Simulation & Graphics at NASA/JSC/Engineering

UofH Lunch and Learn Seminar

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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
HUMAN EXPLORATION
NASA's Path to Mars

EARTH RELIANT
MISSION: 6 TO 12 MONTHS
RETURN TO EARTH: HOURS

PROVING GROUND
MISSION: 1 TO 12 MONTHS
RETURN TO EARTH: DAYS

MARS READY
MISSION: 2 TO 3 YEARS
RETURN TO EARTH: MONTHS

Mastering fundamentals aboard the International Space Station

U.S. companies provide access to low-Earth orbit

Expanding capabilities by visiting an asteroid redirected to a lunar distant retrograde orbit

The next step: traveling beyond low-Earth orbit with the Space Launch System rocket and Orion spacecraft

Developing planetary independence by exploring Mars, its moons and other deep space destinations

www.nasa.gov
• 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
Simulations at JSC

• 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
Flight Software (FSW) and Avionics

• 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/effectort
  • 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
Phobos Hop Animation
• Questions?