Space Smackdown 101

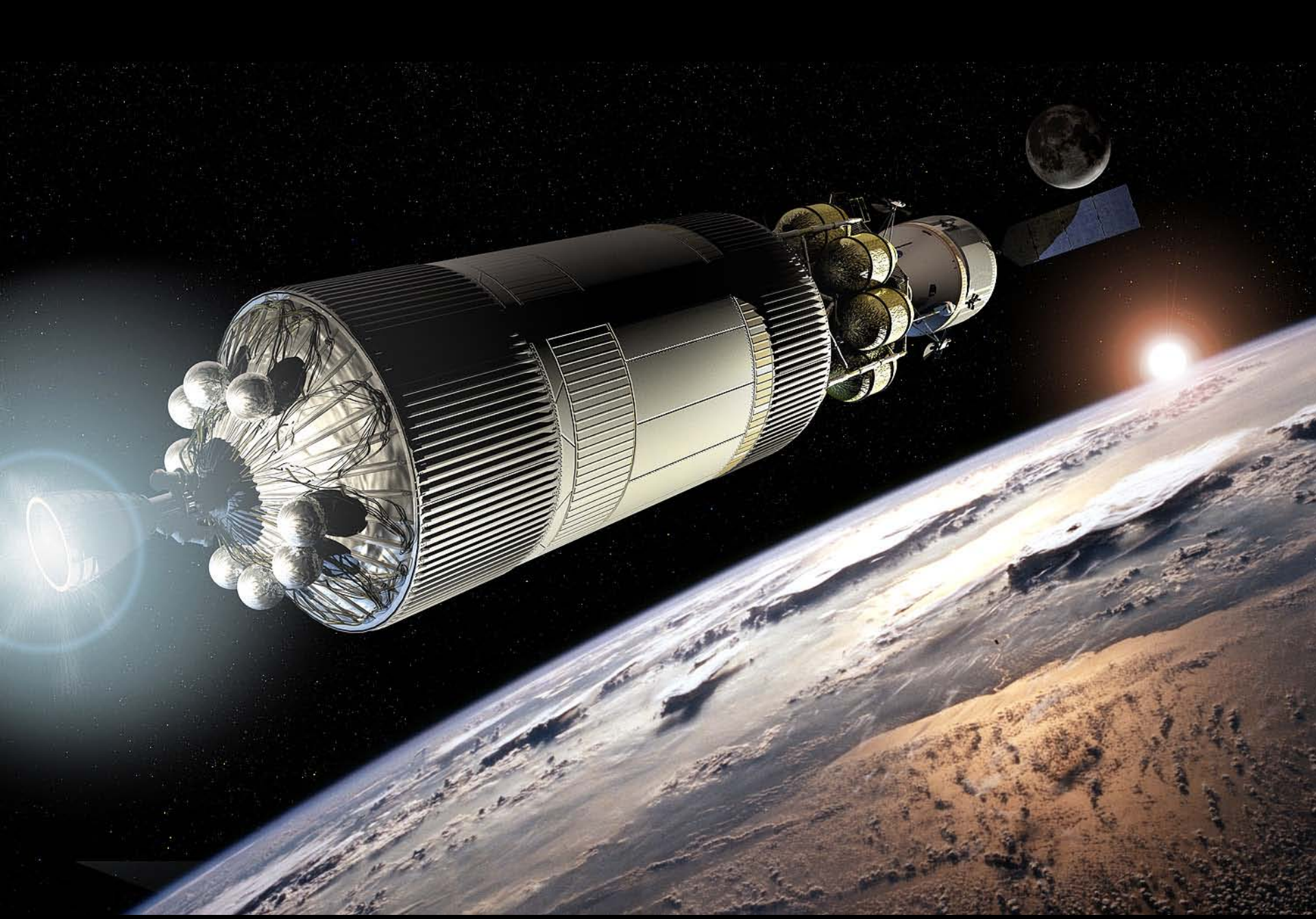
David A. Hasan

L-3 Communications @ NASA/JSC

david.a.hasan@nasa.gov

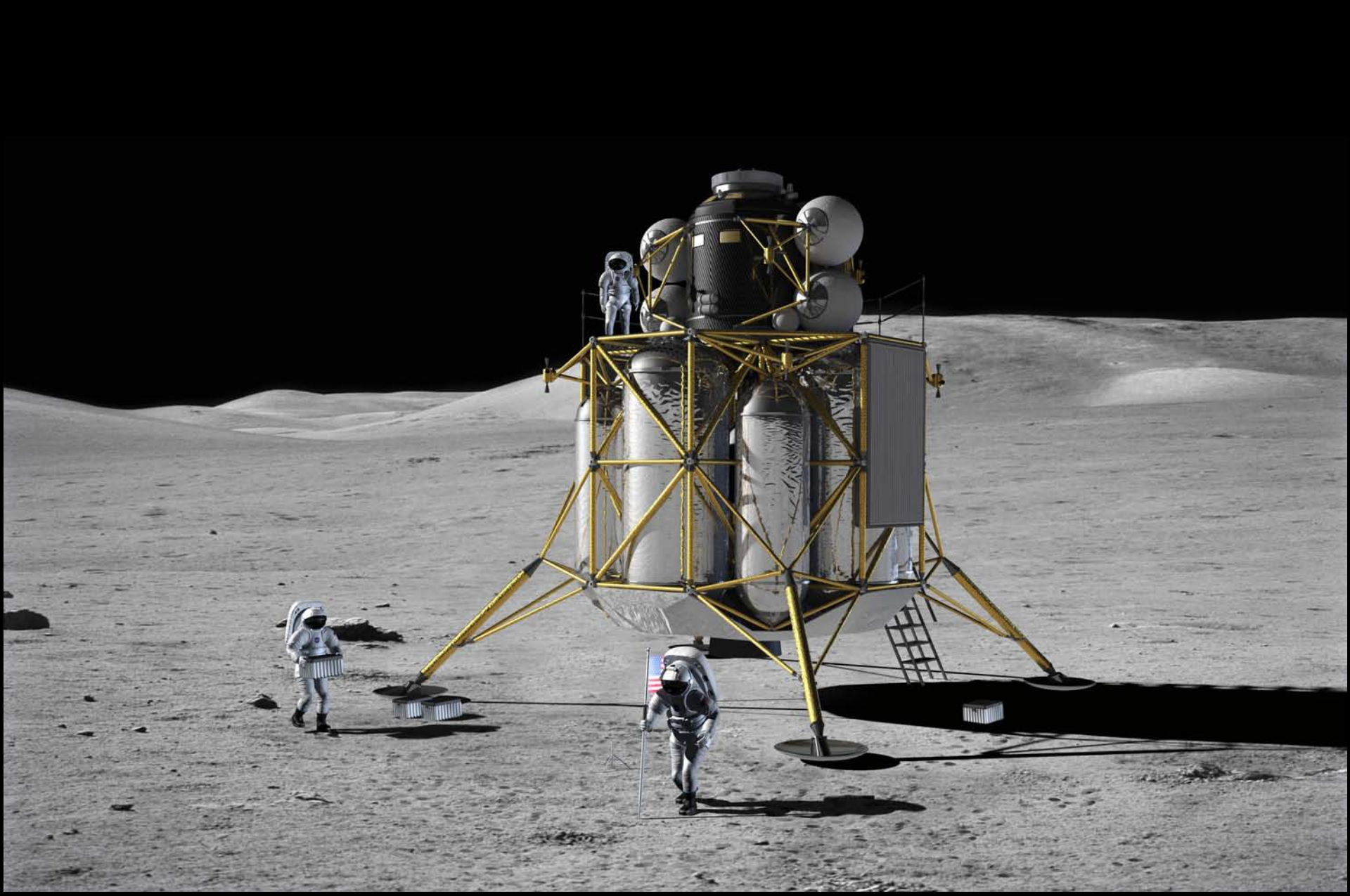
<0>

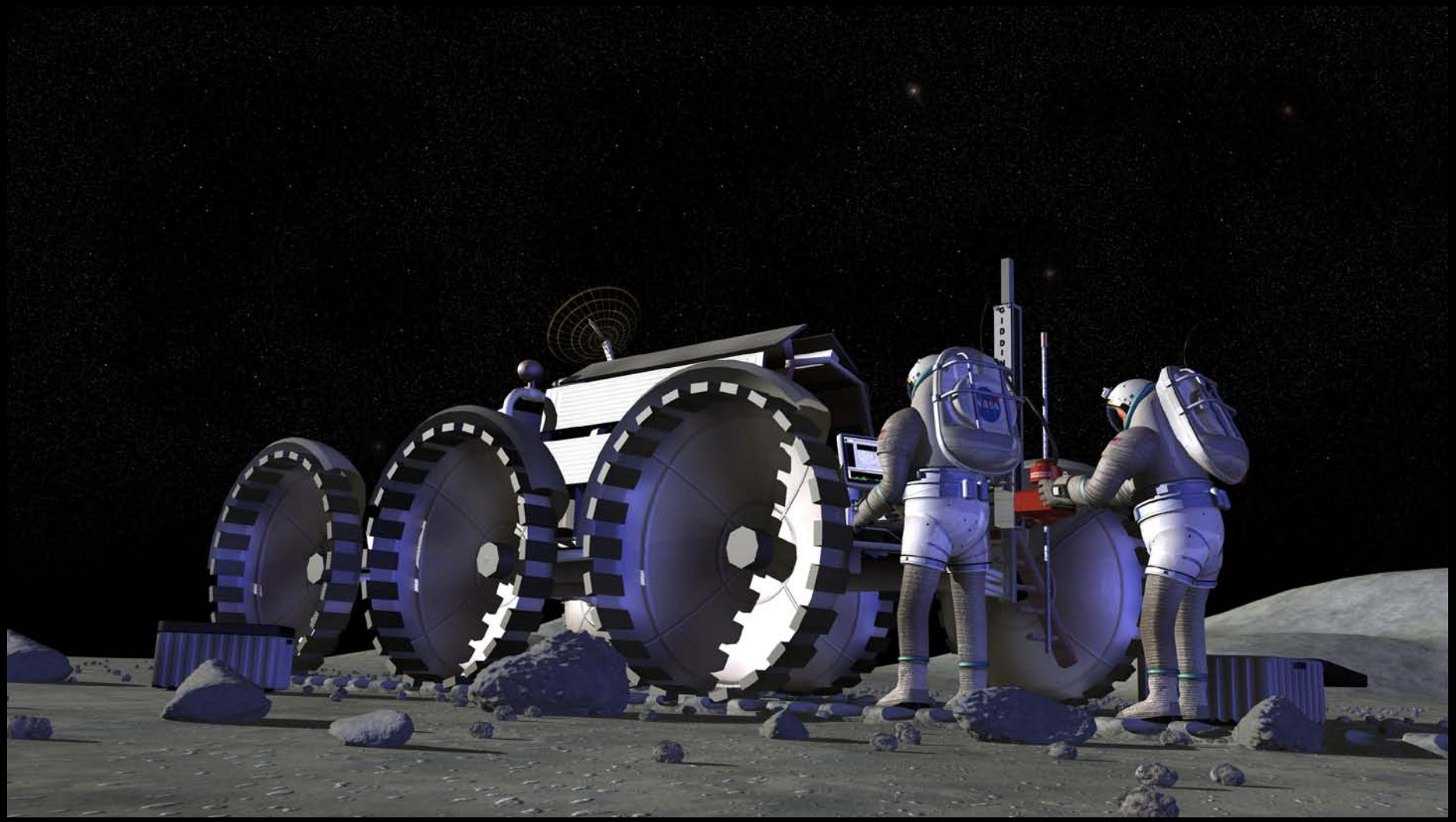
imagine

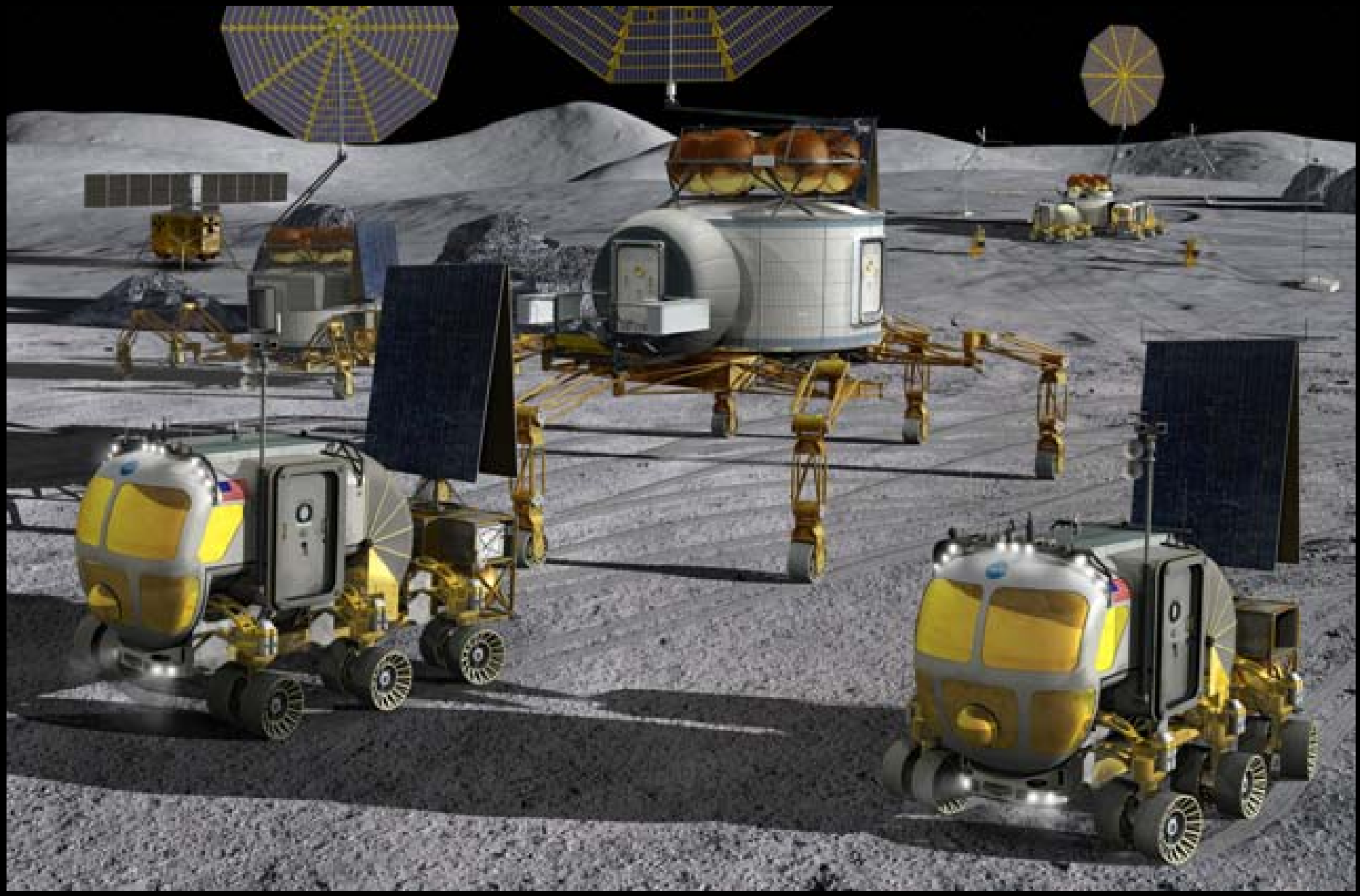



esa


esa







You decide.

agenda

1. *smackdown ?*
2. *review of 2011*
3. *preview of 2012*
4. *conversation ...*
5. *Join us!*

<1>

smackdown ?

What is it?

- collaborative multi-team exercise
  - constructive simulation of a world
  - simulation of vehicles deployed in that world
  - stand-alone and integrated missions
  - other tools (recorders, viewers, …)

- a competition
  - to add some spice to the event
  - 2011 Smackdown didn't have a competition
  - 2012 Smackdown should

- sponsored by SISO, held at the spring Simulation Interoperability Workshops.

Who is involved?

- academia
  - student teams with faculty sponsors
  - federates drawn from their disciplines (aerospace engineering, electrical engineering, computer science…)
- industry and government
  - act as facilitators & mentors
  - provide hardware & software infrastructure
- SISO
  - host the activity at the Spring SIW
  - logistical support (facilities, power, Internet,…)

Why do it? (outward looking)

- general outreach/education
  - engage students in science, technology, engineering and math (STEM)
  - teach young students team collaboration in a compelling context
  - promote general awareness of modeling/simulation
  - show that hands-on work is fun

- specific modeling/simulation education
  - teach practical, hands-on M&S skills
  - create M&S job-ready college graduates
  - introduce M&S activities into university programs

Why do it? (inward looking)

- SISO growth
  - reach new population of potential paper authors
  - attract new potential members
- hands-on HLA interoperability demonstration
- demonstration of HLA-Evolved in action
  - modules used for extensible exercises
  - library compatibility between RTI vendors

What do the teams do?

