U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND ARMY RESEARCH LABORATORY

Scalable, Adaptive, and Resilient Autonomy (SARA)

Sprint Cycle 3 Webinar

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SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

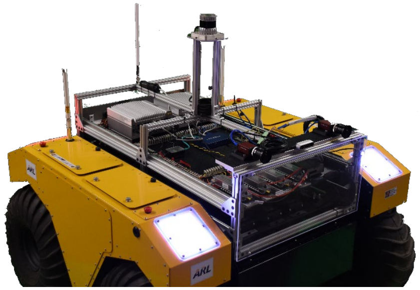
- **Background**
- **Sprint topic logistics**
- **Sprint Cycle 3 Topic Details – Long-Duration Autonomous Maneuver**
  - **Sub-topic #1:** Extended duration and distance mission
  - **Sub-topic #2:** Environmental degradation
  - **Sub-topic #3:** Unified air/ground scene representations
- **Hardware testbeds, autonomy architectures and simulation environments**
- **ARL experimentation location**
- **Proposal process and details**

SARA – WHAT AND HOW

Purpose:
- Accelerate technology development for autonomous mobility
- Collaboratively advance ARL software stack
- Improve air and ground based autonomous vehicle perception, learning, reasoning, communication, navigation, and physical capabilities

Approach:
- Annual technology sprints driven by research gaps and state of autonomy
- Invite collaborators into the autonomy software development ecosystem
- Assess algorithms and full software stack in simulation as well as in real world settings

Off-Road Autonomous Maneuver



SARA – DESIRED OUTCOMES

- **Novel methods for all-terrain ground and aerial maneuver to interact with and move through complex environments**
- **Methods for scalable and heterogeneous collaborative behaviors in support of air and ground manned-unmanned teaming operations**
- **Techniques for improved perception, decision-making, and adaptive behaviors for fully-autonomous maneuver in contested environments**
- **Methods, metrics, and tools to facilitate, simulate, and enable testing and evaluation of emerging approaches for intelligent and autonomous systems under Army-relevant constraints and environments**
- **Experimental testbeds to develop and refine knowledge products to inform and transition technology to Army stakeholders**

ARL AUTONOMOUS SYSTEMS ENTERPRISE

Advancing Autonomous Maneuver and Teaming Behaviors

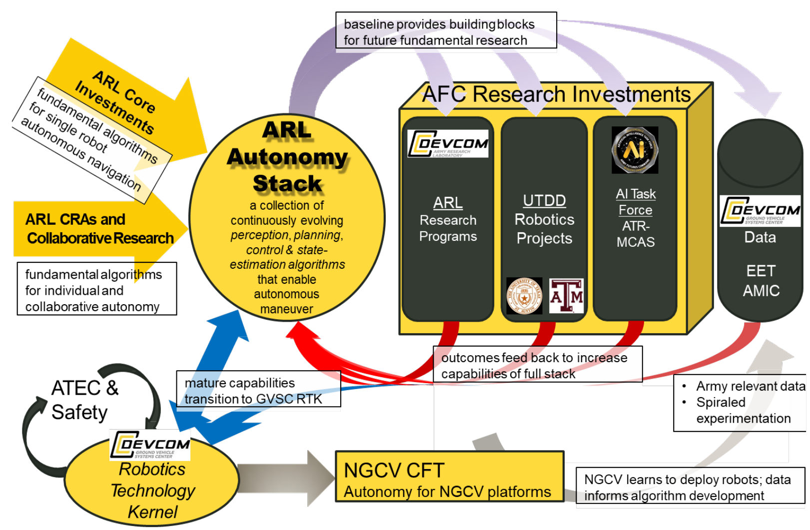
External/CTAs/CRAs:
- *Scalable, Adaptive, and Resilient Autonomy (SARA)*
- *Distributed and Collaborative Intelligent Systems and Technology (DCIST)*
- *Tactical Behaviors for Autonomous Maneuver (New FY22 Start)*
- Internet of Battlefield Things (IoBT)
- Strengthening Teamwork for Robust Operations in Novel Groups (STRONG)
- *A2I2 - AI/ML Research for Expeditionary Maneuver and Air/Ground Reconnaissance*
- ARO: Intelligent Cyber-Physical Systems Program

