NASA/CP—2004-213205/VOL1

Advanced Environmental Monitoring Technologies

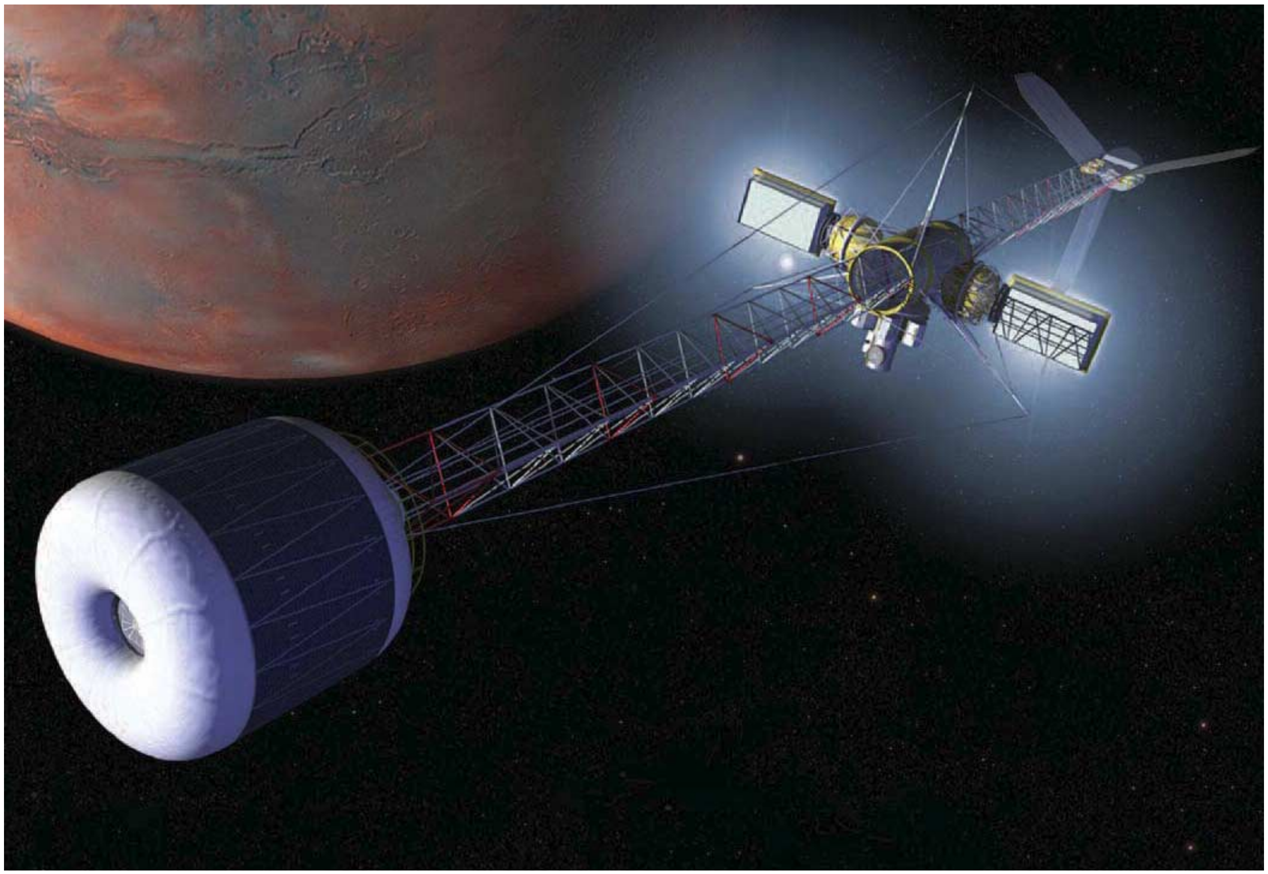
Darrell Jan, Ph.D.
Advanced Environmental Monitoring & Control
Program Element Manager
Life Detection Science & Technology Office
NASA/Caltech-Jet Propulsion Laboratory

