

Exploration Toilet Integration Challenges on the International Space Station

ICES Paper 2019-154

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Outline

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Development of New Exploration Toilet

- The new Exploration Toilet currently in development is based on the Shuttle Extended Duration Orbiter (EDO) Waste Collection System
 - More compact design to accommodate smaller exploration vehicle volumes
 - Urine is collected via a funnel/hose arrangement with airflow to aid in controlling urine flow
 - Feces is collected in a bag and stored in a replaceable fecal canister
- Two units are currently in development
 - The first unit will be integrated into the Orion vehicle for the first crewed mission
 - The second unit will be flown to ISS for a 3-year technology demonstration

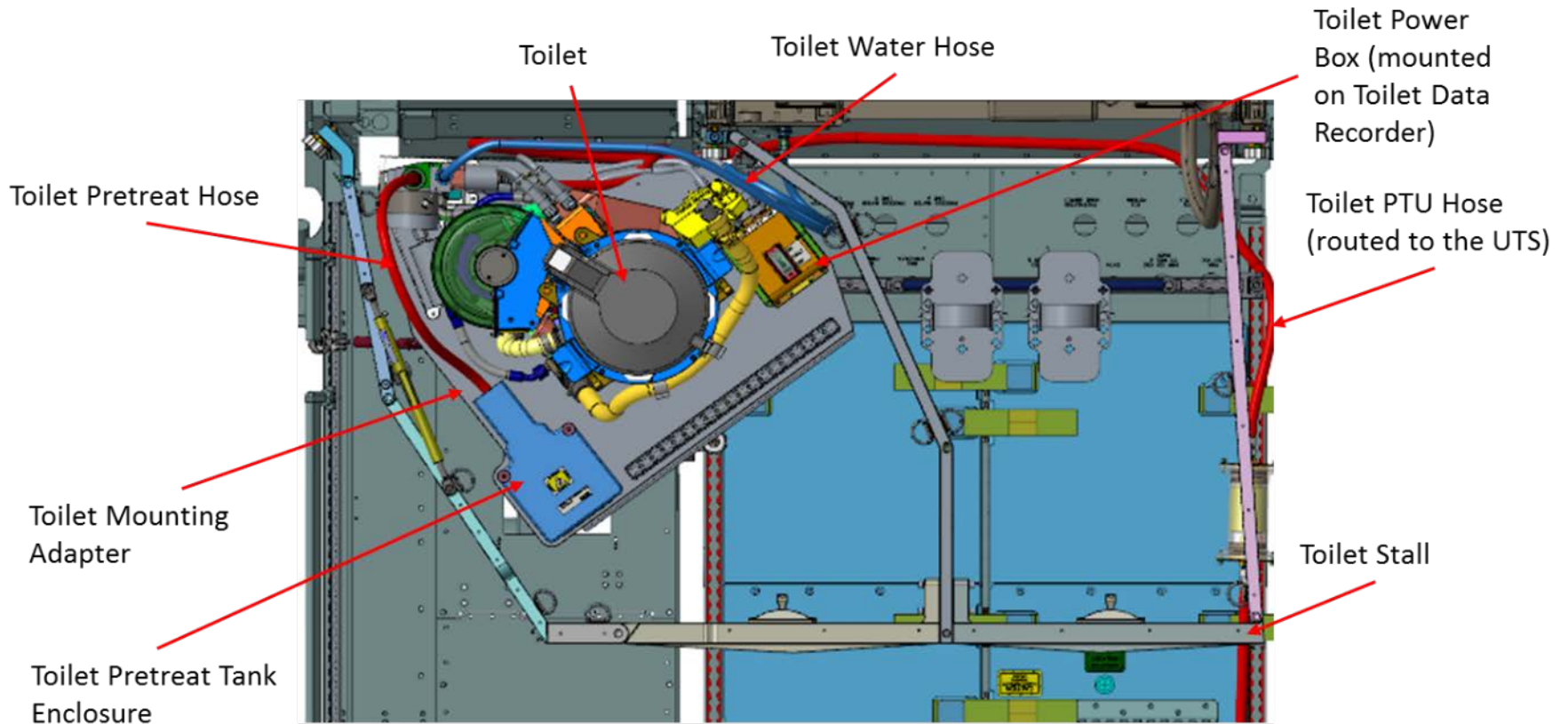


Toilet System Overview

- **Toilet System** consists of Toilet Hardware + Toilet System Integration Hardware
 - The official ISS operations nomenclature for the new exploration Toilet is “Toilet”
- NASA(JSC) is the Principal Investigator for the *Toilet System Technology Demonstration on ISS*
- NASA(JSC) is also the hardware developer for the *Toilet System Integration Hardware*:
 - Toilet Stall
 - Toilet Mounting Adapter
 - Toilet Pretreat Tank Enclosure
 - Fluid Hoses
 - Urine Funnels
 - Toilet Power Box
 - Toilet Data Recorder
- Collins Aerospace is the developer for the *Toilet Hardware*



