

# Facility Condition Assessment of The National High Magnetic Field Laboratory

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# NATIONAL MAGLAB

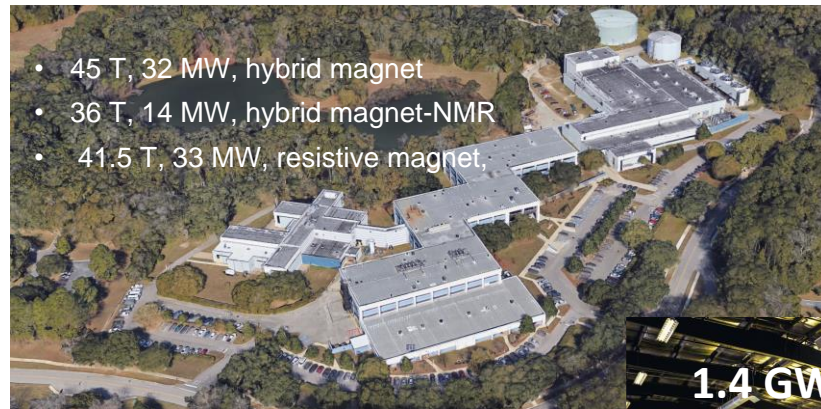


3 Sites  
7 User Facilities  
500,000 square feet

- 45 T, 32 MW, hybrid magnet
- 36 T, 14 MW, hybrid magnet-NMR
- 41.5 T, 33 MW, resistive magnet



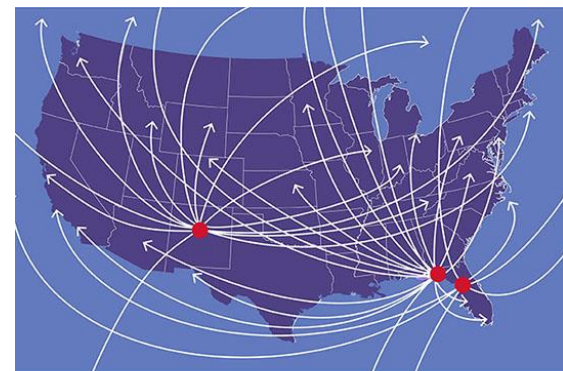
FLORIDA STATE  
UNIVERSITY



## 1.4 GW GENERATOR



- 100 T, Multi-Shot Pulse Magnet
- 60 T, Long Pulse







# AEROSPACE



## ELECTRONICS AND SENSORS

- Microelectronics
- Analog and digital electronics
- Power systems
- Parts, materials, and processes
- Sensor engineering and exploitation
- Data analytics and Multi-INT fusion
- Sensor prototype development
- Optical sensors
- Radar systems
- Electronics survivability systems engineering

## INFORMATION SYSTEMS AND CYBER

- Computer technology
- Data science
- Software engineering
- Software assurance
- Software systems acquisition
- Ground and flight systems
- Cybersecurity

## COMMUNICATION TECHNOLOGIES AND ENGINEERING

- Architectures
- Network systems
- Spacecraft payloads
- Digital signal processing
- RF electronics
- Antennas/ground systems
- Optical communications
- Wireless communications
- Machine learning for digital communications systems
- Spectrum management
- GPS signals and reception
- Geolocation
- Cryptography

## VEHICLE SYSTEMS

- Guidance, navigation, and control
- Embedded systems
- Flight mechanics
- Fluid dynamics
- Propulsion
- Thermal control
- Structures and mechanisms
- Ordnance
- Dynamic loads and environments
- Vehicle engineering

## SYSTEMS ENGINEERING

- Architecting
- Modeling and simulation
- Mission performance
- Concept design
- Cost and schedule engineering
- Systems engineering assessment and acquisition support
- Program analytics and economic market analysis
- Operability assessment
- Reliability and failure analysis
- Systems integration
- Facilities engineering

