MEDICAL ASPECTS OF MANNED SPACE FLIGHT

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MD 1983 – Engineer SupAero 1974
Chairman of ESA Medical Board
Content:

- Medical concerns with manned Spaceflight
- Astronaut selection, psychological and medical selection, annual exams
- Preflight medical training, physical training
- During flight: space related medical issues, their control
  - unforeseeable medical events, their management
- Post flight: recovery period
- Conclusions: medical issues for future interplanetary manned exploration
Medical concerns with manned Spaceflight
History of medical concerns with manned Spaceflight (1)

At the beginning of the manned space flight era, before 1961, the list of the suspected / anticipated medical problems induced by space flight was a long list:

- Anorexia
- Nausea
- Disorientation
- Sleepiness
- Sleeplessness
- Fatigue
- Restlessness
- Euphoria
- Hallucinations
- Decreased g tolerance
- Gastrointestinal disturbance
- Urinary retention
- Diuresis
- Muscular incoordination
- Muscle atrophy

- Demineralization of bones
- Renal calculi
- Motion sickness
- Pulmonary atelectasis
- Tachycardia
- Hypertension
- Hypotension
- Cardiac arrhythmias
- Postflight syncope
- Decreased exercise capacity
- Reduced blood volume
- Reduced plasma volume
- Dehydration
- Weight loss
- Infectious illnesses

Increase of the ionizing radiation whole body exposure was missing
History of medical concerns with manned Spaceflight (2)

After Mercury & Gemini era, 1961-1965, the list of the observed medical problems induced by space flight was much shorter:

- Moderate postflight orthostatic intolerance
- Moderate postflight loss of exercise capacity
- Moderate loss of red cell mass
- Minimal loss of bone calcium and muscle nitrogen
- Minimal loss of bone density
- High metabolic cost of extravehicular activity

Increase of the ionizing radiation whole body exposure was missing in this list
**History of medical concerns with manned Spaceflight (3)**

Following Appolo/Soyuz/Shuttle and Skylab/Saliut/MIR/ISS era, 1965 - today, the era of countermeasures, the consolidated list of the observed medical problems induced by space flight is:

- Vestibular disturbances
- Inflight cardiac arrhythmia
- Reduced postflight orthostatic tolerance
- Reduced postflight exercise tolerance
- Postflight dehydration and weight loss
- Flight diet adequate; food consumption suboptimal
- Decreased red cell mass, plasma volume
- Negative inflight balance trend for nitrogen, calcium, other electrolytes
- Increased inflight adrenal hormone secretion

Increase of the ionizing radiation whole body exposure, around 500 times the received earth natural radiation doses (in Paris region).
“Medical issues along an Astronaut’s career”
Astronauts’ selection (1)

Example: ESA 2008 – 2009

Some statistics about 5 steps

1. 8413 Applicants (10% females)
2. «On-line» screening and ranking
3. 10% through psycho evaluation
4. 1% through medical evaluation
5. 0.05% selected (6 astronauts)

By the end a probability of success for each applicant is: $5 \times 10^{-4}$
Astronauts' selection

Example:
- ESA 2008 – 2009

The main steps
- Step 1 - Psy 2.1
- Step 2 – Psy 2.2
- Step 3 - Med
Astronauts’ selection (2)
Main Psychological exams
(example ESA 2008-2009 – Psycho Step 1)

Basic aptitudes testing:
(or performance testing – 1 day)

- English Test (ET)
- Attention and Vigilance Test (AVT)
- Spatial Comprehension Test 1 (SCT-1)
- Arithmetic and calculation test (ACT)
- Acoustic Memory test (AMT)
- Personality Inventory Test – 10 scales (PIT-10)
- Visual Perception Speed and Capacity (VPSC)
- Technical Comprehension Test (TCT)
- Spatial Comprehension Test 2 (SCT-2)
- Memory Test (MT)
- Personality Inventory Test – 5 scales (PIT-5)
- Multitask Coordination Test (MCT)

Typical schedule:

08.30 – 09:00 Introduction
09.00 – 09:45 ET, AVT
09.45 – 09:55 Break
09.55 – 11:00 SCT-1, ACT
11.00 – 11:10 Break
11.10 – 12:10 AMT, PIT-10
12.10 – 13:10 Lunch Break
13.10 – 14:00 VPSC, TCT
14.00 – 14:10 Break
14.10 – 15:25 SCT-2, MT, PIT-5
15.25 – 15:35 Break
15.35 – 16:45 MCT
16.45 End
Astronauts’ selection (3)
Main Psychological exams
(example ESA 2008-2009 – Psycho Step 2)

