REQUEST FOR INFORMATION (RFI)
ONR RFI Announcement N00014-16-RFI-0013
Torpedo Advanced Propulsion System (TAPS)

I. DISCLAIMER:

This announcement constitutes a Request for Information (RFI) for the purpose of determining market capability of sources or obtaining information. It does not constitute a Request for Proposals (RFP), a Request for Quote (RFQ) or an indication that the Government will contract for any of the items and/or services discussed in this notice. Any formal solicitation that may subsequently be issued will be announced separately through Federal Business Opportunities (FedBizOpps). Information on the specific topics of interest is provided in the following sections of this announcement. Neither ONR nor any other part of the federal government will be responsible for any cost incurred by responders in furnishing this information.

II. BACKGROUND:

The Office of Naval Research (ONR) Code 33 requests information on technologies to extend the range of the current US Navy Heavyweight Torpedo (MK-48 Mod7). Particular areas of interest include improved efficiency of the current Otto fuel engine as well as battery solutions.

III. SPECIFIC INFORMATION OF INTEREST:

See Enclosure

IV. SUBMISSION INSTRUCTIONS and FORMATTING REQUIREMENTS

a. Responses are requested by **19 August 2016, 1600 hours EASTERN STANDARD TIME**. Any response received after this date/time will also be considered but may not be included in initial reporting or assessments.

b. All responses should be in PDF format and emailed to the technical point of contact: Ms. Maria Medeiros, maria.medeiros1@navy.mil. The subject line of the email should read as follows "RFI: TORPEDO ADVANCED PROPULSION SYSTEM"

All responses must be unclassified. No classified response will be accepted. All information received in response to this RFI that is marked proprietary will be handled accordingly. Responses to this notice will not be returned.

c. Responses should not exceed **10** pages and should be typed in 12- point Times New Roman font, single spaced, with 1-inch margins.

d. A suggested submission organization:
   1. Cover Sheet – RFI number and name, address, company, technical point of contact, with printed name, title, email address and date.

2. Table of Contents with page numbers
3. Technical data
4. Technical Approach and Justification
5. Rough Order of Magnitude

No detailed cost or pricing information should be provided. Any received will be deleted and destroyed.

e. Once responses are received and reviewed, responders may be invited to present their information at ONR.

V. QUESTIONS AND POINT OF CONTACT

Questions of a technical nature regarding this RFI may be sent to the following Technical Point of Contact:

Name: Ms. Maria Medeiros
Title: Program Manager
Division Title: Undersea Weapons Programs
Division Code: 333WP
Address: 875 N. Randolph St, Arlington, VA 22203
Email Address: maria.medeiros1@navy.mil

The FY17 Future Naval Capability (FNC) titled "Torpedo Advance Propulsion System" (TAPS) will develop and demonstrate a prototype torpedo propulsion system to evolve the Mk-48 Advanced Capability Heavyweight Torpedo (ADCAP HWT) into an extended-range weapon. Several technologies will be explored: Otto fuel (currently used), an Al-AgO battery and a chemical thermal system. The following is a Request for Information (RFI) for several systems/components to support this FNC:

Mk-48 Otto Fuel Engine

The Mk 48 afterbody/tailcone (AB/TC) contains the engine, accessories (fuel pump, hydraulic, pump, etc.) and the steering assembly. The Mk 48 engine is a six-cylinder swash-plate design, which is a type of reciprocating engine that replaces the common crankshaft with a circular plate. Piston forces act on this non-rotating "wobble plate" in a circular sequence, forcing the plate to nutate around its center, applying force to the angled swash-plate that forces the driveshaft to rotate. The key advantage of the design is that the cylinders are arranged parallel to the driveshaft around the edge of the plate, rather than perpendicular to the shaft, as in crankshaft engines. This results in a very compact, cylindrical engine.

The Mk-48 uses Otto Fuel, a non-explosive, shock-insensitive, liquid monopropellant designed for torpedo application. In most liquid monopropellants, the combination of fuel and oxidizer produces a potential for an explosive hazard. Otto Fuel, however, has passed all required safety testing for submarine and surface ship applications. As such, modification or substitution of the fuel is not part of this request.

This RFI is interested in increasing the range of the existing torpedo by reducing the engine power levels. This can be accomplished by either a different engine or replacing the existing accessories (fuel pump, hydraulic pump, coolant pump and alternator) with higher efficiency accessories. Currently, the accessories are driven off of the forward end of the engine and it is assumed a new engine would require this same configuration. The horsepower (HP) ranges of interest for these accessories are:

Engine Shaft	20 to 400 HP
Total Accessories	10 to 80 HP
Coolant Pump	1 HP (constant)
Hydraulic Pump	5 HP (constant)
Fuel Pump	1 to 40 HP
Alternator	10 to 30 HP

Due to the short timeframe of less than two years, this RFI is limited to the following three areas:

Increasing Combustion Efficiency: Propose modifications to the combustion chamber to increase the overall efficiency of the combustion process. The changes could include:

- Material change to minimize heat transfer and cooling effects in combustor
- Increase in residence time within the combustor
- A change in droplet size/atomization over the wide range in power levels

These changes must be maintained within the physical constraints of the existing torpedo (right circular cylinder, 18.5" diameter and 72" length).

