ADV TECH: The High Energy Electromagnetic Field Generator (HEEMFG)

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

PROJECT DETAILS

T-Code:	(b) (6)	**Portfolio:**	NAWC
TPOC:	(b) (6)	**Primary supporting PMA:**	None or N/A
Secondary TPOC:	(b) (6)	**Interested PMA(s):**	
Start date:	10/3/2016	**Est. total S&T funds:**	$507.3K
End date:	9/30/2019	**NAWC lab:**	AD
Project status:	Active	**Reduced TOC?**	No
NISE BAR type:	Basic Research	**I/I readiness?**	No

Objective: Design a test article and related instrumentation as part of a one-year study to demonstrate the experimental feasibility of achieving high, electromagnetic (EM), field-energy, flux values toward the design of advanced concepts for High Density and High Power systems.

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Description:

FY17:
Create an Experiment within PSEF facilities capabilities:
Task 1: Design of Experiment (DOE) (October 2016 - September 2017)
Physicist (0.2 WY/348 hrs.); PI will be primary author of experiment
Mechanical Engineer, or ME (0.1 WY/174 hrs.); will provide major inputs interfacing with lab equipment
Test Facility Engineer (0.1 WY/174 hrs.); required as major contributor for lab equipment knowledge
Task 2: Design the Test Asset(s) (October 2016 - February 2017)
Physicist (0.05 WY/87 hrs.); supporting roll to evaluate trade space
ME (0.2 WY/348 hrs.); primary designer will interface with other MEs for expertise in loads, vibes, strength, etc.
Task 3: Feasibility Study of Using, Mounting, and Powering PZTs on Test Asset (January - June 2017)
Physicist (0.1 WY/174 hrs.); PI will be primary planner to achieve desired results from excitation
ME (0.1 WY/174 hrs.); primary designer will interface with test engineers and dynamic systems engineers to assess viability of system
Test Facility Engineer (0.05 WY/87 hrs.); required to inform integration decisions
Task 4: Determine Electrical Power Requirements and Source Equipment (November 2016 - January 2017)
Physicist (0.1 WY/174 hrs.); PI will detail calculated requirements
ME/Test Facility Engineer (0.05 MY/87 hrs.); consists of integration roll to determine need for and source new equipment as needed
Task 5: Design/Source Instrumentation to Measure Anticipated Effects (February - June 2017)
Physicist/ME (0.1 WY/174 hrs.); PI will detail calculated range of anticipated effects to be measured and work with lab instrumentation groups to determine need for additional equipment.

FY18
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, answer questions from contracted source of hardware and instrumentation.
Task 2: 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 PSEF rotor spin facility. Calibrate instrumentation prior to conducting the test.
Task 3: Test Readiness Review Preparation
Lab Technicians (0.05 MY, 87 hours) Conduct TRR with facility and technical management.
FY 19
Task 4: Test Execution
Lab Technicians (0.25 MY, 435 hours) Execute the test program in rotor spin facility.
Task 5: Test Reporting
Lab Technicians (0.15 MY, 261 hours) Write rotor spin facility 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.

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Technology challenges:	The primary technology challenge is the commercial-off-the-shelf (COTS) acquisition of PZT modules in the vibrational frequency range of 10^5 to 10^9 Hz, especially those on the high end of this frequency spectrum. However, this may not prove a barrier after all, since the experiment can still be performed at vibrational frequencies of approximately 10^5 Hz, as long as we do this at rapid rates of change of both coupled accelerated spin and accelerated vibration of the electrically-charged test asset (i.e., non-uniform accelerations). For our baseline experiments, we recommend testing with 2,000 RPM spin and 1,000 Hz vibration in order to verify Equation 2 (EM energy flux value) in the attached technical paper, as this is preferred from a safety and test measurement perspective. Also, the test asset can be tested with accelerated spin only or accelerated vibration only, resulting in uncoupled effects.
Starting TRL:	TRL 2: Technology concept and/or application formulated.
Current TRL:	TRL 2: Technology concept and/or application formulated. (Last updated: 9/6/2016)
Estimated TRL at completion:	TRL 3: Analytical and experimental critical function and/or characteristic proof of concept.

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Project accomplishments:

FY	Accomplishment
2017	(30 Sep 17): The team developed a parametric study based on the governing equations of the physical concept. This will predict maximum expected results for EM energy flux based on experimental conditions, and will also be used to bound the experiment based on instrumentation and/or facility limitations. The team also assembled a team of design engineers from the Rotor Spin Facility (RSF) located in the Propulsion Systems Evaluation Facility (PSEF) to design the test asset, arbor, and mount. This team will also assess the dynamic response of the test asset. The test plan was developed as a draft. There were several tests performed to see if test asset and capacitor can sustain an electrical charge.
2018	(20 Sep 18): The team (including RSF engineers) initially planned to incorporate button cell batteries and an in-house designed capacitor to the test design. In June 2018, the team discovered COTS super capacitors with a 4+ Farad capacitance, allowing for a charge of 5.6 coulombs to be reached, rather than being limited to micro-coulombs. Currently, the test facility is prepared and calibrated and the test asset design is complete. EM flux measurement will be accomplished within-house designed/fabricated instrumentation for qualitative detection of EM Flux in the 1 Hz to 3.2GHz range. It consists of three components: an EM Field Receiver Antenna installed around the Test Asset to pick up the EM Flux from the test asset, an EM Flux Detector to sense the EM flux signal received by the antenna, and a High Speed Data Acquisition System to record and display EM Flux Detector output. The EM Flux Detector converts the EM Flux AC voltage signal from the antenna to a DC level voltage proportional to relative EM flux. The EM Flux Detector and EM Field Receiver Antenna are 100% complete with the bench top performance evaluation completed. The High Speed Data Acquisition System is existing facility equipment. The spin test to evaluate the HEEMFG effect took place in late September 2018. The EM Flux Detector did not measure any anomalous electromagnetic effects that would satisfy the theory. It's believed that the reason for this is that the capacitor confined the electrons to its center, rather than the surface, which is necessary for generation of the effect.
2019	To date planning has been in progress to compensate for the effect seen on the capacitor in the end of FY2018, with new experimental setup to be completed by July 2019.

