Research and Technology Studies (RATS) 2012
Multi Mission Space Exploration Vehicle (MMSEV)
Human Factors Test

Overview

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http://www.nasa.gov/exploration/analogs/desertrats/index.html

RATS Websites and Social Media

RATS Homepage	http://www.nasa.gov/exploration/analogs/desertrats/
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RATS Background

- Desert RATS initiated in 1997 with a 4-member team travelling to Death Valley, California to assess shirtsleeve mobility and field-geology tasks
- Grown to a team of over 100 individuals involved in assessing technologies, mission architectures, and operational concepts in an integrated setting
- All testing through Fall 2011 has been completed in the high desert outside Flagstaff, Arizona
- Currently RATS is in its 15th year of testing
- 2012 is the 1st year of testing to occur solely at JSC

RATS 2012 Test Plans

RATS Focus for 2012:

- Mature the design of the 2nd generation (Gen 2A) multi-mission space exploration vehicle (MMSEV)
- Assess near-Earth asteroid (NEA) operations through integrated simulation

Phase 1 Testing (Winter 2011-2012):

- Conduct 2 separate, 3-day/2-night MMSEV human factors & habitability tests at Johnson Space Center (JSC), each with different 2-person crews
    - Part A: December 12-17, 2011 – Completed!
    - Part B: January 17-20, 2012 – In progress!
- Test includes use of 3 Extravehicular Activity (EVA) simulation facilities at JSC's Space Vehicle Mock-up Facility to add mission realism and assess their capabilities for future analog testing

Phase 2 Testing (August/September 2012):

- Complete an integrated, multi-day test evaluating a NEA surface exploration simulation
    - Will include an operational team at JSC's Mission Control Center (MCC)
    - To be conducted under NEA-like time-delayed communications

Test Purpose and Background

- Purpose
  - To determine if the MMSEV Gen 2A functionality and habitability is acceptable for a 2-person crew and identify any changes recommended for the follow-on, Gen 2B design
  - To identify near-Earth asteroid (NEA) EVA simulation capabilities/facilities that can be leveraged for later RATS integrated analog testing
- Background
  - MMSEV Gen 2A cabin design needs to be validated in an operational setting
  - Gen 2B cabin (composite construction) will begin development in January 2012
  - Operational validation of the Gen 2A may influence design improvements to the Gen 2B composite cabin inner mold line (IML)

Gen 1 MMSEV cabins in field operations

Gen 2A MMSEV cabin being assembled

Gen 2A MMSEV cabin during Dec. ‘11 test

Test Articles, Facilities, & Resources

Elements & Facilities to be tested/exercised:

- **Gen 2A MMSEV** next generation space exploration vehicle mounted to a simulated reaction control system (RCS) sled
- **ABF** (Air Bearing Floor, a.k.a. “flat floor”) smooth, level surface for providing realistic reaction forces for MMSEV/EVA crew translation
- **NEA Simulation** with high-fidelity visuals and integration between MMSEV flight controls and Virtual Reality Laboratory (VR Lab)
- **ARGOS** facility to simulate shirtsleeve microgravity EVAs and exercise NEA translation and science collection tools
- **VR Lab** integrated with the NEA sim to allow virtual EVAs with the SEV around an asteroid
- **MMU/”Air Chair” Trainer** (Manned Maneuvering Unit) integrated with the ABF to simulate reaction forces with NEA during simulated EVA
- **RCS Air Sled** (Reaction Control System) simulated propulsion package for ‘flying’ MMSEV on the ABF
- **EVA Tools** for conducting simulated NEA science collection and EVA translation tasks
- **Mission operations team** providing task timeline planning support
- **Science oversight** ensuring scientific procedural rigor is applied to NEA sample collection techniques

MMSEV/RATS Test Objectives

Primary Test Objectives:

