Investigation Summary Form (ISF)
(New Investigations Only – NO PROPRIETARY INFORMATION)

Document Guidelines

- This document is based on ORBIT's RIFD user interface, and is intended to aid with data-entry.
- Please make every attempt to write text in ***present tense*** where applicable.
- To check a box: double click > default value = checked > ok.
- **[nasa.gov]** indicates the field appears on the website http://www.nasa.gov/iss-science/.
- **[ORBIT Only]** indicates the field is internal to ORBIT database.

COMMON DATA

For Investigation
(Required for All Investigations)

Sponsoring Space Agency [nasa.gov]: National Aeronautics and Space Administration (NASA)

Sponsoring Organization [nasa.gov]: *NASA – Advanced Exploration Systems (NASA-AES)*

Parent Investigation [ORBIT Only]: N/A

PROGRAM SCIENCE

Summary Form

Investigation Name [nasa.gov]: BioSentinel

Investigation Title [nasa.gov]: BioSentinel ISS Control Experiment

Category [nasa.gov]: Biology & Biotechnology
Subcategory [nasa.gov]: Microbiology

Detailed Research Description [nasa.gov]:

BioSentinel ISS Control Experiment (BioSentinel) aims to develop biosensors to study the effects of the space radiation environment on biological organisms. Given its similarities to human cells, this investigation performs testing on *Saccharomyces cerevisiae*, budding yeast. Yeast cells share homology to human cells, particularly in the response to deoxyribonucleic acid (DNA) damage caused by ionizing radiation. Most importantly, yeast cells survive in a desiccated form for long periods of time. Thus, budding yeast is the ideal model organism for long-term experiments in preparation for future manned missions to deep space. In addition to the International Space Station (ISS) mission, the biosensors are designated to fly in a nanosatellite designed for deep space.

Two yeast strains have been developed for BioSentinel: (1) a wild type strain used as a control for DNA damage and yeast health, and (2) a DNA repair-defective strain that is sensitive to ionizing radiation. Both strains are loaded and desiccated inside fluidic cards.

Each payload has 18 fluidic cards and each fluidic card has 16 microfluidic wells, for a total of 288 wells. Card activation occurs at different time points throughout the 6-month mission and following ground commands. At each time point, two fluidic cards are filled with growth medium containing nutrients and a metabolic indicator dye. In addition to card filling, the temperature of the cards increases from ~4°C (stasis mode) to 23°C to allow for cell growth. The metabolic dye changes color from blue to pink, then pink to clear in the presence of metabolically active yeast cells. The colorimetric changes and cell growth are monitored using a 3-light-emitting diode (LED) optical detection system. The optical data determines how fast the cells are able to recover after accumulating radiation damage over time.

After ground command initiation, all the fluidics, thermal and optical detection steps in BioSentinel are fully automated.

The biosensor response data is compared to physical dosimetry data collected onboard the same payload. This dosimeter or linear energy transfer (LET) spectrometer is based on TimePix chip technology. This chip measures the total ionizing radiation dose in addition to calculating the LET of each particle that traverses its sensor, thus allowing researchers to characterize the radiation environment around the payload. The biological response (and physical dosimetry) on ISS over time is compared to the deep space mission and to data obtained on the ground.This analysis provides insight on the biological effects of the space radiation exposure in preparation for future long-duration missions to space and inhabitation beyond low-Earth orbit (LEO).

Research Overview [nasa.gov]:

- BioSentinel ISS Control Experiment (BioSentinel) studies the biological response to space radiation with the use of yeast biosensor strains flown to the International Space Station (ISS).
- The model organism, budding yeast *Saccharomyces cerevisiae*, shares cellular processes with human cells, including the response to ionizing radiation.
- Yeast cells survive for long periods of time in desiccated form, making them ideal candidates for long-term space missions.
- Yeast cells fly in desiccated form inside fluidic cards and are activated in space by addition of growth medium containing nutrients and a metabolic indicator dye. Eighteen fluidic cards are activated throughout the mission. The cell growth and metabolic activity are measured using an optical detection system. Investigation data is downlinked to Earth.
- Optical measurements then demonstrate how much radiation damage the cells have accumulated over time as well as how they respond and survive in the space environment.
- This investigation also includes a physical dosimeter that provides information on the amount and type of radiation. This is necessary to draw comparisons between the biological response and the actual radiation environment in space.