New External Combustion Engine: Propose a new engine that operates more efficiently over the power levels desired. These changes must conform to the physical dimensions and engine specifications of the current torpedo for shock and vibration requirements, hot/cold storage and operating condition.

Higher Efficiency Accessories: Propose a replacement for fuel pump, hydraulic pump or alternator (no replacement for coolant pump is desired) with a higher mechanical efficiency to increase torpedo range. These changes must conform to the physical dimensions and specifications of the current torpedo for shock and vibration requirements, hot/cold storage and operating conditions, etc.

Electric Power System

An alternative to the current Mk-48 engine would be an electric propulsion system that leverages advancements in seawater-activated battery systems. Of interest is Al-AgO battery technology, which has been previously demonstrated as safe in torpedo applications. Therefore, information is solicited from industry that has historically played a significant role in the development and manufacturing of torpedo battery technology. Development, maintenance and total ownership costs are drivers that should be addressed.

To support the FNC program schedule, the battery system and balance-of-plant components need to be at, or above, Technology Readiness Level 4 (TRL) at the start of the program and be at TRL 6 and the end of the program. High energy density and efficiency during low-power operation with a high-power capability for burst operation is needed. Specifically for Al-AgO battery technology, a low leakage current design that minimizes the corrosion reaction will be required for efficient operation at low power. Batteries suitable for long-term storage and submarine safety certification, including thermal batteries used for power during torpedo start up, need to supply power to the propulsion motor, circulation pump and vehicle electronics during activation of the Al-AgO system. The system must have hazards identified and be able to obtain weapon systems safety certification.

In order to maintain battery performance over the entire run duration, an electrolyte management system (EMS) is required to be integrated with the battery and the components to be acquired. Critical to the system is a quiet electrolyte circulation pump and motor and system designs to minimize flow noise. Sensors may be required for real-time monitoring of critical electrolyte species (conductivity, viscosity and temperature). A system is needed to store high-concentration replenishment electrolyte and supply it at a controlled, variable rate. A hydrogen gas-liquid separator with high efficiency over a wide flow range will be needed with a hydrogen management system to control/dump the hydrogen gas generated from corrosion. A heat exchanger and thermal control valve(s) are required for operation at multiple electrolyte temperatures to reject waste heat from the system.

A propulsion motor that will operate within the battery voltage range and power range efficiently is needed. The motor can be radial or axial flux, and the design tradeoffs should be provided. Designs that minimize acoustic and electromagnetic signature are needed. The motor shall have sufficient torque capability at low power (i.e. low shaft speed). Cooling required for the motor shall be included in the afterbody section.

Table 1 lists high-level electric power system concept attributes. The operating voltage is an end-of-run value, which the energy section must remain above for the duration of the mission. All emerging technology should be at the TRL 3 and above level in order to meet future integration plans should this concept move forward.

Table 1 – Electric power system concept attributes

Min operating voltage:	300 VDC
Max operating voltage:	600 VDC
Low power:	15 kW
High power:	300 kW
Min Energy:	80 kWh
Weight limit	1500 lbs
Energy section envelope	Right circular cylinder with a 18.5” diameter and 72” length
SUBSAFE	Meet current certification
Shelf life	10-year stowage capability with allowed refueling prior to submarine load out
Environmental operating/stowage	Current
Signature (acoustic and electromagnetic radiation)	No worse than current

Stored Chemical Energy Propulsion System (SCEPS)

SCEPS used the exothermic reaction between sulfur hexafluoride (SF_6) and pure lithium (Li) to generate steam and drive a turbine. Innovative systems and technologies are sought to improve the energy and power density of this Rankine cycle turbine engine across a broad speed range for underwater propulsion applications. Approaches could include innovative heat sources, novel turbine approaches, compact gear reduction, shifting transmissions, high-performance water-pumping elements and compact non-condensable gas separation. This includes:

1) Transmission concepts capable of achieving a shift ratio of approximately 2:1 and transmitting power approaching 100 HP during the shift in a volume of approximately 200 cubic inches or less.
2) Compact, multi-stage turbines in the 400 to 1000 HP range.
3) Single-stage impulse turbine (operating with super-heated steam) that provide more than 85% of full-power efficiency when operated at 10% of rated power but high rotational speed.
4) Quiet water-pumping elements capable of delivering volumetric efficiencies in excess of 80% at back pressures in the 1500 to 2000 psi range are also desirable.

Questions

All responses should address the following questions:

1) Which technology is your company responding to: Otto Fuel, Electric Power System or Stored Chemical Energy Propulsion System?
2) Are you proposing a component or a system?
3) What is the current TRL of your component/system?
4) Is your component or system commercially available?
5) If the component or system is at TRL 3 or below;
    a. What science and technology (S&T) development must be conducted to bring it to TRL 6?
    b. What is the cost and time required to complete this development?
6) If a component is a commercially off-the-shelf technology system (COTS), are modifications required? If so, what are they?
7) Is your company engaged in producing, distributing and supporting these commercial items? What type of contract, terms for warranties, buyer financing, maintenance and packaging, and marking are necessary?
8) Are there any requirements/ laws and/or regulations unique to the item being acquired?
9) What are the component/system size, weight and volume?
10) Are any special interfaces needed (e.g. electrical power requirements)?