



Mission XI
“Managing Microbes in Space”
“Cloud-Aerosol Transport System” (CATS)

Final Report

October 2015

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I. OVERVIEW

A. Mission Statement

To challenge America's students to excel in math and science through their active participation in space-based research.

B. The Program

Orion's Quest is an Internet assisted education program that employs current NASA research to reach and inspire "the next generation of explorers." Utilizing the processes and tools of world-class scientists, Orion's Quest students actively engaged in and supported ongoing research currently being conducted on the International Space Station (ISS). This report is a review of the Orion's Quest *Mission XI programs and activities taking place between October 2014 – June 2015.

C. Program Goals

- Market the Orion's Quest (OQ) Program on a national level
- Establish and develop professional working relationships with partners, collaborators and participants.
- Develop a classroom curriculum that meets research requirements, is aligned with national educational standards, and supports the goals of participating classrooms.
- Develop first OQ elementary component.
- Maintain effective communication throughout the program
- Redesign the Orion's Quest Web Site to support program requirements
- Secure funding in support of the mission

II. MISSION XI

A. Mission XI Research Activities

1. **Experiment "Managing Microbes In Space" (MMIS)**

Focus: Middle/High School

MMIS supports the research of Dr. Cheryl Nickerson at the Biodesign Institute at Arizona State University. This research is in support of astronaut health.

2. **Experiment "Cloud-Aerosol Transport System" (CATS)**

Focus: Elementary School

CATS follows the launch of SpaceX-5 to the installation of the unit on the International Space Station. The CATS system will measure and track aerosols in the earth's atmosphere.

3. “Virtual” Orion’s Quest research activities (based on past missions)

Focus: Middle/High School

- ❖ Butterflies In Space (BFIS)
- ❖ Spiders In Space (SIS)
- ❖ Plant Growth In Space (PGIS)
- ❖ Silicate Gardens In Space
- ❖ Fruit Flies In Space

See Appendix D for specific information.

B. Recruiting

Orion's Quest recruited forty-six (46) teachers in thirty-seven (37) schools to participate in the program. All participants were U.S. schools and represented public, parochial and charter schools, as well as a cross section of urban, suburban and rural settings.

Approximately 2,500 students participated in Mission XI programs.

No fees were assessed for schools to participate in the Orion’s quest Program.

See Appendix B for specific statistics.

C. Web Site

The Orion's Quest Web Site, at www.orionsquest.org, was redesigned and managed by “Dotsignal” in South Lyon, MI. Configured to address program needs, the web site was the primary communication hub of Mission XI and included basic email capabilities and a password-protected page for each participating teacher.

D. The Process

Students were active in their selected activity during the period of March – June 2015.

1. “Managing Microbes in Space” (MMIS)

The goal of the classroom research was to have students analyze and record death rates of *C. elegans* nematodes after being infected with salmonella while immersed in four different solutions.

This was done by video taping each of four quadrants of the experiment flask while on ISS. These videos were downlinked from orbit, and along with videos of the control experiment at ASU, were transferred to classroom computers for counting and measuring, via the OQ Website.

Final data from the classroom research was compiled and submitted to Dr. Cheryl Nickerson for review and, if appropriate, inclusion in research databases.

2. “The Cloud-Aerosol Transport System” (CATS)

The goal of the CATS mission was to develop a lesson plan to allow students to follow the CATS unit from the launch of SpaceX-5 through its installation on the International Space Station.

E. Curriculum

A “mini” curriculum for each activity was developed by the Orion’s Quest staff that included program information and step-by step instructions in program operations. The curriculum is structured to allow the classroom flexibility of process and time, allowing the teacher the ability to determine approach and schedule.

The MMIS curriculum was based on national science and math standards to assist the teacher to meet required classroom goals.

A copy of the MMIS curriculum is available upon request

The CATS curriculum was designed to assist students to follow the mission from launch to placement of the unit on the ISS.

The CATS Teacher’s Guide can be found in Appendix D

Lesson plans included:

- ✓ the organizational structure of NASA
- ✓ an introduction of Dr. Nickerson and her research
- ✓ a description and goals of the mission
- ✓ a guided path through the program
- ✓ a listing of websites for assistance and broader information

F. Teacher Training

Teachers were trained through a series of on-line instruction messages, on site visits, and individual contacts via email or telephone. Teachers were asked to provide feedback on an on-going basis throughout the mission.

