ADVANCED DOCKING BERTHING SYSTEM UPDATE

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Advanced Docking Berthing System Update
NASA Seal Workshop
GRC

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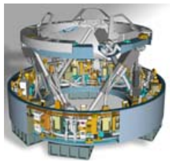

Outline

- Background
- Future Program Needs
- Existing Systems
- Status
- Advanced Docking/Berthing System (ADBS) Overview
- Key Seal Requirements
- Early Seal Development Work

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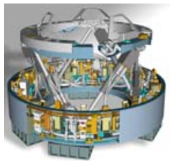
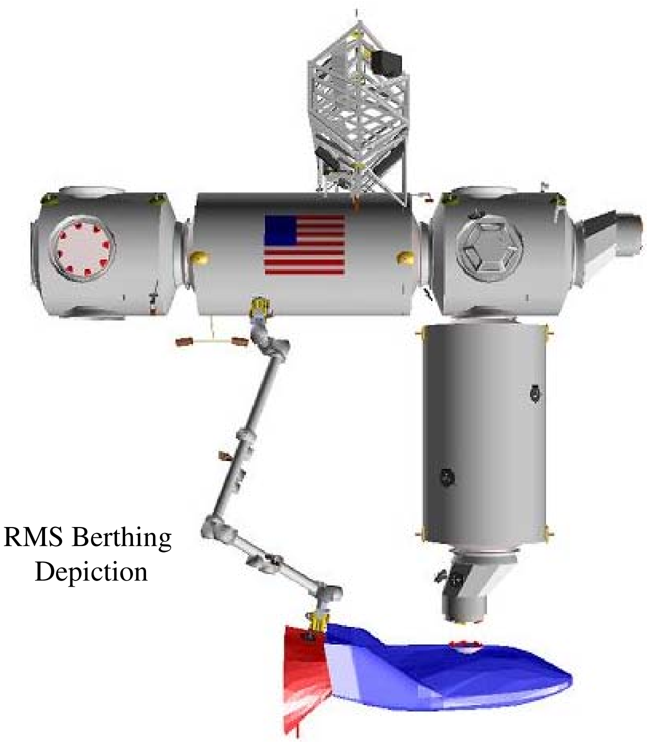


Background

Berthing refers to mating operations where an inactive module/vehicle is placed into the mating interface using a Remote Manipulator System-RMS.

Docking refers to mating operations where an active vehicle flies into the mating interface under its own power.



RMS Berthing Depiction

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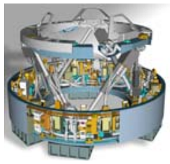

Future Needs

Future Mating System Capability Requirements:*

- A system able to support a variety of missions: CTV/CEV/CRV, lunar gateway, Moon, and Mars
- Lightweight, fault tolerant system that blends well into vehicle OML (aero)
- Capable of autonomous rendezvous & docking
- Berthing capable for modular assembly and vehicle swap-out
- Software reconfigurable for a range of vehicles and operations
- Fast separation for rapid release
- Modular for maintenance and servicing
- Constellation safety & reliability goals
- Adaptable to ISS
- Crew and large cargo transfer
- Power, data, and fluid transfer
- Vehicle to vehicle mating (CRV-CTV-others) requires androgynous interface

*-During FY06, with the Constellation Program and the CEV Project ramping up, detailed requirements development and documentation will occur.

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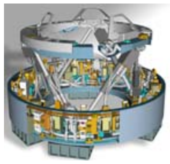
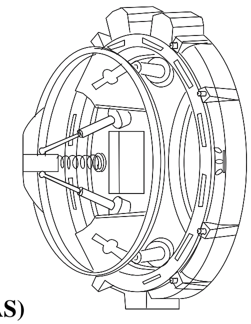
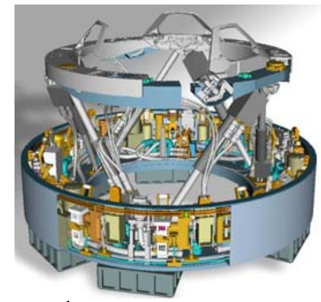


