



NASA Ames Research Center



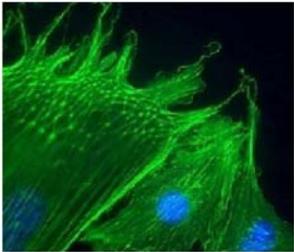
ISS Space Biology Experiment Implementation and Hardware

Cecilia Wigley

Flight Systems and Implementation

Branch Chief

NASA ARC



Areas of Space Biology Research

Cell Research

- Cellular Processes
- Molecular Biology
- Differentiation
- Immunology

Examples of Specimens Studied

- Stem Cells
- 3D Cultures
- Adherent Tissue Cultures
- Non-Adherent Tissue Cultures

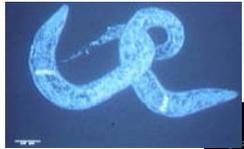


Animal Research

(Vertebrate and Non-Vertebrate Research)

- Physiology
- Immunology
- Development and Differentiation

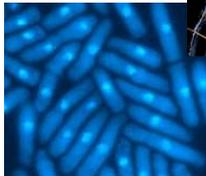
- Rats
- Mice
- *D. melanogaster*
- *C. elegans*
- Newts, Geckos
- Quail
- *X. laevis*



Microbiology Research

- Virulence
- Biofilm
- Molecular Biology

- Bacteria
- Yeast
- Fungus
- Human Virus



Plants Research

- Development and Differentiation
- Cell and Molecular Biology
- Tropisms (Gravity and Light)
- Biomass

- *Arabidopsis* species
- *B. rapa*
- *T. aestivum* (dwarf wheat)





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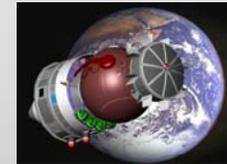


Timeline of Space Biology Missions Implemented by NASA ARC

Bion



Foton



1960's

1970's

1980's

1990's

2000's



Gemini 3, 8, 12



Apollo 17



Skylab 3



Space Shuttle



NASA/MIR



NanoSatellites

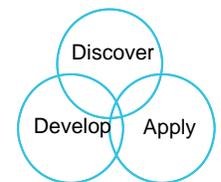
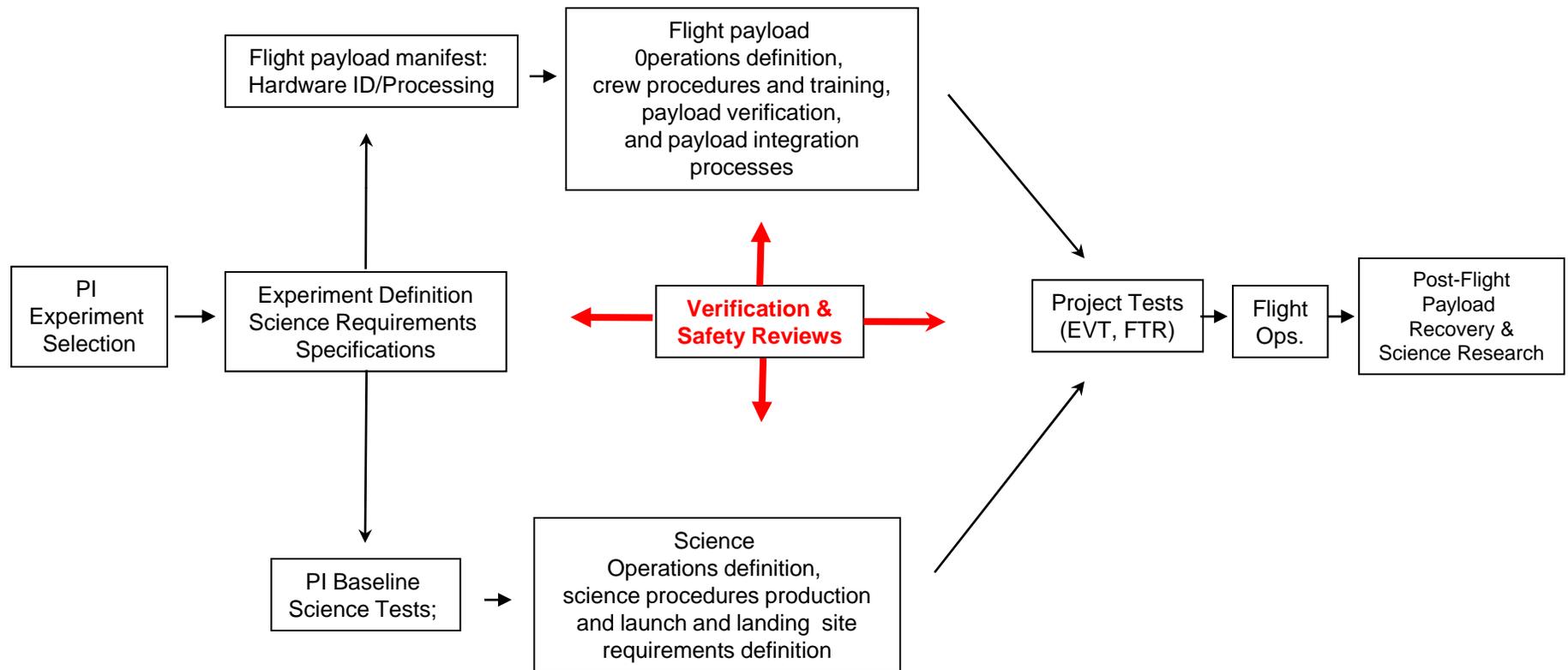


