



Engineering, Test & Technology  
Boeing Research & Technology

# Voltage Round Robin Status Update

An OSU/HR Study

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Presented by: Yonas Behboud, October 2018 FTWG

# Background and Round Robin Purpose

## Prior Presentations

- Voltage vs Heat Flux Study (Presented June 2017)
- Effects of Heat Flux on Heat Release (Presented November 2017)
- Voltage Round Robin (Presented June 2018)

## Round Robin Purpose

- Record the supply voltage and ambient load variations of FTWG labs operating OSU heat release rate units
- Use the results to understand supply voltage variation to assess needs for conditioning
- Evaluate the variation and conditioning solutions to determine HR2 specification criteria and OSU test method guidelines

# Round Robin Participants

## 22 Labs

### 13 Domestic (USA)

- Jamco-America
- General Plastics
- Zodiac Heath Tecna
- Krueger Testing & Consulting
- Element Materials & Technology
- HAECO Americas Cabin Solutions
- AccuFleet Testing Services
- Skandia
- SEKISUI SPI
- Schneller
- Herb Curry Inc.
- SGS Govmark
- TESTCORP

### 9 International

- CTA (Centro de Tecnologias Aeronauticas)
- CSIR, MSM, Nonwovens & Composites Laboratory
- Jamco Singapore Pte Ltd
- AIRBUS
- Zodiac Aerospace (SELL)
- RESCOLL
- DGA Techniques Aeronautiques
- Test Center of Civil Aviation Administration of China (CAAC)
- F. List



# Round Robin Procedure

## Activity – 13 of 22 labs complete

- Fluke Model VR170 Voltage recorder supplied by Boeing
- Voltage recorder connected to unit power supply for 10 days
- Recorders returned to Boeing for data extraction, compilation, and analysis
- Results shared with FTWG
  - October 2018 preliminary results
  - March 2019 full results



