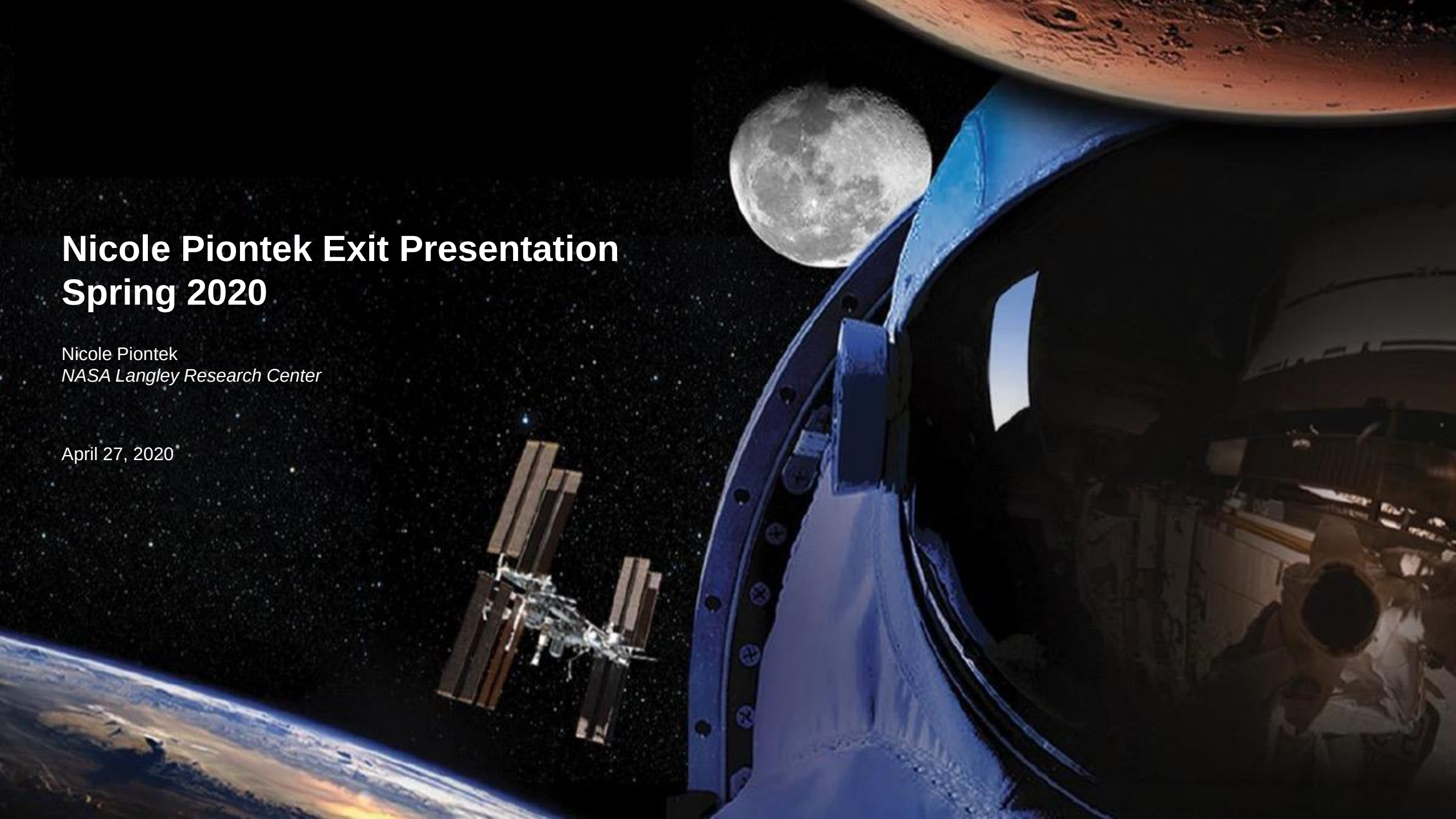


A composite image featuring a space station with solar panels in the lower left, the Earth's horizon at the bottom, the Moon in the upper center, and a curved spacecraft window on the right showing a reflection of the interior.