Individual Behavioral Testing (1 day)

- Individual Interview
- Minnesota Multiphasic Personality 2
- State Trait Anxiety Inventory
- Defense Mechanisms Inventory
- Group Test (Problem Solving)
- Projective Test (Hand Test)
- Group Interview
<table>
<thead>
<tr>
<th>Duration (min.)</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>MRI of brain</td>
</tr>
<tr>
<td>30</td>
<td>MRI of sinuses</td>
</tr>
<tr>
<td>30</td>
<td>Abdominal and pelvic ultrasound</td>
</tr>
<tr>
<td>10</td>
<td>Thyroid US</td>
</tr>
<tr>
<td>10</td>
<td>Full orthopantomogram</td>
</tr>
<tr>
<td>20</td>
<td>Dental</td>
</tr>
<tr>
<td>60</td>
<td>Psychiatry</td>
</tr>
<tr>
<td>60</td>
<td>Anthropometry and orthopaedics</td>
</tr>
<tr>
<td>30</td>
<td>Gynaecology including pap smear</td>
</tr>
<tr>
<td>30</td>
<td>Cardiology (examination + resting ECG)</td>
</tr>
<tr>
<td>60</td>
<td>Ophtalmology</td>
</tr>
<tr>
<td>60</td>
<td>ENT</td>
</tr>
<tr>
<td>120</td>
<td>Complete physical examination</td>
</tr>
<tr>
<td>30</td>
<td>Detailed subject information</td>
</tr>
<tr>
<td>15</td>
<td>Vaccination history</td>
</tr>
<tr>
<td>45</td>
<td>Fitness assessment</td>
</tr>
<tr>
<td>10</td>
<td>Urine drug screen</td>
</tr>
<tr>
<td>45</td>
<td>Biology</td>
</tr>
<tr>
<td>30</td>
<td>Nutrition questionnaire evaluation</td>
</tr>
<tr>
<td>30</td>
<td>DEXA full body</td>
</tr>
<tr>
<td>30</td>
<td>Sigmoidoscopy</td>
</tr>
<tr>
<td>30</td>
<td>Carotid doppler</td>
</tr>
<tr>
<td>20</td>
<td>EBCT (Scanner)</td>
</tr>
<tr>
<td>30</td>
<td>24-Hour ECG monitoring</td>
</tr>
<tr>
<td>30</td>
<td>Echocardiogram, Doppler and color flow study</td>
</tr>
<tr>
<td>60</td>
<td>Exercise maximum stress test on treadmill / Vo2max</td>
</tr>
<tr>
<td>30</td>
<td>Pulmonary function testing</td>
</tr>
<tr>
<td>30</td>
<td>MRI of breast</td>
</tr>
<tr>
<td>60</td>
<td>Angiogram of brain</td>
</tr>
</tbody>
</table>

**Astronauts' Medical Exams**

- **Main Medical Exams**
  - Example ESA 2008–2009: Medical evaluation Step 3, 5 days.
### Astronauts’ selection (5)

**Main Medical Causes of Rejection**
*(based on passed selections in Europe)*

<table>
<thead>
<tr>
<th>Domain of the rejection causes</th>
<th>Among all medical causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ophthalmology</td>
<td>15%</td>
</tr>
<tr>
<td>Anthropometry – Surgical History</td>
<td>11%</td>
</tr>
<tr>
<td>Neurology</td>
<td>8%</td>
</tr>
<tr>
<td>Cardio-vascular</td>
<td>9%</td>
</tr>
<tr>
<td>Laboratory</td>
<td>7%</td>
</tr>
<tr>
<td>ENT</td>
<td>6%</td>
</tr>
<tr>
<td>Digestive Apparatus</td>
<td>7%</td>
</tr>
<tr>
<td>Kidney &amp; Urinary Apparatus</td>
<td>9%</td>
</tr>
<tr>
<td>Lungs</td>
<td>5%</td>
</tr>
<tr>
<td>Dentistry</td>
<td>5%</td>
</tr>
<tr>
<td>Psychiatry</td>
<td>6%</td>
</tr>
<tr>
<td>Others</td>
<td>12%</td>
</tr>
</tbody>
</table>

