



WIND ENGINEERING &  
AIR QUALITY CONSULTANTS

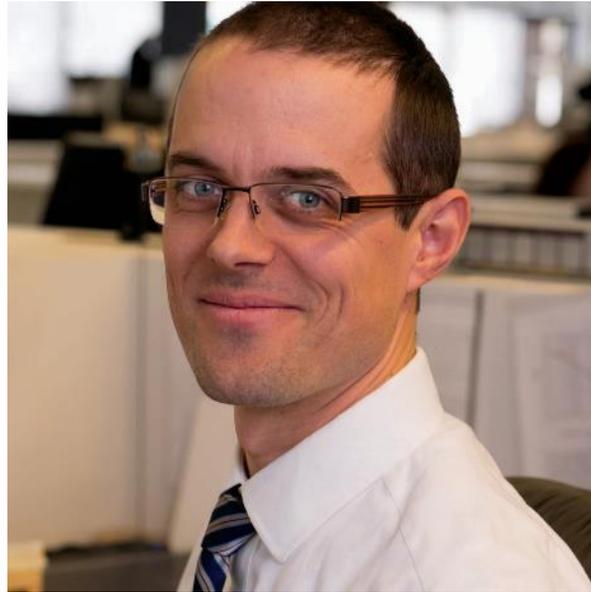
# MODULE WIND LOAD RESISTANCE: STANDARDS VS. REALITY

PV MAG WEBINAR  
AUGUST 30, 2021

PRESENTER:

YARROW FEWLESS

PRINCIPAL AT CPP WIND ENGINEERING



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# PRESENTATION SUMMARY

YARROW FEWLESS, CPP

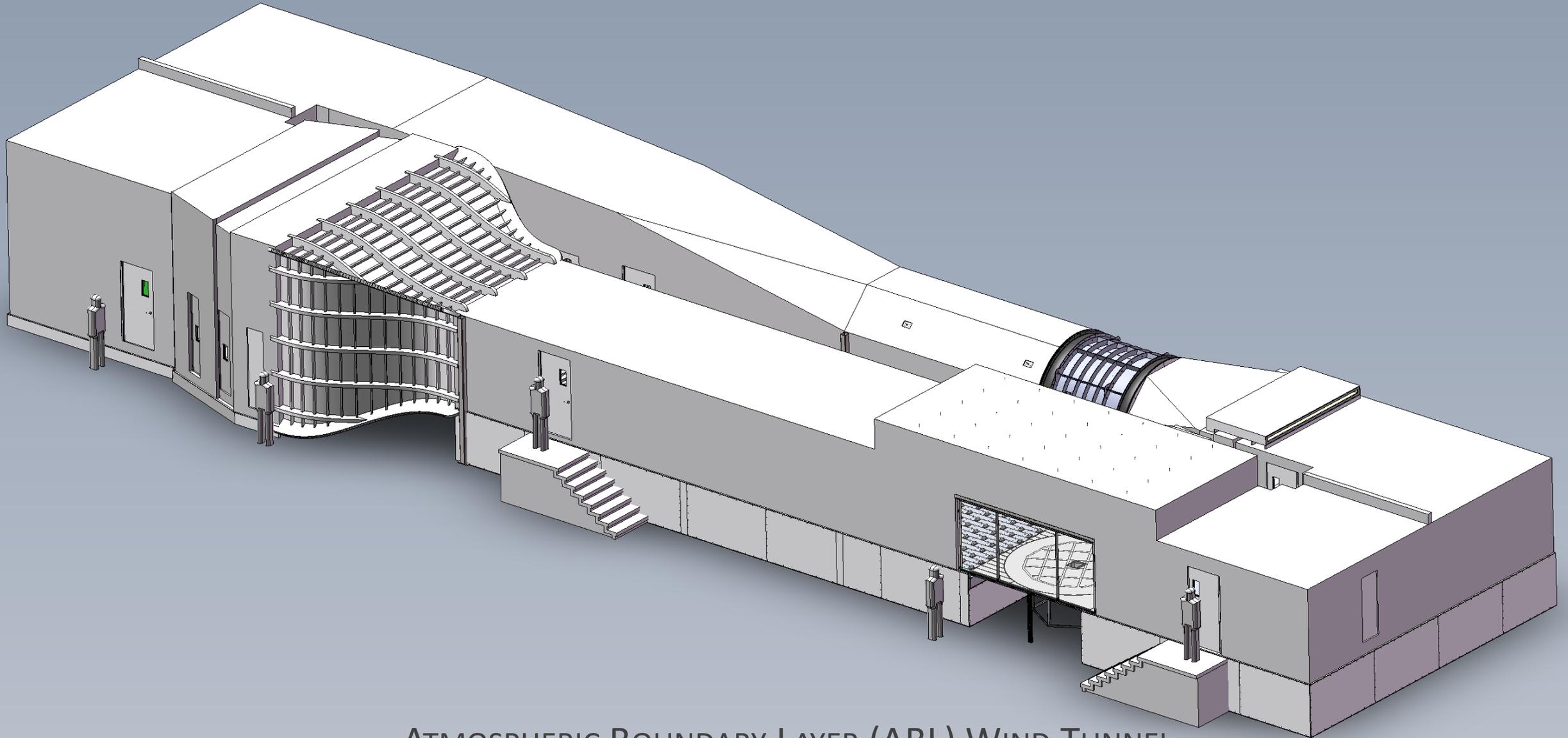
HOW DO WE MEASURE WIND LOADS ON A MODULE?

