Advance Noise Control Fan II Test Rig Fan Risk Management Study

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Background Information

- Since 1995 the Advanced Noise Control Fan (ANCF) has significantly contributed to the advancement of the understanding of the physics of fan ***tonal*** noise generation.

  • The 9’x15’ WT has successfully tested multiple high speed fan designs over the last several decades.

  •This advanced several tone noise reduction concepts to higher TRL and the validation of fan tone noise prediction codes

Current GRC Facilities

Capabilities of current GRC Fan Noise Test Facilities

- ANCF @ AAPL (TRL 2-3) :

  Low speed / ultra-low pressure rise / unique acoustic measurements / limited aero measurements / high flexibility / parametric studies / low cost

- UHB @ 9x15 LSWT (TRL 4-5):

  High speed / pressure rise / aero & performance measurements / acoustic measurements w caveats / forward flight effects / point design / high cost

- W8 (TRL 4):

  High speed / pressure rise / aero & performance measurements / moderate costs

Background Information

NEED:

A new Fan Test Rig to bridge from TRL 3 to 5 enabling the successful completion of NASA/Industry noise reduction program goals.

Test Rig Requirements

What would it look like?

(High level design requirements)

- All electric drive to minimize external support ($) (consider alternatives)
  - Minimize component noise level (initial metric > 20? dB below WT)

- Tested designs transferable to 9x15 WT - 22” fan diameter*
  - (suggested actual hardware a plus)

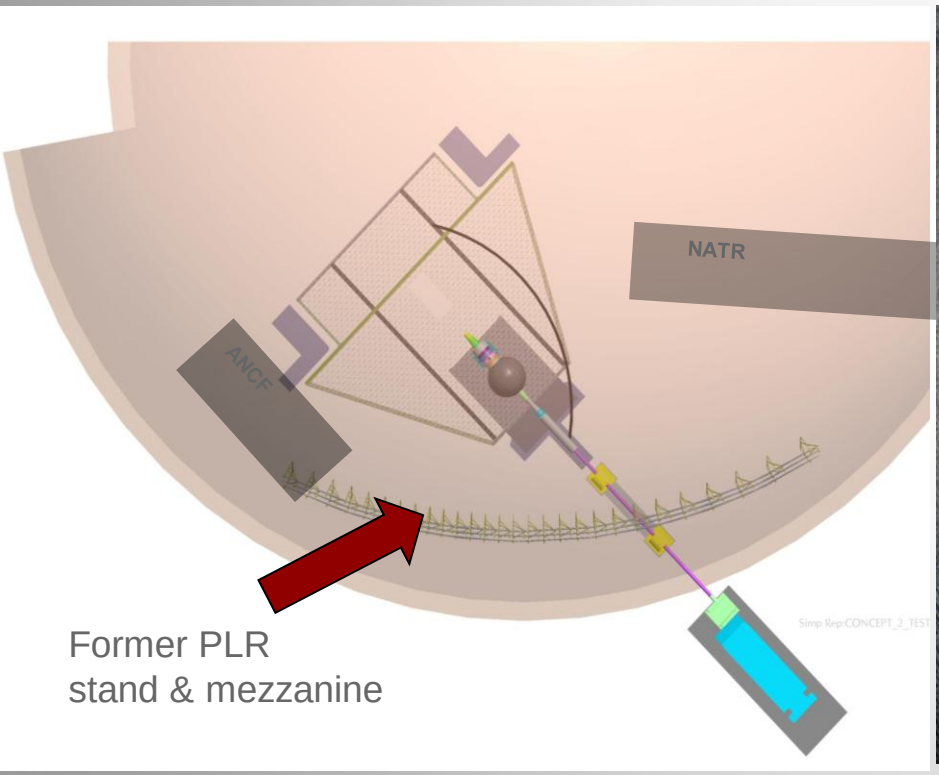
- Maintain current measurement capabilities.
  - Far field, in-duct, wall pressures, flow diagnostics, aero-performance

- Sited in AAPL - Minimal impact on existing rigs
  - Ambient temperature conditions