During their whole career Astronauts have an annual medical exam
Astronauts’ selection (6)
The 6 ESA 2008 – 2009 selected astronauts

Samantha Cristoforetti
Alexander Gerst
Andreas Mogensen
Luca Parmitano
Timothy Peake
Thomas Pesquet

(To day 14 astronauts are Member of the European Astronaut Corp)
During their whole career Astronauts have an annual medical exam. For flight they have the following medical evaluations (example: Short Flight NASA):

<table>
<thead>
<tr>
<th>EXAM SCHEDULE</th>
<th>Annual Exam</th>
<th>F-30 Days</th>
<th>F-10 Days</th>
<th>F-2 Days</th>
<th>F-1</th>
<th>L+0</th>
<th>L+6 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCATION</td>
<td>JSC</td>
<td>JSC</td>
<td>JSC</td>
<td>JSC</td>
<td>KSC</td>
<td>LAND SITE</td>
<td>JSC</td>
</tr>
<tr>
<td>APPROXIMATE DURATION</td>
<td>4:00</td>
<td>1:30</td>
<td>0:45</td>
<td>0:10</td>
<td>0:30</td>
<td>1:30</td>
<td></td>
</tr>
<tr>
<td>EXAM COMPONENTS</td>
<td>PX</td>
<td>L</td>
<td>A</td>
<td>V</td>
<td>T</td>
<td>CST*</td>
<td>D</td>
</tr>
</tbody>
</table>

*Annual 100% treadmill unless under age 35. For under age 35, treadmill is 100% every 3 years and 80% on intervening years.*

- PX: Complete Physical
- PX(ab): Abbreviated Physical
- L: Laboratory
- M: Microbiology
- A: Audiology
- V: Visual Acuity
- T: Tonometry
- CST: Cardiovascular Stress Test
- D: Dental
- CVE: Cardiovascular Evaluation (Stand Test-Echocardiogram)
Preflight Astronaut Basic & Medical Training (1)

Theoretical Astronaut Medical Training

• Atmosphere Physics:
• Vascular Human System
• Respiratory Human Apparatus
• Hypoxia
• Hyperventilation
• Decompression Sickness
• Hyperbaric and blast syndromes
• Environmental disturbances, their health consequences and prevention
  • Noise, Vibration
  • Microgravity
  • Ionizing radiations & non-ionizing radiations
  • Atmosphere contaminants
• Space Adaptation Syndrome (so-called space sickness)
• Day to day habits – addiction syndromes
Preflight Astronaut Medical Practical Training (2)

Medical Practical Training

- Onboard Medical Kits familiarization
- Procedure Training for Private Medical Communication (PMC)
- Respiratory Human Apparatus
- Diagnostic techniques: Pulse, Respiratory Frequency, Blood Pressure Measurements, Eye exam, Ear Exam, Lung Exam, Cardiac Exam, Abdominal Exam, Neurological Exam, Trauma Exam
- Oral airway insertion technique
- Cricothyrotomy Technique
- Intra-muscular injection
- Venous puncture and injection
- Simple sutures
- Oral medications
- Emergency management: SAS, back pain, teeth problems, eyes cares, burns, decompression sickness, bleeding, wounds etc...
Preflight Astronaut Medical Practical Training (3)

**DRUG ADMINISTRATION TECHNIQUE**

1. Tie Penrose Tubing (EMK C1-2)
2. Swab with alcohol wipes (EMK B1-5) (MBK F1-7)
3. Insert butterfly needle (bevel up) into one of three veins in area shown
4. Tape (EMK B1-8) (MBK F1-4), remove penrose tubing
5. Inject Drug

**PREFILLED SYRINGE TECHNIQUE**

1. Unstow:
   - Syringe and Plunger
2. Screw plunger on syringe
3. Express air from syringe

**Storage Configuration**
- Plunger Stowed Over Needle

**Operational Configuration**
- Assembly
Preflight Astronaut Medical Practical Training (4)

TUBEX INJECTOR TECHNIQUE
1. Holding the barrel, pull plunger out and rotate on hinge to expose barrel opening
2. Insert syringe into barrel
3. Screw glass syringe into the tip until 'click'
4. Rotate plunger back to insert into barrel; screw into hub of glass syringe
5. If 1-cc syringe is used, set tab at 1; for 2-cc syringe, set tab at 2
6. To remove Tubex from injector, tab must be set on 2