Essential Research Programs:
- *AI for Maneuver & Mobility (AIMM)*
- *Emerging Overmatch Technologies (EOT)*
- *Versatile Tactical Power and Propulsion (VICTOR)*
- *Human Autonomy Teaming (HAT)*
- Long Range Distributed & Cooperative Engagements (LRDCE)
- Foundational Research for EW in Multi-Domain Operations (FREEDOM)

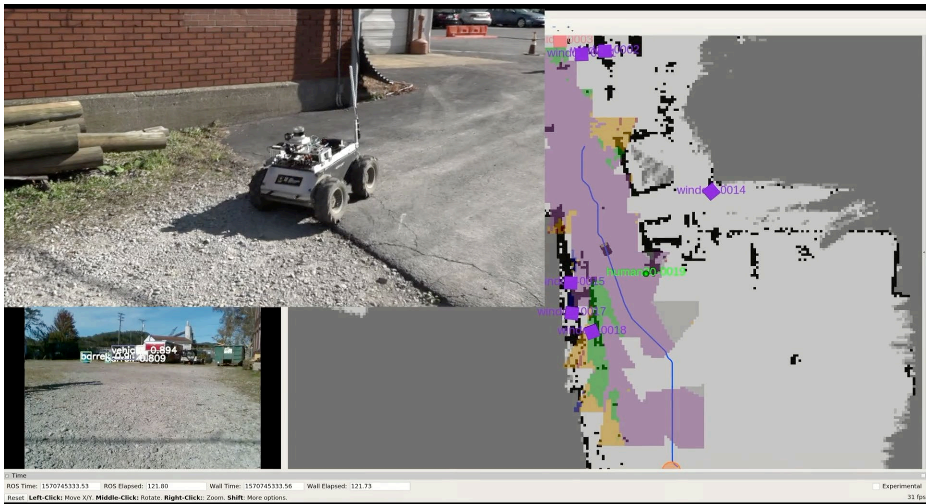
Mission (New efforts):
- Multi-Domain Agile Command & Control (MAC2)
- *Deep Autonomous Reconnaissance & Targeting Sensing (DARTS)*

Coordinating to Build Cumulative Capabilities Addressing Multiple Axes of Complexity for Future RAS Operational Concepts

Single and Multi -Agent Autonomy for Aerial and Ground Robotic Systems

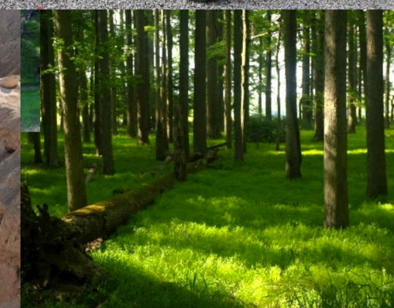


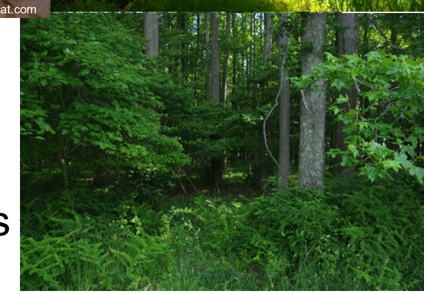
SCALING UP (ENVIRONMENTS, PLATFORMS, CAPABILITIES)



Where we started (RCTA Capstone, October 2019)

- Unstructured (but simple) urban environments
- Typical mission distance (50m)
- GPS-Denied LIDAR-based SLAM
- Terrain semantics projected and used for learning-from-demonstration
- Classifying point clouds from hard-coded geometric rules
- Mission length: 50-100m
- Max speed: 1 m/s





Goals

- Longer-distance missions on bigger/faster platforms (1+ km, 4+ m/s)
- Off-road/trail environments
- Complex terrain with significant changes in elevation

SARA SPRINTS 1 AND 2 – OVERVIEW

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Sprint 1 - Off-road Autonomous Maneuver

Sub-topic 1: Off-road autonomous “GROUND” maneuver

- Increase the operational tempo and mobility of autonomous ground systems
- Traverse increasingly complex off-road environments

Sub-topic 2: Autonomous “AERIAL” maneuver through off-road environments

- Increase the operational tempo and mobility of aerial autonomous systems
- Navigate increasingly complex off-road environments such as forest roads, along field edges, and above, through, and under canopy

Sprint 2 - Autonomous Complex Terrain Maneuver

Sub-topic 1: Autonomous maneuver through increasingly complex levels of vegetation

