On Being NUMBER ONE

(Prevention)

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#1

FIRST

A QUESTION

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What are the differences among VERIFIED TRAUMA CENTERS 1, 2, and 3 ?

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simple

ANSWERS

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There is NO QUALITY (Clinical) difference between Level 1 & 3 What except:

Level 1 has in hospital capability of:

NEUROSURGERY

CARDIOPULMONARY BYPASS

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Between 1 & 2,
LEVEL 1 must have:

-Residency training programs

-Public Education (Outreach)

-PREVENTION PROGRAMS

-Research

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NOW

A few examples of

REVENTION PROGRAMS

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Falling 2 year old babies

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Shattered Dreams

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Helmets
&
Seat belts

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EMS for the 25 month Earth-MARS-Earth Mission

"A rocket will never be able to leave the earth's atmosphere." --The New York Times, 1936

- Mars
- (Red Planet)
- Atmosphere
- ?Water
- ?Life forms
- Volcanoes
- Craters
- ?Rivers

“…..everything you ever wanted to know about manned mission to Mars (but were afraid to ask)…..”

Kenneth L. Mattox, MD
Houston

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Surgical Contingency Planning Team (2001-2006)

- 1 Senior Space Surgeon Manager
  - 2-3 Astronauts
  - 2 General Surgeons
  - 1 Urologist
  - 2 ED physicians
  - 2 Orthopods
  - 1 Psychiatrist
  - 2 flight surgeons
  - 2 Trauma surgeon
  - -1 Antarctica MD
  - -1 pulmonologist
  - -1 Infectious disease
  - -1 Plastic Surgeon
  - -1 Thoracic Surgeon
  - -1 Neurosurgeon
  - -1 Simulator
  - - 1 anesthesiologist

Assumptions – Urban Legends

- Same gender crew
- Pre-mission appendectomy ?
- Screening H & PE assures no health problems during flight
- Can project all probabilities
- Telemedicine
- Robotic surgery

Mission

- Predict the surgical, Medical, Psychological emergencies
- How to diagnosis, treat
- Will it make a difference
- Traits & skills of the Space Surgeon
- Develop a curriculum & skills set


the impossible dream….
United States
NASA
…an incredible experience

FIRST

An earth bound CONSULT

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What would you do?

CONSULT

- Called to ER (or ICU)
- 46 yo severe abdominal pain
- No BM 3 days
- Visible blood in urine, fever
- Loss of pulse one leg
- Blue swollen leg
- Chest pain
- Dyspnea

What would you do?

Tests & Treatment

What tests do you want?

Who would you ask to help you?

What do you want to know?

What treatment would you consider?

What drugs do you want?

Would you operate if needed?

Consider

- Appendicitis
- Cancer
- Pulm embolism
- Diverticulitis
- DVT
- Dead bowel
- Infections
- Pneumonia
- Arrhythmia

- WBC
- X-ray
- Ultrasound
- CT Scan
- INR
- TEG
- Sed Rate
- “lytes”
- Urinalysis
- ABGs
- EKG

- Antibiotics
- Cystoscopy
- Colonoscpy
- Lytics
- Plavix
- Cardiovert
- Heparin
- Lovenox
- Laparotomy

In your hospital you have virtually every test, imaging, consultant, & treatment known to mankind

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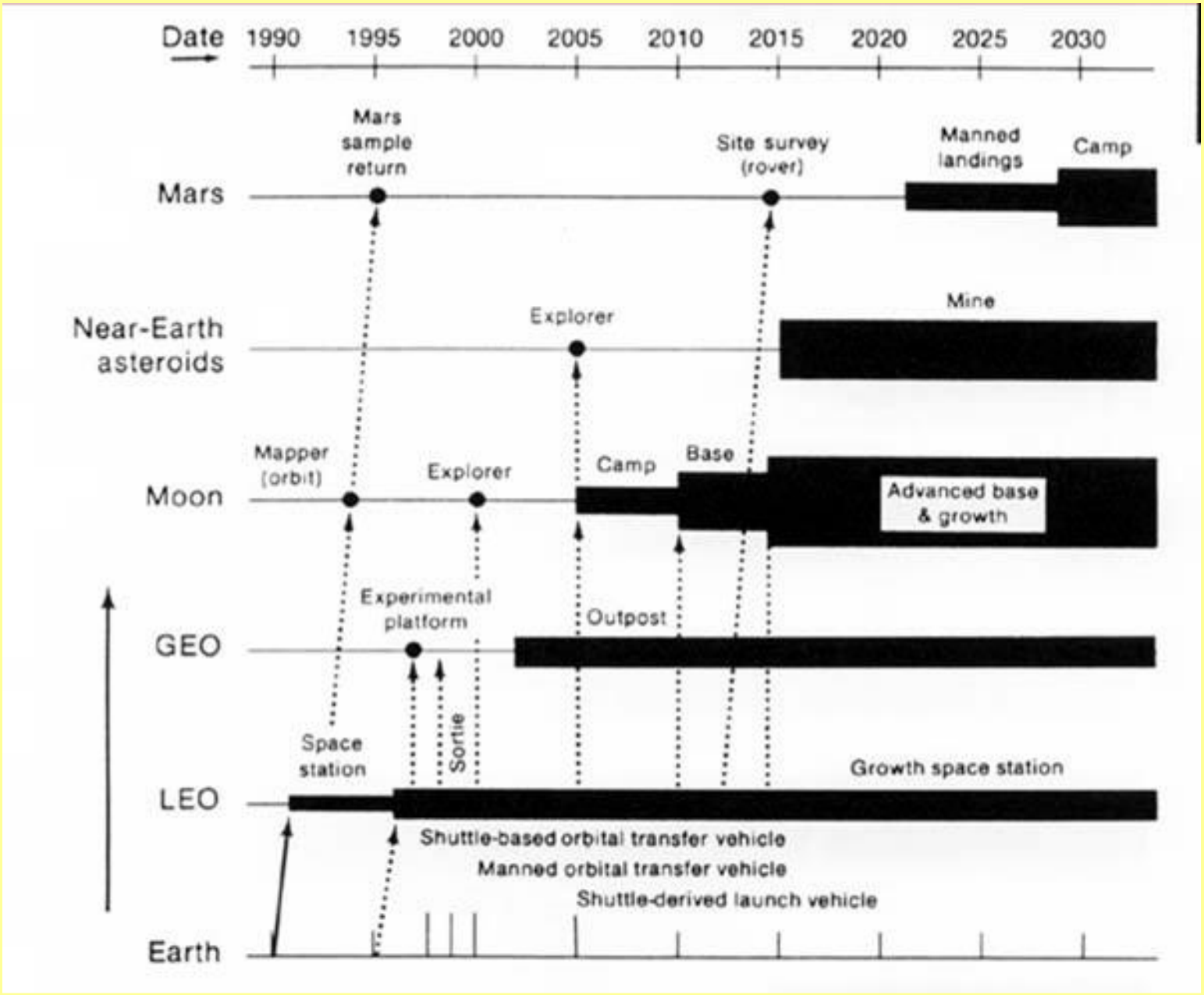
Now, back to exploration

