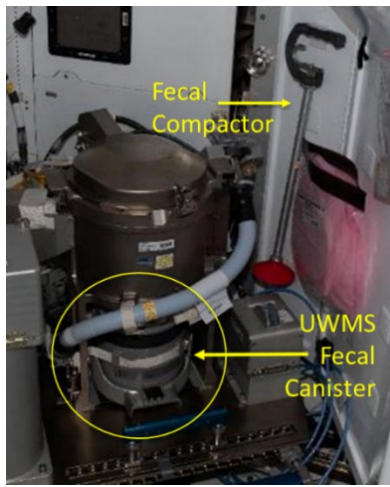
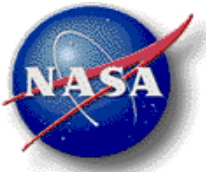




# Excavation of Exploration Toilet Fecal Canister from ISS Operations and Future Mission Impacts

- International Conference on Environmental Systems
- Louisville, KY
- 7/21-25/24
- Presenter: Melissa McKinley
- Coauthors: Melissa Borrego, Mike Ewert

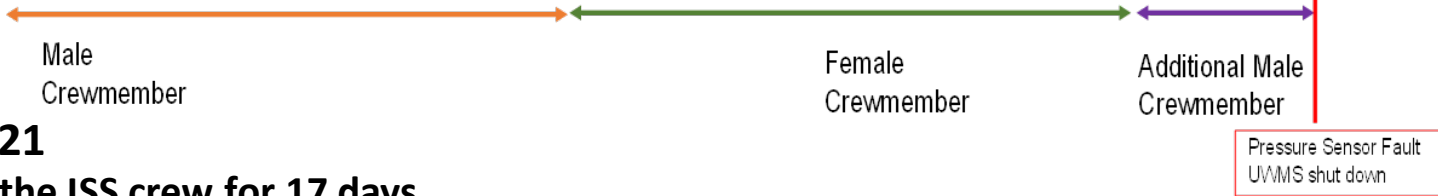




# ISS UWMS Limited Checkout



UWMS ISS Operations GMT 2021



## • Limited Checkout 10/18-11/4/2021

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

- 3 crewmembers
- 17 days
- 80 uses

## • Two crewmembers contributed to a single returned Fecal Canister

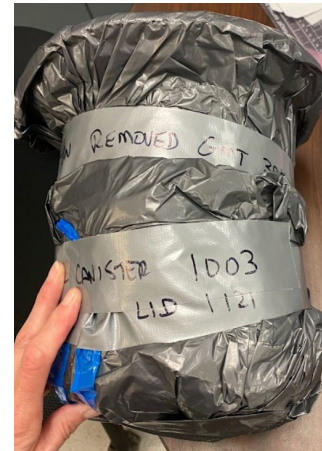
- 1 male, 1 female

## • Canister contains individual Fecal Bags

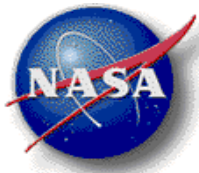
- Fecal Deposit
- Wipes
- Gloves

• Compaction plates used at crew discretion can be seen in x-ray

• Canister was full and contained 13 deposits



Fecal Canister returned from ISS for evaluation



# Compaction Plate Evaluation Details



- **Compaction Plates –**
  - Number in canister = 6
  - Location in canister (4 measurements made around perimeter) - data shown as measured in table, average gap between plates = 1.3 inches, ranged .8 – 2.3 inches
  - Number of deposits between each plate – data shown below, average 2.2 deposits between plates, ranged 1-5 deposits
    - Number of deposits is driven by the need to compact (level of deposits in the canister) which is based on deposit size, number of wipes, number of gloves used, crew discretion on need to compact
  - Condition of plate's surface and relative position noted

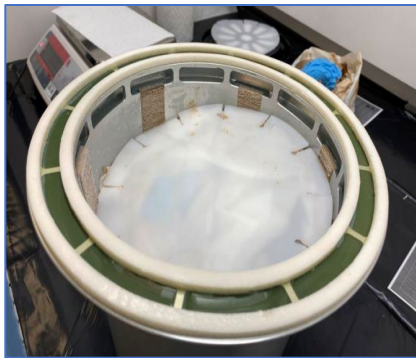
Compaction Plates	
	# deposits
Between Plate 1 (top) and lid	0
Plate 1 and Plate 2	1
Plate 2 and Plate 3	2
Plate 3 and Plate 4	1
Plate 4 and Plate 5	3
Plate 5 and Plate 6	5
Plate 6 and can bottom	1