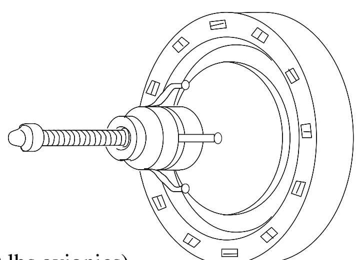
Existing Systems



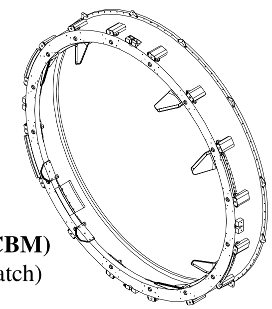
Androgynous Peripheral Docking System (APAS)
Weight: ~950 lbs (660 lbs APDA-6001 + 276 lbs avionics) (hatch not incl.)
Max OD: 69” dia
Hatch Pass Through: 31.38” dia
Source: JSC-26938, “Procurement Specification for the Androgynous Peripheral Docking System for the ISS Missions



Advanced Docking/Berthing System (ADBS)[1]
Weight: est. 750 lbs (includes electronics & hatch)
Max OD: 58” dia
Hatch Pass Through: 32” dia
Source: LIDS Project Group



Russian Probe
Weight: 700 lbs (550 lbs cone + 150 lbs avionics)
Max OD: 61” dia
Hatch Pass Through: 31.5” dia (approximate)
Source: Energia



Passive Common Berthing Mechanism (PCBM)
Weight: 680 lbs[2] (440 lbs PCBM + 240 lbs hatch)
Hatch Pass Through: 50” square
Max OD: 86.3” dia
Source: SSP 41004, Part 1, “Common Berthing Mechanism to Pressurized Elements ICD” & SSP 41015, Part 1, Common Hatch & Mechanisms To Pressurized Elements ICD

[1]ADBS currently under development
[2]Bulkhead hatch ring structure not included

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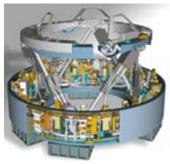

Existing Systems

Limitations of existing systems:

- Do not meet 2-fault tolerant, time-critical release requirement for crewed vehicles
  - APAS for Shuttle relies on 96 bolt EVA to meet 2nd fault tolerance
  - CBM powered bolts in nominal ops are not time critical and are single fault tolerant
- Unique active & passive halves: precludes vehicle-to-vehicle mating using like pairs
- Do not support autonomous operations
  - No automatic mating of fluid, power (APAS does have a power/data connector) and forced air umbilicals
  - CBM cannot mate to unmanned vehicles; requires RMS grappling and berthing
- Standard ISS racks cannot pass through existing docking ports
- Significant velocities required to provide alignment & capture forces
- Crit-1 operations supported by intensive training & analysis
- High part count / mechanical complexity with single point failures (reliability and failure tolerance problems)
- Berthing mechanisms do not dock and docking mechanisms do not berth
- Russian systems are supplied by a foreign vendor with substantial economic concerns
  - Purchase of additional units banned by Iran Missile Proliferation Sanctions Act of 1997
  - Very limited access to engineering data
- Systems designed and/or certified for very few cycles and short exposure life