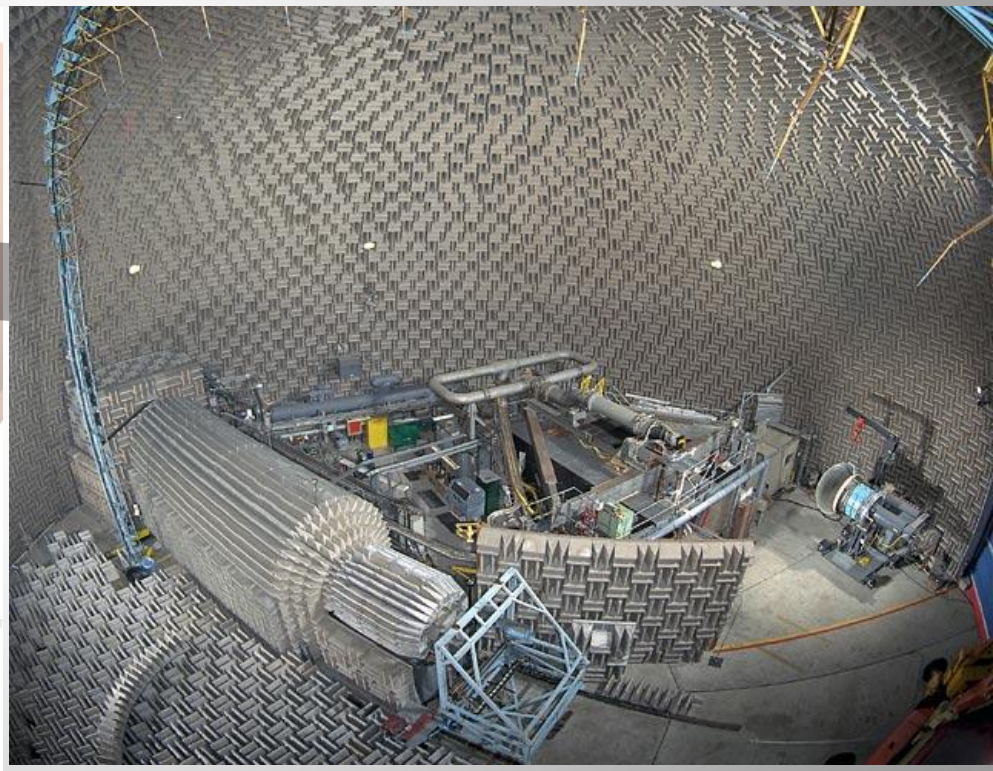
- Static - no external flow lines to complicate / no forward flight effects

ANCF II Location in AAPL

Proposed location of the new test rig with respect to current facility layout.