Nicole Piontek Exit Presentation Spring 2020

Nicole Piontek
NASA Langley Research Center

April 27, 2020

- **Hometown: Canton, MI**
- **University of Michigan**
 - Biomedical Engineering
 - Junior



- **Reliability and Maintenance Logistics Analysis for Crewed Deep-Space Missions Intern**
 - Fall 2019
 - Spring 2020
 - Summer 2020





- **Future human spaceflight missions beyond Low Earth Orbit (LEO) will operate in a logistically isolated environment for longer than any previous mission**
 - System reliability and maintenance logistics will be critical considerations
 - It is necessary to have a data driven understanding

Objectives:

- **Perform an in-depth analysis of reliability and maintenance data and lessons learned for Environmental Control & Life Support Systems (ECLSS) from the International Space Station (ISS)**
 - Improve failure rate estimates
 - Evaluation of candidate system upgrades and their impacts on risk and maintenance logistics for Mars exploration missions
 - Evaluation and optimization of system test campaigns
- **Document and present analysis findings to ISS and AES management and discuss their implications for future systems development and mission/program planning**



- **Last semester I performed a review of the current International Space Station (ISS) databases where I collected data from many different sources and observed many discrepancies**
 - Key data includes prior estimates for failure rate and error factor, mass of components, operating hours, number of failures, and the root cause of those failures
- **In order to perform a spares assessment it is important to have accurate and up to date information so estimates can evolve as more knowledge is gained about the system**
- **Created a system of collecting data in excel**
 - The data collection forms contain the best estimate of key supportability metrics
 - Lay out information in a simple and easily transferable format so that it can be passed on to system experts for them to input information as it becomes available
 - Input form feeds a derivatives sheet that performs Bayesian update on failure rates so the spares model can have the most up to date metrics
- **Having a consistent method of data transfer accelerates our ability to process data**
- **Provides traceability in the data and clearly shows the assumptions made**

Data Input From Sheet 1–Background Information



EXample Data 19-Mar-2020 - Excel

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File Home Insert Page Layout Formulas Data Review View Tell me what you want to do...

Font: Arial, 11, Bold, Italic, Underline, Text Color, Background Color, Wrap Text, General, Conditional Formatting, Cell Styles, Insert, Delete, Format, AutoSum, Fill, Sort & Filter, Find & Replace

1	Updated on 15-May-20											
2												
3	Subsystem: URINE PROCESSING ASSEMBLY											
4	Function: Takes in pretreated urine to produce brine and distillate, the distillate is then sent to the Water Processor Assembly where it becomes potable water for crew to consume.											
5												
6												
7	ORU?	Part Number	MADS Unique ID	Part Name	Other Names / Acronyms	Quantity	Mass of ORU (kg)	Mass of Packaging (kg)	Predicted MTBF (h)	K-Factor (p)	Prior Error Factor	Function
8	Y	ABCD1234	123	Wastewater Storage Tank Assembly	WSTA	1	50.00		90,000	1.00	4.00	The urine is temporarily stored in the WSTA
9	Y	ABCD1235	123	Fluids Control & Pump Assy	FCPA	1	30.00		30,000	1.50	4.00	Moves urine from the WSTA into the DA, takes waste from the DA into the ARFTA and back to the DA, and pumps product distillate from the DA to the wastewater
10	Y	ABCD1236	123	Distillation Assembly	DA	1	50.00		30,000	1.30	4.00	Distills urine using a centrifuge
11	Y	ABCD1237	123	Pressure Control & Pump Assy	PCPA	1	43.33		50,000	1.00	4.00	Removes non-condensable gases and water vapor from the DA. Then, gases and condensed water are pumped to the SPA
12	Y	ABCD1238	123	Separator Plumbing Assy	SPA	1	43.33		70,000	1.20	4.00	Recovers and returns water from the purge gases to the product water stream
13	Y	ABCD1239	123	Advanced Recycle Filter Tank Assembly, Tank Top Assembly	ARFTA, Recycle Tank	1	43.33		90,000	1.20	4.00	Accumulates & stores brine for disposal
14	Y	ABCD1240	123	Advanced Recycle Filter Tank Assembly, Filter Assembly, Brine	ARFTA	1	7.00		110,000	1.20	4.00	Filter
15	Y	ABCD1241	123	Advanced Recycle Filter Tank Assembly, Filter Assembly, 100 Micron	ARFTA	1	3.00		130,000	1.20	4.00	Filter
16	Y	ABCD1242	123	Advanced Recycle Filter Tank Assembly, Filter Assembly, 20 Micron	ARFTA	1	3.00		150,000	1.20	4.00	Filter
17	Y	ABCD1243	123	Firmware Controller Assy (Data Module, Power Module)	FCA	1	10.00		170,000	1.20	4.00	
18												