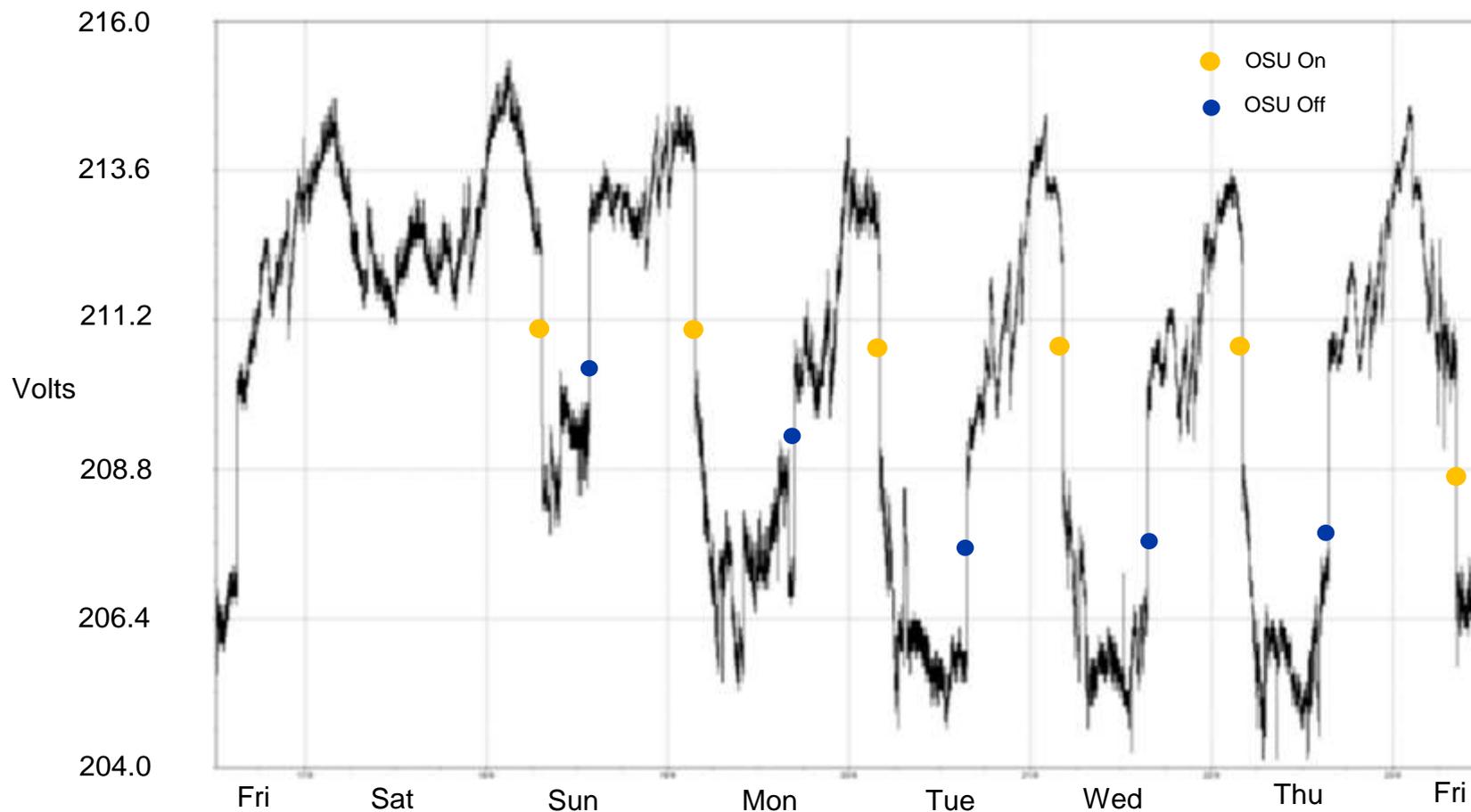
# Round Robin Questionnaire Results

## Questionnaire sent to each participant with the logger

- Only 7 of 13 labs returned a completed questionnaire
- Results displayed in percent of participants

Question	Yes	No
Presence of power conditioning?	0%	100%
Lab adjacent to any manufacturing facility?	43%	43%
Have you ever experienced difficulties calibrating heat flux density	29%	71%
Do you typically need to adjust power settings to the heaters during calibration?	29%	71%
Anomalies/observations during data collection		

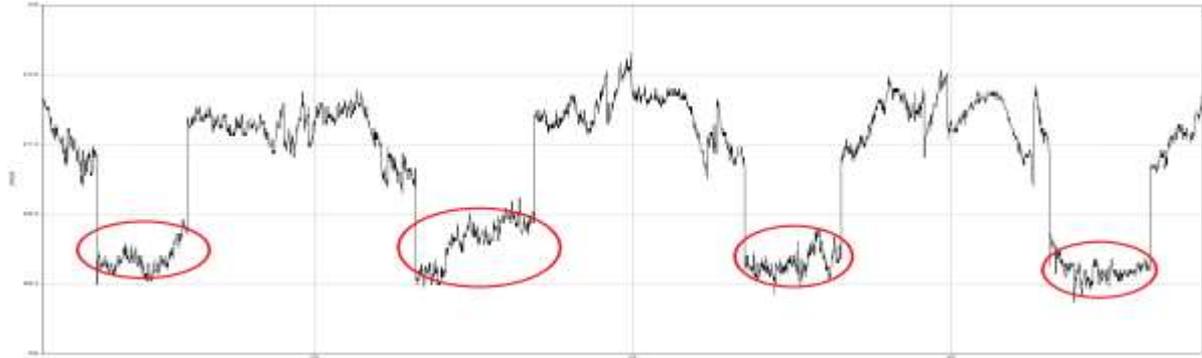
# Graphical Representation of Voltage Recorder Results



# Analysis of Round Robin Data – Voltage Range

## 95% Tolerance Interval Method

- Using the “On” voltage data during times where the globars were powered



- Applied a 95% tolerance method to exclude outliers that represent less than 5% of the total “On” data