June 22, 2004

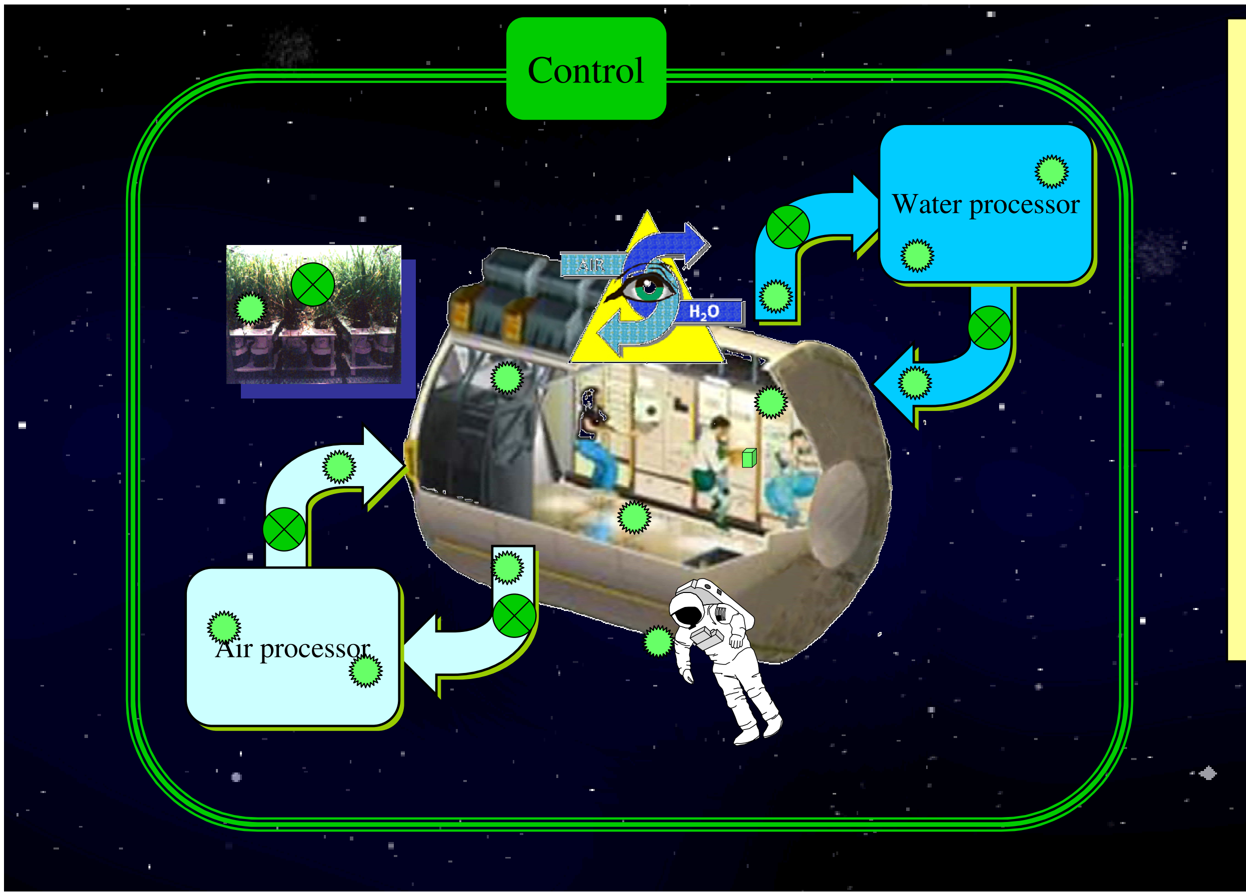
NASA/CP—2004-213205/VOL1

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

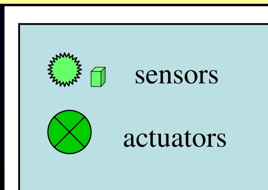
Apollo 12 photograph , taken by lunar module pilot Alan Bean , mission commander Pete Conrad retrieves parts from the Surveyor.

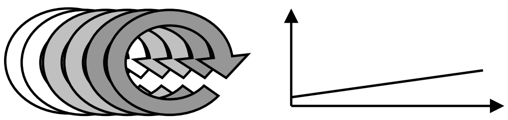


Monitoring & Controlling the environment



- •Air
- •Water
- •Plant chambers
- •Food and Food Preparation surfaces
- •Gradual buildup of toxic species
- •Hazardous events
- •Chemical
- •Biological

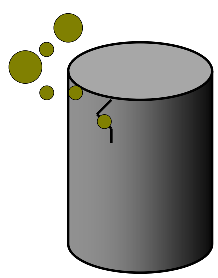




Long time

COMPOUND	DETECTION LIMIT
PRIORITY 1	PPM
Acetaldehyde	0.1
Formaldehyde	0.01
Methanol	0.2
Dichloromethane	0.03
Perfluoropropane (F218)	10
Acetone	1
Octamethylcyclotetrasiloxane	0.05
2-Propanol	3
Freon 82	5