- Maneuver through traversable obstacles while identifying impassible obstacles
- Focus on pushing through dense vegetation

Sub-topic 2: Autonomous maneuver through complex slopes, across dry riverbeds, fordable wet gap crossings, desert dry washes

- Cross terrain containing sharp and varying slopes
- Focus on sand, dirt, gravel, mud

SARA SPRINTS 1 AND 2 OUTCOMES

- **General Outcomes**
  - The annual Sprint model kept all engaged and accountable in continuous development, integration, simulation, and experimentation
  - New capabilities integrated into the ARL Ground and Air Autonomy Stacks
  - New algorithms assessed in simulation and on local testbed platforms
  - Continuing assessment on ARL testbed platforms

- **Specific Outcomes**
  - Predictive control algorithm that **enables high-speed mobility through narrow passages and constrained spaces**
  - Efficient long-term planning algorithms that demonstrate **improvements in optimality, speed and computational load**
  - Local planning algorithm that **takes into account uncertainty in the vehicle's motion** due to inaccurate classification of ground conditions
  - Algorithms that allow the system to **plan and navigate through environments that are considered as obstacles** in the baseline autonomy stack
  - Calibration algorithm that **reduces error build-up in position** over long-distance travel
  - Planning algorithm that provides **rapid adaptation of navigation behaviors** as the terrain type, angle and traction change throughout a mission
  - High-speed local planning, state estimation, and sensor fusion for **thin object detection and avoidance**

Sprint Topic Primer

SARA SPRINT TOPICS

- Sprints are executed through a series of annual program cycles.
- The FOA will be amended annually to identify a specific problem statement, or topic, for that specific Cycle (**current is Cycle 3**).
- Nine new topics (Cycles 1-9) are expected from FY20-FY29, with each topic focused on addressing a different scientific area within the scope of the broad research aims of SARA.
- Each topic will be carefully chosen based on both program achievements from the previous year, on scientific and technological advancements by the broader research community, and in a way to systematically converge on the specific long-term SARA program goals.
- For each topic, funding will be provided to those Recipients selected under a cooperative agreement (CA) described as the “seedling” project.
- The Recipients of a “seedling” CA are then eligible for consideration to receive funding for a single optional extension of up to 3 years at the conclusion of the “seedling” project.

PROPOSING TO FUNDING OPPORTUNITY ANNOUNCEMENT (FOA)

Eligible applicants: under this FOA include institutions of higher education, nonprofit organizations, and for-profit organizations (i.e., large and small businesses) for scientific research in the knowledge domains outlined throughout this Funding Opportunity. Federally Funded Research and Development Centers (FFRDC) may propose as well, with effort as allowed by their sponsoring agency and in accordance with their sponsoring agency policy.

Profit/Fee: Profit/fee is not permitted under the CA.

Cost Sharing: Cost sharing is not required under this FOA.

Event estimated date/timeframe

Opportunity released……………………………..…….21 March 2023
Opportunity Webinar……………………………….…30 March 2023
Deadline for Questions on Funding Opportunity………7 April 2023
Proposals due for Cycle 3………………………………21 April 2023
Notification to Recipient...26 May 2023
Cycle 3 Awards…………………………………..……~25 July 2023 (Expected)

Sprint Cycle 3 Details

SPRINT CYCLE 3 TECHNOLOGY SPRINT TOPIC: LONG-DURATION AUTONOMOUS MANEUVER

Sub-Topic #1: Extended Duration and Distance Mission

- Scalable techniques for geometric and semantic representations of dynamic environments
- Approaches that determine task-relevant information under memory constraints
- Algorithms with constant-time updates for mapping

Sub-Topic #2: Environmental Degradation

- Algorithms that make use of available sensor data in order to provide state estimates, object detections, and terrain classification in degraded environments
- Sensing modalities that are able to independently or collectively overcome limitations induced by degraded environments

Sub-Topic #3: Unified air/ground scene representations

- Methods for extracting out tactically relevant features to use in structuring decision problems for multi-agent systems
- Methods for visually tracking moving objects from the perspective of multiple agents
- Methods for efficient representation of relevant features across heterogeneous systems with varying compute resources and ability to enable episodic memory in collaborative multi-agent planning
- Methods for asynchronous and decentralized information sharing to build unified air/ground representations including prioritization of data/features to be shared