SCOTT VAN PELT, GAMECHANGE SOLAR

HOW DOES THE MEASURED LOAD IMPACT THE RACKING DESIGN?

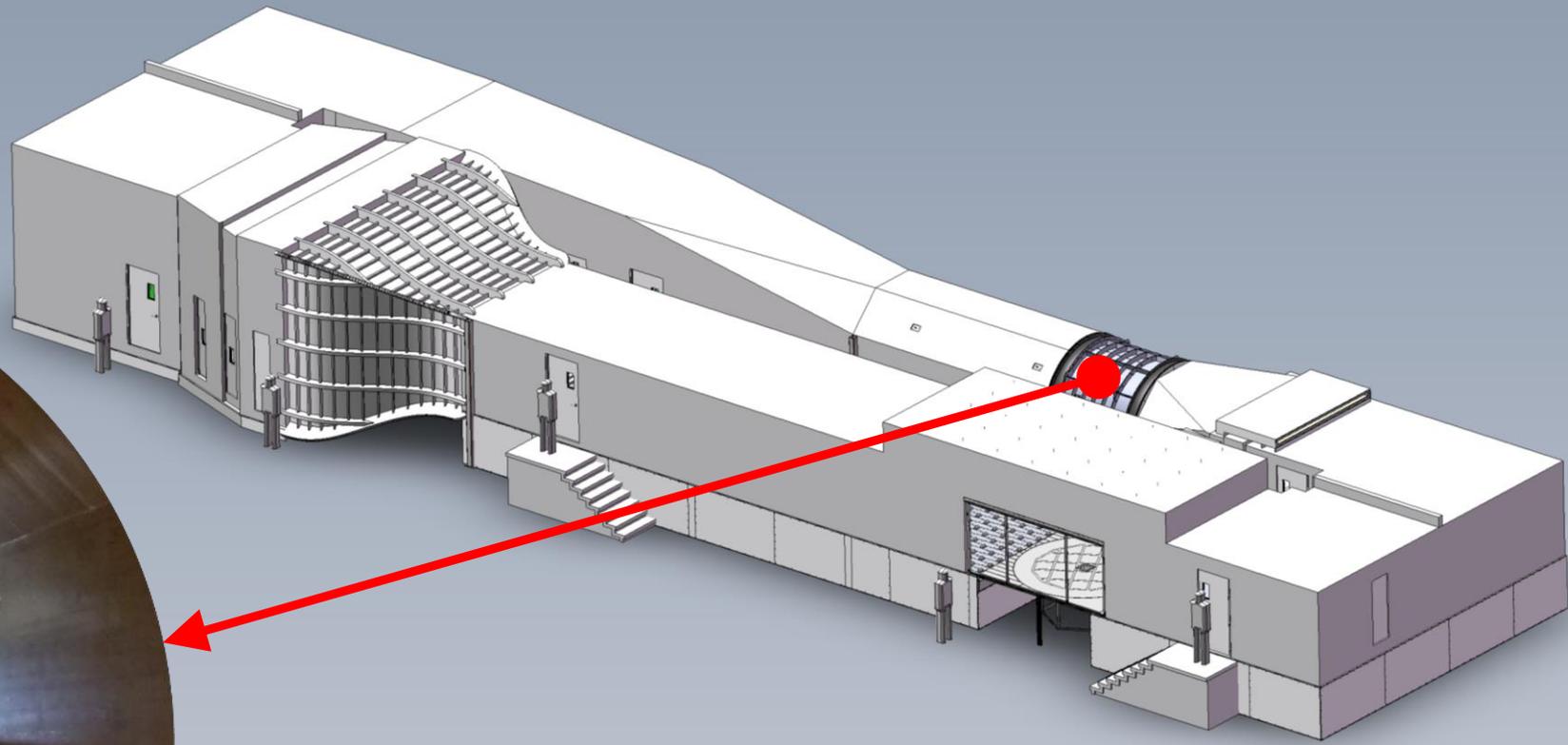
DANIEL CHANG, RETC

HOW DO WE TEST THE MODULES FOR THE LOADS?