1. Conduct 3-day human factors & habitability evaluation of Gen 2A MMSEV cabin
2. Execute a 3-day mission timeline with minimal support team
3. Exercise MMSEV NEA flight simulator and communications loops from Gen 2A cabin
4. Test Mark III Mock-up suit & suit port interface plate (SPIP) with Gen 2A cabin to evaluate suit port human factors
5. Conduct preliminary evaluation of Gen 2A windows to support simulated docking on B9 air bearing floor
6. Exercise some degree of interaction between EVA simulation(s) & SEV IV (intra-vehicular) crewmember(s)

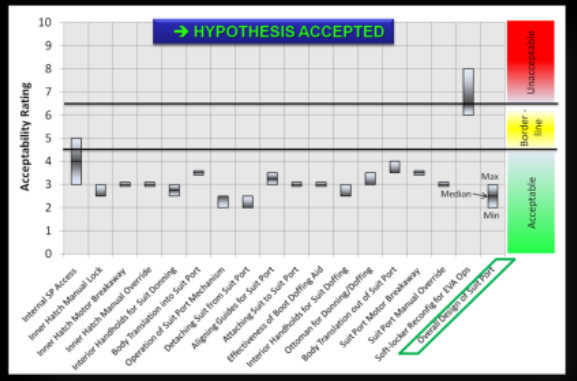
Secondary Test Objectives

1. Use Active Response Gravity Offload System (ARGOS) to perform NEA EVA tasks in simulated weightlessness
2. Stream video and audio between MMSEV and B9 VR lab running SAFER sim
3. Evaluate addition NEA EVA simulation capabilities for future analog testing

Human Factors & Habitability of Gen 2A Cabin

Elements of 3 day, 2 night tests:

- All eating, sleeping, exercising, etc. to be conducted in the cabin
- Cabin will include all necessary consumables and equipment for a 14 day flight manifest
  - Volumetric placeholders used as needed for 11 days
- D-RATS (Desert RATS) ‘08 & ‘09 test protocols used for the 1B cabin will serve as a baseline for habitability and human factors data collection
  - Acceptability, fatigue, workload ratings will be collected

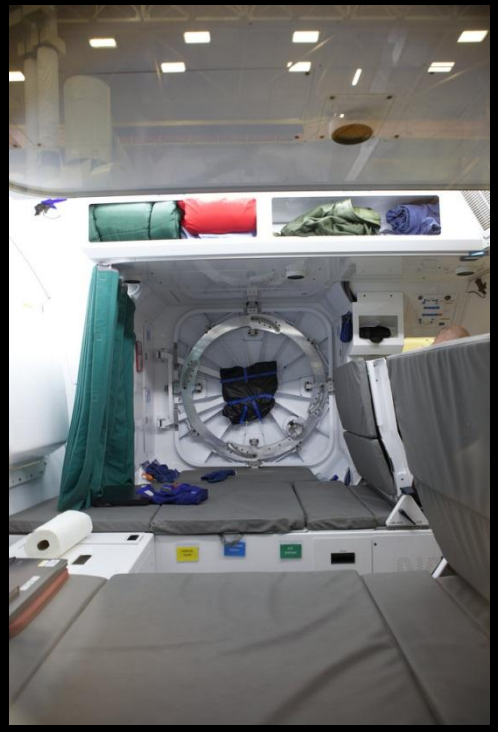


MMSEV Gen 2A Cabin

Seats, Displays, & Controls

Starboard Side Hatch

Inside the MMSEV



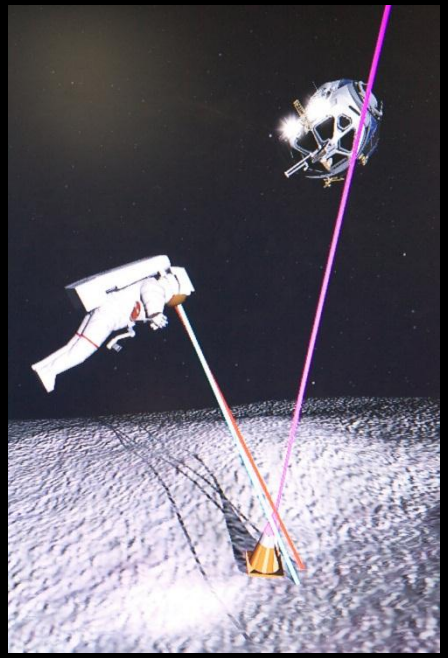
Sleep Station Deployed

Inside Sleep Station

Simulation Integration

- No ‘perfect analog’ for NEA surface activities
- Integrate and evaluate several mission & EVA training methods
- Each activity offers a different experience applicable to NEA ops