*



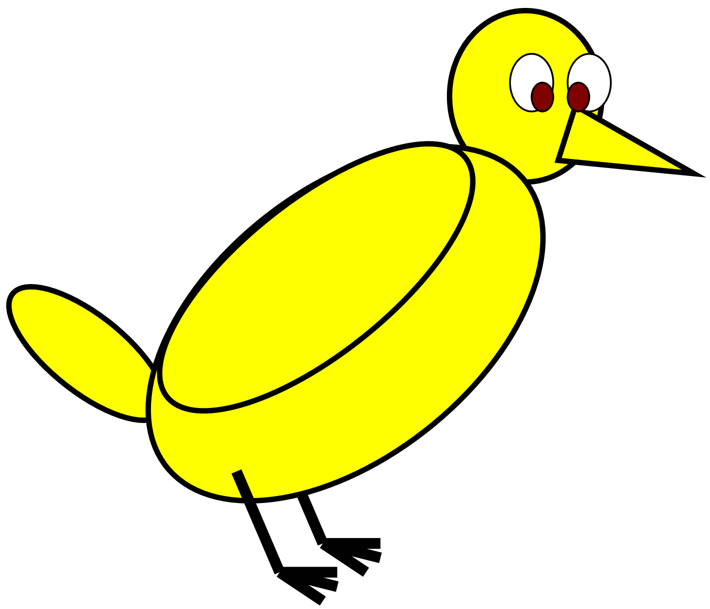
*microgravity combustion not shown

Gradual buildup of harmful chemical or microbials

Hazardous event such as fire or leakage

NASA/CP—2004-213205/VOL1

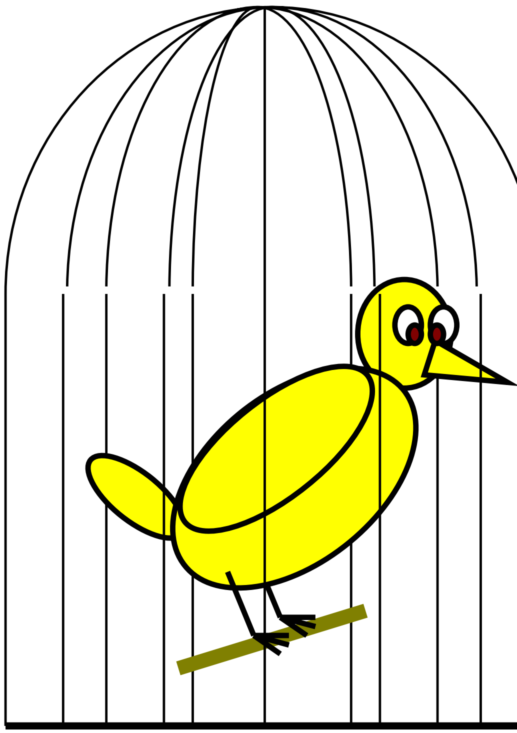
ILLUSTRATIVE EXAMPLE:



CANARY

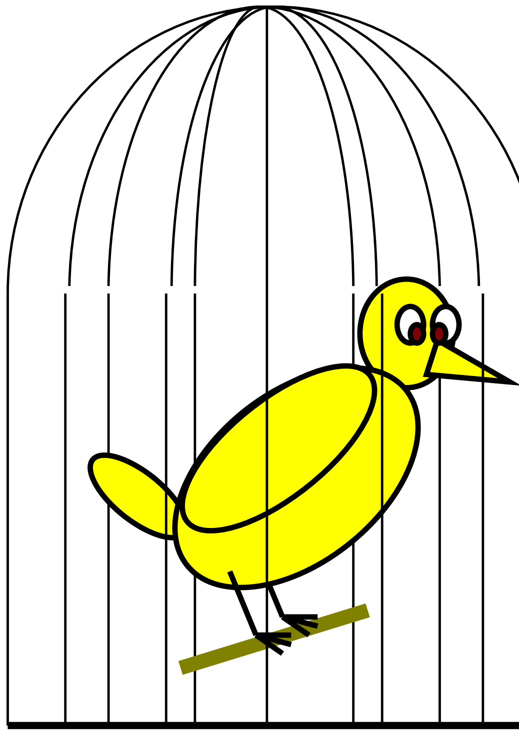
NASA/CP—2004-213205/VOL1

Why a canary?



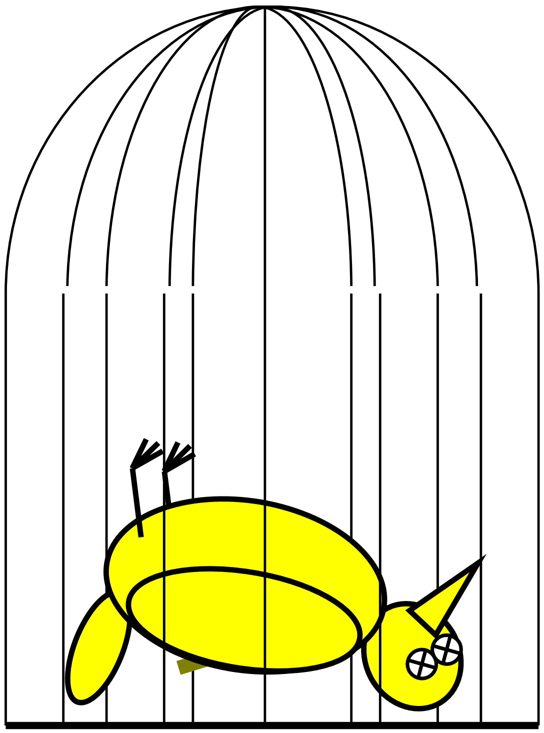
- •Continuous air monitor
- •Ground-based heritage
- •Doesn’t require skilled operator
- •Relatively low mass, low power
  - •Can consider placing in several locations
- •High sensitivity to many toxic gases
- •Multifunctional potential:
  - •air
  - •water
  - •food
  - •music
- •Probably will work in μgravity
- •Built in signal processing
- •Edible

Why not a canary?



