The High Energy Electromagnetic Field Generator (HEEMFG)

(219BAR-17-009)

Naval Innovative Science & Engineering (NISE) – Basic & Applied Research (BAR)

(b) (6) [redacted]

(b) (6) [redacted]

Patuxent River, MD

October 2017

Objective

Objective: Design a test article and instrumentation to demonstrate the experimental feasibility of achieving high, electromagnetic (EM), field-energy, flux values toward the design of advanced High energy Density / High Power propulsion systems.

- Realization of this technology moves propulsion technology beyond gas dynamic systems.
- If we can engineer the local quantum vacuum state (vacuum energy state), we can manipulate a physical system's inertial and gravitational properties.
- This technology will eventually enable Interstellar Flight (successful design of a Space Drive).

Approach

- By coupling an electrically charged system's high frequency of axial operated in a rapidly accelerated transient mode, this project could achieve extremely high electromagnetic field-intensity (EM energy flux) values.

- This one year study has 4 tasks, namely to design the experiment, the test asset, the associated instrumentation and the power requirements.

Total Project Funding
FY17
$152K

FY17 Progress

FY 17 Funding	% Expensed
$152K	76%

- As of 31 AUG 2017, this is behind the plan of 87% expensed
- Determining Power Requirements
  - Parametric study of governing equations complete. This predicts minimal results based on experimental conditions and is used to bound the experiment based on instrumentation and/or facility limitations.
  - Power requirements for instrumenting and charging the asset are nominal and represent a fraction of the power needed to run the test cell.
- Designing Test Asset
  - Engaged with (b) (6) [redacted] in the development of the test plan (directive).
    - The test asset will be a composite disk composed of metal disks surrounding a dielectric material (TBD). This configuration is feasible to build at NAVAIR. The materials will be evaluated as part of the FY18 project to determine the best combination for capacitance, ability to hold charge, and ability to operate at maximum speed without degradation of the test asset.

FY17 Progress

- Designing Test Asset, continued
  - Inducing vibration on the disc may not be feasible.
    - Combined rotation and vibration is likely to cause the disk to burst
    - Physics predicts anomalous effects with spin only, although effects are amplified with vibration.
      - For the proof of concept, using accelerated spin is expected to produce data that will confirm the hypothesis.

- Designing the experiment
  - The test plan is drafted to include all remaining experimentation leading to final test asset design.

Future Expectations
(Execute Test Plan)

- Complete design and calibration of EM flux measurement device.
  - Planned to finish early in FY18 once funding for contractor support is available.
- Bench Top Disk Charging
  - Evaluate various capacitor materials towards fabrication of the test asset.
- Spin Test to Evaluate Rotor Design
  - The Capacitor and any battery used to charge the test asset will be installed in the spin pit and run incrementally up to maximum sped to assess rotor dynamic stability and structural integrity of the test asset.
- Spin Test to Evaluate HEEMFG Effect
- Submit an FY19 PEP in order to extend our current project to incorporate follow-on testing in FY19.

Spending Plan

Burn projection	Q1			Q2			Q3			Q4		
	31-Oct	30-Nov	31-Dec	31-Jan	28-Feb	31-Mar	30-Apr	31-May	30-Jun	31-Jul	31-Aug	30-Sep
Percentage (%)	10%	5%	5%	10%	15%	10%	5%	5%	10%	5%	10%	10%
Cumulative (%)	10%	15%	20%	30%	45%	55%	60%	65%	75%	80%	90%	100%
Amount ($K)	$15.20	$22.79	$30.39	$45.59	$68.38	$83.58	$91.18	$98.78	$113.97	$121.57	$136.77	$151.96
Balance ($K)	$136.77	$129.17	$121.57	$106.38	$83.58	$68.38	$60.79	$53.19	$37.99	$30.39	$15.20	$0.00

- If any step in the execution plan is deemed beyond 4.4 laboratory capabilities or anticipated budget allowances, the investigators will report findings through the leadership chain to determine a new course of action (COA).
  - The conclusion of the FY17 feasibility study is that this test asset can be constructed at NAVAIR or easily purchased. Test instrumentation will be manufactured and calibrated locally.

FY17 Research Products

- “High Frequency Gravitational Wave Generator” (Navy case PAX 233) was filed with the United States Patent & Trademark Office Serial # 15431823 on February 14, 2017 - an interesting aspect of this patent application is that it couples the generation of high frequency gravitational waves (HFGWs) with the possibility of room temperature superconductivity (RTSC) enablement.

- Patent application Serial # 15678672 (Navy case PAX 263) titled ”Piezoelectricity-Induced Room Temperature Superconductor”, has been filed with the United States Patent and Trademark Office on August 16, 2017 - the subject matter of this application describes the design of an active room temperature superconductor, in a novel manner, using HEEMFG-inspired physics.

- Published “A hybrid craft using an inertial mass modification device” – AIAA technical paper (AIAA 2017-5343), Proceedings of the 2017 AIAA SPACE Forum and Exhibition, Orlando Florida, Sept.12-14.

Partnerships / Related Projects

- The feasibility study is anticipated to be a highly collaborative 4.4 effort.
  - Currently working with (b) (6) [redacted] on test asset design and test directive preparation.

- Results of the feasibility study could lead to collaborations with ONR, NRL, and/or DARPA.

Backup

make any inquiries in regard to this project to:

(b) (6) [redacted]

(b) (6) [redacted]

(b) (6) [redacted]

Alignment

Naval S&T Focus Areas Addressed:

- Power and Energy

NAE S&T Objectives (STOs) Addressed:

- Strike Operations (STK) / STO-1: Responsive Engagement
- Theater Air and Missile Defense (TAMD) / STO-2: Airborne Missile Defense

NAVAIR Core Capabilities Supported:

- Power and Energy Systems

The High Energy Electromagnetic Field Generator (HEEMFG)

(219BAR-17-009)

Naval Innovative Science & Engineering (NISE) – Basic & Applied Research (BAR)

[redacted]

Patuxent River, MD

18 April 2017

Objective

Objective: Design a test article and instrumentation to demonstrate the experimental feasibility of achieving high, electromagnetic (EM), field-energy, flux values toward the design of advanced High energy Density / High Power propulsion systems.

- Realization of this technology moves propulsion technology beyond gas dynamic systems.
- If we can engineer the local quantum vacuum state (vacuum energy state), we can manipulate a physical system's inertial and gravitational properties.
- This technology will eventually enable Interstellar Flight (successful design of a Space Drive).

Approach

- By coupling an electrically charged system's high frequency of axial spin with high vibration frequencies operated in a rapidly accelerated transient mode, this project could achieve extremely high electromagnetic field-intensity (EM energy flux) values.
- This one year study has four tasks:
  - Design the experiment, the test asset, the associated instrumentation, and the power requirements.

Total Project Funding
FY17
$151.96K

FY17 Progress

FY 17 Funding	% Expensed
$151.96K	25%

- As of 28 FEB 2017, this is behind the plan of 45% expensed
- Determining power requirements
  - Parametric study of governing equations complete. This predicts minimal results based on experimental conditions and is used to bound the experiment based on instrumentation and/or facility limitations.
  - Working to understand need to ground test stand equipment
- Designing Test Asset
  - Engaged with (b) (6) [redacted] in the development of the test plan (directive). Their group will design the test asset, arbor and mounting. Multiple slip rings required to charge the disc (technical challenge).