Man has ALWAYS wanted to explore the unknown

- Local explorers
- Magellan
- Columbus
- Lewis & Clark
- Sea depths
- Mount Everest
- Antarctica
- SPACE



…..projected missions. -1989

MARS MANNED MISSION

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Current Mission Configuration

- 25 month round trip
- 5 or 7 member crew – mixed gender
- Living room sized space
- ? Intermediary stop at moon or space station for re-supply (going and coming)
- Target dates

Mission Timelines

- Origional-2010-2012
- Reset- 2020-2025
- Realistic-2030+
- ?? Never

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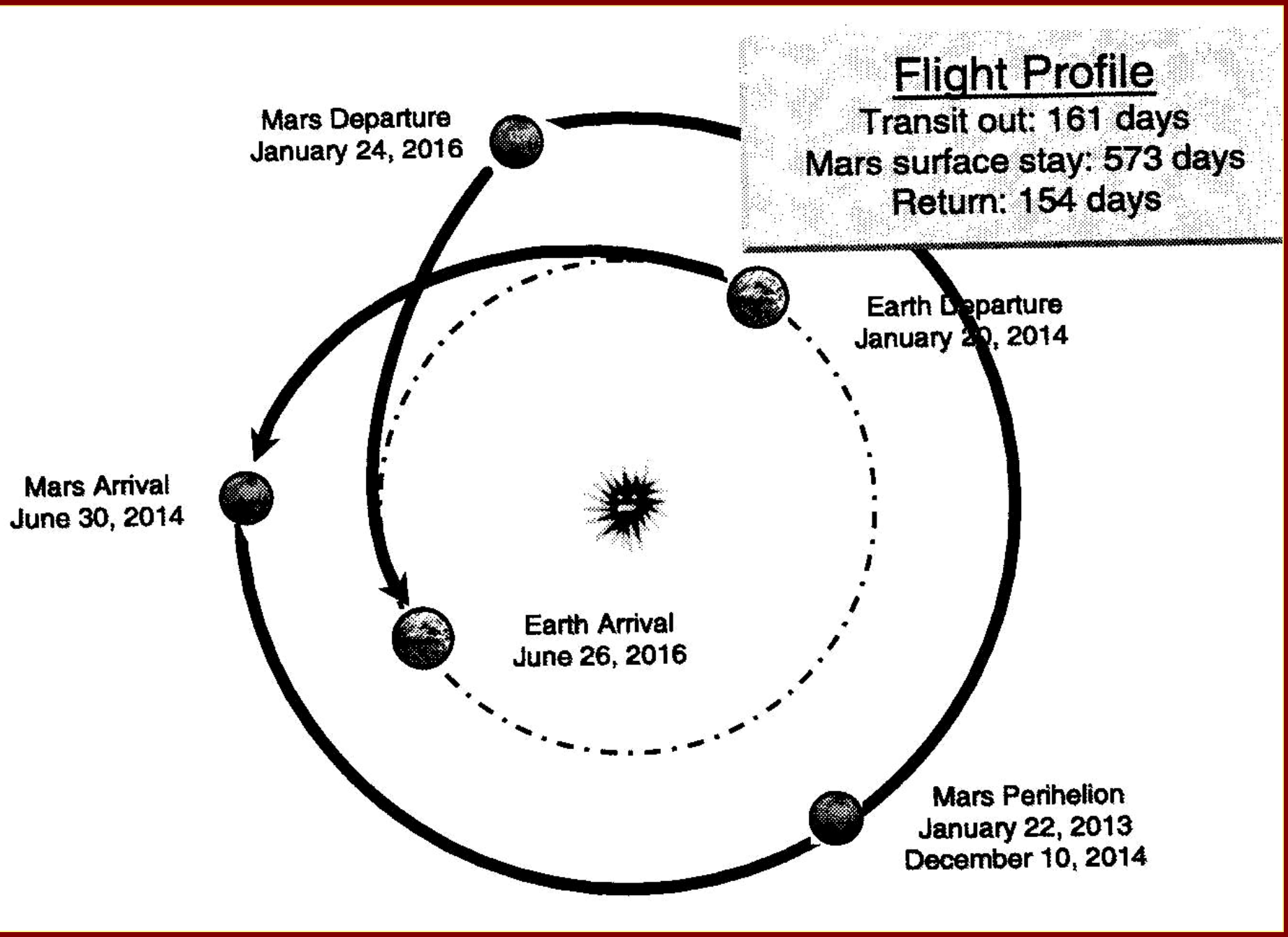

Flight Profile
Transit out: 161 days
Mars surface stay: 573 days
Return: 154 days
Mars Departure
January 24, 2016
Earth Departure
January 20, 2014
Mars Arrival
June 30, 2014
Earth Arrival
June 26, 2016
Mars Perihelion
January 22, 2013
December 10, 2014

