

# **NASA Universal Waste Management System and Toilet Integration Hardware Operations on ISS – Issues, Modifications, and Accomplishments**

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Melissa K. McKinley, Melissa A. Borrego, *NASA Johnson Space Center*

James L. Broyan, Jr. , *NASA Headquarters*



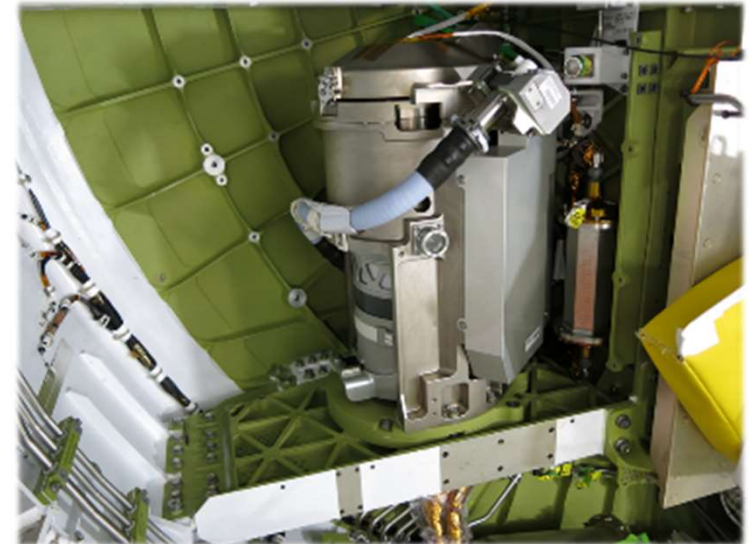
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# Universal Waste Management System (UWMS)

- Universal Waste Management System
  - ISS Unit – Toilet
  - Orion Unit – Waste Management System (WMS)
- Toilet for exploration missions
- Reduction in mass and volume
  - Toilet is 65% smaller and 40% lighter than current ISS toilet (WHC)
  - WMS is 61% smaller than Shuttle Toilet
- ISS Toilet
  - Delivered June 2020
  - Installation and checkout complete 11/1/21
  - Operational status in work
- Orion WMS
  - Delivered December 2019
  - Installed Artemis-2 March 2021



