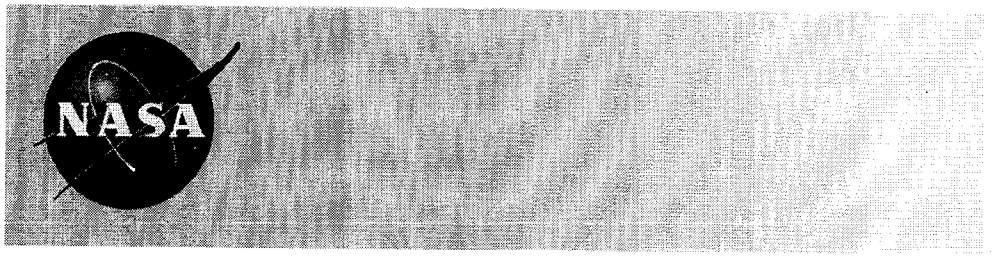
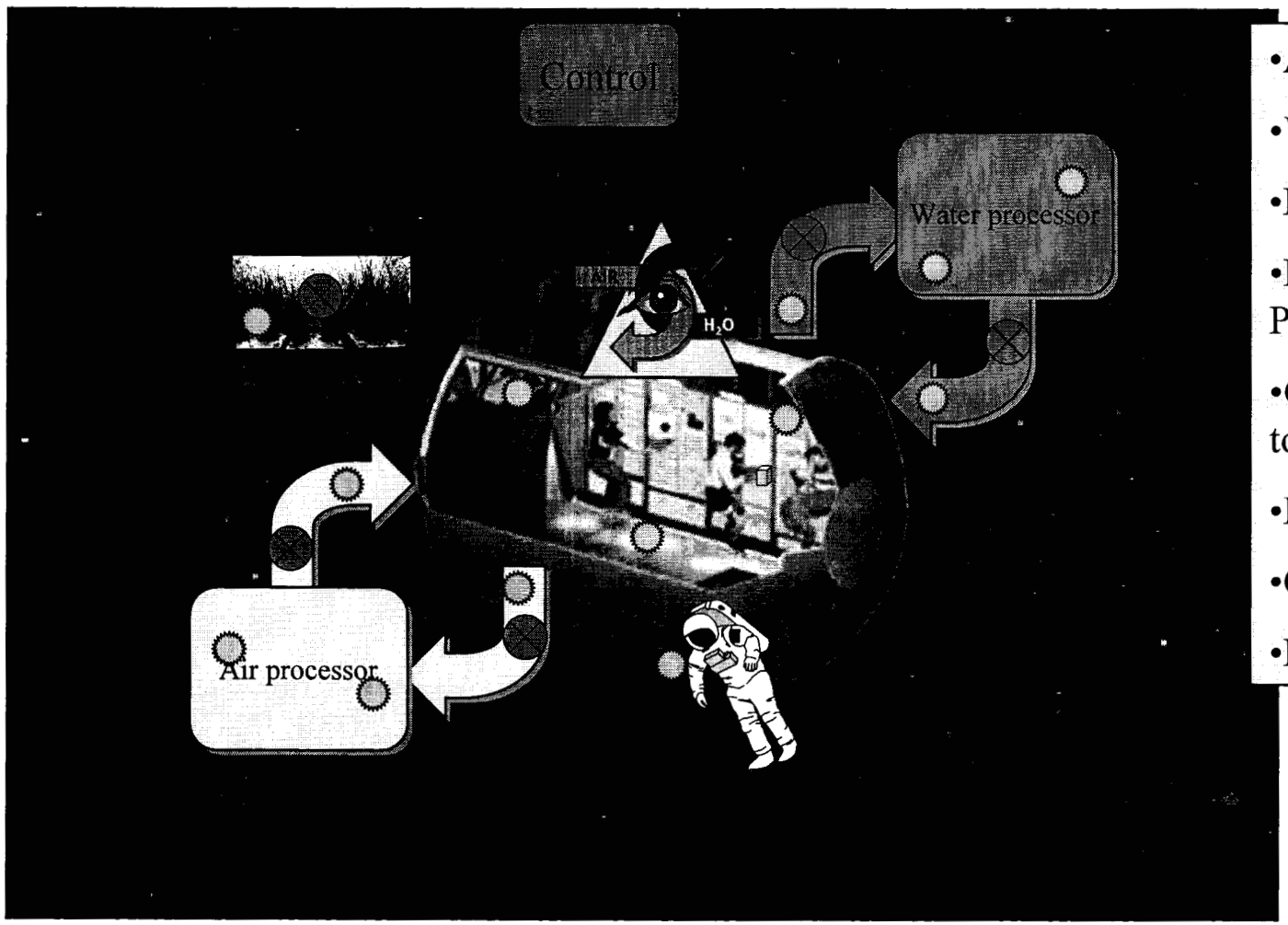


Advanced Environmental Monitoring Technologies and Their Applications to Medical Diagnosis and Pathogen Detection

Darrell Jan, Ph.D.
Life Detection Science & Technology Office
NASA/Caltech-Jet Propulsion Laboratory

