Terrestrial Benefits of Advanced Healthcare Technologies Developed and Used by NASA

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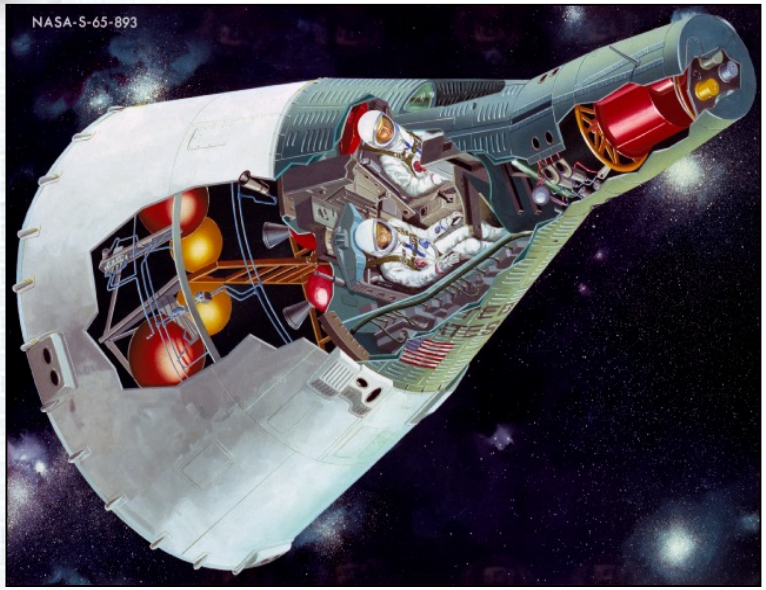
Space Medicine: Over 40 years of Experience



In search for solutions, NASA has been promoting, developing and using advanced, innovative technologies to deliver health care.

For over 40 years, technologies derived from space medicine also enhance health care for everyone on Earth.

Purposes of Space Medicine

- **For every mission / crewmember**
  - Protecting and improving health and performance
  - Preventing long-term health consequences
  - Responding to trauma or illness

- **Long-Term**
  - Improving medical capabilities in microgravity
  - Advancing knowledge in space medicine
  - Advancing the practice of medical telemetry and telemedicine
  - Preparing for return to the moon and missions to Mars

Space Flight is a Model / Example of:

Medicine in a limited-resource environment

Healthy lifestyle and wellness promotion

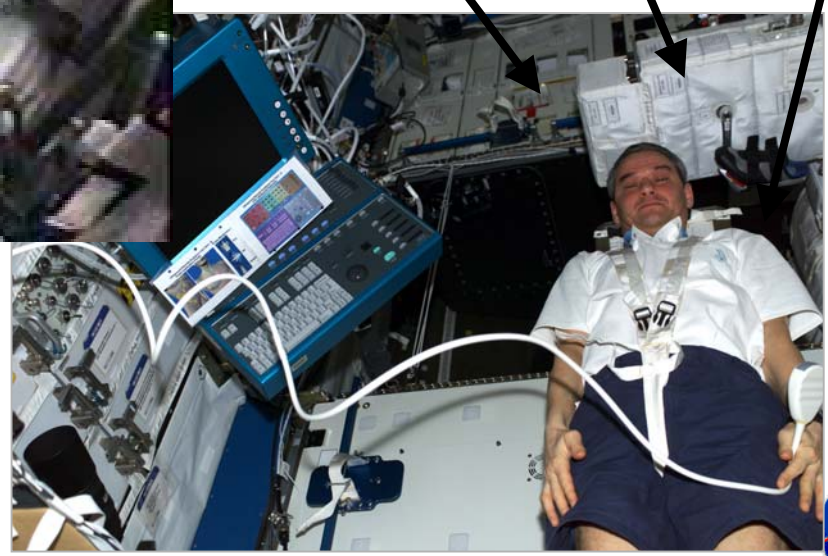
Environmental awareness and resource conservation

Successful operation of a joint multilateral medical system

Two examples of NASA-developed technologies related to telemedicine and medical research

- **Ultrasound**
  - Advanced Diagnostic Ultrasound in Microgravity (ADUM)
  - Onboard Proficiency Enhancement (OPE)
- **Autonomous Space Airway System (ASAS)**
  - Lightweight Trauma Module (LTM)
  - Oxygen Generation with Closed Loop Control