G. Communication

The Orion's Quest Web Site, at www.orionsquest.org, served as the primary communication hub throughout the mission.

Orion's Quest staff members were able to make on-site visits to twenty-one classrooms in eleven (11) schools.

H. Events and Presentations

Orion's Quest staff members participated in a number of events and presented the program at a series of venues.

- September 2014
Met with Dr. Cheryl Nickerson and staff in preparation for "Managing Microbes In Space" (MMIS) mission – Tempe, AZ
- October 2014
Met with Peter Tchoryk, CEO of Michigan Aerospace Corp. in preparation for "CATS" Mission – Ann Arbor, MI
- October 2014
Attended the NASA Human Health and Performance Center (NHHPC)- National Space Biomedical Research Institute (NSBRI) Conference – Houston, TX
- November 2014
Attended Michigan Space Grant Consortium Conference
Ann Arbor, MI
- February 2015
Presented to group of NASA researchers at Johnson Space Center (JSC) - Houston, TX
- Presented at and attended the Space Exploration Educators Conference (SEEC) - Houston, TX
- February 2015
Presented at NASA Space Grant Directors Conference - Washington, DC
- March 2015
Presented at monthly meeting of Detroit Public School Science Teachers – Detroit, MI

I. Budget

- The Mission XI program operated with a budget of \$42,500.00 provided by:
 - Michigan Aerospace Corporation

- \$10,000.00
 - The Michigan Space Grant Consortium
 - \$7,500.00
 - The Lloyd and Mable Johnson Foundation
 - \$25,000
- Orion's Quest staff members were provided, stipends and reimbursement for business expenses.

Financial report included in Appendix C

J. Outcomes

This has been a very successful year in terms of program activities and initiatives.

- MMIS:
 - Approximately 7,000 student analysis data sheets provided to Dr. Nickerson
 - A strong professional relationship was established with Dr. Nickerson and her staff
- CATS:
 - All objectives met.
- Dialog started with Michigan Aerospace Corp. regarding expanding the CATS program to include secondary students involved in analysis. Initial contact made to Dr. Matt McGill, CATS Principal Investigator at NASA's Goddard Space Center.
- Virtual Missions
 - Five teachers in four schools participated in an Orion's Quest "virtual" mission.

See Appendix B for more details

III. SUMMARY

A. Objectives

All objectives were met in each of the mission activities. Dr. Nickerson's research (MMIS) was significant on several levels. This was an extremely complex experiment and the culmination of five years planning. Further, this was the first time an organism (*C. elegans*) was infected with a pathogen (*Salmonella*) in microgravity.

B. Opportunities

Along with the regular mission programs, several opportunities became available during the 2014-15 school year.

1. The Center for the Advancement of Science In Space (CASIS)
 - a) CASIS contacted Orion's Quest regarding several opportunities for outreach support of several research activities currently on ISS
2. Challenger Center of Bangor, Maine
 - b) The Challenger Center has requested curriculum support for activities conducted at the center.
 - c) Curriculum and materials have been provided to the center
3. Former NASA astronaut COL Jerry Ross joined the Orion's Quest Board of Advisors

IV. APPENDICES

Appendix A: “Orion’s Quest Staff”

Peter Lawrie - Executive Director

Tom Drummond – Director of Education

Angela Krause-Kutchka – Educational Coordinator

Rick Patterson - Administrative Assistant

Bob Watson – Education Support

Brett Huffmaster – Business Development

Matt Simmons - Director of Technology

Carla Goulart-Hoehn - Grants

Jennifer Galofaro – Finances

Bio’s available on request

Appendix B: “Mission XI Participating School Statistics”

Schools – Locations

*Indicates multiple teachers in one school

“Managing Microbes In Space” (MMIS)