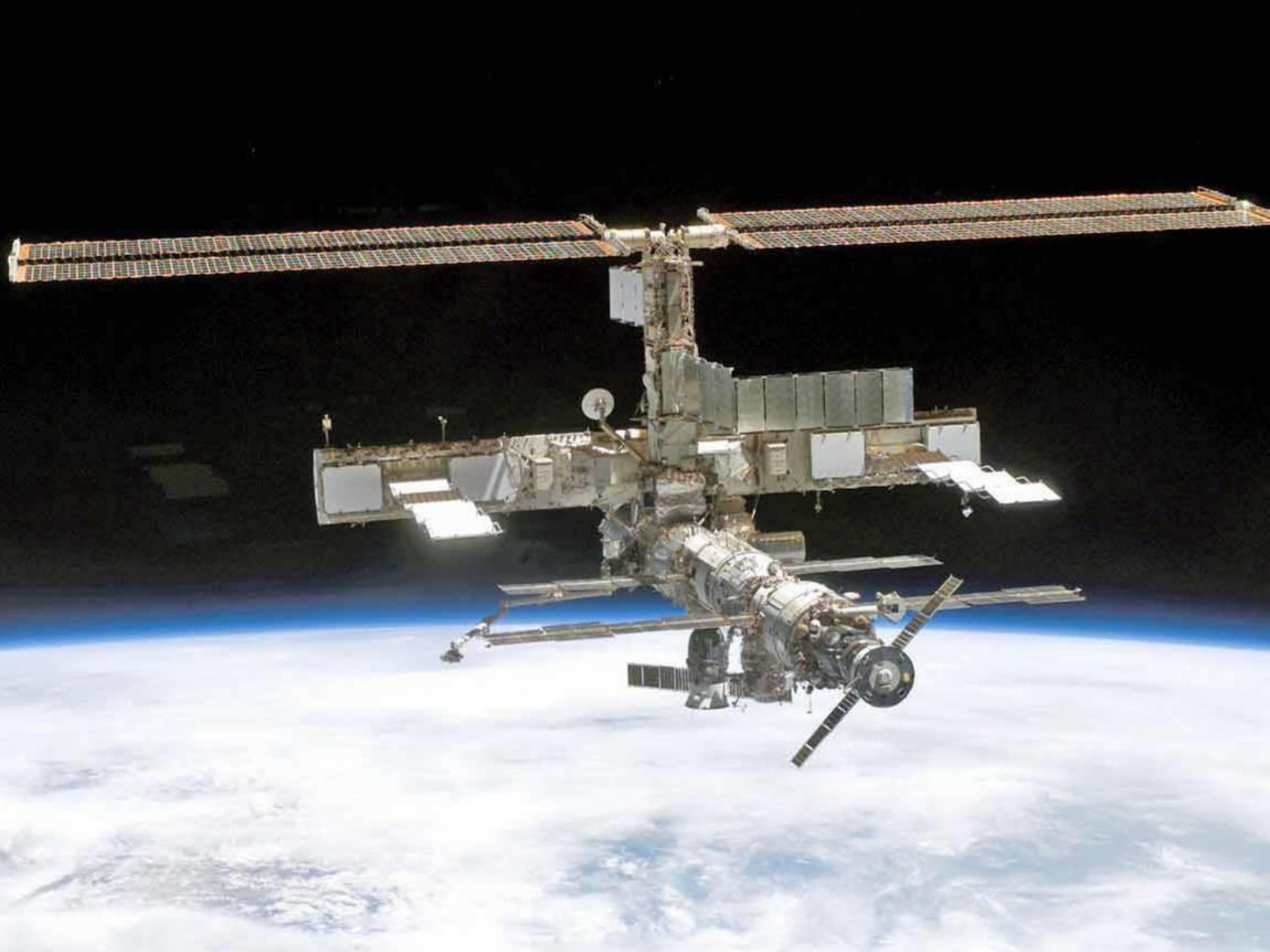
Earth to Mars

Distance

- Closest – 34.58 million miles (2729)
- Longest - >250 million miles
- Average – 170 million miles
- Varies with the 3 dimensional orbits of the 2 planets AND the intermediary re-supply way station and space platform

Communications to Earth

- Types of frequencies
  - Radiowaves
  - Broadband
  - Others
- Time for transmittal
  - ½ way to Mars – 30 minutes ONE WAY
  - Mars – one hour ONE WAY

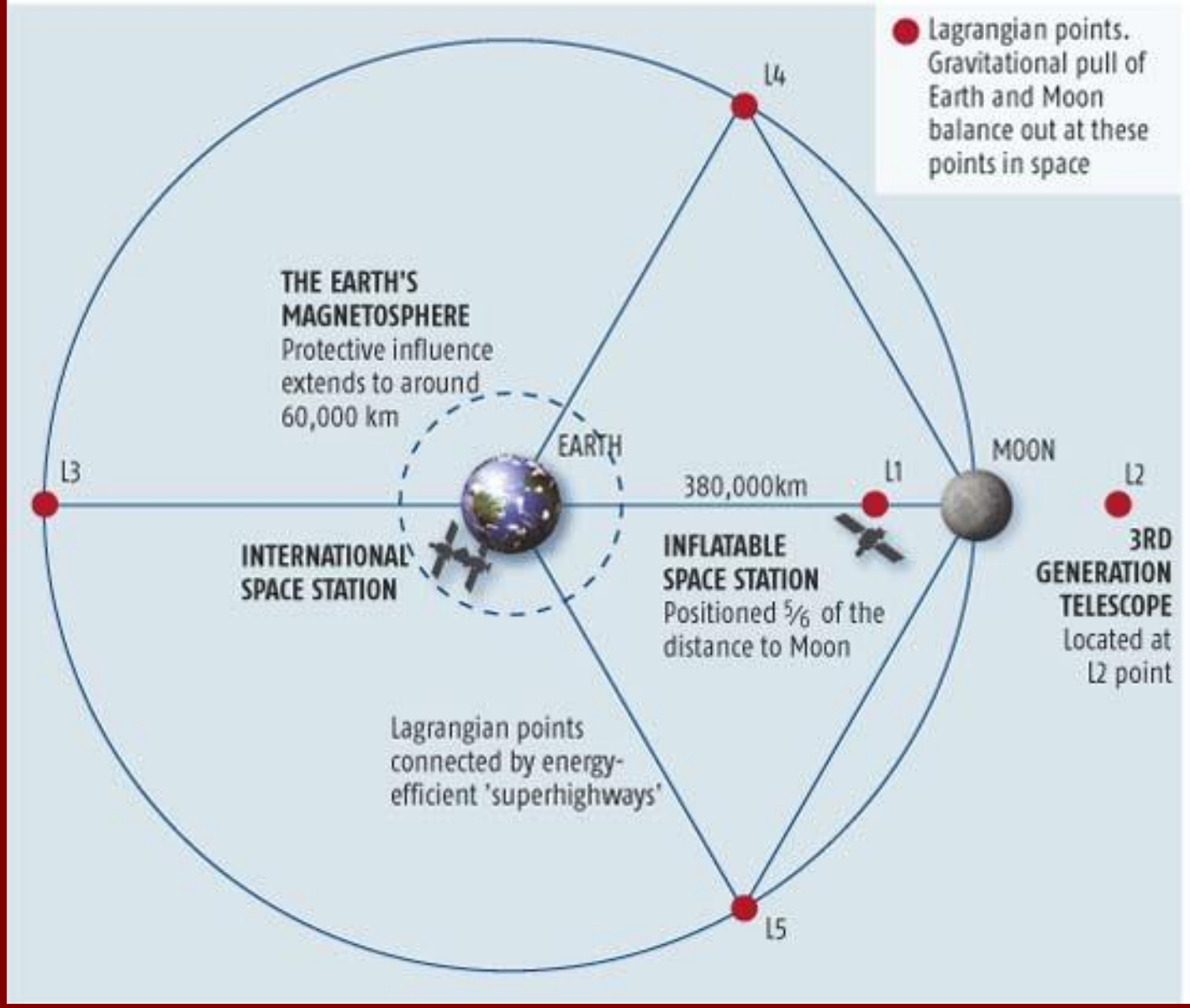


Potential Staging Strategies

- Existing Space Station
- Moon
- New intermediary space station
  - Pre-supplied
  - Emergency rendezvous location
- Pre-positioned re-supply location(s)