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Project issues:

Author	Last modified	Issue
(b) (6)	5/2/2018	Machine work required to fabricate test asset cannot be done in-house due to precision grinding required; schedule risk if this requires a Rapid Acquisition Contract (RAC) purchase
(b) (6)	9/20/2018	May 2018: In-house fabricated capacitor design is not able to hold a charge of more than Pico-Micro Coulombs. Also, the risk of charge variation in test is high due to the possibility of the parallel plates separating while spinning a high speeds (100 krpm). This could result in a HEEMFG effect false-positive measurement.
(b) (6)	9/20/2018	Trial running of test vehicle experienced spindle displacement limiting rotational speed to 83 krpm. Inspection of the spindle after the test showed it to be slightly bent, most likely being the cause of the displacement. Trial testing with a straight spindle is now being worked.
(b) (6)	4/17/2019	The EM Flux Detector did not measure any anomalous electromagnetic effects that would satisfy the theory. It's believed that the reason for this is that the capacitor confined the electrons to its center, rather than the surface, which is necessary for generation of the effect.

Project notes:

Author	Last modified	Note
(b) (6)	9/6/2016	This project was added automatically by STAIRS from an approved FY17 BAR/TT proposal.

PROJECT FUNDING

Funds provided by: Internal NAVAIR/NAWC **Funding source:** NAWC AD Section 219 NISE BAR

FY	Labor ($K)	Travel ($K)	Materials ($K)	Total ($K)
2017	$144.37K	$5.00K	$2.53K	$151.90K
2018	$220.11K	$0.00K	$26.00K	$246.11K
2019	$97.75K	$4.00K	$17.03K	$118.78K
			Total:	**$516.78K**

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PROJECT ALIGNMENT

Competency core capability:	Power and Energy Systems
Secondary core capability:	
Integration/interoperability:	Strike Warfare (STW)
Secondary integration/interoperability:	N/A
Primary NAE Gap/STO:	2014 Strike Operations (STK) / STO-1: Responsive Engagement
Secondary NAE Gap/STO:	2014 Theater Air and Missile Defense (TAMD) / STO-2: Airborne Missile Defense

NAWC ALIGNMENT

Strategic initiatives alignment: Advanced Technologies

NDS strategic focus areas:

Primary?	NDS strategic focus area
✓	Joint lethality in contested environments

Counter IED: No

Overseas contingency operation: No

S&T research area: Power and Energy Technology / Advanced Naval Power Systems

Key technologies:

Category	Subcategory
Physics	Electricity and Magnetism
Physics	Quantum Theory and Relativity
Power Production and Energy Conversion (Nonpropulsive)	Electric Power Production and Distribution
Propulsion, Engines and Fuels	Electric and Ion Propulsion

DoN S&T focus areas:

Primary?	Tier 1 focus area	Tier 2 focus area
Yes	Power & Energy	High Energy and Pulsed Power
No	Power & Energy	Efficient Power and Energy Systems

COLLABORATIONS

Navy:

[FY18] NAWC AD, (b) (6) . Jointly funded, Active.
Comments: Currently working with (b) (6) and (b) (6) on test asset design and test directive preparation. Working with (b) (6) and (b) (6) on the EM Flux Detector design and testing.

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S&T PRODUCTS

Paper for publication:

[FY17] Published: Dr. S. Pais, (2017, September 15). A hybrid craft using an inertial mass modification device (AIAA 2017-5343). AIAA 2017 SPACE Forum and Exhibition - Proceedings. Refereed.

[FY18] Published: Dr. S. Pais, (2017, October 03). High Frequency Gravitational Waves -Induced Propulsion. SAE Technical Paper 2017-01-2040, doi: 10.4271/2017-01-2040. Refereed.

[FY19] Published: Dr. S. Pais, (2019, January 08). Room Temperature Superconducting System for use on Hybrid Aerospace-Undersea Craft. 2019 AIAA SCITECH Forum Proceedings, Conference paper designated AIAA 2019 0869(n/a). Refereed.

Patent/patent application:

[FY17] Application filed: Dr. S. Pais, (2017, February 14). High Frequency Gravitational Wave Generator. Tracking number: 15431823.

[FY17] Application filed: Dr. S. Pais, (2017, August 17). Piezoelectricity-Induced Room Temperature Superconductor. Tracking number: 15678672 (Navy case PAX 263).

[FY18] Application filed: Dr. S. PAIS, (2018, March 22). Plasma Compression Fusion Device. Tracking number: Serial # 15928703 (Navy Case PAX 285).

[FY19] Patent awarded: Dr. S. Pais, (2018, November 28). Electromagnetic Field Generator and Method to Generate an Electromagnetic Field. Tracking number: US Patent # 10135366.

[FY19] Patent awarded: Dr. S. Pais, (2018, December 04). Craft using an Inertial Mass Reduction Device. Tracking number: US10144532B2.

WORKFORCE DEVELOPMENT COMPONENTS

There are currently no workforce development components identified for this project.