FY17 Progress

- Designing Test Asset, continued
  - Inducing vibration on the disc may not be feasible.
    - Combined rotation and vibration is likely to cause the disc to burst
    - Physics predicts anomalous effects with spin only, although effects are amplified with vibration.
      - For the proof of concept, using accelerated spin is expected to produce data that will confirm the hypothesis.

- Designing the experiment
  - We have a sample test plan (test directive) to begin populating as information is gathered.

Future Expectations

- Viability of using PZT to vibrate the disc
  - Planned start in CY2018. Gathering literature now.
- Determining electrical power requirements and instrumentation needed
  - Conversations ongoing with EMI branch for instrumentation. This is going to be a challenge and may limit the scope of possible experimental variables.
- Submit an FY18 PEP in order to extend our current project to incorporate testing in FY18.

Spend Plan

Burn projection	Q1			Q2			Q3			Q4		
	31-Oct	30-Nov	31-Dec	31-Jan	28-Feb	31-Mar	30-Apr	31-May	30-Jun	31-Jul	31-Aug	30-Sep
Percentage (%)	10%	5%	5%	10%	15%	10%	5%	5%	10%	5%	10%	10%
Cumulative (%)	10%	15%	20%	30%	45%	55%	60%	65%	75%	80%	90%	100%
Amount ($K)	$15.20	$22.79	$30.39	$45.59	$68.38	$83.58	$91.18	$98.78	$113.97	$121.57	$136.77	$151.96
Balance ($K)	$136.77	$129.17	$121.57	$106.38	$83.58	$68.38	$60.79	$53.19	$37.99	$30.39	$15.20	$0.00

- If any step in the execution plan is deemed beyond 4.4 laboratory capabilities or anticipated budget allowances, the investigators will report findings through the leadership chain to determine a new course of action (COA).
  - Nothing beyond the 4.4 capability identified, although lab or instrumentation capabilities/cost may limit the range of experimental variables

FY17 Research Products

- High Frequency Gravitational Wave Generator” Navy case PAX 233 was filed with the United States Patent & Trademark Office Serial # 15431823 on February 14, 2017.
    - An interesting aspect of this patent application is that it couples the generation of high frequency gravitational waves (HFGWs) with the possibility of room temperature superconductivity (RTSC) enablement.
- Findings anticipated to be submitted for publication in AIAA or SAE technical journals – possible theoretical paper instead of experimental work.
- It is expected any products from the eventual experiment will transition to the Naval Air Warfare Center.

Partnerships / Related Projects

- The feasibility study is anticipated to be a highly collaborative 4.4 effort.
  - Currently working with (b) (6) [redacted] on test asset design and test directive preparation.
  - Meeting with 5.4.4.9, EMI to discuss instrumentation requirements and EM flux sensor availability.

- Results of the feasibility study could lead to collaborations with ONR, NRL and/or DARPA.

Backup

make any inquiries in regard to this project to:

(b) (6) [redacted]

(b) (6) [redacted]

[redacted]

Alignment

Naval S&T Focus Areas Addressed:

- Power and Energy

NAE S&T Objectives (STOs) Addressed:

- Strike Operations (STK) / STO-1: Responsive Engagement
- Theater Air and Missile Defense (TAMD) / STO-2: Airborne Missile Defense

NAVAIR Core Capabilities Supported:

- Power and Energy Systems

The High Energy Electromagnetic Field Generator (HEEMFG)

219BAR-17-009

Naval Innovative Science & Engineering (NISE) – Basic & Applied Research (BAR)

Salvatore Cezar Pais

(b)(6) [redacted]

Patuxent River, MD

12 OCTOBER 2016

Need / Impact

Objective: Design a test article and instrumentation to demonstrate the experimental feasibility of achieving high, electromagnetic (EM), field-energy, flux values toward the design of advanced High energy Density / High Power propulsion systems.

- Realization of this technology moves propulsion technology beyond gas dynamic systems.
- If we can engineer the local quantum vacuum state (vacuum energy state), we can manipulate a physical system's inertial and gravitational properties.
- This technology will eventually enable Interstellar Flight (successful design of a Space Drive).

Approach

- By coupling an electrically charged system's high frequency of axial spin with high vibration frequencies operated in an accelerated mode, this project could obtain extremely high electromagnetic field-intensity (EM energy flux) values.
- This one year study has 4 tasks to design the experiment, test asset, associated instrumentation and power requirements.

Total Project Funding
FY17
$152K

FY17 Progress

FY 17 Funding	% Expensed
$152K	1%

- Our team had a kickoff meeting and we made this presentation.

Future Expectations

Burn projection	Q1			Q2			Q3			Q4		
	31-Oct	30-Nov	31-Dec	31-Jan	28-Feb	31-Mar	30-Apr	31-May	30-Jun	31-Jul	31-Aug	30-Sep
Percentage (%)	10%	5%	5%	10%	15%	10%	5%	5%	10%	5%	10%	10%
Cumulative (%)	10%	15%	20%	30%	45%	55%	60%	65%	75%	80%	90%	100%
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- If any step in the execution plan is deemed beyond 4.4 laboratory capabilities or anticipated budget allowances, the investigators will report findings through the leadership chain to determine a new course of action (COA).
- If the results of this FY17 feasibility study are favorable, the next step is to secure funding to build the test asset and conduct the experiment.

Research Products

- The PIs plan to publish findings in AIAA or SAE technical journals.
- It is expected any products from this experiment will transition to the Naval Air Warfare Center.

Partnerships / Related Projects

- The feasibility study is anticipated to be a highly collaborative 4.4 effort. The PIs anticipate possible coordination with (b)(6) [redacted] (University of Puerto Rico), and (b)(6) [redacted] (peer-recognized subject matter expert).
- Results of the feasibility study could lead to collaborations with ONR, NRL and/or DARPA.

Alignment

Naval S&T Focus Areas Addressed:

- Power and Energy

NAE S&T Objectives (STOs) Addressed:

- EPE STO-1: Enterprise Enablers
- EPE STO-5: Energy Conservation, Flexibility and Security

NAVAIR Core Capabilities Supported:

- Power and Energy Systems

Backup

(b)(6) [redacted]

(b)(6) [redacted]

(b)(6) [redacted]

4 MAY 2017

[redacted]

AIR 4.4.5.1

NISE BAR Selection Committee

Committee Members:

This letter is my endorsement of the FY18 NISE BAR Project Extension for 'The High Energy Electromagnetic Field Generator' submitted by Salvatore Cezar Pais and [redacted]

This basic research project explores the ability to produce exceptionally high electromagnetic field energy fluxes which is considered instrumental to designing advanced High Density, High Power Systems and significantly increasing future propulsion capability. The basic research project is an important first step toward developing advanced power and propulsion devices. The physics of this experiment have been peer reviewed and deemed sound. The FY17 feasibility study findings indicate the experiment can be conducted in the PSEF Rotary Spin Facility.

The extension of this BAR proposal involves building the test asset, acquiring instrumentation and conducting the test as designed during the FY17 effort. Tests will be conducted in FY18 and provide valuable data in proving the physics needed to design completely new High Density, High Power Systems and Advanced Propulsion devices.

Thank you for your consideration.

[redacted]

AIR 4.4.5.1

The High Energy Electromagnetic Field Generator Test

Technical Risks and Proposed Solutions

Prepared by: [redacted]

Requested capability: Run spin test to evaluate new EM Field Generator technology

- **Identified Technical Obstacle**: Many high risk components of this test may result in a lower probability of success.
- **Proposed Solution**: Prior to running spin test, perform analyses and benchtop testing to ensure the individual components of the test will be successful (See risks below).