NASA'S GRAND PLAN

Space station will be starting point for interplanetary flight



Major Objective
-
Mission Medical Officer

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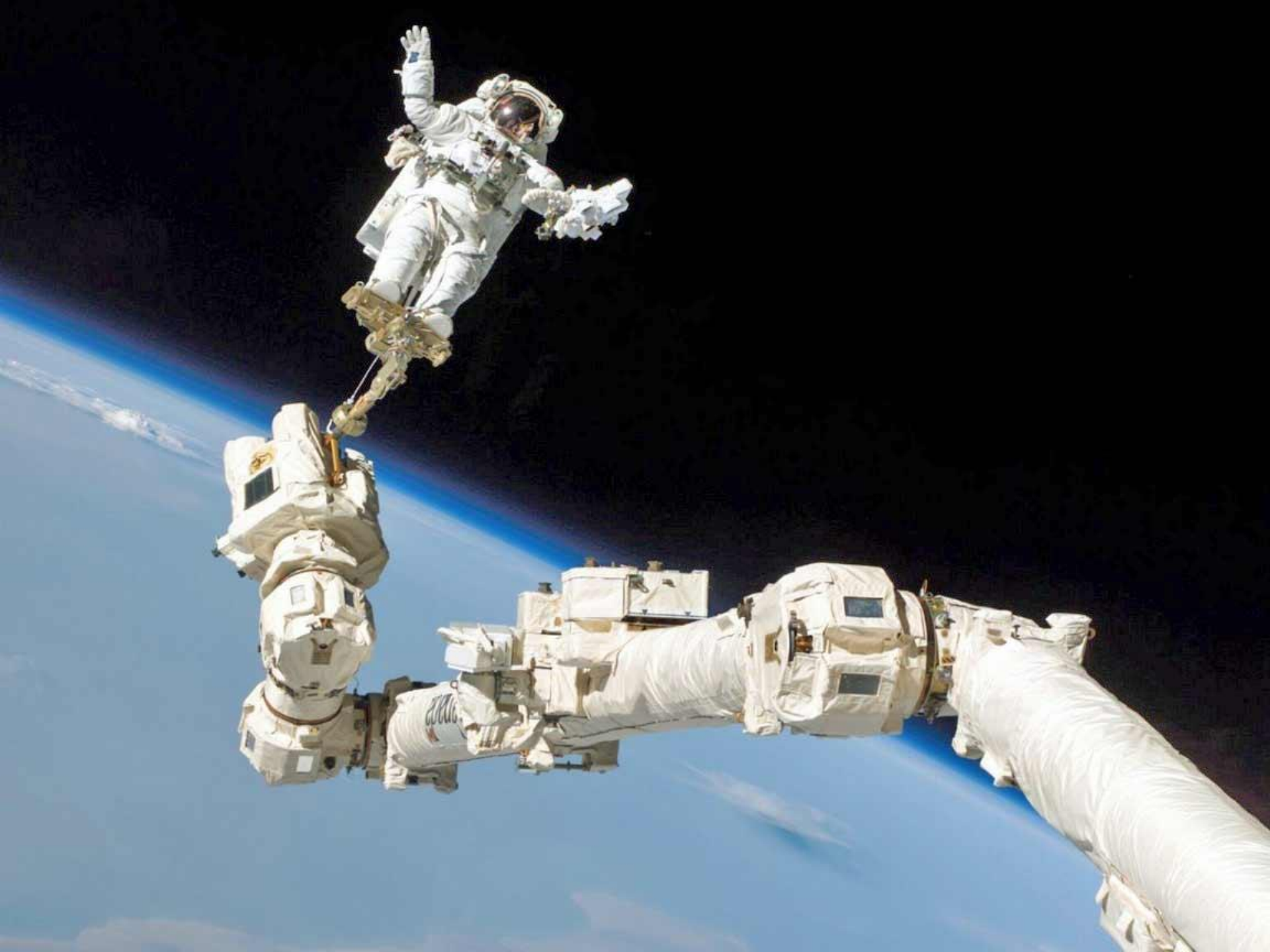
ONE Medical Officer

- Mission Specialist with other duties
  - –How to select
  - –Hot to train
  - –What tools to take
  - –What to do if doctor gets sick



Reality

ALL people have, acquire, develop at some time injury or illnesses of an inherited, congenital, infectious, degenerative, mechanical, metabolic, traumatic, or neoplastic nature.

EVERYONE !

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Reality

Some medical problem (minor to COMPLEX) has developed on every space,

long submarine & Antarctica mission

EVERY ONE !

…and will in the future.

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Reality

…and will in the future (including the Manned Mars Mission).

- Some will be:
  - Surgical
  - Infectious
  - Behavioral
  - Traumatic
  - Psychosomatic
  - Neoplastic
  - Degenerative
  - Allergenic
  - Metabolic
  - Other

Reality

…and will in the future (including the Manned Mars Mission).

- And…….:
  - Will involve EVERY body organ system & subsystem
  - The entire spectrum of diseases affecting humans
  - And…..maybe some new ones
  - (and…probably some new ones)

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Reality

- "illnesses & Injuries" options:
  - Can wait till tomorrow to evaluate
  - Can wait several weeks or months
  - Get "well" without a doctor
  - Have "emergency" complications
  - Have "STAT" requirements
- You are the doctor & exercise judgment

Reality

....some will require surgery.

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Known Space Medicine Science

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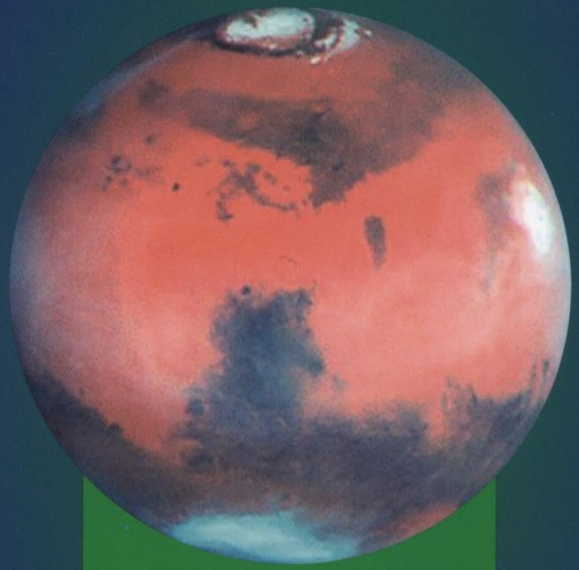
SAFE PASSAGE

Astronaut Care for Exploration Missions



2020
2014
2008
2002

INSTITUTE OF MEDICINE

BOX 2-1
Some Major Human Physiological Changes Resulting from Extended Travel in Earth Orbit

Musculoskeletal System
- Loss of bone mineral density
- Loss of skeletal muscle

Cardiovascular System
- Orthostatic hypotension
- Loss of hydrostatic pressure

Pulmonary System
- Changes in pulmonary circulation and gas exchange

Alimentary System
- Ileus
- Decrease in absorption or malabsorption

Nervous System
- Ataxia
- Motion sickness
- Disturbed fine motor and gross motor functions
- Altered sleep-circadian rhythm and sleep deprivation

Reproductive System
- Effects of radiation on gametes

Urinary System
- Renal calculi

Hematological and Immunological Systems
- Anemia
- Potential immunologic depression

Source: Billica, 2000.