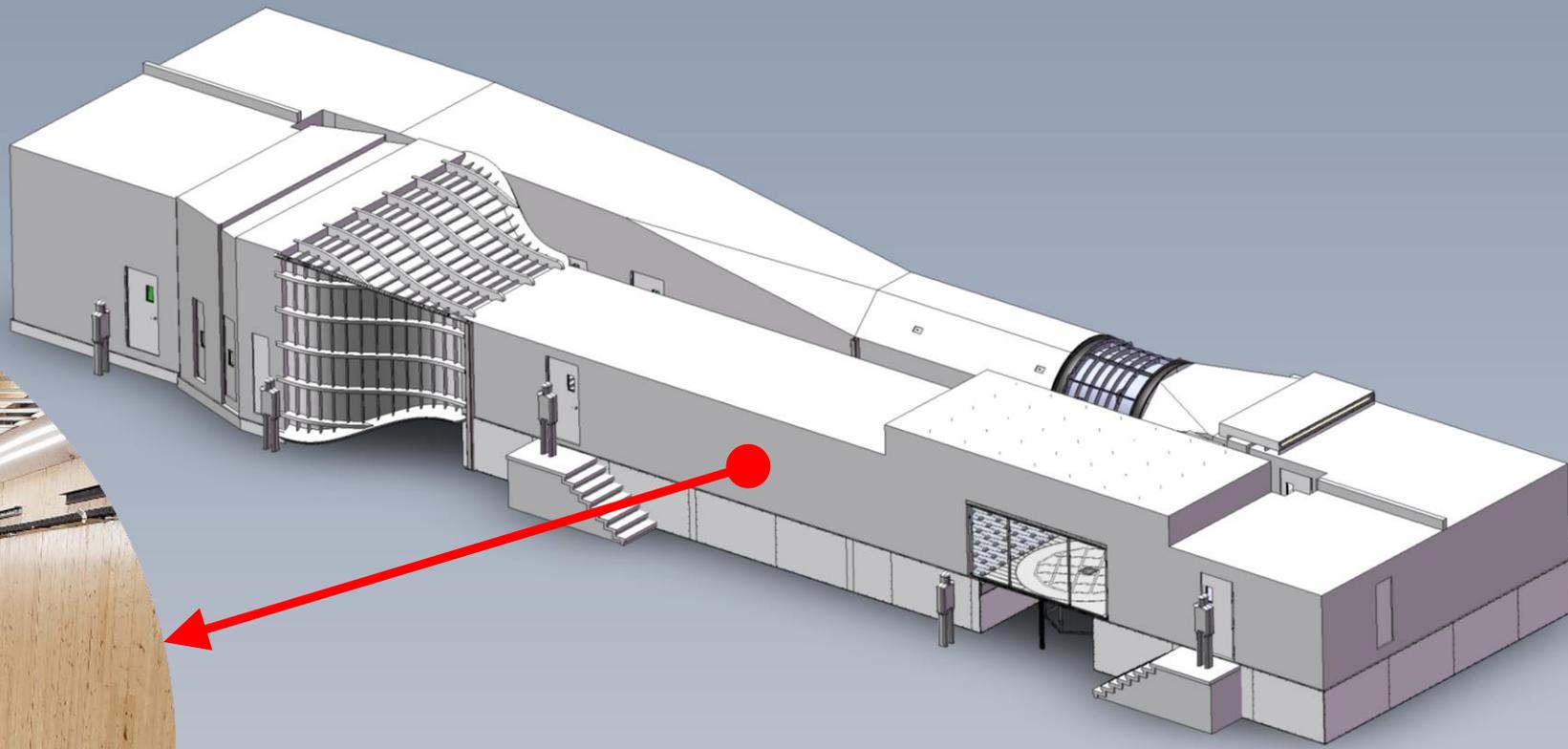
## ATMOSPHERIC BOUNDARY LAYER (ABL) WIND TUNNEL