Advanced Diagnostic Ultrasound (ADUM)



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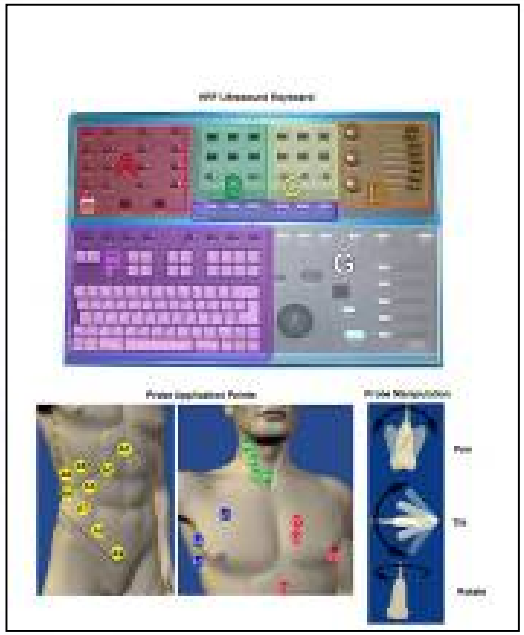
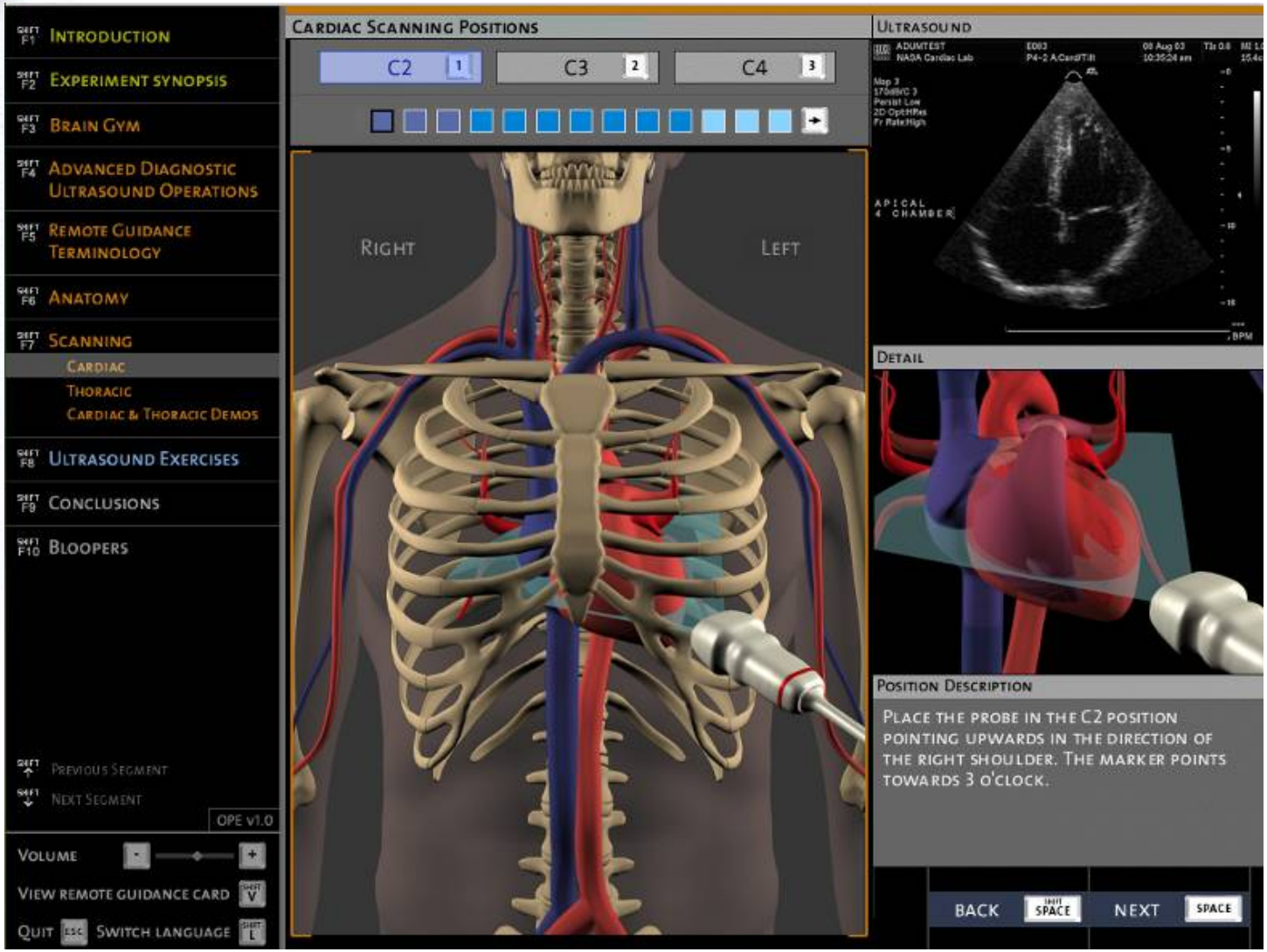
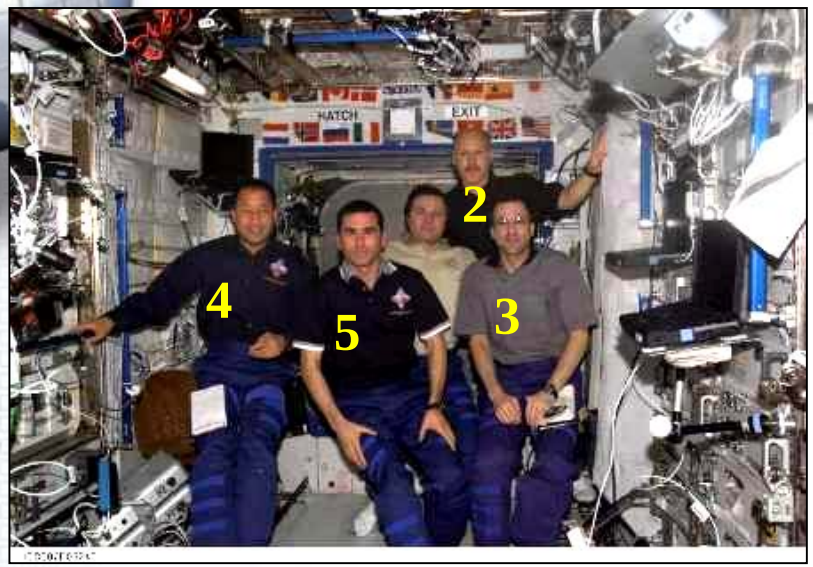