Requested capability: Electrical charge on one side of disk only (1-1000 Volts)

- **Identified Technical Obstacle**: There is no clear way to apply charge to only one side of a conductive disk.
- **Proposed Solution**: Non-conductive coating on one side of rotor.
- **Identified Technical Obstacle**: Non-conductive coating on one side of disk will need to be able to handle centrifugal loading.
- **Proposed Solution**: Material requirements will need to be further defined and evaluated
- **Identified Technical Obstacle**: Conduction path to earth ground may prevent any significant charge on rotating hardware without some way to isolate it from ground.
- **Proposed Solution**: Non-conductive materials can be introduced to isolate rotating disk though they may not be ideal for this application.
- **Identified Technical Obstacle**: Current limitations on slip ring may limit charge applied to rotor.
- **Proposed Solution**: Distribute charge over many slip ring channels to reduce current on any given channel.

Requested capability: Requested rotor vibration is an amplitude of 1 mm @ 1000 Hz.

- **Identified Technical Obstacle**: Need to define the mode of vibration being requested. Is this an umbrella mode, a sine wave traveling along the rim of the disk or some other type of vibration? Is the maximum amplitude at the rim or all over the disk?
- **Proposed Solution:** Further define the desired vibration shape/mode of the disk.
- **Identified Technical Obstacle**: Vibration amplitude may be destructive to rotor disk.

- **Proposed Solution**: Perform analysis to determine combined rotor stress from CF and vibratory loading.
- **Identified Technical Obstacle**: No current way to excite the rotor to generate the desired vibration.
- **Proposed Solution**: Market research – Solution may not be available
- **Identified Technical Obstacle**: Rotor vibration may damage turbine bearings
- **Proposed Solution**: If run is short enough, may not matter.
- **Identified Technical Obstacle**: Power requirements to enable the rotor vibration may be too large for facility slip rings.
- **Proposed Solution**: Distribute charge over many slip ring channels to reduce current on any given channel – may still not be enough capability.

Requested capability: Sensor for measurement of EM Flux is not defined

- **Identified Technical Obstacle**: Sensor is critical to success of test and is currently immature and undefined.
- **Proposed Solution**: Identify adequate sensor that can operate in a spin test environment and determine whether it is sufficiently sensitive to meet the needs of the test.

NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION

PATUXENT RIVER, MARYLAND

UNCLASSIFIED

High Energy Electromagnetic Field Generator Spin Test

NAVAIR 4.4.6
Propulsion & Power
Test Methods & Facilities Department

September 2017

UNCLASSIFIED

DRAFT

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1.0 Background

1.1 The Rotor Spin Facility (RSF) in the Propulsion System Evaluation Facility (PSEF) has been requested to perform a spin test to evaluate the concept of High Energy Electromagnetic Field Generation (HEEMFG). When put in practice, this system can provide the design of energy generation machinery with power output levels much higher than those currently achievable. The utilization of such high power sources for space power and propulsion generation, as it pertains to reduction in the spacecraft's inertial mass as a direct result of local vacuum polarization, is an important application of the described theoretical concept.

1.2 A spin test program is to be performed on rotating test article configured like a capacitor to evaluate the presence and magnitude of the HEEMFG effect.

2.0 Purpose and Objective of Test

2.1 The overarching goal of this program is to verify Equation 2 in the published paper 'S.C. Pais, The high energy electromagnetic field generator, Int. J. Space Science and Engineering, Vol.3, No. 4, 2015 pp.312-317', or any departures from it (namely differences in the experimentally obtained EM energy flux value). This will be achieved via a spin test to be performed in the Rotor Spin Facility.

3.0 Scope of Test

3.1 Testing is to be performed in stages in order to validate the test methodology prior to moving on to actually the enabling of the HEEMFG effect.

3.2 The first test stage will involve the electrical charging of a test assembly mockup to determine whether a disk can be electrically isolated and charged in a bench test environment. A capacitor-like configuration is being considered for this test. The ability of the assembly to hold the charge for the duration of the test will also be evaluated. If successful, the actual rotating hardware will be designed and fabricated. Charging techniques to be used for the test will be evaluated (through slip ring or battery).

3.3 The second stage will involve the evaluation of the electromagnetic flux sensor. Prior to introduction in the spin chamber, a suitable sensor will be acquired via COTS or designed and fabricated locally. Once selected, the sensor will be tested in a benchtop and eventually a spin chamber environment to evaluate potential problems associated with that environment. A calibration source (EM flux emitter) will be required before this testing can be performed.

3.4 Following stages 1 and 2, a rotor will be designed and fabricated for spin testing. The rotor will be configured as a capacitor with two 10 cm metallic plates separated by a dielectric that was determined during stage 1. It will first be spun through the desired speed range to evaluate whether all components can withstand the centrifugal loading. This will primarily be focused on rotor dynamic stability and survival of the dielectric and the battery if used. Runs will be incremental with inspections between to determine at what speed, damage occurs to the individual components. This portion of testing will determine the maximum speed at which testing can be performed. The rotor will then be run in an uncharged state through speed profiles in table 1 while measuring the EM flux to evaluate the performance of the sensor and provide a baseline for that sensor.

3.5 The capacitor will be charged and test article will be run through the same speed profile found in table 1. The speed profile will begin with a conservative profile and will progress to the more dynamic one. The electromagnetic flux sensor will be monitored and recorded during all testing to detect the predicted responses.

Table 1 - Speed Profile

Low Acceleration		**High Acceleration**	
Cumulative **t (sec)**	**RPM**	Cumulative **t (sec)**	**RPM**
20	5000	20	5000
40	10000	30	7500
60	20000	60	30000
80	40000	100	15000
100	80000	120	55000
120	100000	150	80000
140	100000	200	60000
160	80000	220	100000
180	40000	240	7500
200	20000	300	90000
220	10000	320	5000
240	5000	340	100000

3.6 Even though our present tests will focus on the EM energy flux effects of accelerated spin, it is envisioned that a future phase of the test will involve accelerated vibration of the electrically charged test asset. Varying rigid body vibration will be induced while rotating to further test the performance of the theory.

Table 2 – HEEMFG Spin Test Conditions

Speed Range	5000 rpm to 100,000 rpm (max speed contingent on battery and dielectric performance)
Over-speed Limit	101,000 rpm
Test Article Temperature	Ambient
Rotor Disk Charge	1-24 VDC (TBD Coulombs)
Rotor Speed Profile	See Table 1
Chamber Vacuum	<500 mTorr (Best Achievable)
Test Article Vibration Limits	15 mils-rms @ 0 rpm, 1 mils-rms @ 100,000 rpm
Direction of Rotation	Clockwise from above

4.0 Test Schedule

4.1 This test program is planned to be run over the course of FY17 and FY18. Due to the immature status of the testing methodology, this test program will be performed in stages to evaluate the technique. The first stage will evaluate rotor disk charging. The second stage will evaluate EM Flux sensor options and performance. Assuming the first two stages are successful, the rotor can be fabricated and instrumented (if necessary) to perform the spin testing.

