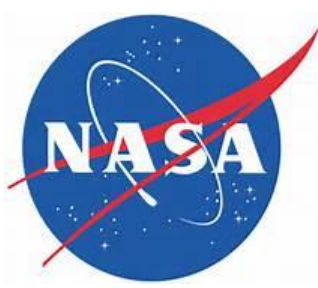




# International Space Station Reliability Analysis



**Melissa Bartush**

The University of West Florida, Pensacola Florida  
Department of Earth and Environmental Sciences

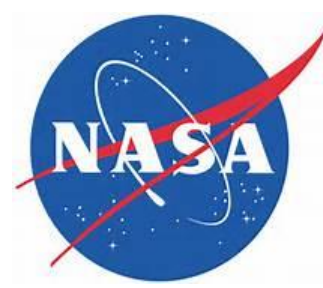
NE/171 Safety Panels Group  
International Space Station Division  
Safety and Mission Assurance Directorate



# Position



- Graduate Student Intern
- ISS Reliability and Maintainability
- Provide reliability data to the ISS program for risk based decisions
  - BPA and EMU Projects

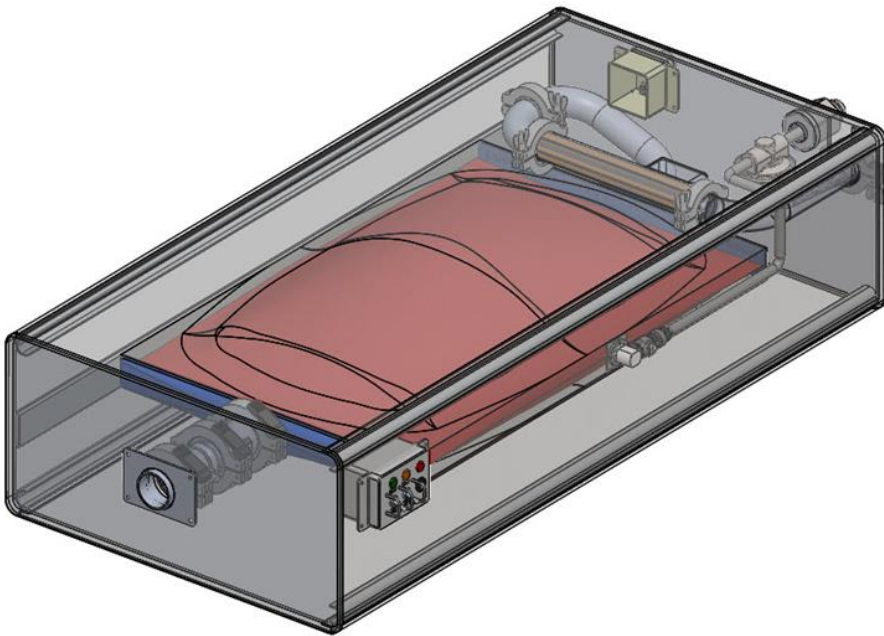


# Brine Processing Assembly (BPA)

## Qualitative Reliability Analysis

### Problems:

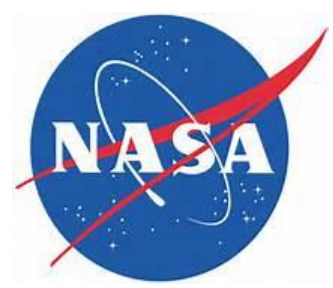
- Class 1E flight hardware for use on the ISS
  - Means no reliability requirements
- Fault Detection, Isolation, and Recovery (FDIR) debate



BPA



# Failure Mode and Effects Analysis (FMEA) Brine Processing Assembly



## Benefits:

- Identified risk areas
- Input on FDIR discussion
- Co-Mentor will use results to drive design

## Analysis:

- Failure Modes and causes
- Effects of Failure
- Corrective actions
- Criticality of system

