



Overview of NASA EVA Virtual Reality Training, Past, Present and Future



*Eddie Paddock/NASA/JSC Engineering
eddie.paddock@nasa.gov*

Virtual Reality Lab (vrlab.jsc.nasa.gov, @vr_doug)





- **Mission**

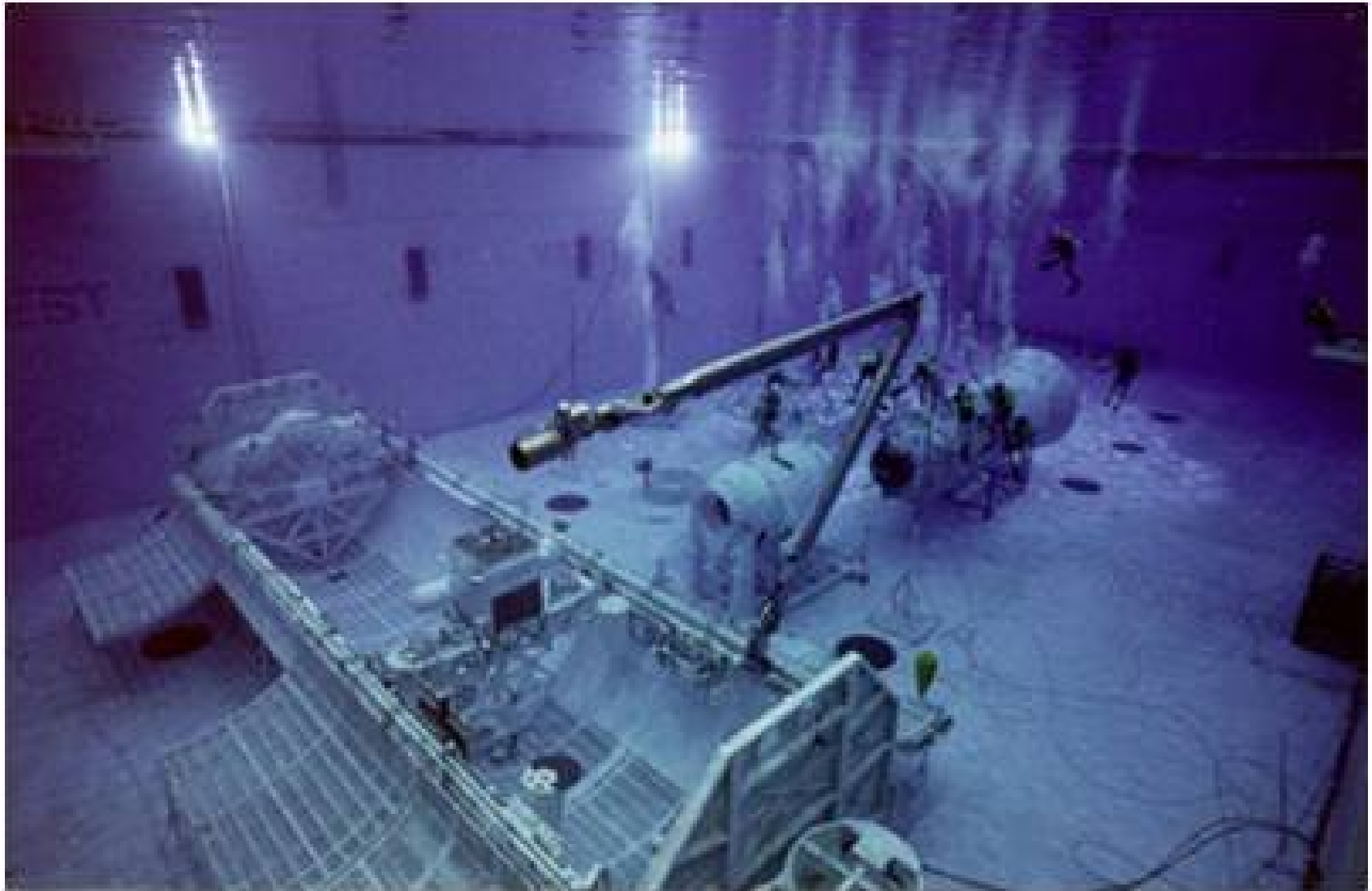
- To provide a VR training facility, products and services to our Space Station Program and Flight Operations Directorate stakeholders in support of ISS EVA and Robotic operations including simulations, 3D graphics, immersive HMDs and tracking systems, mass handling and onboard VR training
- Augment Neutral Buoyancy Lab (NBL) astronaut EVA training