Former PLR
stand & mezzanine



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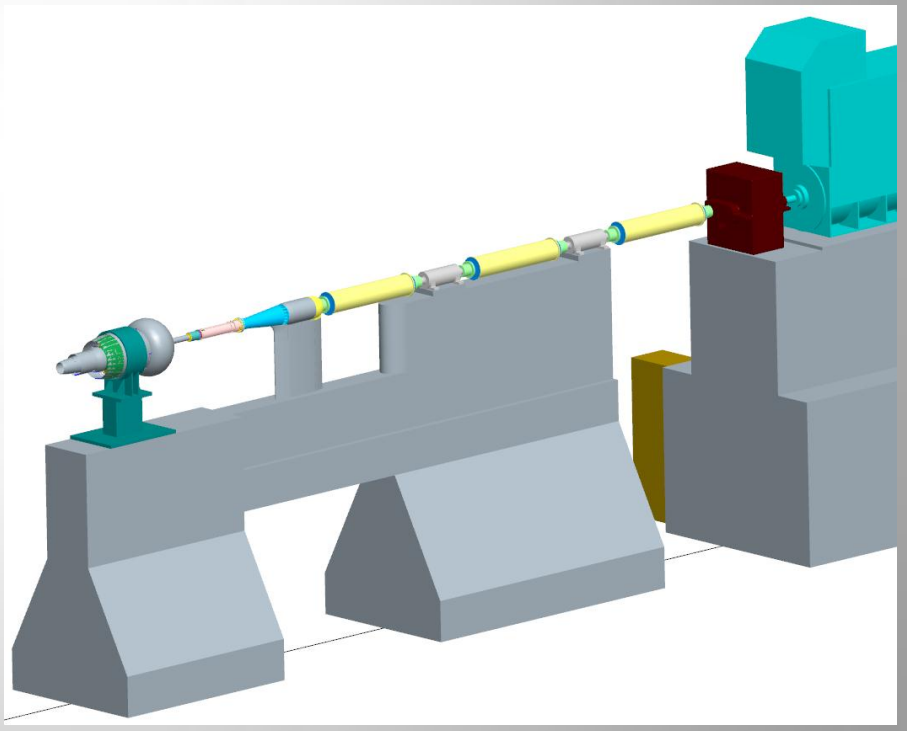
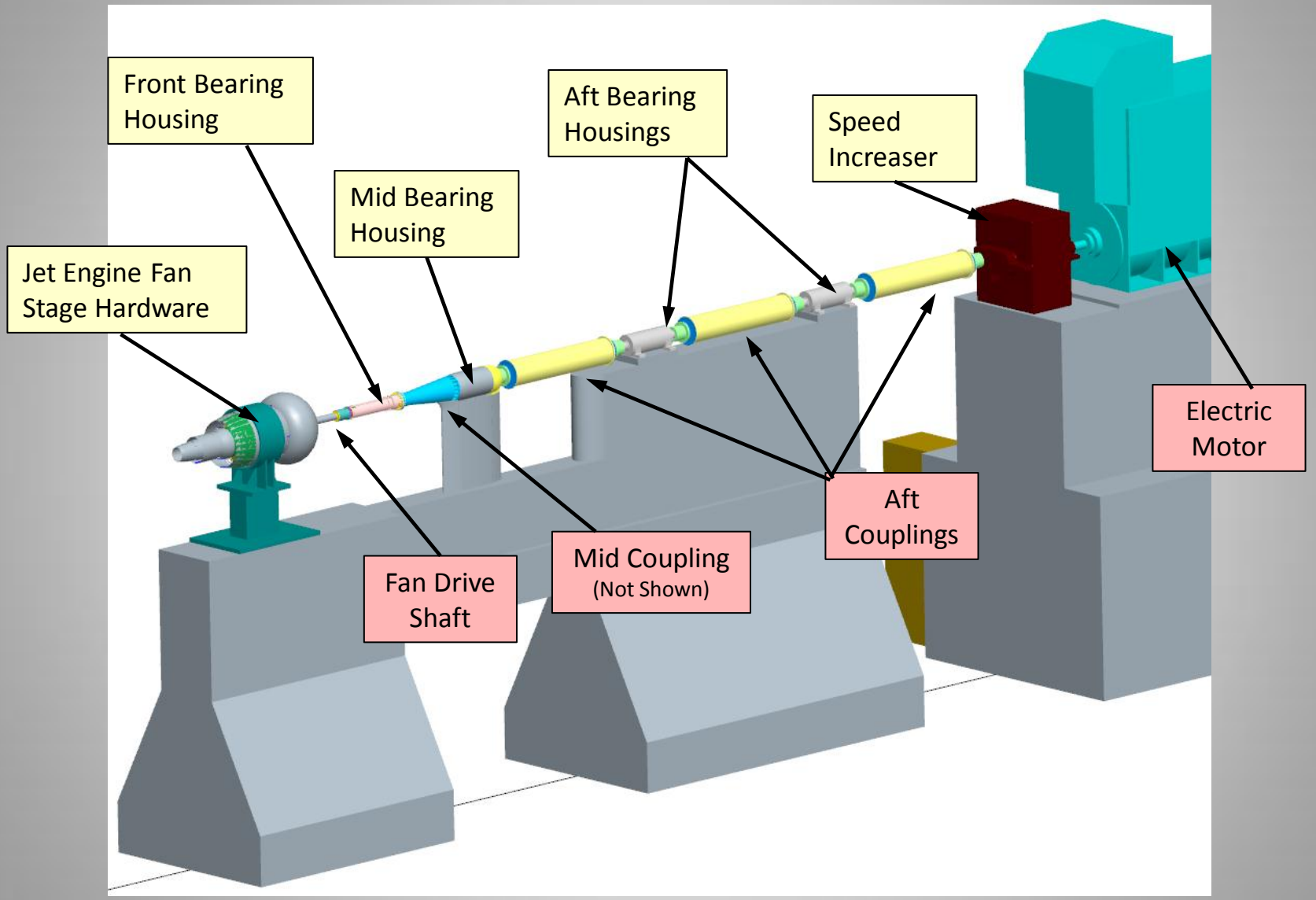
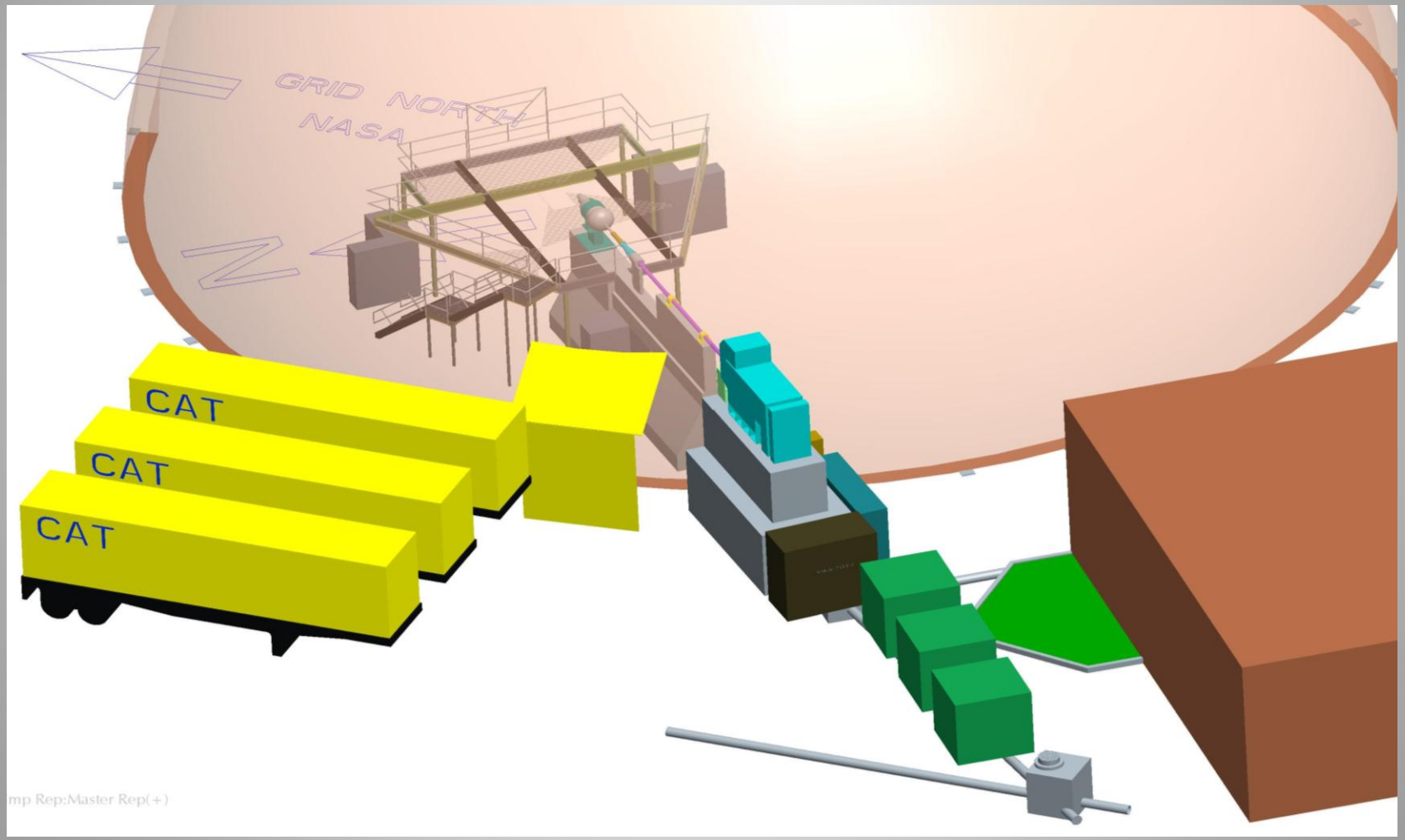