Instructions 1-Background Information 2-History 2.1-Testing 3-Rates

Ready

Notional

Data Input From Sheet 2–History & Testing



EXample Data 19-Mar-2020 - Excel

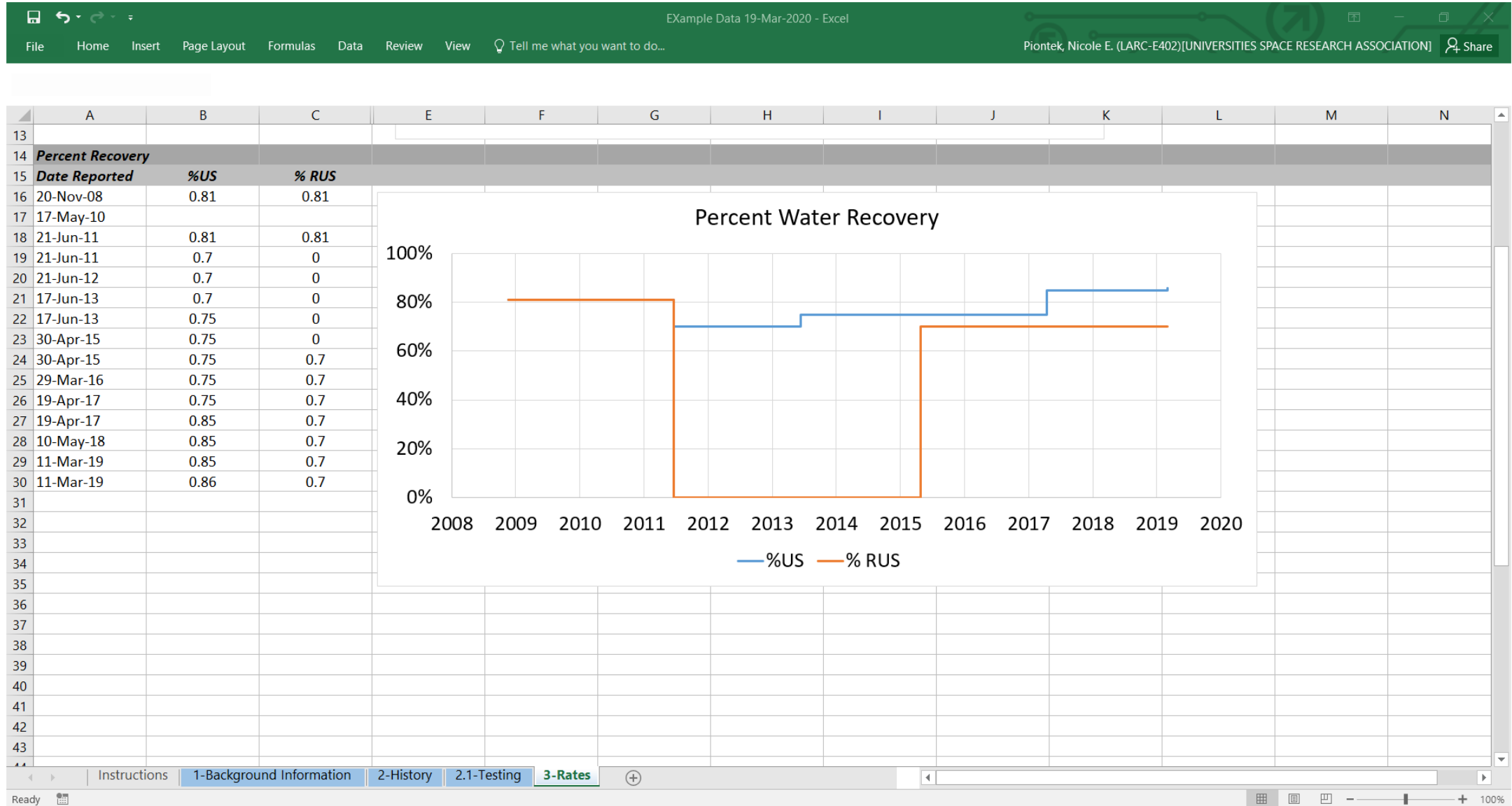
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MADS		Operating									
P/N	Unique ID	Part Name	S/N	Event Date	Event	Type	Location	Hours	Root Cause	Comment	Source
1	Updated on:	15-May-20									
6	ABCD1234	123	UPA	1	20-Nov-08	System Event	On-Orbit		Installation		Report #127365
7	ABCD1235	123	Firmware Controller Assy (Data Module, Power Module)	V 4.A	20-Nov-08	Install	On-Orbit				Report #127365
8	ABCD1236	123	Distillation Assembly	1	20-Dec-08	Install	On-Orbit	847			Report #127365
9	ABCD1237	123	Distillation Assembly	2	19-Jan-09	Install	On-Orbit				Report #127365
10	ABCD1238	123	Firmware Controller Assy (Data Module, Power Module)	V 4.B	18-Feb-09	Remove	On-Orbit				Report #127365
11	ABCD1239	123	Distillation Assembly	2	20-Mar-09	Remove	On-Orbit	33	Calcium build up		Report #127365
12	ABCD1240	123	Hose- Brine Hose		19-Apr-09	Remove	On-Orbit	234			Report #127365
13	ABCD1241	123	Fluids Control & Pump Assy	1	19-May-09	Remove	On-Orbit	32	Removed due to DA precipitation event		Report #127365
14	ABCD1242	123	Distillation Assembly	1R	18-Jun-09	Install	On-Orbit				Report #127365
15	ABCD1243	123	Fluids Control & Pump Assy	2	18-Jul-09	Install	On-Orbit				Report #127365
16	ABCD1243	123	Firmware Controller Assy (Data Module, Power Module)	V 6	17-Aug-09	Install	On-Orbit				Report #127365
17	ABCD1243	123	Fluids Control & Pump Assy	2	16-Sep-09	Remove	On-Orbit	2,000	Harmonic drive failure		Report #127365
18	ABCD1243	123	Fluids Control & Pump Assy	1R	16-Oct-09	Install	On-Orbit				Report #127365
41	ABCD1243	123	Fluids Control & Pump Assy	1R	3-Oct-12	Remove	On-Orbit	8,464	Harmonic Drive Failure		Report #127365
42	ABCD1243	123	Fluids Control & Pump Assy	3	2-Nov-12	Install	On-Orbit				Report #127365
61	683-93460-1	123	Advanced Recycle Filter Tank Assembly, Filter Assembly, Brine		5-Apr-13	Remove	On-Orbit	500			Report #127365
62	683-93460-1	123	Advanced Recycle Filter Tank Assembly, Filter Assembly, Brine		5-May-13	Install	On-Orbit				Report #127365
70	683-93460-1	123	Advanced Recycle Filter Tank Assembly, Filter Assembly, Brine		18-Jul-13	Remove	On-Orbit	847			Report #127365

