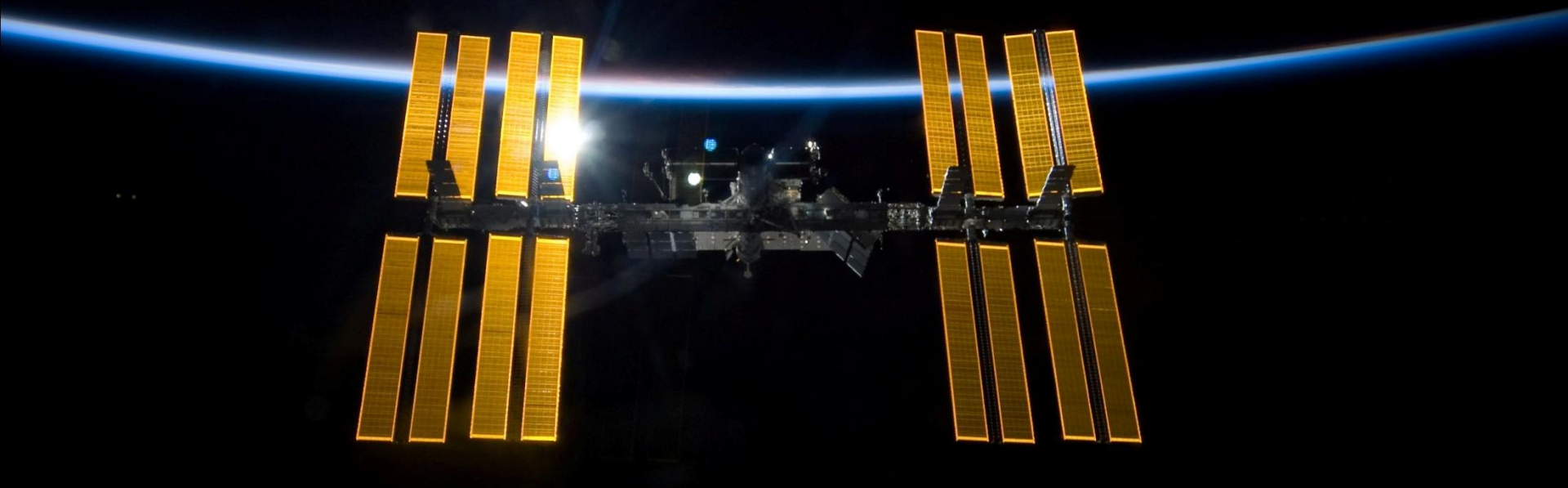
ISS - Enabling Exploration through Docking Standards



ISSMars-DC Conference
April 2011

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International Space Station Program

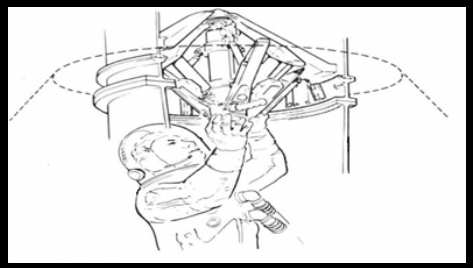
Standards – Enabling Exploration

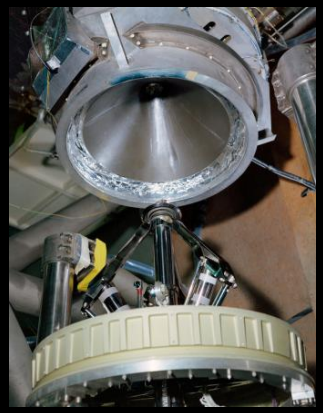
- **Connecting spacecraft from different nations has required unique development and expensive integration and test**
  - Apollo-Soyuz Test Project
  - International Space Station
- **Expansion of spacefaring nations (and non-governmental entities) will compound this issue in the future**
  - Exploration 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

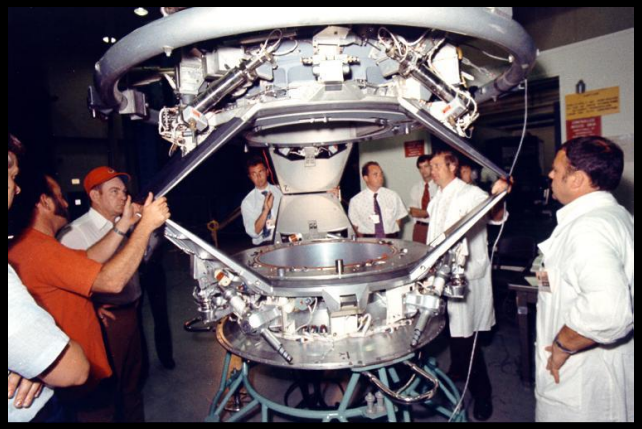
- **The ISS partnership has developed an International Docking System Standard (IDSS)**
  - An expanded version is expected to be approved in the second quarter 2011 by the ISS partnership
  - The latest version of IDSS can be found at http://internationaldockingstandard.com/
- **It is expected that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