- NEA Flight Simulator
- Virtual Reality Lab
- ARGOS
- MMU/Air Chair
- MMSEV Air Sled
- Suit Port Operations

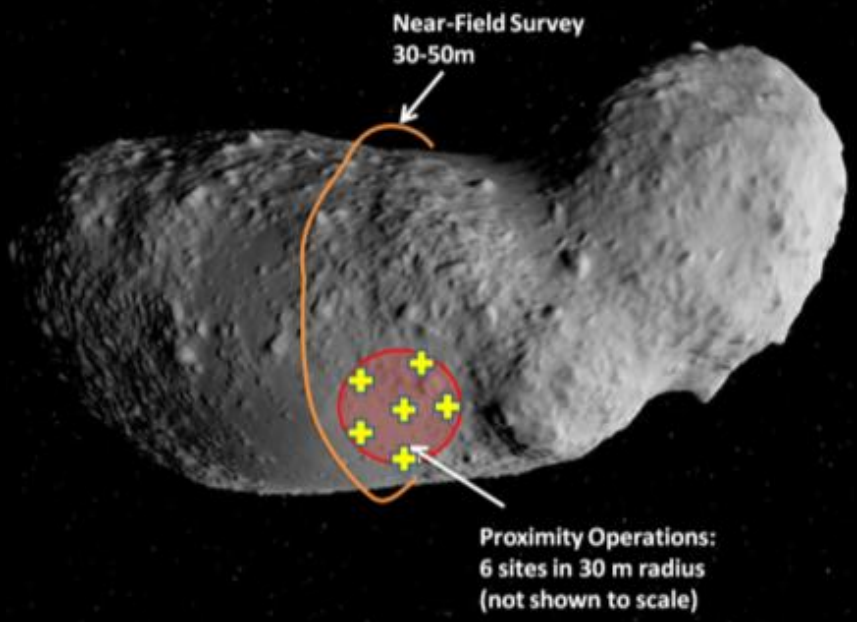


NEA Flight Simulator

- Projection screen in front of MMSEV windows
- Asteroid Itokowa
- 'Fly' from inside MMSEV
- Tasks
  - Near-field Survey
    - Fly one orbit around NEA
    - Maintain 30-50 m altitude
  - Focused Inspection
    - Fly MMSEV to each cone
    - Approach to 10 m of cone
    - Proximity for Astronaut Positioning System (APS)
  - Gain estimates of propellant

