Flow Quality Parameter Study
Low-Speed Regime Review

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WTCWG Face-to-Face Meeting
NASA Ames Research Center
Sept. 20-22, 2022

History

- Flow Quality Parameter Study was started to evaluate what wind tunnel flow parameters are important and how adequately we can measure them.

- The results of this study will help guide investments in test technology and capability advancement to maximize the effectiveness of new test hardware, instrumentation, training, etc.

Approach

- Each flow regime (low-speed, subsonic, supersonic, hypersonic) is treated separately, and each will get their own study.
- The study is broken up into two groups of ratings, importance and competence.
- The results are combined into a risk matrix with high importance and low competence being the most severe and high-risk possibility.

Approach - Importance

- Many combinations of test types and measurements are considered for each flow regime. The importance of flow angle uniformity for a semi-span test will be different than that for a rotorcraft acoustics test.

- Importance is rated on a simple scale of 1-3 (3 being the most important). The resolution was originally 1-5 but 1-3 showed adequate results and is simpler.

- The importance ratings for all test types are averaged to arrive at a single value of how important a given measurement is.

Approach - Competence

- Competence of each of four categories for a given flow quality parameter is collected:
  - Are we applying state of the art?
    - You can think of this as how well are "you" applying it at your facility(s) or your estimate of how well everyone is applying it.
  - How capable is state of the art?
  - Ease/difficulty of use
  - Expertise

- Competence is subjective and requires as much feedback from as many wind tunnel users as possible.

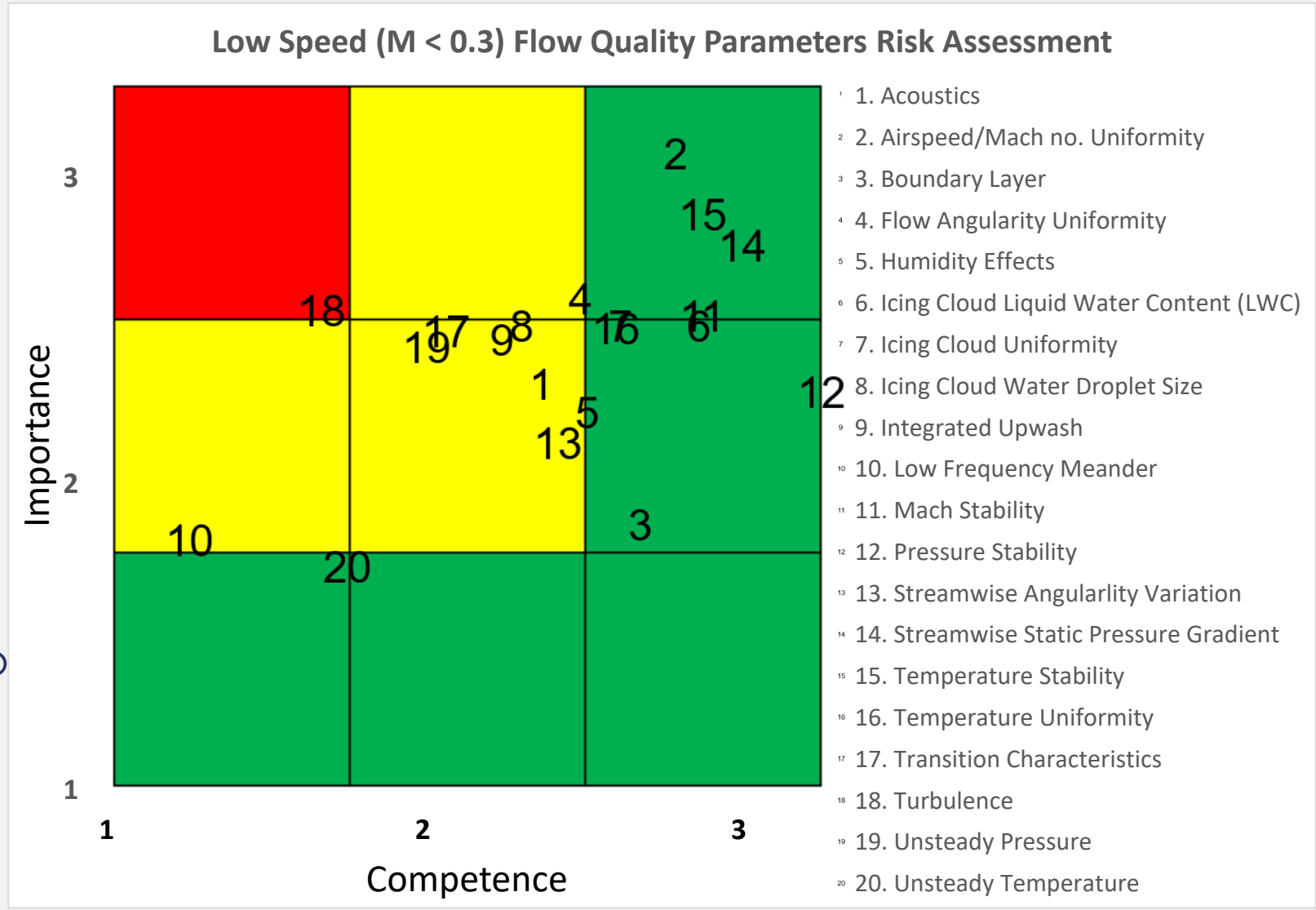
Current Results

- Eight sets of ratings for the low-speed regime (M<0.3) have already been collected and reduced. Ideally, we would have more ratings than this.
- The average competency and importance are tabulated to the right.

