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]:

The main science objective of BioSentinel is to develop biosensors to study the effects of the space radiation environment on biological organisms. Given its similarities to human cells, we decided to use the budding yeast *Saccharomyces cerevisiae*. Yeast cells share homology to human cells, particularly in the response to DNA damage caused by ionizing radiation. Most importantly, yeast cells can be desiccated and survive in that 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 ISS mission, our biosensors will fly in a nanosatellite designed for deep space, which is manifested to fly as a secondary payload onboard NASA's Artemis-1 rocket.

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 will be 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 will occur at different time points throughout the 6-month mission and following ground commands. At each time point, two fluidic cards will be 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 (and then pink to clear) in the presence of metabolically active yeast cells. The colorimetric changes and cell growth will be monitored using a 3-LED optical detection system. The optical data will be used to determine 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 will be compared to physical dosimetry data collected onboard the same payload. This dosimeter or LET spectrometer (LET = linear energy transfer) is based on the TimePix chip technology and measures the total ionizing radiation dose in addition to calculate the LET of each particle that traverses its sensor, thus allowing to characterize the radiation environment around the payload. The biological response (and physical dosimetry) on ISS over time will be compared to the deep space mission and to data obtained on the ground. We hope to use this information to inform us on the biological effects of the space radiation exposure in preparation for future long duration missions to space and inhabitation beyond LEO.

Research Overview [nasa.gov]:

- The budding yeast *Saccharomyces cerevisiae* is a model organism that has been used for many applications throughout the years, including biomedical and space research. This is due to its similarities with human cells and that they share many cellular processes, including the response to ionizing radiation. Importantly, yeast cells can survive for long periods of time in desiccated form, making it an ideal candidate for long-term missions, and thus can provide valuable information for future manned missions beyond low Earth orbit (LEO).
- In order to study the biological response to the space radiation environment, we have developed yeast biosensor strains that will fly to the ISS and in our deep space nanosatellite mission, which will fly onboard NASA's Artemis-1. Ground experiments will also be performed for each of our flight missions.
- Yeast cells will fly in desiccated form inside fluidic cards and activated in space by addition of growth medium containing nutrients and a metabolic indicator dye. 18 fluidic cards will be activated throughout the 6-month mission via ground commands. The cell growth and metabolic activity will be measured using an optical detection system, and the data transferred back to Earth.
- The optical measurements will provide information on how much radiation damage the cells have accumulated over time, and thus inform us on how the cells are able to respond and survive in this environment. Our payload also includes a physical dosimeter that will provide information on the amount and type of radiation. Thus, we

will be able to compare the biological response with the actual radiation environment in space.

PAO Summary [nasa.gov]:

Saccharomyces cerevisiae, or budding yeast, is a model biological organism that has been used for many years in academic research, industry, and biotechnology. Its biology is very similar to humans and budding yeast has been flown to space before, including the International Space Station (ISS). In this experiment, we will use yeast cells as biosensors to measure the effects of the radiation and microgravity environment on the ISS, and to compare these effects to our deep space mission onboard Artemis-1.

Space Applications [nasa.gov]:

This investigation looks at the biological response of a model organism to the space environment on the International Space Station (ISS). The data obtained during this mission will be compared to our ground data and to data obtained from our deep space experiment. The study will report on the potential damage accumulated over several months of exposure to space radiation, and will provide valuable information on how human biology might be affected on long-term missions to deep space.

Earth Applications [nasa.gov]:

The Earth Application for this investigation has yet to be identified.

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 will be required during payload installation and removal. At nine different time points throughout the 6-month mission, two fluidic cards will be 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 will be active for ~ 3 – 5 days, and the growth and metabolic data will be 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 will be 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: In previous years, we have had undergraduate students (Space Biology sponsored summer interns) help with data analyses and biology optimization in preparation for this mission. We expect to continue working with undergraduate students next year.

Project Funding Type: NASA Funding

Grant Number: N/A

Contacts
(Required for All Investigations)

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- **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.* *Ex. Image courtesy of Joe Smith.*	BioSentinel's microfluidics card, designed at NASA Ames, will be used to study the impact of interplanetary space radiation on yeast. Once in orbit, the growth and metabolic activity of the yeast will be measured using a 3-color LED detection system and a metabolic indicator dye. Here, pink wells contain actively growing yeast cells that have reduced the metabolic dye from blue to pink in color. 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 *Ex: DSC0259 or IMG_1234*	BioSentinel_EDU-in_SABL
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 was 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, will be 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)