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PROJECT TRANSITIONS

ADV TECH: The High Energy Electromagnetic Field Generator (HEEMFG)

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Transition type:	G - Product transitions to Naval Air Warfare Center / Fleet Readiness Center
Is this the primary transition?	Yes
Planned transition date:	9/30/2019
Actual transition date:	
Transition manager:	AIR-4.0
Product type:	Business Product / Analysis (e.g. Analysis of Alternatives (AOAs) and Capabilities Based Assessments (CBAs), etc.)
Product description:	Technical Reports
Is a transition agreement in place?	No

Deliverables / milestones:

FY	Estimated TRL	Status	Deliverable
2017	N/A: TRL is not applicable for this project.	Planned	(2) Design of Experiment for Test Plan
2017	N/A: TRL is not applicable for this project.	Planned	(1) File Patent Application based on Project Physics
2017	N/A: TRL is not applicable for this project.	Planned	(3) Draft Theoretical Paper based on Project Findings
2017	N/A: TRL is not applicable for this project.	Actual	(3) Draft Theoretical Paper based on Project Findings. Status (27 Sep 17): 100% complete.
2017	N/A: TRL is not applicable for this project.	Actual	(2) Design of Experiment for Test Plan. Status (27 Sep 17): 100% complete.
2017	N/A: TRL is not applicable for this project.	Actual	(1) File Patent Application based on Project Physics. Status (27 Sep 17): 100% complete.
2018	N/A: TRL is not applicable for this project.	Planned	(4) Complete design and calibration of EM flux measurement device.
2018	N/A: TRL is not applicable for this project.	Planned	(5) Spin Test to Evaluate Rotor Design
2018	N/A: TRL is not applicable for this project.	Planned	(6) Spin Test to Evaluate HEEMFG Effect
2018	N/A: TRL is not applicable for this project.	Planned	(7) Submit an FY19 PEP in order to extend our current project to incorporate follow-on testing in FY19.
2018	N/A: TRL is not applicable for this project.	Actual	(6) Spin Test to Evaluate HEEMFG Effect: Status (20 Sep 18): 60% complete. Test completion expected end of September 2018 at the earliest.
2018	N/A: TRL is not applicable for this project.	Actual	(5) Spin Test to Evaluate Rotor Design: Status (20 Sep 18): 100% complete. Test asset was installed in spin chamber, and run incrementally up to max speed to assess rotor dynamic stability and structural integrity of test asset.

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	2018	N/A: TRL is not applicable for this project.	Actual	(4) Complete design and calibration of EM flux measurement device. Status (20 Sep 18): 100% complete. Three (3) components: (1) EM Flux Detector: 100% complete, proof of concept demonstrated, assembly and checkout of final version completed; (2) EM Field Antenna: conceptual design complete; and (3) High Speed Data Acquisition System: complete; this is existing facility equipment.
	2018	N/A: TRL is not applicable for this project.	Actual	(7) Submit an FY19 PEP in order to extend our current project to incorporate follow-on testing in FY19. Status (20 Sep 18): 100% complete.
	2019	N/A: TRL is not applicable for this project.	Planned	(8) Continue testing based on preliminary FY18 results. Consider different parametric transients.
	2019	N/A: TRL is not applicable for this project.	Planned	(9) Modify testing parameters to detect the HEEMFG effect.
	2019	N/A: TRL is not applicable for this project.	Planned	(10) Analyze acquired data from modified testing.
	2019	N/A: TRL is not applicable for this project.	Planned	(11) Write final report based on modified testing analysis.
	2019	N/A: TRL is not applicable for this project.	Actual	(8) Continue testing based on preliminary FY18 results. Consider different parametric transients. Status (18 April 19): 0% complete. FY19 testing has not begun yet. Different parametric transients have not been explored yet.
	2019	N/A: TRL is not applicable for this project.	Actual	(9) Modify testing parameters to detect the HEEMFG effect. Status (18 April 19): 25% complete. Test design was modified to pull electrons to the surface of charged object to create the effect. No test setup or instrumentation is completed yet.
	2019	N/A: TRL is not applicable for this project.	Actual	(10) Analyze acquired data from modified testing. Status (18 April 19): 0% complete. Test was not yet conducted.
	2019	N/A: TRL is not applicable for this project.	Actual	(11) Write final report based on modified testing analysis. Status (18 April 19): 0% complete. Test was not yet conducted.
Transition details:	2017 N/A: TRL is not applicable for this project. Actual (3) Draft Theoretical Paper based on Project Findings (100% complete). 2017 N/A: TRL is not applicable for this project. Actual (2) Design of Experiment for Test Plan (100% complete). 2017 N/A: TRL is not applicable for this project. Actual (1) File Patent Application based on Project Physics (100% complete).			

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STAIRS ACTIVITY	
Approval status:	This project was approved by (b) (6) on 9/6/2016.
Last modified:	This project was last modified by (b) (6) on 7/17/2019.

ADV TECH: The High Energy Electromagnetic Field Generator (HEEMFG)

219BAR-17-009

NAWC AD Section 219 NISE BAR

T-Code: 4.4T

Generated by the NAE S&T Alignment and Investment Reporting System

Objective: Design a test article and related instrumentation as part of a one-year study to demonstrate the experimental feasibility of achieving high, electromagnetic (EM), field-energy, flux values toward the design of advanced concepts for High Density and High Power systems.

I&I: Strike Warfare (STW)

NAE Gap/STO: 2014 Strike Operations (STK) / STO-1: Responsive Engagement

-- Add photo --

Image caption

Description: FY17:
Create an Experiment within PSEF facilities capabilities:
Task 1: Design of Experiment (DOE) (October 2016 - September 2017)
Physicist (0.2 WY/348 hrs.): PI will be primary author of experiment
Mechanical Engineer or ME (0.1 WY/174 hrs.): will provide major inputs interfacing with lab equipment
Test Fac ility Engineer (0.1 WY/174 hrs): required as major contributor for lab equipment knowledge
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Physicist (0.05 WY/87 hrs.): supporting roll to evaluate trade space
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Task 1: Procure instrumentation and hardware ($70k)
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Lab Technicians (0.4 MY 696 hours) Bu ild up the test cell instrumentation and data collection to conduct the test in PSEF rotor spin facility. Calibrate instrumentation prior to conducting the test.
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Lab Technicians (0.25 MY 435 hours) Execute the test program in rotor spin facility.
Task 5: Test Reporting
Lab Technicians (0.15 MY 261 hours) Write rotor spin facility 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.
Technology challenges: The primary technology challenge is the commercial-off-the-shelf (COTS) acquisition of PZT modules in the vibrational frequency range of 10^{5} to 10^{9} Hz especially those on the high end of this frequency spectrum. However this may not prove a barrier after all since the experiment can still be performed at vibrational frequencies of approximately 10^{5} Hz as long as we do this at rapid rates of change of both coupled accelerated spin and accelerated vibration of the electrically-charged test asset (i.e. non-uniform accelerations). For our baseline experiments we recommend testing with 2 000 RPM spin and 1 000 Hz vibration in order to verify Equation 2 (EM energy flux value) in the attached technical paper as this is preferred from a safety and test measurement perspective. Also the test asset can be tested with accelerated spin only or accelerated vibration only resulting in uncoupled effects.