Disk Charging Mockup Testing	Summer 2017
Rotor Assembly Design and Fabrication	Fall/Winter 2017
EM Flux Sensor Testing (Lab and Spin Pit)	Summer 2017-Winter 2018

5.0 Test Team

Manned operations including troubleshooting and inspections are to be run as a 9-hour shift each day for 4 or 5 days a week depending on the compressed work schedule. The spin testing will be run while manned to ensure that test conditions are stable and meeting test requirements. The required shift personnel for the test are listed below (Table 3):

- 1 Operator/Mechanic – The operator will be responsible to assist the test technician with mechanical operations as well as operation of test controls.
- 1 Test Technician – The technician will be responsible to ensure test cell readiness including performance of mechanical assembly, setup or disassembly, performance of the pre-test checklist and the operation of test controls.
- 1-2 AIR 4.4.6.4 Test & Evaluation Engineer - The test engineer will be responsible for communicating test requirements to the test team, reviewing the overall test setup and providing guidance to test operators with regard to test operations. The test engineer will communicate test related information to the program engineer and relevant test team personnel. The engineer will also be responsible for monitoring and reviewing data on the NSMS and APEX data systems during testing to ensure test conditions are being maintained as required.
- 1-2 AIR 4.4.5.1 Engineers – The program engineer will be present to evaluate test operation and results during spin testing.
- Instrumentation Engineer/Technician – Instrumentation support will be required for initial test setup including test cell calibrations and data acquisition system configuration. During test operations, instrumentation support may be needed to confirm proper equipment operation and for troubleshooting.

Table 3 - HEEMFG Spin Test Team

Personnel	Code	Position	Phone Number
[redacted]	4.4.5.1		([redacted]
[redacted]	4.4.5.1		([redacted]
TBD	4.4.6.4	Test & Evaluation Engineer	([redacted]??
[redacted]	4.4.6.3	Engineering Test Technician	([redacted]
[redacted]	4.4.6.3	Test Mechanic	([redacted]
[redacted]	4.4.6.3	Test Mechanic	[redacted]
[redacted]	4.4.6.5	Instrumentation	[redacted]
[redacted]	4.4.6.5	Instrumentation	[redacted]
[redacted]	4.4.6.5	Instrumentation	[redacted]

6.0 DESCRIPTION OF TEST FACILITY

6.1 The initial stages of this test will be performed on the bench with spin testing to be performed in chamber 4 of the Rotor Spin Facility (RSF), building 2360, at Naval Air Station (NAS) Patuxent River. The Rotor Spin Facility provides experimental support for research, development, test and evaluation programs that pertain to rotor structural integrity, durability and failure protection. The RSF consists of four vacuum chambers capable of performing the test and evaluation of engine rotating components, such as, compressors and turbines.

6.2 The RSF is being used to accommodate the HEEMFG spin test article and accompanying support equipment. The support equipment for the spin test will consist of the arbor, spindle, and rotor disk assembly to be installed in the test chamber. Static hardware will be fabricated to mount EM Flux sensors in proximity to the rotor while testing is executed. The drive system will be the Barbour Stockwell 2" Air Drive Turbine (Model 2850) @ 90 psi. The turbine will be powered by compressed air supplied by the facility shop air compressors. The chamber will be evacuated by one or more Kinney vacuum pumps to a vacuum starting at less than 0.5 Torr with the goal being to run the test at the best achievable vacuum.

6.3 Signal conditioning and data acquisition will be provided by a modular Pacific 6000 system. That system records all data parameters at the desired rate as well as manages all interlocks and safeties while the rig runs. A Barbour Stockwell TC-4 controller paired with the SPIN software will control the test article speed profile through the test. The control systems can automatically shut the test down in the event that a limit is exceeded or if the test needs to be stopped for inspection.

6.4 An Aerodyn Engineering 100-channel slip ring may be needed to provide and measure the charge applied to the rotating disk during test operations. This slip ring has a maximum speed of 50,000 rpm which will preclude dynamic voltage or charge above that speed.

6.5 The speeds, shaft displacements, temperatures and pressures that exceed stated limits will result in a test abort signaled by the Pacific data system or the BSi speed controller. The cause of the shutdown will be indicated on the enunciator panel or the BSi speed control software so that corrective actions can be taken. Test aborts will result in the rotor being slowed to minimal speed (~100 rpm) and then coasting to a stop. During any abort, all support equipment will remain running. The only exception to this is if the speed controller determines there is a problem with speed measurement. In that case, the rotor will go into coast mode as it would not be safe to take any speed control actions without a reliable speed measurement. All shutdown interlocks are verified either with simulated signals or with a dummy rotor with limits set inside the normal operating range for that component prior to actual testing.

7.0 DESCRIPTION OF TEST ARTICLE

7.1 Notionally the test rotor is an Aluminum or Steel disk of 10 cm diameter, 1 cm thickness. A second disk will be attached to it with a dielectric between the two so that the assembly will act like a capacitor. The second disk will be electrically insulated from the rest of the test tooling. The test asset will be mounted to a spindle which must also supply electric power to the disk via a slip ring. If the limitations of the slip ring do not meet test requirements, the arbor will be designed to accommodate 1 or more button batteries to charge the capacitor.

7.2 The test tooling will consist of a steel spindle and arbor that will support the disks. The arbor and spindle will require wire passages so that electrical leads can be run to the rotating disk through the slip ring or to an internal battery.

8.0 DESCRIPTION OF INSTALLATION & TEST EQUIPMENT:

8.1 The test is conducted in a vacuum to meet stated test requirements and to reduce aerodynamic drag and power required to drive the test article. The test assembly is suspended inside the spin pit via a 5/16 inch diameter vertical drive spindle extending up through the spin pit lid into the facility air turbine. A 4 in. layer of lead inside a 4" thick steel ring provides primary radial containment should the test article fail. A Barbour Stockwell axial catcher system will be employed to prevent catastrophic damage to the rotor in the event of a spindle failure.

8.2 Radial displacement (shaft wobble) of the arbor will be monitored using two eddy current type non-contact proximity probes 90° apart measuring the arbor about where it is captured in the catcher. Displacement levels above the prescribed limits will trigger a test shutdown. Some evaluation of whether these sensors interfere with the EM Flux measurement will need to be performed.

8.3 Compressed Air System: The drive turbine is powered by compressed air provided by the facility compressors. The air is routed to each test cell via a 6" manifold.

8.4 Drive System: The test rotor will be driven through the mission cycle using the Barbour Stockwell model 2850 high performance 2-inch air turbine. The turbine has a maximum speed of 100,000 rpm.

8.5 Turbine Speed Control System: Rotor speed measurement is accomplished using a Hall Effect sensor generating pulses from a 6 tooth gear mounted inside of the drive turbine. Drive turbine speed control is handled by the Barbour Stockwell TC4 controller in conjunction with the SPIN IV interface software.

8.6 Vacuum System: The test cell to be used for HEEMFG testing is equipped with one Kinney vacuum pump to evacuate the chamber. Additional pumps tied together via the vacuum manifold. The pumps can be used to reduce test cell vacuum to <500 mTorr or better.

8.7 Turbine Lubrication System: An external oil lubrication cart is used to service the bearings and damper section of the drive turbine throughout testing. SHC-824 oil is used for the test system.

9.0 METHOD OF TEST

9.1 Test Description:

9.1.1 **Disk Charging (Stage 1)**: A bench top capacitor mockup will be tested using steel and aluminum plates surrounding various dielectric materials. The dielectric will be varied in material and thickness to determine the candidate that provides the highest capacitance and lowest leakage current. The materials to be evaluated will include alumina, polycarbonate, Mylar, cardboard and coated paper products.