- **Location**

- JSC, B9, room 2116, x42202
- *vrlab.jsc.nasa.gov, @vr_doug*

- **Current Team Members**

- Eddie Paddock/NASA/ER7 – Simulation and Graphics Branch
- Brad Bell/CACI
- Jeff Hoblit/CACI
- Evelyn Miralles/CACI
- John Schweers/CACI
- Frankie Graffagnino/METECS

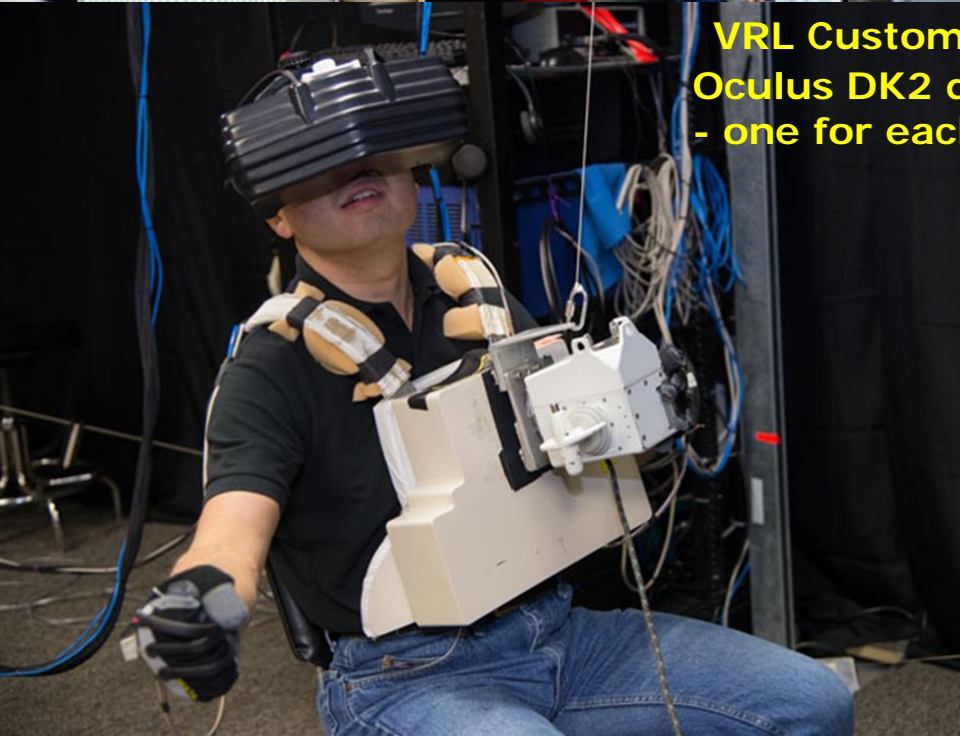




- **1991 – VR Lab was started by Dave Homan/ER7**
 - To augment NBL ISS/Shuttle EVA training
- **1993 – STS-61 Hubble repair, and mass handling training**
- **1994 – Simplified Aid For EVA Rescue (SAFER)**
- **1994 – Shuttle Robotics**
- **2000 – ISS Robotics integrated with EVA/Shuttle Robotics**
- **2001 – DOUG graphics onboard ISS**
- **2004 – Shuttle tile surveying**
- **2012 – VR training onboard ISS**
- **2016 – Upgrading Charlotte Mass Handling Robot VR System**
- **2016 – Using COTS HMDs, Wireless Tracking and Game Engines**
 - Oculus Rift and HTC Vive with Unity and Unreal4 game engines
 - Port of DOUG graphics to Rift and Vive HMDs