## What does this mean?

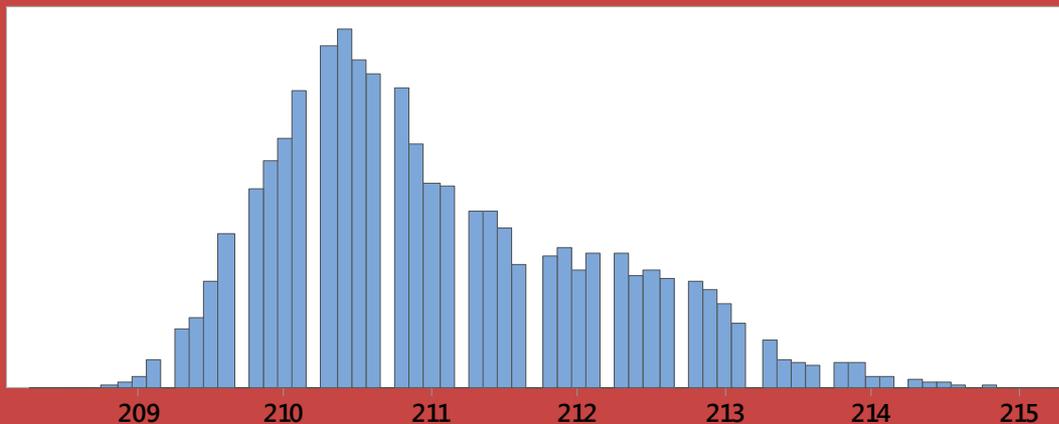
**“We have a 95% confidence that 95% of the data lies between the upper and lower voltage interval limits.”**

# Assumptions of Round Robin Data

1. The data outside of the 95% tolerance interval represents a small portion of the population and does not significantly impact heat flux.
2. Voltage ranges observed during the monitoring period are representative of normal operation.
3. 208V supply cannot exceed  $\pm 1.5\text{V}$  (3V range) in order to maintain a  $3.5 \text{ W/cm}^2 \pm 0.05$  calibration range if calibrated at exactly  $3.5 \text{ W/cm}^2$  (presented June 2017, Boeing Everett OSU).

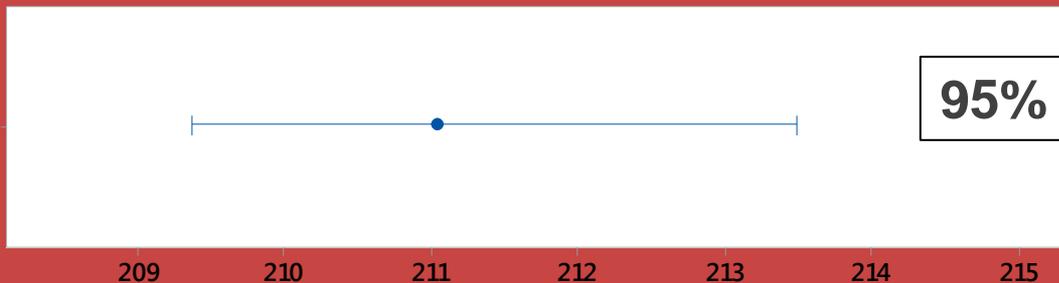
# Example of 95% Tolerance Interval (TI) Analysis