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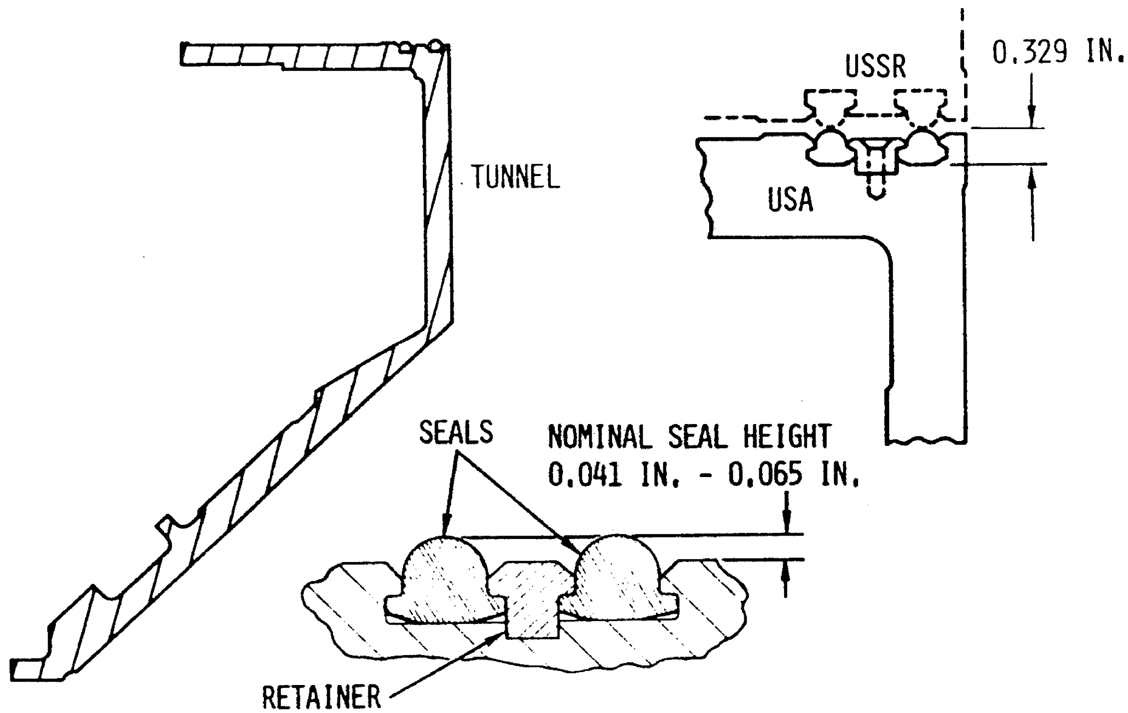
Existing System Seals



Apollo Soyuz Test Program
Docking System Interface Seal Diagram

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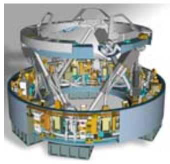

Current Status

Advanced Mating System Development Activities

- In FY05 the Exploration Systems Technology Maturation Program selected the JSC advanced mating systems development to continue as an in-house project.
- In FY06, as a result of ESAS Study (60 Day Study) the CEV Project (within the Constellation Program) has chosen to continue the project as a GFE Flight Hardware development effort.
  - new requirement for CEV to travel and dock with the ISS in 2011/12 in support of retiring the Shuttle and reducing the gap of time where US does not have any US based crew launch capability.
- As before, long-duration compatible seal-on-seal technology (seal-on-seal to support androgynous interface) has been identified as a risk mitigation item.

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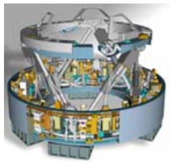
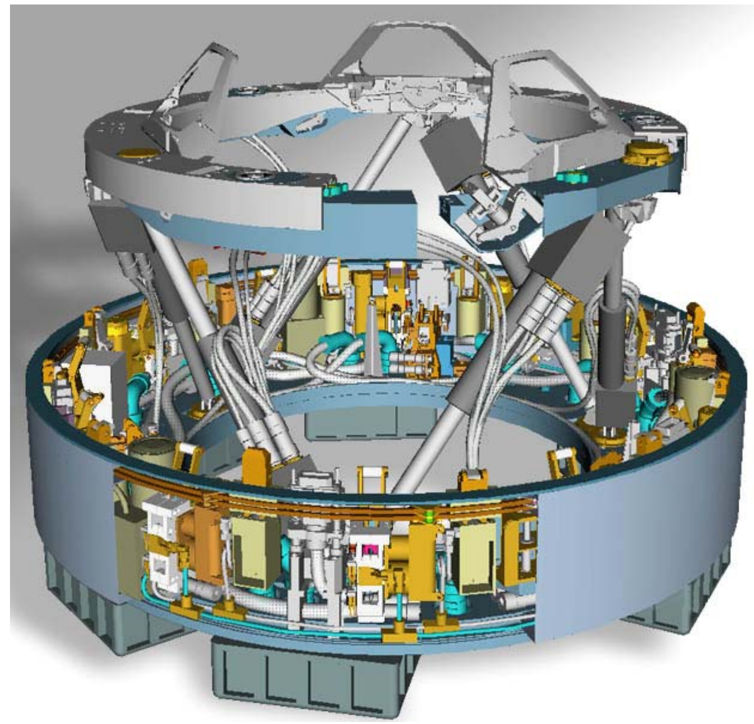


