



Draper Laboratory

Call for Abstracts (CFA)

University Research & Development (URAD) Program

Draper Fiscal Year 2013 (DFY13)

CFA Issued: January 18, 2012

Abstracts Due: February 16, 2012

Period of Performance: June 30, 2012 – June 28, 2013

Abstracts sought in the following areas:

Precision Navigation & Timing
Strategic & Space Guidance, Navigation & Control Systems
Tactical Guidance, Navigation & Control Systems
Miniature Low Power Systems
Autonomous Systems
Complex Reliable Systems
Information & Decision Systems
Secure Networks & Communications
Biomedical and Chemical Systems
Energy Systems
Strategic Systems
Tactical Systems
Special Operations
Space Systems
Air Warfare and ISR Systems

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Introduction

The primary mission of the Charles Stark Draper Laboratory, Inc. (Draper) is to solve our nation's hardest problems. To accomplish this mission, we maintain a strong commitment to advanced research and development, which helps us to bring new technical solutions to our customers. Another aspect of our mission is to support advanced technical education. Draper's Internal Research & Development (IRAD) program is used to develop the technologies and capabilities that best position Draper to compete for future sponsored work. Our University Research and Development (URAD) program is a specific subset of our overall IRAD program, and is designed to bring University researchers and Draper developers together to explore new areas of technology advancement. URAD funding to University teams is intended to facilitate a variety of possible outcomes:

- Exploring the feasibility of a new technology concept to lead to possible further development at Draper, the University, or some combination of the two.
- Maturing a particular technology or concept sufficiently to enable capture of external sponsor funds for further development or implementation by the Draper-University team.
- Collaborating on a mutual topic of interest to build relationships that can be leveraged to develop new project, technologies, and proposal ideas capable of capturing external sponsor funds.
- Engaging skills, capabilities, or technologies at the University that partner synergistically with Draper within the context of a larger program of internal and external development.

Scope of URAD Program

Anticipated Competition

Abstracts that are considered for award must meet the specific needs of Draper's business, technology and R&D programs, which are in a constant state of evolution. **It is imperative that potential PIs review the attached list of project topic areas, and engage the Point of Contact (POC) for that area to discuss possible project topics prior to submitting an abstract.** The Draper abstract review committee will be asking the Draper POC and other staff for additional information, so prior conversation with the Draper POC is required. An abstract submitted without substantial discussion with Draper will not provide sufficient information to allow consideration for funding at this time.

URAD Awards are Contracts, Not Grants

Note that funded URAD projects are implemented as *contracts*, not as *grants*, and have contractual milestones, deliverables, and a statement of work. If you or your organization is not willing to work within this framework, then the Draper URAD program is not the right venue for pursuing your project.

Abstract Schedule and Selection Process

We plan the following schedule, which Draper reserves the right to change if necessary.

- Abstracts due to Draper: **February 16, 2012**
- Draper final selections & presidential approval: week of March 5, 2012
- Notifications sent to PIs: week of March 12, 2012
- Formal proposals due for selected projects: May 15, 2012

Minimum Project Requirements

All projects selected for award will include, at a minimum, a Kickoff, Mid-year, and Final review at Draper. Deliverables will include, at a minimum, the presentation material from the three reviews and a Final Report. These deliverables will be due to Draper no later than 1 week after the reviews (presentations) and three weeks after completion of the project (final report).

Abstract Preparation Guidelines

All abstracts must be submitted using the Draper CFA DFY13 Form. This form is available on our public web site (www.draper.com). Expectations are that PIs have engaged the appropriate Draper Point of Contact for the relevant topic area in preliminary discussions, so that the abstract submitted should be relatively brief, providing a summary of the project concept, a description of the potential impact, an estimated budget and schedule, and a list of expected outcomes. The Draper Point of Contact will then be engaged in discussions to elaborate on the project concept during the abstract review and project selection process. Detailed guidelines for completing the abstract submission form are provided below.

Section A: Identification

Principal Investigator (PI): Provide the full name and title of the Principal Investigator, lead researcher, or proposer for this abstract. Provide the name of the home university and department, including US Mail address, telephone number, and email address.

Co-Investigator(s) & Affiliation(s): Identify any major collaborations or co-investigators for this abstract. For each Co-I, provide full name and title, home university and department, US mail and email address, and telephone number. Also provide a brief (several words – up to one sentence) description of their role or contribution.

Continuation/Evolution of prior funded Project? (Y/N): If this abstract is a continuation or natural evolution of a currently-funded project, indicate Y (yes) and provide the title of the current project. If this is a new, stand-alone proposal, indicate N (no).

Proposal Title: Provide a descriptive title of your proposal; limit 256 characters.