## PHYSICAL SCIENCES LABORATORIES

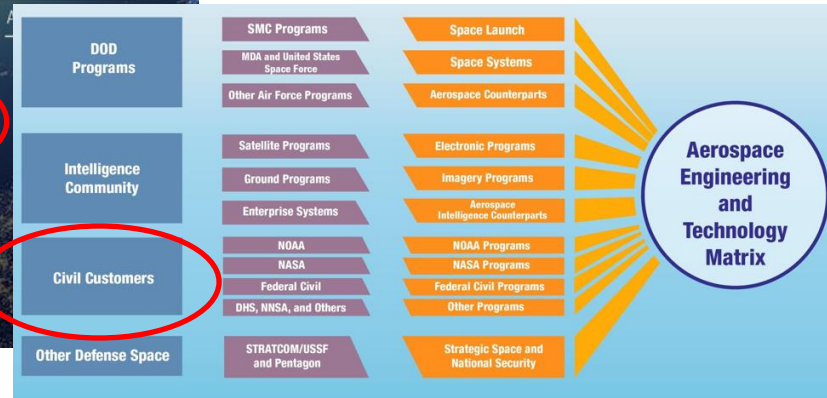
- Exploitation of air and space environments
- Prototype development
- Spectroscopy and remote sensing
- Atomic clocks and precision timing
- Laser applications
- Microelectronics evaluation
- Space power
- Contamination
- Propulsion sciences

# AEROSPACE MATRIX SUPPORT

California Nonprofit Corporation

Operates a Federally Funded Research and Development Center (FFRDC)

Provides scientific and engineering services for DoD, IC, and Civil customers



NATIONAL MAGLAB

# Scope Development – What is an FCA?



## NSF REQUIREMENTS

- Inform NSF and the MagLab of anticipated major and infrequent maintenance expenses that cause a significant departure from the routine funding profile.
- Allow NSF to proactively address these issues before they become immediate needs.
- Contribute to the protection of the health and safety of employees and of members of the public from hazards and to minimize danger to life and property.

## FACILITY REQUIREMENTS

- Funding process for replacement of critical equipment beyond routine grant funding.
- FCA consultant should have expertise beyond typical building systems.
- Focus on risk to the mission rather than just equipment.



## Assessment Approach

- The assessment of each facility includes a review of operations, maintenance, staffing, processes and procedures, and organizational effectiveness with respect to safety, compliance to codes and standards, reliability, performance, capacity, and utilization.