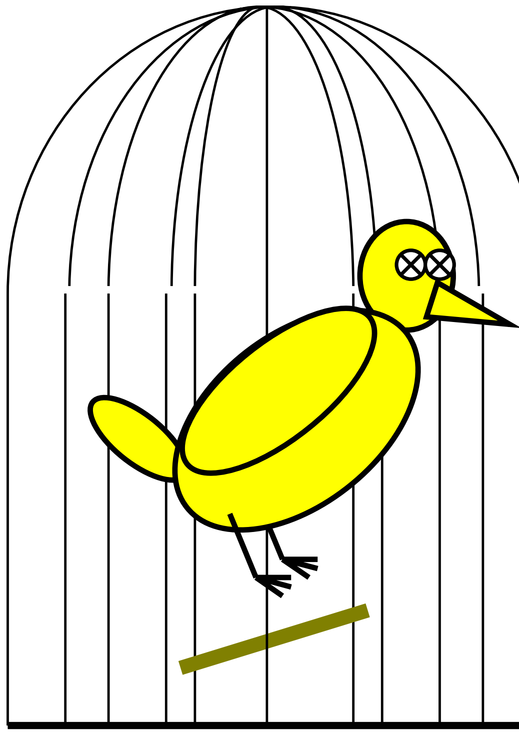
- •Requires fuel (food), water, maintenance
- •Generates waste products
- •Overload requires complete system replacement
- •Quantitative capability suspect
- •Limited life
- •Difficult to interface and network
- •Low precision display
  - •Could be hard to read in µg

Why not a canary?



- •Requires fuel (food), water, maintenance
- •Generates waste products
- •Overload requires complete system replacement
- •Quantitative capability suspect
- •Limited life
- •Difficult to interface and network
- •Low precision display
  - •Could be hard to read in μg

Why not a canary?

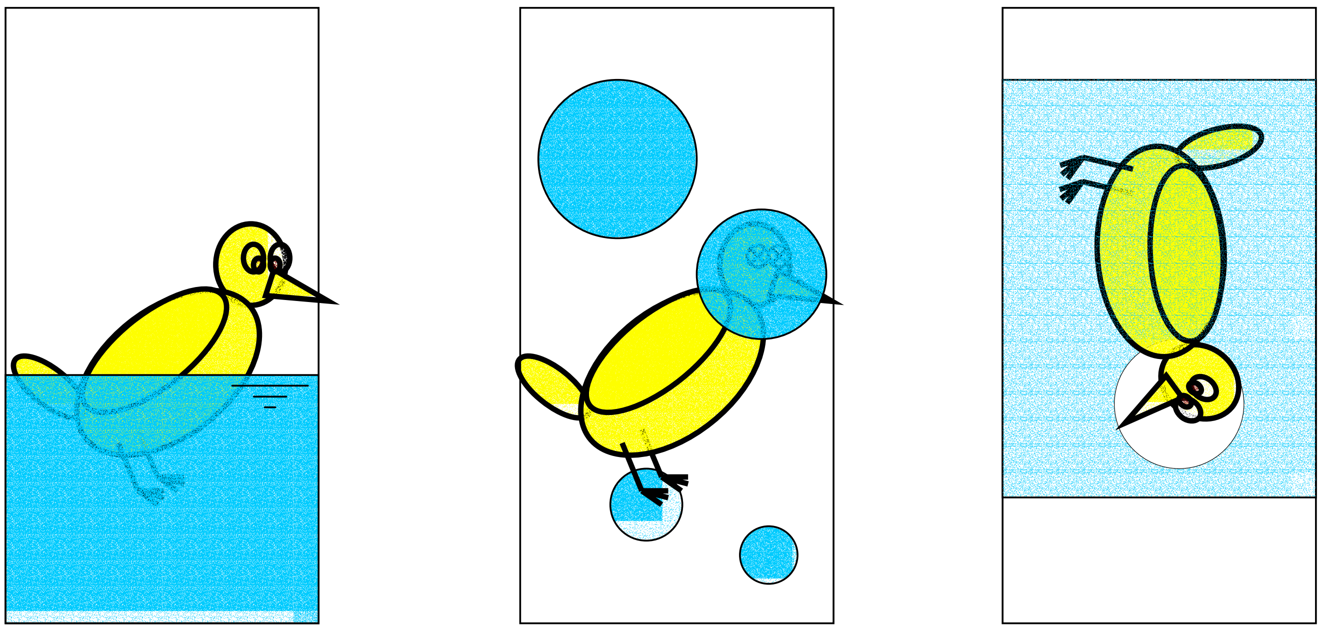


- Requires fuel (food), water, maintenance
- Generates waste products
- Overload requires complete system replacement
- Quantitative capability suspect
- Limited life
- Difficult to interface and network
- Low precision display
  - Could be hard to read in µg

NASA/CP—2004-213205/VOL1

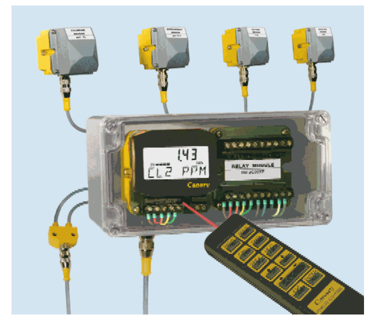
Why not a canary?