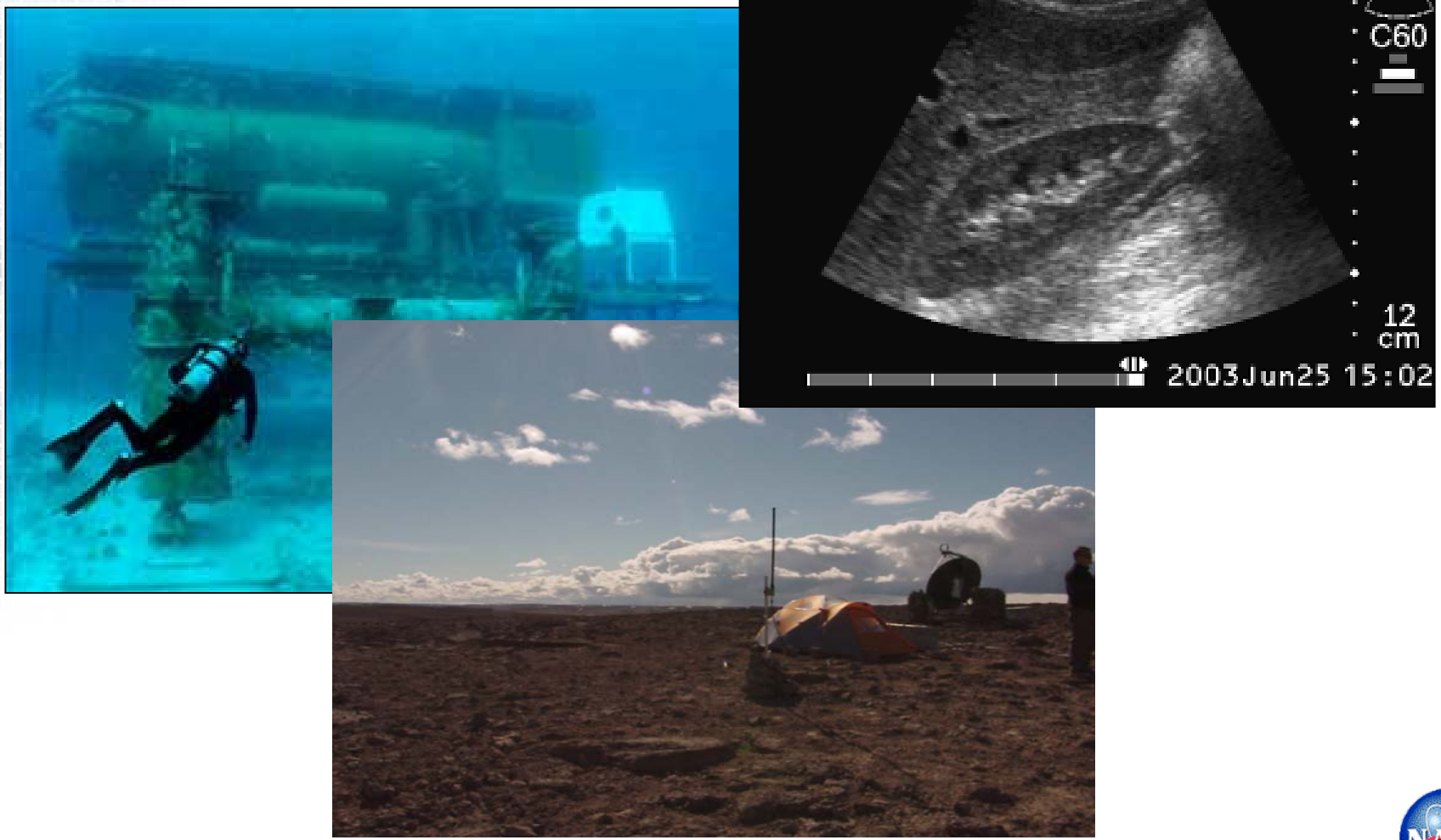
Onboard Proficiency Enhancement (OPE)