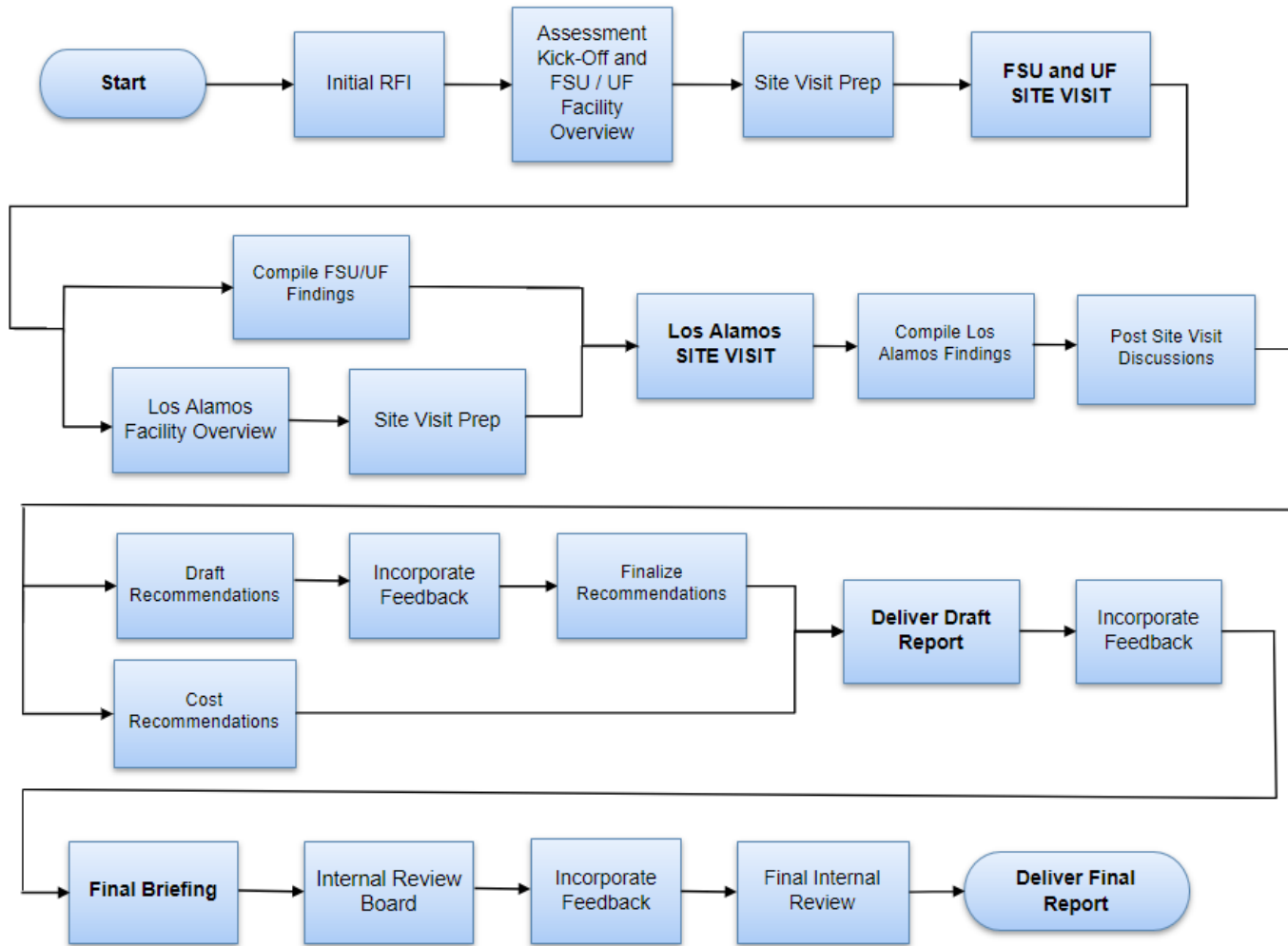
# Procurement



- There were FCA vendors that were solicited that could develop a database of building equipment with lifespan and replacement costs but were unable to assess scientific or industrial electrical equipment.
- The Aerospace Corporation was selected:
  - Aerospace has expertise in assessing specialty equipment and were able to review the facility in various areas regarding risk to our mission.
  - They operate a federally funded research and development center (FFRDC) and are not able to respond to competitive solicitations.
  - The PO was submitted as a sole source exemption.
    - This was approved by the NSF, but not by FSU contracts and grants.
    - We ended up paying for the purchase using non-federal funds.

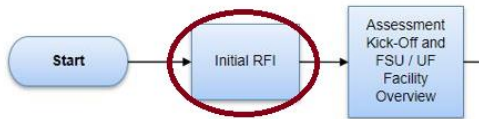


# Assessment – Process Flow Chart





# Initial Request for Information (RFI)



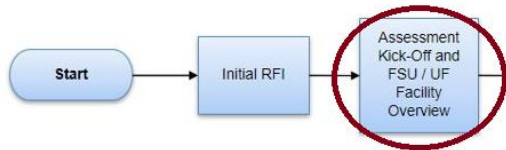
- The purpose of the initial RFI was to collect high-level documents early in the assessment.
- The focus of the RFI was to retrieve documents that were easily accessible.
- The initial RFI helped the assessment team become familiar with the facility organization, the design requirements, how the facility operates, staffing requirements, maintenance strategies, past and proposed projects, and long-range plans.