VRL HMDs



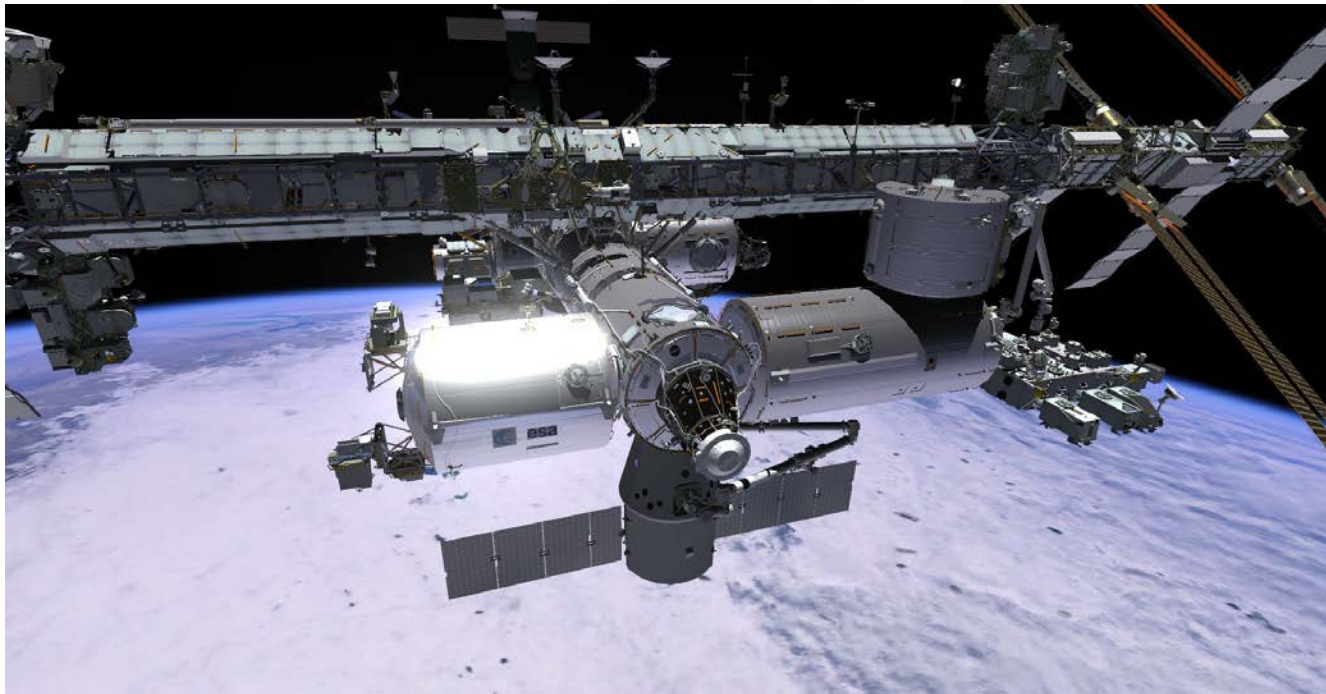
VRL Custom HMD
Oculus DK2 displays
- one for each eye



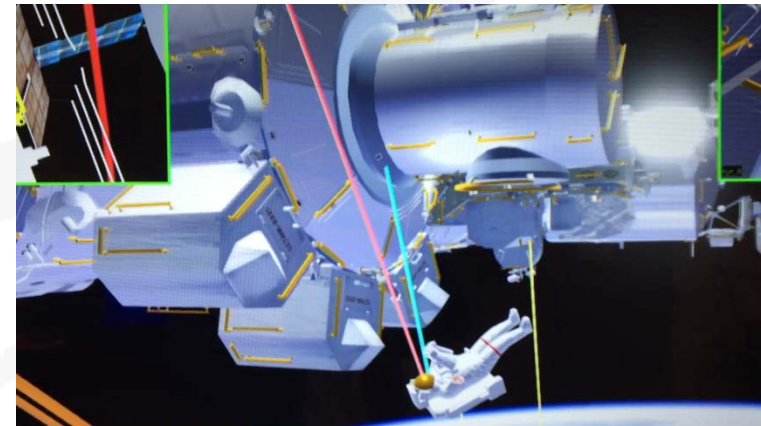
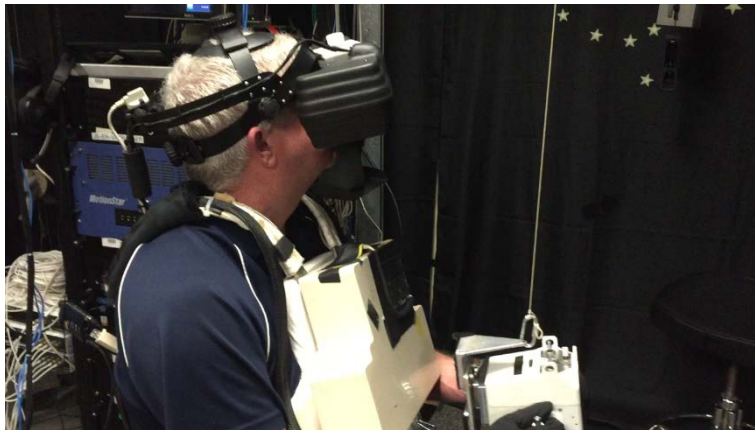
HTC Vive