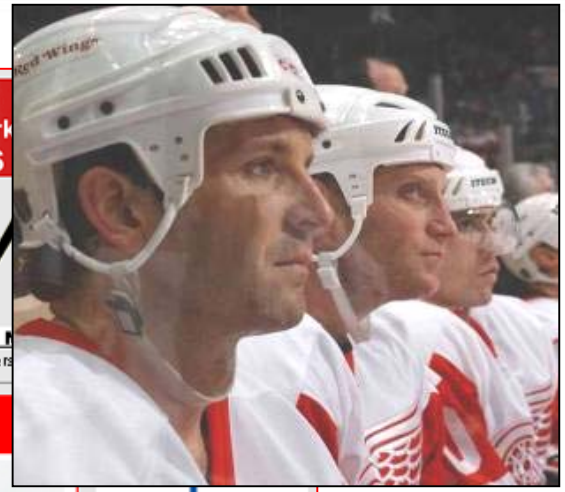


ISS Crewmembers Involved in Telemedicine Development

Terrestrial Applications – Remote Locations



Terrestrial Applications - Sports Medicine



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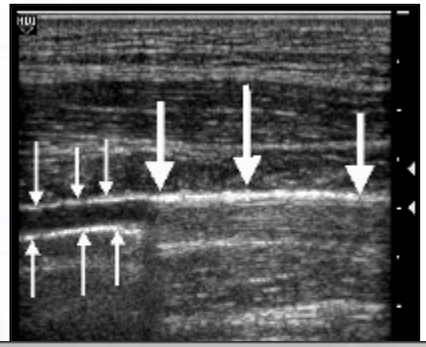
New Diagnostic Methods and Approaches

Hemothorax



Pneumothorax

Kirkpatrick AW, Nicolaou S, Rowan K, Liu D, Cunningham J, Sargsyan AE, Hamilton D, Dulchavsky SA. Thoracic sonography for pneumothorax: the clinical evaluation of an operational space medicine spin-off. *Acta Astronaut.* 2005 May-Jun;56(9-12):831-8.