Ready Filter Mode

Notional

Data Input From Sheet 3—Rates



*Rates taken from Status of the Regenerative ECLSS Water Recovery System 2009-2010 and Status of ISS Water Management and Recovery 2011-2019

Derivatives – ORU History Summary



Example Derivatives 19-Mar-2020 - Excel													
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1	Calculated/Assumptions												
2													
3	Current Date:	15-May-20											
4													
5													
6	Part Name	Part Number				Total Operating Hours	Total Calendar Time	Duty Cycle	Number of Failures (n)	Random Failure	Induced Failure	Infant Mortality	Scheduled/Wear-out
7	Fluids Control & Pump Assy	ABCD1235				11,689	100,128	0.19	11	11	0	0	0
8			S/N	Install Date	Failure Date	Operating Hours	Calendar Hours	Duty Cycle Per ORU	Failure Type				
9			1	20-Nov-08	13-Jul-10	1,100	14400	0.08	Random Failure				
10			2	15-Jul-10	6-Mar-12	1,173	14400	0.08	Random Failure				
11			1R	8-Mar-12	29-Oct-13	1,415	14400	0.10	Random Failure				
12			3	31-Oct-13	23-Jun-15	1,289	14400	0.09	Random Failure				
13			4	25-Jun-15	11-Jan-16	695	4800	0.14	Random Failure				
14			5	13-Jan-16	31-Jul-16	566	4800	0.12	Random Failure				
15			6	2-Aug-16	18-Feb-17	1,048	4800	0.22	Random Failure				
16			1R2	20-Feb-17	8-Sep-17	41	4800	0.01	Random Failure				
17			7	10-Sep-17	29-Mar-18	927	4800	0.19	Random Failure				
18			4R	31-Mar-18	17-Oct-18	882	4800	0.18	Random Failure				
19			5R	19-Oct-18	7-May-19	912	4800	0.18	Random Failure				
20			?	9-May-19	15-May-20	1,641	8928	0.18					
21	Filter Assembly, 20 Micron, ARFTA	ABCD1235				99,086	106,272	1.00	0	0	0	0	3
22			S/N	Install Date	Failure Date	Operating Hours	Calendar Hours	Duty Cycle Per ORU	Failure Type				
23			9	22-Mar-08	1-Jan-14	50,664	50,664	1.00	Scheduled/Wear-out				
24			2	2-Jan-14	1-Jan-16	15,746	17,496	0.90	Scheduled/Wear-out				
25			3	9-Jan-16	2-Feb-18	12,684	18,120	0.70	Scheduled/Wear-out				
26			5	2-Feb-18	15-May-20	19,992	19,992						