1. Seabrook Intermediate	Seabrook, TX
2. *Smith Middle School	Troy, MI
3. *Smith Middle School	Troy, MI
4. *Smith Middle School	Troy, MI
5. Cornerstone High School	Detroit, MI
6. Armada Middle School	Armada, MI
7. Piner High School	Santa Rosa, CA
8. Westside Academy High School	Detroit, MI
9. Elk Rapids High School	Elk Rapids, MI
10. Pin Oak Middle School	Bellaire, TX
11. Cody High School	Detroit, MI
12. Sunnyside High School	Tucson, AZ
13. Forsythe Middle School	Ann Arbor, MI
14. *West Middle School	Traverse City, MI
15. *West Middle School	Traverse City, MI
16. Fisher Magnet Upper Academy Middle School	Detroit, MI
17. Maple Hill High School	Castleton, NY
18. Friendswood High School	Friendswood, TX
19. Caravel Middle Academy Middle School	Bear, DE
20. Menomonie High School	Menomonie, WI
21. Ulrich Intermediate	Houston, TX
22. *University Prep Middle School	Detroit, MI
23. South Lyon High School	South Lyon, MI
24. Westchester Academy	Houston, TX
25. Hastings High School	Hastings, MI
26. *The Seven Hills School Middle School	Cincinnati, OH
27. *The Seven Hills School Middle School	Cincinnati, OH
28. Foreign Language Academy Elementary	Detroit, MI
29. Griffin Middle School	Tallahassee, FL
30. Pearland High School	Pearland, TX
31. The Alva School Middle School	Alva, FL

“Cloud Aerosol Transport System” (CATS)

32. Saline High School	Saline, MI
33. Skyline High School	Ann Arbor, MI
34. Forsythe Middle School	Ann Arbor, MI
35. Highlander Way Middle School	Howell, MI
36. *Bates Elementary	Dexter, MI
37. *Bates Elementary	Dexter, MI
38. Creekside Middle School	Dexter, MI
39. Mill Creek Middle School	Dexter, MI

40. Maltby Intermediate	Brighton, MI
41. Pathfinder Middle School	Pinckney, MI
42. Kingston Elementary	Kingston, NY
<i>“Butterflies In Space” (BIS)</i>	
43. *Kingston Elementary	*Kingston, NY
44. *Kingston Elementary	*Kingston, NY
45. *University Prep Middle School	Detroit, MI
<i>“Plant Growth In Space” (PGIS)</i>	
46. Highlander Way Middle School	Howell, MI
<i>“Spiders In Space” (SIS)</i>	
47. Clippert Academy Middle School	Detroit, MI

Demographics

Level

- 13 - High Schools
 - Ninth grade general biology – twelfth grade Advanced Placement (AP)
- 21 - Middle Schools
 - Sixth grade – eighth grade general science
- 3 - Elementary Schools
 - Second grade – eighth grade general science

States

1. Arizona	1
2. Delaware	1
3. Florida	2
4. Michigan	22
5. Ohio	1
6. New York	2
7. Texas	6
8. Wisconsin	1
9. California	1

Location

	<u>Number</u>	<u>Percentage</u>
Urban	11	33%
Suburban	14	42%
Rural	7	25%

Approximately 2,500 students participated in Mission XI programs.

Appendix C: "Finances"

Mission XI was support by the following funding streams:

Grants:

- Lloyd and Mabel Johnson Foundation \$25,000
- Michigan Space Grant Consortium \$7,500

Contracts:

- Michigan Aerospace Corporation \$10,000

Total \$42,500

Mission XI Program Costs; \$26,375.73

Consultants (Staff):	35%
Program	28%
Conferences	20%
Administration	7.0%
Supplies/Equipment	6.0%
Printing	3.5%

Appendix D: “Research Description”

2014 – 2015 Research Activities

1. “Managing Microbes in Space” (MMIS)
Grade Level Focus: Middle and High School

*“Managing Microbes in Space” mission supports the ground breaking research of Principal Investigator Dr. Cheryl Nickerson of the Center for Infectious Diseases and Vaccinology, at the Biodesign Institute at Arizona State University. Over the last decade studies appear to have shown that some pathogens become more virulent in space while the human immune system becomes weaker.

This NASA sponsored space-based research looks for ways to not only counteract or prevent illness in astronauts, but potentially assist in developing vaccines for preventing infections here on earth. To do this, the Nickerson team infected a host organism, the nematode *Caenorhabditis elegans* (*C. elegans*) with the bacterium *Salmonella sp.* pathogen to study the effects of various growth media to determine if the virulence of the Salmonella can be altered. The experiment was conducted on the International Space Station (ISS) along with a control activity in the laboratory at ASU. This was the first experiment to infect a living organism to study host-pathogen interactions in space in real time.