- **Dynamic Onboard Ubiquitous Graphics (DOUG)**
 - **3D Graphics Models and Renderer for ISS**
 - **VR Head Mounted Display (HMD) Rendering**
 - **GUIs and Simulation Interfaces**
 - **Windows, Linux and Mac**
 - **EDGE (Engineering DOUG Graphics for Exploration)**



- **Astronaut EVA (Extra-Vehicular Activity) Training**
 - Space walks for ISS sustaining including robotics ops
 - SAFER (Simplified Aid For EVA Rescue)
 - EVA Mass Handling
 - VRT (Virtual Reality Trainer) - Onboard ISS









Historical Training Statistics

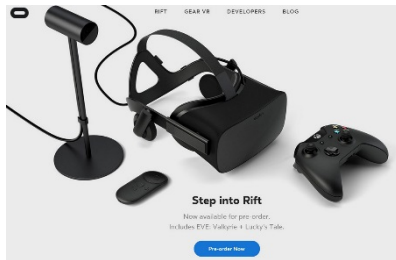


Total EVA Training	1225
Total SAFER Training	2443
Total SSRMS	705
Total RMS	321
Total STS missions	83
Total Expeditions ISS	43
Spacewalks	200+
Total Mass Handling	265

Year	EVA Training	RMS Training	SSRMS Training	SAFER Training	Mass Handling Training
1992-1999	60			60	50
2000	22	14	16	58	4
2001	192	123	200	357	22
2002	141	47	172	192	7
2003	46	7	32	166	3
2004	50	1	8	152	1
2005	67	13	10	170	20
2006	208	11	34	371	46
2007	114	4	16	162	26
2008	52	7	18	121	12
2009	68	44	88	168	26
2010	55	24	48	93	14
2011	43	25	50	64	10
2012-2015	107	0	13	309	24
Totals	1225	320	705	2443	265

■ Oculus DK2, Rift

- HERA (next slide)
- Possible use for VRT onboard ISS

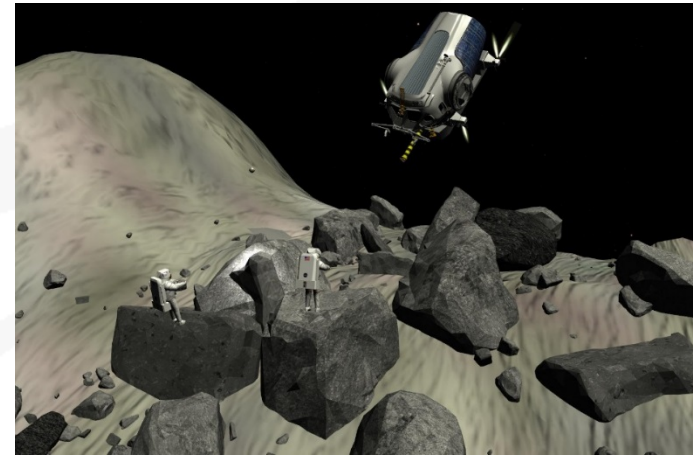


■ HTC Vive/Unreal4

- Hybrid Reality/ISS IVA Demo
- F. Delgado and M. Noyes/ER6



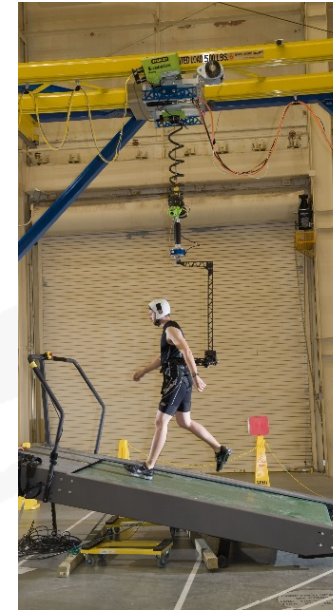
- **Multi-Mission Space Exploration Vehicle (MMSV) Itokawa asteroid simulation with VR EVA**
- **2 crew EVA and 2 crew flying the MMSEV**
- **HERA is interested in team dynamics while the crew are under stress performing an exploration mission**



- Oculus DK2
- OptiTrack



- **Active Response Gravity Offload System (ARGOS)**



- **Integrating VR/AR/MR technologies with ARGOS to support EVA training, planetary surface mission development, hardware evaluations, tele-operation, and human performance/ergonomic studies for current and future NASA missions**
- **Investigating MR with “green screen” or chroma key techniques of using optics for tracking and mixing in real filtered video for avatar and physical bodies with virtual scenes**