Chiao L, Sharipov S, Sargsyan AE, Melton S, Hamilton DR, McFarlin K, Dulchavsky SA. Ocular examination for trauma; clinical ultrasound aboard the International Space Station. *J Trauma.* 2005 May;58(5):885-9.

Autonomous Space Airway System (ASAS)

The Autonomous Space Airway System project is an effort to develop and test algorithms, technology, and operational concepts to provide autonomous airway support with minimal resources, training, and caregiver intervention.

Background

- **Collaborative partnership between industry, military, NASA, and Academia.**

Activities

- **Human clinical trials of closed loop control algorithms underway at the University of Cincinnati.**
- **Developing Lightweight Trauma Module to meet ventilator and monitoring requirements of Autonomous Space Airway System.**
- **Developing in-situ oxygen concentration system to generate oxygen for medical use without changing total cabin O2 concentration or requiring consumables.**

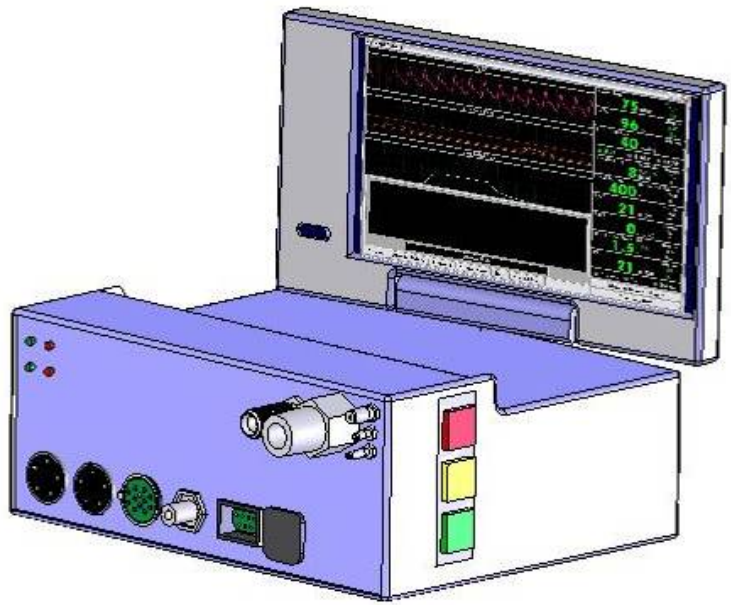
Lightweight Trauma Module: Overview

Integral:

- Ventilator
- 12-lead ECG
- Pulse-Ox
- NIBP
- AED
- End-tidal CO2
- Temperature
- Ethernet Communications
- Smart help
- Closed-loop control
- Electronic medical record

Planned Modules:

- Aspirator
- I.V. pumps
- Patient controlled analgesia
- Spirometer
- O_2 concentrator
- Patient warming
- Stress test
- Anesthesia Module
- Ultrasound imaging
- Visualization
  - Oto/ophthalmoscope
  - macrolens camera



Lightweight Trauma Module: Status

- Functional version 2.0 prototype completed and demonstrated.
- Significant military funding complements NASA's support of the Space Act Agreement to develop 'next generation of autonomous, light, and lean' patient transport and treatment hardware.
- Version 3.0 prototype currently being developed with significant design input from NASA Space Medicine engineers.
- Represents lowest possible mass/power/volume system with FDA/MIL SPEC approval.

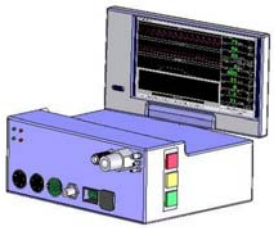
Closed Loop Control Algorithms

- The 754-AP ventilator was collaboratively developed under a Space Act Agreement between NASA and Impact Instrumentation, Inc., and provides both local and remote control and monitoring of ventilator parameters and settings.
- Clinical trials began in July 2005. The trials pair the ventilator with laptop based algorithms to investigate the effectiveness of closed loop control of FiO2 based on SpO2.
- Ten patients of a planned 15 patient study have been successfully treated to date.