ISS

- Since the 1960's – over 450 flight experiments implemented
- 60 STS and 8 ISS missions
 - Over 170 Principal Investigators flight experiments support
- Flight science collaborations with commercial partners (Bioserve, TechShot, ORBITEC) and other NASA Centers

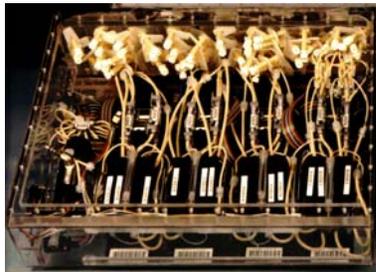


Flight Experiment Implementation Process Overview





Cell Culture Module (CCM; WRAIR; TGI)

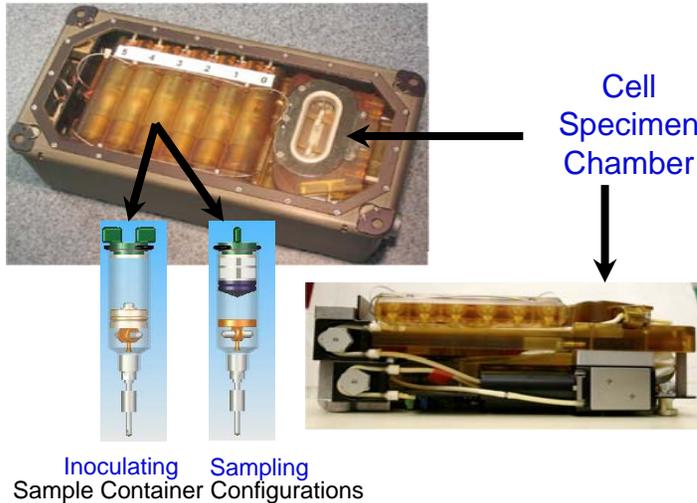


- Hollow Fiber Bioreactors (max of 24 [3] ml or max of 16 [7] ml bioreactors); Custom bioreactor accommodated, mix types in CCM
- Supports adherent cells, non-adherent, and 3D tissue culture
- Temperature settings: +4 °C to +39 °C (CCM-A, CCM-C)
- Humidity: Ambient in Module
- CO₂ control: 5%
- Fluid loops and Oxygenator system for CO₂ gas exchange perfusion system
- Fluid/Medium delivery rate can be User-defined
- User defined medium bags, fixative bags, and sampling bags need
- Sensor (Temp, CO₂) Data collection and downlink capable
- Automated sampling and injection
- Flown on Shuttle (18 flights); Study in progress for adapting the CCM for ISS

Animal Enclosure Module (AEM; NASA ARC)



- Self contained habitat for rats and mice that provides living space, food, water, air circulation, ventilation, and lighting
- Supports up to 5 adult rats or 8 adult mice
- Optional two separate housing areas
- No active thermal control
- On orbit use limited by capacity of waste control filters (approximately 20 days)
- Flown on 24 STS flights
- Study in progress for adapting the AEM for use on ISS and as a transporter in the COTS vehicles



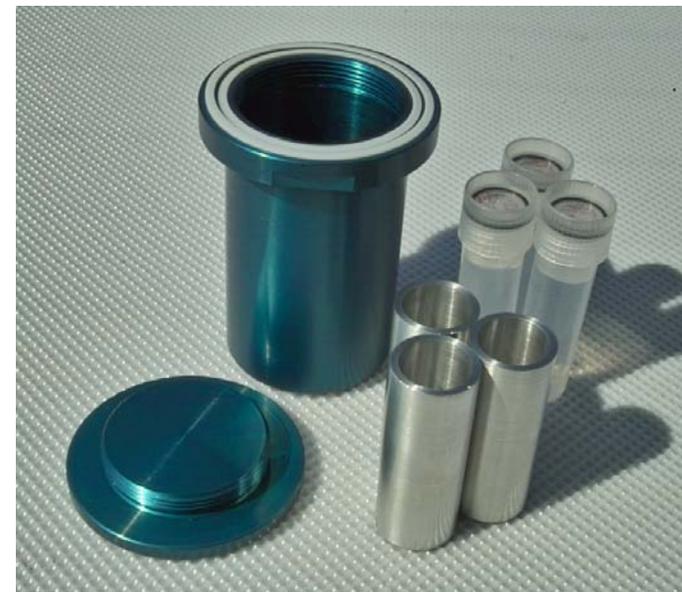
Single Loop Cell Culture (SLCC)