Toilet System Top View



Top View of the Toilet Stall with Toilet and Integration Hardware Installed

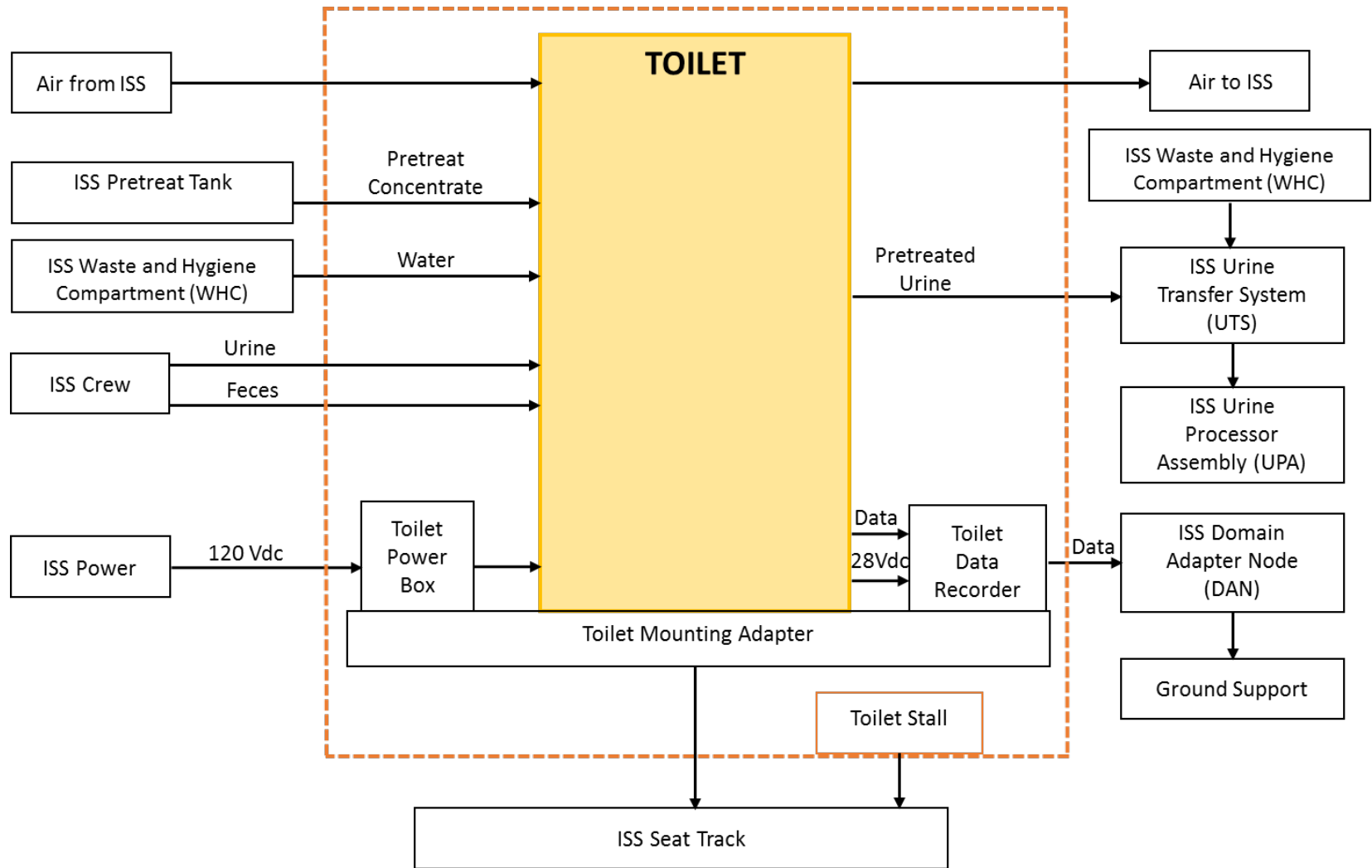


ISS Technology Demonstration

- On ISS, the Toilet System will undergo two technology demonstration periods
- The first period will demonstrate the following:
 - Two 30-calendar day testing periods with a minimum 90-day quiescent period
 - Daily use by at least 3 crew - combination of male and female crew (if possible)
 - Continuous fan operation for one period of a minimum of 60 min
 - Evaluate at least 2 different seats
 - Periodic photo documentation of crew interfaces
 - Acoustic survey at the user's head position
 - Return of minimum of three full fecal canisters to assess compaction efficiency
- The second period will demonstrate the following:
 - Operation for a minimum of 3 years
 - Characterize system reliability, including validation of spares and consumables usage rates
 - Characterize long-term operation of the Toilet System integrated with the vehicle ECLS system (i.e. UPA)
 - Daily use by at least 3 crew - combination of male and female crew (if possible)