Overall program assumptions – applicable to all Sub-Topics

- GPS limited/denied navigation; GPS is not available or is only intermittently available, which requires drift-free mapping
- Unprepared terrain, defined by forest environment
- Point A to B navigation over distances on the order of kilometers with potential for area/zone search at B
- Ability to operate with and without a stale map a priori
- Not reliant on communication/data feeds to complete a commanded task
- All approaches must be robust to sensor degradation and dropout

SPRINT 3 METRICS

- **Recipients will be required to integrate their solutions into the ARL Autonomy Stack(s) for experimentation events at ARL facilities, on ARL testbeds**

- **An objective is for ARL to experimentally assess the impact of each Recipient's contribution to the Stack(s). As such, the Recipient and ARL will document and track relevant metrics at least at the component level, and ideally also at the system level.**

- **System-level performance will be evaluated using metrics such as:**
  - Number and duration of human interactions needed to complete task
  - Mean Distance Between Interactions
  - Mean Time Between Interactions
  - Speed to complete navigation task compared to a single teleoperated ground RAS
  - Complexity of terrain traversed based on number, density, and type of obstacles

- **Component-level performance will be evaluated using the metrics defined in each Sub-Topic**

- **An Applicant may propose alternative component and system metrics in their proposal to help advance state of the art as well as set standards for long-duration autonomous maneuver in complex terrain**

SPRINT 3, SUB-TOPIC #1

Extended Duration and Distance Mission

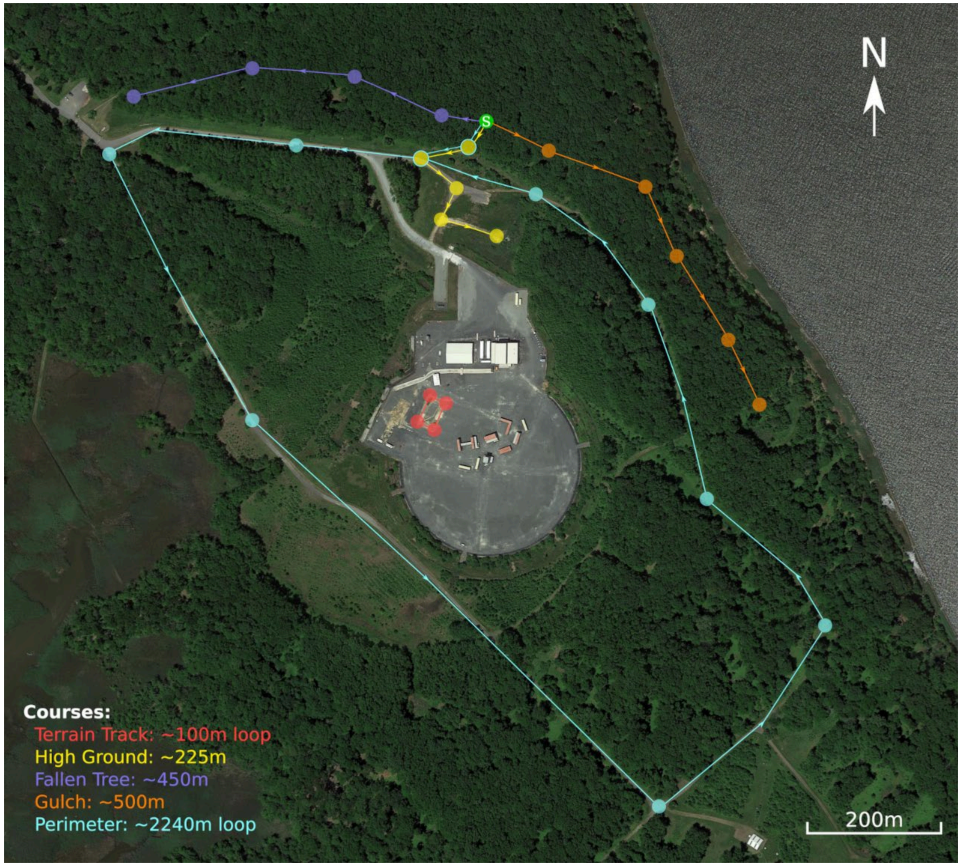
- Algorithms that are capable of scaling to operations over large areas and long time horizons. Approaches that address computational time and memory complexity limits when moving 10s of kilometers over days of operation.

