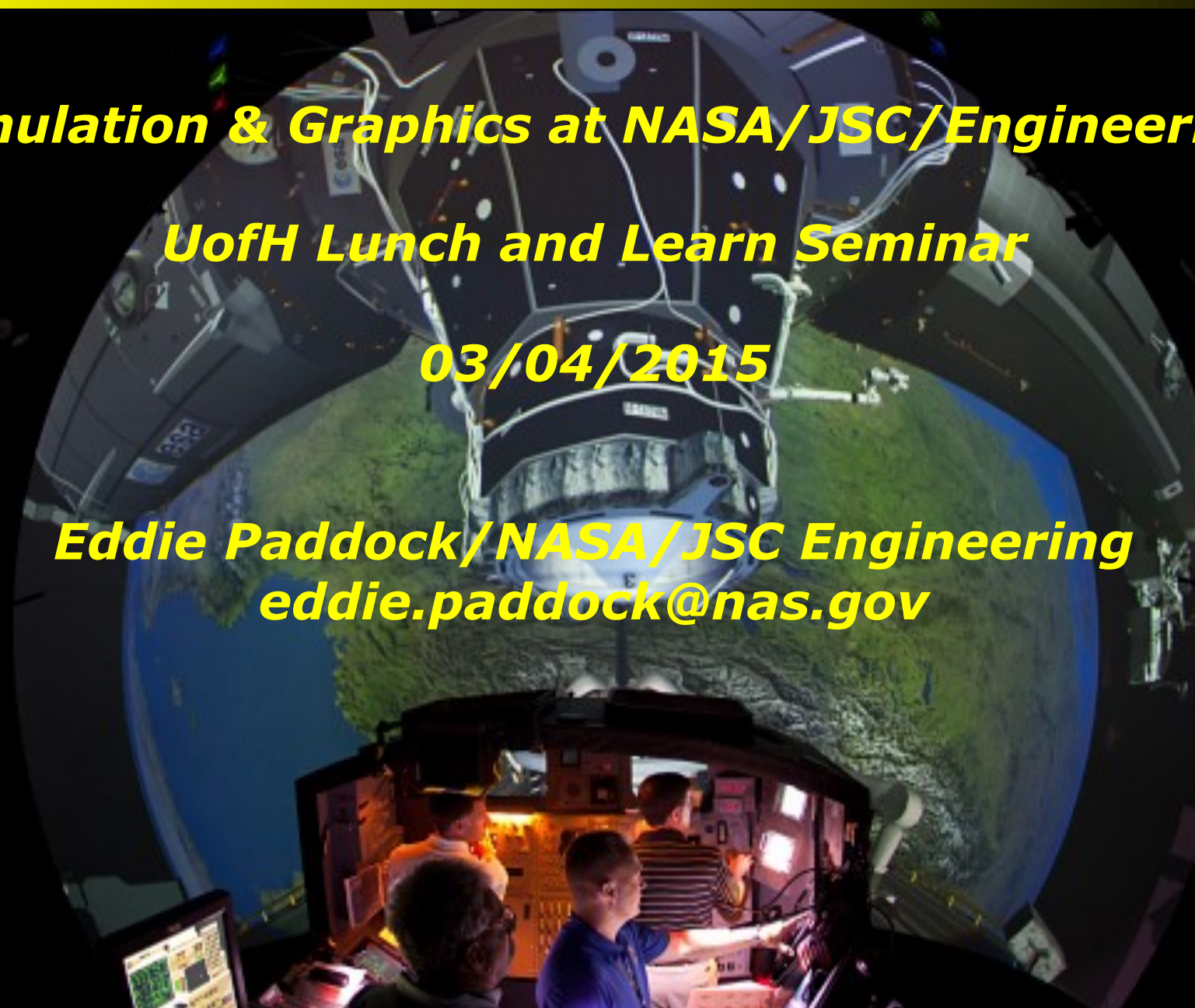*Simulation & Graphics at NASA/JSC/Engineering*