BOX 3-1
Major Health and Medical Issues During Spaceflight

Health or Medical Issue	GRD	AIR	STS	ISS	EXP
Radiation protection	G	G	G	Y	R
Hearing conservation	G	G	G	R	TBD
Cardiovascular	G	G	G	Y	TBD
Muscle	G	G	G	Y	TBD
Bone loss	G	G	G	Y	TBD
Neurovestibular	Y	NA	G	R	TBD
Habitability	NA	G	Y	Y	TBD
Extravehicular activity risk	NA	G	Y	Y	TBD
Medical care	Y	NA	Y	Y	TBD
Diversity (age, gender, etc.)	Y	NA	Y	Y	TBD
Psychological issues	Y	G	G	Y	TBD
Workers' compensation	Y	G	G	Y	TBD

Abbreviations: GRD, ground; AIR, airflight; STS, space shuttle; ISS, International Space Station; EXP, exploration-class mission; G, green, little or no risk; Y, yellow, moderate risk; R, red, severe risk; TBD, to be determined; NA, not applicable.

Source: Williams, 2000.

TABLE 3-1 In-Flight Medical Events for U.S. Astronauts During the Space Shuttle Program (STS-1 through STS-89, April 1981 to January 1998)

Medical Event or System by ICD-9[a] Category	Number	Percent	Incidence/14 days
Space adaptation syndrome	788	42.2	2.48
Nervous system and sense organs	318	17.0	1.00
Digestive system	163	8.7	0.52
Skin and subcutaneous tissue	151	8.1	0.48
Injuries or trauma	141	7.6	0.44
Musculoskeletal system and connective tissue	132	7.1	0.42
Respiratory system	83	4.4	0.26
Behavioral signs and symptoms	34	1.8	0.11
Infectious diseases	26	1.4	0.08
Genitourinary system	23	1.2	0.07
Circulatory system	6	0.3	0.02
Endocrine, nutritional, metabolic, and immunity disorders	2	0.1	0.01

[a]International Classification of Diseases, 9th edition.

SOURCE: Billica, 2000.

TABLE 3-2 Medical Events Among Seven NASA Astronauts on *Mir*, March 14, 1995, through June 12, 1998

Event	Number of Events	Incidence/100 Days
Musculoskeletal	7	0.74
Skin	6	0.63
Nasal congestion, irritation	4	0.42
Bruise	2	0.21
Eyes	2	0.21
Gastrointestinal	2	0.21
Psychiatric	2	0.21
Hemorrhoids	1	0.11
Headaches	1	0.11
Sleep disorders	1	0.11

NOTE: Data from the Russian Space Agency reports that there were 304 in-flight medical events onboard the *Mir* from February 7, 1987, through February 28, 1998. The numbers of astronauts at risk or the incidence per 100 days was not reported.

SOURCE: Marshburn, 2000b.

TABLE 3-3 Medical Events and Recurrences Among Astronauts of All Nationalities on *Mir,* March 14, 1995, through June 12, 1998

Event	Number of Events	Recurrences
Superficial injury	43	2
Arrhythmia	32	98[a]
Musculoskeletal	29	NR[b]
Headache	17	8
Sleeplessness	13	9
Fatigue	17	4
Contact dermatitis	5	3
Surface burn	5	NR
Conjunctivitis	4	2
Acute respiratory infection	3	NR
Asthenia	3	2
Ocular foreign body	3	NR
Globe contusion	2	NR
Dental	2	NR
Constipation	1	NR

[a]See Chapter 2.
[b]NR, not reported.

SOURCE: Marshburn, 2000b.

TABLE 3-4 Pharmacopoeia Usage During *Mir* Missions

Medications	Number of tablets or doses dispensed
Pseudoephedrine	131
Zolpidem	81
Temazepam	68
Diphenhydramine	60
Aspirin	55
Acetaminophen	37
Bisacodyl	32
Ibuprofen	28
Terfenadine	18
Long-acting phenylpropanolamine	13
Nose drops (Neosynephrine)	9

SOURCE: Marshburn, 2000b.

NOTE: This list reaffirms the discomforts experienced by crew of previous missions and suggests the probability that nasal congestion, sleep disorders, pain, and constipation will afflict the crews of longer-duration space missions.

TABLE 3-5 Incidence of Health Disorders and Medical-Surgical Procedures During 136 Submarine Patrols

Disorder	Number/100,000 Person-Days
Injury (includes accidents)	48.8
Respiratory	24.6
Skin or soft tissue	19.0
Ill-defined symptoms	10.5
Infections	10.0
Procedure	**Percentage of All Procedures Performed**
Wound care, splinting	42.0
Suturing	18.7
Cleansing	8.2
Nail removal	6.8
Fluorescein eye examination	4.2
Incision and drainage of abscess	2.9
Tooth restoration	2.0

SOURCE: Thomas et al., 2000.

TABLE 3-6 Reasons for 332 Medical Evacuations from All Submarines, U.S. Atlantic Fleet, 1993 to 1996

Reason for Evacuation	Number of Cases
Trauma	71
Psychiatric illness	41
Chest pain	34
Infection	40
Kidney stone	23
Appendicitis	21
Dental problem	31
Other	71
Total[a]	332

[a] Rate = 1.9 to 2.3 per 1,000 person-months.

SOURCE: Sack, 1998.

TABLE 3-7 ANARE Health Register Illnesses in Antarctica from 1988 to 1997

Disorder	Number	Percent
Injury and poisoning	3,910	42.0
Respiratory	910	9.7
Skin, subcutaneous	899	9.6
Nervous system or sensory organs	702	7.5
Digestive	691	7.4
Infection or parasitic	682	7.3
Musculoskeletal or connective tissue	667	7.1
Ill-defined symptoms	335	3.6
Mental	217	2.3

SOURCE: Lugg, 2000.

BOX 3-4
"Normal" Findings on Physical Examination in Microgravity

Facial and periorbital edema
Oily facial skin
Hyperemia: facial skin, conjunctivae, mucosae of the nose, and mucosae of the pharynx
Jugular venous distention
Elevation of diaphragms by two intercostal spaces
Point of maximal cardiac impulse displaced substernally or not palpable
Posture: barrel chest, hyperextended back, flexion of upper and lower extremities
Extremities: thinning of lower extremities
Neurological: hyperreflexia