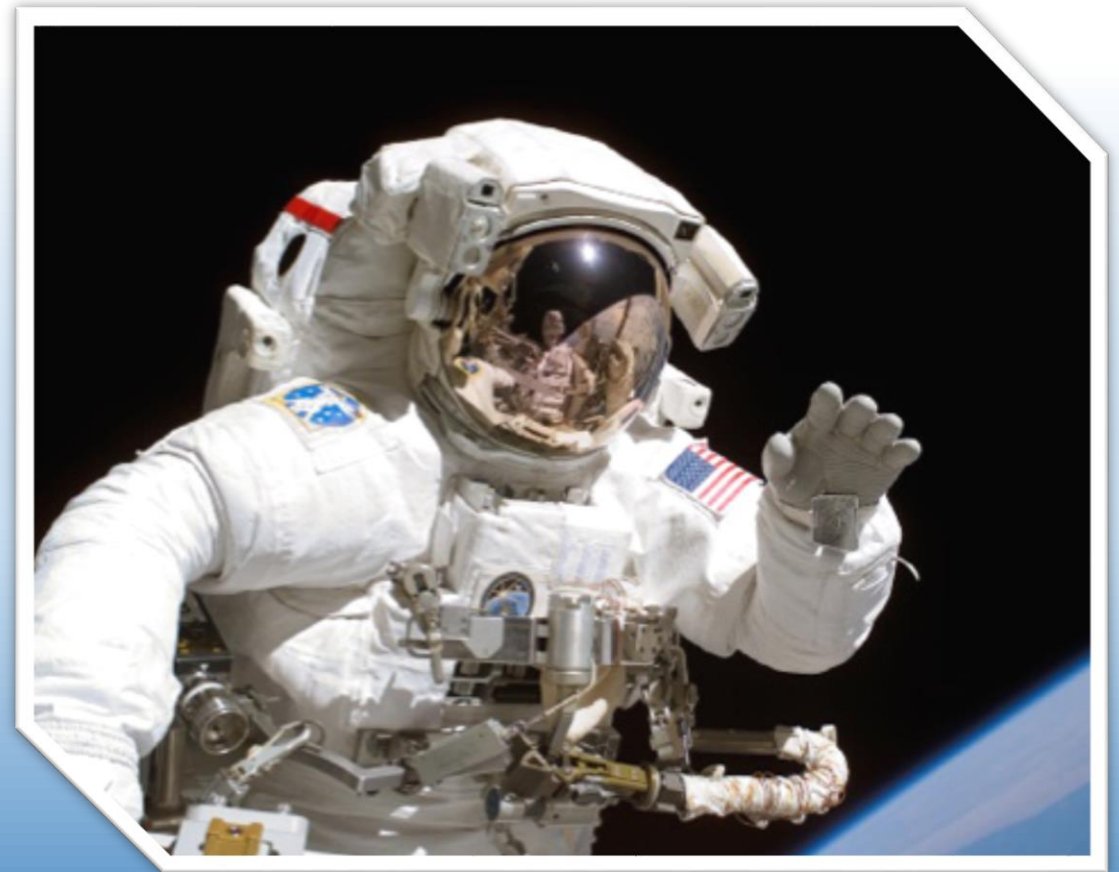


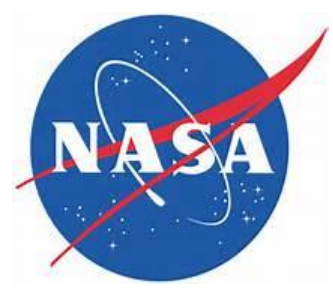
**FMEA-CIL**  
International Space Station