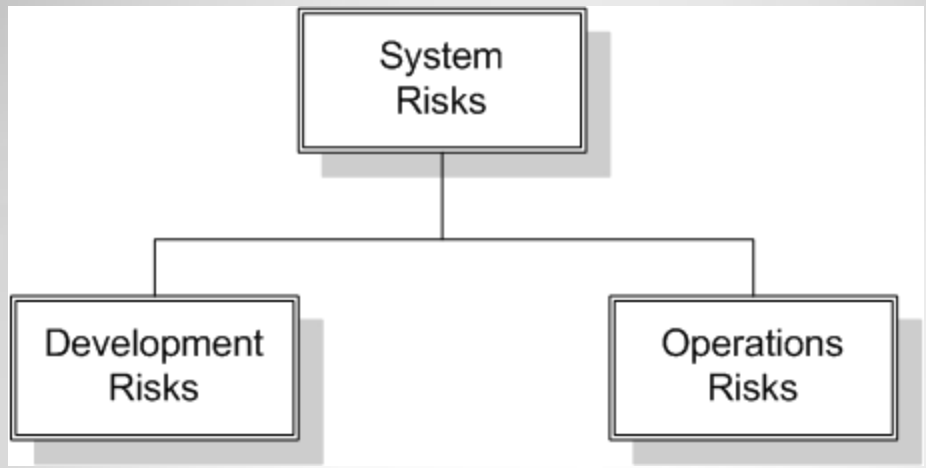
Front Driven Fan- Test Rig Overview



Objective: Identify, prioritize and manage risks



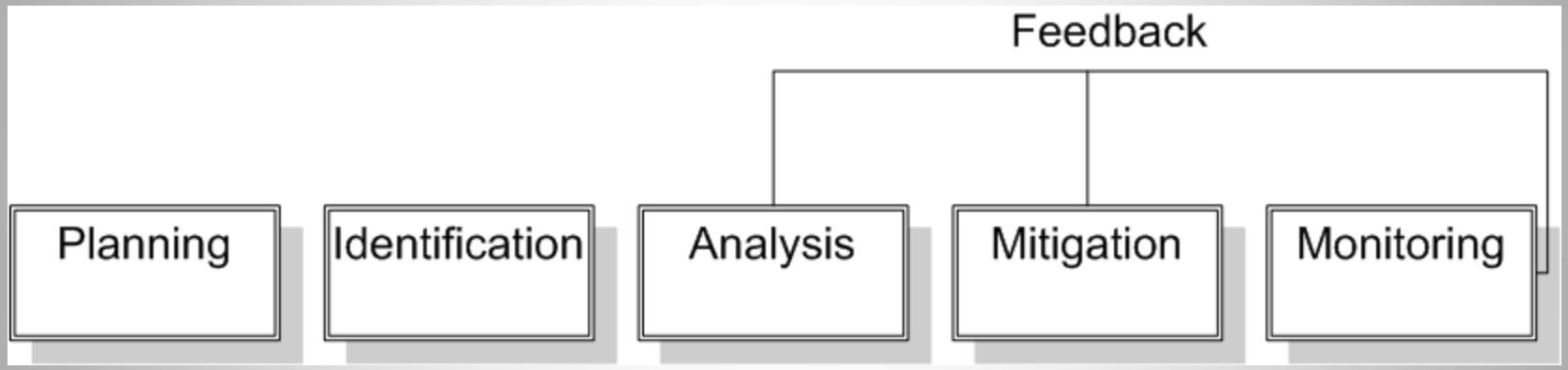
Risk Management



- Programmatic Risks
- Technical Risks
- Schedule Risks
- Cost Risks

- Failure Risks
- Safety Risks
- Supportability Risks
- Environmental Risks

Risk Management Sequence



Work Area Description	Issue(s)	FY12 Status	FY 13 Objective
Project Management			
Coordinate Risk Reduction design development efforts	Current design has options that must be reviewed	High risk items identified	Develop design solution for high risk areas
Detailed Work Plan Development	Funding limitations for FY13, resource planning and estimated costs	Elements of work plan exist, but need to be updated and organized	Improved fidelity of work plan required
PDR Request for Actions	PDR closure required	PDR action items identified	Resolve all open PDR Action Items
Systems Engineering			
Update Requirements Document (baseline)	Requirements document needs to be baselined for PDR completion	Requirements Document draft complete	Update Requirements Document and baseline for PDR closure
Update Risk Mitigation Plan	High risk design development tasks have been identified and need to be documented	Risk Mitigation Plan draft complete	Update Risk Mitigation Plan and baseline for PDR closure
Update ANCF II Interface Control Document	UHB Drive Rig interfaces with ANCF II test hardware MUST be maintained for desired capability to test on both rigs	Interface Control features identified	Develop a draft document that controls interface features, and references common capabilities