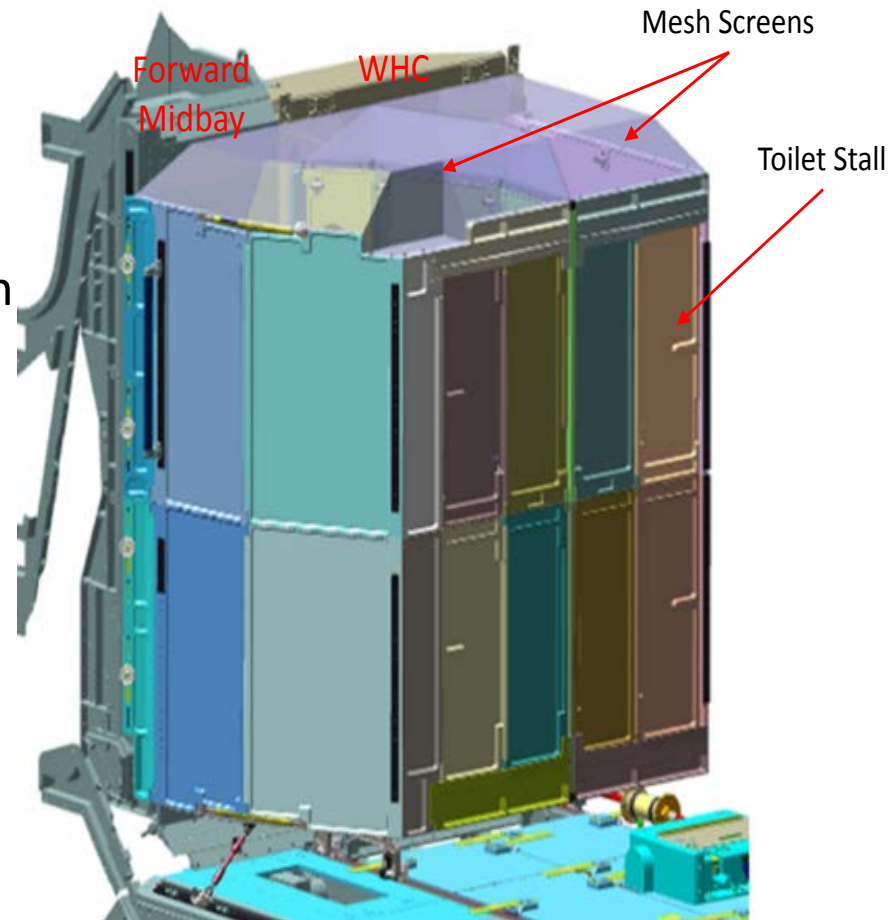


Toilet Interfaces on ISS



Toilet Stall

- Stall provides two separate volumes for the Toilet System and the Waste and Hygiene Compartment (WHC)
 - Replaces the current WHC Kabin
- Includes 6 panel assemblies which attach to ISS seat track
- Stall is ~1.7 m high and is located 20 cm above the Node 3 Deck
- Each Stall compartment includes:
 - Bi-fold door that opens inward
 - Mesh frame for containing free fluids/particles
 - External/Internal seat track for attaching crew translation aids
 - Internal attachment points for crew items

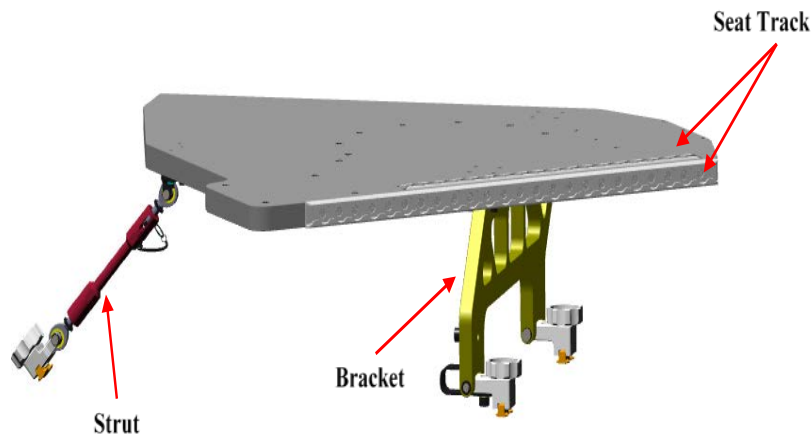