**Lab E Tolerance Interval Plot for Vavg (V)**  
 95% Tolerance Interval  
 At Least 95% of Population Covered



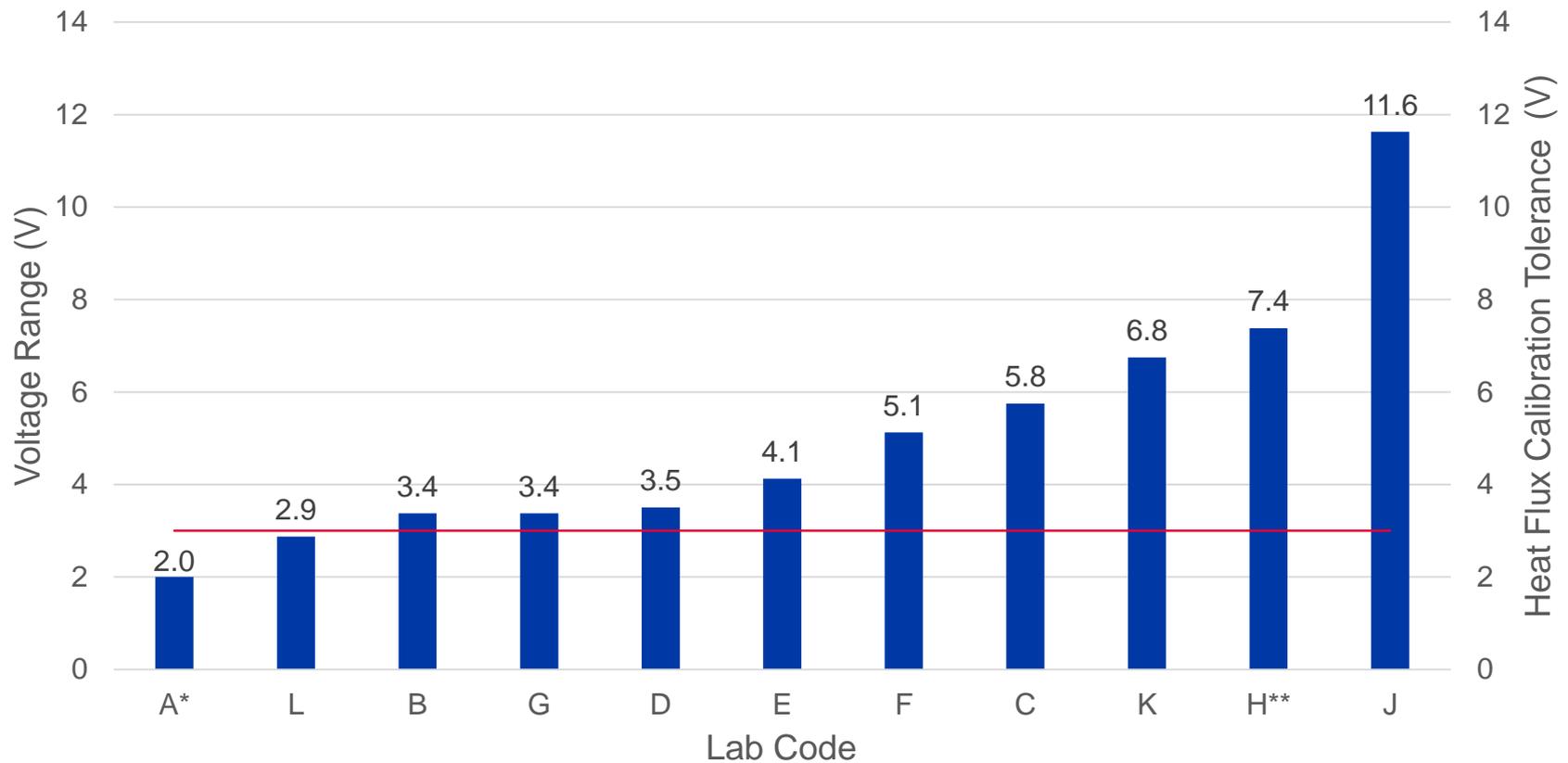
Statistics	
N	17205
Mean	211039
StDev	1115
Nonparametric	
Lower	209.375
Upper	213.500
Achieved Confidence	95.4%