February 13, 2003

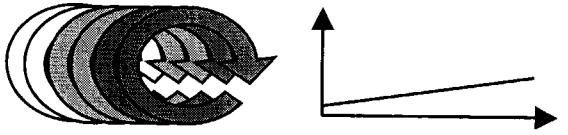
Monitoring & Controlling the environment



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

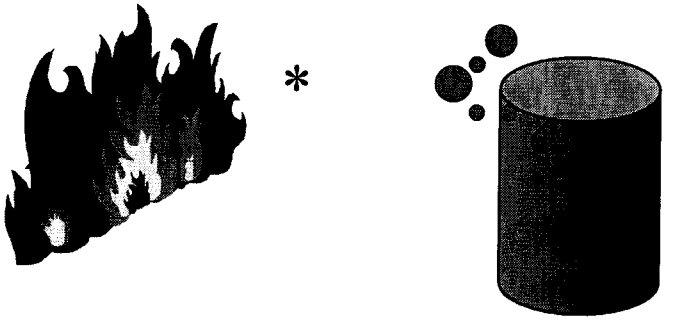
sensors

actuators



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

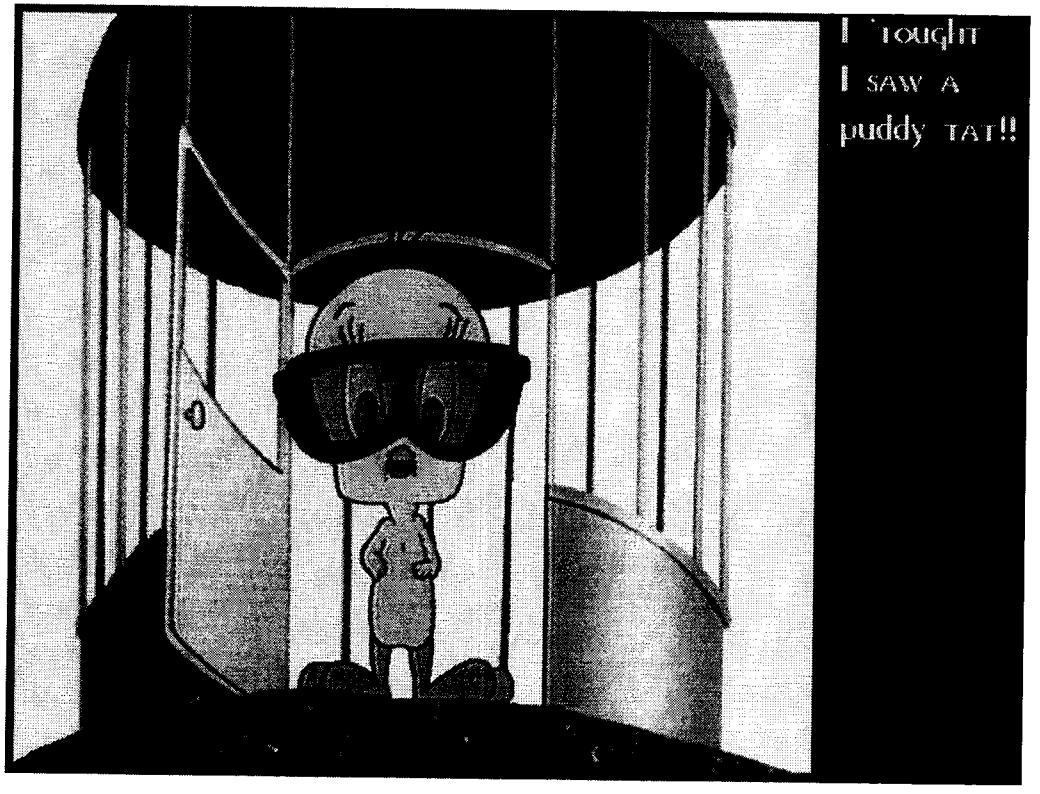


*microgravity combustion not shown

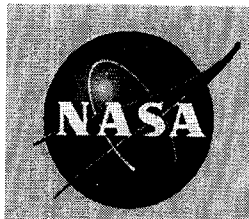
Gradual buildup of harmful chemical or microbials

Hazardous event such as fire or leakage

ILLUSTRATIVE EXAMPLE:

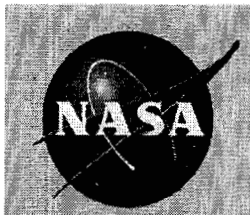


CANARY



Why a canary?