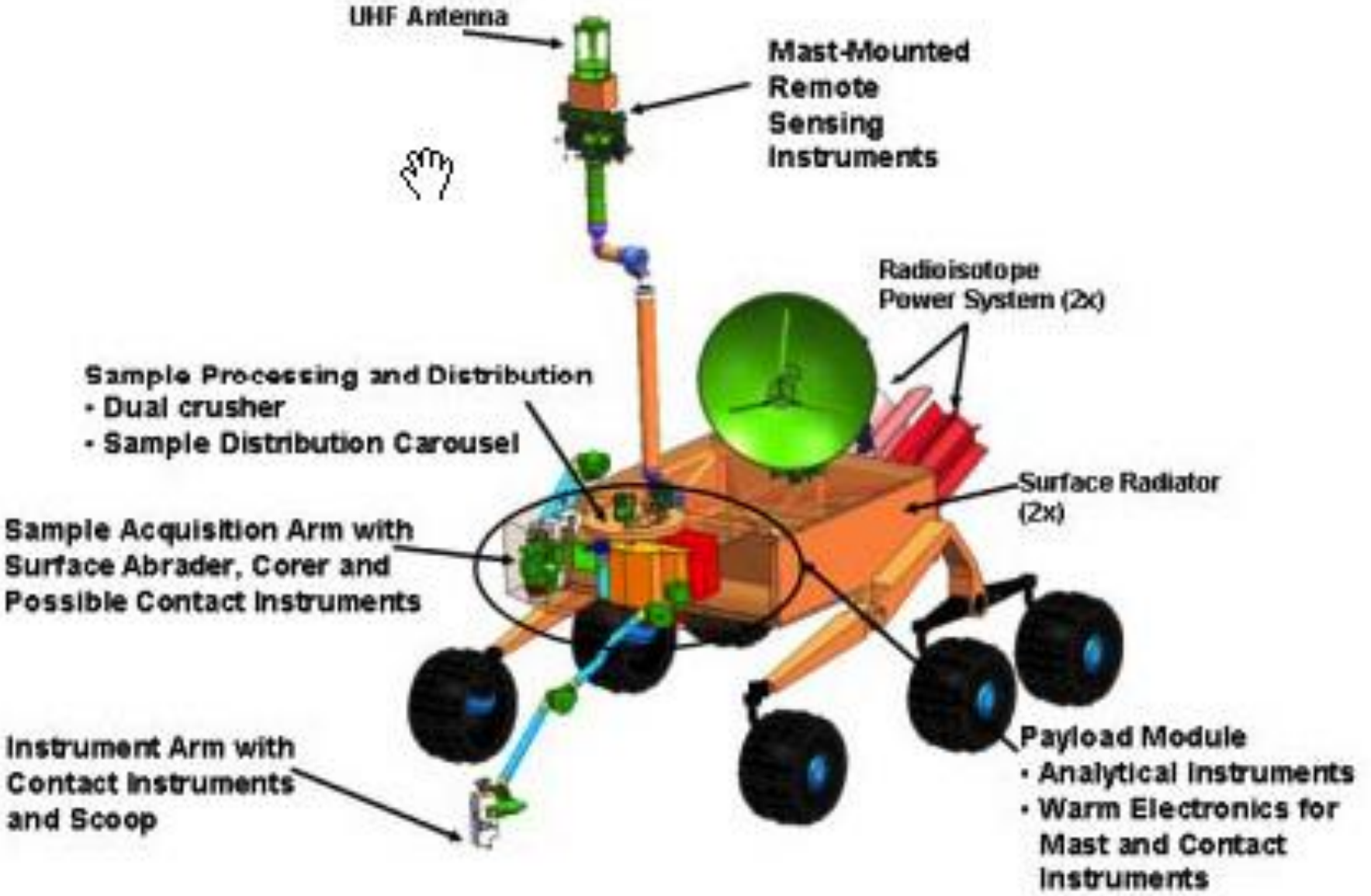
Source: Harris et al., 1997.

Surgery in Weightlessness

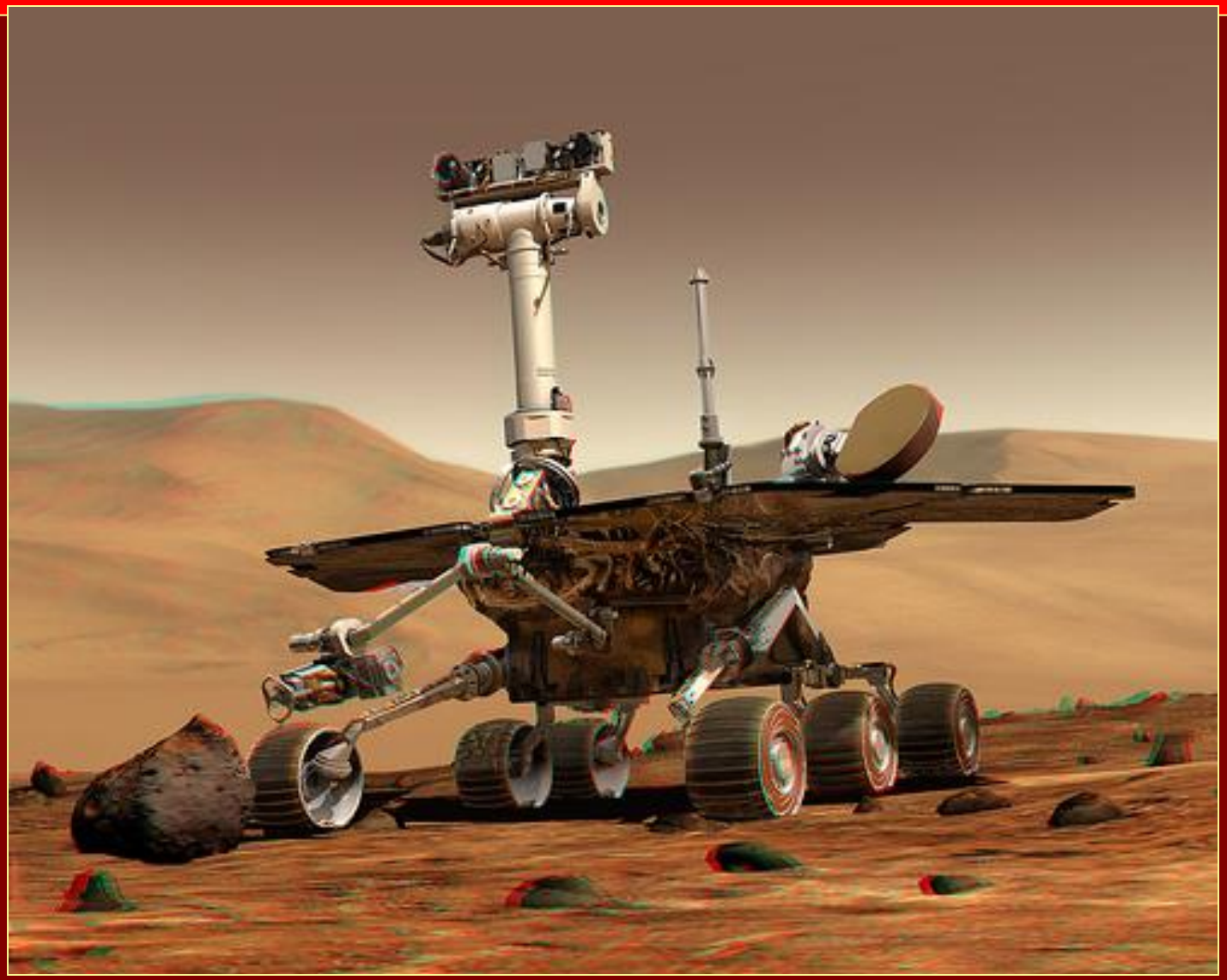
- Blood forms globules, streams & floats in the air space
- Instruments float
- Surgeon tethered to base
- Intestines float into space
- No real “sterile” field