Data Request	
<b>General</b>	
1	Organizational Charts <i>Include positions for relevant departments</i>
2	Department Roles and Responsibilities
3	Site Plans/Layouts
4	Description of Facility Operations <i>Examples: CONOPs, Program/Project Manual, etc.</i>
5	Facility/Equipment Overviews <i>Description and capabilities of major systems and critical equipment.</i>
6	Internal/External Assessments (past 5 years) <i>Facility Assessments, Self-Assessments, Audits, etc.</i>
<b>Design Documents</b>	
7	System Schematics <i>Piping &amp; Instrumentation Diagrams (P&amp;ID), Functional Operating System Diagrams (FOS), Control Logic, Electrical Single Line Diagrams, etc.</i>
8	System Requirements <i>Overview of facility/system design requirements and specifications. Overview of any specialized and/or critical equipment.</i>
9*	FMEAs, Fault Trees, and/or Risk Evaluations
10*	Design Evaluations <i>Any open design concern evaluations: Low margin, equipment workarounds, severe unresolved degradation, etc.</i>
<b>Operations</b>	
11	Major Facility/Equipment Outages (past 5 years) <i>Planned and Unplanned: Include description, duration, cause.</i>
12	Failure/Incident Reports <i>Root Cause Analysis, Equipment Cause Analysis, etc.</i>
13*	Climate Resiliency/Severe Weather Mitigation Plans <i>Strategic plans, procedures, and/or upgrades implemented or planned to mitigate the effects of severe weather and/or climate change.</i>
14*	System/Equipment Health Reports <i>Includes any open operability evaluations, operator work arounds, and equipment in alarm.</i>
15*	Upcoming Unique or Large Tests/Evolutions
16*	Safety Concerns <i>Any open personnel, equipment, or environmental safety concerns. Electrical ArcFlash/Analysis. Provide incident reports and evaluations.</i>
<b>Maintenance</b>	
17	List of Planned Maintenance Performed (past 5 years) <i>Include Preventative, Corrective, and Emergent</i>
18	List of Unplanned Maintenance Performed (past 5 years) <i>Include Preventative, Corrective, and Emergent</i>
19	Maintenance Backlog/Deferred Maintenance
20*	Obsolesce Plans <i>List of unique/obsolete components with long-lead replacement times.</i>
21*	Maintenance Plans of Program Document <i>Provide lists of PMs, description of PM task, etc.</i>
<b>Capital Improvements</b>	
22	Major Projects Planned or Completed (past 5 years)



# Facility Overview Briefings



- Each facility leader provided an overview briefing prior to the site visits (~ 30 min. per briefing)
- Facility Overview Agenda:
  - Overview of facility mission, major systems, and critical/high value assets
  - Overview of organization, staff, and functions
  - Recent successes
  - Recent failures/issues
  - Major projects/upgrades implemented and planned
  - Q&A

NATIONAL HIGH  
**MAGNETIC**  
FIELD LABORATORY

2023 Aerospace Corp. Site Visit  
DC Field Facility Overview

AMRIS Mission

To leverage high magnetic fields and magnetic resonance technology to illuminate structure, chemistry, and function in biological systems

Metabolic flux measurements (dissolution DNP)

Neural tracks at better than 100  $\mu\text{m}$  resolution

In vivo / ex vivo metabolomic analyses via MRS and NMR

Solids / solution NMR structural biology

Los Alamos NATIONAL LABORATORY

Pulsed Power Systems at the MagLab

Generator

Power Supplies

PSRs

GENERATOR START-UP POWER SYSTEM

Power Supplies & PSRs

- Converts AC power to DC power for magnet
- 5 modules for 60 T LP, all 7 or 100 T.
- Brains that control the power precisely the thyristors, which pulse waveform (phase), energy after the pulse which reduces heating of the magnet, the lifetime and reliability of the

Past successes: major high-field magnets produced over 30 years

Year	Magnet Type
1990	28 Resistive Magnets (NSF)
1990	45 T Hybrid (NSF)
1990	900 MHz NMR Magnet (NSF)
1990	Repetitively Pulsed (DOE)
1990	Insinger Magnet (NSF)
1990	4 Resistive Magnets (NSF)
1990	Series-Connected Hybrid (NSF)
1990	363 Neutron Scattering (NSF)
1990	425 Neutron Scattering (NSF)
1990	Neimogen 45 T (NSF)
1990	4 Resistive Magnets (NSF, DOE)
1990	32 T SC (NSF)
1990	40 T SC (NSF)
1990	Each (Private)
2000	45 T Hybrid
2000	900 MHz NMR (Ultra-wide bore)
2010	1 ppm Series-connected Hybrid
2010	26 T neutron scattering Hybrid
2010	32 T all-superconducting
2023	40 T all-superconducting