Notional

Derived Parameters – Calculated



Example Derivatives 19-Mar-2020 - Excel

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	A	B	C	D	E	F	G	H	I	J	Q	R	S	T	U	V	W
1	Updated on:	15-May-20															
2																	
3	Subsystem:	URINE PROCESSING ASSEMBLY (UPA)															
4																	
5																	
7	Subsystem	ORU?	Part Number	Part Name	Quantity	Mass of ORU (kg)	Mass of Packaging (kg)	Duty Cycle	t_o	n	Failure Rate (1/h) Posterior	Error Factor Posterior					
8	UPA	Y	ABCD1234	Wastewater Storage Tank Assembly	1	50.00		1.00	908,434	0	9.712E-07	4.00					
9	UPA	Y	ABCD1235	Fluids Control & Pump Assy	1	30.00		0.20	13,652	11	3.628E-04	1.59					
10	UPA	Y	ABCD1236	Distillation Assembly	1	50.00		0.18	236,404	5	2.306E-05	1.91					
11	UPA	Y	ABCD1237	Pressure Control & Pump Assy	1	43.33		0.14	305,479	0	2.732E-06	4.00					
12	UPA	Y	ABCD1238	Separator Plumbing Assy	1	43.33		0.14	384,962	3	8.988E-06	2.18					
13	UPA	Y	ABCD1239	Advanced Recycle Filter Tank Assembly, Tank Top Assembly	1	43.33		1.00	4,566	1	2.552E-05	2.87					
14	UPA	Y	ABCD1240	Advanced Recycle Filter Tank Assembly, Filter Assembly, Brine	1	7.00		1.00	32,579	0	7.977E-06	4.00					
15	UPA	Y	ABCD1241	Advanced Recycle Filter Tank Assembly, Filter Assembly, 100 Micron	1	3.00		1.00	239,752	2	8.612E-06	2.43					
16	UPA	Y	ABCD1242	Advanced Recycle Filter Tank Assembly, Filter Assembly, 20 Micron	1	3.00		1.00	293,752	0	2.332E-06	4.00					
17	UPA	Y	ABCD1243	Firmware Controller Assy (Data Module, Power Module)	1	10.00		1.00	923,674	0	9.115E-07	4.00					
18																	
19																	
20																	
21																	
22																	
23																	

1-Background Information ORU History Summary Calculated

Select destination and press ENTER or choose Paste

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- **Reliability Testing is Critical for Crewed Missions Beyond Low Earth Orbit**