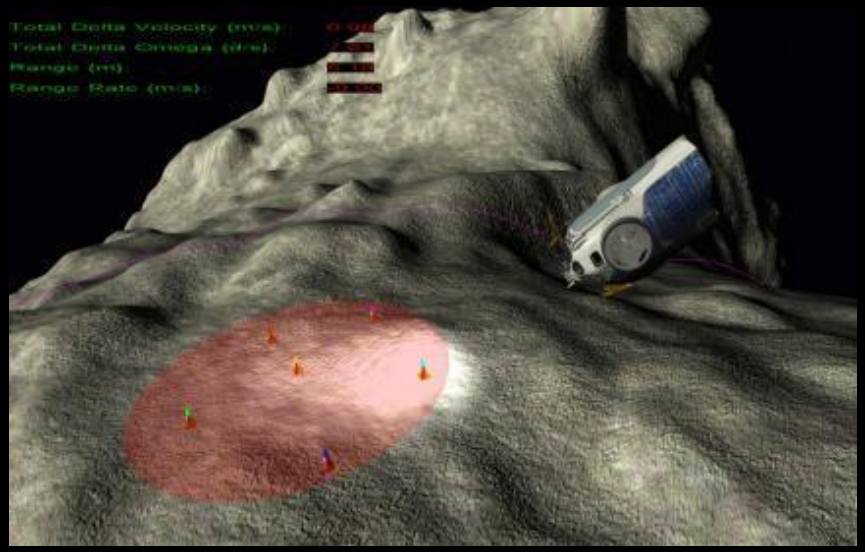
NEA Flight Simulator

Near Field Survey

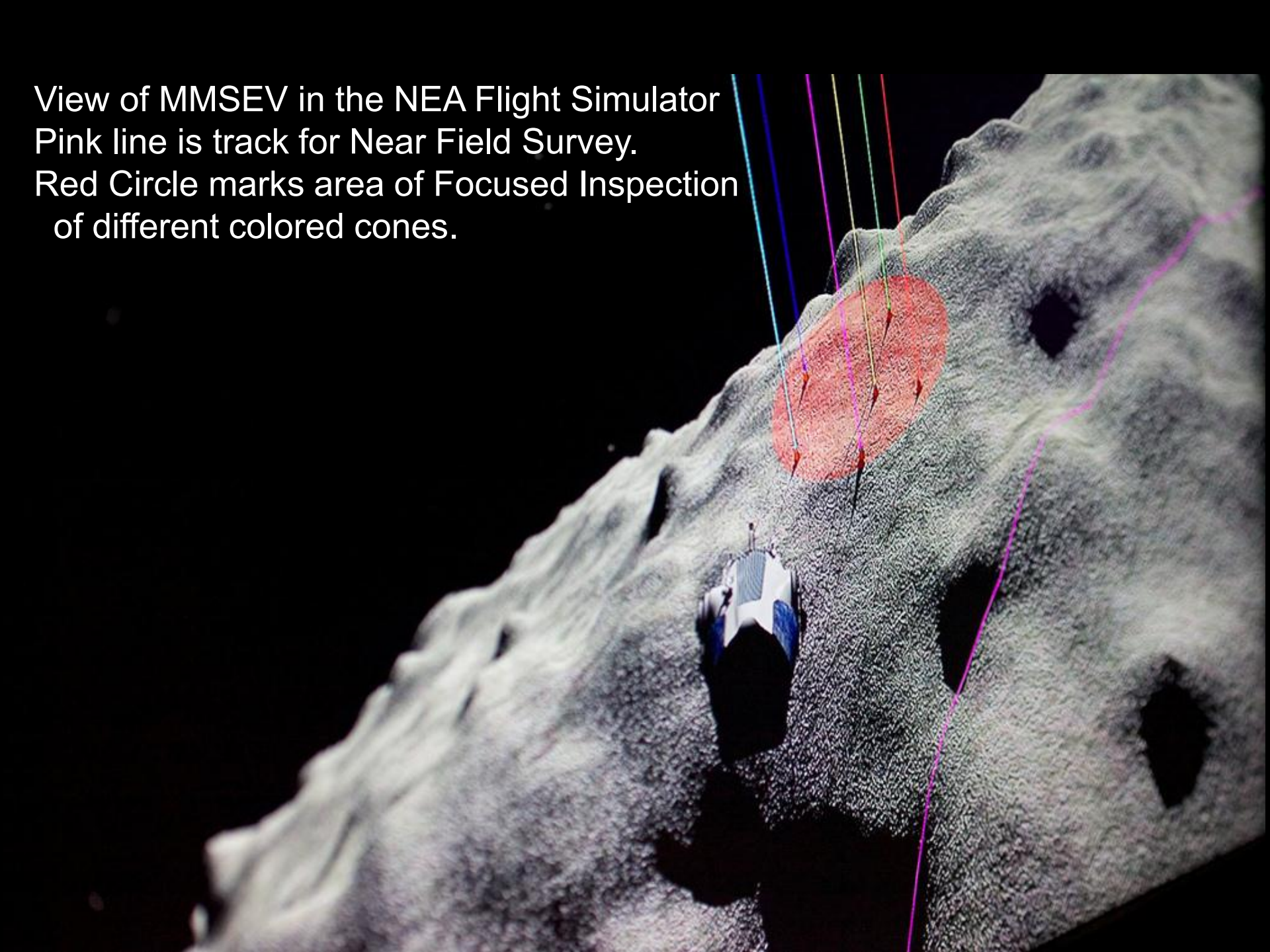


Fly one orbit around NEA
Maintain 30-50 m altitude

Focused Inspection



Fly MMSEV to each cone
Approach to 10 m of cone
Proximity for Astronaut Positioning System (APS)