A canary in water



QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Ground-based Commercial technology

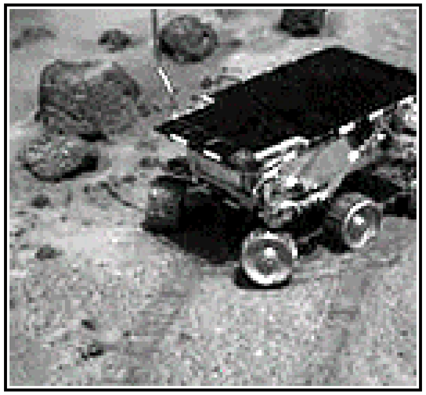


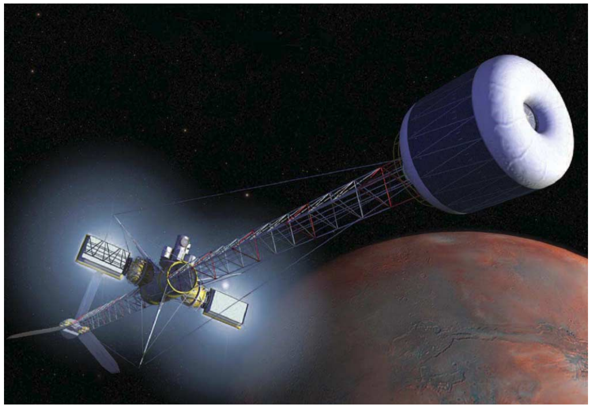
- High mass
- High power requirement
- High operator skill
- High capability
- May require gravity

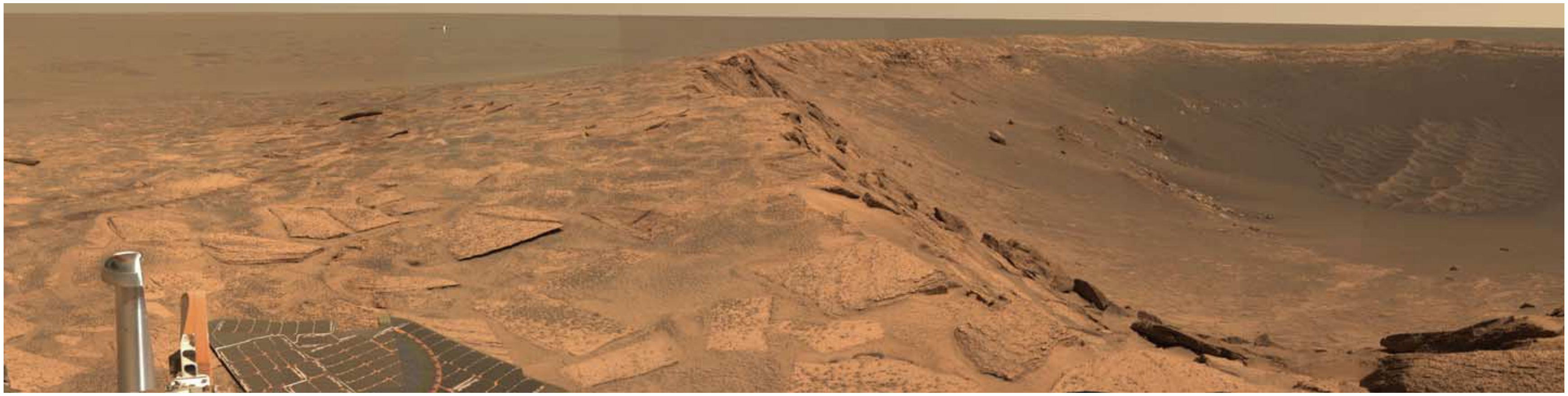
- Lower mass
- Lower power requirement
- Low operator skill
- Low capability
- May require gravity

•Breakthroughs needed to achieve high capability and low mass/power plus autonomy

High Capability & Low Mass/Power + Autonomy = key to future SpaceFlight



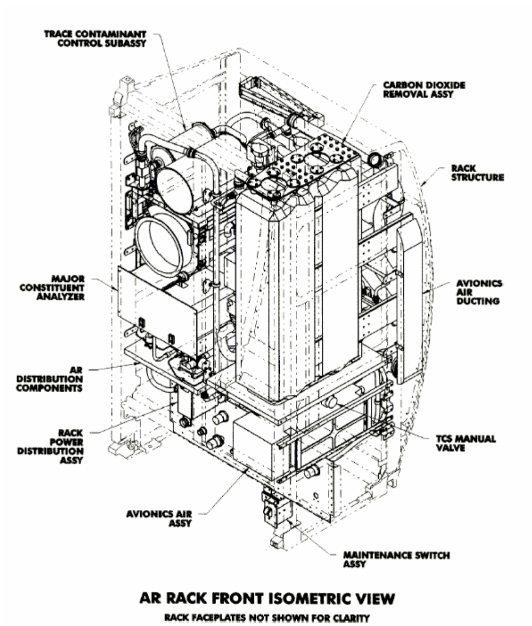




Current Practice: in flight

Volatile Organic Analyzer (VOA):
measures about 30 volatile organic species

ICES 2003-01-2646 Validation of the Volatile Organic Analyzer (VOA) aboard the International Space Station
Thomas Limero, et al



Major Constituent Analyzer (MCA):
Nitrogen, Oxygen, Carbon Dioxide, Water vapor

2000-01-2345
International Space Station Carbon Dioxide
Removal Assembly Testing
James C. Knox