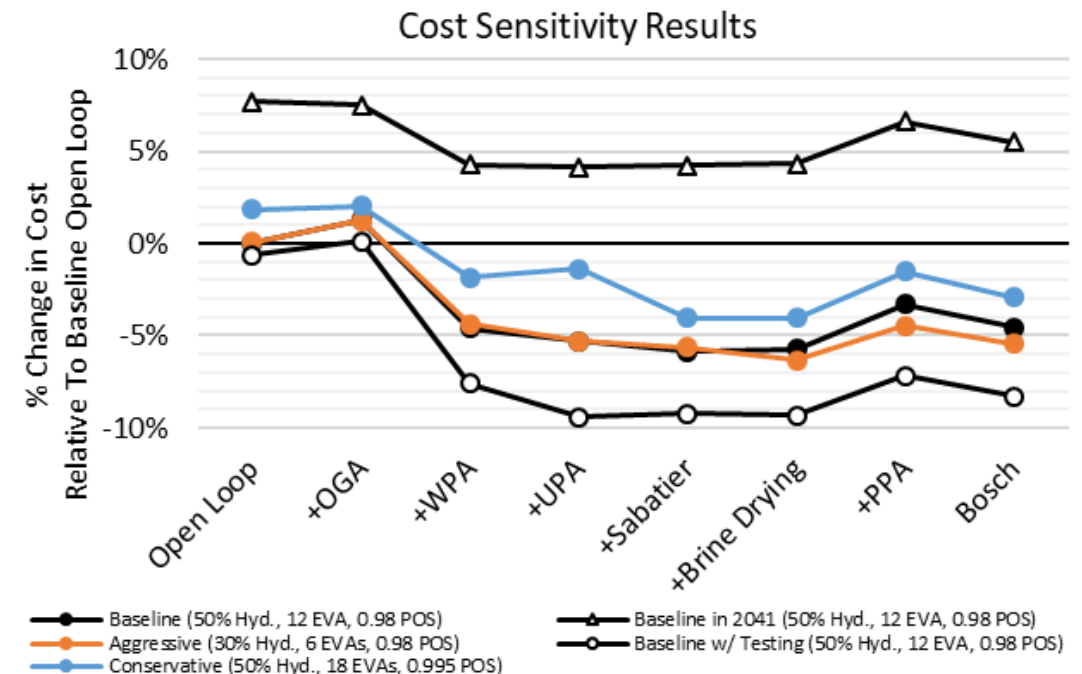
- Performed literature review of existing NASA test guidelines related to reliability & design life testing
- Discussed how changes in mission context from LEO operations and short lunar missions to long-duration beyond-LEO missions may impact reliability testing

- **ECLSS Does Not Exist in a Vacuum: Integrated Analysis is Necessary to Inform System Architecture Decisions**

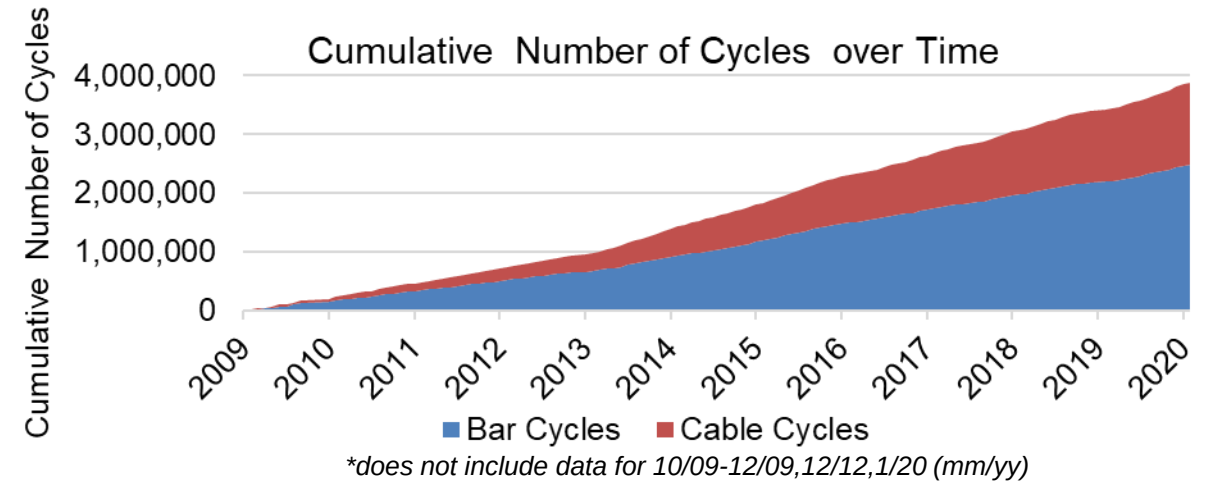
- Purpose was to examine the mission-level impacts of various levels of ECLSS loop closure
- Separated line items in Master Equipment List (MEL) that were being modeled at a lower level of detail
- Data collected in input forms was used to update inputs to supportability model
- Compiled supportability model outputs to inform cost models with spares counts
- Ran PRICE H cost model to assess habitat and transportation system cost under various conditions