Objective

- Develop techniques for enabling an autonomous platform to continuously localize, map, and plan over an extended duration, long-distance mission

Assumptions

- Single platform
- The scene will change over time and even cross over during operation (e.g., day and night)
- Systems may need to resolve information constraints on what can be stored locally, off-line, and what can be forgotten
- Systems may need varying levels of abstraction and scalable mapping solutions



SPRINT 3, SUB-TOPIC #1 – METRICS

- **Reconnaissance**
  - Will be based around accuracy of representation (global position error, entropy of the map representation, precision/recall of objects/semantics) only at specifically interesting points in the recon area, and the interesting points will not be known ahead-of-time but will be assumed to be contained in the data feed
- **Security**
  - Will be based around the ability of the system to recall changes in the environment at any location.
  - Experiments will introduce many dynamic changes (cars moving, people moving, movement of objects, etc.) and then the system is tested on either (a) accuracy of map at specific checkpoints (not known ahead-of-time) at specific points in time (that will correspond to times that the area is actually being observed by the platform), or (b) accurate count and class identification of discrete changes in the checkpoints over the duration of mission during the windows that the checkpoints are being observed

An Applicant may propose alternative component and system metrics in their proposal to help advance state of the art as well as set standards for long-duration autonomous maneuver in complex terrain

SPRINT 3, SUB-TOPIC #2

Environmental degradation

- Perform basic autonomy functions (e.g., terrain classification, target detection, waypoint navigation, obstacle avoidance, etc.) in degraded environments

Objective

- Develop techniques to ensure the ability to safely perceive and act in a degraded environment

Assumptions

- Single platform
- Platform can be air or ground
- Sensors can be from the standard ARL set or proposers may offer alternative sensors if they cost them into their proposal
- Safe maneuver is possible in the experimentation environments

SPRINT 3, SUB-TOPIC #2 – METRICS

- **Autonomy**
  - Number of human interventions as a function of environment
  - Uncertainty in RAS state estimations, object detections, and terrain classification as a function of environment
  - Time to complete mission versus same mission with no degradation; this includes which type of degradation is induced, and whether it can be controlled (such as sensor dropout)
  - Performance as a function of number and type of sensing modality used
- **Teleoperated data collected in adverse conditions**
  - the quality of motion estimation and obstacle detection algorithms will be compared to the same mission taken in benign conditions.
  - While this is not a perfect one-to-one comparison (because the platforms will actually move differently across different teleoperated runs), it will be used to validate the basic functionality of algorithms in adverse conditions.

An Applicant may propose alternative component and system metrics in their proposal to help advance state of the art as well as set standards for long-duration autonomous maneuver in complex terrain

SPRINT 3, SUB-TOPIC #3

<u>Unified air/ground scene representations</u>

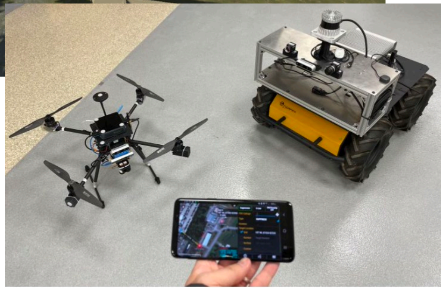
- Combining multiple perspectives and sensing technologies to build richer situational awareness for collaboration

Objective

- Exercise technologies that enable air and ground vehicles to build a joint picture of the terrain and the situation

Assumptions

- Objects in the scene are dynamic and will require tracking and disambiguation
- Semantic scene information such as objects of interest, scene geometry (buildings, forests, etc.) will be shared across agents for the purposes of mission and motion planning
- Approaches must be suitable for lossy and limited bandwidth networking and differing computational capabilities