Dr. Cheryl Nickerson research explanation video:

<http://www.spark101.org/video/researching-bacterias-virulence-in-space/>

**MMIS curriculum available on request. Contact Tom Drummond:
drummond@orionsquest.org)*

2. “The Cloud-Aerosol Transport System” (CATS)
Grade Level Focus: Elementary Grades 2-5

The Cloud-Aerosol Transport System (CATS) investigation uses a light detection and ranging (LiDAR) system to measure the location, composition and distribution of pollution, dust, smoke, aerosols and other particulates in the atmosphere. CATS is mounted on the Japanese Experiment Module's Exposed Facility and is used to study the atmospheric constituents that impact global climate. By gaining a better understanding of cloud and aerosol coverage, scientists can create a better model of the Earth's climate feedback processes.

“The Cloud-Aerosol Transport System (CATS) Teacher’s Guide”



Mission XI b Resource Guide Cloud-Aerosol Transport System (C.A.T.S.) Project

Current SpaceX-5 Launch Information



Launch Date: December. 16, 2014 -- 2:31 p.m. Eastern Daylight Time
<http://www.nasa.gov/missions/schedule/#.VH01Ar6DdJO>

Mission: [Fifth SpaceX Commercial Resupply Services Flight with Cloud-Aerosol Transport System \(SpaceX CRS-5\)](#)

Description: Launching from Cape Canaveral Air Force Station, Fla. SpaceX CRS-5 will deliver cargo and crew supplies to the International Space Station. It will also carry CATS, a laser instrument to measure clouds and the location and distribution of pollution, dust, smoke, and other particulates in the atmosphere.

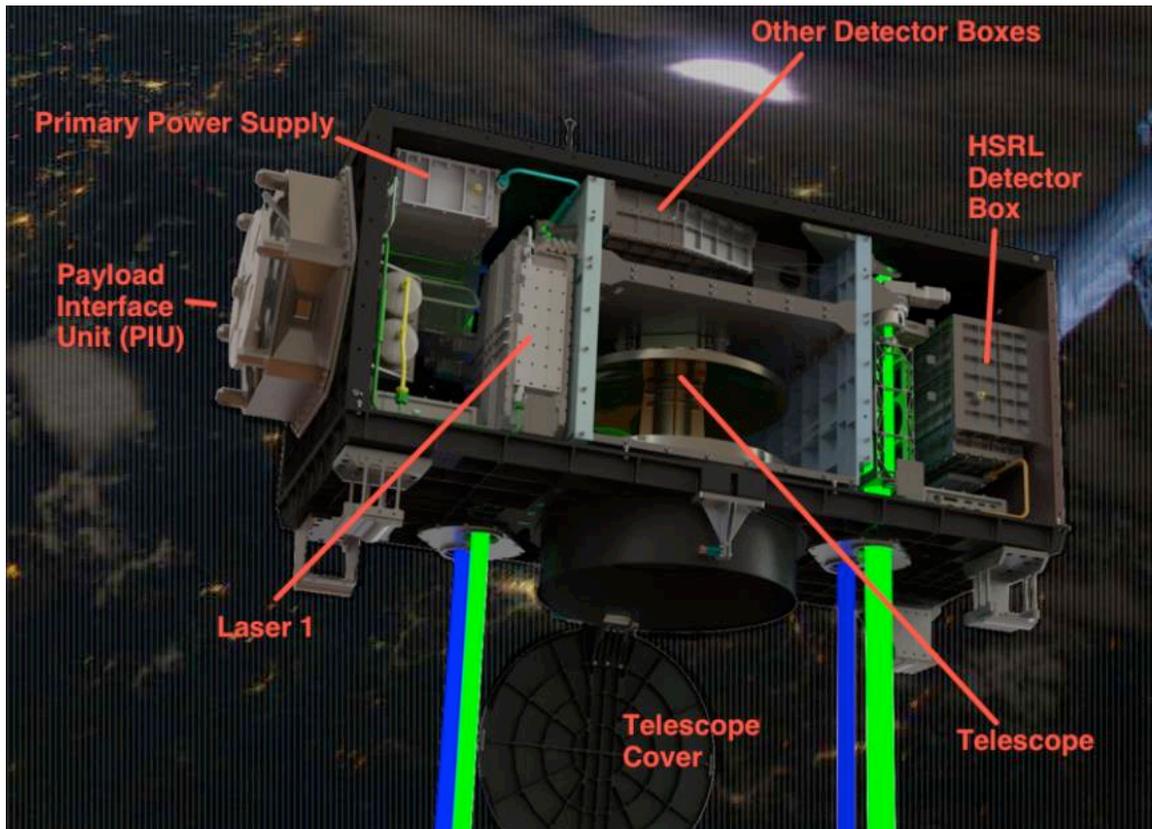
The fifth SpaceX cargo mission to the International Space Station (ISS) under NASA's Commercial Resupply Services contract is scheduled to launch Tuesday, Dec. 16, from Space Launch Complex 40 at Cape Canaveral Air Force Station in Florida. NASA Television coverage of the launch begins at 1:15 p.m. EST.