View of MMSEV in the NEA Flight Simulator
Pink line is track for Near Field Survey.
Red Circle marks area of Focused Inspection
of different colored cones.

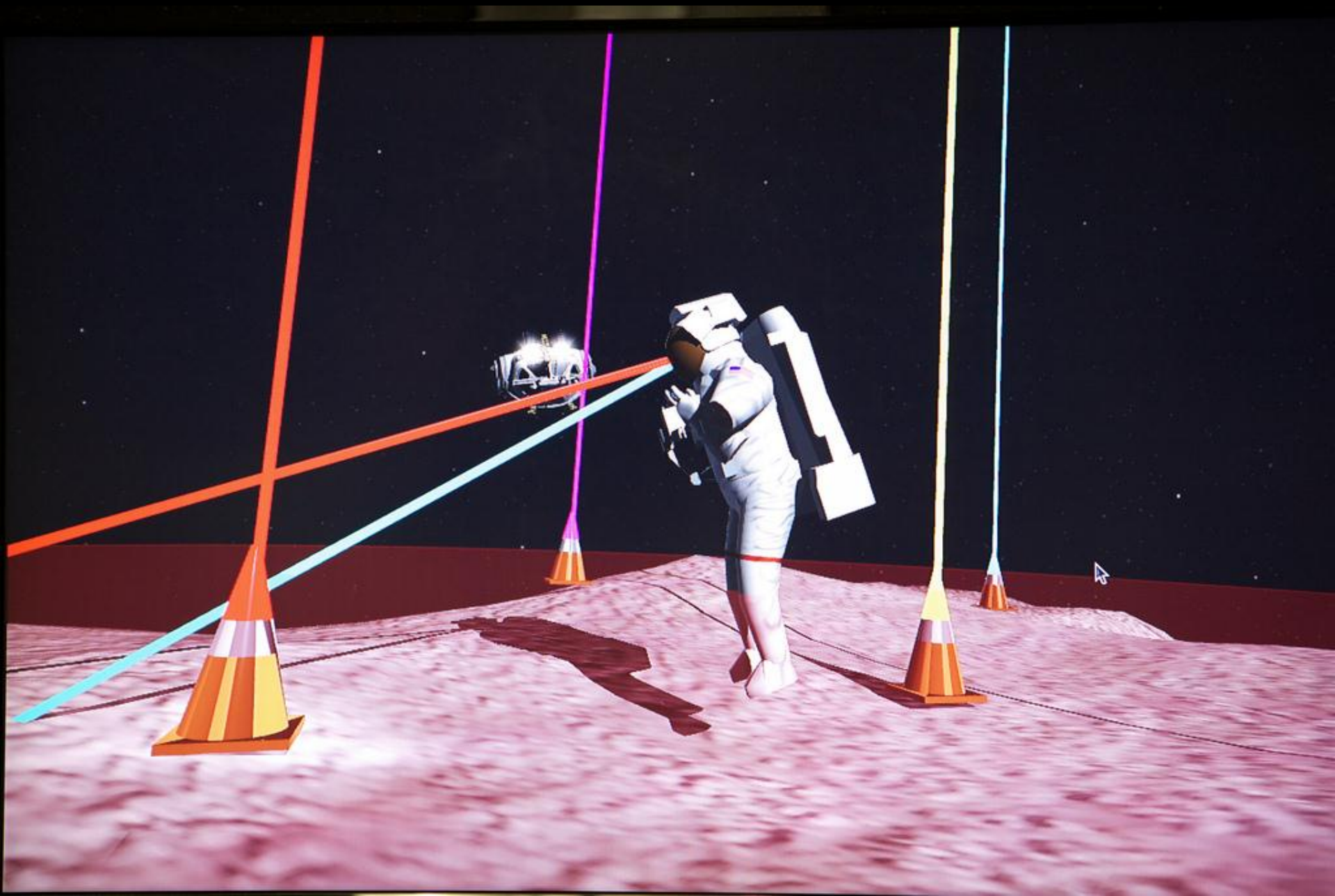
Crew inside cabin conducting near field survey of NEA