Topic Area(s) – indicate up to 2: Identify the specific topic area(s) from the list that is most relevant to this abstract. Up to 2 different areas can be identified. The choices are:

- Precision Navigation & Timing
- Strategic & Space Guidance, Navigation & Control Systems
- Tactical Guidance, Navigation & Control Systems
- Miniature Low Power Systems
- Autonomous Systems
- Complex Reliable Systems
- Information & Decision Systems
- Secure Networks & Communications
- Biomedical and Chemical Systems
- Energy Systems
- Strategic Systems
- Tactical Systems
- Special Operations
- Space Systems

- Air Warfare and ISR Systems

Person(s) at Draper with whom this abstract has been discussed: Indicate the names of those at Draper with whom the abstract was pre-reviewed / discussed. These individuals will be asked to comment on / review your abstract.

Section B: Abstract Overview

Abstract Summary: The abstract must contain a summary of the project not more than one page in length. It should be a self-contained description of the activity that would result if the project were funded. The summary should be written in the third person and include a statement of objectives and methods to be employed. It must clearly address in separate statements (within the one-page summary):

- the intellectual merit of the project; and
- the broader impacts¹ resulting from the project.

It should be informative to other persons working in the same or related fields and, insofar as possible, understandable to a scientifically or technically literate lay reader. Abstracts that do not separately address both merit review criteria within the one-page Project Summary may be considered non-compliant and rejected without further review.

Problem being addressed: Provide a short (up to ½ page) description of the specific problem that will be addressed.

Competitive assessment: Provide a short (up to ½ page) assessment of the uniqueness of the project, and identify competitive approaches or solutions, indicating relative merits of each (Why is your project “better” than the others?).

Approach: Provide a short (up to ½ page) description of the approach to be used to implement the project. Describe methods to be used, elements to be evaluated, figures of merit and performance / success criteria, specific tasks and activities.

Schedule: Provide a brief schedule that outlines the tasks, major milestones, and deliverables for the project. This can be provided as a bulleted list.

Deliverables: Provide a list of all deliverables to Draper (see “Minimum Requirements”, above) and provide a date when each deliverable will be provided to Draper.

Risks: Describe any known risks.

Section C: Estimated Budget /Scope

Personnel: Provide an indication of the number and type of personnel that would be involved in and paid for by the project, the %level of coverage expected by the project by year, and the rough costs for each. An example is provided in the template form.

Indirect/Non-Labor: Provide a rough estimate for all the indirect costs associated with the project. Materials & Services should include a description of what is included (e.g. test articles; machining; consumables). Travel should include travel costs for trips to Draper for the required reviews, and for any other travel pertinent to the project. NOTE that Draper does NOT pay for conference travel. Use “Other” to capture categories unique to your

¹ Examples of broader impacts include (among others): developing the next generation of U.S. Science, Technical, Engineering and Math (STEM) workforce; broadening participation of underrepresented groups; advancing discovery and understanding while promoting, teaching, training and learning; and benefits to society.

project/home institution; be sure to itemize all elements. A few examples are provided in the template form.

Contributions: Indicate any contributions (from the home organization or other source) that will augment this research. Cost-sharing is not required. Examples can include students working for credit rather than monetary pay; use of major capital equipment without charge to the project; or inclusion of pre-existing components (or components generated in a parallel effort) as part of the deliverables to Draper. List or describe any items included here. A few examples are provided in the template form.

Abstract Submission Process

The following describes the required steps of the abstract submission process.

- Use the provided Abstract Submission Form and complete all sections of the form. Follow the Abstract Preparation Guidelines provided above to complete the form. This form must be submitted as a Microsoft Word document via email sent to the Draper Education Office at urad@draper.com.
- Complete the Self-Identification Form. Individuals who do not wish to provide the personal information are still required to submit a form, and should check the box indicating their desire to decline providing additional information.
- Estimated cost data in the form of a not-to-exceed estimate is required. Formal cost data and proposal submission from your home institution is not required by Draper at this time; a final formal proposal will be required only for those projects selected for award.
- Submit the two forms, the Abstract Submission Form and the Self-Identification Form, via email to urad@draper.com **no later than February 16, 2012**. Hardcopy submissions will not be accepted. PDF or other formats for the electronic forms will not be accepted unless also accompanied by the Microsoft Word format forms.
- Any appendices or attachments must be submitted in electronic form with the submission email and the total of all appendices or additional attachments to any one abstract cannot exceed 5MB in size.

Failure to meet any of these requirements may result in the abstract being considered noncompliant and rejected without further review. If you need copies of any of the required forms, please visit the Draper public web site at www.draper.com.

Draper Fiscal Year 2013 (DFY13) URAD Project Topic Areas

Project abstracts are sought for our Technical Capability and Business Areas. Technical Capability Areas generally seek concepts for advanced technology that may be 3-10 years or more from the maturity level needed to seek customer funding for further development. Business Areas are generally seeking concepts for technologies and concepts with a shorter timeframe to maturity. Descriptions of the various topic areas sought are provided below. When you have identified a possible match for your concept, and **prior to abstract submittal, you must contact the individual named for that topic area** to preview your concept and determine whether further refinement or development of the concept is needed or encouraged prior to abstract submission. Discussions with the individuals named may result in decisions to pursue other avenues of collaboration and joint work rather than abstract submission to this URAD call.