NASA/CP—2004-213205/VOL1

Current Practice: Post Flight

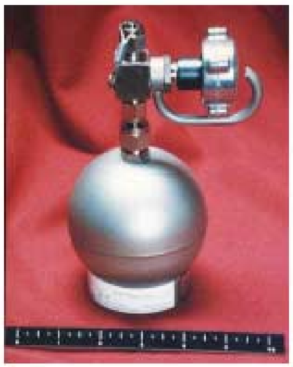


Figure 5: Grab Sample Container (GSC)

Grab Sample Bottles: Thorough analysis
By GCMS, over 100 species

ICES 2003-01-2646 Validation of the Volatile Organic Analyzer (VOA) aboard the International Space Station
Thomas Limero, et al

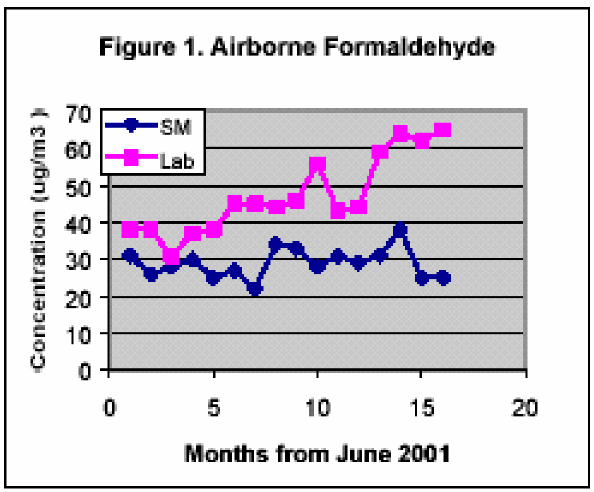
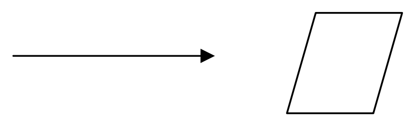


Figure 1. Airborne Formaldehyde

Formaldehyde Badges



2.5 in x 2.5 in

ICES 2003-01-2647 Toxicological Assessment of the
International Space Station Atmosphere with Emphasis on Metox Canister Regeneration
John James, et al

Current Practice: Post Flight

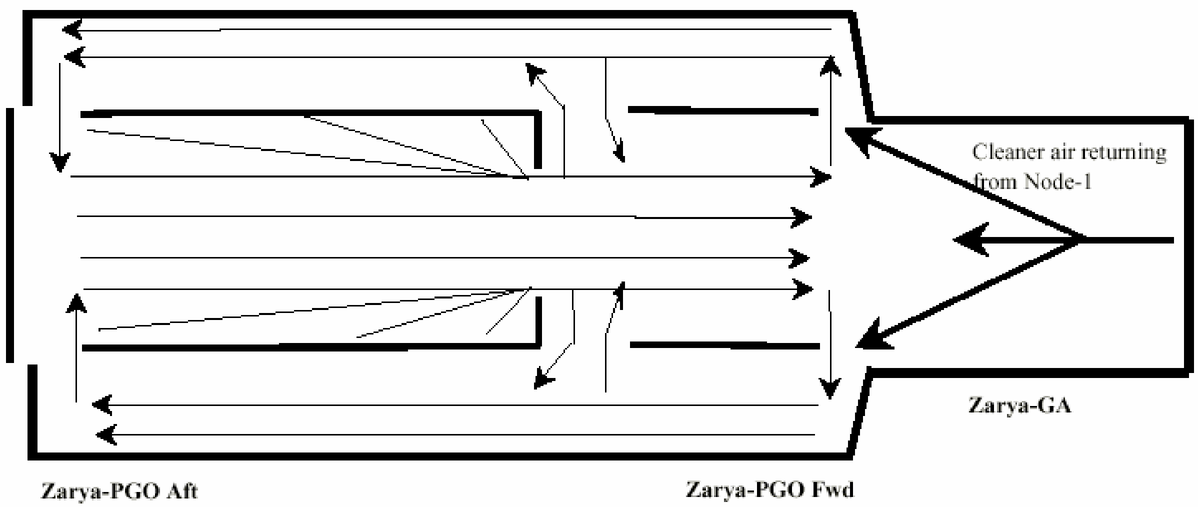


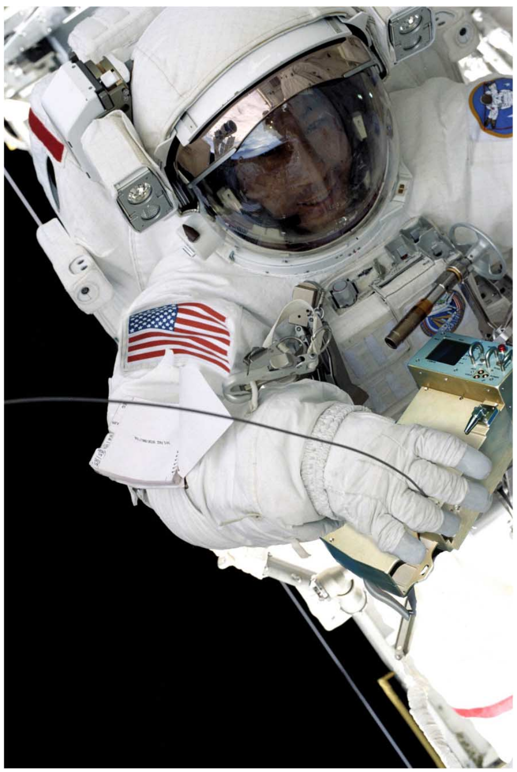
Figure 1. Overview of the airflow inside Zarya with opposed panels opened to 90 degrees. This diagram was adapted from Alibaruho et al. (1999) with addition of the flow arrows going from the walls toward the isle through open panels. The goal of the figure is to indicate the potential for disrupted airflow where panels have been opened.