# FAN



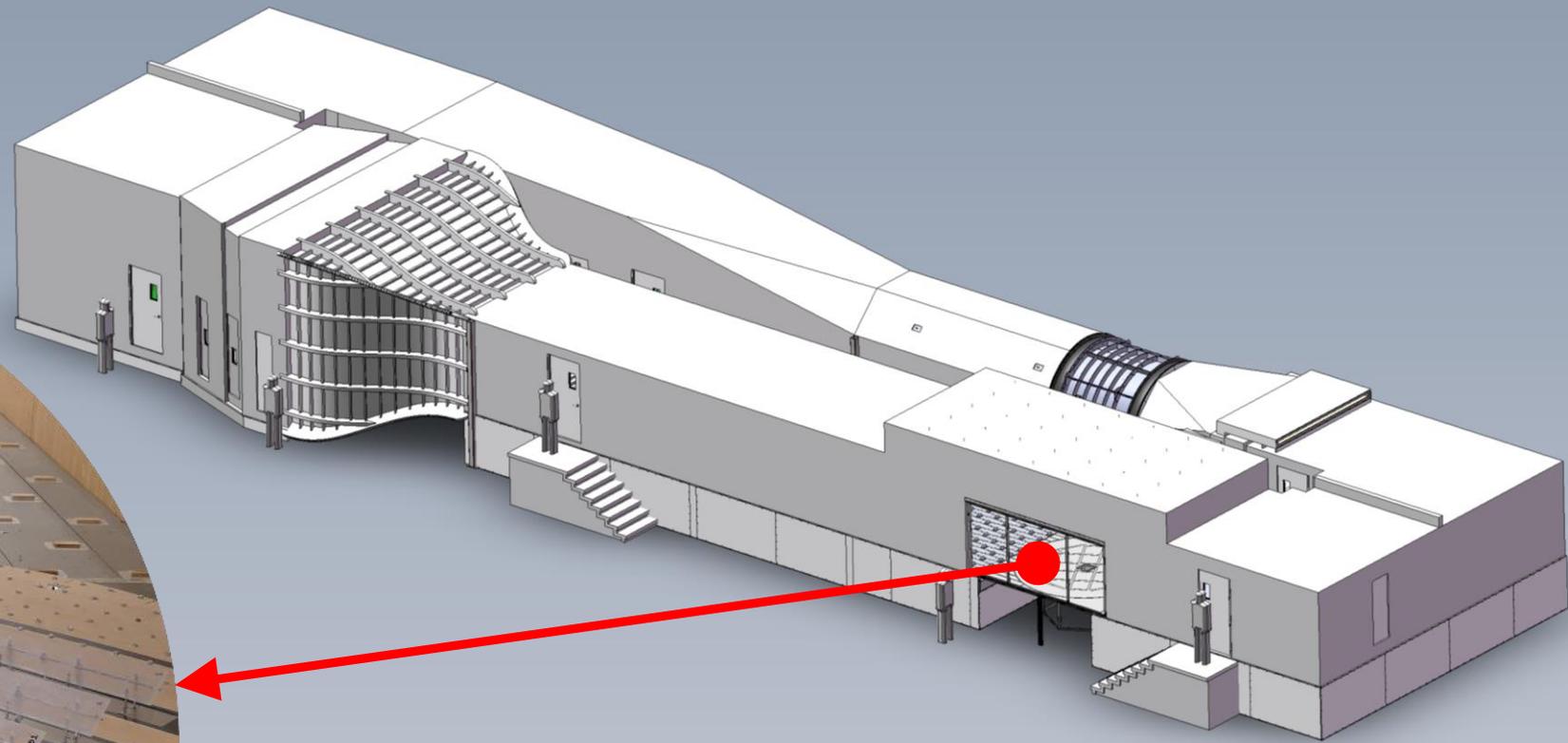
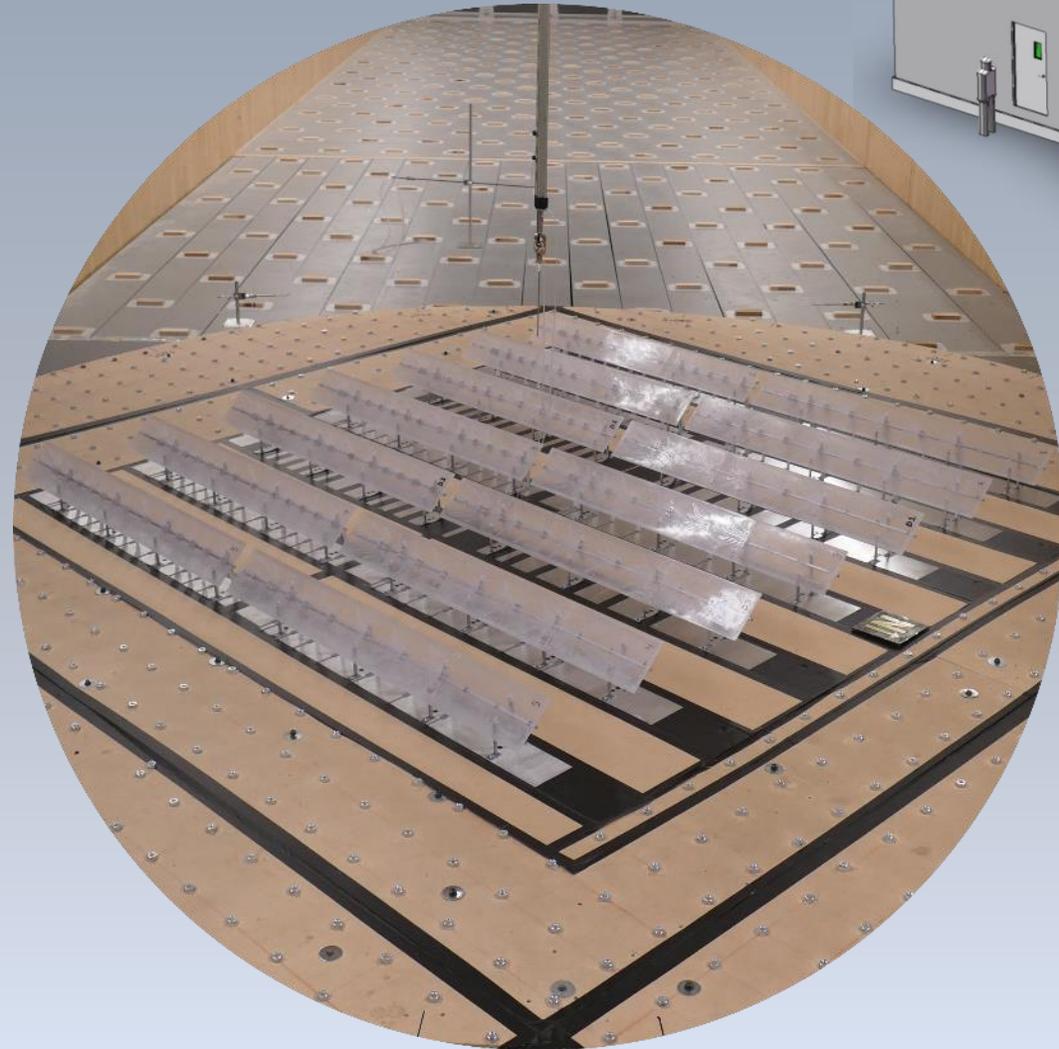
- GENERATES THE FLOW WITH MINIMAL TURBULENCE AND SWIRL
- TREATMENTS DOWNSTREAM FURTHER STRAIGHTEN THE FLOW AND REMOVE SIGNIFICANT TURBULENCE
- THE DESIRED GUSTINESS OF THE WIND IS ADDED FURTHER DOWNSTREAM