Diagnostic Equipment

- Pre-mission physical exams
- In-flight physical examination
- “I-Stat” type lab device
- Ultrasound
- Limited “scopes”
- Stethoscope
- ? Near infrared spectroscopy
- ? Thrombo-elastogram


UHF Antenna
Mast-Mounted Remote Sensing Instruments
Radioisotope Power System (2x)
Sample Processing and Distribution
• Dual crusher
• Sample Distribution Carousel
Surface Radiator (2x)
Sample Acquisition Arm with Surface Abrader, Corer and Possible Contact Instruments
Instrument Arm with Contact Instruments and Scoop
Payload Module
• Analytical Instruments
• Warm Electronics for Mast and Contact Instruments

? Space Ambulance ?



Surgical Equipment

- Scalpel, scissors, hemostats
- Suture, staples, needles
  - Reusable vs. Disposable
- Scope(s)
- “Autoclave” ??
- Splints, external fixators
- Tubes, catheters

Drugs, Solutions, Medications

- Plasma, platelets, blood
- Plenty of water can be generated
- Make electrolyte solutions on board
- ? Food & Supplements ? (25 months)
- Analgesics, Sedatives, Anesthetics
- Antibiotics, Creams, ointment, drops
- GI medicines, antihistamines
- Anti-nausea, vestibular, eye meds

Pharmacopeia

- Antibiotics
- Analgesics
- Anesthetics
- Antihistamines
- Sedatives/hypnotics
- Mental health medications
- Cardiac medications

Cardiac Arrest

- Newton's 1st Law
- CPR
  - Tether rescuer to body
  - Heart is displaced in space
- If revived, where is ICU?
- "Moses Capsule" ??
- If dies…
  - What to do with body ?

Treating Devices

- OR Table ?
- Endoscopes – types, multiple purpose, reuse, cleaning
- Splints, casts, fixations
- Dressings, drugs, sutures, staples
- OTC medications
- Psycho-Social support, diagnosis, treatment

Mars surface shelter & exploration ?

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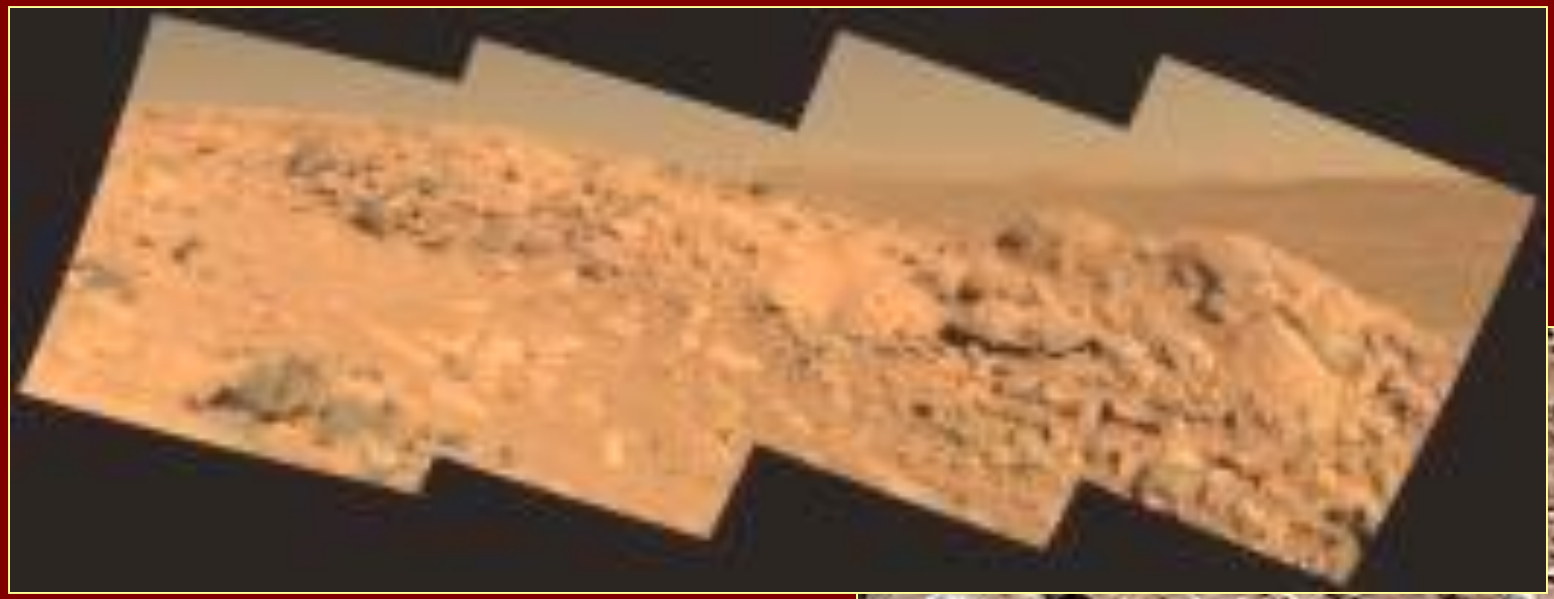
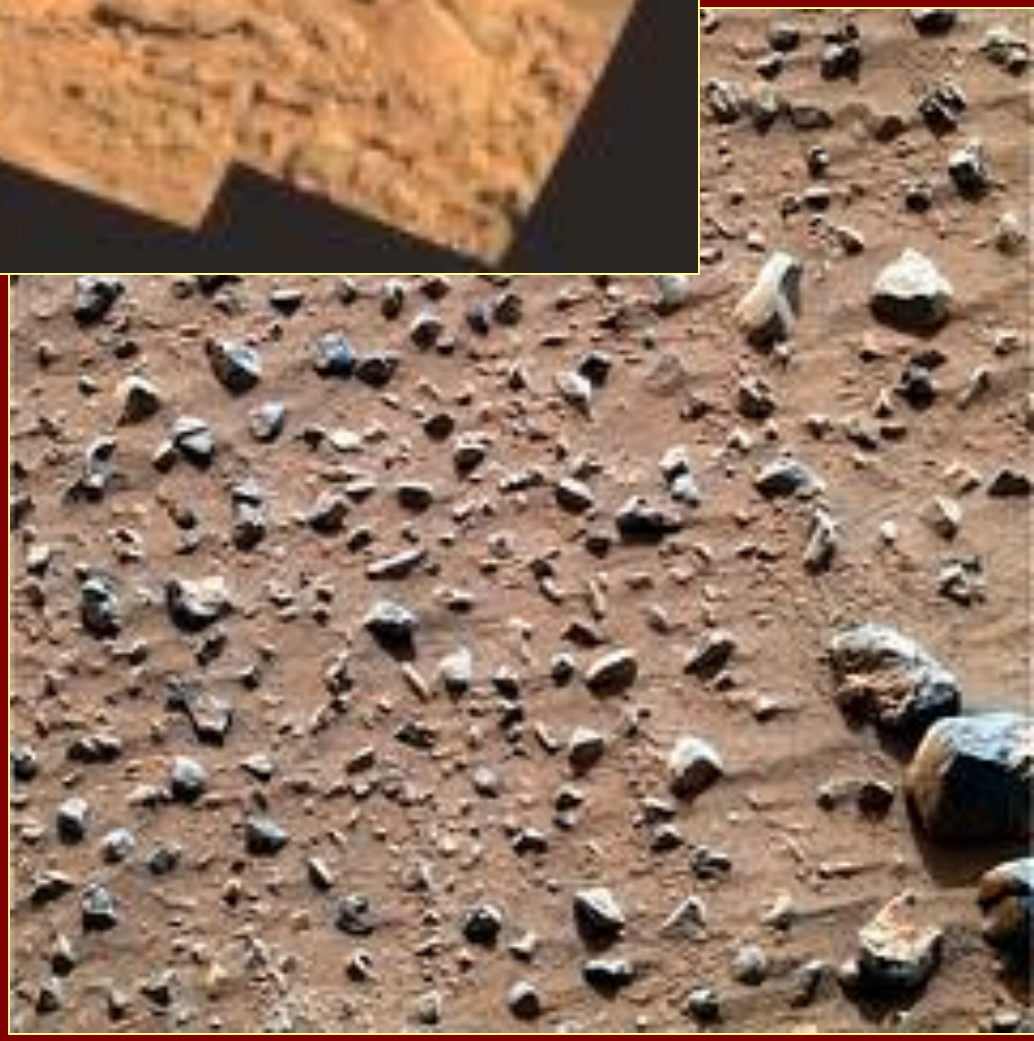
Mars • Syrtis Major • March 10, 1997
HST • WFPC2