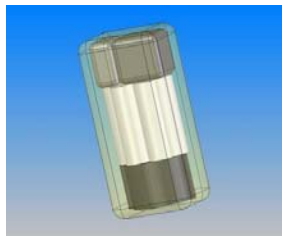
Oxygen Generation with Closed Loop Control

Patient

LTM



Portable Oxygen Generating System



Problem:

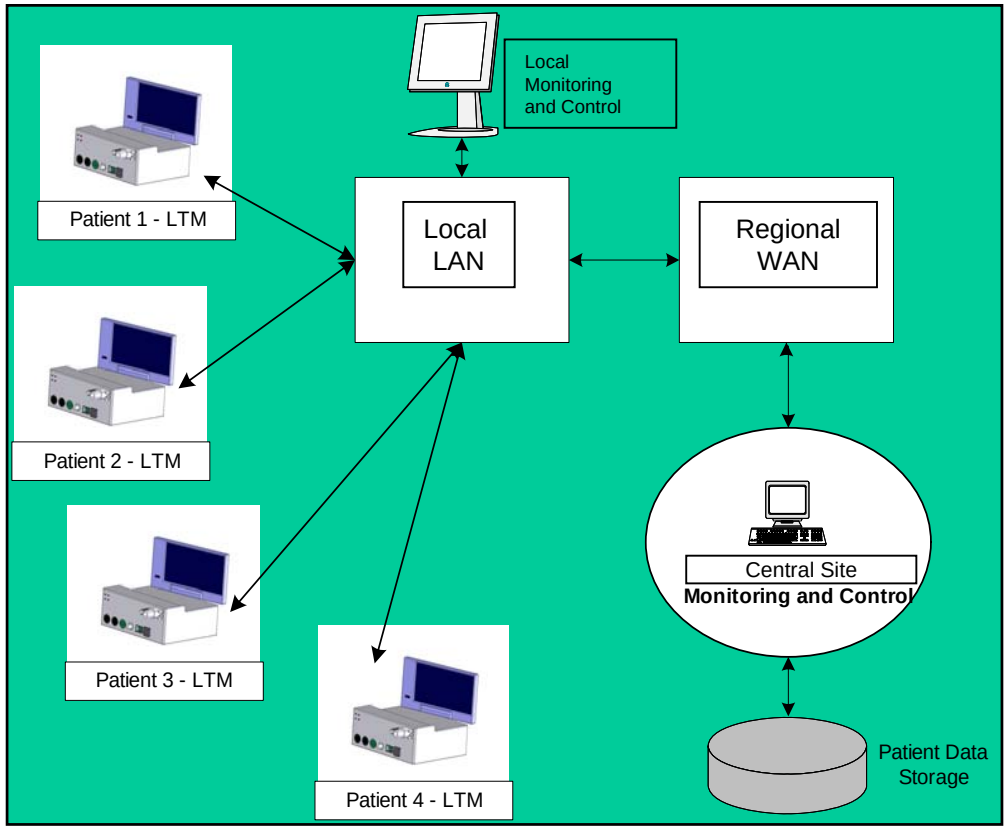
When providing medical oxygen, O2 not metabolized is returned to the cabin and rapidly increases the partial pressure of O2 in the cabin until a fire limit is reached. In a conventional O2 system, this fire limit, rather than patient needs, would determine the end point of care. Access to compressed O2 is another limitation that dictates treatment capability, especially in patient transport.

Solution:

An O2 concentrator extracts oxygen from the ambient environment to deliver to a patient. Patient exhalation returns unused O2 to the cabin. This creates no net change in O2 concentration and does not require additional consumables. FiO2 range 21-60%. Closed loop control of oxygenation, oxygen generation, and power.