CAUTION
Aspirate before injecting
Performing the injection: If injection is IM/no blood in syringe upon aspiration

CHOKING
Airway Obstruction - Conscious Adult

<table>
<thead>
<tr>
<th>Step</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&quot;Are you choking?&quot; Victim may be using the “Universal Distress Signal” of choking: clutching the neck between thumb and index finger</td>
</tr>
<tr>
<td>2</td>
<td>Perform Heimlich Maneuver Deliver 6-10 abdominal thrusts Repeat thrusts until either foreign body is expelled or victim becomes unconscious (see below)</td>
</tr>
<tr>
<td>3</td>
<td>Perform finger sweep</td>
</tr>
<tr>
<td>4</td>
<td>Open airway - Head-Tilt/Chin Lift Attempt to ventilate by mouth-to-mouth resuscitation - Two Breaths</td>
</tr>
<tr>
<td>5</td>
<td>Perform 6-10 abdominal thrusts</td>
</tr>
<tr>
<td>6</td>
<td>If unsuccessful, repeat steps 3-5 Two Times</td>
</tr>
<tr>
<td>7</td>
<td>If unable to ventilate, go to CPR STATION, pg 3-6b, and prepare for CRICOThYROTOMY TECHNIQUE, pg 3-6</td>
</tr>
</tbody>
</table>

3-4 MED/ALL/GEN 3
**Preflight Astronaut Medical Practical Training (5)**

**OBSTRUCTED AIRWAY - UNCONSCIOUS ADULT**

<table>
<thead>
<tr>
<th>Step</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Open airway - Head-Tilt/Chin Lift</td>
</tr>
<tr>
<td>2</td>
<td>Attempt to ventilate/Mouth-to-Mouth</td>
</tr>
<tr>
<td>3</td>
<td>Airway remains obstructed, reattempt ventilation</td>
</tr>
<tr>
<td>4</td>
<td>Perform 6-10 abdominal thrusts</td>
</tr>
<tr>
<td>5</td>
<td>Perform finger sweep</td>
</tr>
<tr>
<td>6</td>
<td>Attempt to ventilate</td>
</tr>
<tr>
<td></td>
<td>If unsuccessful, repeat steps 4-5 <strong>Two Times</strong></td>
</tr>
<tr>
<td></td>
<td>If unable to ventilate, go to CPR ___ __ ___ _STATION, pg 3-6b, and prepare for CRICOTHYROTOMY PROCEDURE, pg 3-6</td>
</tr>
</tbody>
</table>

**Cricothyrotomy Technique**

For Victim With Obstructed Airway

- Tape
- Restraints
- Towel(s)
- Cricothyroid membrane
- Cricoid cartilage
- Trachea

Locating Cricothyroid membrane: Using your index finger, locate Adams Apple (thyroid cartilage), slide down and feel for next ridge (cricoid cartilage). Feel for a small triangular soft spot above this ridge.

- Endotracheal Connector
- Cannula
- Tube
- Knife
- Notch
- Scribed line

3-5   MED/ALL/GEN

3-6   MED/ALL/GEN
### Preflight Astronaut Medical Practical Training (6)

<table>
<thead>
<tr>
<th>Step</th>
<th>Activity</th>
</tr>
</thead>
</table>
| 1    | Open airway  
Look, feel, and listen |
| 2    | Position, tighten resuscitator mask  
to crewmember's face using head  
cap, straps  
Ventilate twice by depressing O2  
trigger arm for 1-1/2 sec or perform  
mouth to mouth resuscitation  
Observe chest rise |
| 3    | Check for circulation  
Feel for carotid pulse (5-10 seconds) |
| 4    | Begin compression/ventilation cycles  
15 compressions/2 ventilations for  
one (1) person CPR  
5 compressions/1 ventilation for two  
(2) person CPR  
Rate of compression is 80-100 per  
minute  
Feel for pulse after 1 minute and  
then every 2 minutes |

**ORAL AIRWAY INSERTION**

For The Unconscious, Breathing Patient

- Insert
- Rotate 180°
- Complete Insertion

*Med/ALL/GEN* 3
Preflight Astronaut Medical Practical Training (7)