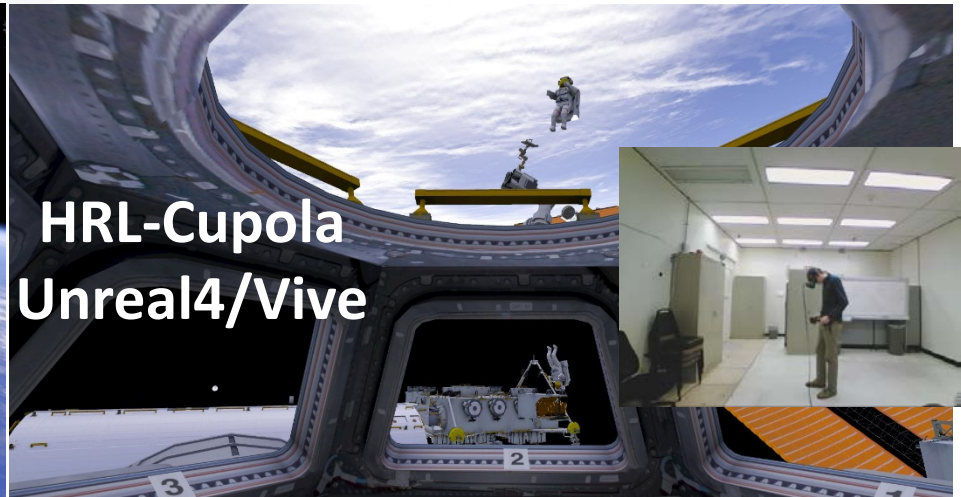
VRL SAFER & Robotics DOUG/HMD/RWS



ARGOS-EVA Unity/Vive



HRL-Cupola Unreal4/Vive



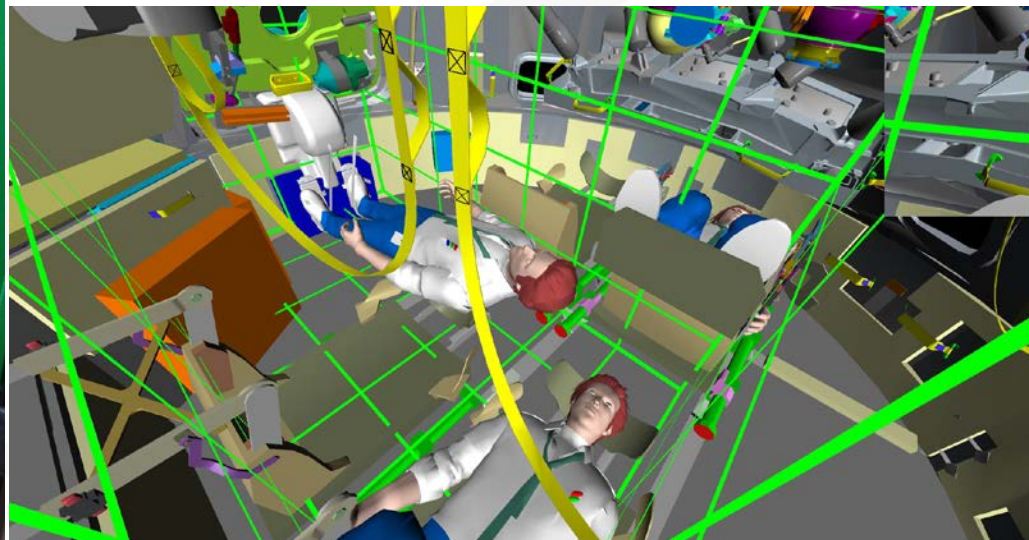


ARGOS Facility Demo



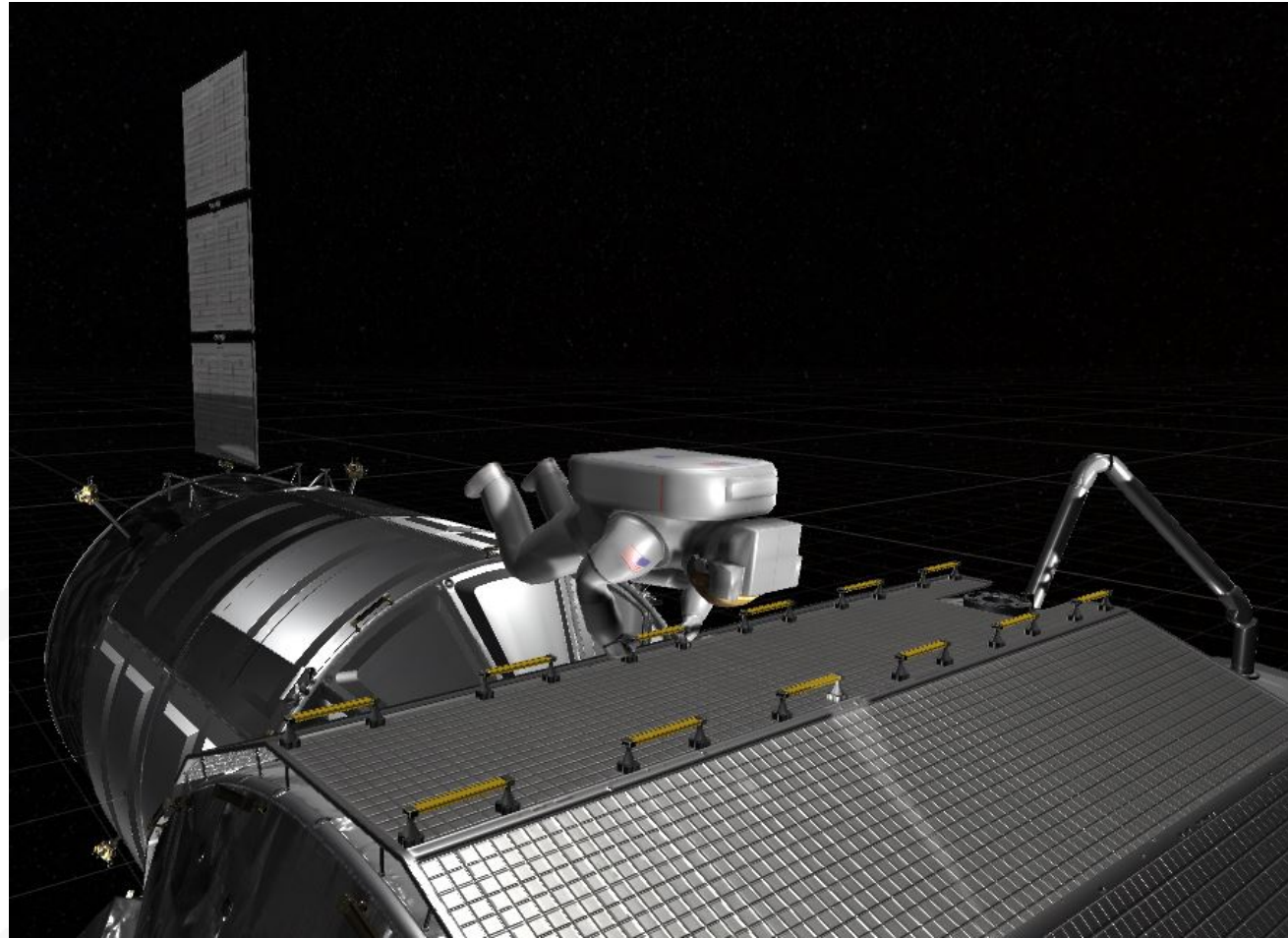


- **Mini-Exercise Device (MED) Exercise Volume Study**





Deep Space Gateway EVA





- **Integration of VR into ARGOS**
- **More use of COTS HMD Systems**
 - **Virtual Reality Trainer (VRT) onboard ISS**
 - **Augmented Reality Applications - HoloLense**
- **Tracking systems and Avatar imaging**
 - **OptiTrack with passive reflectors**
 - **Lighthouse tracking**
 - **Wireless tracking systems**
 - **Hands and finger tracking**
- **Continue with Green Screen Mixed Reality Work**
 - **Performance improvements**
 - **ARGOS integration**
- **Habitat Design Evaluations for Deep Space Gateway**



- Latest HMDs including wireless, high resolution displays, backpack solutions like HP's Z VR backpack
- Room scale wireless passive and active tracking systems (Lighthouse, Optitrack and other more unique concepts like accelerometer suits), and integration with game engines and HMDs
- Inside-out onboard tracking systems
- Rendering Engine upgrades and plugins for better performance (Unity, Unreal4 and performance upgrade packages like Nvidia's Holodeck)
- Hand and finger tracking (Manus VR, Valve Knuckle's controllers, etc.)
- High performance graphics cards and configuration options
- Distributed Host/client and state synchronization VR technologies