PAO Summary [nasa.gov]:

Science writer edits:
BioSentinel ISS Control Experiment (Bio Sentinel) measures the effects of radiation and microgravity on *Saccharomyces cerevisiae*, or budding yeast. This model biological organism, used for many years in academic research, industry and biotechnology, has biology very similar to humans and has flown in space before. Scientists plan to compare the effects of the space station environment on this yeast to effects from a deep space mission.

Space Applications [nasa.gov]:

Science writer edits:
The investigation compares data from yeast on the space station and ground samples, which will be compared to data from a future deep-space experiment. This process provides a picture of potential damage accumulated over several months of exposure to space radiation and contributes to understanding of how long-term missions to deep space may affect humans.

Earth Applications [nasa.gov]:

Science writer edits:
Improved understanding of the effects of space radiation on a model organism has potential applications in settings on Earth where organisms, including humans, may be exposed to radiation.

Operations Location: Indicates where the investigation is performed.

- ☐ Ascent Only
- ☐ Descent Only
- ☒ ISS Internal
- ☐ ISS External – Attached
- ☐ ISS External – Deployed
- ☒ Pre/Postflight
- ☐ Sortie

Research Operational Requirements and Protocols [nasa.gov]:

Minimal crew time is required during payload installation and removal. At nine different time points throughout the 6-month mission, two fluidic cards are activated via ground command (18 fluidic cards total). All payload operations are automated once the command is sent. For card activation, cell growth medium containing nutrients and a metabolic indicator dye is injected into 16 microfluidic wells per card. In order to start the cell growth and metabolic activity measurements, the card temperature increases from ~4°C (stasis mode) to 23°C (growth mode). Each pair of fluidic cards is active for 3 to 5 days, and the growth and metabolic data is downlinked back to Earth. After each time point, the used cards return to stasis mode. At the end of the mission, the payload containing the samples is returned to the research team at NASA Ames Research Center for ground processing.

Previous Missions [nasa.gov]: N/A

Summary Form - Additional Information
(*Optional for non-US Sponsored Investigations*)

Educational Impact:
Will this investigation involve students (K-12, Undergraduate, Graduate), teachers, or schools?
☒ Yes ☐ No

Educational Activities: Undergraduate students (Space Biology sponsored summer interns) are expected to help with data analyses and biology optimization in preparation for the mission.

Project Funding Type: NASA Funding

Grant Number: N/A

Contacts
(Required for All Investigations)

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- **Institution Location [nasa.gov]:** Moffett Field, CA
- **Institution Type:** Space Agency

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- **Institution Type:** Space Agency

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First Name MI Last Name

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Developer(s)
(Required for All Investigations)

Developer Information [nasa.gov]: NASA Ames Research Center, Moffett Field, CA

Websites
(*Optional for non-US Sponsored Investigations)*

Web Sites [nasa.gov]:
https://www.nasa.gov/centers/ames/engineering/projects/biosentinel.html

Images
(Required for all investigations displayed on nasa.gov.)

NOTE: ***It is understood that any Principal Investigator/Payload Developer submitting imagery has the authority to release the rights to the imagery and where applicable, have waivers for any identifiable persons (adult or minor) in said imagery. All imagery submitted is classified as "Shared" as defined in SSP 50521 (Return, Processing, Distribution and Archiving of Imagery Products from the International Space Station).***

The images and information provided are added to NASA's official databases, linked to future publications and used in reports for NASA Headquarters, Congress, Crew Briefings, Press Briefings, and released to various social media outlets. We would like to thank you and your team for contributing to the success of International Space Station (ISS) research. NASA is very appreciative of the hard work, scientific insight and tremendous accomplishments of the ISS research community.