SPRINT 3, SUB-TOPIC #3 – METRICS

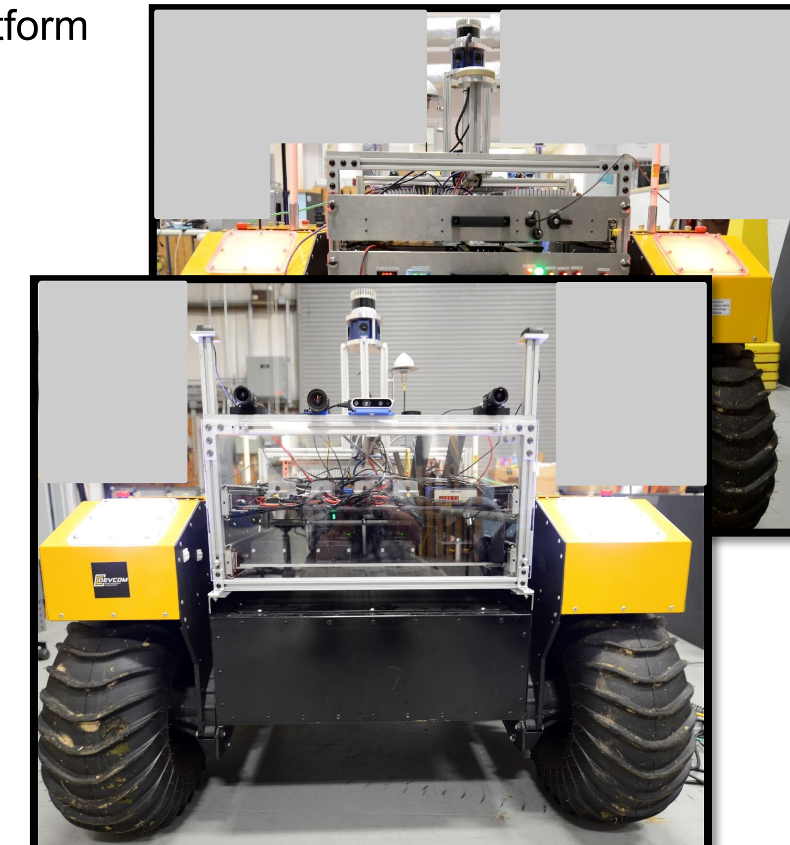
- Ability of the overall system-of-systems to share semantic information, including numbers and types of objects
- Ability to reason about environmental representation. Examples include:
  - Find areas with no line of sight to a target
  - Identify roads, tree lines, lakes, alley ways, and other tactically relevant objects
  - Ground or air based obstacles
- Scalability of proposed methods including compute, memory and communication bandwidth required as a function of the number of agents and the area of the scene
- How accurately systems can resolve observed sensor readings compared to data in the collective world model. Successful demonstration of this capability will allow one agent to collect information about the world, and allow another agent with degraded sensing capability to move through the world. For example, an air agent collecting scene information that allows more optimal path planning for a ground robot.

An Applicant may propose alternative component and system metrics in their proposal to help advance state of the art as well as set standards for long-duration autonomous maneuver in complex terrain

Hardware, Autonomy Software, and Simulation

ARL GROUND TESTBED PLATFORM

- Development will be done by Recipients on their local RAS testbeds, but experimentation events will be performed using ARL platforms* and with Recipient autonomy solutions integrated into the ARL Autonomy Stack(s).
- ARL has integrated its Ground Autonomy Stack onto the Clearpath Robotics Warthog platform as the planned ground experimental testbed for Cycle 3 experimentation.
- ARL plans to support continuous development and integration of Recipient capabilities
- Data collection will be done with the ARL testbed platform
- The ARL Warthog is approximately 2 m^3 with a maximum speed of 5 m/s, and is equipped with the following baseline compute and sensor payload:
  - Two (2) Intel i7 computers with minimum 32GB RAM, 1TB of onboard SSD storage, 1TB of additional storage, and NVIDIA T4 GPU w/ minimum 16GB RAM
  - LiDAR: Ouster OS1-64
  - IMU: LORD Microstrain 3DM-GX5-25
  - GNSS: u-Blox EVK-M8T
  - RGBD Camera: Intel RealSense D435i
  - Two (2) High Resolution Cameras: FLIR Blackfly S, BFS-PGE-16S2C-CS
  - Two (2) camera lenses: Fujinon DF6HA-1S
  - Hardware Time Synchronization: Masterclock GMR1000 providing PTP server to LiDAR and cameras, PPS signal to IMU



*It is not a requirement to match the ARL configuration one-for-one

ARL GROUND AUTONOMY ARCHITECTURE

- The autonomy architecture is based on packages and components implemented with the Robotic Operating System (ROS) to enable reproducibility and modularity.
- We consider modularity at two scales: both individual algorithms/nodes and clusters of nodes that provide capability
- The architecture depends on the TF library and adheres to the ROS Enhancement Protocol
- Central to the world model and representations of the architecture is the adoption of pose-graph-based solutions to the simultaneous localization and mapping (SLAM) problem for GPS-denied or degraded localization. That is, representations of the world consume a list of frame correction (e.g., map to odometry) in order to process observations in a consistent frame (e.g., map)
- We assume a federated world model; the location and communication of data is in the hands of the system designer