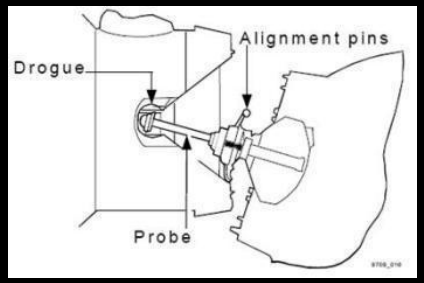


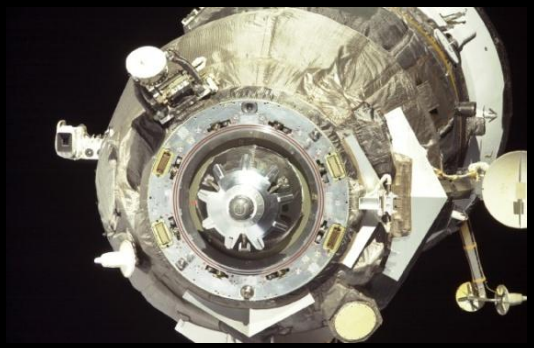


Apollo Probe Cone

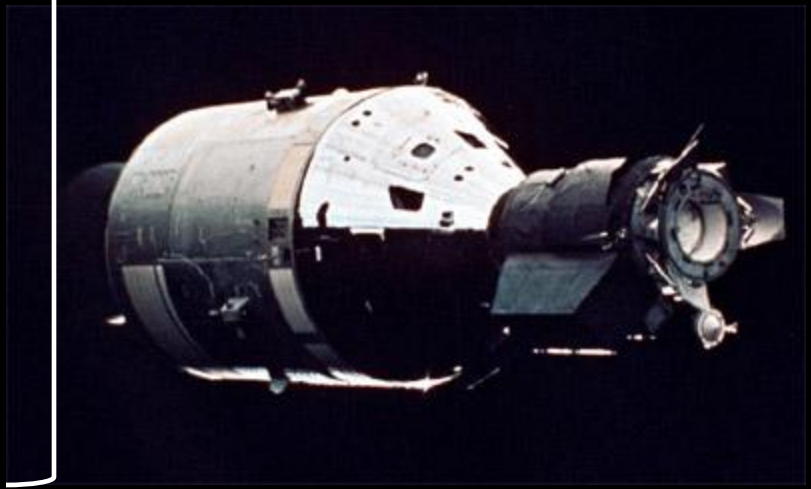


Apollo Soyuz – the first androgynous system





Russian Probe Cone



(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

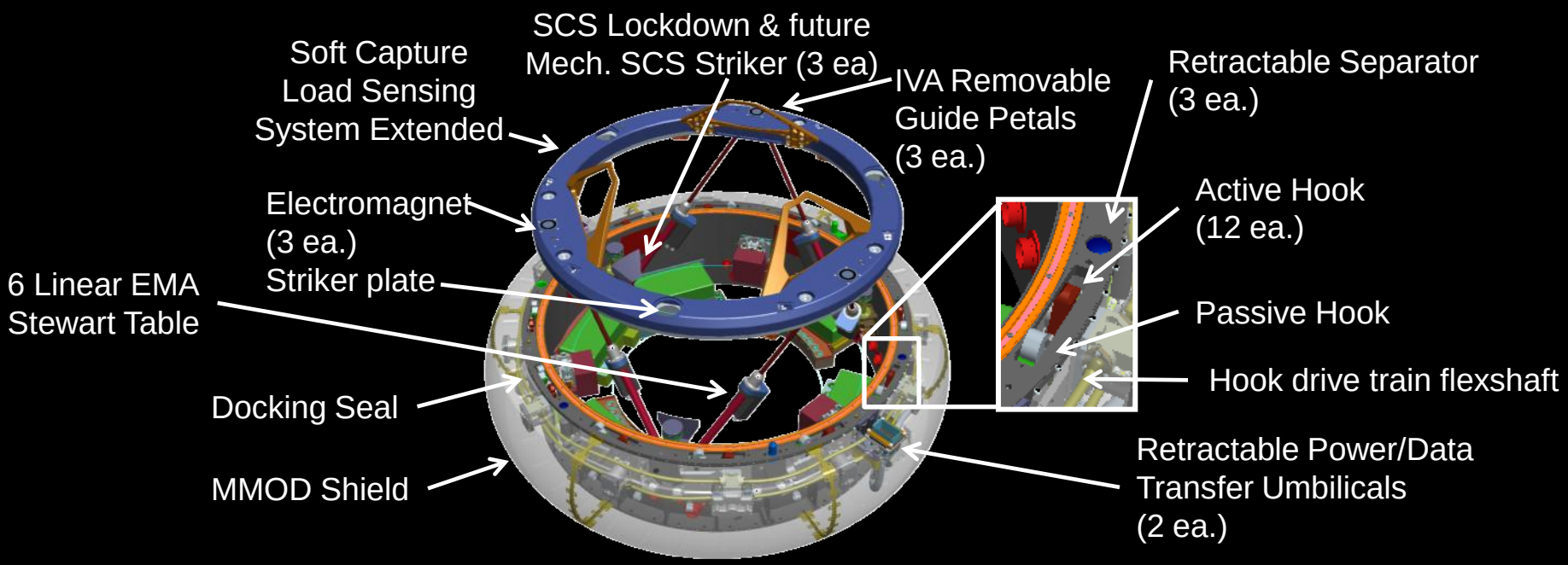
- **Evolutionary**
  - Based on peripheral type architecture, incorporating proven hard capture system
  - Peripheral systems satisfy capture performance requirements for the widest range of vehicles (small crew capsules to orbiter like vehicles)
  - Peripheral systems allows for max pass through the 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**



ISS Docking and Berthing Ports

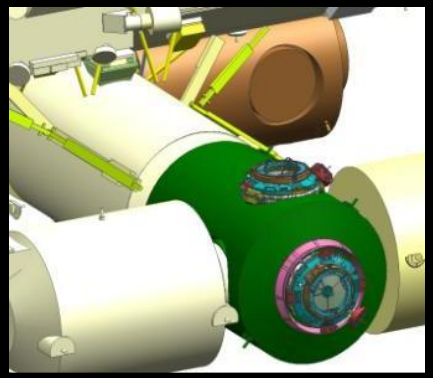
NDS installation will update existing APAS systems on PMAs to be IDSS compatible