Typical Cost: \$15 to \$20M  
Typical time to design and construct: 8 to 13 years

★ Major high-field superconducting magnets:

- 45 T Hybrid
- 900 MHz NMR (Ultra-wide bore), 105 mm bore
- 36 T 1 ppm Series-connected Hybrid
- 25 T neutron scattering for Helmholtz-Centrum Berlin
- 32 T all-superconducting
- 40 T all-superconducting (presently in design phase)

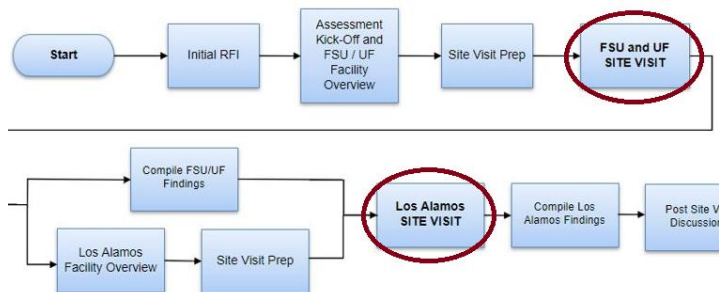
• Five major superconducting user magnets have been produced in the US over the past 30 years. Four of these five operate at the highest fields of their type. One was decommissioned due to German government nuclear policies.

• Centralized team in Tallahassee provides all aspects of high-field magnet development from "concept to commissioning".