Toilet Stall will be installed in Node 3 in front of the WHC and forward midbay

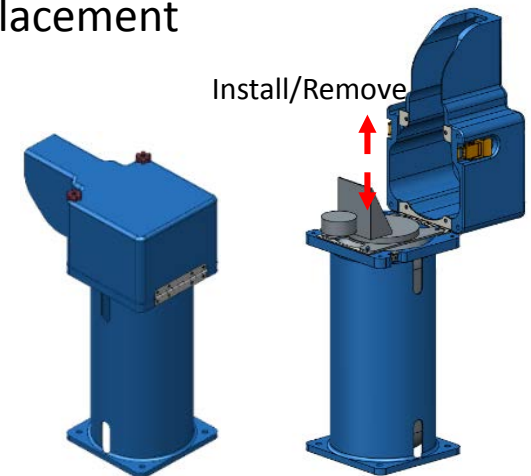


Toilet Mounting Adapter

- Mounting Adapter provides the mechanical interface between the Toilet System and ISS
 - Includes a baseplate for hardware attachment, an adjustable strut and bracket to attach to ISS seat track on the WRS2 rack and Midbay Deck
 - Adjustable strut accounts for installation tolerances and keeps the baseplate level with the Node 3 Deck
- Pretreat Tank Enclosure protects the Russian Pretreat Tank from kick loads
 - Mounted on the Mounting Adapter
 - Lid opens via captive fasteners to access tank for replacement