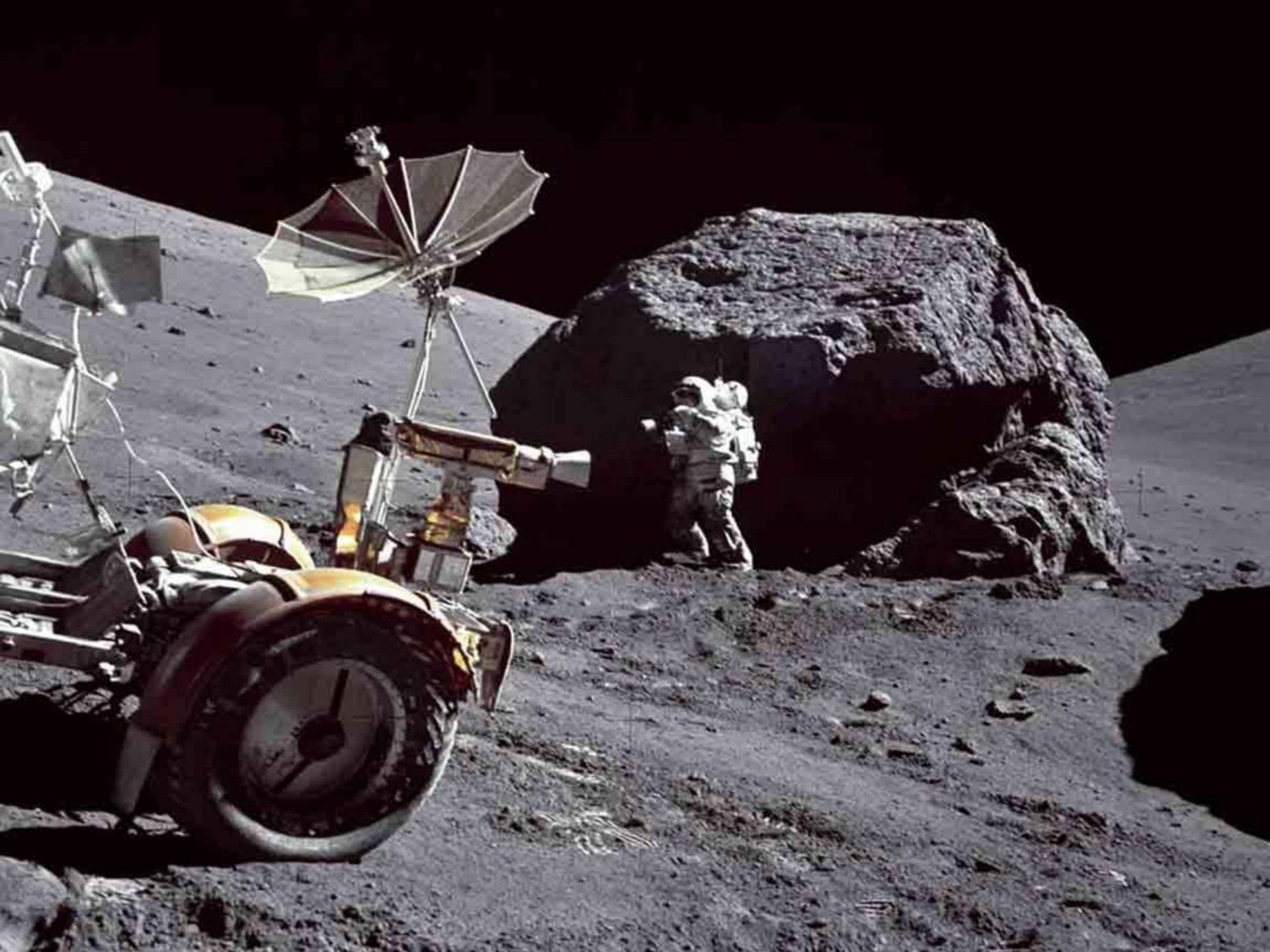


Critical Care, Transfusions

- No real isolation
- Monitors are miniaturized
- ? Artificial ventilation - ? When, ? Why
- No “long term” supplies
- Heimlich valves, not chest bottles
- ? End points ?

Deaths

- Probability of death during mission – less than a fraction of 1%
- BUT NOT ZERO
- Potential causes of death
  - Trauma
  - Cardiac arrythmias
  - Infection, obstruction
  - GI & other bleeding



Special Issues

- Bone demineralization
- Radiation
- Infections
- Mental health
- Mixed gender crew
- Microbiological colonization
- Environmental health polution
- ? Ethics & protocols

Summary

Mission

- Predict the surgical emergencies
- How to diagnosis, treat
- Will it make a difference
- Traits & skills of the Space Surgeon
- Develop a curriculum & skills set