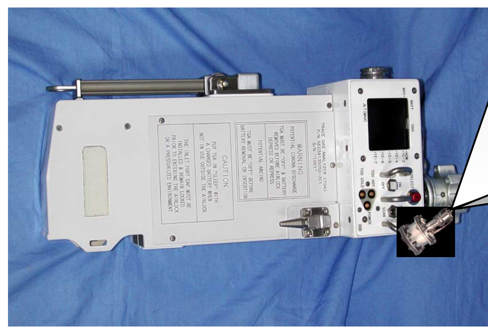
ICES 2000-01-2432 Toxicological Assessment of the
International Space Station Atmosphere
John James, et al

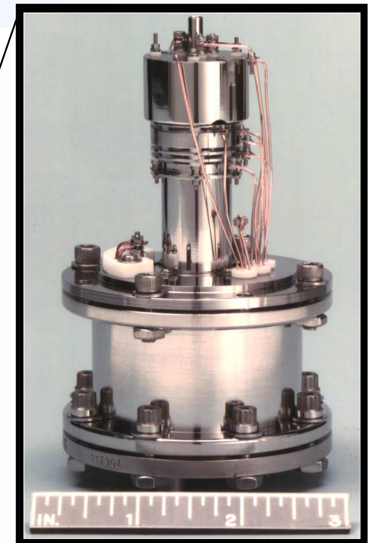
NASA/CP—2004-213205/VOL1

Miniature Mass Spectrometer for Planetary Exploration and Long Duration Human Flight

- 0.5 amu resolution, 1-300 amu range
- Used by astronauts in Shuttle Mission 5A and beyond to detect ammonia and air leaks outside the International Space Station





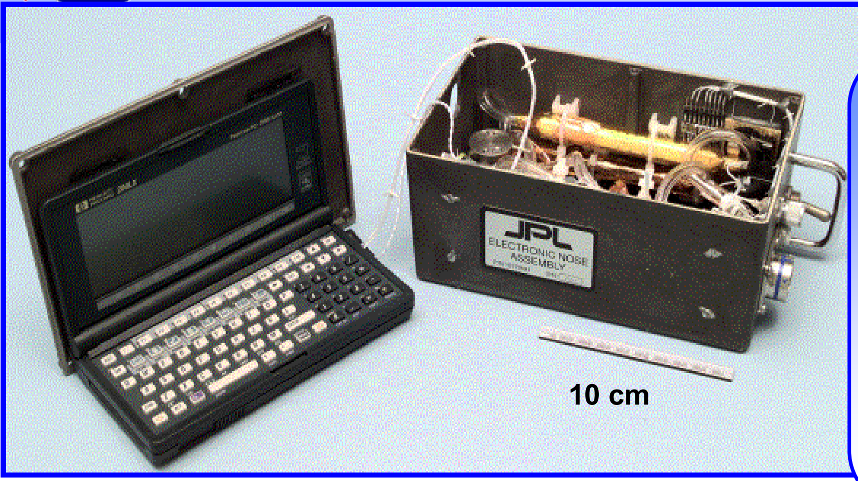


The Quadrupole Mass Spectrometer Array (QMSA)

The QMSA Packaged as the Astronaut's Trace Gas Analyzer (TGA)

Smallest flight Mass Spectrometer in the world !

HARDWARE AND DATA ACQUISITION SYSTEM



First Generation Enose: Flight Experiment

Volume: 2000 cm^3 Mass: 1.4 kg
Power: 1.5 W ave., 3 W peak
Computer: HP 200LX

Materials:

container -	**cast aluminum**
wetted surfaces -	**glass, PTFE, polypropylene**
seals -	**silicon rubber**