Toilet Mounting Adapter



Pretreat Tank Enclosure
(Lid Closed and Open)



Toilet Power and Data

- Toilet Power Box will connect the Toilet to ISS Power
 - Removes power from the Toilet if the power draw is too high
 - Include an on/off switch with indicator light to remove power from Toilet for maintenance activities
 - Mounted on top of Toilet Data Recorder
- Toilet Data Recorder captures Toilet operational data
 - Data is sent to the ground real-time
 - Operational data such as pressure, temperature and motor speed are captured
 - Powered by the Toilet (28Vdc interface)
 - Mounted on the Mounting Adapter (mounting interface for the Power Box)



Flight Power Box in Burn-in Testing at JSC



Toilet Fluid Transfer (1/2)

- Toilet Pretreated Urine (PTU) Hose delivers pretreated urine from the Toilet to ISS for processing (Urine Processor Assembly)
 - Includes a 100-micron filter to reduce the number of particles introduced into the UPA
 - Length of 4.6 meters and diameter of 1.3 cm
- Toilet Pretreat Hose delivers pretreat concentrate from the Pretreat Tank to the Toilet
 - Length of 96.5 cm and diameter of 1.3 cm
- Toilet Water Hose delivers water from the WHC Flush Water Interface to the Toilet
 - Flush Water interface located on the WHC front panel
 - Length of 3 m and diameter of 0.95 cm



Toilet Fluid Transfer (2/2)

- The Toilet EDV Adapter is used nominally with the Urine Transfer System to deliver pretreated urine to a backup tank
 - If UPA and UTS are unavailable, the EDV Adapter can interface to the PTU hose to deliver pretreated urine to a backup tank
 - Length of 20 cm
- Urine Funnels collect urine from the crewmember via the Toilet Urine Hose
 - Designs based on previous Shuttle funnels and current Russian funnels
 - New designs are intended to aid female during simultaneous urination and defecation (improved alignment with seat and body)
 - Three designs launched on NG-10 for crew evaluations with WHC
 - Comments included decreasing funnel length to improve cleaning, materials selection and improving cap closure mechanism

Funnels evaluated on ISS



International Conference on Environmental Systems
Boston, MA 2019



3-D printed Funnel prototypes

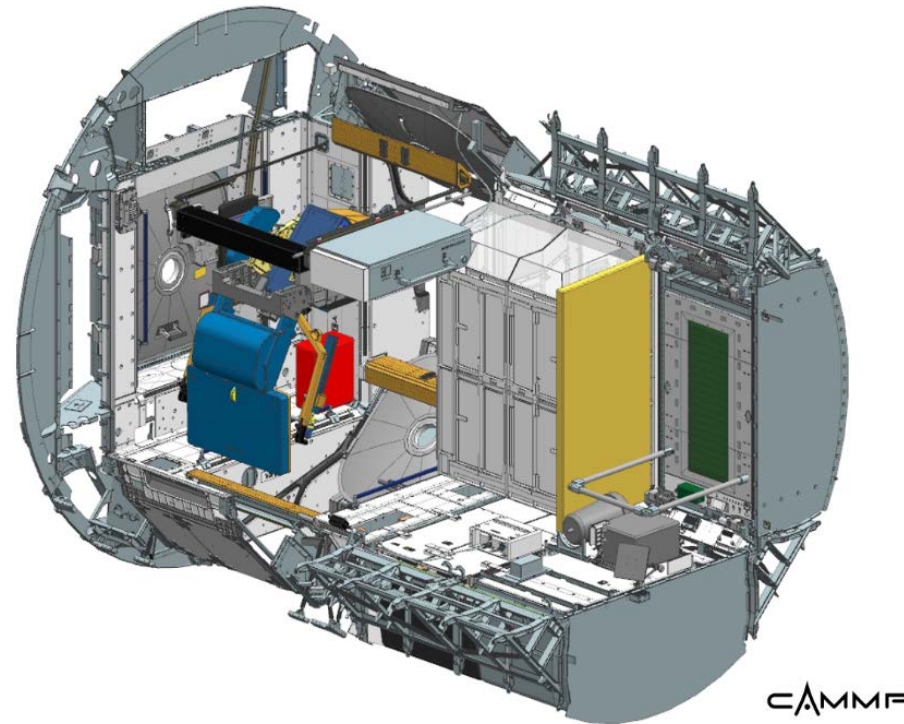
Integration Challenges on ISS (1/3)