The company's “Falcon 9” rocket will lift off at 2:31 p.m., carrying its “Dragon” cargo spacecraft. It is loaded with more than 3,700 pounds of scientific experiments, technology demonstrations and supplies, including critical materials to support 256 science and research investigations that will take place on the space station during ISS Expeditions 42 and 43.

The mission, designated SpaceX CRS-5, is the fifth of 12 SpaceX flights NASA contracted with the company to resupply the space station. It will be the sixth trip by a “Dragon” spacecraft to the orbiting laboratory.

The science research aboard the “Dragon” includes the Cloud-Aerosol Transport System (CATS), which will characterize and measure the worldwide distribution of clouds and aerosols -- the tiny particles that make up haze, dust, air pollutants and smoke.

Follow the launch live at; <http://www.nasa.gov/multimedia/nasatv/>



C.A.T.S. instrument diagram

Listed below are internet resources on several important aspects of this mission including the instrument, the science, the launch vehicle, and the destination.

NASA websites

This is a good place to start for the best explanation of CATS experiment, equipment and goals

<http://cats.gsfc.nasa.gov/>

Press release with diagram (overview, background on CATS) 12-1-14

<http://www.nasa.gov/content/goddard/cats-eyes-clouds-smoke-and-dust-from-the-space-station/>

Press release 11-4-14

http://www.nasa.gov/mission_pages/station/research/experiments/1037.html

Michigan Aerospace

www.MichiganAerospce.com

Scientific Instruments or Tools websites

Scientific tools overview with PowerPoint elementary level

<http://teachertech.rice.edu/Participants/cmonmouth/lessons/ScienceTools/index.html>

Making Scientific Tools Activity elementary level

<http://www.brighthub.com/education/k-12/articles/47702.aspx>

CALIPSO information. CATS will use a Laser to measure the vertical distribution of clouds and aerosols similar.

<http://www-calipso.larc.nasa.gov/outreach/>

My NASA Data

<http://mynasadata.larc.nasa.gov/calipso/>

International Space Station

International Space Station main page

http://www.nasa.gov/mission_pages/station/main/index.html

ISS Interactive Reference Guide

<http://www.nasa.gov/externalflash/ISSRG/>

ISS Component Virtual Guide

http://i.usatoday.net/tech/graphics/iss_timeline/flash.htm

Several video tours from inside the ISS are available on YouTube

https://www.google.com/?gws_rd=ssl

SpaceX

Main page

<http://www.spacex.com/>

Commercial Resupply News and Features

http://www.nasa.gov/mission_pages/station/structure/launch/

Dragon and Falcon 9 two stage rocket used for transporting cargo to the ISS

<http://www.spacex.com/falcon9>



Aerosols

NASA fact sheet on aerosols, what they are, and why they so important:

<http://www.nasa.gov/centers/langley/news/factsheets/Aerosols.html>

My NASA Data - Seasonal Patterns of Aerosols with lesson plans middle and high school

http://mynasadata.larc.nasa.gov/lesson-plans/?page_id=474?&passid=132



Appendix E: “Partners, Collaborators and Sponsors”

Partners:

- Dr. Cheryl Nickerson
Biodesign Institute
Arizona State University
Tempe, Arizona
- BioServe Space Technologies
University of Colorado
Boulder, Colorado
- Post, Smythe, Lutz and Ziel of Plymouth, LLP
Plymouth, Michigan

Collaborators:

- Wayne County RESA
Wayne, Michigan
- Baylor College of Medicine
Houston, Texas
- NASA Human Health and Performance Center (NHHPC)
Houston, Texas
- Harris County Intermediate School District
Houston, Texas

Sponsors:

- Lloyd and Mabel Johnson Foundation
Brighton, Michigan
- Michigan Space Grant Consortium
University of Michigan
Ann Arbor, Michigan
- Michigan Aerospace Corporation
Ann Arbor, Michigan
- Greenman’s Printing and Imaging
Farmington Hills, Michigan

Appendix F: “Evaluation Results”

Fifteen (15) teachers completed the Survey Monkey questionnaire. These teachers participated in the following activities.