Technical Capability Areas

Precision Navigation & Timing

Point of Contact: Steve Smith, 617.258.1953 ssmith@draper.com

Precision navigation and timekeeping is essential for functioning of a number of highly sophisticated platforms and weapons systems in our National defense and security arsenal and infrastructure deployed across the Globe and in Space. Although Global Positioning System (GPS) is capable of providing the required level of precision and accuracy alone, access to high-fidelity GPS signals in many missions is often challenged if not completely denied by either natural or man-made causes. In addition, many applications requiring precise navigation and timekeeping may also demand that sensing and measurement units be operated in otherwise adverse environments, such as high-g setting or extreme environments. Coupled with demanding mission concepts of tomorrow that seek vastly increased autonomy, reach, and threat detection, these challenges impose stringent constraints on the performance of needed sensors, instruments, and systems, as well as on their size, weight, power consumption, reliability, and cost.

The Precision Navigation & Timing (PNT) Technical Capability at Draper Laboratory addresses conceptualization, design, and prototyping of sensing and metrology instruments and systems for precise and accurate navigation and timekeeping. PNT is also focused on advancing a variety of related enabling technologies, including advanced imaging and image processing techniques, MEMS, NEMS, GPS, guided fiber and integrated optics, electro-optics, nanophotonics, and atom-based technologies for quantum sensing and metrology. General applications can include attitude and position measurement on or near the Earth's surface, in the subsea environment, or in space, and can also include advanced gravimetry and magnetometry concepts.

Abstracts are sought in the areas of revolutionary concepts for sensors, instruments, and architectures, which enable significant improvements in performance and/or reduction in size, weight, power, and cost.

Advanced manufacturing technologies in support of these PNT initiatives is also an area of active interest and focus. Abstracts are sought for advanced fabrication and assembly methods

for multi-scale systems, including those used for producing rapid, functional prototypes. The fabrication and assembly should be extremely flexible and be able to be used on a variety of materials and a wide range of size scales.

More specific applications of interests are outlined elsewhere in this Call for Abstracts (see, for example Strategic and Space GN&C Systems; Tactical GN&C Systems; Autonomous Systems; etc.).

Strategic & Space GN&C Systems

Point of Contact: Tom Bucklaew, 617.258.4245, tbucklaew@draper.com

The focus of this capability area is on the application and maturation of GN&C technology to support long-term national objectives in strategic deterrence, civilian and military space, missile defense, and the exploration of our solar system. Relevant scope encompasses system concept and architecture development, hardware, algorithms, software, integration, test, and evaluation for the afore-mentioned application domains. The set of systems covered by this capability area is quite diverse and includes, for example: launch vehicles, strategic missiles, re-entry bodies, interceptors, satellites, spacecrafts, landers, and planetary exploration vehicles. Specific inertial sensor technologies or mission-critical avionics required to implement algorithms or solutions will be drawn from the Precision Navigation and Timing or Complex Reliable Systems capability areas, respectively, described elsewhere in this call for abstracts.

Abstracts are sought for projects that can demonstrate basic proof-of-principle, feasibility, or benefit within a 2-year timeline (with prototype development, where appropriate, potentially being a subsequent activity) in the following areas:

- **Hardened Electronics.** Component technology and novel design approaches suitable for the hardening of electronics to the effects of radiation environments and high-power microwaves.
- **Navigation Aiding.** Navigation aiding techniques and/or algorithms relevant for missiles or spacecraft in GPS-denied or GPS-unavailable environments.
- **Hypersonic Vehicle Guidance/Control Technology.** Specifically (a) miniature divert and/or control subsystem hardware for hypersonic projectiles/munitions, (b) integrated guidance and control for air-breathing ramjet/scramjet systems, or (c) innovative concepts for deployable/inflatable aerodynamic devices for hypersonic entry/re-entry vehicles.
- **Micro-propulsion.** Propulsion technology or concepts applicable for any of micro-, nano-, pico-, and chip-scale satellites that are enabling for expanded system capability.
- **Lightweight Navigation-grade IMU.** Inertial sensor technology or integrated design approaches that can support the development of an affordable, rugged, and lightweight (e.g. ≤ 2 lbm) navigation-grade IMU or equivalent.
- **Advanced Algorithms or Ground Test Methods.** Truly novel algorithm concepts that can demonstrably improve system performance or enable new capability in any of the indicated application domains, as well as innovative, non-destructive, high-fidelity ground test methods and fixtures that can significantly advance the state-of-practice, are generally of interest.