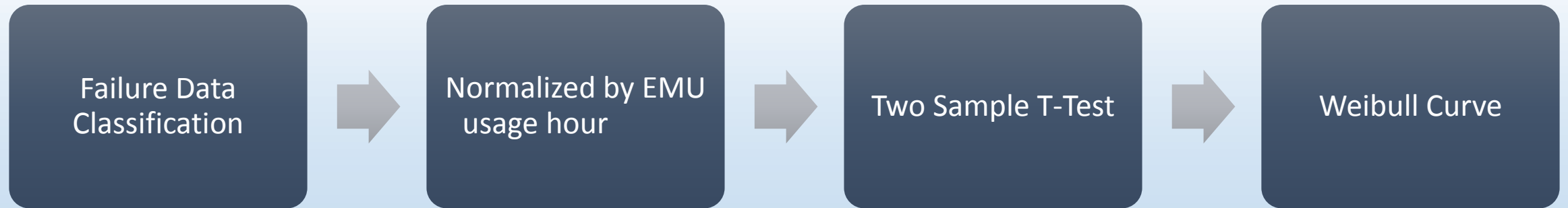
# Statistical Analysis Extravehicular Mobility Unit (EMU)

- Action: Use statistical tools to test the EMU failure data for any trends that are present
- Developed analysis to determine failure rate comparison between maintenance intervals





# Analysis Steps





# Results

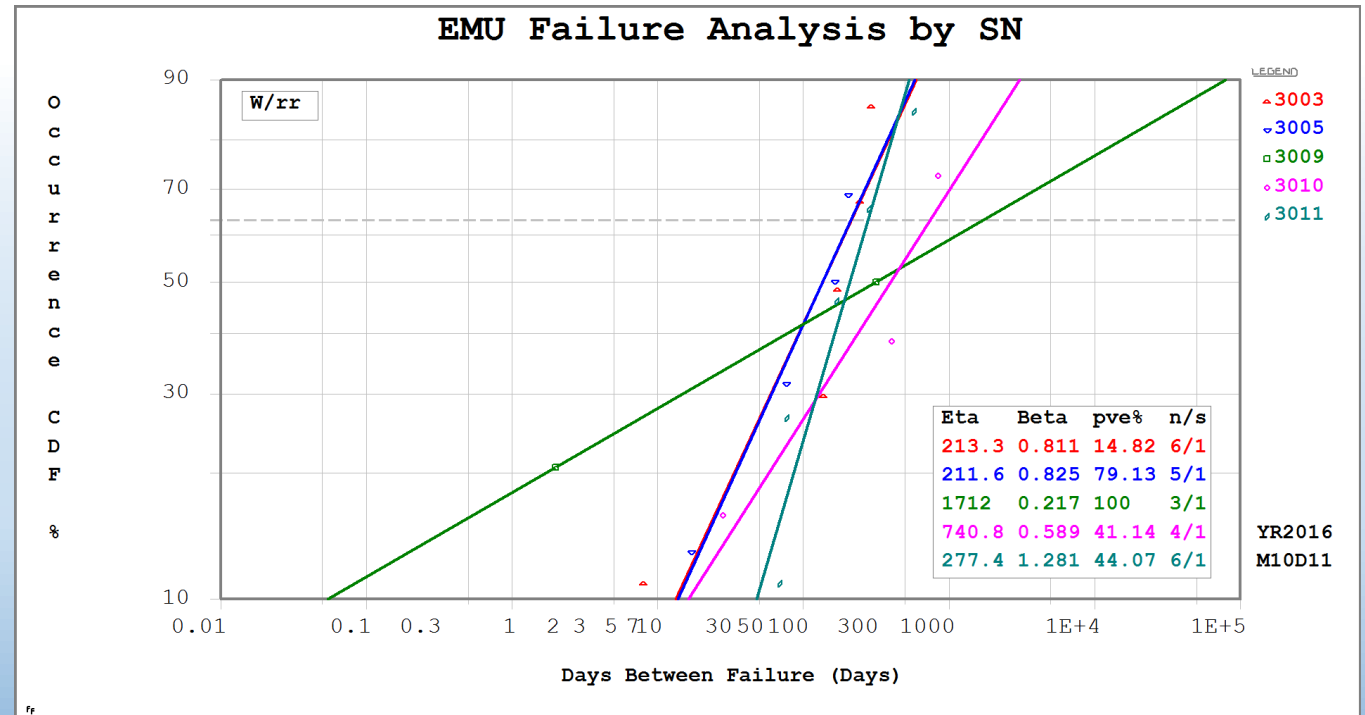
- T-Test:

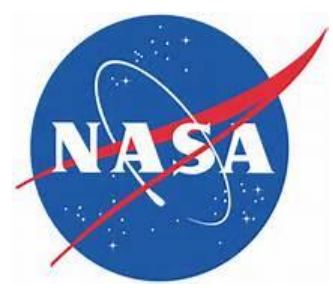
- Failure Rates (FR) between the two groups are different
- 6 Year EMU decreasing FR

- Weibull Plot:

- Overall the EMU has a decreasing FR
- Each EMU has its own failure curve
- Insufficient data for individual component analysis

- Reported data and results to EVA Chief Engineer





# Professional Growth and Accomplishments

## Technical Skills:

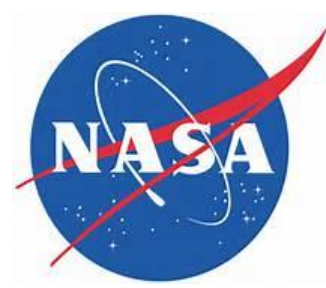
- Performing FMEA's to aid in FDIR analysis
- Real world statistical analysis
- Weibull Analysis

## Interpersonal Skills:

- Testing knowledge in professional setting
- Confidence by doing meaningful work
- Conflict resolution



# The JSC Experience

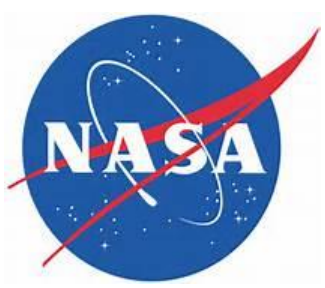


- Astronauts
- Tours
- русский язык



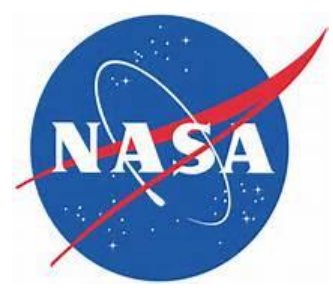


# Forward Work



- Apply for NASA Pathways Internships
- Complete Masters degree
- Scout for NASA careers





# MANY THANKS

Mentor

Van Keeping

Co-Mentor

Nicholas Meyer

Advisors

Mesha Keuss

Alan Currie

Bill McAllister

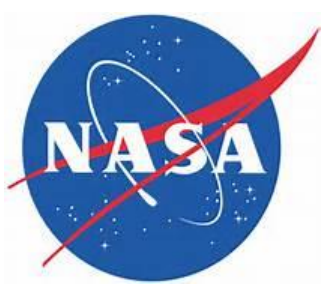
Internship Coordinators

Veronica Seyl

Missy Matthias

Melissa Corning

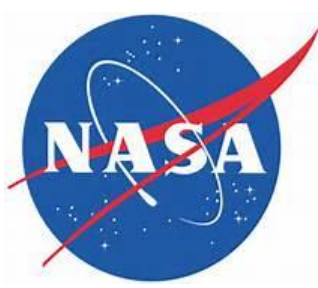
...And all of my 'Safety' family!



# Backup Slides



# Normalizing the Data



Without Precise maintenance times, the following formula was used to estimate approximate usage hours:

$$\begin{aligned} \text{Approximate Usage Hours} = & \text{Total time on EVA} \\ & + \text{Base Maint/Year} * (\# \text{EMUs on orbit}) \\ & + \text{Maint/EVA} * (\# \text{EMUs on orbit}) \end{aligned}$$