Compaction Plates Location, Description and Depth						
Plates numbered from top	depth loc 1	depth loc 2	depth loc 3	depth loc 4		notes
Plate 1	0.63	0.81	0.81	1.13		
Plate 2	1.50	1.25	1.13	2.25		noticeable canted
Plate 3	2.38	2.38	1.94	2.63		pretty flat, top has yellow staining, bottom is moist
Plate 4	missing data					compressed well between plates
Plate 5	5.75	4.38	4.75	5.75		concave- higher on sides
Plate 6	6.38	9.00	7.75	7.25		plate is concave, fouled
						liquidy fecal matter on sides of canister below plate 6

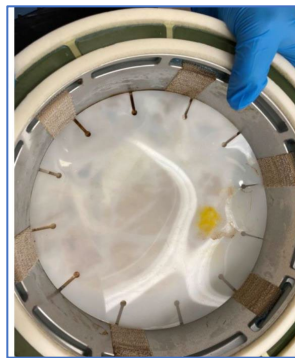
1



2



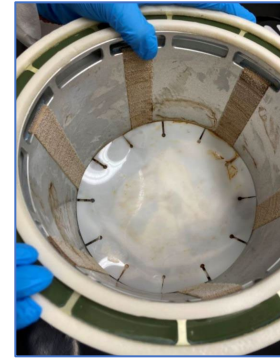
3



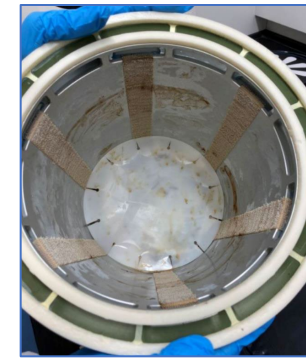
4



5

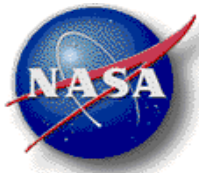


6



Bottom





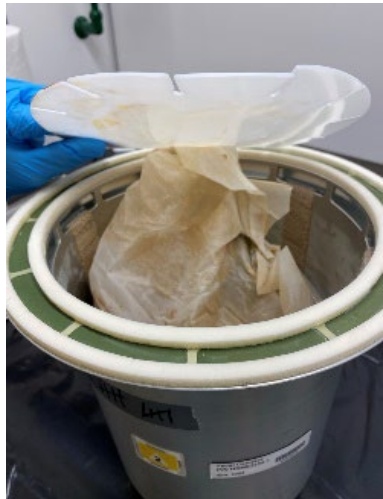
# Fecal Bags Evaluation Details



Under Plate 1



Under Plate 6



Under Plate 5



Under Plate 6

- Contents were removed, examined, weighed and photographed
  - Fecal Bags – Inspected for leakage and condition of seal
    - Fecal Deposit – Notations made for weight, consistency
    - Wipes – Number used of each type: US dry wipes, Russian dry wipes, wet wipes, antiseptic
    - Gloves – Number used



# Fecal Dig Data

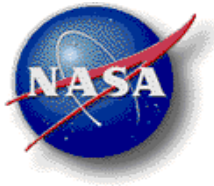


## • Results:

Crew Member	# Fecal Bags Used	Consumables Use	US Dry Wipe	Gloves	Russian Dry Wipe	US Wet Wipe	Disinfectant wipe	Fecal Deposit Average Weight (lbs)	Overall Average Weight (lbs)
<b>TOTAL</b>	<b>13</b>		<b>0</b>	<b>12</b>	<b>46</b>	<b>64</b>	<b>3</b>		
<b>Male</b>	6	<i>total</i>	0	0	11	25	0		0.420
		<i>avg per use</i>	0	0	1.83	4.17	0.00	0.221	
		<i>mass per use (lbs)</i>		0.00	0.04	0.21	0.00		
<b>Female</b>	7	<i>total</i>	0	12	35	39	3		0.503
		<i>avg per use</i>	0.00	1.71	5.00	5.57	0.43	0.427	
		<i>mass per use (lbs)</i>		0.02	0.12	0.28	0.02		
<b>Overall</b>	<b>13</b>	<i>total</i>	<b>0</b>	<b>12</b>	<b>46</b>	<b>64</b>	<b>3</b>		<b>0.490</b>
		<i>avg per use</i>	<b>0.00</b>	<b>0.92</b>	<b>3.54</b>	<b>4.92</b>	<b>0.23</b>	<b>0.333</b>	
		<i>mass per use (lbs)</i>		<b>0.01</b>	<b>0.08</b>	<b>0.25</b>	<b>0.01</b>		