Tactical GN&C Systems

Point of contact: Sharon Donald, 617.258.3268, sdonald@draper.com

The Tactical GN&C capability provides innovative solutions for warfighters, weapons, sensors, and vehicles across a variety of complex, GPS-challenged environments. Relevant applications include: urban navigation, collaborative navigation, EO/IR vision-aided algorithms, UAV navigation and targeting, rapid north-finding, GN&C for guided aerial delivery, maritime vehicle GN&C, precision sensor emplacement, long-endurance/low-profile GPS-denied navigation, GPS Anti-Jam for guided munitions, and GN&C for novel projectile concepts, targeting and object geolocation. Challenges facing this area include constrained size, weight and power; availability of aiding signals; ability to operate autonomously; and fast response requirements.

Abstracts are sought which will provide the basis for unique approaches to algorithms, signal processing, software, sensors, or systems design which will advance the state of the art in the following areas of interest:

- **GPS-denied navigation**, including sensors, systems and algorithm designs. Some specific areas of interest include:
 - Systems that exploit signals of opportunity such as WiFi, radio and television transmissions, cell tower transmissions, etc; or that make novel opportunistic use of non-GNSS satellite signals.
 - Vision-aided navigation and image-based target tracking/geolocation techniques employing robust feature tracking algorithms and novel approaches to vision-based landmark identification and correlation.
 - Sensors and algorithms to provide prompt, precision, non-magnetic attitude determination
- Advanced technologies in **adaptive reconfigurable flight control systems** for fixed wing, rotary wing, and morphing aircrafts.
- Novel, robust, low size, weight and power, computationally efficient **guidance optimization algorithms** for low size, weight and power systems, exploiting COTS sensors where feasible.
- Novel approaches to **collaborative navigation**, targeting and mission operations with a focus on robust, low size, weight and power (SWaP) mobile processing for GPS challenged environments This includes systems, sensors and algorithms.
- New approaches to **processing GNSS and modernized GPS signals** for precision position, time, or attitude, or that provide a substantial improvement in solution integrity in the face of intentional or unintentional jamming or spoofing, graceful transitions between GPS environments, and including novel use of COTS sensors.

Miniature Low Power Systems

Point of Contact: John Fullford, 617.258.3147, jfullford@draper.com

The design, development, prototyping and low-rate production of miniature, electro-mechanical systems is an established business area for Draper for both low power battery operated equipment and high power component-level assemblies. This capability includes system conceptualization and design methods for addressing demanding customer

requirements, and draws upon miniature electronics packaging technology, low-power electronics design principles, advanced thermal management techniques, and advanced sensor integration as needed. Many applications also require advanced digital communications (e.g., antennas, RF circuitry, analog/digital electronics) and signal processing technology.

Abstracts are sought for projects that can be implemented and demonstrated in a 3 to 5 year time horizon and that will dramatically reduce the size (thickness or volume), lower power consumption, improve RF performance or improve the thermal management for miniaturized systems. At present, the main drivers for overall system size are batteries (power source), antennas, thermal management features, and sensors. For low power miniaturized systems, we are working to improve overall energy efficiency to enable longer mission durations or smaller batteries (power sources). We are seeking technologies to enable the design and fabrication of next generation Miniature Systems. These enabling technologies include:

- **Miniaturized antenna technologies** – including innovative approaches to packaging, materials, and form factors.
- **Miniaturized RF High Power Amplifier** topologies suitable for L and S band applications in monolithic and hybrid implementations.
- **Advanced power systems**– including power conversion and management, energy scavenging, tiny discrete components (especially high frequency, low loss inductors and capacitors), novel battery chemistries, and battery management systems.
- **Advanced communications systems** – including advanced signal processing of signals such as GPS; highly power efficient receive/transmit strategies, compressive sensing and data compression.
- **Advanced 3D electronics packaging** technologies including:
 - Novel high-density interconnect designs for fabrication of low-profile, high current density electrical connections between adjacent layers in Multi Chip Module (MCM) stacks as well as between MCM stacks and underlying PCB substrates.
 - Test methodology for evaluating signal integrity of 3D interconnect with capability to accurately characterize 3D structures employing wirebonded, flip-chipped, PoP, TSV interposer, and monolithic 3D features.
 - Novel temporary wafer bond materials and methods.
- **Advanced solutions for package-scale thermal management** of 3D structures including:
 - Novel materials that combine the concepts of heat sinking, chip-to-chip electrical I/O, and underfill for mechanical integrity.
 - Modular instrumentation for high throughput thermal testing.
 - Millimeter-scale fluid pump technology.
 - Thermal test chip design combining spatially- and temporally-varying heat loads and distributed thermal sensing accurate to > 10 mK.
 - Heat sink and spreader design for ultra-low profile requirements.
 - Generalized computational models for heat spreading in hybrid silicon-epoxy multi-chip module including the influence of inter-chip electrical interconnects.
 - Self-contained microfluidics-based two phase cooling loops.
- **Advanced biocompatible packaging** techniques for miniaturized systems.