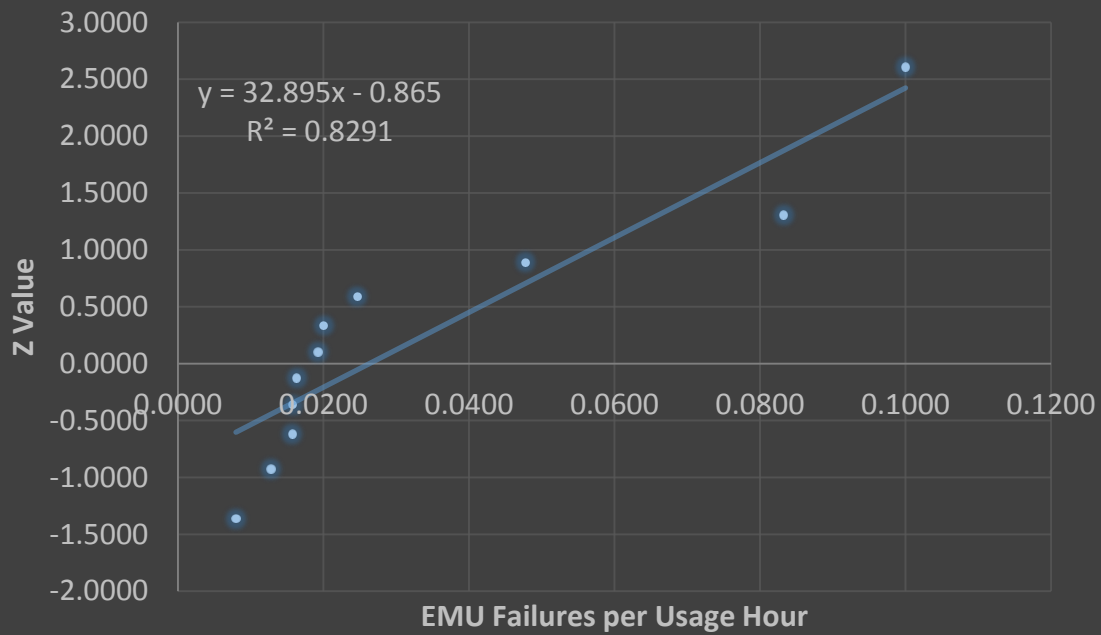
## Assumption:

- 20 Hours Base Maint/Year
- 20 Hours Maint/EVA

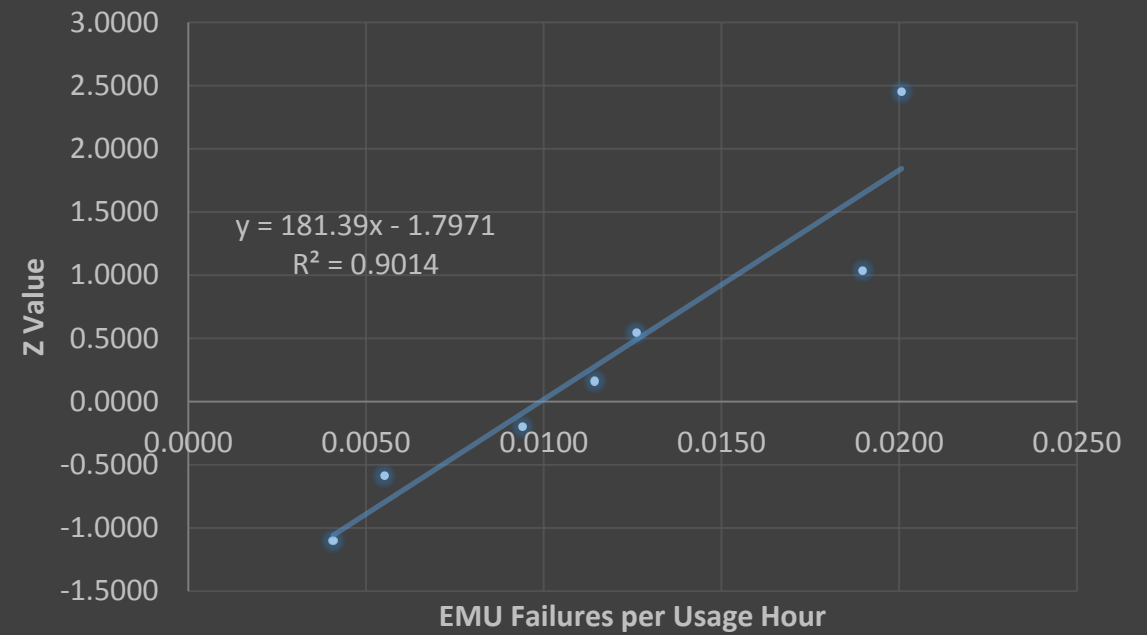


# EMU Backup

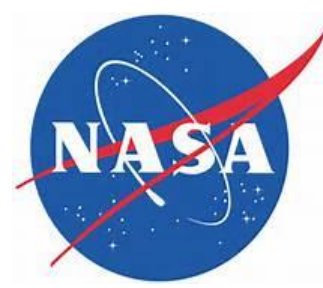
### Probability Plot for Failures per Usage Hour (1998-2008)



### Probability Plot for EMU Failures per Usage Hour (2009-2015)



Normalized non-MEGA and MEGA data



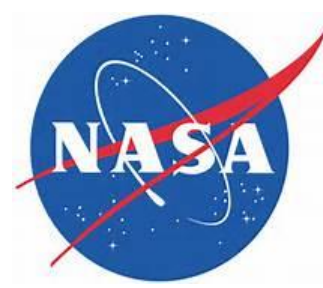
# Two Sample t-Test/Hypothesis Test

t-Test: Two-Sample Assuming Unequal Variances

	1998-2008	2009-2015
Mean	0.033	0.012
Variance	0.00096	0.000038
Observations	11	7
Hypothesized Mean Difference	0	
df	11	
t Stat	2.219	
P(T<=t) one-tail	0.024	
t Critical one-tail	1.796	
P(T<=t) two-tail	0.048	
t Critical two-tail	2.201	

Note: if t-Stat > t-Critical, reject Null Hypothesis

**Result:** t-Stat > t-Critical, therefore, at 95% confidence, the test shows that the failure rates between non-MEGA and MEGA EMU's is different. It appears that the failure rate actually **decreases** for MEGA EMU.



# Scrub criteria:

- Failures that happened in flight or in a flight-like atmospheric situation (such as chamber runs for specific serial numbers in preparation for a specific flight).

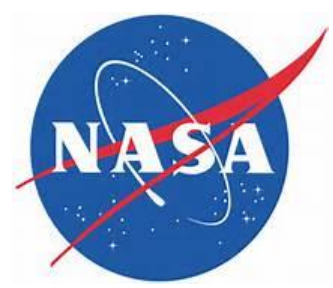
PART filter: JSC GFE PRACA, IFI, PRACA

## Scrubbed:

NBL Testing	Receiving
Acceptance Testing	NVR Testing
Build-Up	EMI
SSER	Paperwork
Battery	BIO-MED
PIA, UIA	Vibration Test
Glove	Qual Testing
Functional test	Manufacturing
Usage, Expired, Limited Life	METOX



# EMU Flight Failures 1998-2008



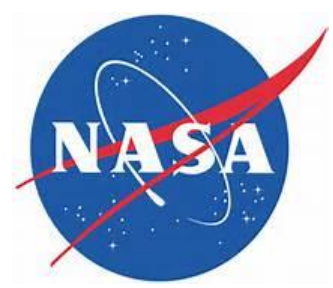
Year	Failures/Year	Total EVA's/Year	Avg Failure/EVA
1998	5	3	1.67
1999	8	1	8.00
2000	10	9	1.11
2001	14	16	0.88
2002	16	18	0.89
2003	7	2	3.50
2004	4	0	0.00
2005	2	4	0.50
2006	8	11	0.73
2007	19	21	0.90
2008	17	15	1.13