Update Concept of Operations plan (baseline)	The planned operation of a test rig can help drive some design requirements	A significant amount of operations input has been gathered from 9x15 and Dome test engineering teams	Complete a Concept of Operations Plan and baseline for PDR

Risk Management Approach

1. Conduct risk brainstorming session
2. Identify top ten risks
3. Summarize each risk on Risk Capture Form
4. Analyze risks through Risk Analysis Form
5. Develop ordinal scales and score on Risk Matrix
6. Prepare Risk Mitigation Plan
7. Incorporate business rhythm for risk management
8. Update Risk Mitigation Plan as circumstances warrant

Top Identified Risks

1. Low experience powering fan from front
2. Front drive passes through ICD
3. Aft drive requires reconfiguration from baseline
4. Simultaneous data from front and aft
5. Fan exhaust damage
6. Fan exhaust data
7. Gear Box Noise
8. Conditioned Inlet Flow Interference
9. Gear Box Delivery
10. Fan Drive Bearing System
11. Fan Drive Shaft System

Example - Risk: R.1a Summary Report

Open Date: 04/03/2012 Status as of

Risk Title: Low experience powering fan from front. **Escalation Level:** **Phase(s):** PDR	**Owning Requirement:AR1** **Risk Owner: Shook**

Risk Statement:

Given that the experience level for providing power to the front of the fan is low, the chance of unseen technical issues is greater.

Context:

Engineering Risk

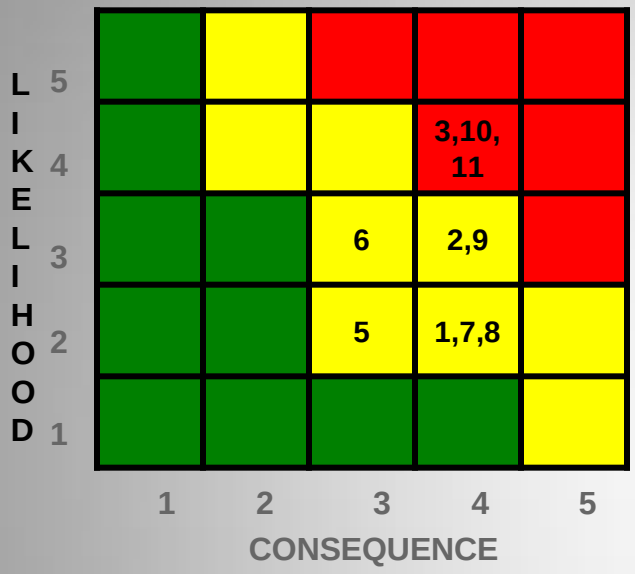
Likelihood: 2

Consequence - Safe: 0 **Perf: 2** **Sched: 4**
Cost: 3

Status: Open, risk has been identified and no mitigation defined.