Total funding (last 5 years):

FY17	FY18	FY19	Total:
$151.9K	$246.1K	$118.8K	$516.8K

Transition sponsor: AIR-4.0

Technical point of contact: (b) (6)

(b) (6) [redacted]

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

14 September 2018

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 Intergalactic Flight (successful design of a Space Drive).

Objective - continued

- **Moreover, the HEEMFG technology teaches the fundamentally unique innovative principle of 'Controlled Motion of electrically charged matter (from solid to plasma) via Accelerated Spin and/or Accelerated Vibration under Rapid Acceleration Transients', which can result in high intensity electromagnetic energy flux, thereby resulting in novel energy harvesting and generation techniques and devices. These devices can greatly enhance NAVAIR/NAWCAD's electronic warfare technologies arsenal.**

- **This pioneering concept can lead to the enablement of Macroscopic Quantum Coherence (the engineering of macroscopic states to behave as if quantum mechanical in nature - superposition, entanglement, tunneling, teleportation) , which translates into Emerging Technology breakthroughs in Tactical High Energy Lasers, Wireless Power Transmission, Advanced Field Propulsion (hybrid aero-space craft and power plants), High Temperature (Room temperature) Superconductivity and Quantum Technologies, such as Spintronics and Quantum Computing.**

- **Furthermore, this technology has National Security importance in leading to the generation of thermonuclear Fusion Ignition Energy with commercial as well as military application potential, in ensuring National Energy Dominance.**

Approach

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

- This experimental investigation has four (4) tasks, namely to design the experiment, the test asset, the associated instrumentation and the power requirements.

Total Project Funding			
FY17	FY18	FY19	Total
$151.90K	$197.60K	$117.30K	$466.81K