UofH Lunch and Learn Seminar

03/04/2015

Eddie Paddock/NASA/JSC Engineering
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- **BIO and Introduction**

- **NASA Programs and Projects**

- **Simulation and Flight Software, Tools and Products**

- **Space Vehicle and Robotics Simulation Applications**

- **NASA Pathways (Co-op) and Internship information**

- **Simulation Videos and Animations**

- **Questions**

- **BS/CS Southern Illinois University (SIUE) - 1983**
  - **Minor in Electrical Engineering/Microprocessors**

- **30+ years of software/simulation experience in Aerospace**
  - **Fighter aircraft flight test and simulation, Shuttle, ISS, Robotics, Orion and other spacecraft simulation projects**
  - **McDonnell Douglas/Boeing, LinComm, Titan, L3, and NASA/ Engineering**

- **Deputy Branch Chief of the Simulation and Graphics Branch (ER7) at JSC**
  - **Software, Robotics and Simulation Division (ER) of the Engineering Directorate (EA)**

- **Why am I here?**
  - **To inform University of Houston Computer Science students about NASA programs and specifically about the type of software work performed in the Simulation and Graphics Branch at the Johnson Space Center**

  - **Show how software and Computer Science is a major part of what NASA does**

  - **Inform students about NASA's "Pathways" Co-op program and Internship opportunities at JSC**

- **International Space Station (ISS)**

- **Orion – Multi-Purpose Crew Vehicle (MPCV)**

- **Robonaut**

- **International Station Visiting Vehicles**
  - **HTV (JAXA) and AVT (ESA)**
- **ISS Robotics**
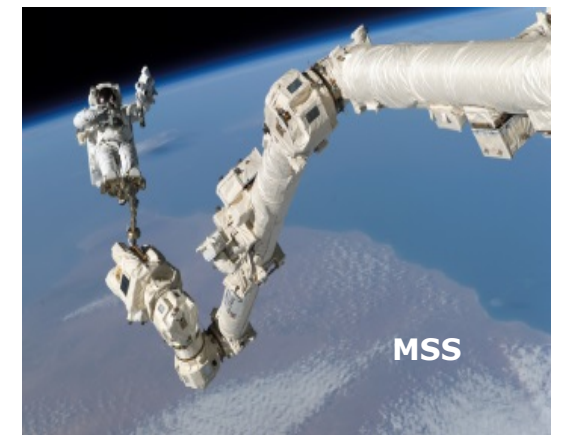 - **Mobile Service System (MSS) Robotics**
- **Commercial Cargo and Crewed Vehicles**
  - **Dragon (SpaceX) and Cygnus (Orbital Science)**

- **Commercial Crewed Vehicles**
  - **Boeing's CST-100**
  - **SpaceX's Dragon V2**

Orion

ATV

HTV

EFT-1
Dec/14

MSS

- **How simulations are used at JSC**
    - **Design and analysis of spacecraft and robotics systems**
    - **Verification of Flight Software (FSW) and avionics in Systems Integration Labs**
    - **Mission operations support and training for astronauts and flight controllers**

- **How simulations are built at JSC**
    - **Software Process paradigms**
        - **Waterfall, Extreme, and Agile**
        - **CMMI (Capability Maturity Model, Integrated) where appropriate**
    - **Software Design/Development paradigms**
        - **Object Oriented and Functional/Procedural**

- **What computer languages are used to build simulations**
  - **C++, C, Python, TCL/TK, Web and OpenGL on Linux workstation platforms**
  - **Some Windows based development also**
  - **There is still some Fortran and Ada around too**

- **Matlab/Simulink**
  - **Commercial Off The Shelf (COTS) tool used to quickly generate and unit test Flight Software (FSW) and simulations**

- **Simulation architectures and infrastructure**
  - **Executive scheduling and Input-Output (IO)**
  - **Syntax parsing and auto code generation**
  - **Graphical User Interfaces (GUIs)**
- **Class, data structures and databases**
- **Threading, parallel software design and data mutual exclusion**
- **Networks, sockets, shared/reflective memory and distributed programming**
- **Real-time synchronization**