ANCF II Top Risk List

April 10, 2012



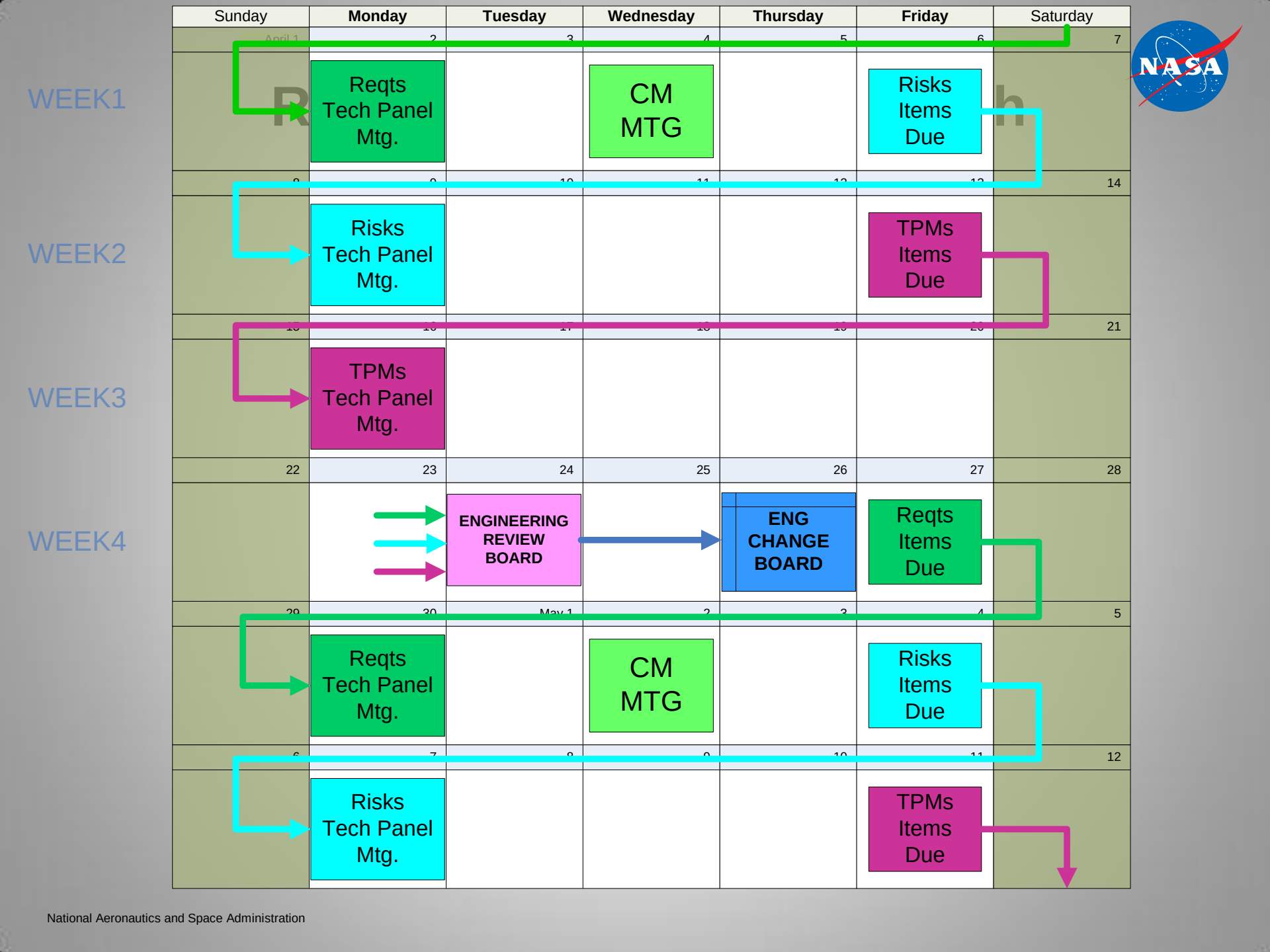
Legend

- Decreasing (Improving)
- Increasing (Worsening)
- Unchanged
- $ Cost Threat (Level 1, 2, 3)