# TURBULENCE DEVELOPMENT

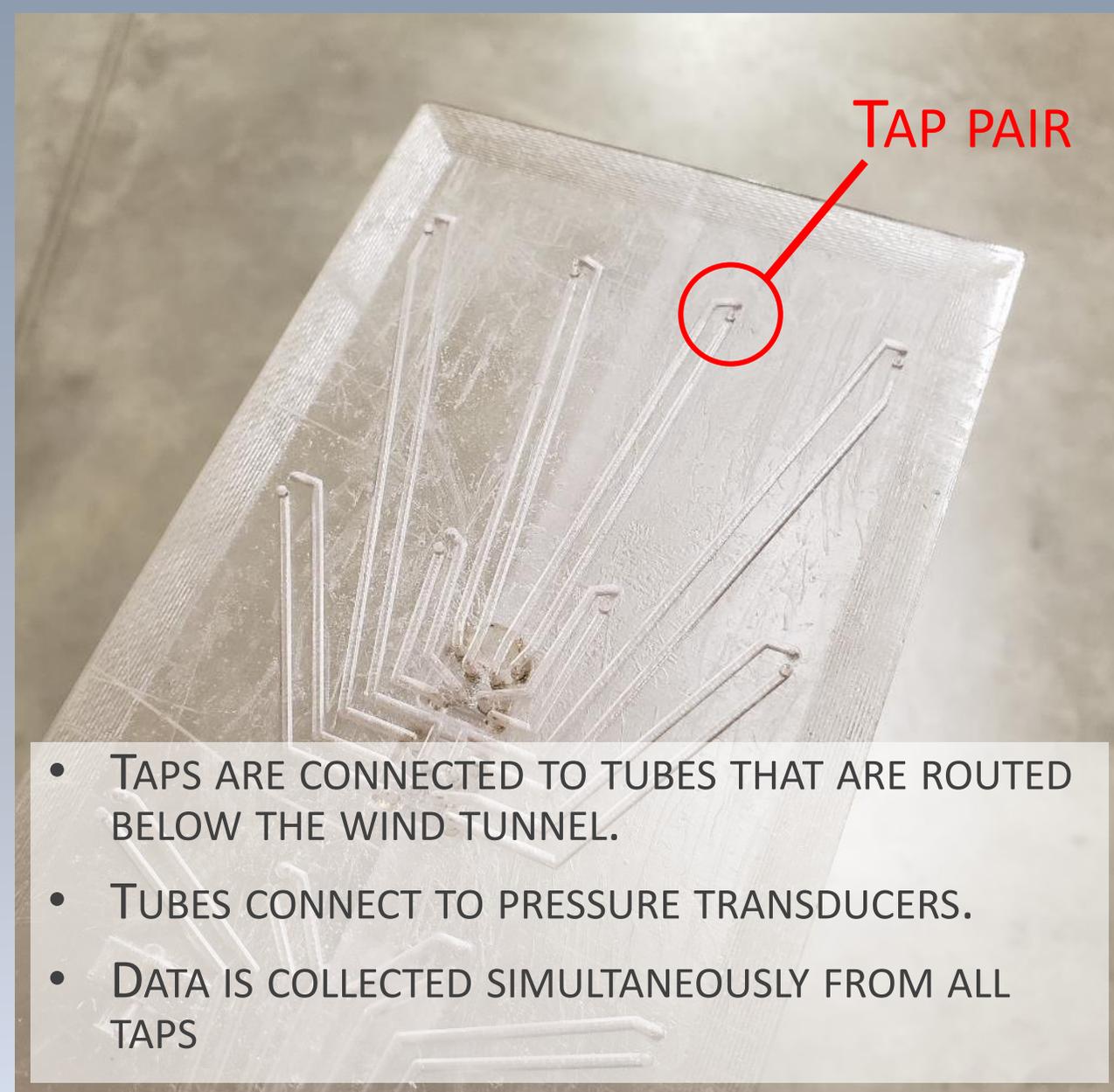


- WIND TUNNEL FLOW MUST SIMULATE THE GUSTINESS OF THE WIND AT MODEL SCALE
- THE SPIRES (LIGHT GRAY TRIANGLES), TRIP BOARD (DARK GRAY STRIP BEHIND SPIRES), AND ADJUSTABLE ROUGHNESS ELEMENTS ON THE FLOOR SIMULATE THE WIND AT MODEL SCALE