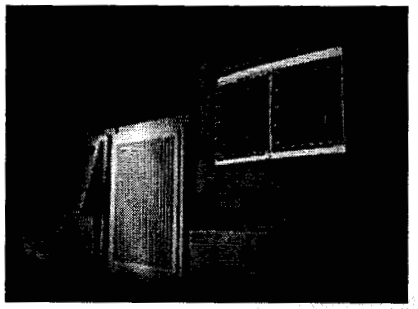
- Continuous air monitor
- Ground-based heritage
- Doesn't require skilled operator
- Relatively low mass, low power
  - Can consider placing in several locations
- High sensitivity to many toxic gases
- Multifunctional potential:
  - air
  - water
  - food
  - music
- Probably will work in μgravity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

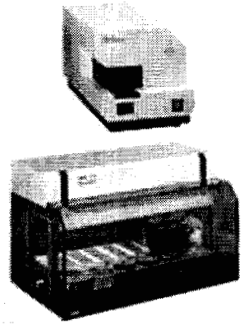


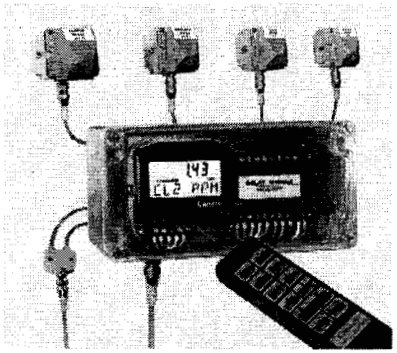
Why not a canary?

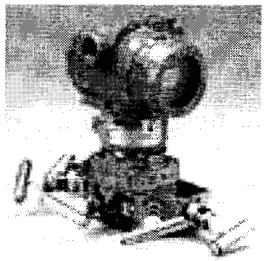
- Requires fuel (food), water, maintenance
- Generates waste products
- Low precision display
  - Could be hard to read in μg
- Overload requires complete system replacement
- Quantitative capability suspect
- Limited life
- Difficult to interface and network

Ground-based Commercial technology







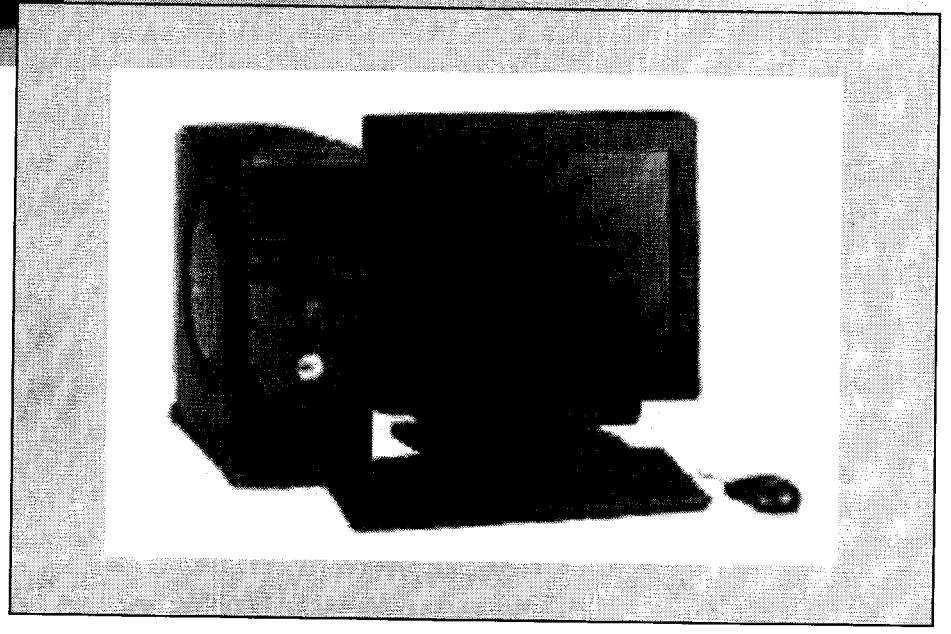


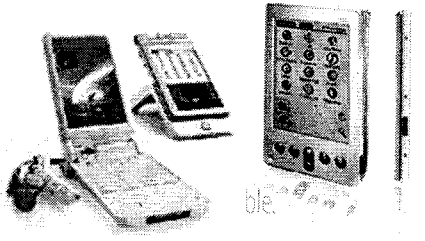
- High mass
- High power requirement
- High operator skill
- High capability
- May require gravity