ISS UWMS installed in Node 3, ISS



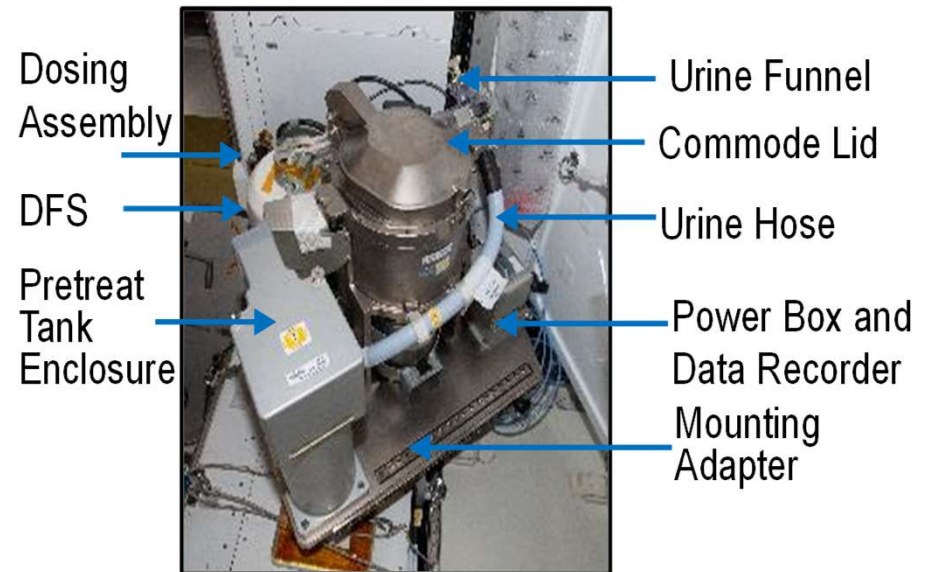
Orion UWMS installed in Artemis-2



# UWMS and Toilet Integration Hardware on ISS

## Key Elements

- Designed for Orion launch/landing loads and electrical interface and adapted for ISS
- Dual Fan Separator (DFS)
  - Unit uses air to aid in capture of urine and deposit of fecal material
  - Single motor drives two fans and rotary urine separator
  - Fiberglass acoustic enclosure (internal to UWMS)
- Simple operations with no control panel
- Urine Collection
  - Pretreat solution pump and conductivity sensor
  - Uses Russian pretreat concentrate tank
- Fecal Containment
  - Individual fecal collection bags
  - Canister holds ~20 deposits
  - Canister cap provides odor control
  - Lifting mechanism ensures tight seal to prevent odor release
- Simultaneous Urination and Defecation
  - Redesigned urine funnels, and notched housing to improve female urination during simultaneous operations



ISS UWMS installed in Node 3, ISS

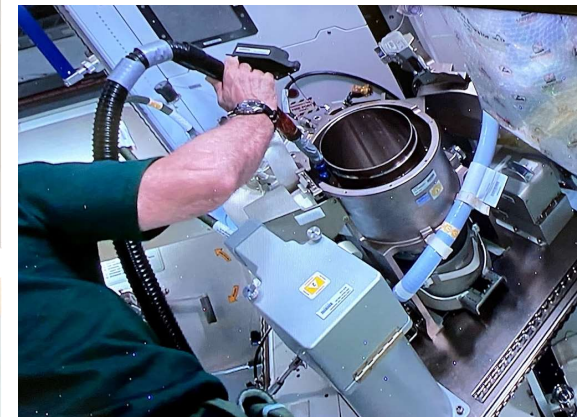


Toilet Integration Hardware Stall installed in Node 3, ISS



# Dual Fan Separator Issues, Testing, Replacement on ISS

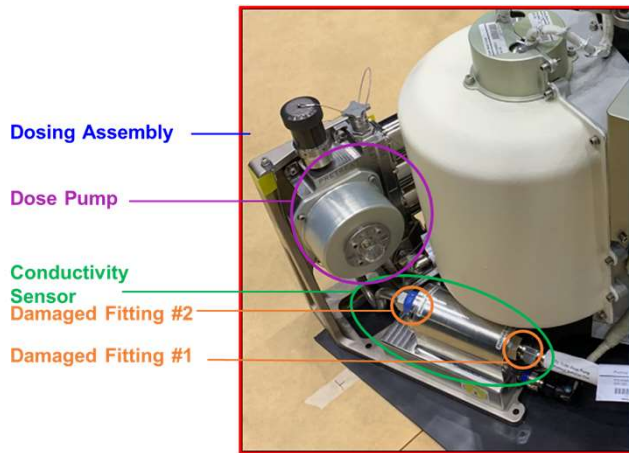
- Originally installed DFS Failed to start during power up of UWMS
  - ❑ Locked Rotor Fault 5/26/21
- Attempts to free the unit with the on-board vacuum cleaner were unsuccessful
- Replaced with on-orbit spare 7/20/21
  - ❑ Ground investigation to determine root cause of on-orbit failure indicated failure due to off-nominal configuration of testing with pretreated urine in gravity environment: Ground handling & testing
  - ❑ Not a risk to spares fleet
  - ❑ Failed unit repair and refurbishment in-work for return as spare



**ISS UWMS Dual Fan Separator (top images and left lower image) and attempt to move stuck separator with on-orbit vacuum cleaner (right lower image)**