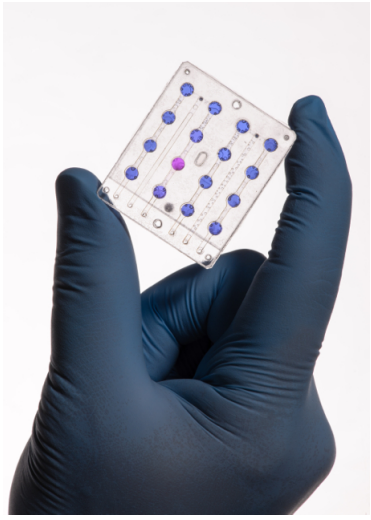
Imagery Submittal [nasa.gov]: Imagery shall be provided as a separate file (not embedded in Word or PowerPoint) as digital still Original Camera File (RAW), Tagged Image Format (TIF), or Joint Photographic Equipment Group (JPEG) file. The preferred resolution for still imagery is a minimum of 2k x 3k pixels or in the case of payloads with imbedded cameras, the original camera file resolution. Manipulated ("photoshopped") images with the investigations aboard the ISS are not acceptable.

Submit imagery and below forms along with the ISF to your designated Program Science point of contact.

Imagery Description Form

The first image is used for communication projects. Photographs of the investigation taken on the ISS are added following operation.

The following information is required for each image submitted:



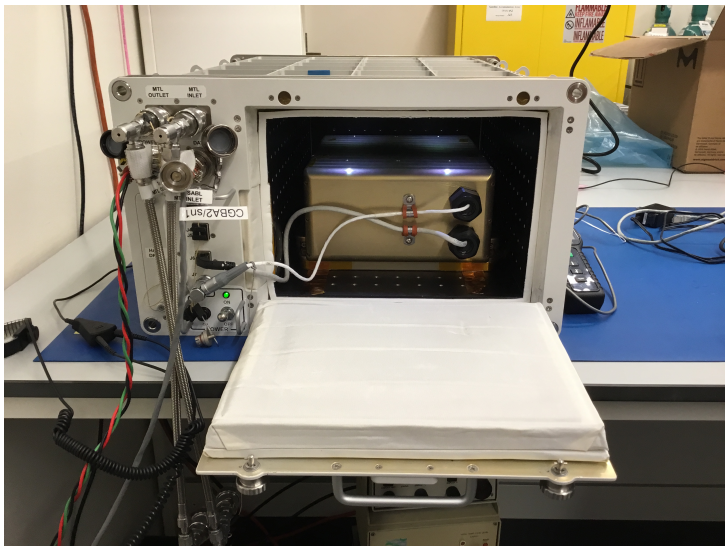
Mandatory Fields

Original Image File Name *Ex: DSC0259 or IMG_1234*	ACD15-0042-007
Image Date *Date the image taken*	March 24, 2015
Image Title *Ex: Bio-Analyzer*	Fluidic wells
Image Caption *Description of the image contents, activity occurring in the image, a NASA number if available, names of the individuals in the image, and image credit information.*	BioSentinel's microfluidics card, designed at NASA Ames, is used to study the impact of interplanetary space radiation on yeast. Once in orbit, the growth and metabolic activity of the yeast is measured using a 3-color LED detection system and a metabolic indicator

Ex. Image courtesy of Joe Smith.	dye. Here, pink wells contain actively growing yeast cells that have reduced the metabolic dye color from blue to pink. Image courtesy of NASA Ames
Investigation/Facility Name *Ex: AngieX Cancer Therapy, AMS-02, Glacier, Veg-03H.*	BioSentinel

Optional Information

Part Number *Ex: SV809111-3, SED46117957-305.*	
Serial Number *Ex: 1001*	
Place Taken *Ex: Space Station Processing Facility/KSC, MIT Engineering Lab, Apollo HS – Washington, DC.*	
Event *Ex: filling the VCHS-Protein Crystallization in Space experiment with protein solutions, Discovery HS Science Fair – Springfield, MO.*	
Additional Information *Ex: Wide view. This series of photographs documents the XYZ hardware assembly activity…*	



