ISS - Enabling Exploration through Docking Standards

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Standards – Enabling Exploration

• Connecting spacecraft from different nations has required unique development and expensive integration and test
  – Apollo-Soyuz Test Project
  – International Space Station

• Expansion of spacefaring nations (and non-governmental entities) will compound this issue in the future
  – Exploration cooperation could be much easier with internationally accepted interface standards

• One of the key elements involved in mating dissimilar spacecraft is docking systems
  – Enabling dissimilar spacecraft mating for crew and cargo exchange
  – Enabling spacecraft assembly (e.g., APAS joining USOS and Russian Segments on ISS)
Enabling a Docking Standard

- The ISS partnership has developed an International Docking System Standard (IDSS)
  - An expanded version is expected to be approved in the second quarter 2011 by the ISS partnership
  - The latest version of IDSS can be found at http://internationaldockingstandard.com/

- It is expected that several versions of IDSS compatible docking systems will eventual emerge
  - Both NASA and ESA are currently developing systems

- NASA will install an adapter to use this standard on the U.S. segment of ISS beginning in 2015
  - The two new adapters will replace existing APAS adapters used by the Space Shuttle
Docking System Early Design Progression

Apollo Probe Cone

Russian Probe Cone

Apollo Soyuz – the first androgynous system

(No scale is implied between figures)
Docking and Berthing

Docking
- Enables direct mating of vehicles
- Controlled by chasing vehicle
- Attenuates contact forces and moments

Berthing
- Large passageway and load carrying capability
- Ease of utility routing in pressurized volume
- Needs manipulator for installation

Androgynous Peripheral Attach System (APAS)  Common Berthing Mechanism (CBM)
Next Generation Systems and IDSS

• **Evolutionary**
  – Based on peripheral type architecture, incorporating proven hard capture system
  – Peripheral systems satisfy capture performance requirements for the widest range of vehicles (small crew capsules to orbiter like vehicles)
  – Peripheral systems allows for max pass through the docking interface without hardware dismantling

• **Androgynous**
  – Enables either vehicle to be the active “chaser”

• **Allows both docking and berthing**

• **Enables Low Impact technology**
  – All previous docking mechanisms have required the use of impacts (i.e. velocity or post-contact thrusting) to create the energy required for soft capture mechanism interface alignment and capture between mating docking interfaces
  – Low impact technology can accommodate wide range of vehicle contact and capture conditions
NASA ISS Docking System Policy

• NASA plans to use the International Space Station as the first use of the IDSS
  – Will be the docking system used on the U.S. segment of the ISS for all visiting vehicles

• All vehicles visiting the USOS will be required to be IDSS compliant

• NASA is building and qualifying the NDS system as reference design

• NASA will provide the NDS data package to commercial vehicle providers having agreements with NASA to provide services, who can
  – Build their own design
  – “Build to print” the NDS design
  – Buy the system from the production vendor
  – Request NASA provision the NDS
NASA Docking System – Features

- Low Impact six degree of freedom force feedback platform for soft capture
- IDSS Compatible
- **Simple interfaces to host vehicle**
- Block development with a family of configurations planned

![Diagram showing various components of the NASA Docking System](image)

- 6 Linear EMA Stewart Table
- Soft Capture Load Sensing System Extended
- Electromagnet (3 ea.) Striker plate
- MMOD Shield
- Docking Seal
- SCS Lockdown & future Mech. SCS Striker (3 ea.)
- IVA Removable Guide Petals (3 ea.)
- Retractable Separator (3 ea.)
- Active Hook (12 ea.)
- Passive Hook
- Hook drive train flexshaft
- Retractable Power/Data Transfer Umbilicals (2 ea.)
ISS Docking and Berthing Ports

NDS installation will update existing APAS systems on PMAs to be IDSS compatible

Planned NDS (IDSS): 2

Berthing Ports: 2

Probe & Cone: 4
Until recently, new CBM-based adapters were planned for ISS.

Change was made to use existing Pressurized Mating Adapters (PMA) as a base for the new adapters:
- Providers greater clearance for winged vehicles
- Frees an additional CBM port for potential use
NDS and Docking Adapter Status

• NASA is working closely with the ISS partnership to further refine the IDSS standard
  – Further revisions after the upcoming release are not anticipated in the near future
  – NDS team is collaborating with other agencies to agree on remaining interface features (e.g., connectors)

• NDS design kicked off CDR this week
  – Long lead part procurement underway
  – Flight representative EDU assembly early 2012
  – Qualification program begins late 2012, complete 2013

• ISS Docking Adapters planned for launch beginning in 2015

• http://dockingstandard.nasa.gov/documents.html
Summary

- NASA and the ISS partnership are jointly developing a key standard to enable future collaborative exploration.

- The IDSS is based on flight proven design while incorporating new low impact technology:
  - Low impact technology accommodates a wide range of vehicle contact and capture conditions.

- This standard will get early demonstration on the ISS.

- Experience gained here will enable operational experience and the opportunity to refine the standard.

- NASA and ESA are developing new docking system; others are expected later:
  - ESA: IBDM
  - NASA: NASA Docking System (NDS)
Backup
Block 0 System Configurations Summary

- **-301/Core**
  - Active, Fully Androgynous*, 120VDC power, integrated electronics
  - Configuration can dock in either active or passive mode to all configurations or to any IDSS compatible system

- **-302/Short**
  - Reduced height; electronics boxes remotely mounted
  - Current NDS ISS adapter and Hub baseline
  - *Note: This configuration detailed features are under review*

- **-303/Lower Voltage**
  - Same as -301 except 28VDC power input
  - -301 avionics was designed to support power board swap out; board has not been designed
NDS-to-Host Vehicle Interfaces

Vehicle to hook pyro
2 x (Active/Passive)

Structural I/F
48-bolts on 53.150" (1350 mm) DIA BC (thru holes on NDS, inserts on host, NDS provides bolts)
3 shear pins different than

Docking Umbilicals
2 x ISS FRAM type connectors (Channel A/B), each has:
• Two 8 AWG power circuits w/ both
  • MIL-STD-1553B
  • 100 Base T Ethernet
All wiring passed thru to inside of tunnel for host

Seal I/F
Two concentric seal beads (NDS provides)

Electrical Bonding
NASA-STD-4003, Class R/H

NDS Data
2 x TIA-422-B or MIL-STD-1553B (A/B)

NDS Power
2 Connectors for 120V (or 28v) feeds (A/B) for system and heater power

Return
## NDS Mass Status

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<th>Title/Description</th>
<th>-301</th>
<th>-302***</th>
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<tr>
<td>Base Mass</td>
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<tr>
<td>Basic Mass + MGA</td>
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<td>Allocated Mass</td>
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<tr>
<td>System Roll-up*</td>
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<td>Hard Capture System (HCS)**</td>
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*System Roll-up mass includes top components assembled at a higher level than the HCS and SCS sub-assemblies.
**Box masses below are included in the Hard Capture System Mass Above. The same boxes are used in -301 & -302
***302 Mass does not include host provided h/w (MMOD shiel, box mounting, extension cables, etc.)