ADBS Overview

A Next-Generation Mating Mechanism

- Designed specifically to take advantage of modern electromechanical technology
- Incorporates the lessons learned and experiences from previous/current mating mechanism development and use
- Desensitizes mating mechanism operations and performance from other vehicle systems requirements
- Supports both docking and berthing operations
- Supports autonomous rendezvous & mating
- Aligned with NASA Strategic Plan



CAD Image

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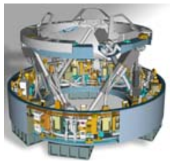

Key Seal Requirements

- Seal-on-seal interface
  - ASTP did it.
  - Russian APAS has it.
- Very low leak rate
  - Long-duration pressurized volumes requiring minimal atmospheric volume loss
- Long life
  - Long-duration exposed periods
  - Long-duration mated periods
  - LEO, deep-space and lunar/Mars environments
  - May also be a potential for high mate/demate cycle life
- Redundancy
- Damage tolerance

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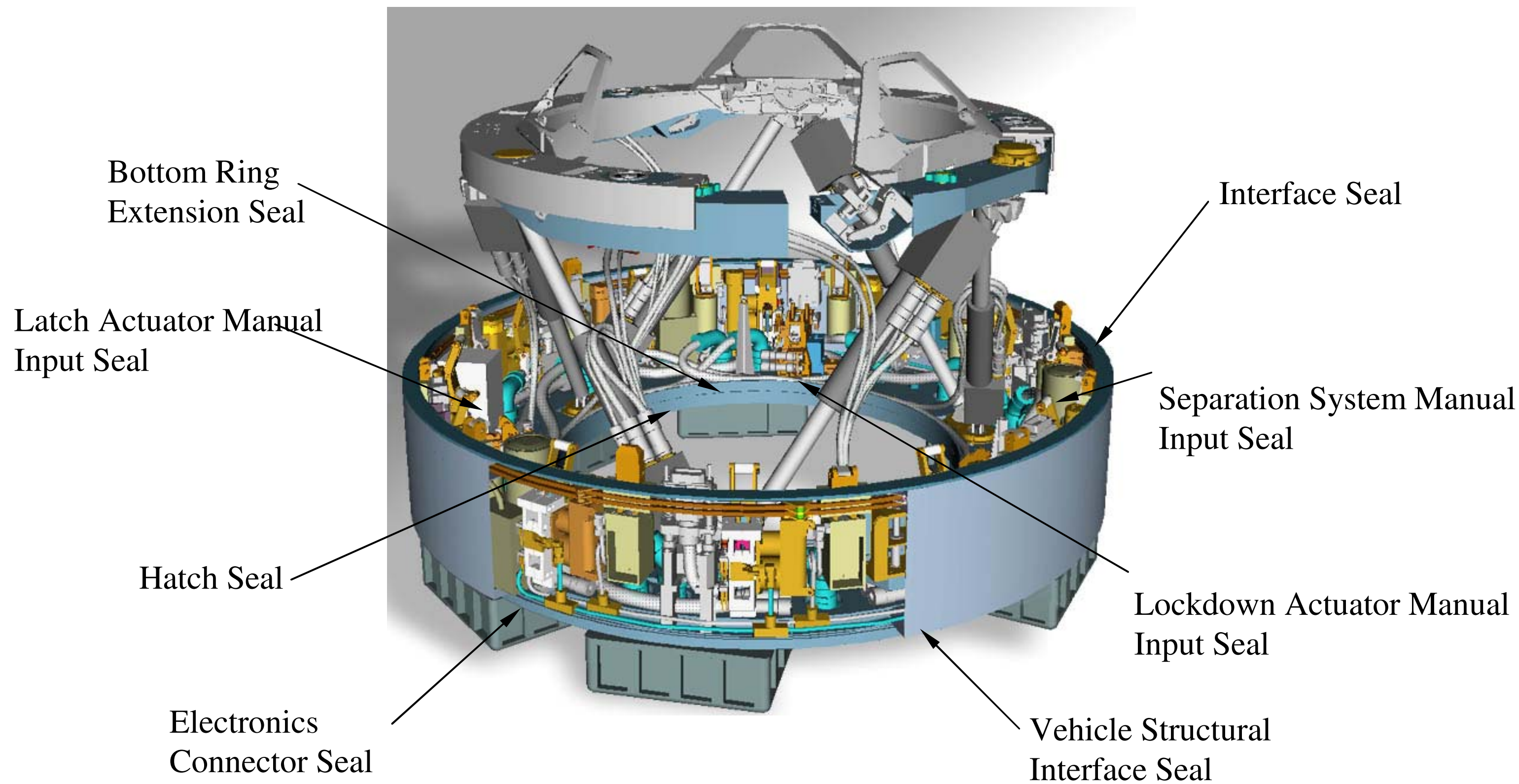
ADBS Seal Locations