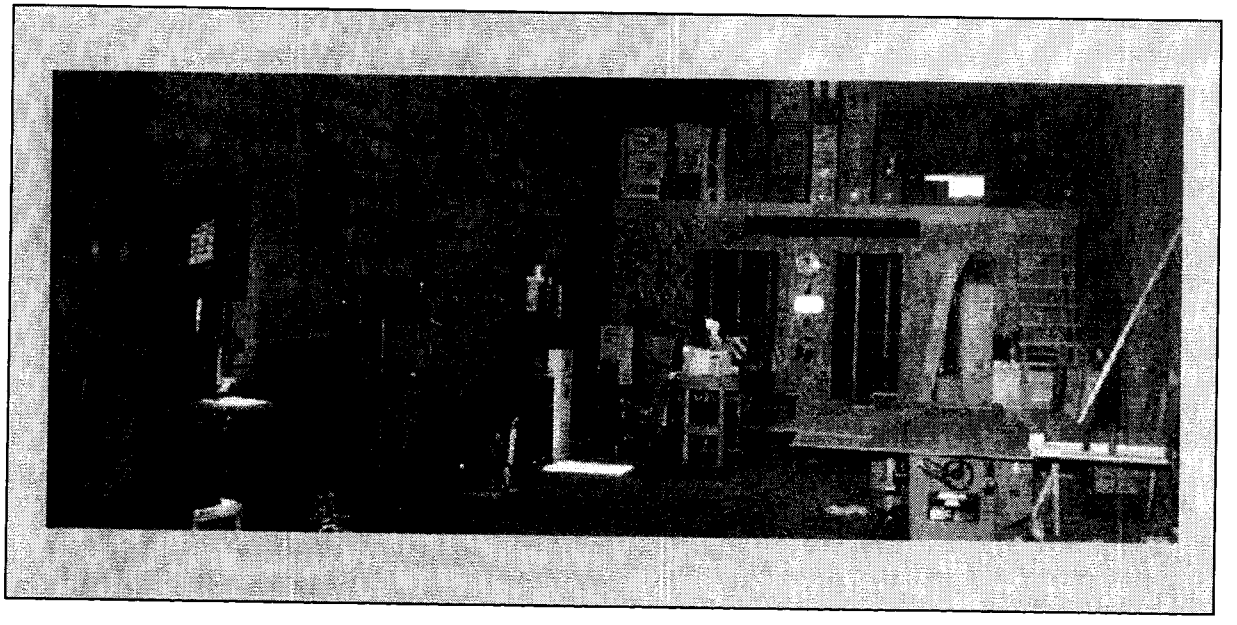
- Lower mass
- Lower power requirement
- Low operator skill
- Low capability
- May require gravity

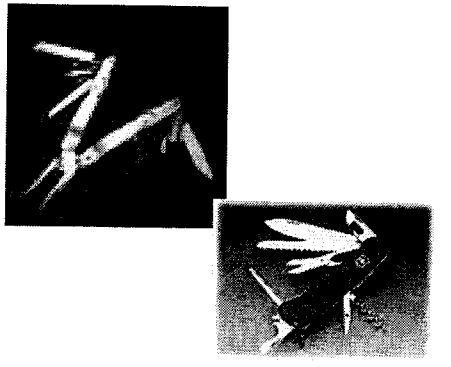
•Breakthroughs needed to achieve high capability and low mass/power plus autonomy