Virtual Reality Lab

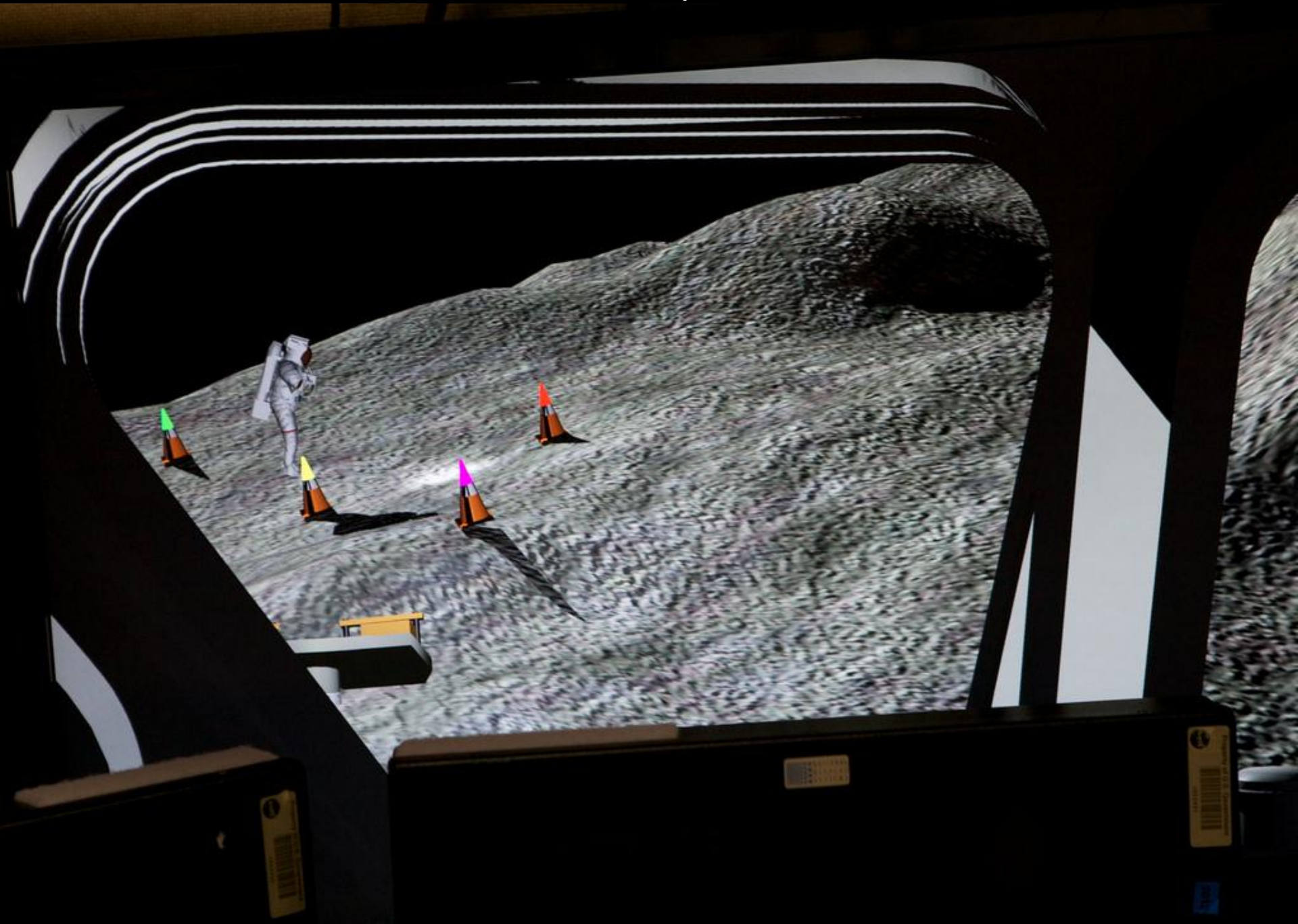
- VR lab used for ISS crews
- Solo EVA ops. on NEA
- ‘Fly’ using Super SAFER
- Real-time communication with MMSEV
- Colored cones represent points of interest
- Tasks
  - Two EVA operation concepts
    - Cones spaced close together
    - Cones spread out on surface
  - MMSEV provides support
  - Rendezvous with MMSEV

