Hardware for Space Flight Biological Experiments

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Timeline of ARC Life Sciences Space Flight Missions

US Biosatellites (3)

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Bions (9)

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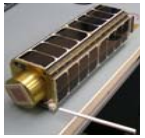
Fotons (2)



NanoSatellites (2)

1960's | 1970's | 1980's | 1990's | 2000's

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Gemini 3, 8, 12

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Apollo 17

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Skylab 3

Space Shuttle

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ISS

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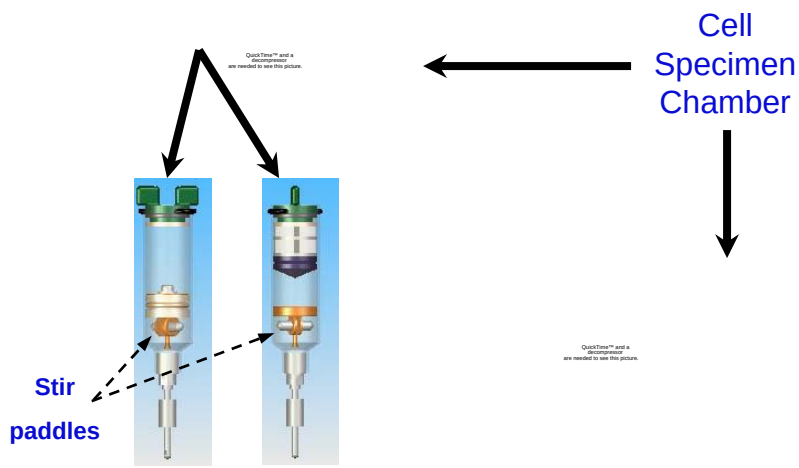
NASA/MIR

56 STS and 7 ISS missions

- Over 165 Principal Investigators supported
- Diverse model specimens studied
  - Mammalian tissue cultures, microbes, plants, rats, mice, non-human primates, avian eggs, amphibians, lizards, aquatic species, insects, snails…



Sample Container Configurations

NASA ARC, Aurora Flight Sci., & BioServe Space Tech.

Single Loop Cell Culture (SLCC)

- Mammalian cell and microbial cultures
- 1 cell culture perfusion loop with a 10 ml Cell Specimen Chamber (CSC) with stirring capability
- Gas exchange
- Six removable sample/inoculation containers with mixing capability
- Fresh and spent media bags
- Subculturing
- Autonomous operations
- Fixatives pre-loaded in sampling containers optional
- Inline bubble trap
- Provides temperature and humidity data
- Crew accessible
- Requires power, thermal conditioning,and CO_2 gas supply from an incubator

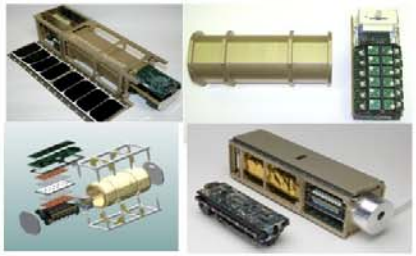
Microbial Canister

- Microbial Cultures
- 8 ml culture volume per vial (3 vials)
- Passive system providing an anaerobic environment
- Can be frozen down to -100 ^{o}C
- Ambient temperature condition or optional thermal conditioning in an incubator, refrigerator, or cryogenic freezer
- Previous flight on STS-118 (SPEGIS) in MERLIN (Univ. of Alabama, Birmingham [CBSE], NASA JSC)

NASA ARC and Lockheed Martin

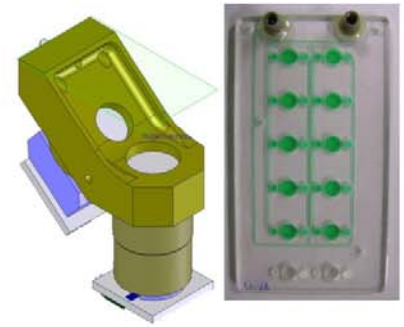
Microwell Incubator

GeneSat



NASA ARC

- 10 fluidic wells, 2 reference wells
- 110 µL/well ⇒ 1.1 mL total well volume
- 12 detectors for fluorescent optical assay
- 12 detectors for culture optical density
- Sensors for temperature, absolute pressure, humidity, 3-axis acceleration, radiation flux

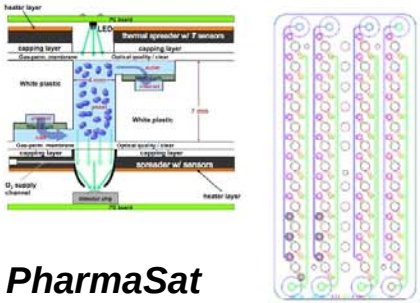


GeneSat Optics and Fluidics Card

PharmaSat

NASA ARC

- 48 fluidic wells (4 sets of 12); 12 ref. wells
- 90 µL/well ⇒ 4.5 mL total volume
- 11 active valves, 2 pumps for mixing,dilution,multi-concentration dosing
- RGB absorbance at every well for culture density & metabolic activity
- Sensors for temperature, pressure, humidity, acceleration, radiation flux