- **Acute and chronic in-vivo validation of hermetic micro-packaging** electronics for deep-brain stimulation and neuroprosthetics.
- **Spin-exchange magnetometers** and noise cancellation techniques for bio-magnetic recordings.
- **Advanced manufacturing technologies** for the fabrication and assembly of these miniature systems, particularly those used for producing rapid, functional prototypes. The fabrication and assembly should be extremely flexible and be able to be used on a variety of materials and a wide range of size scales.

Autonomous Systems

Point of Contact: Troy Jones, 617.258.2635, tbjones@draper.com

The Autonomous Systems Technical Capability encompasses a broad set of technologies to address problems in closed-loop decision making for commanding, controlling, estimating and predicting the state of a broad class of assets ranging from teams of heterogeneous autonomous vehicles to tasking, analysis and dissemination of information.

Abstracts are sought in the following areas:

- **Autonomous Vehicle Mission Management:** Novel algorithms and approaches for a variety of on-board mission management activities (which include tasking and planning, situation awareness and situation assessment). This area also includes approaches that facilitate multi-vehicle operations and shared situational awareness; and novel approaches to facilitate operator tasking of and interaction with autonomous vehicles. Also sought are algorithms or other concepts to make autonomous vehicles more robust to unanticipated mission conditions, unstructured and highly dynamic environments, and to improve overall mission reliability.
- **Assurance:** Techniques and approaches to assure that autonomous systems are trusted and reliable, including assurance that they have not been co-opted by hostile agents. Examples include – but are not limited to – system intrusion detection and defense and continuous self assessment of commands against a set of core values.
- **Perception:** Techniques and approaches that define how autonomous systems “see” or “perceive” the world to develop an understanding of their environment. Emphasis on environmental perception for underwater, ground, and air systems that utilize passive sensing is encouraged.

Complex Reliable Systems

Point of Contact: Jeff Zinchuk, 617.258.2769, jeff@draper.com

The Complex Reliable Systems capability addresses the development of system, software and hardware solutions for applications where a high degree of reliability and performance are required, such as: manned space flight systems, Unmanned Autonomous Vehicles (UAV’s), and biomedical systems.

Abstracts are sought in the primary following areas:

- **Software Reliability and Assurance:**
Innovative methods and approaches to modeling software complexity to enable design

and development of highly reliable software and software safety. Innovative methods and approaches to verify and certify the software operation and implementation.

▪ **Model-Based Design and Engineering Approaches:**

Processes and tools that allow system conceptualization; requirements capture and operational constraints; subsystem apportionment, design and implementation; and system integration, verification, validation, and certification.

- Components that enable **fault-tolerant and highly reliable system** operations, such as fault-tolerant computers. This may include techniques to allow programming of multi-core processors or dynamically-reconfigurable gate arrays to accommodate failures in non-repairable systems
- Tools and methods for modeling, analyzing, and developing **massive, extremely complex enterprises**, while enabling reliability and safety assessments and evaluations. Tools that can be applied to such systems of systems as a squadrons of cooperating UAV's or the control of large electrical power grids

▪ **Trusted and Assured Computing:**

Point of contact: Bob Breton, 617.258.3305, rbreton@draper.com

The Trusted and Assured Computing capability is chartered developing technologies in support highly assured systems where mission completion with precision, reliability, and/or security are critical. Three primary areas of interest in this calling are 1. protection and recovery of embedded systems from malicious attack and 2. Development and certification of mission critical systems and 3. Protection of system software against tamper and reverse engineering. The focus of these technologies is on the trust and assurance of embedded systems. Interest areas include:

- Embedded control system cyber security including intrusion tolerance, intrusion detection, anti-spoofing, recovery from contaminated systems, graceful degradation of compromised systems or systems under attack...etc
- Embedded system software anti-tamper techniques
- Verification and validation of trusted systems
- Distributed Wireless fault-tolerance
- Fault protection in multi-core systems
- Parallel processing algorithm architectures
- Software reliability analysis and reliable software design
- Advanced verification and validation techniques for complex, highly assured systems
- Algorithm and Software design techniques for highly assured systems
- Qualifying software reliability of legacy and life extension systems

Information & Decision Systems:

Point of contact: John Irvine, 617.258.4957, jirvine@draper.com

We define Information & Decision Systems as the collaborative use of machine processing and human cognition to extract meaningful information from raw data, enhance the understanding of complex, dynamic processes, and support improved decision making across a range of applications and missions. This encompasses the collection of technologies that advance the transformation of data into information through human and/or machine systems to enable enhanced decision making. Included in this topic are aspects of heterogeneous data fusion, human-machine collaboration and augmented cognition to improve human-intensive information processing in real-time decision situations (e.g., combat intelligence analysis, intensive

care)and/or analysis situations (e.g., imagery, geospatial, biosurveillance). Abstracts are sought in the following area:

- **Data-intensive discovery:** Novel techniques and algorithms are sought for dramatic improvement in situational awareness and the creation of actionable knowledge given the enormous existing body of persistent data and overwhelming flood of real-time streaming data available across a variety of applications. Of particular interest are applications that develop knowledge about individuals and society and clinical decision support algorithms that operate in real-time and leverage the concurrent availability of physiological and phenotypic data. Relevant areas of research include network and graph analytics, game theory, fusion, advanced physiological signal processing, human guided algorithms, biometrics, semi-supervised learning, semantics, prediction, and optimization. Models of interest include physical, mathematical, and social science models, and especially their integration.

Secure Networks & Communications:

Point of contact: Jim Zagami, 617.258.4883, jzagami@draper.com

The Secure Networks and Communications capability enables the reliable and efficient transport of data through and across challenging field environments. Within these environments the propagation and interference characteristics are both unknown *a priori* and rapidly varying with time. Environments of interest include the low power satellite channel, power lines, underwater and underground, and free space optical. Networks of interest include both commercial and governmental local, metropolitan and wide-area networks. Abstracts are sought in the following areas:

- **Integrated sensing and communication** architectures, achieving superior performance by means of symbiotic design. Of particular interest are communication systems associated with a guidance, navigation and control (GN&C) architecture. Communication and distributed sensor networks that depend on and/or take advantage of guidance, navigation, and control (GN&C) technologies.
- **Communication methods** and system architectures that achieve high overall energy efficiency. Of specific importance are systems optimized in terms of energy required to transport each data bit over a specified channel.
- **Advanced communications** concepts, including novel materials and approaches to enable next generation communications capabilities, and/or secure and assured communications.
- **Electrically small broadband antenna** technologies
- **Innovative Low Probability of Intercept/Detection** waveforms (beyond traditional spread spectrum techniques)

Biomedical and Chemical Systems

The goal of the Biomedical and Chemical Systems capability area is to capitalize on the in-house engineering expertise and skills of Draper to develop practical solutions to the critical needs in clinical and military medicine and chemical/biological defense. We are seeking proposals where the university investigator is willing to work closely with Draper staff to push technology development and/or address identified sponsor needs. Proposals are being sought in the following areas:

In vitro Models of Human Tissue

Point of Contact: Joseph L. Charest, 617.258.4927, jcharest@draper.com

An in vitro model of human tissue provides a well-controlled platform to study physiological system function in a controlled laboratory setting. Applications include studying disease progression, evaluating biological warfare countermeasures, and assessing pharmaceutical toxicity to organs. Draper has established several in vitro models and has established a strong presence in the scientific community through leveraging microfabrication methods to create unique environments for cell culture. There is currently strong interest from DARPA, DTRA, NIH and pharmaceutical companies in this area.

Abstracts are sought for projects that can be implemented and demonstrated in a 2 to 5 year time horizon that will show means to improve the physiological realism and scale-up of in vitro models of human tissue. Currently, in vitro models leverage media formulations, mechanical stimuli, materials, and cell type selection to recreate partial function of a human organ in the lab on a small scale. Two areas of improvements are of interest: 1) technologies to improve the physiologic realism of an in vitro model and 2) technologies which enable scale up of a single in vitro model to an array suitable for high-throughput screening methods. Potential technologies of interest to Draper include, but are not limited to:

- Cell types with the potential to replicate phenotypic function in vitro. Pluripotent, progenitor, stem cells, and mechano-responsive cells are of particular interest with a preference for human cells.
- Platforms for cell culture which provide physiologic realism such as 3D gels, biomimetic scaffolds, or engineered ligand interactions.
- Methods to sample and analyze small, approximately nanoliter-scale, samples of perfusate for biomarkers of toxicity or cell function.
- Strategies, platforms, or interface technologies to replicate complex in vitro model architectures in large arrays (96 units or more) with access for sampling, fluid delivery, and analysis.
- Platforms and cell systems to study the interactions of biowarfare pathogens and toxins or chemical/radiological agents with human cells. Also, systems to assess the efficacy of countermeasures designed against these agents.
- Surface treatments or coatings to improve blood health in extracorporeal microfluidic structures.

Miniaturized Medical Device Technologies

Point of Contact: Bryan McLaughlin; 617.258.4003; bmclaughlin@draper.com

Technologies that enable the advancement and miniaturization of implantable medical devices (eg, neural recording and stimulation). Topics include validation of existing devices for in-vivo degradation and accelerate lifetime testing, hermetic electronics micro-packaging, biocompatibility enhancements, energy efficient bio-telemetry circuits, neural stimulator circuits, and optical fiber sensors. Projects that can integrate with our miniature systems capability (described above) for medical and military applications are of particular interest.