In order to evaluate capacitance for a given configuration, a 10 volt potential difference will be applied across the plates to charge the capacitor. A Sencor LC102 Capacitor-Inductor analyzer will be used to measure the capacitance of each configuration.

9.1.2 **EM Flux Measurement Design/Evaluation (Stage 2)**: An electromagnetic flux detection system will be designed and fabricated to identify changes to the EM field associated with the predicted HEEMFG effect. The system will consist of a detection circuit, an amplifier and an antenna that will surround the test article. The detection circuit will be designed to detect frequencies ranging from 3 Hz to >3 GHz, and will convert the signal to a predominantly DC value above 20 KHz. Below 20 kHz, a predominantly AC signal will output from the detector to the data system. The detector/ amplifier system signal output matches the installed data system capability.

Once designed and fabricated, the EM flux detector will be tested by applying an AC signal across the mockup capacitor at frequencies varying from 3 Hz to 3 GHz while monitoring the detector for signal changes throughout the frequency range. A Keysight 8648C and Agilent 33220A signal generators will be used to generate the signal throughout the entire frequency range. The detector antenna will surround the capacitor to simulate the configuration that will be used in the spin chamber.

The detector/ amplifier system output will provide a qualitative indication to changes in EM field strength, but will not be calibrated to actual field strength. The basic excitation signal input amplitude will be 2 volts, and the value will be adjusted to assess sensitivity.

9.1.3 **Spin Test to Evaluate Rotor Design (Stage 3)**: A rotor shall be designed based on the requirements of the test plan as well as the results of the previous stages of this test. Requirements will include the desired capacitance and charge of the rotor and its maximum speed capability. The rotor will be installed into a spin pit with a BSi 2” High Performance air turbine capable of up to 100,000 rpm. The assembly shall have accommodations for internal power (battery) or wiring for a slip ring. The rotor will be run incrementally up to maximum speed to assess rotordynamic stability and structural integrity of all components.

For the first spin test runs, the dielectric and any power source should be removed from the rotor and it should be accelerated to 100,000 rpm in increments of 5000 rpm . Assuming no problems are identified with rotordynamic stability based on the shaft wobble, the EM flux detector shall be installed to measure a baseline signal while in an uncharged state. The rotor shall be run through the speed profiles specified in table 1 while monitoring/recording EM Flux.

The dielectric shall be installed into the rotor with no connection to a power source. The rotor will be accelerated to 50,000 rpm and then stopped for an inspection of the hardware as well as a measurement of the capacitance. The rotor will then be accelerated in increments of 10,000 rpm up to 100,000 rpm with inspections between each run. This test will determine the maximum speed that the rotor can repeatedly operate without degradation of the dielectric.

9.1.4 **Spin Test to Evaluate HEEMFG Effect (Stage 4)**: Testing of the HEEMFG effect will begin with the rotor charged to 1.5 volts. The rotor will be accelerated through the low acceleration speed profile in table 1 while monitoring/recording the EM Flux detector. The profile will be run multiple times to establish repeatability. Upon completion of the test runs, the rotor will be inspected for charge on the rotor using a voltmeter and whether the dielectric is intact both visually and with the Sencor LC102 Capacitor-Inductor analyzer.

The second set of runs will use the high acceleration speed profile in table 1 and a 1.5 volt charge. As with the first run, the speed profile will be run multiple times to establish repeatability of any EM flux results. At the request of the customer, follow-on test runs can be run at a higher voltage by adding batteries in series. A voltage up to 24 volts can be applied to the rotor by stacking batteries into the arbor. The same speed profiles will then be run at the higher voltage condition.

9.2 TEST OPERATIONS

9.2.1 Emergency Procedures

The following procedures shall be followed for the scenarios as detailed below.

1. **Loss of speed control**: Due to a problem with instrumentation or control hardware, the test article no longer responds to control inputs or safety limits.
    - Stop Test
        - Test Abort: Hit abort in the Spin IV software or the red abort button on the TC-4 twice to bring the speed to zero rpm.
        - Manual Mode: Centering the three speed control toggle switches will cut off air from the drive and brake lines. Toggling the main air and brake air switches to "Manual" will allow for a manually controlled deceleration to a stop.
        - Emergency Stop Button: If the other methods fail to stop the test article, the red E-Stop button on the control panel will prevent the rotor from continuing to accelerate (coast mode).
    - Troubleshoot Control Problem
2. **Loss of Speed Indication**: Due to an instrumentation problem, there are either no speed indications or the indications are different between the two probes.
    - Stop Test
        - Test Stop: Hit abort in the Spin IV software or the red abort button on the TC-4 to bring the speed to zero rpm.
        - Manual Mode: Centering the three speed control toggle switches will cut off air from the drive and brake lines. If no indication of speed is available, allow rotor to coast to a stop.
        - Emergency Stop Button: If the other methods fail to stop the test article, the red E-Stop button on the control panel will prevent the rotor from continuing to accelerate (coast mode).
    - Troubleshoot Control Problem

3. **Suspected Catastrophic Failure**: Sudden loss of in-pit instrumentation, significant unexpected speed change and a loud bang are potential indications of a failure.
    - Stop Test
        - Test Abort: Hit abort in the Spin IV software or the red abort button on the TC-4 twice to bring the speed to zero rpm.
        - Manual Mode: Centering the three speed control toggle switches will cut off air from the drive and brake lines. Toggling the main air and brake air switches to "Manual" will allow for a manually controlled deceleration to a stop.
    - Maintain Vacuum: The vacuum shall be maintained for at least 15 minutes to clear any oil vapors.
    - Lock Data System Backup Drive: On the Pacific PC, ensure the backup drive has been locked to prevent loss of this data.
4. **Rapid Loss of Vacuum**: Due to a breach in the pressure vessel, the chamber vacuum has increased to greater than .5 atm while the test is running.
    - Stop Test
        - Test Abort: Hit abort in the Spin IV software or the red abort button on the TC-4 twice to bring the speed to zero rpm.
    - Secure Vacuum Pump
        - Once test article has stopped, perform shutdown of vacuum pump to prevent overheating and damage to pump.
5. **Loss of Operator Screens**: One or more of the operator screens blacks out during operation.
    - Reference Discrete Displays for Test Status: Use standalone displays to confirm that the test is running properly/safely. Check for loose cables on monitors.
    - Stop Test
        - Fix Monitors: If test is running normally based on alternate displays, attempt to fix displays.
        - Test Abort: Hit abort on the TC-4 twice to automatically brake the speed to zero rpm.
        - Manual Mode: Centering the three speed control toggle switches will cut off air from the drive and brake lines. Toggling the main air and brake air switches to "Manual" will allow for a manually controlled deceleration to a stop.
    - Troubleshoot Monitors: Repair/replace monitors as needed to continue testing.

10.0 DATA ACQUISITION AND INSTRUMENTATION REQUIREMENTS

10.1 Spin test instrumentation consists of the parameters necessary to ensure the desired test conditions are continuously met and that the test equipment is operating safely. These parameters are listed in Table 4. The setup for the strip chart recorder can be found in Table 5. Any time the test article is spinning, all parameters shall be reading properly and the data acquisition systems shall be recording. In the event that a parameter appears to be erroneous (noisy signal or unbelievable reading), the test shall be shut down as soon as practicable and the measurement fixed unless otherwise authorized by the test team.