# Urine Pretreat Systems – Conductivity Sensor Issues, Planned Replacement



UWMS Dosing Assembly including Conductivity Sensor



Syringe with pretreat sample for return and analysis

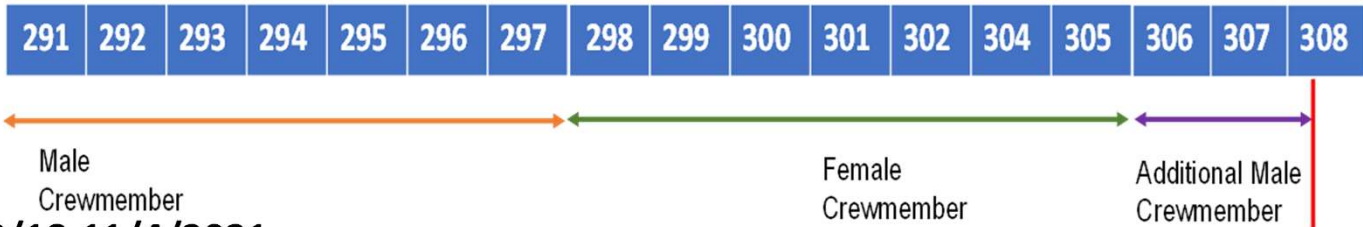
- Low pH and strong oxidizing chemicals (pretreat) used to prevent microbial and fungal growth
- Dose pump dispenses metered volumes of concentrated pretreat and water for each urination
- Conductivity Sensor measures solution to provide a warning of incorrect pretreat concentration to protect downstream recycling systems which indicates pretreat volumes are appropriate to treat urine
- Lack of data can lead to over/under dose of pretreat
  - Waste of pretreat solution (over-dose)
  - Lack of adequate treatment leads to fungal growth and possible damage to Urine Processor Assembly (under-dose)
- On-orbit unit and spare ground units failed to perform
- Samples of pretreat solution color change and analysis indicated dose dispensing occurred allowing further operations of UWMS to proceed
- UWMS pressure sensor data and ISS water bus data used to provide assurance of pretreat dispensing
- Sensor upgrades in work for on-orbit replacement
  - Updating materials in original sensor
  - COTS toroidal sensor, Optical Sensor



# ISS UWMS Technical Demonstration Status



## UWMS ISS Operations GMT 2021



Pressure Sensor Fault  
UWMS shut down

- **Limited Checkout 10/18-11/4/2021**

- 3 crewmembers
- 17 days
- 80 uses to date

- Toilet was successfully used by the ISS crew for 17 days

- Pressure sensor hard fault at day 17

- Caused from organic debris occluding pitot tube

- **Crew debrief indicated that the toilet is “easy to use” and it works**

- Successful performance of fecal and urine collection functions

- Received crew feedback on fit and function of UWMS, seat, urine funnel, stall hardware

- Valuable information obtained for exploration missions including Artemis-II and -III+

- Crew filled one fecal canister which was returned and evaluated

- Collected and processed pretreated urine in two EDV’s

- Crew use of headphones was an acceptable mitigation of the acoustic concern.

- **Crew Top Three Issues**

- **Noise – Unit is way too loud.**

- **Odor – Smells noted when unit is in use.**

- **Seat/Bag opening size too big/Seat location not adjacent to bag/Height of seat and fecal bag too high**



ISS UWMS and Toilet Stall in Node 3



# UWMS Acoustics Level Exceedance and Crew Feedback



ISS UWMS in Acoustic Testing at JSC



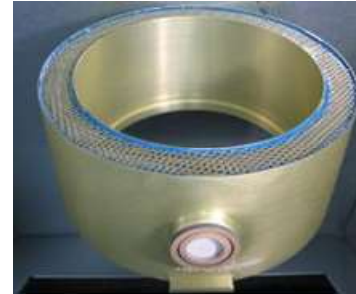
ISS UWMS Trainer at JSC with Acoustic Cover

- Acoustic exceedance known at time of Environmental Testing of ISS (11/2019) and Orion (10/2019) units
  - Average A weighted requirement is 68 dBA (log scale)
    - ISS - 72.9 dBA
    - Orion - 75.9 dBA
- Noise from Dual Fan Separator includes case radiated and duct born components
- On-orbit ISS crew complaints on noise levels; using headphones for mitigation
- Acoustic cover on ISS awaiting testing for reduction levels
  - Orion considering similar cover for Artemis-II
- Orion Artemis-II plan to use hearing protection; Artemis-III+ contract mods in work to update DFS design
- Root Cause – DFS design including gearbox, air flow, and speed