ARL GROUND AUTONOMY ARCHITECTURE – MODULES

The existing ARL Autonomy Stack provides an implementation of the architecture described above and will be provided as GFE to seedling Recipients. It consists of four major capabilities:

1. **Perception pipeline:** Take sensor data, e.g., RGB images and point clouds, and process to symbolic observations. Components include object detection, per-pixel image classification, object position/pose estimation based on LIDAR, etc.
2. **Simultaneous Localization and Mapping (SLAM):** Using sensor data and perception pipeline products, formulate SLAM problem as a pose-graph optimization and solve. Includes components for point cloud alignment (ICP), pose-graph optimization (GTSAM), caching/data-association/fusion of symbolic object measurements, renderers of terrain classes/occupancy grids/point clouds.
3. **Metric Planning and Execution:** Use metric model of the world to achieve metric goals, e.g., waypoint navigation. Includes components for global planning (e.g., lattice-based motion planning), local planning (e.g., trajectory optimization), and an executor to sequence planning and control.
4. **Symbolic Planning:** Use symbolic model of the world to achieve symbolic goals, e.g., going near a particular object. Underlying symbolic planning architecture is based on behavior trees. Includes components for mission planning (e.g., the Planning and Acting using Behavior Trees), mission execution, sample behaviors that interface with mission planning/execution and the metric planning/execution layer (e.g., going to an object).

OVERVIEW OF BASELINE GROUND AUTONOMY STACK

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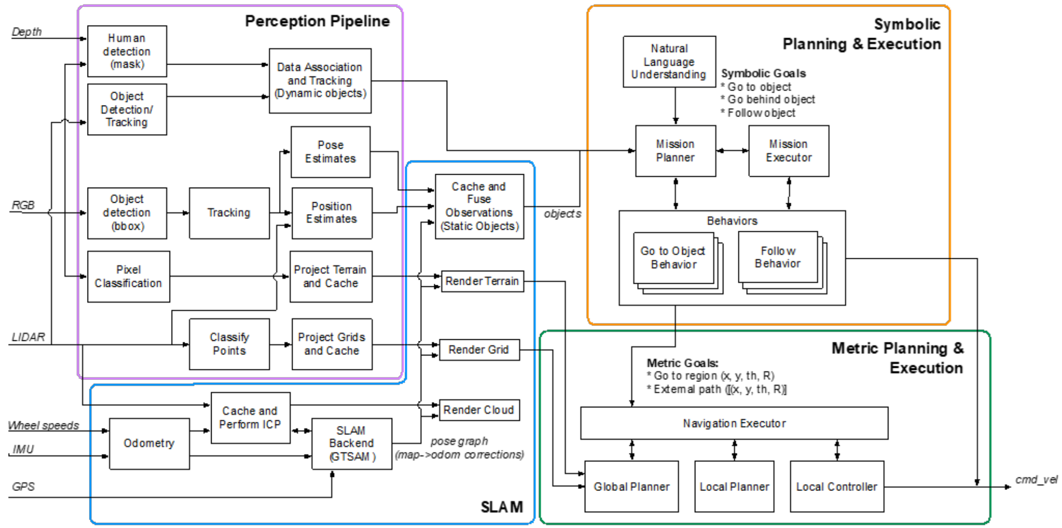
- **ARL Ground Autonomy Stack**
  - Focal point of ARL ground autonomy research
  - ROS1 based – taking advantage of a flexible framework
  - Monolithic repository to encourage cross-functional development and collaboration with a focus on supporting reproducible research
  - Common simulation environment (Unity)
  - Feature branches documented in Gitlab with merge request reviews for integration into master
- **Mostly an accumulation of internal, MAST, RCTA capabilities**
- **Core functions**
  - Perception (LiDAR and vision)
  - Localization and mapping
  - Metric planning and execution
  - Symbolic planning and execution
  - Simulation



Intended platform set:

ROS

MAST = Micro Autonomous Systems and Technology
RCTA = Robotics Collaborative Technology Alliance