Rank	Trend	Title	Owning Team	LIKE	Consequence			
					SAFE	PERF	SCH	COST
	→			3	0	0	3	0
CANDIDATE RISKS								
	→	1- Low experience powering fan from front.	Des.	2	0	2	4	3
	→	2- Front drive passes through ICD	Des.	3	0	4	4	4
	→	3- Aft Drive requires Reconfiguration from Baseline Design	Des.	4	0	3	2	4
	→	4-Simultaneous Data from front and aft	Res.					
	→	5-Fan Exhaust Damage	Des.	2	3	0	3	3
	→	6-Fan Exhaust Data	Des.	3	0	3	3	3
	→	7-Gearbox Noise Level	Des.	2	1	3	4	3
	→	8-Gearbox Conditioned Inlet Air Flow Interference	Des.	2	0	3	4	3
	→	9-Gearbox Delivery Schedule	Des.	3	0	0	4	4
	→	10- Fan Drive Bearing System	Des.	3	1	4	2	3
	→	11 – Fan Drive Shaft system	Des.	2	1	4	3	2
ASSOCIATED RISKS								
	→							
	→							
	→							
	→							

Fan Drive System

Work Area	Issue	FY12 Status	FY13 Objective	FY13 Status
Fan Drive (facility)	Long drive system at high speed, potential vibration problems	Preliminary design is complete and component level calculation satisfy mechanical requirements	Further develop the test facility drive design and complete detailed component and system mechanical analysis	Commercial vendors are supporting further development of the facility drive design, and analytical models are being used at component level to look at static and dynamic capabilities to meet design requirements; 25% complete
Fan Drive Shaft (mechanical)	Small diameter(3 in), 4 ft long, and rigid	Preliminary design is complete and component level calculation satisfy mechanical requirements, shaft proto-type made	Further develop Fan Drive Shaft design to eliminate any manufacturing or performance risks	Proto-type Fan Drive Shaft design based on performance requirements has been built, balanced and verification testing planned; 75% complete
Fan Drive Shaft Verification Tests	Analytical estimates need verified	Manufactured a proto-type Fan Drive Shaft, in-house technical support identified, and basic plans defined	Verification of Fan Drive Shaft design	Preparation for verification tests on proto-type shaft are nearly complete, with tests and documentation to follow; 75% complete
Fan Drive Shaft (aero)	Need better understanding of shaft impact on aero-acoustics in front drive configuration	Initial discussions with aero-acoustic contractors about our concerns	Confirm that final shaft design meets Research criteria/requirements	Provided aero analyst contractor SOW for evaluation of shaft design to determine aero impact on front fan drive; 25% complete
Fan Support Bearing Housing	High speed, high thrust loads, limited space, limited lube access	Detailed evaluation of greased packed rolling bearings shows sever limits on performance	Identify a Fan Shaft bearing alternative to grease packed rolling bearing option	Identified bearing options and their performance capabilities; conduct a study based on weighted criteria to select design solution; 100% complete
Fan Support Bearing System Prototype	Need to better understand commercial part limitations/options	Several bearing vendors and NASA experts have been consulted	Develop a Fan Shaft Bearing system that meets critical performance requirements with	Bearing study has been completed and a type/vendor selected; NASA team will work with vendor to develop proto-type design to test Fan Shaft Support bearing system performance; cost estimate is


Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
WEEK1
WEEK2
WEEK3
WEEK4
Reqts Tech Panel Mtg.
CM MTG
Risks Items Due
Risks Tech Panel Mtg.
TPMs Items Due
TPMs Tech Panel Mtg.
ENGINEERING REVIEW BOARD
ENG CHANGE BOARD
Reqts Items Due
Reqts Tech Panel Mtg.
CM MTG
Risks Items Due
Risks Tech Panel Mtg.
TPMs Items Due

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Summary

Have we addressed these basic concerns?

- Risk monitoring must be tailored to project needs
  - Integrate into Schedule
  - Track critical path in frequent management meetings
  - Update schedules accordingly
- Periodic Assessment
  - Discuss frequently in meetings
  - Update risk level as needed and monitor closely
  - Review prioritization accordingly by Team Leads
- Rigorous Risk Identification
  - Unidentified risks are show stoppers
  - Unidentified risks unmanageable
  - Use external peer review

Summary

- Most failures traced to original proposal
  - Minimize risk in proposal stage
  - Cost and Schedule dreams
- Programmatic interfaces
  - External risk is outside our control
  - It's their problem not mine
  - Review prioritization accordingly by Team Leads
- Risk management consists of:
  - Contingency (unknown- unknown)
  - Engineering margins (known-unknown)
  - Reserves (unknown cost unknown)