemic heart diseases, dysrhythmias, aortic aneurysm, peripheral vascular diseases, uncontrolled hypertension, or autonomic neuropathy associated with hypotension.*
- *Cerebrovascular diseases such as stroke, transient ischemic attack (TIA), intracranial bleed, intracranial aneurysm, AV malformations, cavernous angiomas.*
- *Cerebral tumors.*
- *Loss of consciousness of unknown origin or recurrent syncope.*
- *Musculoskeletal disorders such as symptomatic cervical arthritis, recent spinal injury, severe osteoporosis, spondylolysis, spondylolisthesis, herniated nucleous pulposus, non-healed displaced fractures, non-reduced dislocations of large joints.*
- *Ophthalmologic disorders such as retinal detachment, hemorrhages or other retinal vascular problems.*
- *Individuals with high degrees of myopia (<-6 diopters) may be at increased risk of retinal detachment*
- *Severe chronic dizziness, positional vertigo, motion sickness, or other vestibular/orientation problems of any cause.*
- *Recent intra-cranial, intra-thoracic or intra-abdominal trauma.*
- *Acute or chronic hemorrhagic states of any cause.*
- *Chronic symptomatic hernias.*
- *Draining fistulas.*
- *Pregnancy.*
- *Recent significant health problems or recovery from surgery*

IAA Study group: medical history and physical examination

RECOMMENDED MEDICAL HISTORY ASSESSMENT OF PROSPECTIVE ORBITAL SPACE PASSENGERS

Prospective space passengers should be required to provide their medical history (including family history), emphasizing those medical conditions that could be adversely impacted by exposure to the operational and environmental risk factors of orbital space flight.

In addition, they should provide information about the following:

- Use of implanted pacemaker or defibrillator.
- Tuberculosis, hepatitis, AIDS, or other serious infectious disorders.
- Use of medications (over-the-counter or prescription), alcohol and other drugs.
- History of psychiatric and/or psychological problems, based on the most current DSM, ICD or other classification systems
- Occupational exposure to ionizing radiation
- Date of last menstrual period, current pregnancy, recent post-partum (less than 6 weeks), or recent spontaneous or voluntary termination of pregnancy.
- Recent significant trauma.
- History of surgery and/or any implanted medical devices.
- Recent significant illness.
- Recent admission to a hospital.
- Current medical conditions requiring treatment.
- Any rejection for life or health insurance. Including medical military discharge or medical disability
- Any medical practitioners seen in the last 3 years and reason for visit.

RECOMMENDED PHYSICAL EXAMINATION OF PROSPECTIVE ORBITAL SPACE PASSENGERS

Prospective space passengers should undergo a general physical examination including:

- Vital signs (heart rate, respiratory rate, temperature, blood pressure).
- Head, face, neck, and scalp.
- Nose, sinuses, mouth, throat, ears (including eardrum integrity and function, Eustachian tube function).
- Eyes
- Lungs and chest.
- Heart.
- Peripheral vascular system.
- Abdomen and viscera.
- Genitourinary system.
- Rectal, pelvic, and breast examination (only if indicated by medical history).
- Upper and lower extremities.
- Spine.
- General neurological evaluation.
- General psychiatric evaluation including a mental status examination.

RECOMMENDED MEDICAL TESTS FOR PROSPECTIVE ORBITAL SPACE PASSENGERS

Prospective space passengers should complete the following medical tests:

- Routine hematology.
- Clinical chemistry (serum).
- Urinalysis.
- Resting electrocardiogram.
- Chest X-ray (PA & lateral).
- Corrected visual acuity.
- Tonometry
- Audiogram.
- Pulmonary function testing and/or metacholine provocation test (if clinically indicated).

Preflight clearance

Human Centrifuge

Gagarin Centre

NASTAR Centre

Parabolic flight

Challenges

- Elderly people
- Pregnant women
- Remote locations of spaceports
- Crew considerations

IAA Study Group 2.11

- Medical Safety guidelines for Space Crews involved in Short-Duration Commercial Orbital Spaceflight Operations

ESAM Space Medicine Group

preparing the “Homo *Spaciens*” ?

…. The Romans left us the Latin too!!!


Thanks
for your
attention!