10.2 Prior to testing, the instrumentation shall be calibrated following normal calibration practices. This will include end-to-end checks of all test instrumentation using calibrated standards. Calibration shall be documented on calibration sheets indicating the current date, parameter of interest, input signal level, output measurement, deviation, the calibration equipment used (description, part number, serial number) and its calibration due date, and the personnel performing the calibration. Calibration sheets shall be provided to the test engineer for record prior to test start.

10.3 The Rotor Spin Facility automated data acquisition system is a Pacific 6000 system responsible for both signal conditioning and recording of data. The system will capture all of the data parameters listed in table 4 at a rate of 100 samples per second per channel (single scan mode). The data system will be set to record during all test activities when the rotor is spinning. It will be ensured that the data will be recorded to both the acquisition PC and the Pacific chassis mounted backup drive. In the event of a limit exceedance for the proximity probe, the system shall be configured to save the data at 100 samples per second starting 60 seconds before the trigger and ending 60 seconds after it. The data will be stored in an MS-Excel compatible format in a location that is accessible to the test team.

10.4 Data from the EM field detector will be recorded on the APEX high speed data acquisition system at the 200 kHz data rate. This will provide the highest likelihood of detecting short transients that may occur during testing. In addition to the EM field detector signal, the rotor speed signal will also be recorded on this data system.

10.5 Additional data will be acquired by the Barbour Stockwell speed controller computer. The speed controller will collect rotor speed related data including cycle counts, acceleration rates and control valve states.

10.6 During the test, the test parameters will be available in tabular and chart form at both the operator and engineer stations. The operator station will show the complete list of measured parameters in tabular form and charts of rotor speed, drive/brake pressure and displacement. At the engineering station, the speed vs. displacement plot will be placed on the large monitor.

11.0 TEST SUCCESS CRITERIA

11.1 Disk Charging Mockup Testing: A mockup capacitor shall be constructed to evaluate whether the desired charge can be repeatedly applied to disk and measured by test instrumentation. Dielectric and rotor materials shall be selected to meet the charge and mechanical stress requirements of this test program.

11.2 Rotor Assembly Design and Fabrication: The rotor will be designed to act as a capacitor capable of holding a charge as required by the test plan. The rotor shall have capability to maintain charge throughout testing via slip ring or internal battery. The rotor shall withstand the mechanical stresses associated with 50,000 rpm with a goal of up to 100,000 rpm.

11.3 EM Flux Sensor Testing (Lab and Spin Pit): EM flux is expected to be emitted as a result of the HEEMFG effect. The sensor system will be capable of detecting changes to the EM field during spin testing. The sensor shall be capable of detecting an EM flux with an amplitude of at least 2 volts and a frequency range between 3 Hz and 3 GHz. The sensor will not output a calibrated measurement of W/m^2.

11.4 Test conditions as listed in the test plan are maintained throughout the program

11.5 Test completed on schedule and within cost estimate

12.0 DELIVERABLES & REPORTING REQUIREMENTS

The planned deliverables consist of daily test reports, test logs, photos, and a final test report.

12.1 Status Reports: There will be regular Status Reports completed on a daily basis during test operations or upon the occasion of significant test events. The report will contain a summary of test events including, but not limited to, description of testing completed, time and date of the event and problems encountered and their solutions. The test and evaluation engineer is responsible for completing the Daily Test Report.

12.2 Test Logs: There will be test logs to record the progress of the program. The log sheet will include cycle counts, dates and times as well as notes detailing significant events and reasons for shutdowns

12.3 Final Test Report: There will be a Final Test Report generated at the completion of the testing, which will describe the test method, results, conclusions, and recommendations. The test and evaluation engineer is responsible for completing the Final Test Report.

13.0 References

'S.C. Pais, The high energy electromagnetic field generator, Int. J. Space Science and Engineering, Vol.3, No. 4, 2015 pp.312-317

Table 4 - Facility Instrumentation List

Parameter Description	Parameter Label	Measurement Range	Units	Alarm Set Point	Indicator Display	Pacific	Strip Chart	APEX	Shut Down
Drive Air Pressure	PDRAIR	0–150	psig		X	X	X		
Brake Air Pressure	PBRAIR	0–150	psig		X	X	X		
Main Air Pressure	PMAINAIR	0–150	psig		X	X			
Balance Air Pressure	PBALAIR	0–40	psig			X			
Return Oil Pressure	PSOIL	0–40	psig			X			
Supply Oil Pressure	PROIL	0–40	psig	<10 psi		X			X
Return Oil Temperature	TKROIL	50–200	°F			X			
Supply Oil Temperature	TKSOIL	50–200	°F	> 175 °F		X			X
EM Flux	EMFLUX	0-200 mV	Volts			X	X	X	
Speed #1	SPDR1	0–100k	rpm	<1000 rpm		X	X	X	X
Speed #1	SPDR1	0–100k	rpm	> 101000 rpm	X	X			X
Spindle Displacement X	DISPX	0–15	mils	> 3 mil@15000 rpm		X	X		X
Spindle Displacement Y	DISPY	0–15	mils	> 15 mil@1950 rpm		X	X		X
Spindle Displacement X	DISPX	0-15	mils	>15 mils	X				X
Vacuum Level	VACUUM	0.1–1	Torr	1 Torr	X	X	X		X
Cycle Time				999999		X			

Table 5 - Astro-Med Strip Chart Setup

Input Channel	Parameter Label	Strip Chart Graph#	Strip Chart Display Range	Chart Text	Chart Size
1	SPDR1	1	0 – 100000 rpm	Speed (0 – 100000 rpm)	1/4
2	DISPX	2	0 – 15 mil-pk-pk	Displacement (0 – 15 mils p-p)	1/8
3	DISPY				
4	PDRAIR	3	0 – 100 psig	Drive/Brake Air Pressure (0-100 psig)	1/8
5	PBRAIR				
6	EM Flux 1	4	Relative Field Strength	Relative Field Strength	1/4
7	SPDR1	5	75000-10000 rpm	Speed (75000 – 100000 rpm)	1/8
8	VACUUM	6	0 – 20 torr	Vacuum (0 –1 Torr)	1/8