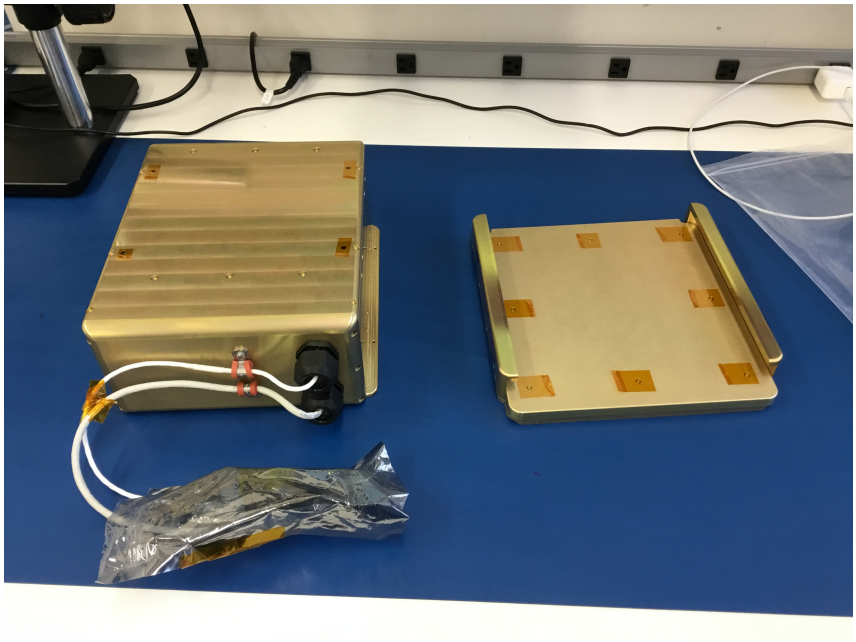
Mandatory Fields

Original Image File Name	BioSentinel_EDU-in_SABL

Ex: DSC0259 or IMG_1234	
Image Date *Date the image taken*	January 30, 2020
Image Title *Ex: Bio-Analyzer*	BioSentinel EDU in SABL
Image Caption *Description of the image contents, activity occurring in the image, a NASA number if available, names of the individuals in the image, and image credit information.* *Ex. Image courtesy of Joe Smith.*	The BioSentinel ISS Payload engineering unit is successfully installed in the SABL ground unit for interface testing in a representative flight environment. Image courtesy of NASA Ames
Investigation/Facility Name *Ex: AngieX Cancer Therapy, AMS-02, Glacier, Veg-03H.*	BioSentinel

Optional Information

Part Number *Ex: SV809111-3, SED46117957-305.*	A9SP-1404-M600
Serial Number *Ex: 1001*	001
Place Taken *Ex: Space Station Processing Facility/KSC, MIT Engineering Lab, Apollo HS – Washington, DC.*	BioServe Space Technologies, Boulder, CO
Event *Ex: filling the VCHS-Protein Crystallization in Space experiment with protein solutions, Discovery HS Science Fair – Springfield, MO.*	
Additional Information *Ex: Wide view. This series of photographs documents the XYZ hardware assembly activity…*	



Mandatory Fields

Original Image File Name *Ex: DSC0259 or IMG_1234*	BioSentinel_EDU_Carrier_MountPlate
Image Date *Date the image taken*	January 30, 2020
Image Title *Ex: Bio-Analyzer*	BioSentinel ISS Carrier and Mount Plate
Image Caption *Description of the image contents, activity occurring in the image, a NASA number if available, names of the individuals in the image, and image credit information.* *Ex. Image courtesy of Joe Smith.*	BioSentinel's ISS Control Experiment, designed at NASA Ames, is used to study the impact of interplanetary space radiation on yeast. The Mount Plate, right, provides the mechanical and thermal interface to the SABL incubator. The Carrier, left, houses the BioSensor science payload. Image courtesy of NASA Ames
Investigation/Facility Name *Ex: AngieX Cancer Therapy, AMS-02, Glacier, Veg-03H.*	BioSentinel

Optional Information

Part Number *Ex: SV809111-3, SED46117957-305.*	A9SP-1404-M600, A9SP-1404-M614
Serial Number *Ex: 1001*	001
Place Taken *Ex: Space Station Processing Facility/KSC, MIT Engineering Lab, Apollo HS – Washington, DC.*	BioSentinel Laborator, ARC
Event	

Ex: filling the VCHS-Protein Crystallization in Space experiment with protein solutions, Discovery HS Science Fair – Springfield, MO.	
Additional Information *Ex: Wide view. This series of photographs documents the XYZ hardware assembly activity…*	

INCREMENT OPERATIONS

General Info
Increment Operations
(Required for All Investigations)

Increment(s) [IDRD] [nasa.gov]: 63/64 (planned launch on SpX-21)