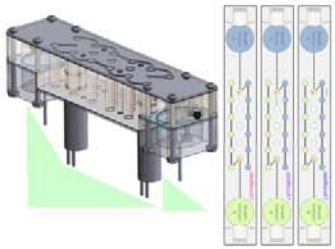


PharmaSat Fluidic/Optical/Thermal Cross Section & Fluidics Card

O/OREOS

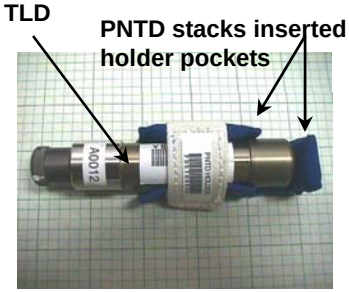
NASA ARC

- 3 independent fluidic "bioBlocks" w/ dual pumps
- 12 fluidic wells, 75 µL ea., per Block (36 total)
- 2 on-board 1.6-mL reservoirs per bioBlock
- Time-resolved optical density & RGB colorimetry
- Radiation exposure "window", 6-month mission life
- Sensors for temperature, pressure, humidity, acceleration, integrated radiation dose



O/OREOS bioBlock & Fluidic Wells

PDS Operated by Jim Voss on ISS



TLD/PNTD Assembly

TLD Reader

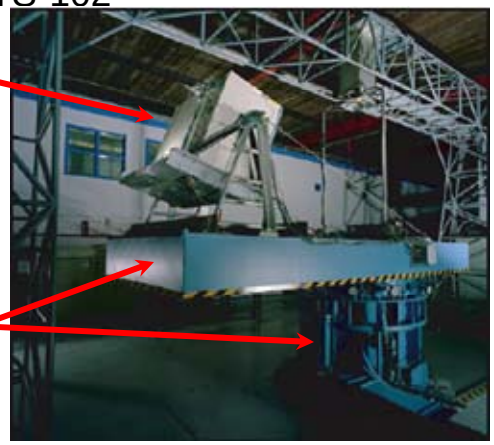
NASA ARC and Hungarian Space Office (KFKI Nuclear Inst.)

Passive Dosimeter System (PDS)

- Measures and records the biologically active space radiation dose at experimenter defined locations on ISS
  - Thermo luminescent Detector (TLD): measures ionizing radiation dosage
  - Plastic Nuclear Track Detector: measures the linear energy transfer spectrum
- TLD Reader measures the cumulative radiation exposure collected on the TLD by heating; heating also returns the TLD to an unexposed state for for re-use
- PNTD delivered to ISS prior to each use and returned to Earth for reading
- TLD can be used independent of the PNTD
- 48 TLDs and 1 TLD Reader currently on ISS
- PDS delivered to ISS on STS-102

Low Vibration Rotational Device (LVRD) & Incubator

- Single arm centrifuge with a 10-foot radius and hydrostatic oil film bearing for precise linear accelerations with low vibration
- Configured with a tissue culture incubator for short and long duration hypergravity exposure
- Chronic exposure to hyper-G up to 5xg
- Offboard incubator available for 1xg controls
- Computer control centrifuge system
- Ground studies and variable comparative studies

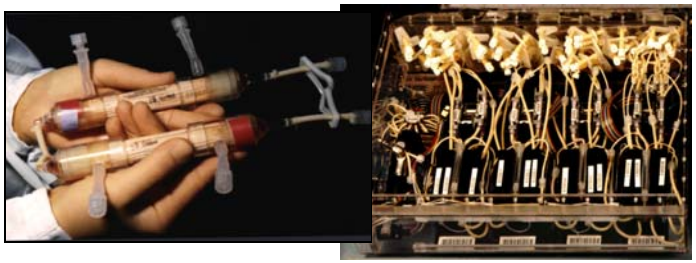


NASA ARC

ARC Hardware and Payload Implementation Collaborations

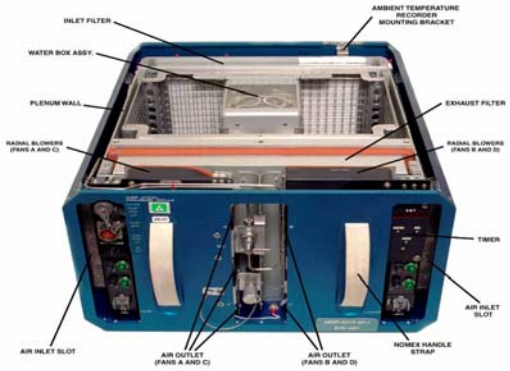
Group Activation Pack/Fluids Processing Apparatus

- BioServe Space Technologies (Hardware owner)
- STS-115 (Microbe), STS-123 (MDRV), and STS-126 (BoneMac), STS-106 (NIH-B1)
- Pathogenic bacteria, yeast, murine bone marrow cells, *Drosophila melanogaster*



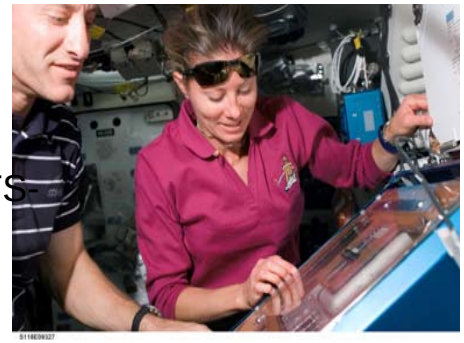
Cell Culture Module

- Walter Reed Army Institute of Research (Hardware owner)
  - Tissue Genesis, Inc. (CCM Program Management)
- National Institutes of Health space flight series (NIH.C) on STS-59, STS-66, STS-63, STS-69, STS-72, STS-77, STS-80, and STS-95,
- STS-131 (3/2010; STL)
- Multiple types of human tissue culture cell lines



Animal Enclosure Module

- NASA ARC (Hardware owner)
- BioServe Space Technologies
- STS-60 (Immune -1), STS-63 (Immune -2), STS-77 (Immune-3), STS-108 (CBTM-1) and STS-118 (CBTM-2)
- Rats and mice



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