- Mounting Adapter
 - The biggest integration challenge for the Mounting Adapter was hardware placement in a limited volume
 - All Toilet hardware will reside inside the Stall volume and be installed on the Mounting Adapter baseplate
 - Mounting adapter baseplate is approximately 76.2cm x 88.9cm (30"x35")
- Required several design iterations to optimize hardware location
 - Maximize the volume around each piece of hardware to aid in installation
 - Provide adequate habitable volume for the crew to perform waste collection activities
 - Provide adequate space for air inlets and outlets, fluid hose bend radius and cable bend radius
 - Provide enough access to HEPA filters on Deck Midbay for weekly cleaning



Integration Challenges on ISS (2/3)

- For the Toilet Stall, integration challenges included:
 - Identifying a permanent location for the 3-year tech demo
 - Node 3 not scarred for an additional Toilet
 - Advanced Resistive Exercise Device (ARED) dynamic envelope interferences
 - Stall attachment hardware protrudes into the dynamic envelope
 - Design changes to the Stall hardware would only reduce the protrusion
 - Decision was made to train crew on these additional protrusions when using ARED
 - Crew translation aids (handrails) installed on the Stall panels also protrude into the envelope
 - An operational constraint limits locations on the Stall where handrails can be installed



Toilet Stall installed in Node 3
(in front of WHC and Midbay)



Integration Challenges on ISS (3/3)

- Accommodate new hardware
 - Brine Processor Assembly (BPA) will be installed in Midbay Overhead
 - Stall mesh frame was modified to allow access to BPA for regular maintenance
- Node 3 Seat Track Variability
 - Midbay seat track is installed at a 45 degrees angle from rack seat track
 - It is also offset approximately 1 cm (0.35") in the vertical direction from the seat track on the WHC rack
 - Introduced uncertainty in the mounting locations for Stall
 - Photogrammetry was used to analyze photos taken on ISS to quantify the dimensions needed to design the Stall mounting interfaces
 - Dimensions were obtained that were within 0.25 cm (1/10 inch) accuracy
 - Data provide confidence that hardware would install as designed
 - In addition, adjustable struts were added to allow adjustments to be made in the wall angles/location (as needed) during installation
 - Insured proper interface between the 3 Stall walls
 - Added rigidity to reduce audible rattle
- Mesh Frame
 - Complex geometry to accommodate BPA and provide additional head room during Toilet use



ISS Hardware Status

- In February 2019, the Toilet Stall hardware was deployed on ISS
 - Crew will use the Starboard side for WHC activities
 - Crew was given the option to perform other hygiene activities on the Port side until the remaining Toilet hardware arrives
- The remaining integration hardware and the Toilet will be launched and deployed at a later time



Toilet Stall deployed on ISS Node 3



Concluding Remarks

- Integrating any new piece of hardware on ISS can introduce challenges
- Overcoming challenges requires:
 - A flexible design
 - Extensive coordination with hardware stakeholders and vehicle integration teams
- Crew Evaluations/Inputs are beneficial
 - Toilet is a crew-centric piece of hardware (it needs to be usable by the crew)
 - Crew evaluations provide crew perspective on how hardware will be used
 - Valuable inputs on hardware location, crew interfaces and volume that will ease use
 - Important to involve crew early in the design cycle to minimize potential changes during manufacturing phase



Questions?