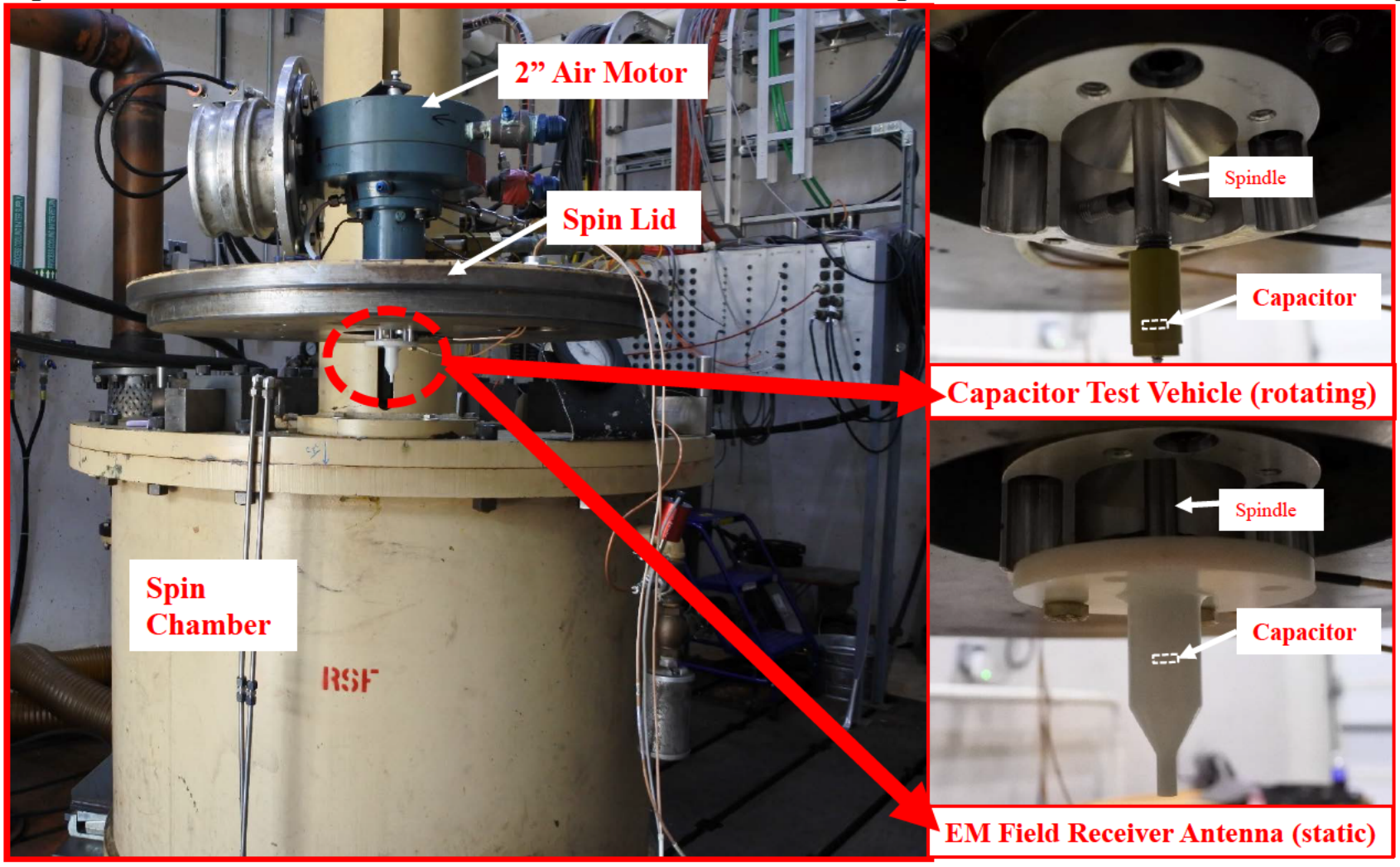
FY18 Progress

FY 18 Funding	% Expensed
$197.60K	99%

- As of 30 September 2018: we will be 99% expensed.
- Design of Experiment

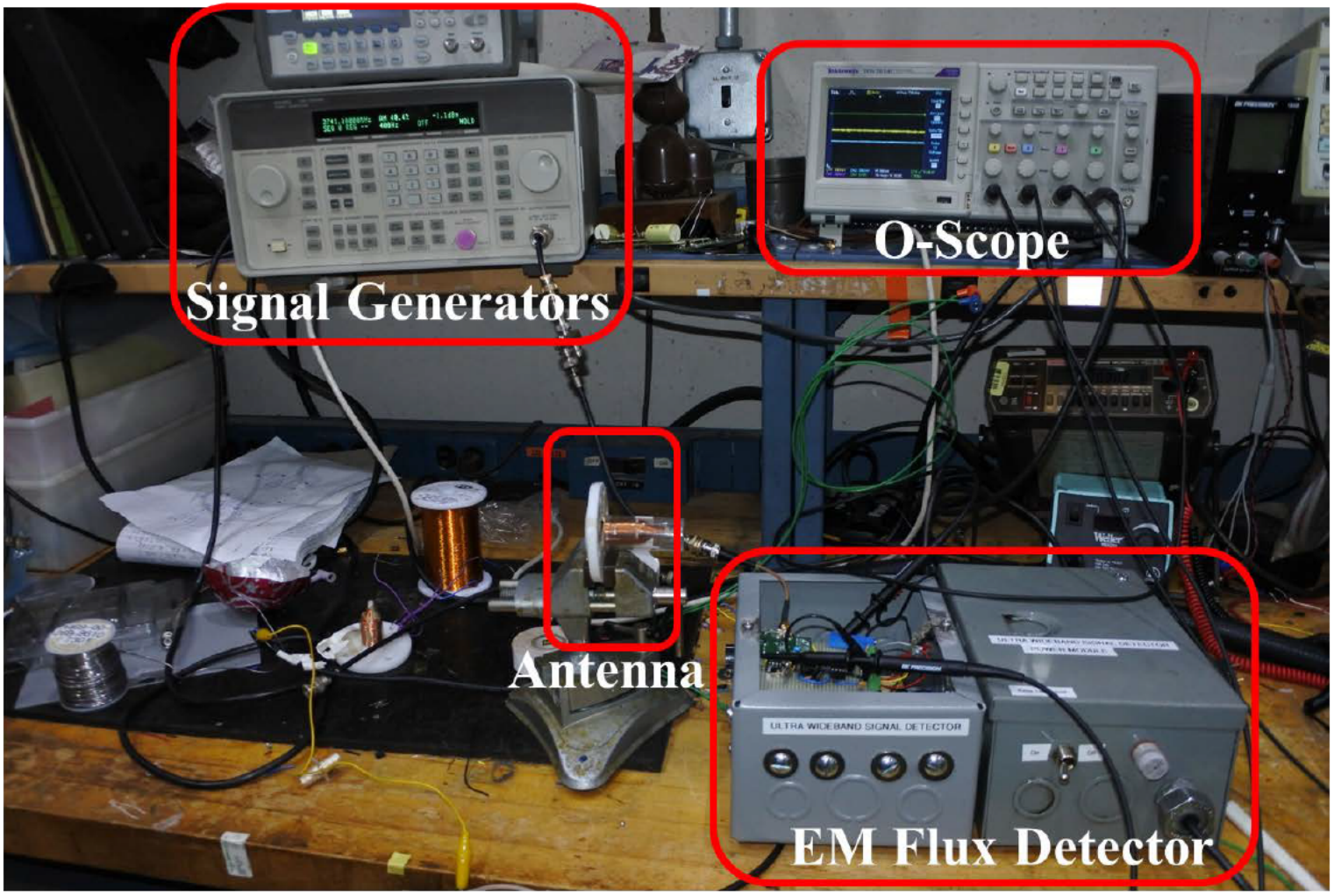
- Testing will be conducted in the Propulsion Systems Evaluation Facility (PSEF), building 2360, Rotor Spin Facility (RSF). A **charged test asset, in the form of a coin cell capacitor**, will be installed in spin chamber #4 and spun by a 2 inch air motor at speeds up to 100,000 rpm (goal). The test asset is suspended on the air motor's 5/16" diameter vertical drive shaft; the *test asset is not constrained in bearings* so the test asset can 'wobble' during spinning. The test asset rotational speed versus time profile will include rapid acceleration and decelerations.
- In-house designed EM Flux Detector and EM Field Receiver Antenna surrounding the charged test asset will be used for detection of the HEEMFG Effect.
- A detailed test plan is completed.
- A test readiness review (TRR) was conducted on 5 September 2018.
- There is no provision for inducing vibration into the disk; there may be some vibration induced due to 'wobble' of the test asset while spinning.