# Site Visits



**FSU:** Oct 30, 2023 – Nov 1, 2023

**UF:** Nov 2, 2023

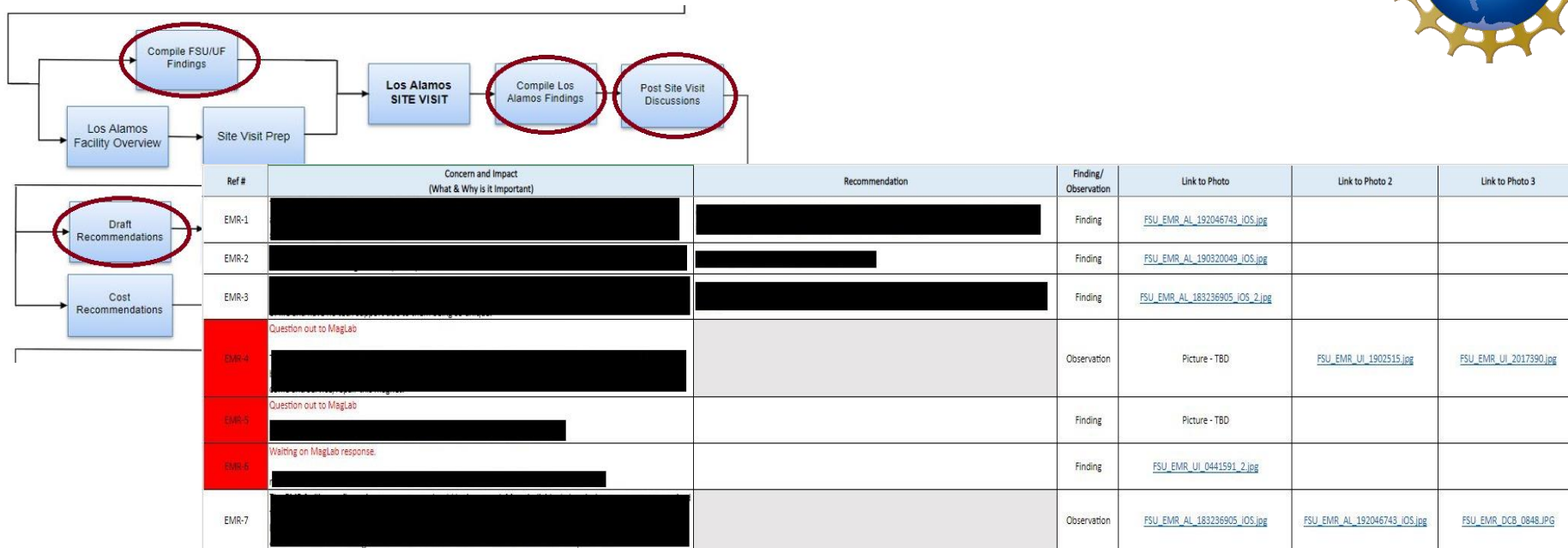
**LANL:** Nov 14, 2023

- Kick-off meeting for introductions and to discuss schedule
- Exit meeting to share any major findings (safety issues), general thoughts, and next steps
- Time at the beginning and end of the day for assessment team tag-up independent of MagLab
- Time to talk with facility staff including management, operations, maintenance, and engineering staff
- Guided tours to orient the assessment team and point out areas of concern with time allocated to walk the facility independently (or with an escort)
- It was also requested to have subject matter expert available to answer questions about the equipment

Start (ET)	Duration (minutes)	2. Day, October 31, 2023 (Tuesday)
		Breakfast (on your own)
9:00 AM	30	Short kick-off meeting - room: B101
		Introduction everyone in person
		Discussion about schedule
9:30 AM		Drop off items at B210 - Walkdowns - Nuclear Magnetic Resonance (NMR) Facility
		Overlook look down at the 900 MRI and 850/830 space
		NM112 and NM111 (900/control room)
		NM118 (future 850)
		NM104: 800#1 and 800#2
		NM116 (part 1): 600 DNP, 600 ODNP
		NM116 (part 2): 800SOL replacement
		NMR Building Inspection
12:00 PM	60	Self Organized Lunch
1:00 PM		Walkdowns - Ion Cyclotron Resonance (ICR) Facility
		NM117 9.4T passive/ active
		NM117 14.5T/ Eclipse
		NM-117 - Eclipse
		NM137 - 21T Magnet
		NM137 - 21T Support Infrastructure
		Walkdowns - Electron Magnetic Resonance (EMR) Facility
		B114 - 12.5T, 16T magnets
		C101 - HIPER spectrometer, amplifier, 9T magnet
		C101 - PPMS 7T, 15-17T magnets
		C116 - Bruker new X- Q-band spectrometer
		NMR wing - ODNP console, gyrotron, magnet
		General Science Building Inspection
		Organizing meeting (closed door) - room: B210
5:00 PM		Adjourn



# Initial List of Findings and Observations



- The purpose of this review was to present results prior to the draft report being delivered so we can discuss any major concerns to prevent delays in delivering the final report.
- The results were presented as “Findings” (items which present risk to the mission) and “Observations” (items which are “good to do”).
- Each facility leader had the opportunity to review the list and provide comments. In certain cases, follow-up meetings were held for further discussion.



# Draft Report



- A 150-page technical report was put together for review and comment by MagLab leadership and internal Aerospace senior reviewers.
- Technical Report included:
  - Executive Summary
  - Purpose and Scope
  - Assessment Process
  - Overview of facility mission and infrastructure
  - Results of the assessment:
    - Overall impressions of the facility, positive practices, major concerns, and areas for improvement
    - Assessment findings and observations
    - Risk rankings and impact areas
    - Facility condition ratings
    - ROM costing of recommendations

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AEROSPACE REPORT NO.  
VTR-2024-00246

Facility Condition Assessment of the National High Magnetic Field Laboratory (NHMFL)

Month XX, 2024

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# Draft Report



Tables summarize each facilities finding, recommendation, impact area, risk priority, and ROM cost.


Table 17. Findings Risk and Priority Summary - DCF (Part 4)

Reference Number	Findings	Recommendation	Impact Area		Risk			ROM Cost	
			Primary Impact Area	Secondary Impact Area	Consequence	Likelihood	Risk Priority	Low (\$K)	High (\$K)
DCF-22			System, Structure, Component	Maintenance	1	1	5		
DCF-23			System, Structure, Component	Reliability	2	2	4		
DCF-24			System, Structure, Component	Maintenance	Reference #: DCF-23				

Appendix's have tables that present each finding and observation in detail. These include pictures and impact areas.