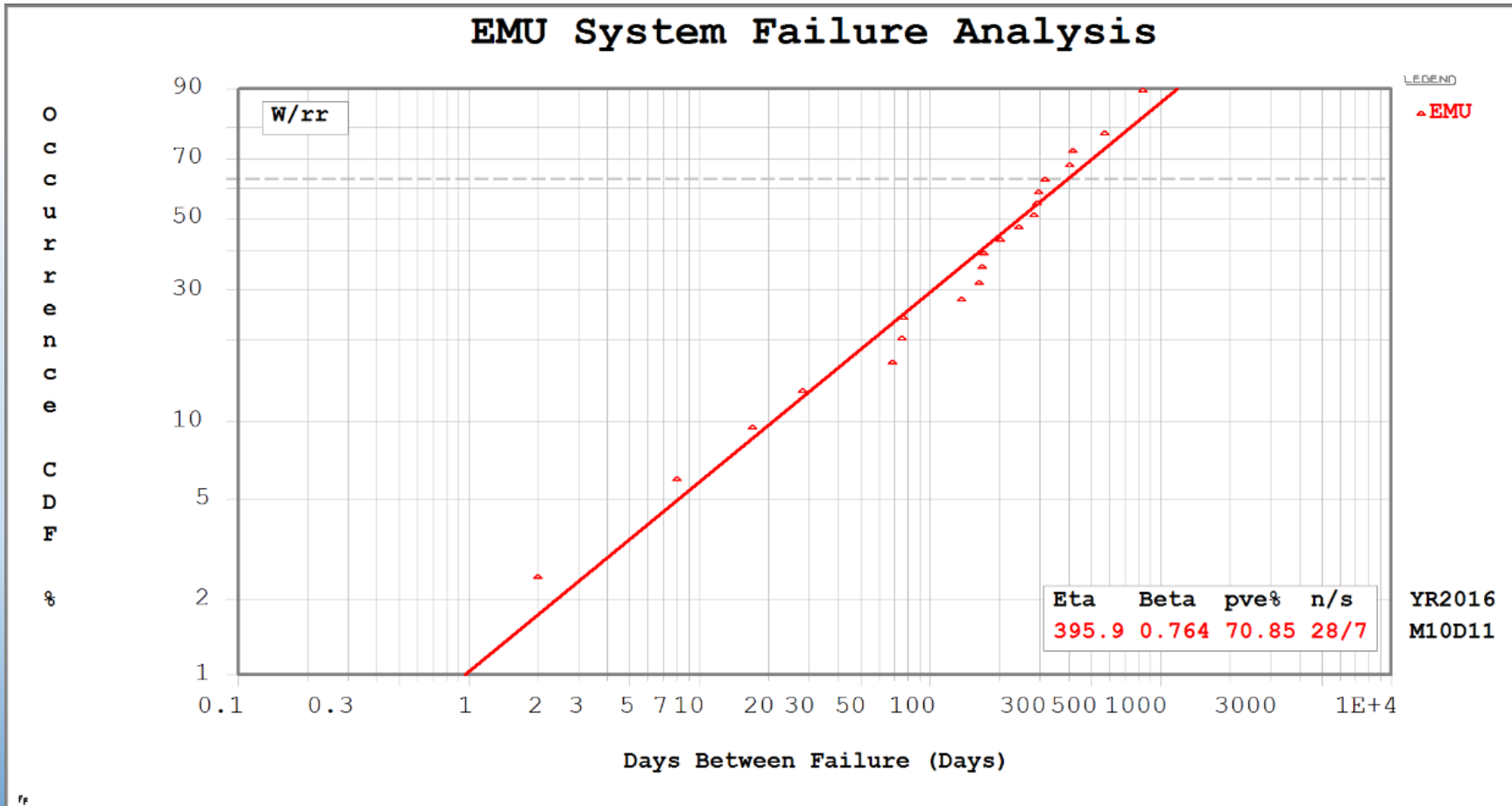
# EMU Flight Failures 2009-2016\*

Year	Failures/Year	Total EVA's/Year	Avg Failure/EVA
2009	12	19	0.63
2010	13	12	1.08
2011	3	7	0.43
2012	2	3	0.67
2013	5	5	1.00
2014	7	3	2.33
2015	8	6	1.33
2016	2	3	0.67