- build vehicle simulations
  - e.g., rovers, transfer vehicles, landers, bases, …
  - define and execute stand-alone missions
- build simulation tools
  - data recorders and playback tools
  - data visualization
  - mission dashboards
- collaborate with other teams
  - define and execute joint missions
  - executions may be remote from the SIW venue

What are the moving parts? (1 of 3)

- use HLA-Evolved
  - *Why HLA?*
    - background of the original Smackdown planning team.
  - *Why HLA-Evolved?*
    - Modular FOMs are a perfect fit for a loosely coupled set of simulated space vehicles/missions.
    - So we could start showing the new standard in action.
    - So we could demonstrate vendor support of the new standard.

- collaboration tools
  - collaboration **website** for file sharing
  - **VPN, DHCP, DNS** for geographically distributed testing and remote participation in the event

What are the moving parts? (2 of 3)

- collaboration documents
  - Scenario Overview document
  - FOM: the lingua franca of the simulations
  - FOM description document: to avoid agonizing over XML when bringing new teams on board
  - Federation Agreement: to get everyone on the same page
  - Federation initialization instructions
- execution tools
  - VPN: to allow geographically distributed teams to join the Smackdown event from outside the venue
  - run-time HLA tools: vendor-supplied RTIs and other useful tools
  - vendor licenses: free for university teams participating in the event (Pitch, VT MÄK, ForwardSim)

What are the moving parts? (3 of 3)

- computing platforms provided by the teams (even at the Smackdown event)
  - hardware
  - operating system
  - language tools (Java, C++, Matlab…)
- facilities and other logistical details
  - room, tables, Internet connectivity, power provided by SISO
  - some network cabling provided by participating organizations
  - VPN hardware and DHCP server provided by NASA / Johnson Space Center
  - dynamic domain names arranged by NASA / Johnson Space Center

process ? (1 of 2)

- coordinated and facilitated by SISO Space Smackdown Committees
  - *Executive Committee* – Smackdown/SIW coordination
  - *Outreach Committee* – attract new participants
  - *Planning Committee* – logistics
  - *Technical Committee* – scenario definition and testing

- three-part process
  1. get started
  2. incrementally test and refine the federations
  3. deploy the final federations at the Space Smackdown at the SISO Spring SIW

process ? (2 of 2)

1. **getting started**
   - initial committees and teams (and mentor assignments)
   - vehicle/scenario ideas and initial federates
   - kickoff meeting at the Fall SIW
   - monthly schedule

2. **incrementally refine and test**
   - *refine*
     - team roster (and mentor assignments)
     - vehicles and scenarios
     - documentation (Scenario Description, FOM, Federation Agreement)
     - logistics (e.g., room size, network, microphones …)
   - *test*
     - to verify federate and federation behavior
     - to verify the VPN, DHCP, DNS infrastructure

3. **go-live**
   - dry-run testing just prior to the event (remotely from team locations)
   - execution of the joint simulation as the Space Smackdown event at the Spring SIW

<2>

2011

participants (1 of 2)

- **University of Alabama / Huntsville**
  - lunar communications satellite
- **University of Bordeaux / University of Calabria**
  - lunar supply depot
- **Massachusetts Institute of Technology**
  - in situ resource utilization
- **North Carolina State University**
  - lunar rover
- **Pennsylvania State University**
  - lunar lander

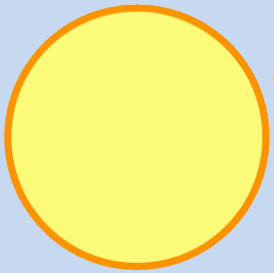
participants (2 of 2)

- **NASA / Johnson Space Center**
  - environment and transfer vehicle federate
  - VPN, DHCP and technical support
- **Aegis Technologies**
  - SharePoint collaboration web site and technical support
- **ForwardSim Inc.**
  - Matlab-based 3-D viewer
- **Pitch Technologies & VT MÄK**
  - RTI, simulation tools and product licenses
- **VT MÄK**
  - RTI, simulation tools and product licenses

the constructive world (1 of 3)