- Please select the name of the mission you are evaluating. (15 Responses)

Managing Microbes in Space	13	86.67%
Butterflies in Space	2	13.33%

- School Level (15 Responses)

7 middle schools
8 middle school Teachers

5 High Schools
5 High Schools Teachers

1 Elementary School
2 Elementary School Teachers

- How many days did you dedicate to this mission? (12 Responses)

Days	2	3	4	5	6	7	8	9
Teachers	2	1	2	2	1	1	2	1

- Is this your first mission with Orion's Quest? (15 Responses)

Yes	No
11	4
73.33%	26.67%

- The program was effective in introducing science concepts with real-world applications. (14 Responses)

<u>Strongly Agree</u>	<u>Agree</u>	<u>Neutral</u>	<u>Disagree</u>	<u>Strongly Disagree</u>
9	5	0	0	0
64.29%	35.71%	0.0%	0.0%	0.0%

- The program was effective in introducing students to the concept of authentic research. (15 Responses)

<u>Strongly Agree</u>	<u>Agree</u>	<u>Neutral</u>	<u>Disagree</u>	<u>Strongly Disagree</u>
10	4	0	1	0

66.67% 26.67% 0.0% 6.67% 0.0%

7. Students understood why this research needed to be conducted in both space-based and earth-based environments. (15 Responses)

<u>Strongly Agree</u>	<u>Agree</u>	<u>Neutral</u>	<u>Disagree</u>	<u>Strongly Disagree</u>
5	9	1	0	0
33.33%	60%	6.67	0.0%	0.0%

8. The program's flexibility allowed me to fit it into the time I had available. (15 Responses)

<u>Strongly Agree</u>	<u>Agree</u>	<u>Neutral</u>	<u>Disagree</u>	<u>Strongly Disagree</u>
13	2	0	0	0
86.67%	13.33%	0.0%	0.0%	0.0%

9. This program assisted me in meeting my classroom goals (15 Responses)

<u>Strongly Agree</u>	<u>Agree</u>	<u>Neutral</u>	<u>Disagree</u>	<u>Strongly Disagree</u>
5	8	2	0	0
33.33%	53.33%	13.33%	0.0%	0.0%

10. The program quality was worth the time and effort necessary to carry it out. (15 Responses)

<u>Strongly Agree</u>	<u>Agree</u>	<u>Neutral</u>	<u>Disagree</u>	<u>Strongly Disagree</u>
10	4	1	0	0
66.67%		26.67%	6.67%	0.0%
				0.0%

11. The Orion's Quest staff was responsive to my needs. (14 Responses)

<u>Strongly Agree</u>	<u>Agree</u>	<u>Neutral</u>	<u>Disagree</u>	<u>Strongly Disagree</u>
14	0	0	0	0
100%	0.0%	0.0%	0.0%	0.0%

12. The website was easily navigated in support of the program. (15 Responses)

<u>Strongly Agree</u>	<u>Agree</u>	<u>Neutral</u>	<u>Disagree</u>	<u>Strongly Disagree</u>
9	6	0	0	0
60%	40%	0.0%	0.0%	0.0%

13. The website contained the proper content to carry out the program. (15 Responses)

<u>Strongly Agree</u>	<u>Agree</u>	<u>Neutral</u>	<u>Disagree</u>	<u>Strongly Disagree</u>
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11	4	0	0	0
73.33%	26.67%	0.0%	0.0%	0.0%

Appendix G: "Student Certificate of Appreciation"

CERTIFICATE OF PARTICIPATION



ORION'S QUEST

ORION'S QUEST

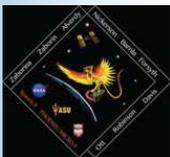
MANAGING MICROBES IN SPACE
MICRO-5

PRESENTED TO:



ISS

In recognition of contributions made to NASA research
by providing pertinent data
in support of
Human Space Exploration



MMIS Mission Patch

2015



SpaceX-5 Mission Patch



COL Jerry Ross, USAF
Astronaut
Spacewalker



Dr. Jennifer Barrila
Assistant Research Professor
Biodesign Institute, ASU



Dr. Cheryl Nickerson
Principle Investigator
Biodesign Institute, ASU



Peter Lawrie
Executive Director
Orion's Quest



COL Jack Lousma, USMC
Astronaut
Space Shuttle Commander