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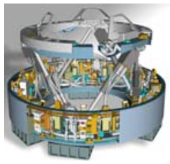

Early ADBS Seal Development

To preserve the fully androgynous design concept the seal design approach baselined was a seal-on-seal implementation similar to the Apollo Soyuz (ASTP) seals.

Subscale seal-on-seal elastomeric development with Parker Inc.

- Quick development and testing to evaluate seal-on-seal potential
- 2 cross-sections (flat top and elliptical) and 2 different durometer silicon materials
- Helium leak testing and seal load force testing completed in July 2001
- Adhesion testing

Test results

- Leak rates comparable to ISS CBM seals with offset of 0.050 inches and no gapping (~20 configurations tested)
- Compression force testing showed that “flat top” slightly higher than “elliptical” for the 70 durometer at (96 & 87 lb/in) and for the 50 durometer at (46 & 42 lb/in). Results indicated that seal-on-seal in the “acceptable” range for use.
- Adhesion test results pending; series of “buttons” molded from each material are currently mated and compressed for eventual separation and inspection at TBD regular intervals of time.

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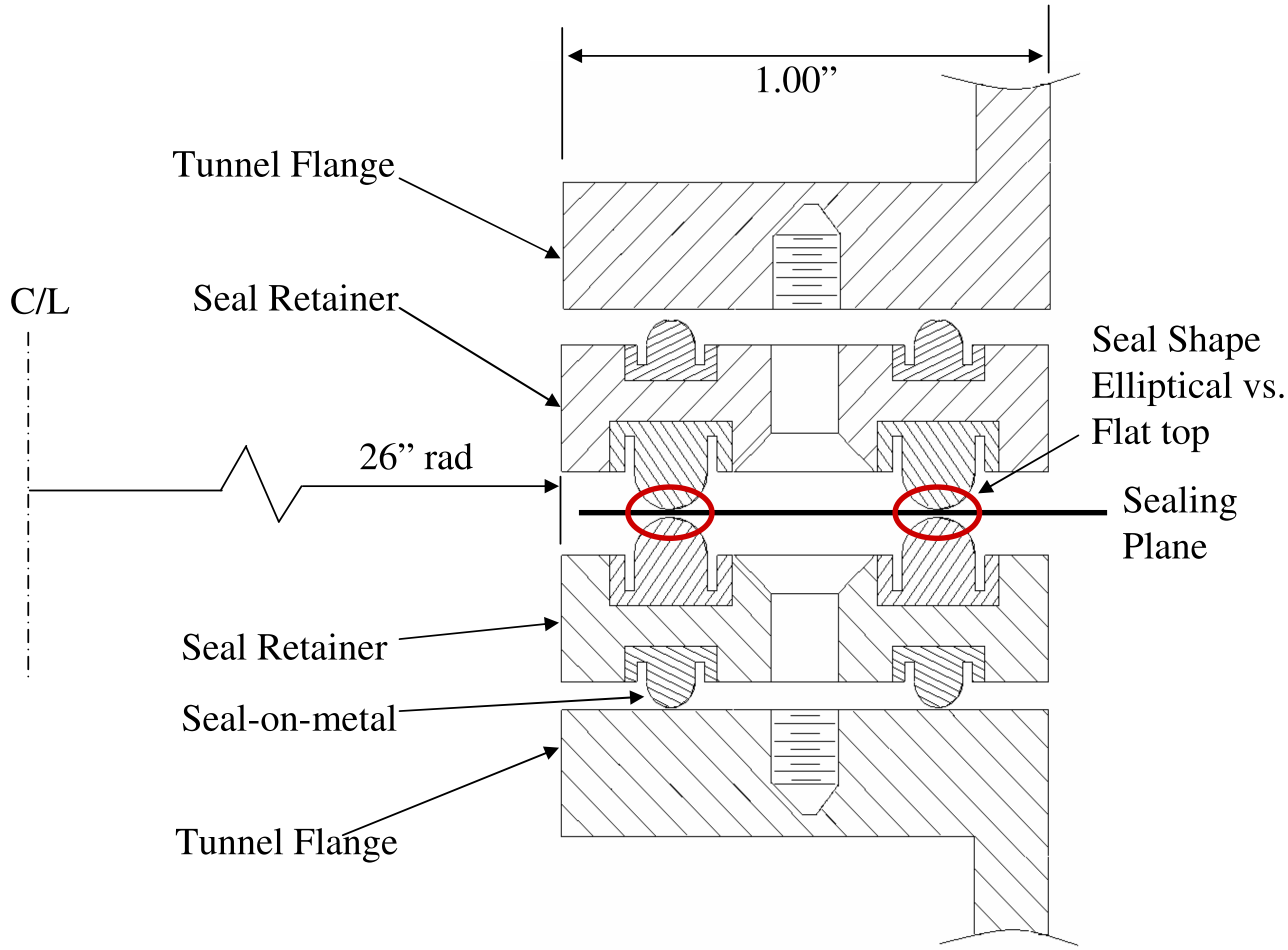
RRU Interface Seal Concept



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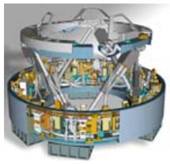

Early ADBS Seal Development

Conclusions

- GRC Seal Team has been working since Feb and has some early results
- They are currently establishing the processes and development plans for the next few years.

Forward work

- Evaluating early space flight demonstration opportunity on private space modules.
    - Move forward with a full scale development seal purchase for the RRU
    - Continue long duration seal material characterization and test program
- Need to establish baseline seal cross-section design
    - Optimize seal to guarantee optimal sealing: percent of fill, squeeze, crown profile and height, if elastomeric
    - Establish total potential seal mismatch: misalignment, thermal expansion, flange deflection
    - Establish on-orbit/lander environment requirements & acceptable seal force and leak rate
    - Determine full scale hardware development approach.
- Evaluate concepts and results for full-scale implementation
    - Evaluate design upward scaling
- Continue to investigate alternate seal materials
    - Metallic seals
    - Hybrid metallic/elastomeric

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