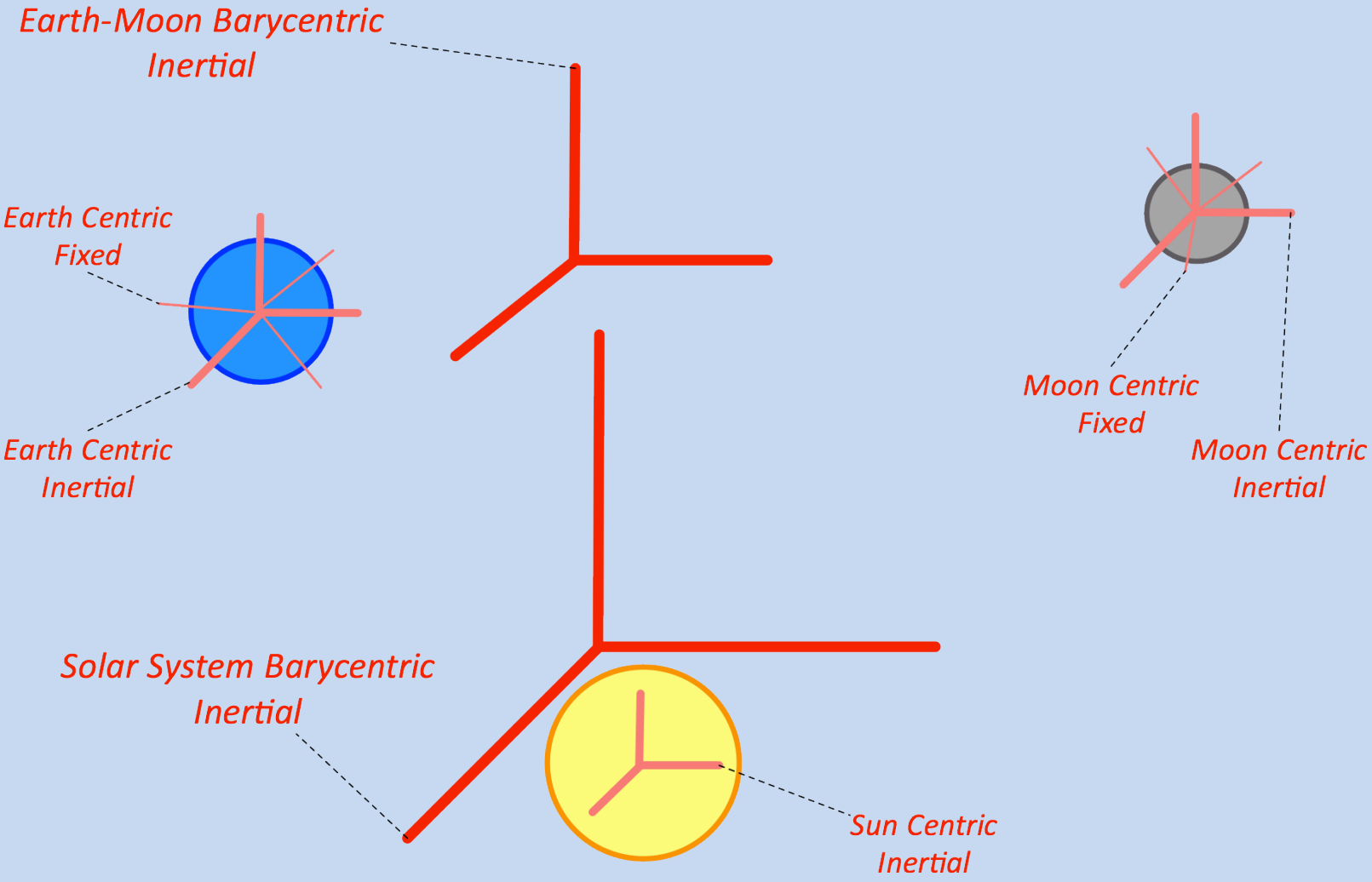
Earth

Moon 

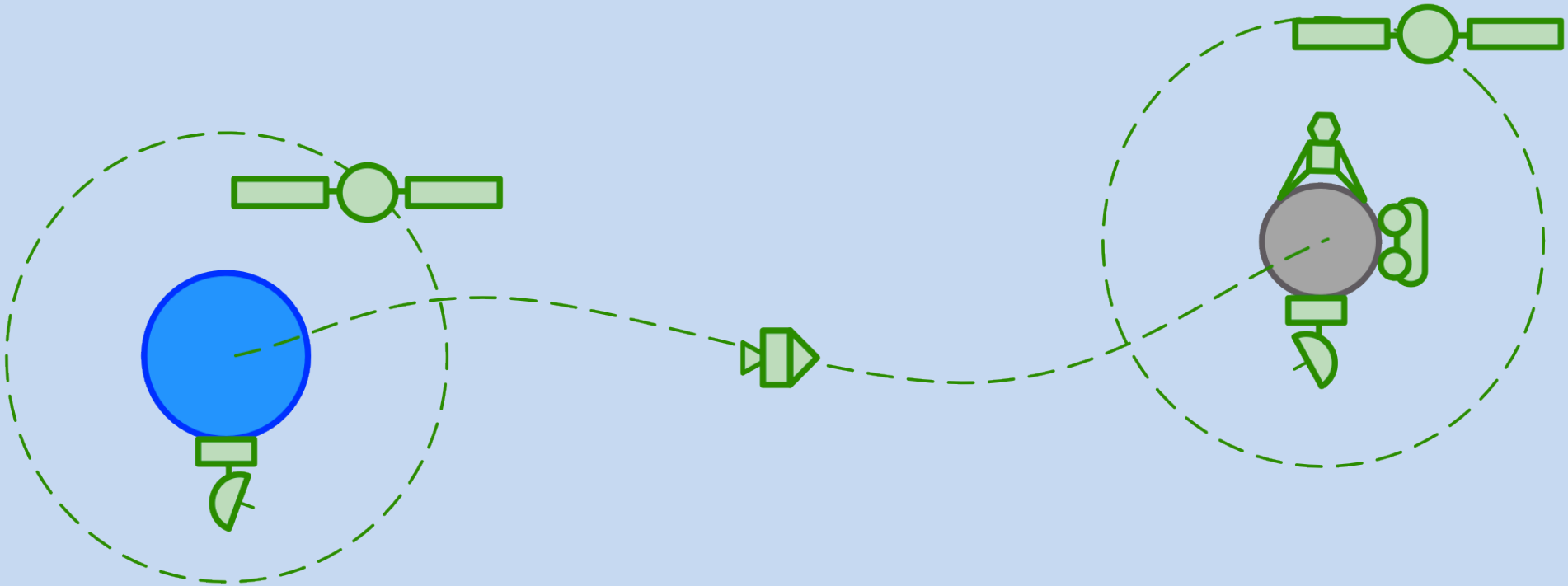


Sun

the constructive world (2 of 3)



the constructive world (3 of 3)



FOM

- modular FOM concept:
  - common modules for the basic mission
  - specialized modules for vehicle/mission extensions