NOSEBLEED STOPPAGE TECHNIQUE

When inserting, apply Polysporin (MBK 51-7) on tube

Nasostat (EMK C1-2)

Inflate as required (1-10cc)
Syringe (EMK B1-4)

NOSE CONGESTION

Treatment:

1 Decongestants
MBK (blue) 1 Sudafed (EZ-14)
Dose: 1-2 tablets every 6 hr as needed

OR

2 Afrin Nasal Spray (51-1,2)
Dose: 1-2 sprays every 12 hr as needed
Preflight Astronaut Medical Practical Training (8)

DENTAL SYRINGE TECHNIQUE

1. Open needle by twisting off clear cap
2. Screw needle cartridge into syringe by turning cw until firmly seated
3. Insert dental carpule into syringe body by sliding toward needle, snapping in place
4. Push plunger arrow into dental carpule; ensure head of arrow is firmly seated
5. To inject, remove Yellow Needle Cap and go to DENTAL INJECTION TECHNIQUE, pg 5-9

NOTE
Withdraw plunger before inserting dental carpule

CAUTION
Aspirate before injection

DENTAL INJECTION TECHNIQUE

Inject into movable membrane above fixed gum (labial buccal fold)

Depth of Injection - 3/8 in.

Dental Syringe (EMK 02-8)
Xylocaine with Epinephrine (EMK 02-1)
Short needle (EMK 02-2)

Direct Needle to Root Apex of Tooth to be Anesthetized. Inject 1.8 cc Xylocaine with Epinephrine

Figure 1

Lower (Mandibular) Molar Anesthesia

• Depth of Injection - 1 in.
• Inject Entire Syringe

Dental Syringe (EMK 02-8)
Xylocaine with Epinephrine (EMK 02-1)
Long needle (EMK 02-2)

Serum of Syringe over third & fourth tooth back on opposite side of injection

Figure 2
Preflight Astronaut Medical Practical Training (9)

**OXYGEN - SUPPLEMENTAL**

* Use Helmet Retention Assembly and *
* LES helmet for Oxygen delivery to a *
* crewmember who is awake, breathing *
* but needs protection of airway from *
* toxins, smoke, or bends. Connect to *
* Orbiter 02 (M032M, M069M, or C6) *

**NOTE**
Use Resuscitator for unconscious patient

1. Unstow Resuscitator (Med Kit locker), connect to Orbiter 02 (M032M, M069M or C6), 02 wlv - ON
2. O2 flow upon depressing O2 trigger arm

**WARNING**
Do not provide forced O2 to a breathing crewmember

3. Position, tighten Resuscitator mask to crewmember's face using head cap, straps

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**CPR STATION**

Rescuer
Restraint
Belt

**Pip Pin**
(Insert into holes within locker latches)

Patient
Restraints (2)

---

Head Cap
Face Mask
O2 Trigger Arm
Straps
O2 Hose Connected to Orbiter 02
Valves: M032M
PSID: C6

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MED/ALL/GEN 3
Preflight Astronaut Physical Training

Principles:

• To be selected it is not necessary to be a high performer in sports activities (some-times it can be even a “handicap” i.e. marathon runner / cardio-vascular status).

• During their whole career they have to maintain a good physical shape (safe sports practice 2 – 3 times per week, = with minimum injury’ risk)

• On NASA side, the sports practices are left on the initiative of each astronaut “self practice”, in Star City the sports’ practices are scheduled and managed in the training time-tables.
In US, NASA Houston, several « physiological » trainings are mandatory or proposed:

- Training in Neutral Buoyancy Facility (for EVA)
- Parabolic flight KC 135
- Training against “sensory conflict effects” (see later Space Adaptation Syndrome) DOME (Device for Orientation and Motion Environment) et le TTD (Tilt Translation Device), AFT (Autogenic Feedback Training)

In Russia, Star City, these trainings are systematic:

- Centrifuge for nominal and emergency descent acceleration Soyuz profiles
- Training against “sensory conflict effects” rotating chair (Coriolis Accelerations)
- Training for hypoxia tolerance (altitude chamber)
- Parabolic Flight Iliouchin 76
- Vacuum and hyperthermia chambers training in suits IVA (SOKOL) et EVA (ORLAN)
- “biofeedback” training
During Flight: space related medical issues, their control (1)