Terrestrial Application - Lightweight Trauma Module

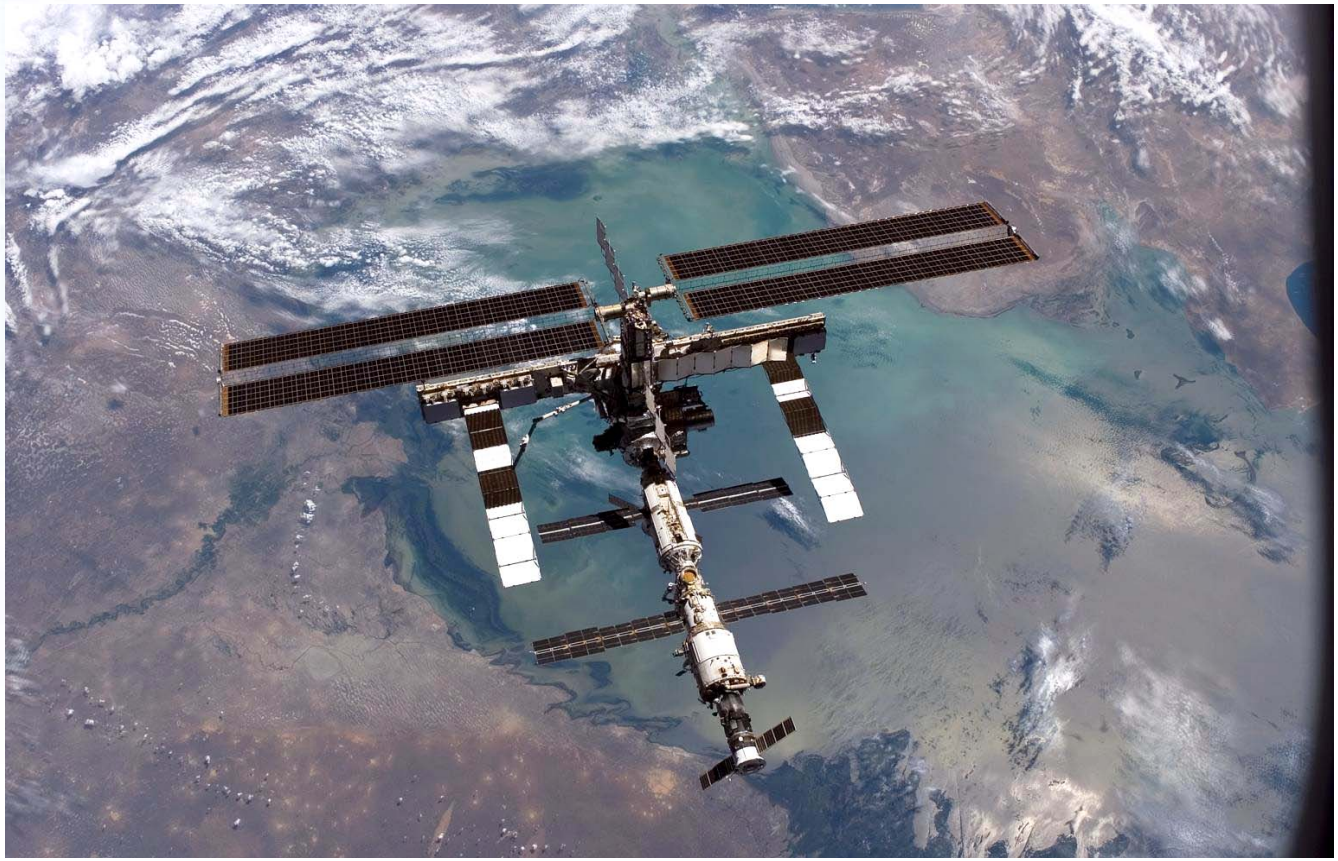
- For limited-resource settings on Earth, such as aeromedical transport or a disaster site
- Requires minimal manpower to deploy
- Small, lightweight and accessible in confined spaces
- Single caregiver can maintain multiple critical patients
- Modular, hence adaptable
- Minimal power and consumable requirements
- Multiple units can be connected through a LAN or WAN
- Remote patient monitoring, equipment control and adjustment, and data storage
- Remote troubleshooting, calibration, maintenance, reporting and documenting



The Promise of Exploration – Future Technologies

- As part of the NASA work on Exploration, appropriate technologies must be adapted or created in
  - **Medical informatics**
  - **Smart medical and environmental sensors**
  - **Decision support systems**
  - **Data / image compression**
  - **New teaching aids - enhanced on-board training, skill maintenance and just-in-time performance enhancement**
  - **Virtual presence technologies and adaptive expertise delivery (remote guidance) systems**
  - **Noninvasive and minimally invasive procedures.**
- NASA telemedicine technologies will be applicable to medical practice in special environments on Earth, as well as in mainstream terrestrial medicine

Conclusion



NASA will continue to share its knowledge, so as the Agency proceeds with the space exploration initiative, we hope to better understand life's processes in an effort to enhance the quality of life for all people.