- No US Dry Wipes were found; crew feedback was they preferred Russian Dry Wipes
- Russian Dry Wipes, US Wet Wipes and a few disinfectant wipes
- Gloves averaged ~1 glove/use
- Russian Dry Wipes averaged ~4 per use
- US Wet Wipes averaged ~5 per use
- Disinfectant Wipes averaged less than 1 per use





# Comparison to Historical Data



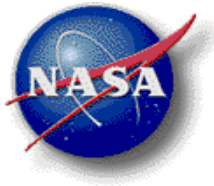
- Findings:

	Avg fecal mass (lbs.)	US Dry Wipes	US Wet Wipes	Toilet Tissues	Russian Dry Wipes	Disinfectant Wipes	Gloves
Shuttle	.17	1.50	2.30	.60	-	-	1
ISS/UWMS	.33	0	4.92	-	3.54	.23	.92
ISS/KTO	.29	1	2	-	3	-	2

- UWMS Toilet Volumetric Efficiency (number of deposits per canister volume in cubic inches) is similar to canisters for Shuttle and ISS KTO
- Differences seen in volume of fecal bags themselves
  - KTO bags are smaller than Shuttle and ISS Toilet
- KTO has no compaction plates to aid in compaction efficiency
  - Crew does compaction using a repurposed handrail and by hand
- Average Fecal deposit mass for shuttle missions much smaller than ISS Toilet and WHC KTO
- Compaction appears to contribute to better packing efficiency**
- Size of Fecal Bag does not appear to have much impact

	Canister Volume (in <sup>3</sup> )	# Deposits	# Compaction Plates	Avg. Fecal Bag volume (in <sup>3</sup> )	Vol. Efficiency (#deposits/in <sup>3</sup> )
Shuttle EDO	678	23	23	502.4	.034
ISS/UWMS	501	13	6	249.9	.026
ISS/KTO	915	30	none	117.7	.033

\*small data set available for ISS Toilet



# Impact on Orion's Artemis-2 Mission



# Toilet Uses	# Fecal Bags Used	# Compaction Plates Used	US Dry Wipe	Gloves	Russian Dry Wipe	US Wet Wipe	Disinfectant wipe	Fecal Deposit Average Weight (lbs)	Overall Average Weight (lbs)
	13	6	0	12	46	64	3		
	6	total	0	0	11	25	0		
Sub D (male)		avg per use	0	0	1.83	4.17	0.00	0.221	0.420
		mass per use (lbs)		0.00	0.04	0.21	0.00		
	7	total	0	12	35	39	3		
Sub C (female)		avg per use	0.00	1.71	5.00	5.57	0.43	0.427	0.503
		mass per use (lbs)		0.02	0.12	0.28	0.02		
	13	total	0	12	46	64	3		
Overall		avg per use	0.00	0.92	3.54	4.92	0.23	0.333	0.490
		mass per use (lbs)		0.01	0.08	0.25	0.01		

- September 2025 is the current launch date for Orion's Artemis-2
  - Manifest in review based on Artemis-1 flight and mass/volume constraints
  - WMS consumables in review
    - Fecal Canisters significant mass/volume
- UWMS Limited Checkout on ISS produced a single filled fecal canister which was returned for evaluation
- Previously performed ground testing to evaluate capacity and compaction efficiency
  - 20 deposits per fecal canister
  - Deposit = Fecal material, dry and wet wipes, gloves
  - 4 compaction plates used per canister
- Excavated returned canister
  - 13 deposits found with 6 compaction plates
  - Only found Russian dry wipes and US "Huggies" wet wipes

## Orion Impacts:

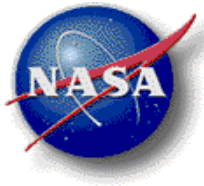
- Crew interviews revealed strong preference for Russian dry wipes
  - Evaluating alternatives to Russian Dry Wipes on ISS for Artemis-2+
- Updated manifest to add additional fecal canisters and compaction plates

## Summary

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- Savings in volume and mass are crucial for space vehicle design
  - Reductions in logistical item such as fecal canisters can mean high demands due to the quantities needed for long term exploration missions.
  - Compaction efficiency, number of compaction plates used, size of fecal bags and number of wipes needed can be optimized for mass/volume reductions
- Additional data is expected when UWMS Technology Demonstration resumes on ISS to validate findings





# Questions/Feedback



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