14.0 Risk Analysis
TBD

Table 6 - Risk Assessment

APPENDICIES

Appendix - Figures

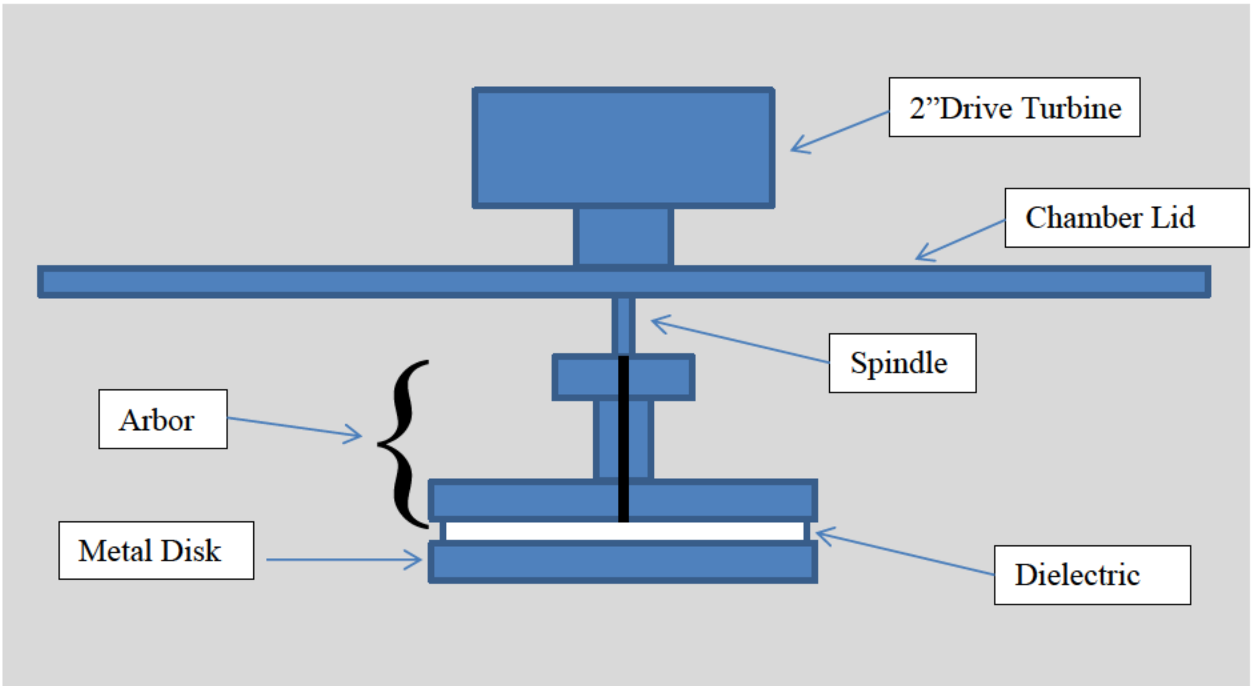

Figure 2 – HEEMFG Spin Rig 2-Disk Test Setup

Test Requirements – The High Energy Electromagnetic Field Generator (HEEMFG)

Overview

This test rotates an electrified aluminum disc (to be designed) at 5000 to 50,000 RPM. The disc is mounted in a vacuum chamber and one surface is charged with up to 1000 V. The objective is to also vibrate the disc in the range of 10^3 Hertz to 10^6 Hertz. Control of both vibration and spin response of the test object is required to include ability to vary acceleration of each. The expected outcome is a high electromagnetic flux, so it is anticipated a Faraday cage will be required for safety of test. The object is to measure the electromagnetic flux or design a method to determine relative strength of the field at various test conditions.

Test Asset

Notionally, this is an Aluminum 6061 disc of 10 cm diameter, 1 cm thickness and electrically insulated on one side. The test asset is mounted to a shaft which must also supply electric power to the disc (2 separate power sources, potentially). A method of inducing controlled vibration in the spinning disc is required to realize the full potential of this experiment. Possibilities for vibrating the test object include using lead zirconate titanate (PZT) modules which are mounted circumferentially in a cruciform configuration on the underside of the disc or acoustic vibration.

Test Notes

For our baseline experiments we recommend testing with at the lower range of spin and accelerated spin listed in Table 1. This is preferred from a safety and test measurement perspective. Testing uncoupled effects of spin and vibration build up to the desired goal to vibrate the spinning test asset in an accelerated manner, and the feasibility study will determine what is needed to achieve the combination of spin and vibration. The overarching goal of this experiment is to verify Equation 2 in the published paper 'S.C. Pais, The high energy electromagnetic field generator, Int. J. Space Science and Engineering, Vol.3, No. 4, 2015 pp.312-317', or any departures from it (namely differences in the experimentally obtained EM energy flux value).

It is highly desired to separately induce and control accelerated modes of vibration and spin. The rapid rates of change of accelerated-decelerated-accelerated vibration and/or accelerated-decelerated-accelerated gyration (axial spin) of the electrified test object are expected to produce the most interesting results. These rapid acceleration transients (RATs) may produce anomalous effects, possible energy amplification counting principally among these.

Test Conditions and Parameters

The test object is mounted in a vacuum chamber evacuated at pressures on the order of 500 mili-Torr (preferred, however vacuum quality will be facility dictated). The disc spins clockwise as viewed from the top of the test asset. Control for spin and vibration shall allow for acceleration of each motion.

Table 1: Test Conditions

Testing Measurands	**Baseline**	**Objective (Desired / Max)**	**Available (Yes/No)**
Test Asset Configuration	Disc	Disc	No (needs fabrication)
Polish of aluminum surface	Smooth surface (0.1 cm)	Rough surface	Yes
Thickness of test asset	1 cm	1 cm	Yes
Diameter of test asset	10 cm	10 cm	Yes
DC Power	1 Volt	1000 Volts	Yes (needs design)
Faraday cage	N/A	N/A	No (needs procurement)
Evacuated Chamber	0.1 Pa	0.0001 Pa	No (not Vacuum desired – still permissible)
EM Energy Flux detector	0 W/m^2	10^{23} W/m^2	No (needs procurement) < 300 W/m^2 (available)
Vibration acceleration Control	Max in 2 min. (test may be conducted at constant (max) vibration)	Max in 2 min. (test may be conducted at constant (max) vibration)	No (manual drive needed to achieve rapid acceleration transients)
Spin acceleration Control	Max spin in 2 min.(operational time of 18 min.)	Max spin in 2 min.(operational time of 18 min.)	Yes (manual drive needed to achieve rapid acceleration transients)
Test Asset Vibration (Hertz)	1000	1,000,000	Yes
Test Asset Spin (RPM)	5000	50,000	Yes

The High Energy Electromagnetic Field Generator (HEEMFG)

219BAR-17-009, NAWC AD Section 219 NISE BAR

FY2018 Project Execution Plan (PEP), version 1

Execution Summary

FY 2018 approved project funding:

Labor:	$0.00 K
Travel:	$0.00 K
Materials:	$0.00 K
Total:	**$0.00 K**

This FY 2018 project execution plan:

Labor:	$192.28 K
Travel:	$0.00 K
Materials:	$70.00 K
Total:	**$262.28 K**

Variance from currently approved funding:

Labor:	over by $192.28 K
Travel:	$0.00 K
Materials:	over by $70.00 K
Total:	**over by $262.28 K**

Burn projection	Q1			Q2			Q3			Q4		
	31-Oct	30-Nov	31-Dec	31-Jan	28-Feb	31-Mar	30-Apr	31-May	30-Jun	31-Jul	31-Aug	30-Sep
Percentage (%)	9%	14%	10%	19%	7%	7%	4%	7%	7%	4%	4%	7%
Cumulative (%)	9%	23%	33%	52%	60%	67%	71%	78%	85%	89%	93%	100%
Amount ($K)	$22.73	$59.46	$86.57	$137.30	$156.53	$175.75	$185.37	$204.60	$223.82	$233.44	$243.05	$262.28
Balance ($K)	$239.55	$202.82	$175.71	$124.98	$105.75	$86.53	$76.91	$57.68	$38.46	$28.84	$19.23	$0.00

Labor

Burn projection	Q1			Q2			Q3			Q4		
	31-Oct	30-Nov	31-Dec	31-Jan	28-Feb	31-Mar	30-Apr	31-May	30-Jun	31-Jul	31-Aug	30-Sep
Percentage (%)	10%	10%	5%	10%	10%	10%	5%	10%	10%	5%	5%	10%
Cumulative (%)	10%	20%	25%	35%	45%	55%	60%	70%	80%	85%	90%	100%
Amount ($K)	$19.23	$38.46	$48.07	$67.30	$86.53	$105.75	$115.37	$134.60	$153.82	$163.44	$173.05	$192.28
Balance ($K)	$173.05	$153.82	$144.21	$124.98	$105.75	$86.53	$76.91	$57.68	$38.46	$28.84	$19.23	$0.00

	Name	Code	GS/GSE	Hourly rate	% WY	# Hours	Est. cost
1.	(b) (6) [redacted]	4.4	PAX - GS/GSE-13	$73.67/hr	30%	522	$38.46K
2.	(b) (6) [redacted]	4.3	PAX - GS/GSE-13	$73.67/hr	30%	522	$38.46K
3.	Lab Technician	4.4	PAX - GS/GSE-13	$73.67/hr	40%	696	$51.27K
4.	Lab Technician	4.4	PAX - GS/GSE-13	$73.67/hr	50%	870	$64.09K
					Labor total:		$192.28K

Travel

There are no travel costs associated with this cost proposal.