1. Space Adaptation Syndrome (so-called space sickness)
2. Cardio-vascular deconditioning: loss of exercise capacity (mainly for lower limbs)
3. Cardio-vascular deconditioning: after flight orthostatic hypotension
4. Muscle loss (mainly for lower limbs and trunk)
5. Bone loss
6. Whole body radiation exposure
During Flight: space related medical issues, their control (2)

**Space Adaptation Syndrome** (so-called space sickness)

- It is a cinetosis (movement sickness)
- Occurred immediately after orbit arrival
- During 2-4 days (some exceptions)
- 70 – 80% of astronauts are concerned

Countermeasures:

- Preflight training against “sensory conflict effects” (Coriolis acceleration, Dome, TTD, AFT)
- Limit head movements when arriving on orbit
- Medications: prevention and care (promethazine and scopolamine)
- Explained by the “sensory conflict theory”
- NB: after flight “ground sickness” (during some hours)
During Flight: space related medical issues, their control (3)

Cardio-Vascular Deconditioning (1)
(loss in the exercise capacity for lower limbs)

• Consequences of microgravity and hypo kinesia

• This deconditioning occurred slowly and increase with the flight duration

• After a 6 month flight at the level of the lower limbs there is a capacity loss of 20 – 30 % (despite the in flight countermeasures)

• Countermeasure, in flight exercises, 2 times per day one hour session with treadmill, bicycle or ARED

• after flight progressive reconditioning within 1 - 6 weeks depending of the flight duration and after flight physical training intensity.
During Flight: space related medical issues, their control (4)

Cardio-Vascular Deconditioning (2)  
(After flight orthostatic hypotension)

- Consequences of the loss of the “stand-up cardio-vascular reflex”
- This deconditioning occurred after 3 days of microgravity
- After flight 33% of the astronauts are concerned
- After landing it lasts 10 hours up to 72 hours

Countermeasure:
- in flight Low Body Negative Pressure (LBNP / Chibis) 1 time / day on the 5 lst days of the flight (Russian)
- anti-g trousers during reentry (US & Russian)
- water & salt loading (US & Russian)
- after flight progressive reconditioning (1 – 5 days)
During Flight: space related medical issues, their control (4)

**Muscle Loss**
*(Mainly for lower limbs and trunk)*

- Consequences of microgravity and hypo-kinesia
- This muscle loss is occurring slowly and is increasing with the flight duration
- After 6 month flight loss of 4-6 cm on the tigh circumference and 3-5 cm on the calf circumference
- All astronauts are concerned (long flight > 1 month)
- Countermeasure, in flight exercises, 2 times per day one hour session with treadmill, bicycle or ARED
- After flight recovery within 1 - 6 weeks depending of the flight duration and after flight physical training intensity.
During Flight: space related medical issues, their control (5)

**Bone Loss**

- Consequences of microgravity and no more mechanical impacts along the skeleton (# on earth walking, running, jumping, stairing etc.....)

- This bone loss is occurring slowly and is increasing with the flight duration

- After 6 month flight bone loss:
  - Lumbar spine -4% to -6%
  - Pelvis -9 to -12%
  - Femoral neck -6 to -9%
  - Calcaneum -6 to -8%
  - Skull 0 to +2%
  - Whole body -1.4±0.4%

- All astronauts are concerned (long flight > 3 months)

- Countermeasure, “pinguin” suit not efficient, ARED bone efficiency is under evaluation on ISS

- After flight recovery within 3 – 6 months (depend of the physical activity with mechanical impacts)
During Flight: space related medical issues, their control (6)

**Whole Body ionizing radiation Exposure**

- Consequences of the ionizing radiation above the earth atmosphere, Van Allen belt and cosmic galactic sources. Many types of particles (heavy ions up to Iron number) in a large range of energy 10-1000 MeV)
- Permanent flux + solar flares,
- In low orbit There is magnetosphere protection + shielding of the spacecraft
- Solar Flares are a health risk for interplanetary manned exploration (Safe shelter in the spacecraft).