- **Due to ongoing COVID-19 impacts we decided to withdraw the papers from ICES 2020**

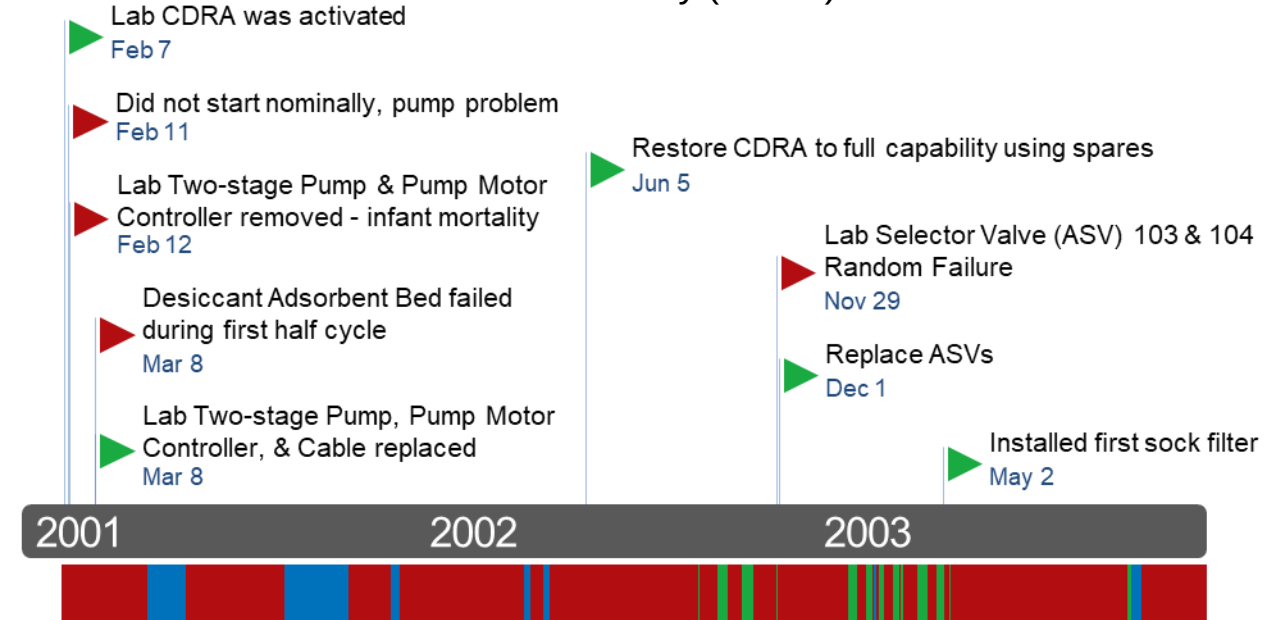
- Looking into other ways to distribute the information



- Exercise equipment is not currently included in supportability model but will likely be a significant contributor to spares mass
- Gathering and analyzing data on ISS exercise systems to provide baseline inputs for supportability modeling
 - Advanced Resistive Exercise Device (ARED)
 - Cycle Ergometer with Vibration Isolation and Stabilization (CEVIS)
 - Treadmill (T2)
- Estimates for updated exercise equipment can leverage this heritage data
- Correlating recorded cycle counts operating hours and duty cycle to enable spares forecasting for various mission profiles
- Used timelines as to represent data over time to get a better visualizations of how system acted over time



Carbon Dioxide Removal Assembly (CDRA) Timeline of Events



Other Experiences



- **Returning for Summer 2020!**
- **Finish my degree at the University of Michigan**
 - Four semesters left
- **Biomedical Engineering Pathways Intern at JSC**
 - Set to start in January 2021
- **Grad school**
 - Medical Engineering
 - Focus in bioastronautics or aerospace medicine
 - M.D. or Ph.d.



Nicole Piontek

- Biomedical engineering at the University of Michigan
- Reliability and Maintenance Logistics Analysis for Crewed Deep-Space Missions Intern Fall 2019 – Summer 2020

Main Projects

- Supportability Data Collection System
- Contributed to Papers for the International Conference of Environmental Systems (ICES)
- Researched Exercise Equipment & Created Timelines for ISS Systems

Thank you!

- Andrew Owens
- Supportability Team
- SMAB

Questions?



Contact Info



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