**Primary Impact:** Structure, Component

**Secondary Impact:** Reliability



Score	Rating	Condition
5	Excellent	Plant in sound physical condition designed to meet current standards. Operable and well-maintained. Asset likely to perform adequately within routine maintenance for 10 years or more. No work required and/or only normal maintenance required
4	Good	Acceptable physical condition but not designed to current standards or showing minor wear. Deterioration has minimal impact on asset performance. Minimal short-term failure risk but potential for deterioration or reduced performance in medium term (5 – 10 years). Only minor work required (if any).
3	Fair	Functionally sound plant and components but showing some wear with minor failures and some diminished efficiency. Minor components or isolated sections of the asset need replacement/repair, but asset still functions safely at adequate level of service. For example, bearing and gland wear becoming evident and some corrosion present. Deterioration beginning to be reflected in performance and higher attendance for maintenance. Failure unlikely within 2 years but further deterioration likely and major replacement required within next 5 years. Work required but asset is still serviceable.
2	Poor	Failure likely in short-term. Likely need to repair health or safety but works required within 2 short-term, asset barely serviceable.
1	Very Poor	Failed or failure imminent. Immediate need to service/operated without risk to personnel. Major work or replacement required urgently.

	Priority 1	Priority 2	Priority 3	Priority 4	Priority 5	Total	ROM Low (\$K)	ROM Low (\$K)
	0	0	6	2	1	9		
	1	5	9	3	2	22		
	0	2	1	1	0	4		
	0	0	0	1	0	1		
	1	2	4	1	0	8		
	0	1	0	0	0	1		
	0	2	1	0	0	3		
	0	1	1	1	1	4		
	1	1	1	1	0	4		
	1	1	10	5	1	18		
<b>Total</b>	<b>6</b>	<b>15</b>	<b>33</b>	<b>15</b>	<b>5</b>	<b>74</b>		
ROM Low (\$K)							Total ROM Low (\$K)	
ROM High (\$K)							Total ROM High (\$K)	

Each facility was assigned facility condition ratings broken up by "building equipment" and "scientific equipment" sub-element.

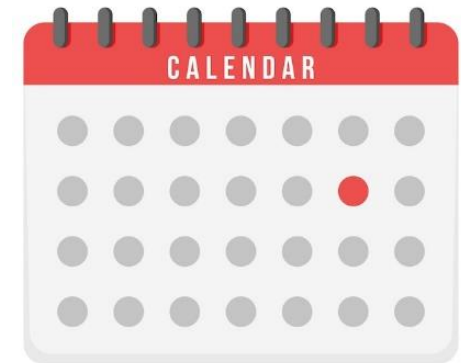
Various summary tables were generated to help visualize assessment results and identify trends.



# FCA Schedule



- **May 2023** – Meetings with Internal Stakeholders & NSF Program Manager to Develop Scope
- **June & July 2023** – Meet with Vendors & Develop Statement of Work & Funding Plan.
- **August & September 2023** – Procurement; Facility Equipment Lists
- **October 2023** – Information Gathering
  - RFI, Kickoff Facility Overviews ( 7 different user programs)
- **November 2023** – Site Visits ( FSU, UF, LANL)
- **January 2024** – Findings Table, Findings Table Review
- **February 2024** – Draft Report, Draft Report Review
- **March 18, 2024** – Final Report
- **April 30, 2024** – Limited Asset Management Plan
- **Summer 2024**– NSF Site Visit & FCA Review



# Facility Condition Assessment – Lessons Learned



- The assessment takes a long time!
  - Start planning early about 1 year out.
- You will need to convince facility managers of the value
  - The more staff time spent engaging in the assessment, the better the results will be.
- The site visits schedules were very tight
  - Have a preliminary scoping visit with the consultant before the site visit.
- Have an open mind when receiving feedback
  - An experienced FCA consultant has seen many different facilities.
- Scope the FCA to integrate into the AMP
  - This will help with the development of an Asset Management Plan (AMP).
- Keep open communication between the facility, NSF program manager and third-party consultant.
  - Collaboration between all parties helps align expectations