Spin Chamber #4: Coin Cell Capacitor Test Setup



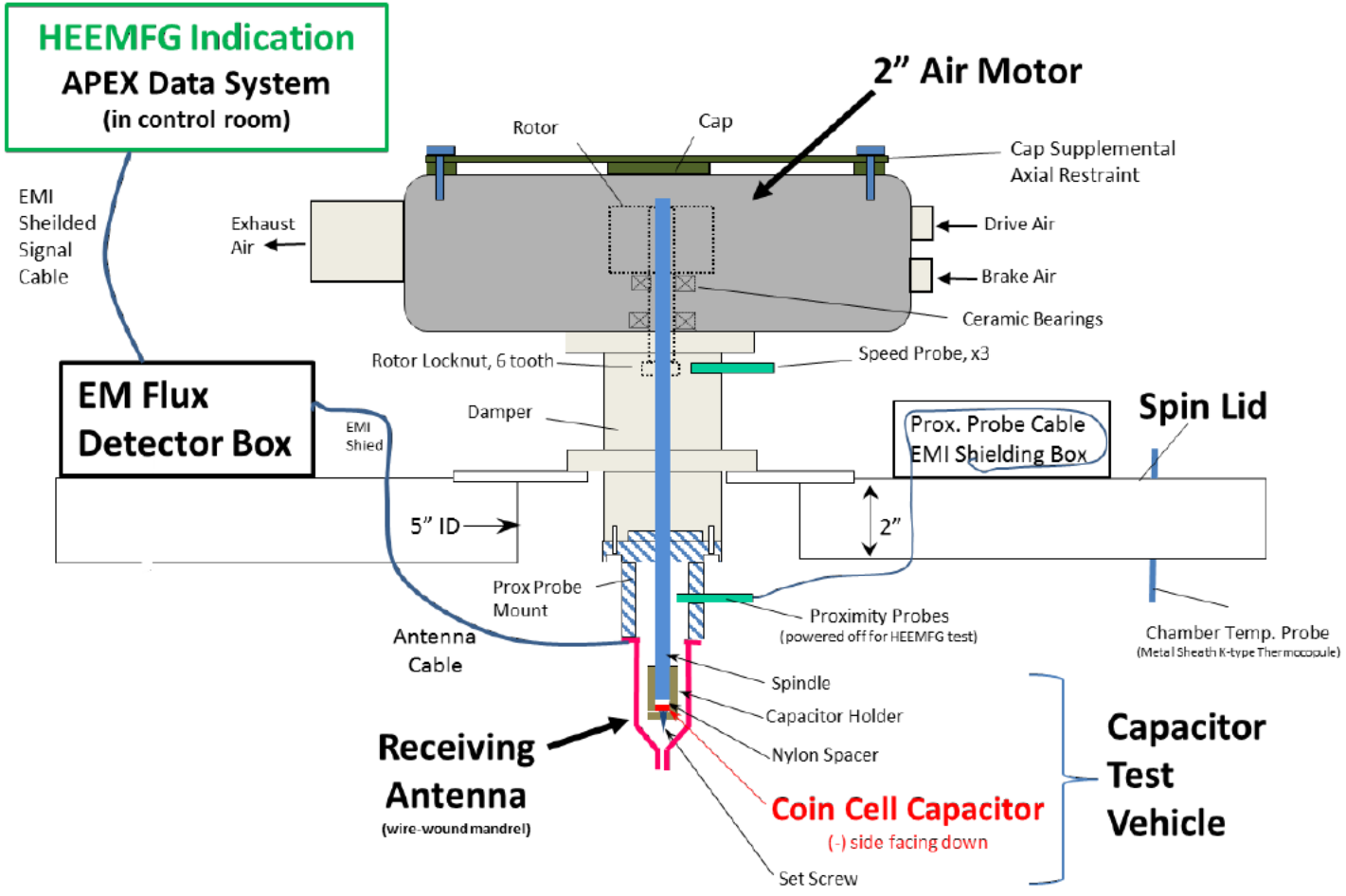
Approach

EM Flux Detection Instrumentation Bench Testing



Approach

COIN CELL CAPACITOR SPIN RIG



FY18 Progress

- **Test Facility Prepared and Calibrated – Ready for test.**

- **Design of Test Asset – Complete**
  - Charged disk test asset: coin cell capacitor, 0.276 inch diameter, charged to 5.6 coulombs.
  - Capacitor Test Vehicle: consists of adaptive hardware to connect coin cell capacitor to the facility 2-inch air motor's, 5/16" diameter, vertical drive spindle via a threaded plastic capacitor holder.

FY18 Progress (cont'd)

- **EM Flux Measurement Device**

- EM flux measurement will be accomplished with in-house designed/fabricated instrumentation for *qualitative* detection of EM Flux in the 1 Hz to 3.2GHz range. It consists of three components: an **EM Field Receiver Antenna** installed around the Test Asset to pickup the EM Flux from the test asset, an **EM Flux Detector** to sense the EM flux signal received by the antenna, and a **High Speed Data Acquisition System** to record and display EM Flux Detector output. The EM Flux Detector converts the EM Flux AC voltage signal from the antenna to a *DC level voltage proportional to relative EM flux*.

- ***EM Flux Detector:*** 100% complete, bench top performance evaluation completed.

- ***EM Field Receiver Antenna:*** bench top evaluation and down select of final configuration completed; antenna is a wire-wrapped plastic mandrel surrounding the test asset.

- ***High Speed Data Acquisition System:*** complete; this is existing facility equipment

Future Expectations

- **Spin Test to Evaluate HEEMFG Effect** (late September 2018)

FY18 Research Products

- **“High Frequency Gravitational Waves - Induced Propulsion”** published as peer-reviewed SAE Technical paper 2017-01-2040 , October 03, 2017. Presented at the SAE AeroTech Congress & Exhibition.
 - It may be possible to generate high power / high frequency gravitational waves (HFGWs) by high frequency accelerated axial rotation (spin) and/or accelerated high frequency vibration of an electrically charged, possibly asymmetric structure, within the context of non-equilibrium thermodynamics, namely far-from-equilibrium physics, highly non-linear in nature. Therefore, it may be feasible to propel a hybrid craft equipped with an HFGWG, by producing high frequency gravitational waves which in turn generate their own gravitational fields upon which the craft would propagate in a ‘wave-surfing’ fashion.