The High Energy Electromagnetic Field Generator (HEEMFG)

219BAR-17-009, NAWC AD Section 219 NISE BAR

Materials

Burn projection	Q1			Q2			Q3			Q4		
	31-Oct	30-Nov	31-Dec	31-Jan	28-Feb	31-Mar	30-Apr	31-May	30-Jun	31-Jul	31-Aug	30-Sep
Percentage (%)	5%	25%	25%	45%	0%	0%	0%	0%	0%	0%	0%	0%
Cumulative (%)	5%	30%	55%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Amount ($K)	$3.50	$21.00	$38.50	$70.00	$70.00	$70.00	$70.00	$70.00	$70.00	$70.00	$70.00	$70.00
Balance ($K)	$66.50	$49.00	$31.50	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00

	Type	Description	IT Approval	Mechanism	Est. cost
1.	Material cost	instrumentation	N/A	Contract	$40.00K
2.	Material cost	Hardware Fabrication/Procurements	N/A	Other	$30.00K
				Materials total:	$70.00K

Total FY 2018 execution costs: $262.28K

FY 2018 Project Execution Plan Comments / Justification of Costs

	Comment	Last updated by	Last updated on
1.	PIs, 0.3 MY each for analysis of test results, reporting, and technical paper	(b) (6) [redacted]	4/18/2017
2.	Refer to attached HEEMFG Test Requirements and HEEMFG Problems and Solutions for additional information regarding experiment proposed.	(b) (6) [redacted]	4/14/2017
3.	Instrumentation - $35k notional	(b) (6) [redacted]	4/13/2017
4.	Test Execution (2 weeks) - 10 manweeks and $32K notional	(b) (6) [redacted]	4/13/2017
5.	Test Reporting - (3 weeks) -4 manweeks - $12.8K notional	(b) (6) [redacted]	4/13/2017
6.	Test Cell Setup/Calibration (4 weeks) - 16 manweeks and $51.2K notional	(b) (6) [redacted]	4/13/2017
7.	Hardware Fabrication/Procurements (up to 14 weeks) - $30K+ notional	(b) (6) [redacted]	4/13/2017
8.	Test Readiness Review Preparation (2 weeks), 2 manweeks, $12.8K	(b) (6) [redacted]	4/13/2017

FY18 BAR/TT CALL

REVISED PROPOSAL

The High Energy Electromagnetic Field Generator (HEEMFG)
(219BAR-17-009)

(b) (6) [redacted] AIR 4.4.5.1)
(b) (6) [redacted]

Updated: 9 May 2017

I. PROPOSED TASKS

Task 1: Procure Instrumentation and Hardware ($70k)

- PIs (0.1 MY, 174 hours).
- PI approves final design of experimental test article prior to manufacture.
- Anticipated low level of effort to approve design as well as answer questions from contracted source of hardware and instrumentation.
- Approved final design will take into account HEEMFG technical risks and proposed solutions listed below.

Task 2: Rotor Spin Test Cell Setup and Calibration

- Lab Technicians (0.4 MY, 696 hours).
- Build up the test cell, instrumentation, and data collection to conduct the test in Bldg. 2360, the Propulsion Systems Evaluation Facility (PSEF) Rotor Spin Facility (RSF).
- Calibrate instrumentation prior to conducting the test.

Task 3: Test Readiness Review Preparation

- Lab Technicians (0.05 MY, 87 hours)
- Conduct Test Readiness Review (TRR) with facility and technical management.

Task 4: Test Execution

- Lab Technicians (0.25 MY, 435 hours).
- Execute the test program in PSEF RSF.

Task 5: Test Reporting

- Lab Technicians (0.15 MY, 261 hours).
- Write RSF test report including data analysis.

Task 6: Final Project Report and Technical Papers

- PIs (0.5 MY, 870 hours); Lab Technicians (0.05 hours).
- Final Report submission to NISE project and preparation of technical papers.

II. DELIVERABLES:

(1) Technical papers (for journal publication) and/or patent applications.

(2) Detailed Final Report with experimental results and test instrumentation calibration data.

III. TECHNICAL RISKS AND PROPOSED SOLUTIONS (HEEMFG)

(1) Requested Capability: Run Spin Test in PSEF RSF to evaluate new EM Field Generator Technology

- **Identified Technical Obstacle:** Many high risk components of this test may result in a lower probability of success.
- **Proposed Solution:** Prior to running spin test, perform analyses and benchtop testing to ensure the individual components of the test will be successful (See risks below).

(2) Requested Capability: Electrical Charge on One Side of Disk Only (1-1000 Volts)

- **Identified Technical Obstacle:** There is no clear way to apply charge to only one side of a conductive disk.
- **Proposed Solution:** Non-conductive coating on one side of rotor.

- **Identified Technical Obstacle:** Non-conductive coating on one side of disk will need to be able to handle centrifugal loading.
- **Proposed Solution:** Material requirements will need to be further defined and evaluated.

- **Identified Technical Obstacle:** Conduction path to earth ground may prevent any significant charge on rotating hardware without some way to isolate it from ground.
- **Proposed Solution:** Non-conductive materials can be introduced to isolate rotating disk though they may not be ideal for this application.

- **Identified Technical Obstacle:** Current limitations on slip ring may limit charge applied to rotor.
- **Proposed Solution:** Distribute charge over many slip ring channels to reduce current on any given channel.

(3) Requested Capability: Requested Rotor Vibration of 1-mm Amplitude @ 1000 Hz

- **Identified Technical Obstacle:** Need to define the mode of vibration being requested. Is this an umbrella mode, a sine wave traveling along the rim of the disk, or some other type of vibration? Is the maximum amplitude at the rim or all over the disk?
- **Proposed Solution:** Further define the desired vibration shape/mode of the disk.

- **Identified Technical Obstacle:** Vibration amplitude may be destructive to rotor disk.
- **Proposed Solution:** Perform analysis to determine combined rotor stress from HCF and vibratory loading.

- **Identified Technical Obstacle:** No current way to excite the rotor to generate the desired vibration.
- **Proposed Solution:** Perform market research (**note:** solution may not be available).

- **Identified Technical Obstacle:** Rotor vibration may damage turbine bearings.
- **Proposed Solution:** If run is short enough, may not matter.

- **Identified Technical Obstacle:** Power requirements to enable the rotor vibration may be too large for facility slip rings.
- **Proposed Solution:** Distribute charge over many slip ring channels to reduce current on any given channel (**note:** still may not be enough capability).

(4) <u>Requested Capability: Sensor for Measurement of EM Flux is Not Defined</u>

- **Identified Technical Obstacle:** Sensor is critical to success of test and is currently immature and undefined.
- **Proposed Solution:** Identify adequate sensor that can operate in a spin test environment and determine whether it is sufficiently sensitive to meet the needs of the test.