Business Areas

Energy Systems Business Area

Point of contact: Eric N. Balles, eballes@draper.com, 617.258.4574

Draper is leveraging its strengths in sensing and control, information and decision systems, and architectures for complex systems to develop solutions that address critical needs in our nation's energy generation, transmission and distribution, and end-use infrastructures. Proposals are being sought for:

- **Novel real-time sensors** for measurement of key performance data and reliability indicators in power generation plants, electrical transmission and distribution systems, petrochemical operations (upstream and downstream) and pipeline systems.
- **Sensors and system level approaches** for real time evaluation of the dynamic state and security level of general power distribution systems. Of particular interest are methods for evaluating decentralized grid topologies (i.e., clusters of micro-grids).
- **System level tools and methodologies** for evaluating power grid design concepts. These tools should address the broad range of pertinent issues from grid security to economic and environmental concerns. These tools should permit system level tradeoff studies to investigate such questions as what kind of sensing, levels of control, and on-grid storage are need to enable a higher penetration of intermittent and/or distributed energy sources? What communications architecture is necessary? How does the current grid architecture facilitate or impede transition to the next generation grid?
- **Novel concepts** that improve overall energy efficiency in end-use applications including buildings and transportation.
- **Novel energy conversion** and energy storage concepts of all types including, but not limited to, direct carbon fuel cells, Zn-air batteries, and energy harvesting in harsh environments.

Strategic Systems Business Area

Point of contact: Bill Tsacoyeanes, billt@draper.com, 617-258-2597

Strategic Systems support a variety of needs, including our current work for the Trident Life Extension project for the US Navy. We seek concepts and technologies to enable future strategic guidance systems (both inertial and strapdown), Prompt Global Strike, re-entry guidance, g- and rad-hard components and systems; as well as novel technologies or concepts for accurate long term underwater navigation.

Tactical Systems Business Area

Point of contact: Neil Adams, nadams@draper.com, 617.258.2411

Our Tactical Systems business area is seeking ideas to support soldier systems, munitions & precision weapons, missile defense, maritime systems (including unmanned underwater vehicles), and counter terrorism. Specifically, ideas for:

- **Soldier systems**, including very low cost (<\$1k) navigation and communications component solutions in GPS challenged/denied environments; pedometer-based and human motion modeling techniques, optical or RF velocimeters and other motion detection or direction determination "aiding" technologies.

- **Maritime related sensors, components, capabilities, and systems** to enable autonomous operation in challenging environments including verification and validation methods to support “trusted” autonomous systems.
- **Missile defense:** Concepts which extend enhanced ground test (EGT) methods to interceptors with closed-loop seekers.
- **Social network influencing and modeling of behavior**, particularly as a way to automatically identify specific behaviors.
- **New sensors, systems, and approaches for imaging;** compressive imaging; the ability to detect and recognize features directly rather than through post-processing.
- **Advanced sensors and systems** and/or novel approaches to enable subsurface imaging; sensors that utilize atomic physics effects to measure inertial forces, Micro-sized atomic clocks and clock subcomponents for precision timing applications. Miniature and Resonator structures that could be used in motion detection or as subcomponents in precision timing circuits.
- **Multi-function communications devices and systems**, such as broadband and/or high frequency (millimeterwave) antennas and wide angle, tunable and scanning antennas, which can receive or transmit. Antennas that can be conformably shaped and that can perform their intended functions (detection, communication, and/or imaging) while embedded within high temperature, transmissive material.
- **RF, millimeterwave, optical, and vision-aided technology for small terminal guidance components** and systems capable of high resolution and tolerant to hi “g” levels for gun launched projectiles. Components that can withstand thermal shock and high temperatures.
- **High temperature RF material** that will perform as an RF window or support the transmission of RF signals from embedded antennas over frequencies from GPS range up to millimeterwave frequencies.
- **Material Technology** that provides unique capabilities for RF transmission or optical acuity including new fabrication methods for RF/optical circuits that allows integration and fabrication in a cost effective manner.
- **Miniature ball bearing like components** and approaches that provide the same functions and lower torque under load in the same dimensions or smaller while surviving high-g shock loads (10,000 to 35,000 g’s or higher).
- **Kinematic, “energetic” (rocket or powered), and aerodynamic components** and systems that could provide maneuvering or divert capability in a small supersonic munition or platform.
- **RF signal propagation near the Earth;** including effects such as the environmental perturbations, soil compression, moisture, rain, snow, metamorphic snow, surface materials and layer structure on the propagation of RF signals.
- **Logic Framework for Autonomy:** Specifically a revolutionary Logic Framework and underlying mathematics that describe and enable the generalized “autonomous” complex motion needed to achieve an intended task.
- **Mathematics for Analysis of Networks:** Statistical Network Analysis that identify and quantify the cumulative effects of a multitude of “low impact”, “high probability” events, and/or also predict behavioral patterns of individual agents that lead to “high impact events”.