- **Navy Case PAX 285 titled "Plasma Compression Fusion Device"** has been filed with the United States Patent & Trademark Office as a patent application / Serial # 15928703, on March 22, 2018.
 - The Plasma Compression Fusion Device (PCFD) generates energy gain by plasma compression-induced nuclear fusion, via a novel method of magnetic confinement. This concept has the capability of maximizing the product of plasma pressure and energy confinement time in order to maximize energy gain and thus give rise to fusion ignition conditions. Moreover, this invention can give our Navy the technological edge in achieving National Energy Dominance, besides its many commercial benefits in energy generation.

FY18 Workforce Impact

- List any of the following that have been completed, are in progress, or are expected as a result of the work on this project:
  - Training Attended/ Developed/ Provided
  - Higher Education, Degree Achieved or In Progress
  - Mentoring Relationships
  - Developmental Rotations
  - Student Interns
  - Dissertations Completed or In Progress
  - STEM (SMART/ NREIP/ SEAP Students/ Outreach)
  - Summer Faculty

Chart is NOT APPLICABLE

Partnerships

- The experimental study is a highly collaborative AIR 4.4 and AIR 4.3 effort.
  - Currently working with (b) (6) on test asset design and test directive preparation.
  - Working with (b) (6) and Team on the EM Flux Detector design and testing.
- Results of the experimental 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:

- 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

Related Projects:

- None

Backup

(b) (6) [redacted]

(b) (6) [redacted]

(b) (6) [redacted]

The High Energy Electromagnetic Field Generator (HEEMFG)

219BAR-17-009

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

(b) (6)

(b) (6)

Patuxent River, MD

April 2018

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 Intergalactic Flight (successful design of a Space Drive).

Approach

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

- This experimental investigation has 4 tasks, namely to design the experiment, the test asset, the associated instrumentation and the power requirements.

Total Project Funding			
FY17	FY18	FY19	Total
$151.90K	$197.60K	$117.30K	$466.81K

FY18 Progress

FY 18 Funding	% Expensed
$197.60K	32%

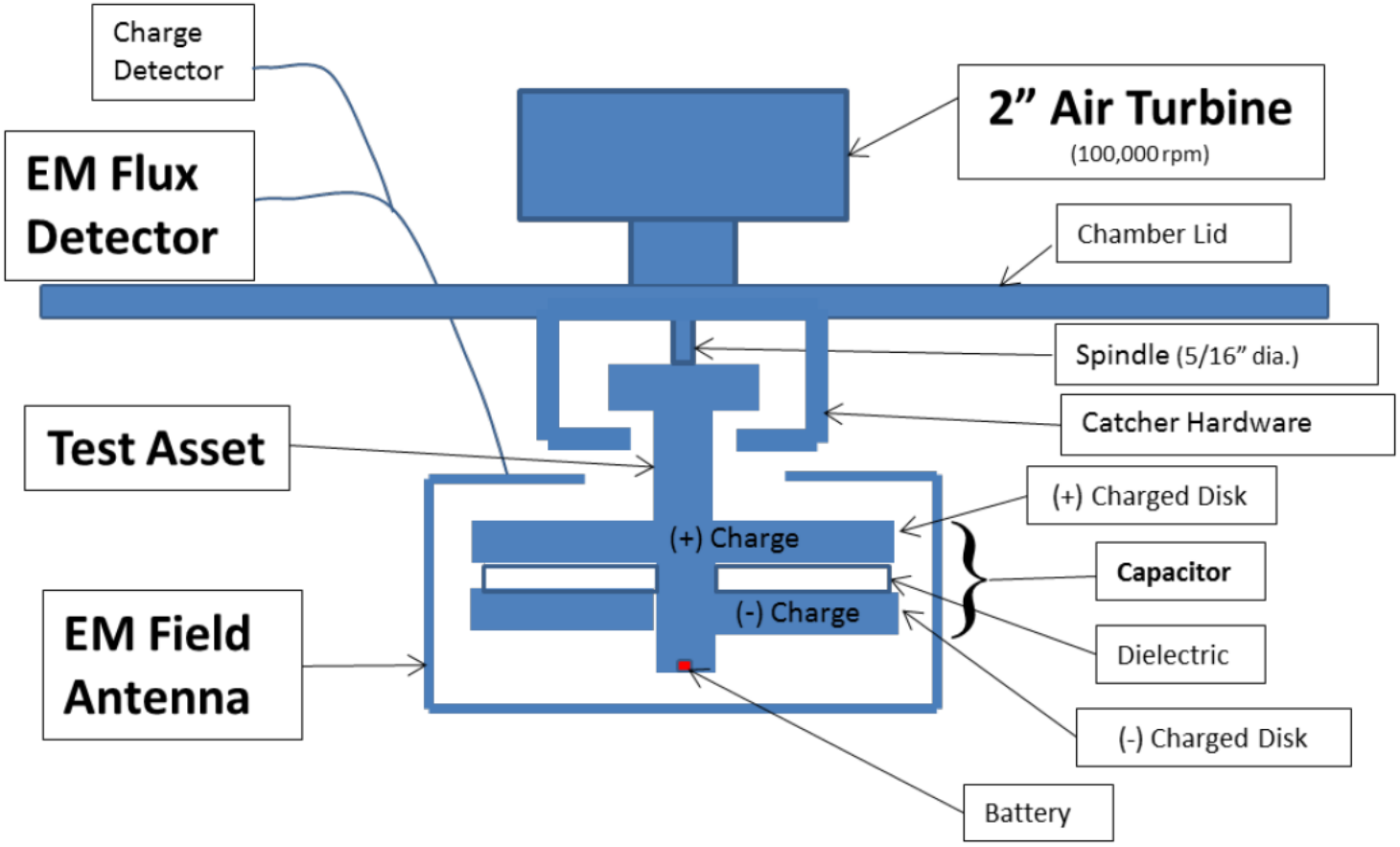
- As of 31 MAR 2018: behind the plan of 68% expensed.
- Design of Experiment