# Crew Feedback: Odor Control

- Odor Bacteria Filter (OBF) does not meet requirement for 84 crew-day use based on original ground testing
- Validation of capacity/life on ISS key insight for Orion manifesting
- **Crew noted smells during UWMS use for both urination and defecation**
- OBF was of unknown capacity since it had been installed in UWMS in May 2021
- Seal at OBF inlet found to be folded over in off-nominal position which allowed an incomplete seal and release of odors
- Additional on-orbit testing is needed to confirm proper use and actual life/capacity of OBF units



OBF unit



ISS UWMS showing location of OBF (not installed)



Crewmember with OBF and UWMS on ISS



# Crew Feedback: Urine Funnel and Commode Seat



- Urine Funnels

- NASA updated urine collection with a urine funnel design optimized for female crew.
- Size and shape of funnel intended to improve simultaneous operations (urination and defecation) for female crew
- Numerous Crew evaluated and provided feedback which resulted in three designs
- On-orbit evaluation in the ISS Waste and Hygiene Compartment (WHC) influenced design changes
- Limited Checkout crew debriefs indicated that all urine funnels work with UWMS
  - Male crewmembers had no preference
  - Female crewmember preferred the notch option but indicated the plain funnel worked as well



UWMS with 5" commode seat

- Commode Seat

- Seat size and shape optimized to work with the urine funnel and to improve placement of female crew
- Two sizes were flown for evaluation
  - Male crewmembers had no preference but noted the seat opening was too large; one male crewmember didn't use the seat
  - Female crewmember also noted the opening was too large and preferred the 4" seat since it is not as tall



# Crew Feedback: Airflow

- Air Flow
  - ❑ Used for aid in entraining waste, both liquid and solid as well as for odor control
  - ❑ Crew procedures instruct to verify air flow before use by placing hand over commode or funnel
  - ❑ **Crew noted air flow was less than that experienced on WHC**
  - ❑ Opening is slightly bigger than WHC with seat installed
  - ❑ Volumetric Air Flow is greater than WHC
  - ❑ Velocity at the opening is less due to a larger opening
  - ❑ Crew noted that the air flow was adequate for urination but less than usual for defecation
    - Use was unaffected and no escapes were noted.

<b>Toilet Air Flow Rates in CFM</b>				
	<b>Shuttle</b>	<b>Shuttle EDO</b>	<b>WHC/ACY</b>	<b>UWMS</b>
<b>Urine</b>	9.9	13.5	8.8	<b>14</b>
<b>Fecal</b>	16	15	14	<b>16</b>



# AES Technology Demonstration – Remaining to Complete

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- **Not yet evaluated**

- ❑ Performance with multiple crew members daily for concurrent days to mimic Orion 21-day mission
- ❑ Evaluate capacity of fecal canisters with return of 3 full canisters
- ❑ Evaluation of OBF capacity
- ❑ Evaluation of urine prefilter and postfilter expected life
- ❑ Performance of conductivity sensor and validation of dose pump
- ❑ Complete consumables usage analysis for Artemis manifesting and ISS planning

- **Orion Impact**

- ❑ Current additional operational period will not provide details to fully evaluate consumables use, multiple crew/longer duration use.
- ❑ Risk to Artemis missions
  - Increased mass/volume – Fecal Canisters, OBF's
  - Validation of operations with multi-crew operation



# Accomplishments and Forward Work

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- Checkout Complete – 11/7/2021
  - ❑ Obtained valuable insight into consumables use, crew preferences and forward work to improve operational use
- Installation and on-orbit testing of updated conductivity sensor planned late-2022
- Completion of Technology Demonstration planned late-2022
  - ❑ Provides additional details on consumables usage
  - ❑ Ability of crew to perform simultaneous operations
  - ❑ Overall information on use of a compact toilet in micro-gravity for future program use
- Continue improvements based on ISS use and crew feedback
- Fly Orion unit on Artemis-2 mid-2025 to inform future Artemis-3+ missions



## Questions and Feedback?

- Melissa K. McKinley
  - UWMS Principal Investigator and Project Manager
  - 281-684-0597
  - [melissa.k.mckinley@nasa.gov](mailto:melissa.k.mckinley@nasa.gov)