Optimizing Size vs Capability

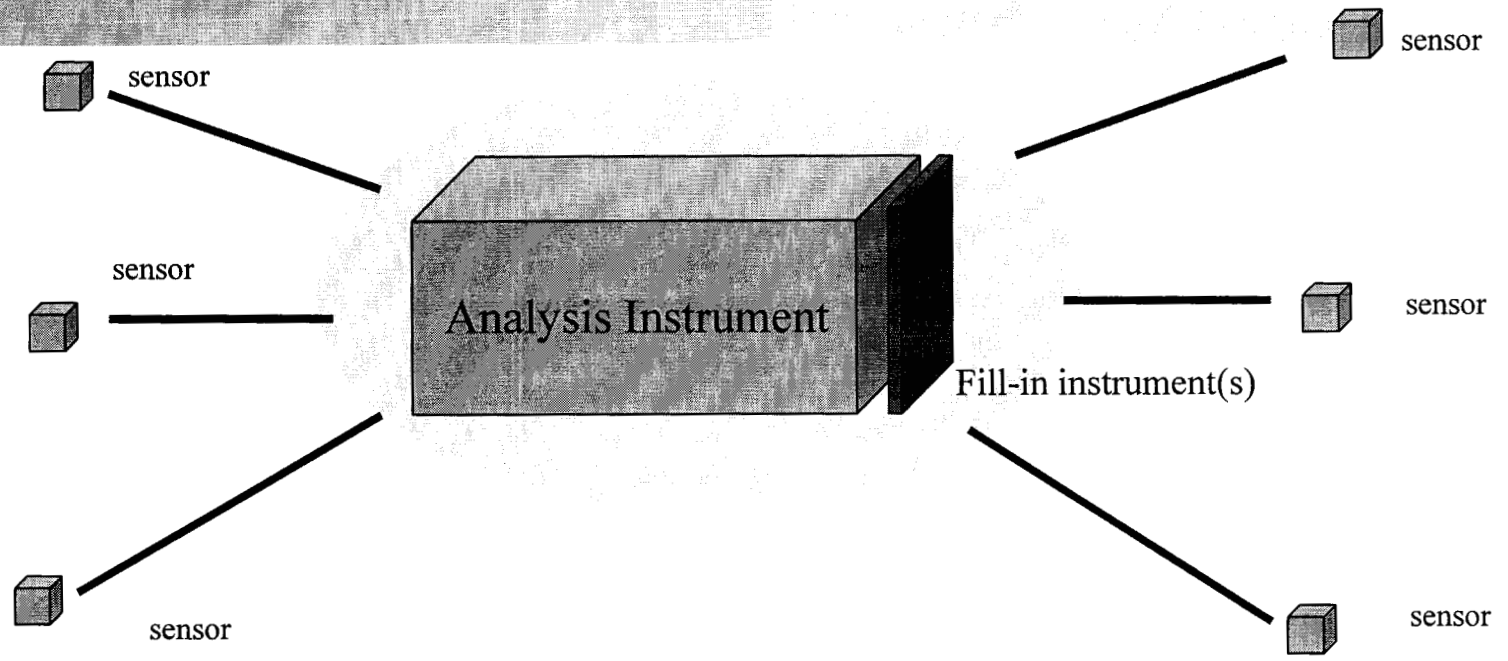






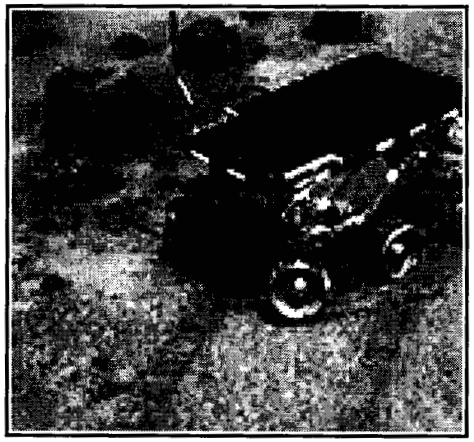


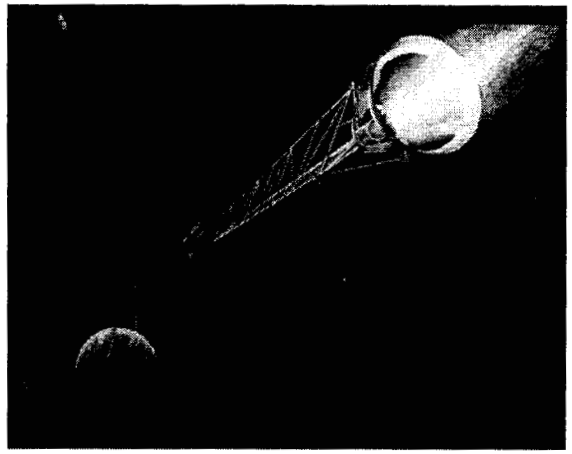
AEMC Vision: Hierarchical monitoring/control

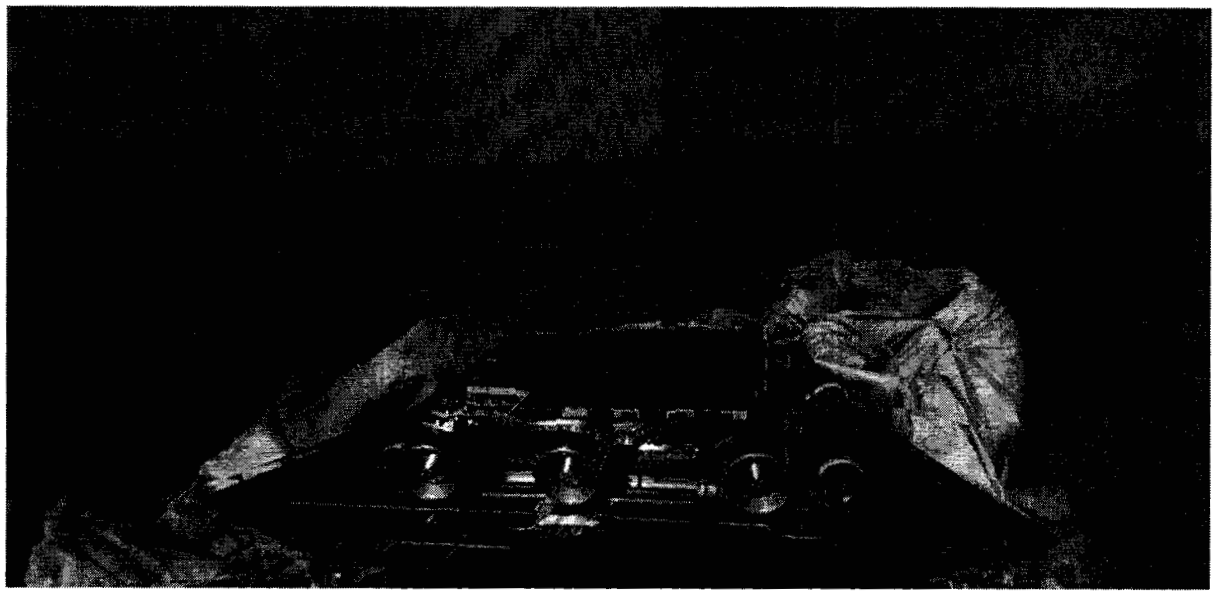


- Analysis Instrument: eg GCIMS, GCMS, FTIR
  - Analyzes for almost everything
  - Complex, expensive (although low mass)
  - Probably only one on board
  - "Fill-in" covers the few things that the Analysis Instrument doesn't cover (eg, formaldehyde, O2, CO2…)
    - eg TDL, SERS
- Sensor is simpler, cheaper, more robust
  - May be fixed or portable
  - Much more capable than off the shelf
  - eg Enose, Bioarray