Low Speed Competency		Low Speed Importance	
1. Acoustics	2.42	Acoustics	2.05
2. Airspeed/Mach no. Uniformity	2.58	Airspeed/Mach no. Uniformity	2.89
3. Boundary Layer	2.88	Boundary Layer	2.25
4. Effects of Bleed		Effects of Bleed	
4. Flow Angularity Uniformity	2.33	Flow Angularity Uniformity	2.34
5. Humidity Effects	2.75	Humidity Effects	2.25
6. Icing Cloud Liquid Water Content (LWC)	3.00	Icing Cloud Liquid Water Content (LWC)	3.00
7. Icing Cloud Uniformity	2.75	Icing Cloud Uniformity	3.00
8. Icing Cloud Water Droplet Size	2.13	Icing Cloud Water Droplet Size	3.00
9. Integrated Upwash	3.00	Integrated Upwash	2.20
10. Low Frequency Meander	1.00	Low Frequency Meander	1.67
11. Mach Stability	3.00	Mach Stability	2.50
Model Blockage Effects	3.00	Model Blockage Effects	
12. Pressure Stability	3.00	Pressure Stability	1.50
Pressure Uniformity		Pressure Uniformity	2.80
13. Streamwise Angularlity Variation	2.17	Steamwise Angularity Variation	1.67
14. Streamwise Static Pressure Gradient	2.75	Streamwise Static Pressure Gradient	2.79
15. Temperature Stability	3.00	Temperature Stability	2.50
16. Temperature Uniformity	2.33	Temperature Uniformity	2.16
17. Transition Characteristics	2.08	Transition Characteristics	2.28
18. Turbulence	1.50	Turbulence	2.34
19. Unsteady Pressure	1.75	Unsteady Pressure	2.23
20. Unsteady Temperature	1.50	Unsteady Temperature	1.18

Current Results

- Example risk matrix for the low-speed regime
- Shows parameters 17-transition characteristics, 18-Turbulence, and 19-Unsteady Pressure are the highest risk
- The turbulence related metrics were expected to be the highest risk. How do we improve our unsteady measurements?



Review

- What is the working group's opinion on the format and current results?
- Are there any suggested changes?
- Some feedback from research suggested we reduce the number of parameters.
- What changes are needed to review the subsonic regime (0.3<Mach<0.8)?

Questions?

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Parameters

Flow Uniformity	Airspeed/Mach no. Uniformity Pressure Uniformity Streamwise Static Pressure Gradient Temperature Uniformity Flow Angularity Uniformity Streamwise Angularity Variation Integrated Upwash
Flow Stability	Unsteady Pressure Unsteady Temperature Low Frequency Meander Pressure Stability Mach Stability Temperature Stability
High Frequency Parameters	Turbulence Acoustics Transition Characteristics
Contaminations / Impurities	Humidity Effects Particulates Air Liquefaction
Test Section Characteristics	Boundary Layer Model Blockage Effects Effects of Bleed
Icing	Icing Cloud Uniformity Icing Cloud Liquid Water Content (LWC) Icing Cloud Water Droplet Size

Test Types

Force and Moment – Drag	Propulsion system acoustics (emissions)
Force and Moment - high-lift	Propulsion System Aeromechanical Performance
High alpha/Post-stall maneuvering	Thrust vectoring
Powered lift	Jet Effects Interactions
Landing gear aerodynamics	Store Separation
Decelerator testing (parachutes)	Aircraft Icing
Weapons Bay/Cavity Acoustics	Aircraft Icing - certification testing
Air data probe	Rotorcraft – performance
Laminar flow testing	Rotorcraft – acoustics
Airframe Integration	Rotorcraft – icing
Boundary Layer transition	Launch Vehicles – lift-off transition
Reynolds number effects	Launch Vehicle - transition to High Speed
Flutter	Launch Vehicles – ground loads
Stability and Control	Launch Vehicles – launch abort/stage separation
Semi-span	Launch Vehicle – jet interactions
Propulsion-Airframe Integration	Building Loads
Inlet Performance	CFD Validation
Propulsion system performance	

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Test Types	Pressure Uniformity	Unsteady Pressure	Acoustics	Temperature Uniformity	Unsteady Temperature	Flow Angularity Uniformity	Airspeed/Mach no. Uniformity	Turbulence	Integrated Upwash	Streamwise Static Pressure Gradient	Streamwise Angularity Variation	Transition Characteristics	Icing Cloud Uniformity	Icing Cloud Liquid Water Content (LWC)	Icing Cloud Water Droplet Size	Low Frequency Meander	Reynolds Number	Pressure Stability	Mach Stability	Model Blockage Effects	Humidity Effects	Effects of Bleed	Boundary Layer	Temperature Stability	Notes
Force and Moment – Drag																									
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CFD Validation																									
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		Flow Uniformity								Flow Stablilty								High-Frequency Parameters				Contamination or Impurities				Test Section Characteristics				Icing Cloud Characteristics			
Competency Rating Elements		Airspeed/Mach no. Uniformity	Pressure Uniformity	Streamwise Static Pressure Gradient	Temperature Uniformity	Flow Angularity Uniformity	Streamwise Angularity Variation	Integrated Upwash		Unsteady Pressure	Unsteady Temperature	Low Frequency Meander	Pressure Stability	Mach Stability	Temperature Stability			Turbulence	Acoustics	Transition Characteristics		Humidity Effects	Particulates	Air Liquefaction		Boundary Layer Model Blockage Effects	Effects of Bleed			Icing Cloud Uniformity	Icing Cloud Liquid Water Content (LWC)	Icing Cloud Water Droplet Size	
User 1																																	
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State of Measurement Hardware																																	
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