- Mammalian cell and microbial cultures
- 10 ml cell culture volume
- Continuous perfusion of medium for gas exchange
- Six 3 ml containers for inoculums or samples
- Automated inoculation or sampling per a pre-set time sequence
- Fixatives pre-loaded in sampling containers
- Provides temperature and humidity data
- Requires power and thermal conditioning from an incubator

NASA ARC, Aurora Flight Systems, and Bioserve Space Technologies

ARC Canister

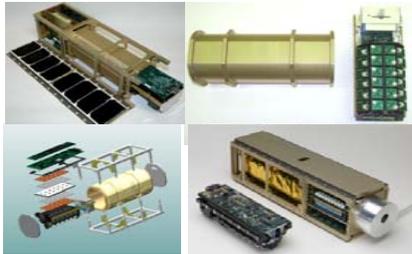
- Microbial Cultures
- 8 ml culture volume
- Passive system providing an anaerobic environment
- Can be frozen down to -100 °C
- Requires thermal conditioning from an incubator
- Previous flight on STS-118 in MERLIN (UAB CBSE)





Microwell Incubators

GeneSat



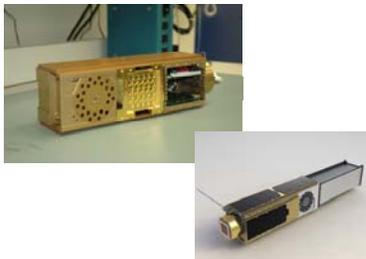
- 10 fluidic wells, 2 reference wells
- 110 $\mu\text{L}/\text{well} \Rightarrow 1.1 \text{ mL}$ total well volume
- 12 detectors for fluorescent optical assay
- 12 detectors for culture optical density
- Sensors for temperature, absolute pressure, humidity, 3-axis acceleration, radiation flux

PharmaSat



- 48 fluidic wells (4 sets of 12)
- 90 $\mu\text{L}/\text{well} \Rightarrow 4.5 \text{ mL}$ 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

O/OREOS

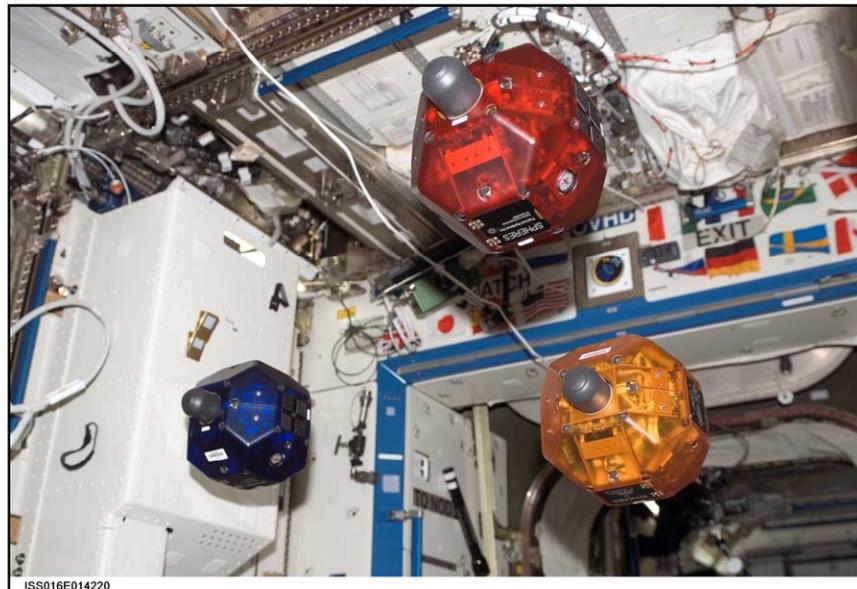


- 3 independent fluidic “bioBlocks” w/ dual pumps
- 12 fluidic wells, 75 μL ea., per Block (36 total)
- 2 on-board 1.6-mL reservoirs per bioBlock
- Time-resolved optical density & RGB colorimetry
- Radiation exposure “window”, 6-month mission life
- Sensors for temperature, pressure, humidity, acceleration,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



SPHERES

- SPHERES is an internal test bed for the development and testing of estimation, control, and autonomy algorithms for distributed satellite systems
 - Test how to program satellites so that they do missions that need formation flight, docking, in-space assembly, etc, with minimal human intervention
 - Useful for future missions such as separated spacecraft telescopes, autonomous servicing missions, and in-space assembly of inter-planetary spacecraft





For over 50 years, NASA ARC has been a lead NASA Center for providing services and support to the Life Sciences research community for conducting biological experiments

- Space flight experiments have spanned a broad spectrum of biological model specimens and life science research objectives
- Expertise and experience in working with PIs to define, develop, manifest, and implement their experiments on ISS and transportation vehicles
- Provide consultation to PIs to address questions concerning the flight process, experiment definition, and flight hardware (commercial, NASA, NASA Commercial Centers, commercial, international partner)



NASA ARC contact Information:

Ken Souza

kenneth.souza@nasa.gov

Sid Sun

sidney.sun@nasa.gov

Cecilia Wigley

cecilia.wigley@nasa.gov