- Testing will be conducted in the Propulsion Systems Evaluation Facility (PSEF), building 2360, Rotor Spin Facility (RSF). A charged test asset installed in spin chamber #4 will be spun by a 2 inch air turbine at speeds up to 100,000 rpm (goal). The test asset is suspended on the air turbine's 5/16" diameter vertical drive shaft; the *test asset is not constrained in bearings* so the test asset can 'wobble' during spinning. The test asset rotational speed versus time profile will include rapid acceleration and decelerations.
- In-house designed EM Flux Detector and EM Field Antenna will be used for detection of the HEEMFG Effect.
- The test plan is drafted awaiting an update with final details of instrumentation, test asset hardware design and assembly details, and procedures.
- There is no provision for inducing vibration into the disk; there may be some vibration induced due to 'wobble' of the test asset while spinning.

Approach

HEEMFG Spin Rig

(notional)



FY18 Progress

- Test Facility Preparation

- Spin chamber #4 is being prepared to support testing.

- Design of Test Asset

- The test asset will consist of a dielectric material clamped between two ~3.5 inch diameter metal disks to form a parallel plate capacitor; a button cell battery will be incorporated to maintain the charge on the capacitor.

- The test asset will be designed to connect to the 2-inch air turbine via the turbine's 5/16" diameter vertical drive spindle.

- Spin Test of Battery - complete

- Evaluated a button cell battery in spin chamber #2. Battery *survives 25 minutes at 100,000 rpm* and passes functional test "at rest" – there was no practical method to determine function while spinning. Moving forward to incorporate battery into test asset design.

- Bench Top Disk Charging

- Evaluated various capacitor mockups toward design of test asset. Dielectric materials evaluated included paper, magazine grade laminated paper, polycarbonate, alumina, Mylar, and cardboard. Magazine paper and alumina are the best candidates.

FY18 Progress

- EM Flux Measurement Device

- EM flux measurement will be accomplished with in-house designed/fabricated instrumentation for *qualitative* detection of EM Flux in the 1 Hz to 3.2GHz range. It consists of three components: an **EM Field Antenna** installed around the Test Asset to pickup the EM Flux from the test asset, an **EM Flux Detector** to sense the EM flux signal received by the antenna, and a **High Speed Data Acquisition System** to record and display EM Flux Detector output. The EM Flux Detector converts the EM Flux AC voltage signal from the antenna to a *DC level voltage proportional to relative EM flux*.
- EM Flux Detector: 90% complete, proof of concept was demonstrated, assembly and checkout of final version nearing completion
- EM Field Antenna: conceptual design complete
- High Speed Data Acquisition System: complete; this is existing facility equipment

- Charge Detector Device

- Test asset capacitor charge could be lost during spinning preventing the HEEMFG Effect from occurring; for example, centrifugal loads on the test asset could cause battery failure, dielectric failure, or disk separation from the dielectric. A **Charge Detector** will be designed/fabricated to provide indication that the test asset has a static charge when spinning. It will use the signal from the EM Field Antenna.

Future Expectations

- Complete test asset and supporting hardware design
- Fabricate test asset (machine work cannot be done in-house due to precision grinding required; schedule risk if this requires a Rapid Acquisition Contract (RAC) purchase).
- Fabricate support test hardware (catcher assembly, EM flux antenna)
- Spin Test to Evaluate Rotor Design

- The test asset will be dynamically balanced without dielectric material, installed in the spin chamber, and run incrementally up to maximum speed to assess rotor dynamic stability and structural integrity of the test asset.

- Complete EM Flux Detector Build Up and Checkout
- Design/fabricate/functionally test EM Flux Antenna
- Spin Test to Evaluate HEEMFG Effect (late June - best case)

FY18 S&T Products

- **“High Frequency Gravitational Waves - Induced Propulsion”** published as peer-reviewed SAE Technical paper 2017-01-2040 , October 03, 2017. Presented at the SAE AeroTech Congress & Exhibition.
 - It may be possible to generate high power / high frequency gravitational waves (HFGWs) by high frequency accelerated axial rotation (spin) and/or accelerated high frequency vibration of an electrically charged, possibly asymmetric structure, within the context of non-equilibrium thermodynamics, namely far-from-equilibrium physics, highly non-linear in nature. Therefore, it may be feasible to propel a hybrid craft equipped with an HFGWG, by producing high frequency gravitational waves which in turn generate their own gravitational fields upon which the craft would propagate in a ‘wave-surfing’ fashion.

- **Navy Case PAX 285 titled "Plasma Compression Fusion Device"** has been filed with the United States Patent & Trademark Office as a patent application / Serial # 15928703, on March 22, 2018.
 - The Plasma Compression Fusion Device (PCFD) generates energy gain by plasma compression-induced nuclear fusion, via a novel method of magnetic confinement. This concept has the capability of maximizing the product of plasma pressure and energy confinement time in order to maximize energy gain and thus give rise to fusion ignition conditions. Moreover, this invention can give our Navy the technological edge in achieving National Energy Dominance, besides its many commercial benefits in energy generation.

FY18 Workforce Development Components

- List any of the following that have been completed, are in progress, or are expected as a result of the work on this project:
  - Training Attended/ Developed/ Provided
  - Higher Education, Degree Achieved or In Progress
  - Mentoring Relationships
  - Developmental Rotations
  - Student Interns
  - Dissertations Completed or In Progress
  - STEM (SMART/ NREIP/ SEAP Students/ Outreach)
  - Summer Faculty

Chart is NOT APPLICABLE

Collaborations

- The experimental study is a highly collaborative 4.4 effort.
  - Currently working with (b) (6) [redacted] on test asset design and test directive preparation.
  - Working with (b) (6) [redacted] and (b) (6) [redacted] on the EM Flux Detector design and testing.
- Results of the experimental 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

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