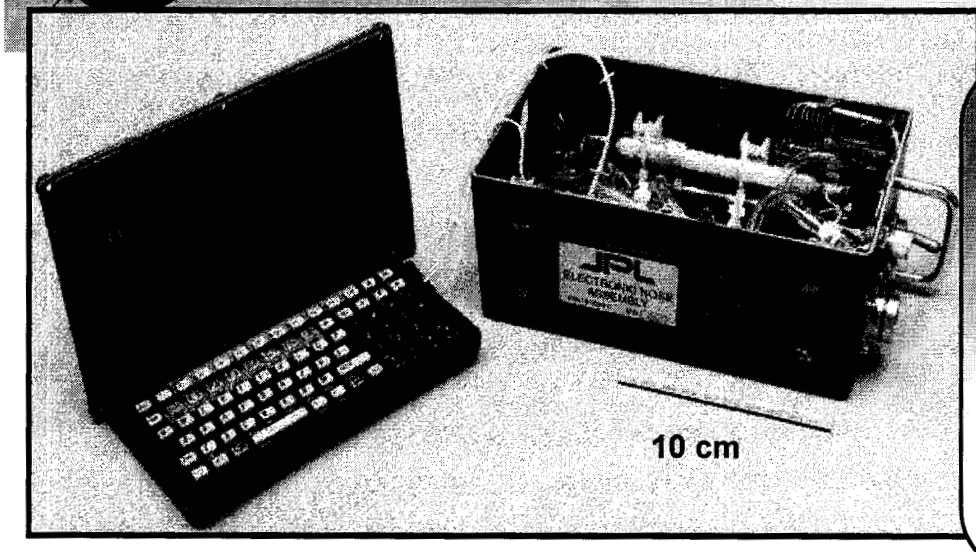
High Capability & Low Mass/Power + Autonomy = key to future SpaceFlight







HARDWARE AND DATA ACQUISITION SYSTEM



First Generation Enose: Flight Experiment

Volume: 2000 cm³ **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

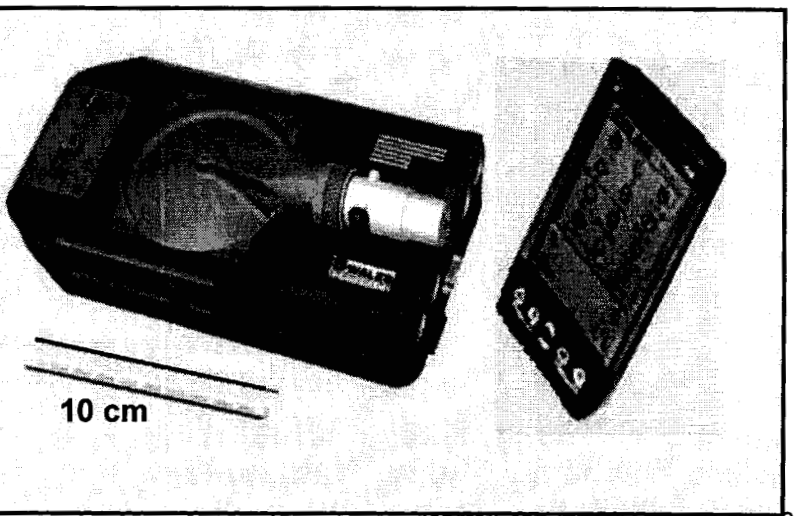
Second Generation ENose

Optimized sensors, faster analysis, improved sensitivity

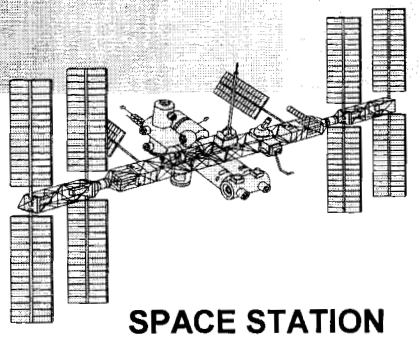
Volume: 760 cm³ **Mass:** 0.8 kg
Power: 1.5 W ave., 3 W peak
Computer: Handspring Visor Neo PDA

Materials:

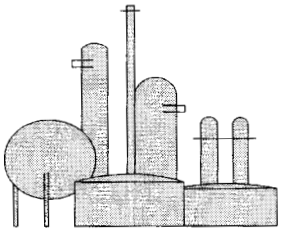
container -	anodized aluminum
wetted surfaces -	alumina, parylene
seals -	Kal-Rez



ELECTRONIC NOSE

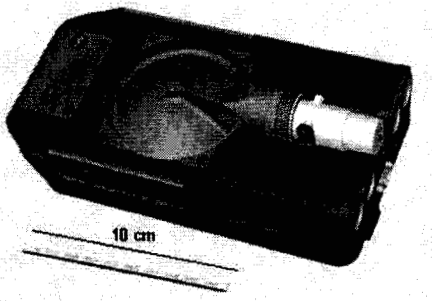


SPACE STATION ENVIRONMENTAL MONITORING
Event monitor - spills, leaks, clean up

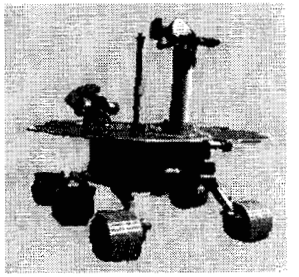


INDUSTRIAL MONITORING AND PROCESS CONTROL
Identity and condition of raw materials, leaks and buildup of toxic compounds
Monitor food processing

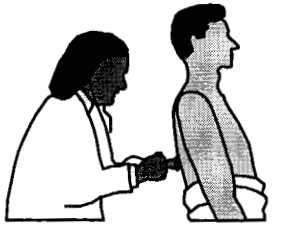
OTHER ENVIRONMENTAL MONITORING
Air quality in buildings, aircraft. Presence of toxic materials in designated spaces.