VR Lab setup with SAFER controller

View of integrated VR Simulation with MMSEV and Crew Member on EVA



View of VR simulation out MMSEV cockpit windows of crew member on EVA



ARGOS EVA Operations

Active Response Gravity Offload System

- Two operation modes
  - Vertical harness
  - Horizontal harness
    - fewer degrees of freedom
- Real-time communication with MMSEV
- IVA crew: Fly MMSEV around asteroid with different spin rates
- Tasks
  - Translation Tools
    - Translation lines
    - Telescoping pole/boom
  - Geologic Sampling
    - Float & Regolith
    - Hammering tool concepts
  - Deploy Instruments/Sensors

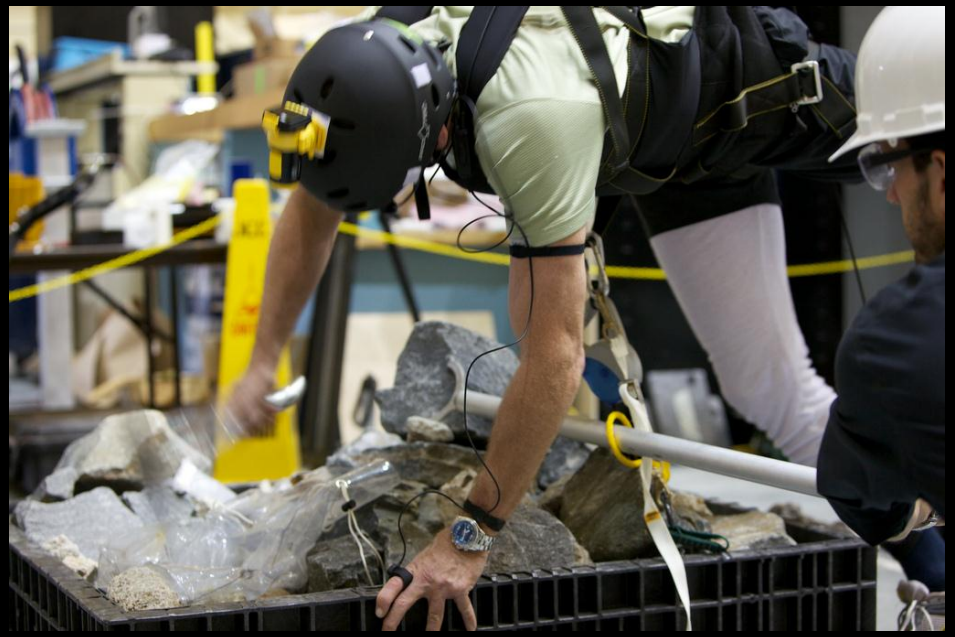
ARGOS Horizontal Harness

ARGOS EVA Circuit

Crew tethered to a translation line, preparing to collect a regolith sample

Deployment of Sensors using the Boom

Rock Chip Sampling



Boulder Sample

MMU/ “Air Chair” Trainer

- Manned Maneuvering Unit (MMU) used on Air Bearing Floor (ABF)
- 3 Degrees of Freedom
  - (Forward/Back, Left/Right, Yaw)
- Tasks
  - Geologic sampling
  - Deploy translation lines
  - Tethered vs. un-tethered
  - Rockwall proximity ops.