Note: 2016 data included as of end of FY16



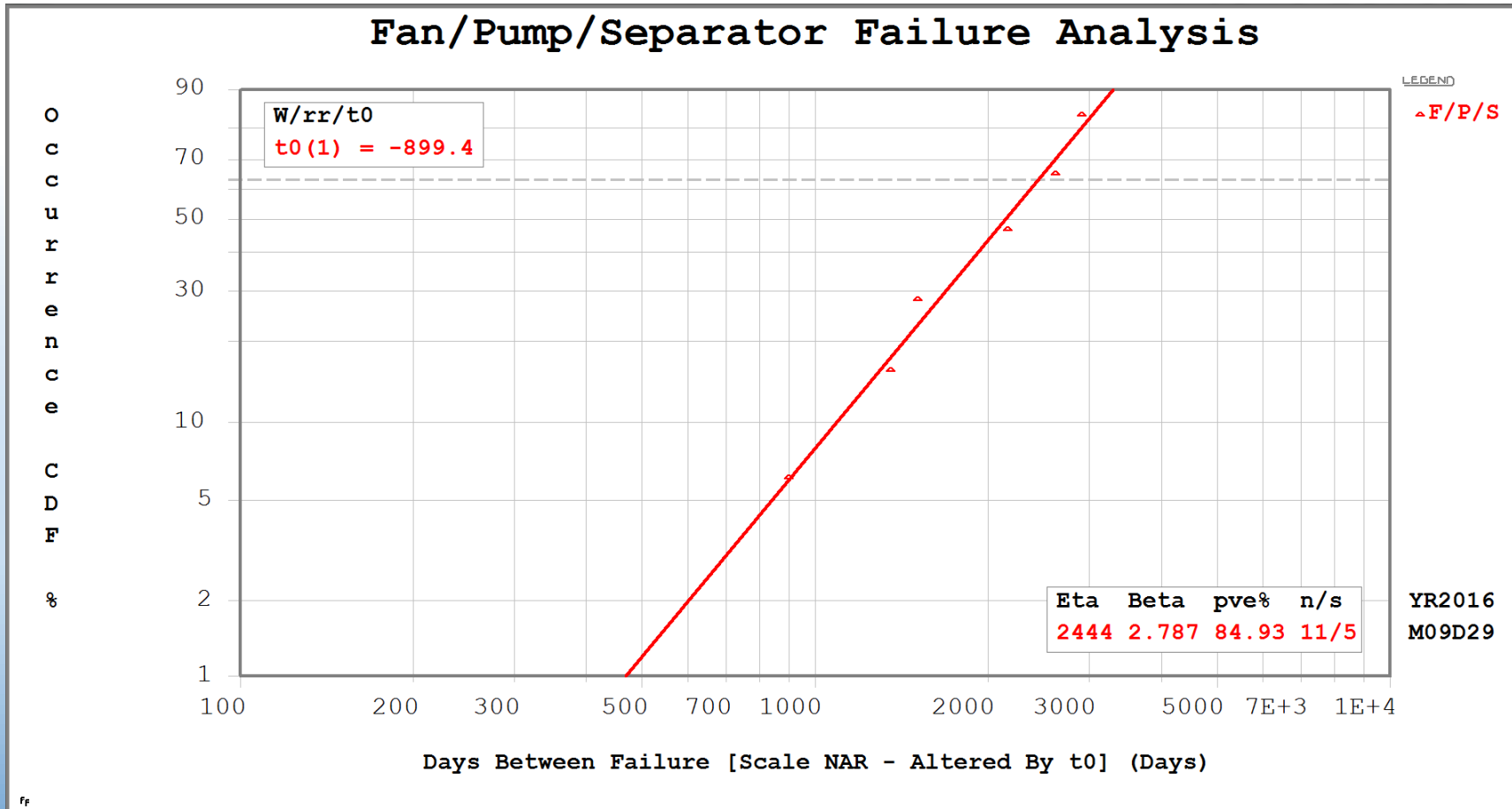
# Flight EMU



Weibull Plot of EMU system as a whole



# Fan/Pump/Separator Failure Analysis



Beta indicates increasing failure rate. It is likely this failure mode is driving the higher beta for 3011.