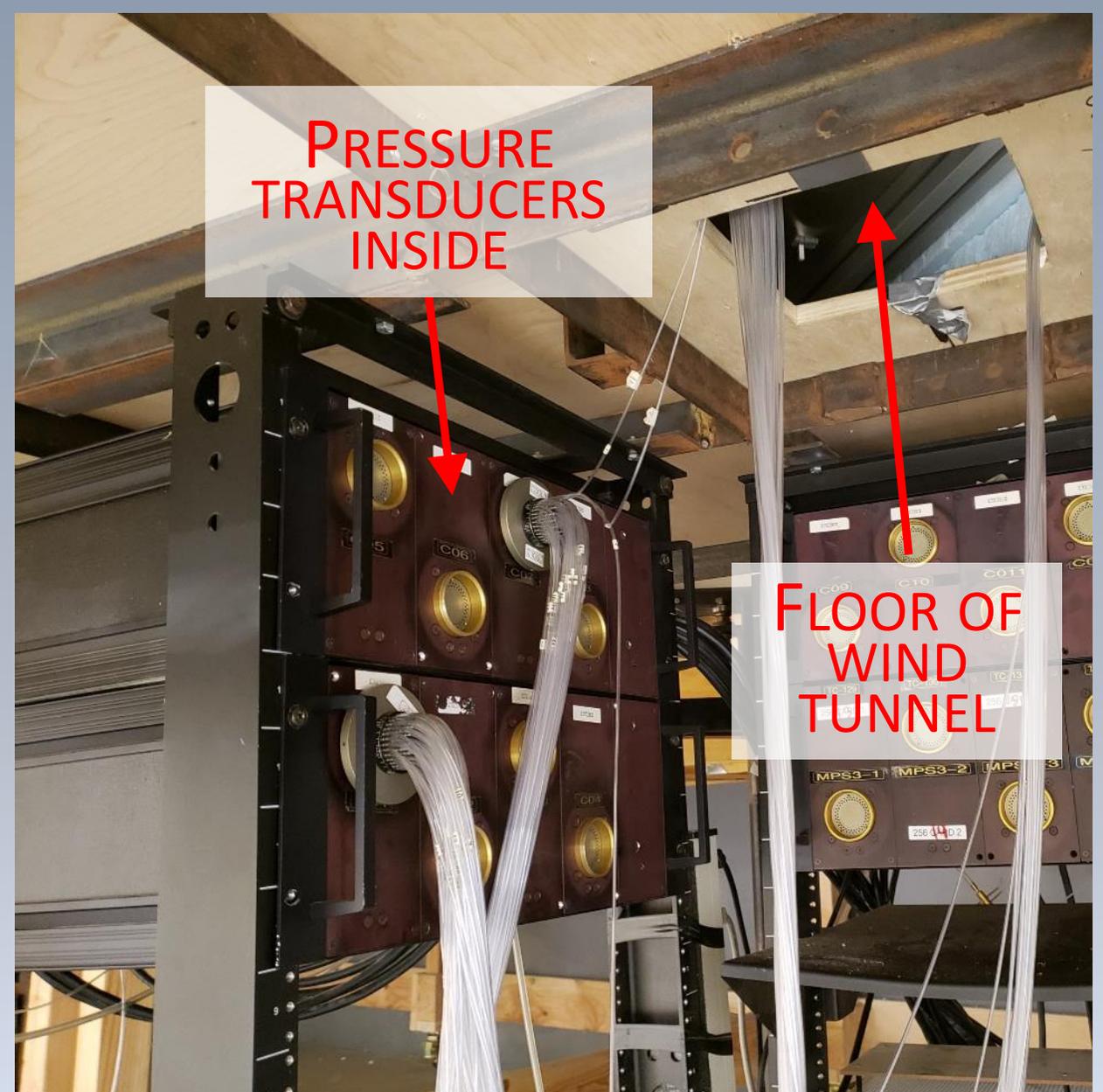
# TEST SECTION



- THE TEST MODEL IS MOUNTED ON A TURNTABLE TO SIMULATE WIND FROM ANY APPROACH DIRECTION
- A TYPICAL MODEL HAS SEVERAL HUNDRED PRESSURE MEASUREMENT LOCATIONS (TAPS) INTEGRATED INTO THE MODEL
- INSTRUMENTATION IS MOUNTED UNDER THE FLOOR OF THE WIND TUNNEL