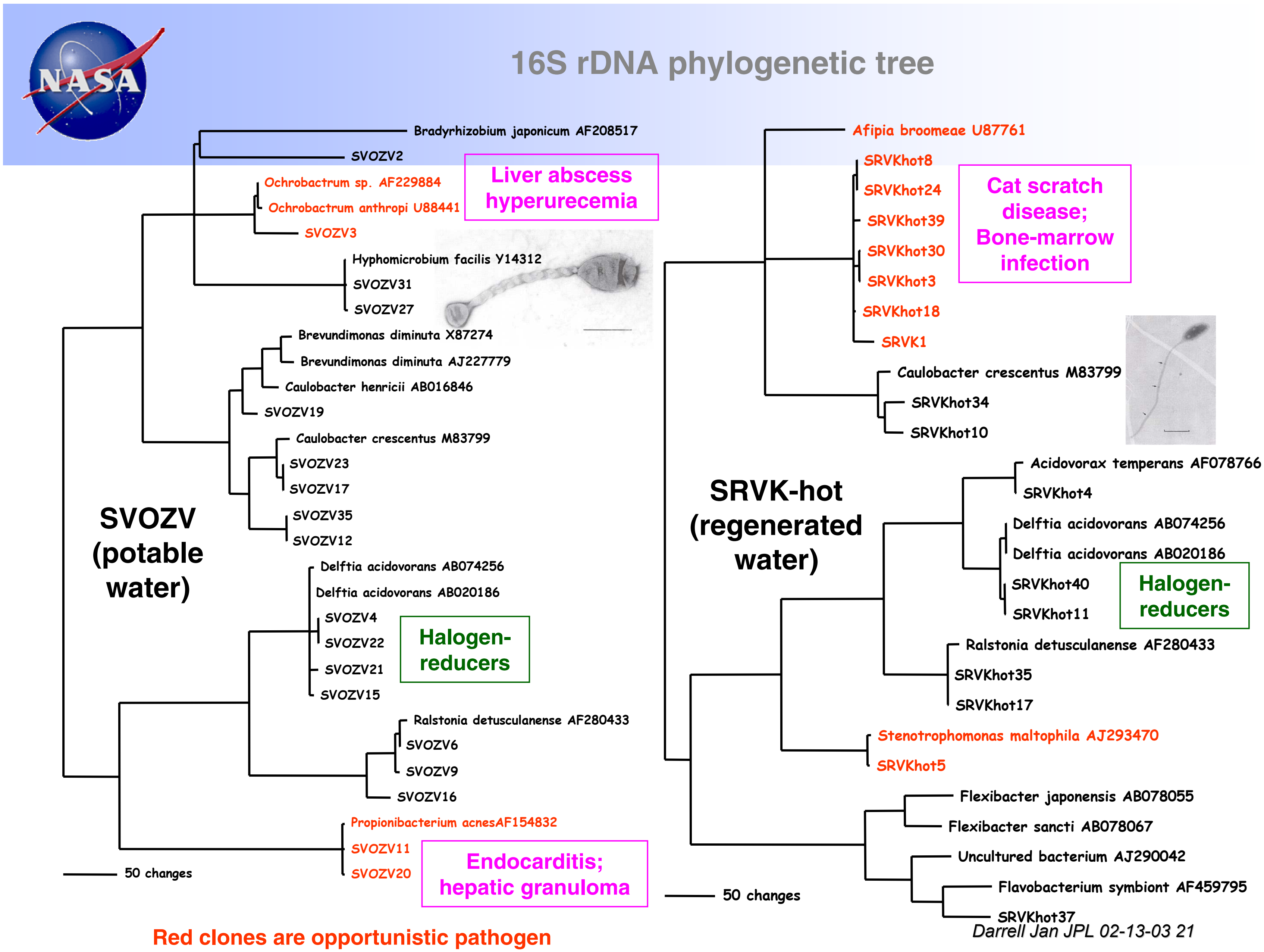
Second Generation ENose

Optimized sensors, faster analysis, improved sensitivity

Volume: 760 cm^3 Mass: 0.8 kg
Power: 1.5 W ave., 3 W peak
Computer: Handspring Visor Neo **PDA**

Materials:

container -	**anodized aluminum**
wetted surfaces -	**alumina, parylene**
seals -	**Kal-Rez**


16S rDNA phylogenetic tree
Bradyrhizobium japonicum AF208517
SVOZV2
Ochrobactrum sp. AF229884
Ochrobactrum anthropi U88441
SVOZV3
Liver abscess hyperurecemia
Hyphomicrobium facilis Y14312
SVOZV31
SVOZV27
Brevundimonas diminuta X87274
Brevundimonas diminuta AJ227779
Caulobacter henricii AB016846
SVOZV19
Caulobacter crescentus M83799
SVOZV23
SVOZV17
SVOZV35
SVOZV12
SVOZV (potable water)
Delftia acidovorans AB074256
Delftia acidovorans AB020186
SVOZV4
SVOZV22
SVOZV21
SVOZV15
Halogen-reducers
Ralstonia detusculanense AF280433
SVOZV6
SVOZV9
SVOZV16
Propionibacterium acnesAF154832
SVOZV11
SVOZV20
Endocarditis; hepatic granuloma
50 changes
Red clones are opportunistic pathogen
Afipia broomeae U87761
SRVKhot8
SRVKhot24
SRVKhot39
SRVKhot30
SRVKhot3
SRVKhot18
SRVK1
Cat scratch disease; Bone-marrow infection
Caulobacter crescentus M83799
SRVKhot34
SRVKhot10
SRVK-hot (regenerated water)
Acidovorax temperans AF078766
SRVKhot4
Delftia acidovorans AB074256
Delftia acidovorans AB020186
SRVKhot40
SRVKhot11
Halogen-reducers
Ralstonia detusculanense AF280433
SRVKhot35
SRVKhot17
Stenotrophomonas maltophila AJ293470
SRVKhot5
Flexibacter japonensis AB078055
Flexibacter sancti AB078067
Uncultured bacterium AJ290042
Flavobacterium symbiont AF459795
SRVKhot37
50 changes
Darrell Jan JPL 02-13-03 21

Preview of Porter