MILITARY APPLICATIONS
air quality monitor, detection of explosives and other hazards



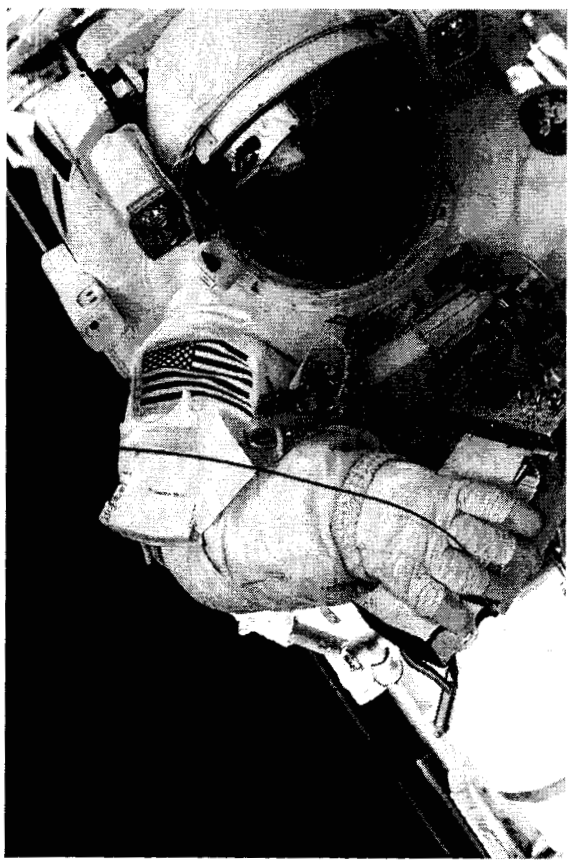
PLANETARY EXPLORATION
Study planetary atmosphere to determine constituents and fluctuations

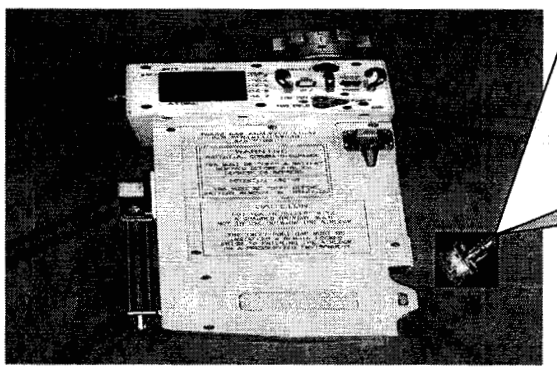


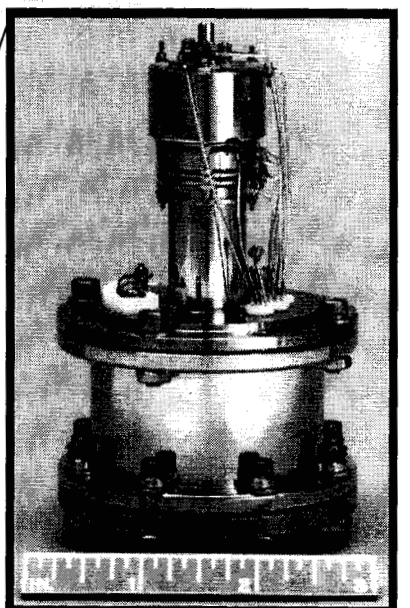
MEDICAL APPLICATIONS
Diagnosis through breath or body fluid analysis; remote monitoring of patient condition

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)

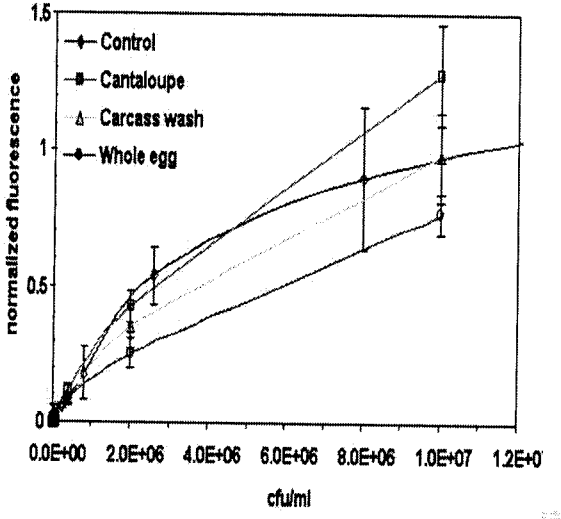
The QMSA Packaged as the Astronaut's Trace Gas Analyzer (TGA)