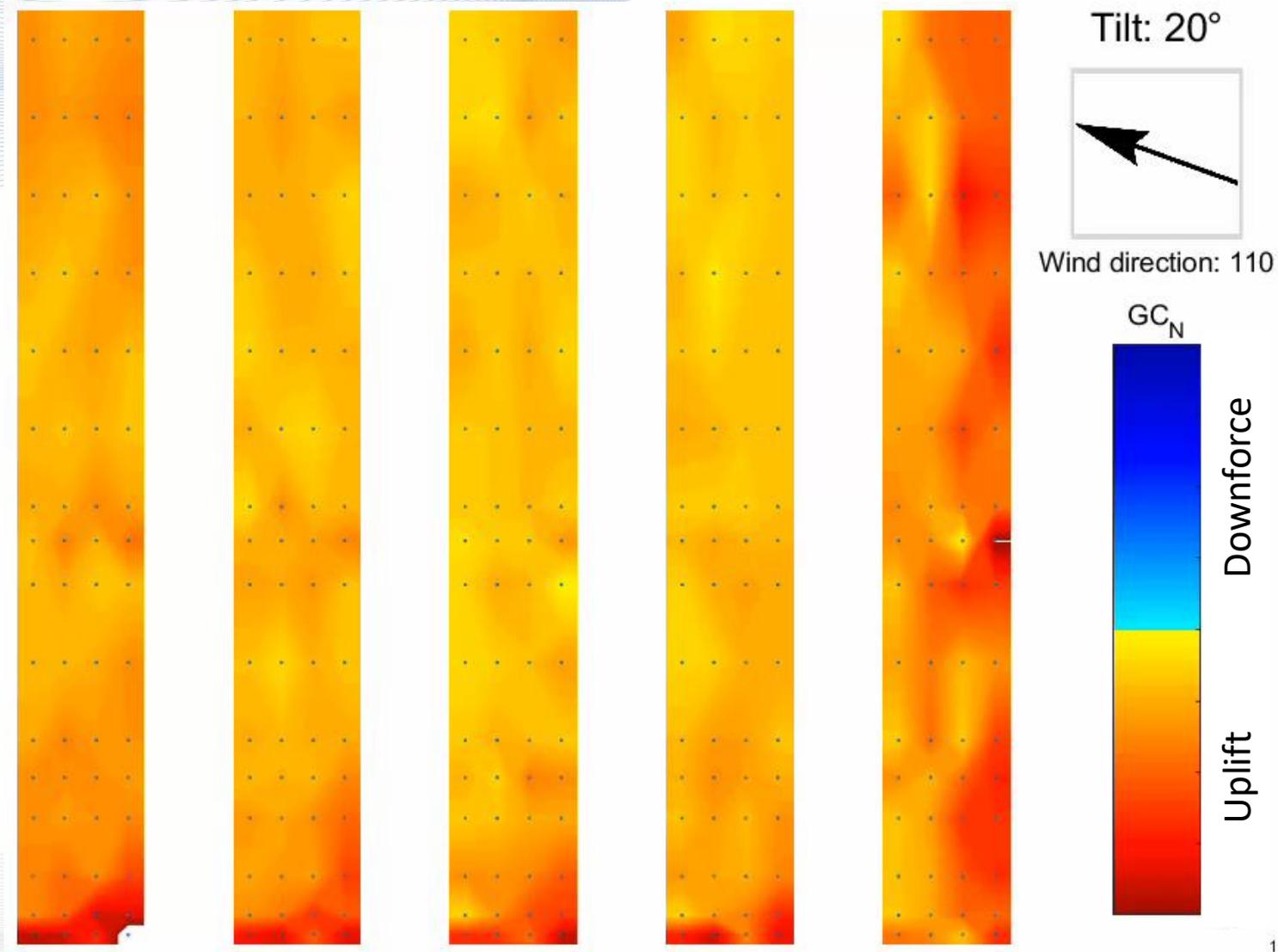


- TAPS ARE CONNECTED TO TUBES THAT ARE ROUTED BELOW THE WIND TUNNEL.
- TUBES CONNECT TO PRESSURE TRANSDUCERS.
- DATA IS COLLECTED SIMULTANEOUSLY FROM ALL TAPS



## INSTRUMENTATION

# FLUCTUATING PRESSURES



FIVE INSTRUMENTED ROWS OF SOLAR (LEADING EDGE UP)

# ANALYSIS

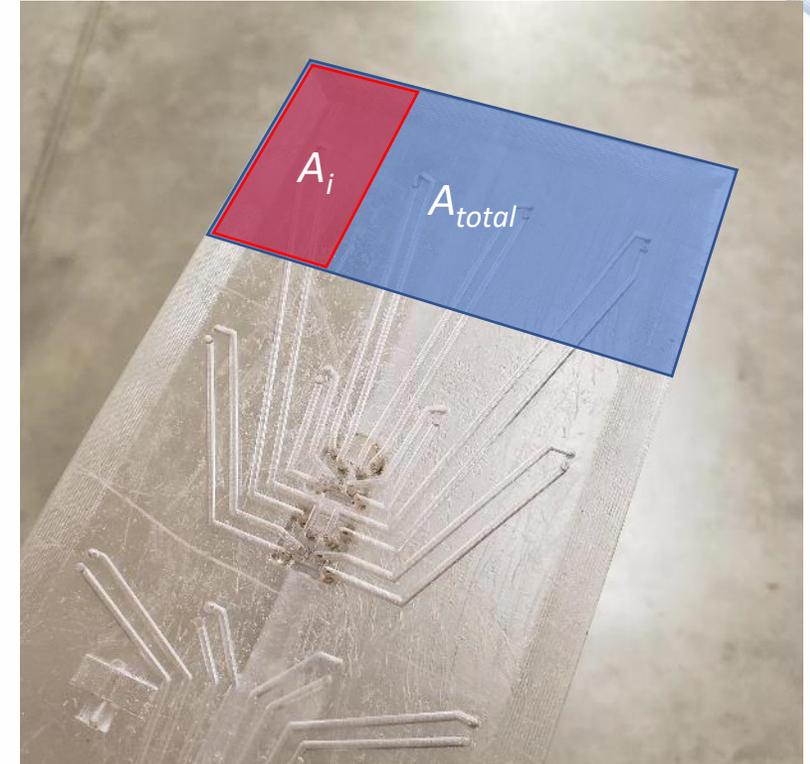
STARTING FROM A SIMULTANEOUS TIME SERIES OF ALL TAPS ON THE MODEL...

- EACH TAP PRESSURE TIME SERIES IS MULTIPLIED BY A WEIGHT ( $w$ ), AND WHEN SUMMED PRODUCES A TIME SERIES OF LOAD ON THE OBJECT OF INTEREST.