- **Physics based math models**

  - **Can require domain expertise**

  - **Aero, dynamics, robotics, GN&C, mechanisms, ECLSS, sensors & propulsion**

  - **Dynamics and equations of motion, F=MA, numerical analysis, time step integration**

- **3D graphics, and Virtual Reality**

- **Spacecraft software that executes on flight computers and avionics**
  - **Test and verification usually requires a physics based simulation**
  - **Test-as-you-fly ground testing in SIL (System Integration Lab)**
- **FSW is hosted and tested on embedded systems on single board computers**
  - **Core Flight Software (CFS), VxWorks, GreenHills, etc.**
- **Flight computer bus technologies for communications to sensor/effector**
  - **VME, PCI, 1553, and Time Triggered Ethernet interfaces**

- **Trick is ER's simulation development flagship tool**
  - **Simulation Executive and IO processor with auto code generation**
- **Dynamics toolset**
  - **JSC Engineering Orbital Dynamics (JEOD) and MBDyn (Multi-Body Dynamics)**
- **General-Use Nodal Network Solver (GUNNS)**
  - **Common software approach for solving networks of fluids, electrical and thermal systems (use in Environment Control & Life Support Systems (ECLSS))**
- **Core Flight Software (CFS) – Lore Prokop/NASA just gave a talk on this**
  - **Environment for developing and operating FSW**
- **In-house built Open-GL based 3D graphics renderers**
  - **Dynamic Onboard Ubiquitous Graphics (DOUG), and Advanced Graphics for Engineering Applications (AGEA)**
 - **Also use Unity game engine as renderer in some cases**
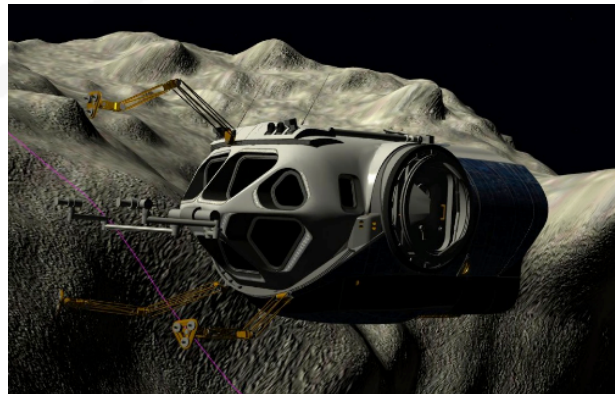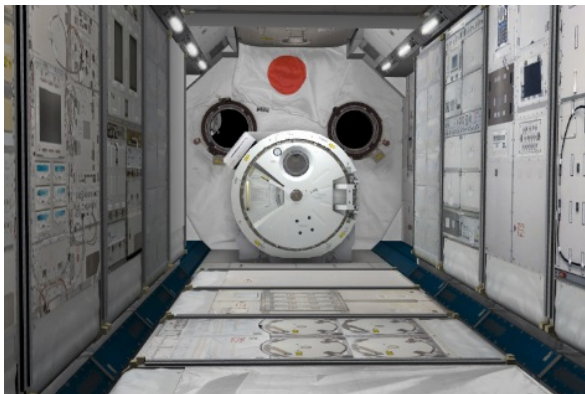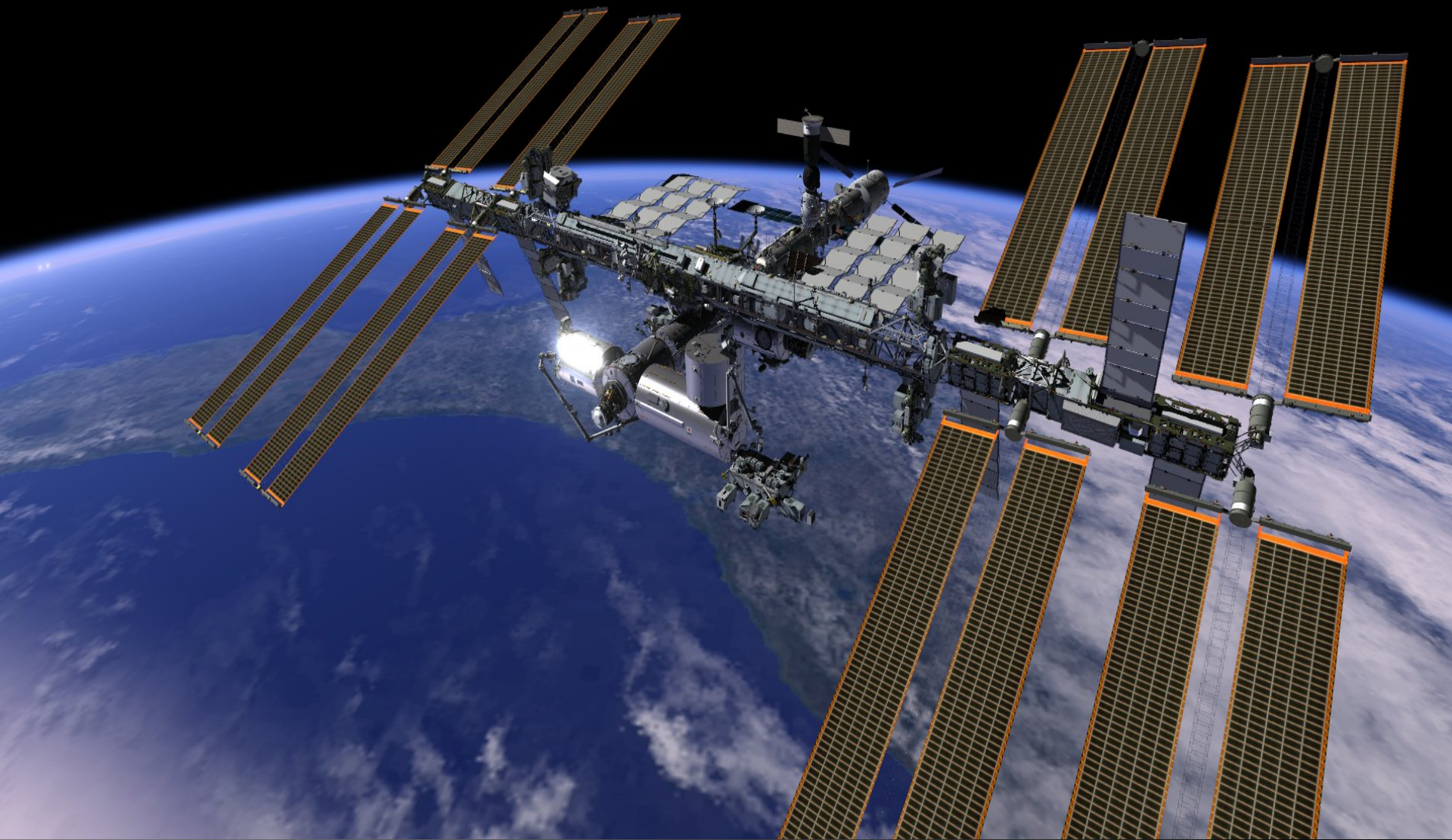
- **Design, Analysis and Training for Flight Controllers and Astronauts**
  - **International Space Station (ISS)**
  - **MSS Robotics**
    - **SSRMS (Space Station Remote Manipulator System)**
    - **Special Purpose Dexterous Manipulator (SPDM)**
  - **ISS Visiting Vehicles**
- **Avionics and Flight Software Test and Verification**
  - **Orion MPCV**
- **Virtual Reality (VR) training with mass handling robotics**