Nonparametric



**95% TI Range = 4.1 Volts**

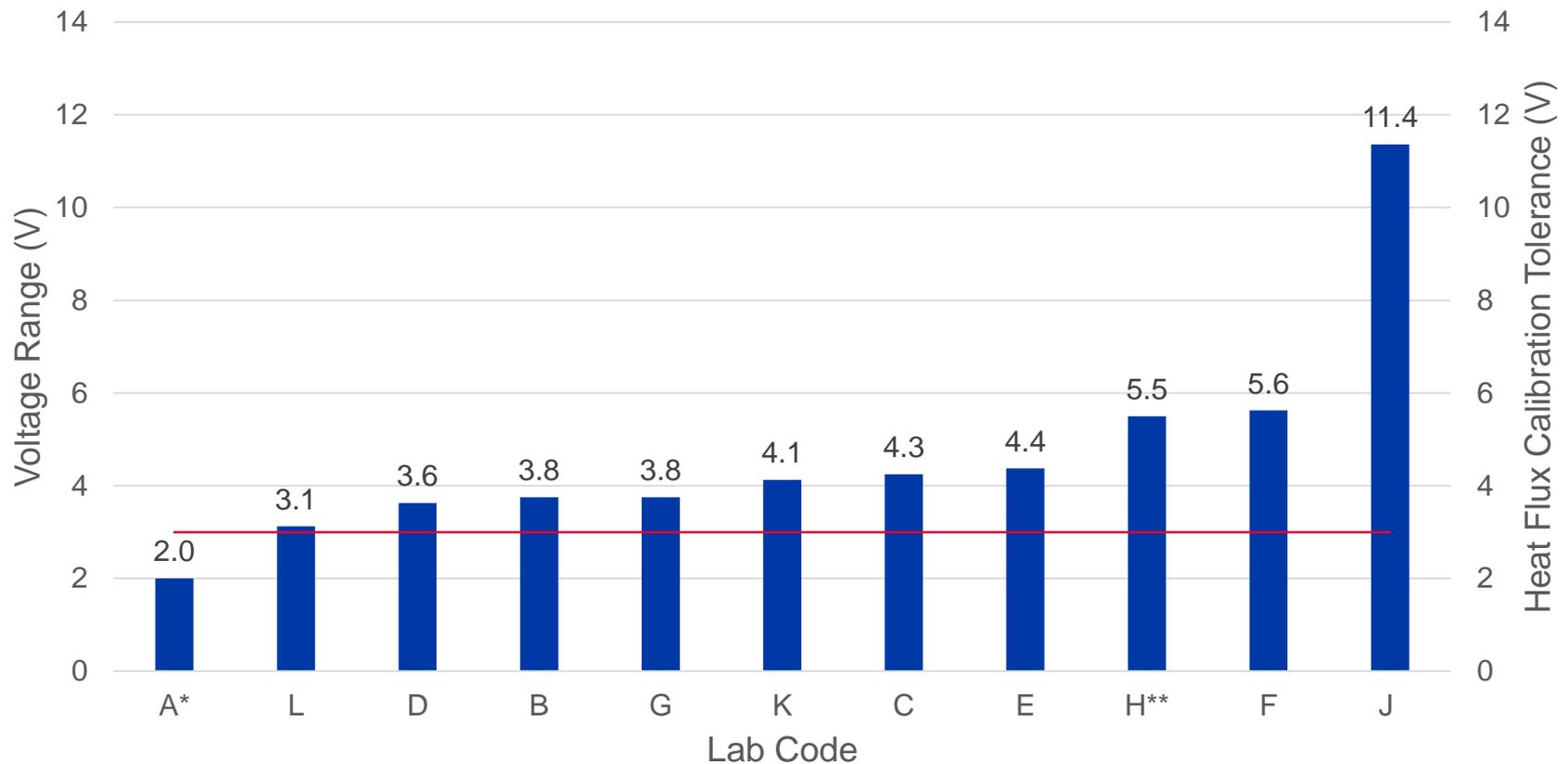
## INTRA-WEEK 95% TOLERANCE INTERVAL RANGE



\*Lab only included a 2 hour period of time where the OSU was turned on

\*\*Lab voltage was in the 120V range compared to 208V or 240V

## INTRA-DAY 95% TOLERANCE INTERVAL RANGE



\*Lab only included a 2 hour period of time where the OSU was turned on

\*\*Lab voltage was in the 120V range compared to 208V or 240V

# Preliminary Observations

## Reiterating 3<sup>rd</sup> Assumption

- 208V supply cannot exceed  $\pm 1.5V$  (3V range) in order to maintain a  $3.5 \text{ W/cm}^2 \pm 0.05$  calibration range if calibrated at exactly  $3.5 \text{ W/cm}^2$  (presented June 2017, Boeing Everett OSU).
- Assuming other OSU units have an equivalent relationship between voltage and heat flux, observations to date may indicate a benefit for voltage conditioning industry-wide

# Future Actions

## Complete Round Robin Data collection

- 9 labs left
- Collect, analyze, distribute data to each lab
- Present findings in March meeting

Thank you for your time

Questions?