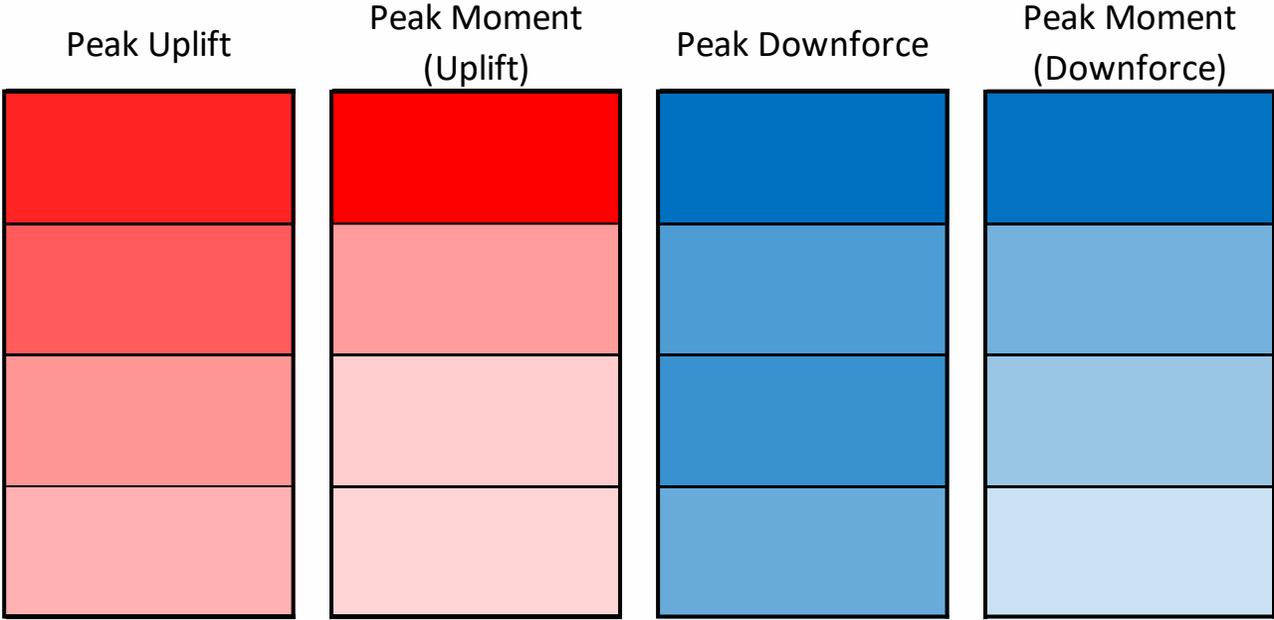
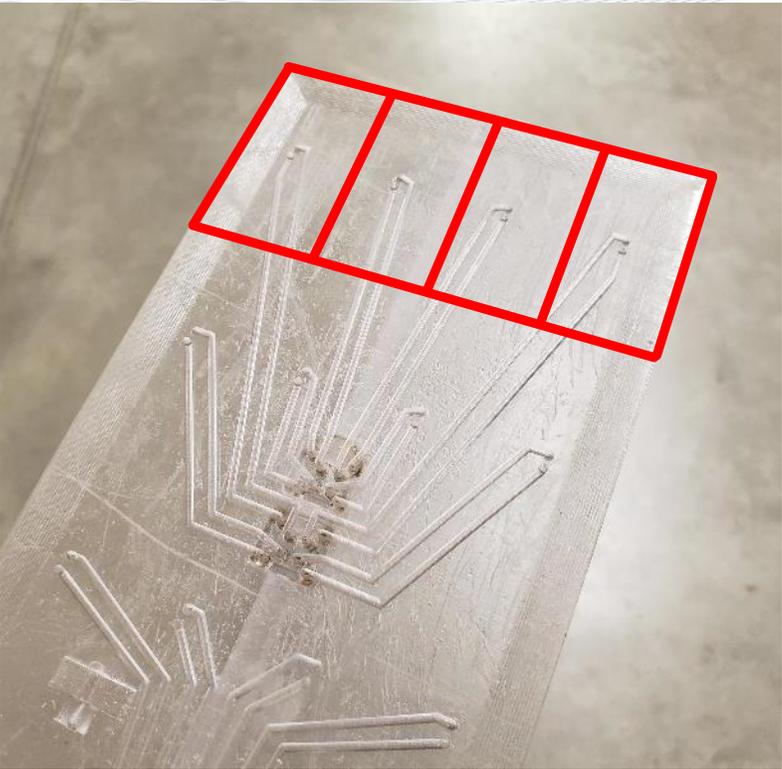
- FORCE: 
$$F(t) = \sum_{i=1}^{\# \text{ taps}} \frac{A_i}{A_{total}} \cdot p_i(t)$$

- MOMENT: 
$$M(t) = \sum_{i=1}^{\# \text{ taps}} \frac{A_i}{A_{total}} \cdot L_i \cdot p_i(t)$$

- FIND THE PEAK AND DIVIDE BY THE REFERENCE PRESSURE TO PRODUCE A COEFFICIENT
- LOAD CASE (AKA SNAPSHOT) IS THE INDIVIDUAL PRESSURES THAT PRODUCED THE PEAK LOAD



# QUALITATIVE RESULTS



TYPICAL MODULE LOAD CASES

(RED = UPLIFT NET PRESSURE; BLUE = DOWNFORCE NET PRESSURE)