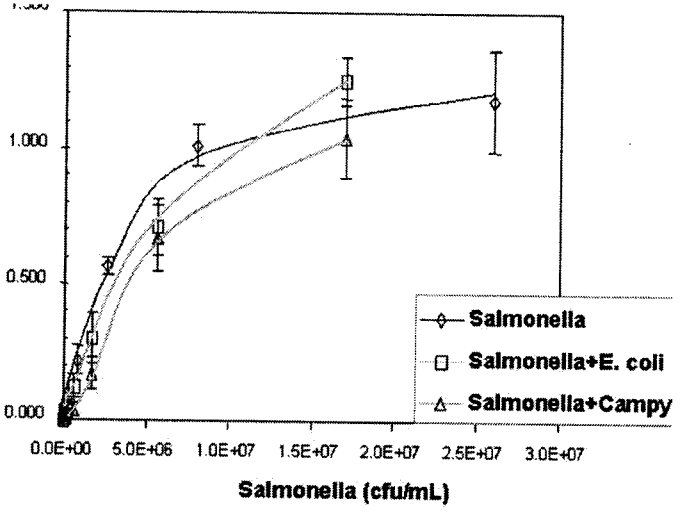
Smallest flight Mass Spectrometer in the world!

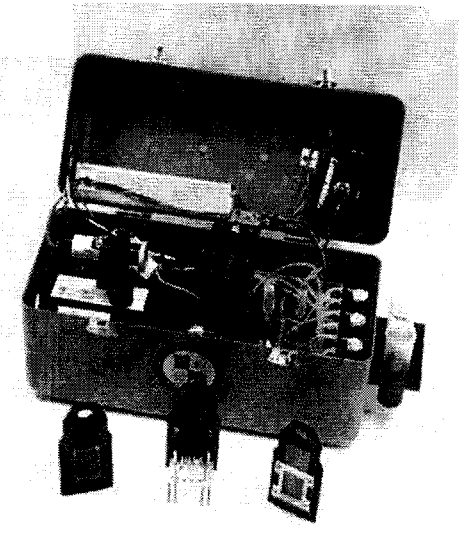
Darrell Jan NASA/JPL 09-17-02 13

Portable array biosensor miniaturization

Fran Ligler, Naval Research Lab

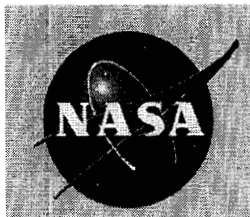






NASA Plans/Options

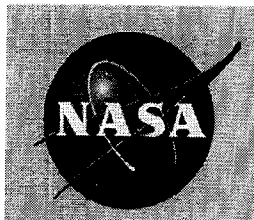
- Internal development
  - *GCMS: not much more internal development*
  - *Enose:not much past our current plans*
- Partnering/Collaboration/Sponsorship
  - *Would look for expertise in GC analysis and medical breath analysis*
  - *Enose: manufacturing, user interface*
- Patent/licensing
  - *GCMS: MS is patented and licensed.*
  - *Enose: ready to be licensed*



Future Developments

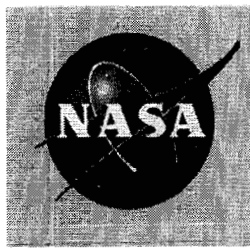
Remaining R&D

- Technical risk
  - *GCMS : very little risk remaining to technology; needs manufacturable design*
  - *Enose:*
- Remaining milestones
  - *GC development*
  - *Enose: finish operations prototype*
- Future enhancements
  - *GCMS: Electronics miniaturization*
  - *Enose: more sophisticated design with more capability*
- Need for outside expertise or resources
  - *GCMS: GCexpertise*
  - *Enose: clinical applications expertise: breath analysis, patient compliance, veternairy applications*



Applications Identified

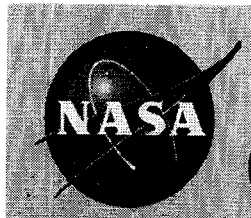
- Commercial / Government
  - *Air quality*
  - *Medical breath analysis*
- By industry
  - *Manufacturing*
  - *Clinical*



Product Benefits

Examples: *(Industry wants to know what's in it for them, what will make them want to use what you have developed. Bus. Development managers will need this info to pitch to their management)*

- GCMS:small size -> field portable
- Enose: Quantitative, unlike other Enoses
  - *Better air quality monitoring performance*

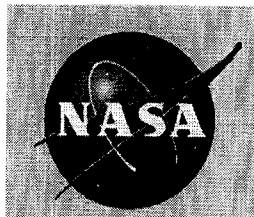


Commercial Advantages

- Opens new market applications
  - GCMS: smaller, portable, more numerous placement
  - Enose: multiple placement with more information

Next steps

- *http://aemc.jpl.nasa.gov*
- *Contact Darrell Jan for technical info*
- *Contact JPL Technology Affiliiates office , 818-354-3821*



Long Term

- Expectation of benefits to NASA and industry if partnerships are developed
  - *Basis for a viable product*
  - *Benefits of mass production, ergonomic interface and design*