Translation along a Tether

Free Flying the Air Chair

MMSEV RCS Air Sled Integration

- Reaction Control System (RCS) air sled
- ‘Fly’ MMSEV on the Air Bearing Floor (ABF)
- 3 Degrees of Freedom
  - (fwd/back, Lft/Rgt, Yaw)
- Tasks
  - Close approach
  - Simulated docking
  - Evaluate windows

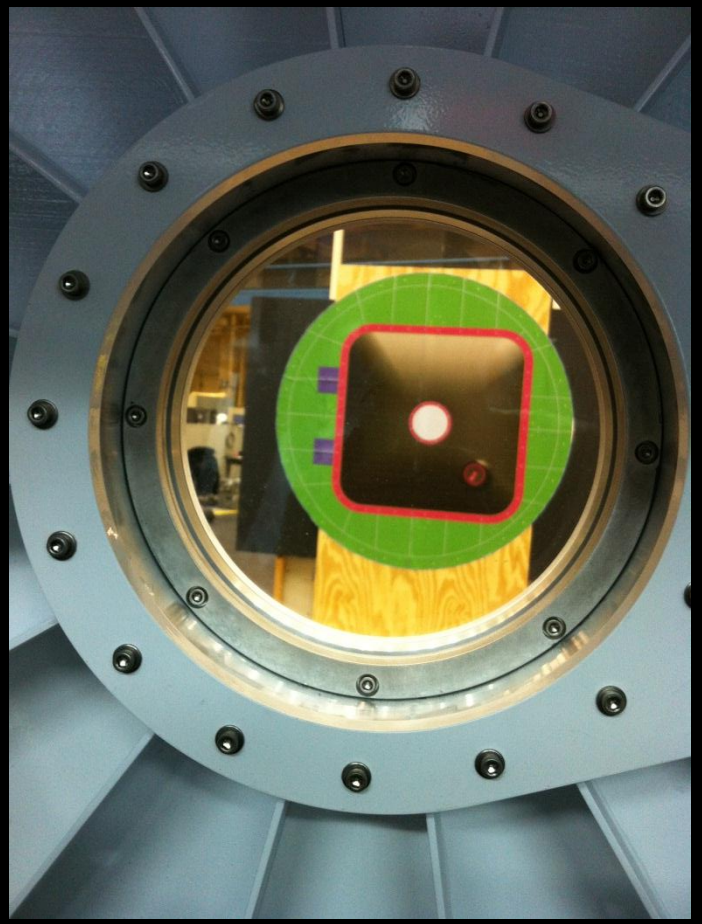
Air Thrusters

MMSEV docking operations on the ABF

MMSEV docking operations on the ABF

Closing the gap on the docking target

View from side hatch window



MMSEV docking operations on the ABF

Mark III Mock-Up Suit Port

- Rear-entry suit port
- 15 minutes for ingress & egress
- Lowered control panel
- Upgraded interface
- Tasks
  - Conduct suit port ops for each EVA
  - Evaluate Gen. 2A interface & controls

Ideas for Science Integration in Future RATS Testing

- Incorporate asteroids with dimensions representative of a 2025 NEA mission into the NEA flight simulator

- Integrate high resolution surface imagery into the NEA flight simulator. Allow crew to make geologic observations to prioritize surface activities.

- Design EVA activities so that the current EVA tasks build on prior EVA tasks in the integrated simulation.

Summary

- The focus of RATS 2012 test activities are to evaluate the Gen 2A MMSEV cabin design, EVA simulation activities, and mission operation concepts for NEA exploration.

- Training for NEA exploration builds on the foundation of both LEO and lunar surface operations, but modifications must be made for the unique environment of asteroids.

- Vehicles, operation concepts, and equipment need to be tested within an integrated mission simulation to drive new designs, concepts, and mission protocols for NEA exploration.

RATS Team

Dec. 2011 Test