- **NASA Exploration Systems Simulation (NExSyS)**
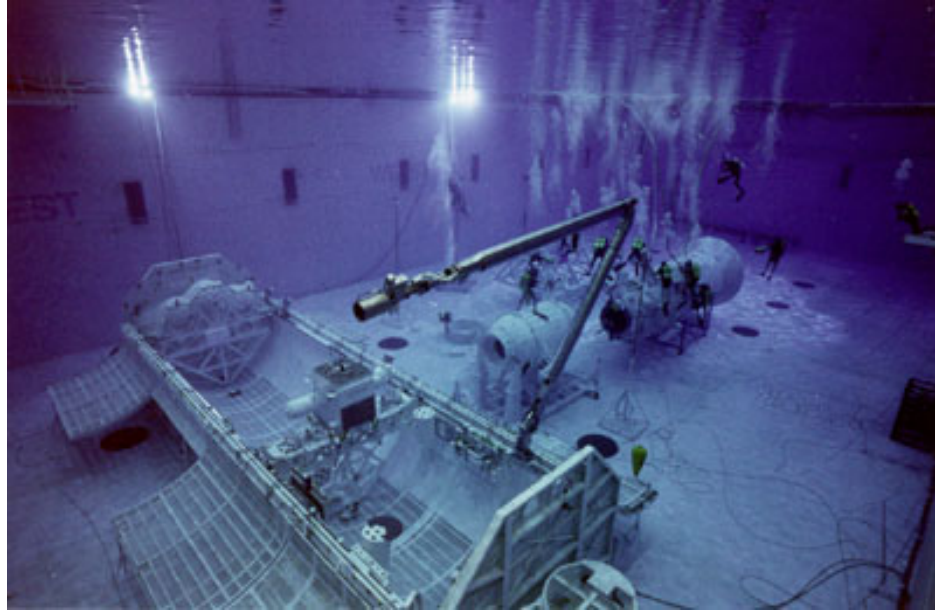 - **Future exploration vehicles and space systems**
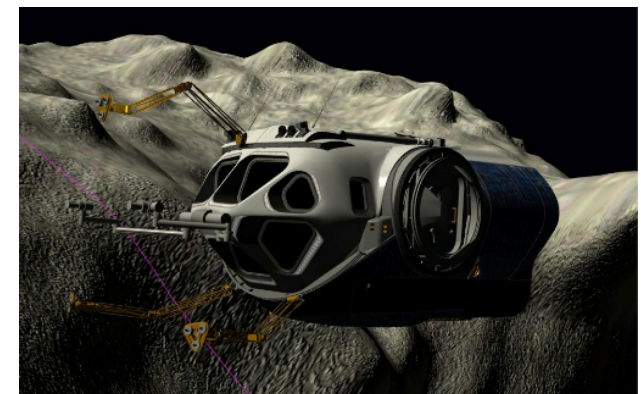
- **Systems Engineering Simulator**
  - **Simulation and graphics driven dome/projection system for engineering analysis and training**

- **Hardware-in-the-loop simulation applications**
    - **Neutral Buoyancy Lab (NBL)**
    - **Multi-use Remote Manipulator Development Facility (MRMDF)**

- **NASA Pathways (Co-op), but labeled internally as Internship**
  - **http://nasajobs.nasa.gov/studentopps/Pathways.htm**
  - **Path to becoming NASA civil servant**
    - **Very competitive, only 30-50 per semester**
    - **Requires early (sophomore) enrollment to achieve three required terms for permanent hire**
    - **Some graduate Co-ops are also offered**
  - **Pathways opportunities will be posted on USA Jobs site, starting spring/2015**
- **USA Jobs site**
  - **https://www.usajobs.gov/StudentsAndGrads**
  - **Pathways Co-op job announcements**
    - **Listed in spring for summer and fall, and fall for spring terms**
- **NASA Internship site – OSSI (One Stop Shopping Initiative)**
  - **https://intern.nasa.gov/ossi/web/public/main**
  - **Summer and spring/fall semester internships not part of Pathways Co-op Program, but may help you for Pathways visibility and term credits**
- **Internships/Co-ops with NASA contractors are also a good option**

- **Questions?**