<table>
<thead>
<tr>
<th>Whole body exposure</th>
<th>European Experience Career</th>
<th>Russian Experience career</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 flights (&lt;1month)</td>
<td>2 flights (&lt;1month) + 1 long duration flight (6 months)</td>
</tr>
<tr>
<td>Career Radiation dose received in space</td>
<td>0.9 rem / 10%</td>
<td>10.1 rem / 57%</td>
</tr>
<tr>
<td>Career Radiation dose received for medical reasons</td>
<td>5.1 rem / 60%</td>
<td>5.1 rem / 29%</td>
</tr>
<tr>
<td>Career Radiation dose received in aeronautical activity</td>
<td>0.8 rem / 8%</td>
<td>0.8 rem / 4%</td>
</tr>
<tr>
<td>Career Radiation dose received from earth (natural irradiation)</td>
<td>1.8 rem / 21%</td>
<td>1.8 rem / 10%</td>
</tr>
<tr>
<td>TOTAL :</td>
<td>8.6 rem / 100%</td>
<td>17.8 rem / 100%</td>
</tr>
</tbody>
</table>

*NB: maximum accepted limits for professional exposure: 5 rem / year or 200 rem / career (career = 40 years). Accepted risk is an increase of 3% to have ionizing radiation inducted cancer / non exposed population.*
## During Flight: medical events, their management (1)

### Statistics:

<table>
<thead>
<tr>
<th>Sickness</th>
<th>Among 200 medical events (US sources)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Adaptation Syndrome (medication taken)</td>
<td>58%</td>
</tr>
<tr>
<td>Skin diseases (technical reason)</td>
<td>12%</td>
</tr>
<tr>
<td>Loss of water – Deshydratation (technical reason)</td>
<td>2%</td>
</tr>
<tr>
<td>Colitis</td>
<td>5%</td>
</tr>
<tr>
<td>Dental problems</td>
<td>2%</td>
</tr>
<tr>
<td>Stomatitis</td>
<td>2%</td>
</tr>
<tr>
<td>Decompression sickness (bends)</td>
<td>4%</td>
</tr>
<tr>
<td>Otitis (baro trauma)</td>
<td>2%</td>
</tr>
<tr>
<td>Cardiac Arrhythmia</td>
<td>2%</td>
</tr>
<tr>
<td>Respiratory system infection and congestion</td>
<td>7%</td>
</tr>
<tr>
<td>Minor wounds</td>
<td>4%</td>
</tr>
</tbody>
</table>

NB: on Russian side 3 missions have been stopped for medical reason: 1 non public, 1 prostatitis, 1 cardiac Arrhythmia
During Flight: medical events, their management (2)

The ISS diagnostic & monitoring equipment
During Flight: medical events, their management (3)

The ISS decompression sickness / bends care equipment
During Flight: medical events, their management (4)

The ISS physical exercise equipment
During Flight: medical events, their management (5)
The ISS other countermeasure equipment

On orbit Weight Scale
During Flight: medical events, their management (6)
The ISS Russian medical kits
During Flight: medical events, their management (7)

The ISS US/NASA medical kits
During Flight: medical events, their management (8)
The ISS list of medications (~ 120 items, some are without prescription others are used under flight surgeon control through Private Medical Communications or PMC)

<table>
<thead>
<tr>
<th>Item Code</th>
<th>Item Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2.1</td>
<td>Acetaminophen (Acetosalicylicum)</td>
</tr>
<tr>
<td>2.2.2</td>
<td>Acetaminophen (Acetaminemum)</td>
</tr>
<tr>
<td>2.2.3</td>
<td>Analgesin</td>
</tr>
<tr>
<td>2.2.4</td>
<td>Antacian</td>
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<tr>
<td>2.2.5</td>
<td>Anthocian</td>
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<td>2.2.6</td>
<td>Anaspiclo</td>
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<td>Analgin</td>
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<td>2.2.8</td>
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<td>2.2.9</td>
<td>Actalz</td>
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<tr>
<td>2.2.10</td>
<td>Ascorbic acid</td>
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<tr>
<td>2.2.11</td>
<td>Aspirin (water-soluble tablets)</td>
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<tr>
<td>2.2.12</td>
<td>Aspim Cetril</td>
</tr>
<tr>
<td>2.2.13</td>
<td>Assitrol</td>
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</tr>
<tr>
<td>2.2.99</td>
<td>Zentuz</td>
</tr>
</tbody>
</table>