- FOM modules developed:
  - **core**: common information, settings and datatypes
  - **environment**: reference frame and time object classes
  - **entity**: PhysicalEntity object class for vehicles such as rovers and transfer vehicles
  - **MIT**: datatypes, object classes, interaction classes for the in situ resource utilization federates
  - **NASA/JSC**: object classes for the lunar rover and lander

federates

- lunar communications satellite (UAH)
- lunar supply depot (Bordeaux/UNICAL)
- in situ lunar resource utilization (MIT)
- lunar rover (NCSU)
- lunar lander (PSU)
- Earth-Moon-Sun reference frames (NASA/JSC)
- Earth-Moon transfer vehicle (NASA/JSC)
- 3-D viewer (ForwardSim)

joint documentation

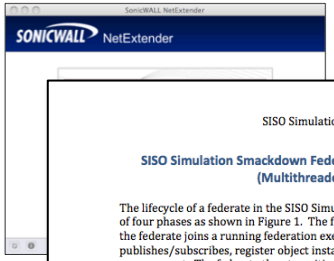
Configuring the MÄK RTI to run over the SISO Simulation Smackdown VPN

This document describes how to configure the MÄK Runtime Infrastructure (RTI) to work with the SISO Simulation Smackdown Virtual Private Network (VPN). It will be assumed that you have already configured your computer to connect to the Smackdown VPN.

Configuring the Pitch RTI to run over the SISO Simulation Smackdown VPN

This document describes how to configure the Pitch Runtime Infrastructure (RTI) to work with the SISO Simulation Smackdown Virtual Private Network (VPN). It will be assumed that you have already configured your computer to connect to the Smackdown VPN.

Step 1: Connect to the Smackdown VPN using the NetExtender application.



SISO Simulation Smackdown

SISO Simulation Smackdown Federate Startup Process Using HLA Evolved (Multithreaded Approach) - Draft

The lifecycle of a federate in the SISO Simulation Smackdown can be viewed as consisting of four phases as shown in Figure 1. The first phase is "Startup and Initialization" where the federate joins a running federation execution, indicate what data and/or interactions it publishes/subscribes, register object instances it will publish, and configure time management. The federate then transitions to the second phase "Running" where the federate is sending out updated data and/or interactions, processing queued received data, runs federate specific models, waits for time advance grants, and makes time advance requests. The third phase "Handle Callbacks" runs in parallel with the first two phases where the federate handles all the callbacks from the High Level Architecture (HLA) Runtime Infrastructure (RTI). The fourth and last phase "Shutdown" is where the federate resigns from the federation execution.

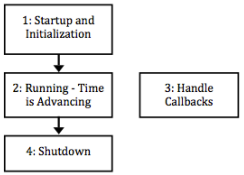


Figure 1: Simplified Federate Lifecycle Overview

The flow chart on the following pages shows the simple initialization scheme for the SISO Simulation Smackdown, which expands on the lifecycle concept shown in Figure 1. The initialization scheme assumes the Environment federate will be started first and is the federate responsible for creating the federation execution. The initialization scheme has been designed to allow federates to join late (i.e. join an already running smackdown simulation).

When a time-constrained non-regulating federate joins the simulation late, its logical time will start at zero but the logical time of the Environment federate (time-constrained and time-regulating) will be much larger. The late joining time-constrained non-regulating federate will not receive any Timestamp Order data from the Environment federate until its logical time catches up to it. To keep the late joining federates from having to catch up their logical time, the initialization scheme has been updated to allow late joiners to query for their Greatest Available Logical Time (GALT) then do a time-advance request to the GALT. The result is the late joining federates start with a logical time in sync with the Environment federate.

November 2, 2010 Dan Dexter: dan.e.dexter@nasa.gov 1

SISO Spring 2011 SIW

Simulation Smackdown

Scenario Overview

Author:
Version:

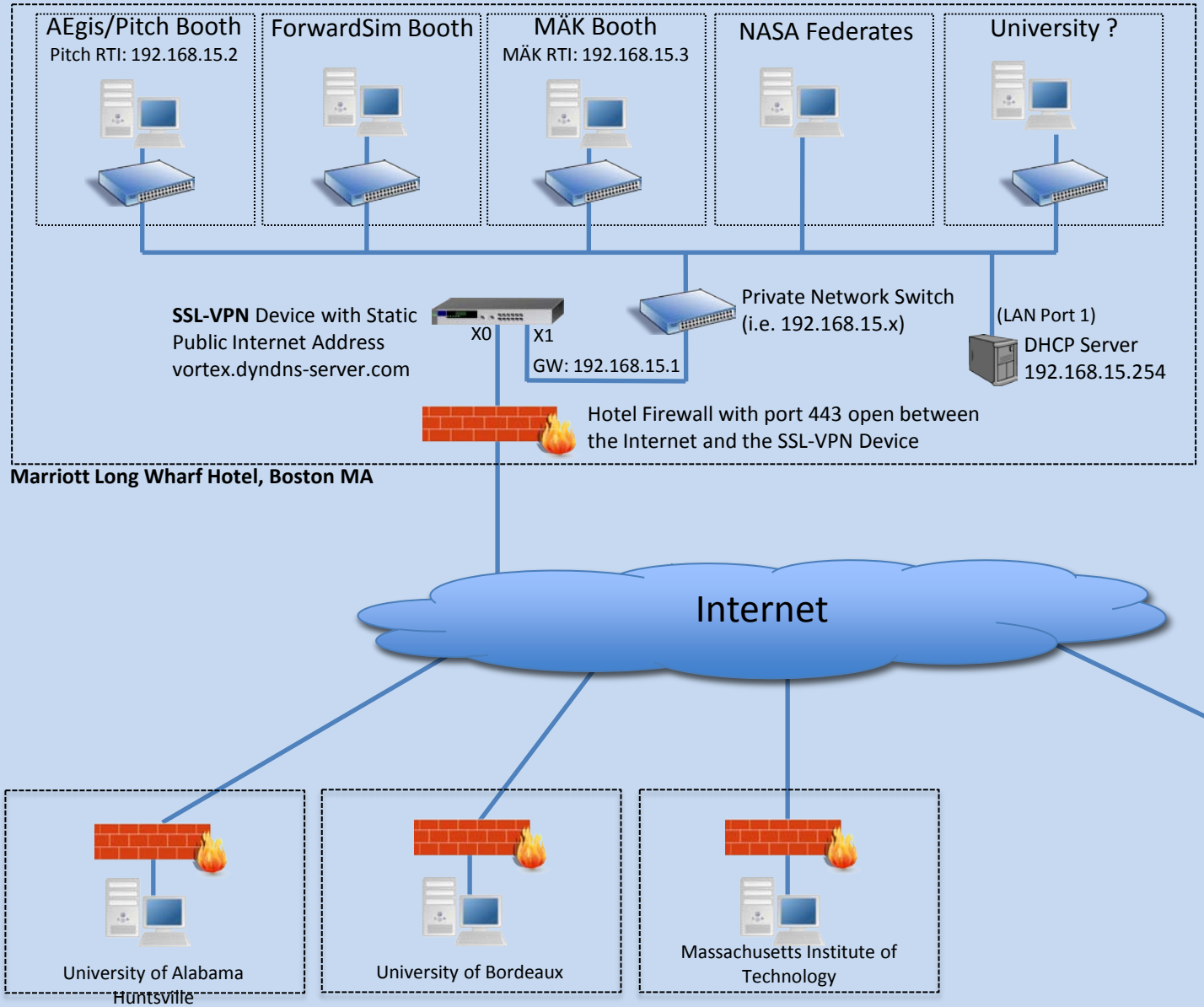
SISO Spring 2011 SIW

Smackdown Federation Agreements

Version: 23 February 2011

```
41    <objects>
42        <objectClass>
43            <name>HLAobjectRoot</name>
44            <objectClass>
45                <name>PhysicalEntity</name>
46                <sharing>PublishSubscribe</sharing>
47                <semantics>A man-made vehicle or major sub-element of a man-made vehicle. Space vehicles
48    have two reference frames intrinsically attached to them: a 'body frame' and a 'structural
49    frame'. Neither of these is part of the ReferenceFrame object hierarchy. The body frame
50    origin is the vehicle center of mass. The structural frame is located at some well-defined
51    point on the vehicle, but this point is not specified in this FOM. The offset of the body
52    frame origin from the structural frame origin is captured as the vehicle's center of mass
53    location attribute. The relative orientation of the structural and body frames is assumed
54    fixed (not time varying), but it is not specified in this FOM. All dynamics of the vehicle
55    are calculated by propogating the body frame with respect to the vehicle's 'parent
56    reference frame' which is an object instance in the ReferenceFrame hierarchy and is named
57    by the vehicle's parent_reference_frame attribute.</semantics>
58                <attribute>
59                    <name>entity_name</name>
60                    <dataType>HLAunicodeString</dataType>
61                    <updateType>Static</updateType>
62                    <updateCondition>during initialization</updateCondition>
63                    <ownership>NoTransfer</ownership>
64                    <sharing>PublishSubscribe</sharing>
65                    <dimensions/>
66                    <transportation>HLAreliable</transportation>
67                    <order>TimeStamp</order>
68                    <semantics>A non-empty string that identifies the vehicle. Each SpaceVehicle instance in
69    the federation must have a unique name.</semantics>
70                </attribute>
71                <attribute>
72                    <name>status</name>
73                    <dataType>HLAunicodeString</dataType>
74                    <updateType>Periodic</updateType>
75                    <updateCondition>when changes</updateCondition>
76                    <ownership>NoTransfer</ownership>
77                    <sharing>PublishSubscribe</sharing>
78                    <dimensions/>
79                    <transportation>HLAreliable</transportation>
80                    <order>TimeStamp</order>
81                    <semantics>An informative string that documents the current status of the vehicle
82    (whatever that might be).</semantics>
83                </attribute>
```

VPN



Smackdown Private Network
Gateway: 192.168.15.1
Pitch RTI: 192.168.15.2
MÄK RTI: 192.168.15.3
Static IPs: 192.168.15.10 - 49
SSL-VPN Clients: 192.168.15.50 - 199
DHCP Clients: 192.168.15.200 - 253
DHCP Server: 192.168.15.254

lessons learned (1 of 2)

- Teams did best when working with explicitly assigned **mentors**.
- Java/C++ **programming skills** really are a prerequisite. Sample federates were available to illustrate HLA for C++, Java & Matlab.
- Over time, we expect to have mission scenarios that involve more **vehicle-to-vehicle cooperation**.
- **Network connectivity** (firewalls)
  - adopted an SSL-VPN device
  - special instructions to configure RTIs for the VPN
  - VPN IP address management

lessons learned (2 of 2)

- **FOM table interpretation**
  - testing revealed different vendor interpretations of some FOM tables.
  - led to FOM modules that only worked for one vendor.
  - gave feedback to Pitch and VT MÄK, and the incompatibilities were resolved.

- **explicit initialization process**
  - to allow federates to join the federation late and rejoin a federation already in progress.
  - This is important for an event such as the Smackdown.

- **time** required to develop federates
  - Teams must get started building federates before December.
  - Interest must be translated into coding quickly.


SMACKDOWN
2011
.....from an idea
RAPID DEVELOPMENT OF HLA
FEDERATES IN MATLAB & SIMULINK

<3>

2012

mission ?

- start with Sun/Earth/Moon
  - i.e., build on last year's scenario
  - existing FOM and FOM description documents
- add new federates
- that do new things
  - new missions for new vehicles
  - more vehicle-to-vehicle **cooperation**

federates ?

- Sun/Earth/Moon
- lunar landers
- lunar launchers
- unmanned lunar rovers
- manned lunar rovers
- lunar habitats
- lunar power stations
- communications satellites
- navigation satellites
- space solar power satellites
- lunar prospector vehicles
- orbit transfer vehicles
- mission monitoring tools
- data visualization tools
- **<…your ideas here>**

cooperative missions ?