Special Operations Business Area

Point of contact: Tami Peli, tpeli@draper.com, 617.258.3608

- **Exploitation of open source data:** The exploitation of publicly available sources is becoming a common practice in the intelligence community. Thus there is a need for robust automated tools that enable finding, selecting and analyzing information from these sources. The development of bibliometric techniques for studying technological innovation and advancements of dual use applications is one area of interest.
- **Video atomic semantic units:** Development of video atomic semantic units that can be used as building blocks for describing activities in un-constrained multi-media.
- **Semantic inferencing and reasoning for multi-media:** Development of inference and semantic similarity reasoning techniques that support data-driven ontology construction, ontology matching and alignment.

Point of contact: Dan Coskren, dcoskren@draper.com, 617.258.3726

University Research and Development for Human Systems: Examine the interpersonal dynamics between individuals with special emphasis in multi-modal metrics for interpersonal relationships (neuro-physiological, psychological, and behavioral); modeling techniques for detecting breaches of this interpersonal relationship (both intentional and unintentional) and predicting its repair across interactions. Specifically we are seeking a university collaborator who can collect neurological and physiological signals across ecologically valid protocols. The protocols will include studies of group dynamics, human performance/resilience, negotiation, and studies of neuro marketing for eliciting various forms of relationship within dyads and small groups that capitalize on real-time neurological signals related to interpersonal relationships. Protocols will be implemented by integrating and synchronizing multiple sensors (e.g., audio, video, EEG and Biopac).

Point of contact: Brad Gaynor, bgaynor@draper.com, 617.258.1552

Cyber domain: Draper Laboratory is seeking innovative research in the cyber domain. The first topic area of interest is focused on the hardware/software boundary, such as vulnerability discovery for embedded firmware and hardware platforms. The second topic of interest is focused on developing rigorous tools for the vulnerability analysis of cyber-physical systems.

Point of contact: Tony Radojevic, aradojevic@draper.com, 617.258.4258

Abstracts are sought in the following areas:

- Low-light imaging; multi-spectral and hyperspectral imaging; low-bandwidth hyperspectral image transmission.
- Extreme form-factor optics.
- Nano-Opto-Mechanical Systems for energy efficient on-chip communication, information storage, and sensing.
- Miniature devices for energy harvesting and storage.
- Quantum sensing for remote detection of gravitational, magnetic, and electro-magnetic signatures.
- Miniature low-power sensors for geolocation and precision navigation in GPS-denied environments.

- Miniature low-power chemical, biological, radiological, nuclear, and environmental sensors.
- Forensics/ origin/ pathways for biological pathogens and toxins.
- Technologies for remote threat identification in urban areas and detection of structural layouts.
- Technologies and techniques for reduced signatures and reduced probability of detection.
- Improved front-end signal processing for persistent and extended range sensor systems.
- Advanced image and audio compression.
- Vehicle telematics.
- Anti-tamper technologies.
- Miniature smart antenna technologies.
- Advance manufacturing technologies for producing rapid, functional prototypes at the small scale.

Space Systems Business Area

Point of contact: Seamus Tuohy, stuohy@draper.com, 617.258.1407

Space Systems supports robotic and human space exploration as well as National security space applications. We seek concepts and advanced technologies supporting alternate mission concepts for existing capabilities and innovative mission concepts for new capabilities that are enabled by small spacecraft, hosted payloads, and/or integrated operations of such. These technologies include: architecture level analysis to determine mission utility, miniature, low-power systems, sensors/instruments, and information and decision support systems. In addition, we seek concepts for testbeds and payloads to be carried by testbeds that advance the state-of-the-art in human and robotic exploration; launch vehicle development, space operations, and robust landing, ascent and surface operations on planets and small bodies (moons, asteroids).

Air Warfare and ISR Systems Business Area

Point of contact: Mark Chapin, mchapin@draper.com, 703.403.5788

This area is primarily focused on innovative technology solutions to support Air Force and DoD airborne weapons systems and theater level Intelligence, Surveillance, and Reconnaissance (ISR) using manned and unmanned/remotely piloted aircrafts (RPA). Areas of emphasis include:

Intelligence Solutions

- Automated Sensor/Imager data (EO/IR/FMV/MI/SAR/HSI) processing, correlation, analytics, exploitation.
- Automation for Geospatial Intelligence data/imagery/product management, virtual access, and dissemination.

ISR Systems and Capabilities

- ISR systems/sensors designs and interfaces to optimize size, weight, power, and modularity of airborne sensors and C2.
- Human-systems interaction for virtual simulation and operation for manned and RPA missions and functionality.

Rapid Precision Strike

- Automation for enhanced UAV/RPA planning, command and control, sensor operation and integration.
- Alternative navigation and guidance concepts for UAV/RPA using on-board sensors/systems in GPS denied areas.