+ in the first aid kit

- 2.3.2. Asalgin
- 2.3.3. Devalin
- 2.3.4. DETA Cream
- 2.3.5. Drawings
- 2.3.5.1. Sterile Medical Gauze Bandage
- 2.3.5.2. Package of First Aid Medical Dressing With Two Sterile Pads
- 2.3.5.3. Bacterial Adhesive Plaster
- 2.3.6. Hygenic Lipstick
- 2.3.7. Pasteil
- 2.3.8. Phosphorphan
- 2.3.9. Potassium permanganate
- 2.3.10. Prowedol
- 2.3.11. Salbutamethol
- 2.3.12. Synecard
- 2.3.13. Tetracycline
- 2.3.14. Tetracycline Eye Ointment
After Flight: recovery period for space related medical impairments, their management (1)

- after flight “ground sickness”, during some hours, medication are used (mainly prometazine)

- After flight orthostatic hypotension progressive reconditioning (within 1 – 5 days), with anti-g suit constraints adjustment coupled with active orthostatic tests.

- After flight muscle and exercise capacity losses (mainly at the lower limbs level): progressive reconditioning within 1 - 6 weeks depending of the flight duration and after flight physical training intensity. Important: avoid back pain

- After flight bone loss recovery within 3 – 6 months physical activities with mechanical impacts are recommended
Conclusions (5)

• Up to now few medical events (non space related) during flights

• For interplanetary exploration manned mission (500 up to 1000 days duration) with no possibility of emergency descent/return to a ground medical facility (from low earth orbit an evacuation within 12 hours is possible):
  • a specific individual and crew selection process shall be invented for psychological issues
  • the spacecraft design and the crew training will be oriented to insure the full autonomy of the crew during the mission (medical and surgical skillness onboard).
  • the onboard medical equipment shall allow the diagnostic and treatment of more diseases than it is done presently on low earth orbit.
  • as much as possible automatic and reliable environmental control system shall be used onboard the spacecraft.
  • more efficient countermeasures against bone loss, exercise capacity loss, ionizing radiation risk shall be found or invented.
Study on the Survivability and Adaptation of Humans to Long-Duration Interplanetary and Planetary Environments

WP 3300

Limiting Factors for Human Health and Performance:

Psychological Issues

D. Manzey, DLR, Hamburg
Stressors in Space

Space Environment

Mission Tasks

Space Habitat

Social Situation

HUMEX WP 3300

Final Presentation

ESTEC, 30 May 2001
Currently Applied Psychological Countermeasures

- Selection
- Training

In-Flight Support
- Ground-based monitoring
- Uplink of news
- E-mail up-/downlink
- Private family conferences
- Psychological conferences
- Crew packages
- Onboard entertainment
- Visiting crews
Missions to Mars will not be comparable to any other undertaking humans have ever attempted given the distance of travel, the duration of life under constant dependence on life-support systems in isolation and confinement, and the lack of short-term rescue possibilities.

Currently applied countermeasures to maintain individual performance, health and well-being, as well as crew morale via audio-/video contacts can only be provided to a very limited degree.

Most of the possible risks arising from psychological issues will be LARGELY INCREASED. In addition new psychological risks will arise which, in principle, cannot be assessed in advance.
Specific Psychological Key Issues of the 1000-Day Mission Arising from Leaving 2 CM’s in Orbit

- The orbiting crew members will be exposed to excessive levels of
  - monotony and boredom (due to low variety of task demands)
  - social monotony (only partially balanced by intercom contacts to surface crew)
  - sensory deprivation (due to stay in the same spaceship for 1000 days)

- Issues of maintaining motivation of orbiting crew

- Break-down of crew cohesiveness
  - interpersonal and “inter-subcrew” conflicts after re-union during transfer back
  - leadership issues

Whenever possible this feature of the 1000-day reference mission should be avoided
Levels of Possible Countermeasures

Accommodation of living and working conditions during the mission to human needs and capabilities
- Design of habitat (e.g. private crew quarters, interior decor)
- Design of autonomous systems (e.g. concepts of adjustable autonomy)
- Work-Rest Scheduling

Adaptation of humans to the extreme living and working conditions during the mission
- Selection
- Training
- In-flight support
- Post-flight support
Relative Significance of Psychological Countermeasures for Mars Missions

Selection & Crew-Composition

Pre-Flight Training

In-Flight Monitoring & Support

Post-Flight Support