- line-of-sight communications
- line-of-sight power (from solar power station)
- GPS-like navigation
- in-orbit rendezvous / docking
- surface rendezvous
- multi-vehicle surface missions
- lunar hopper / in situ resource utilization communication
- **<…your ideas here>**

a competition ?

- hypothetical award categories
  - best evidence of teamwork
  - most original federate
  - most ambitious/challenging technical problem
  - team with most interfaces to other teams' federates
  - most FOM modules / object and interaction classes
  - most object/interaction instances
  - most published/subscribed attributes
  - most federates
  - number of post-event observations / lessons-learned
  - degree of participation (observer, passive federate, active federate…)
  - **<…your ideas here>**
- details (scoring, awards, judges, categories) TBD

resources

- wiki: **http://smackdown.inarisolutions.com**
  - for collaboration & document sharing
  - contact Paul Grogan or Dan Dexter for accounts

- software available to university teams
  - sample “EZButton” Java federate (contact Zack Crues)
  - Pitch & VT MÄK RTI and tools
  - ForwardSim HLA Toolbox for HLA

- Contact Priscilla Elfrey for:
  - SISO-provided IEEE-1516 standard documents
  - simulation- and HLA-related educational resources
  - Space Smackdown Starter Kit

draft schedule (1 of 2)

- Sep 2011 *(Fall SIW, Orlando)*
  - initial documents on the wiki
  - *Space Smackdown 101* tutorial
  - papers by 2011 smackdown participants
  - kickoff smackdown planning
- Oct 2011 *(Planning and Technical committees)*
  - initial list of teams and mentors
  - deploy the VPN
- Nov 2011 *(Planning and Technical committees)*
  - initial testing over the VPN
- Dec 2011 no activity (holiday break)

draft schedule (2 of 2)

- Jan 2012 *(Planning and Technical committees)*
  - final list of teams and mentors
  - more testing over the VPN
- Feb 2012 *(Planning and Technical committees)*
  - documentation updates
  - full federation test over the VPN
- Mar 2012 *(Planning and Technical committees)*
  - documentation updates
  - full federation test over the VPN
- Apr 2012 *(Spring SIW, Orlando)*
  - pre-SIW federation dry-run testing over the VPN
  - ***2012 Space Smackdown***

to do

- planning kickoff (tomorrow 19:00, Legacy South 3)
- assemble the teams and assign mentors
- define the vehicles & mission scenarios
- execute the schedule
- Space Smackdown at the 2012 Spring SIW

<4>

conversation …

panel discussion

- ***Zack Crues,*** *NASA / Johnson Space Center*
- ***Dannie Cutts,*** *Aegis Technologies*
- ***Dan Dexter,*** *NASA / Johnson Space Center*
- ***Paul Grogan,*** *Massachusetts Institute of Technology*
- ***Joe Hubbard,*** *NASA / Johnson Space Center*

questions ?

<5>

Join us !

a simple getting-started checklist

- ☐student team members
- ☐faculty sponsor
- ☐designated smackdown mentor
- ☐POC for Technical Committee meetings
- ☐Java or C++ skills
- ☐willingness to learn HLA
- ☐ideas for a simulated mission
- ☐model development technical skills
- ☐time
  - for model/simulation development
  - to coordinate with other participants
  - for integrated federation-wide testing

immediate next steps

- planning meeting (tomorrow 1900-2100, Legacy South 3)
  - 2012 Spring SIW Smackdown "kickoff"
  - gather initial interest and have people sign up
  - committee assignments (Executive, Outreach, Planning, Technical)
  - mission scenario definition
    - What are we going to simulate? (the things, the nouns)
    - What are they going to do? (the activities, the verbs)
  - competition
    - award categories
    - judging criteria
    - panel of judges
  - open question/answer session
  - preliminary schedule
- contact us (see next slide) to become a participant
- wiki: `http://smackdown.inarisolutions.com`
- Bring your ideas, and join us!

points of contact

- ***Zack Crues**, EZButton federate, NASA/JSC*
  edwin.z.crues@nasa.gov
- ***Dan Dexter**, Technical Committee, NASA/JSC*
  daniel.e.dexter@nasa.gov
- ***Priscilla Elfrey**, SISO coordination, NASA/KSC*
  priscilla.r.elfrey@nasa.gov
- ***David Hasan**, L-3 Communications*
  david.a.hasan@nasa.gov
- ***Joe Hubbard**, Planning Committee, NASA/JSC*
  joseph.v.hubbard@nasa.gov
- ***Björn Möller**, Pitch*
  bjorn.moller@pitch.se
- ***Tom Stanzione**, VT MÄK*
  tstanzione@mak.com
- ***Martin Steele**, Space Forum, NASA/KSC*
  martin.j.steele@nasa.gov
- ***Bill Waite**, SISO industry outreach, AEgis*
  bwaite@aegistg.com

<fin>

acronyms (1 of 2)

acronym	meaning
DHCP	dynamic host configuration protocol
DNS	domain naming system
FOM	federation object model
GPS	Global Positioning System
HLA	High Level Architecture
IP	internet protocol
JSC	NASA Johnson Space Center
M&S	modeling and simulation
MIT	Massachusetts Institute of Technology
NCSU	North Carolina State University
POC	point of contact
PSU	Pennsylvania State University
RTI	runtime infrastructure

acronyms (2 of 2)

acronym	meaning
SISO	Simulation Interoperability Standards Organization
SIW	Simulation Interoperability Workshop
SSL	secure sockets layer
TBD	to be determined
STEM	science, technology, engineering and mathematics
UAH	University of Alabama / Huntsville
UNICAL	University of Calabria
VPN	virtual private network
XML	extensible markup language