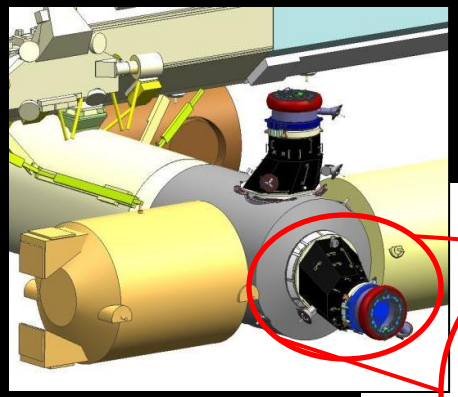
Planned NDS (IDSS): 2

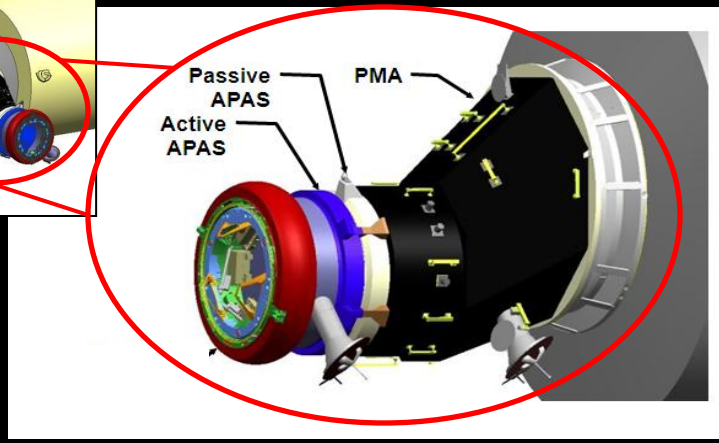
Probe & Cone: 4

Berthing Ports: 2

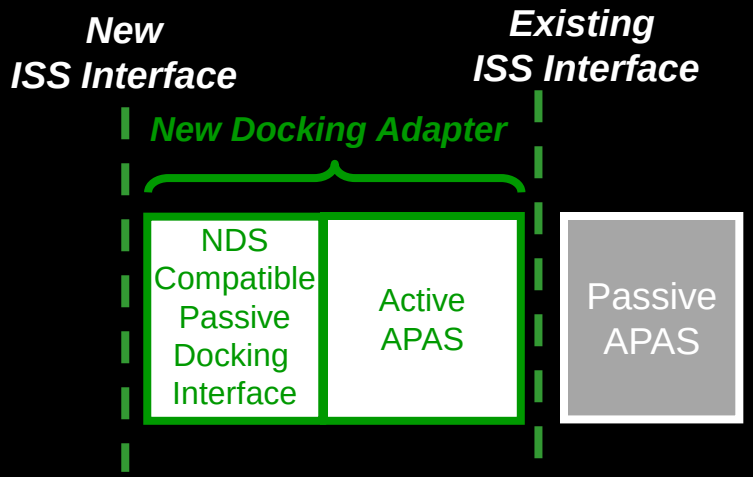
New Docking Adapter Configuration







- **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)

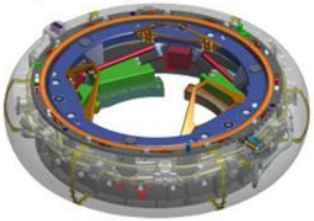
Backup

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

Ready to Dock (Active Mode)
Soft Capture System Extended

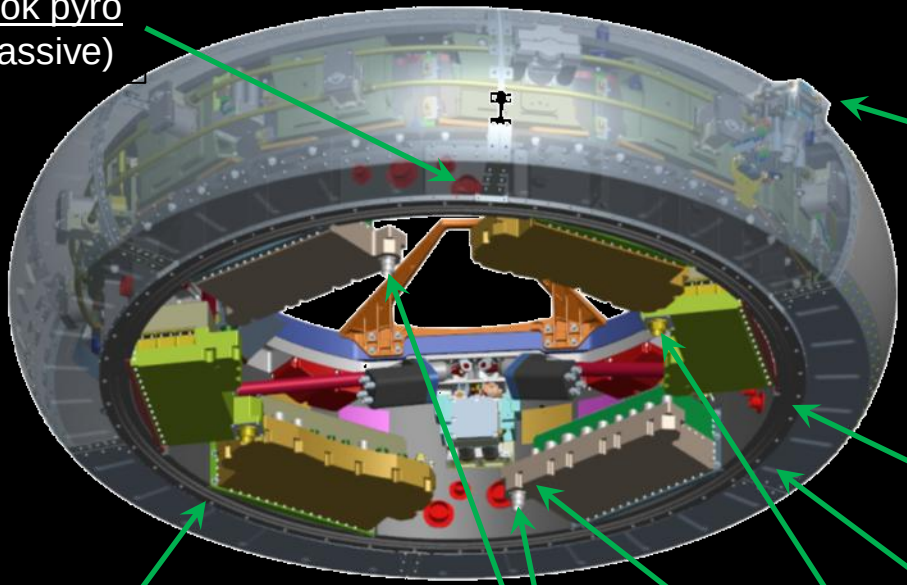
Ready to Dock/Launch
(-301 Passive Mode)
Soft Capture System Retracted



Ready to Dock/Launch
(-302 Passive Mode)
Electrical Boxes mounted in host

Return

NDS-to-Host Vehicle Interfaces



Vehicle to hook pyro
2 x (Active/Passive)

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

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

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

	-301			-302***		
Title/Description	**Base Mass**	**Basic Mass + MGA**	**Avg MGA**	**Basic Mass**	**Basic Mass + MGA**	**Avg MGA**
Allocated Mass	**n/a**	**750**	**N/A**	**n/a**	**704**	**N/A**
System Roll-up*	**679.65**	**744.31**	**10%**	**630.65**	**684.54**	**9%**
Hard Capture System (HCS)**	480.43	527.39	**10%**	357.39	387.01	**8%**
Soft Capture System (SCS)	135.16	147.20	**9%**	135.22	147.27	**9%**
*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 shield, box mounting, extension cables, etc.)						
Control Box Assy** (Qty 2)	31.51	34.39	**9%**	31.51	34.39	**9%**
Motor Box Assy** (Qty 2)	34.05	37.04	**9%**	34.05	37.04	**9%**
Power Box Assy** (Qty 2)	45.35	49.39	**9%**	45.35	49.39	**9%**

Return