ARL AIR TESTBED PLATFORM

DEVCOM ARMY RESEARCH LABORATORY

- Development will be done by Recipients on their local RAS testbeds, but experimentation events will be performed using ARL platforms and with Recipient autonomy solutions integrated into the ARL Autonomy Stack(s)*
- ARL plans to support continuous development and integration of Recipient capabilities
- Data collection will be done with the ARL testbed platform

- The ARL Grazer A has a gross takeoff weight of approx. 2.5 kg and is equipped with the following baseline compute and sensor payload:
  - Flight controller: mRo Control Zero H7
  - Onboard computer: Modal AI VOXL 2
  - RGB camera: One forward-facing 4K**
  - Stereo camera: One forward-facing**
  - Stereo camera: One downward facing**
  - Rangefinder: One downward-facing**
  - Gimbaled camera**
  - Radio: Doodle Helix mesh

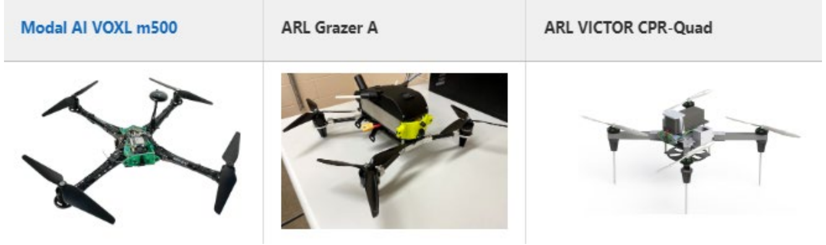
- The Grazer A platform is available for purchase and conforms to National Defense Authorization Act (NDAA) 2020 requirements for DoD UAS
- Flying any UAS at ARL facilities requires close coordination between the Recipient and ARL, to ensure hardware, software, and safety pilot meet the necessary requirements and certifications.

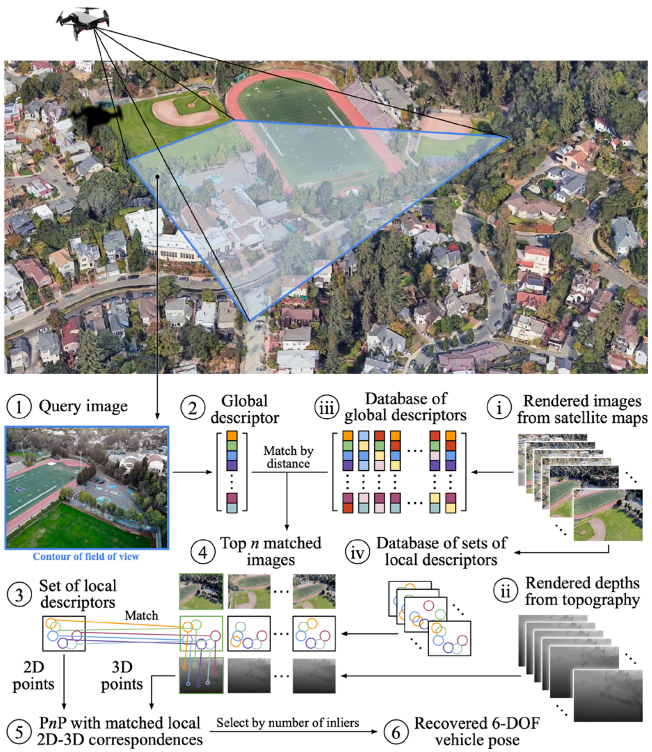
*Awardees are not required to use the Grazer A platform, but all algorithms developed or modified during performance of the SARA program must be compatible with the Grazer A components.

**Awardees will be provided with manufacturer and model number

ARL AIR AUTONOMY ARCHITECTURE

- Small UAS (< 20 lbs) software platform focused on vision-aided flight, detection and localization, onboard decision making and multi-agent teaming
- Comprised of DoD-owned and open-source software:
  - ROS2 based autonomy platform
  - PX4 based flight controller running on a pixhawk
- Goal is to create a pipeline to transition academic state-of-the-art algorithms into demonstrating Army and DoD concepts Examples:
  - Machine learning for perception and decision making
  - Vision enabled/GPS denied flight
  - Air-ground and multi-agent teaming
- Target a common software environment that can build on and expand these capabilities over time
- Generally these are autonomous, non-teleoperated behaviors with most/all algorithms running onboard the vehicle
- Leverages DIU Blue UAS Architecture

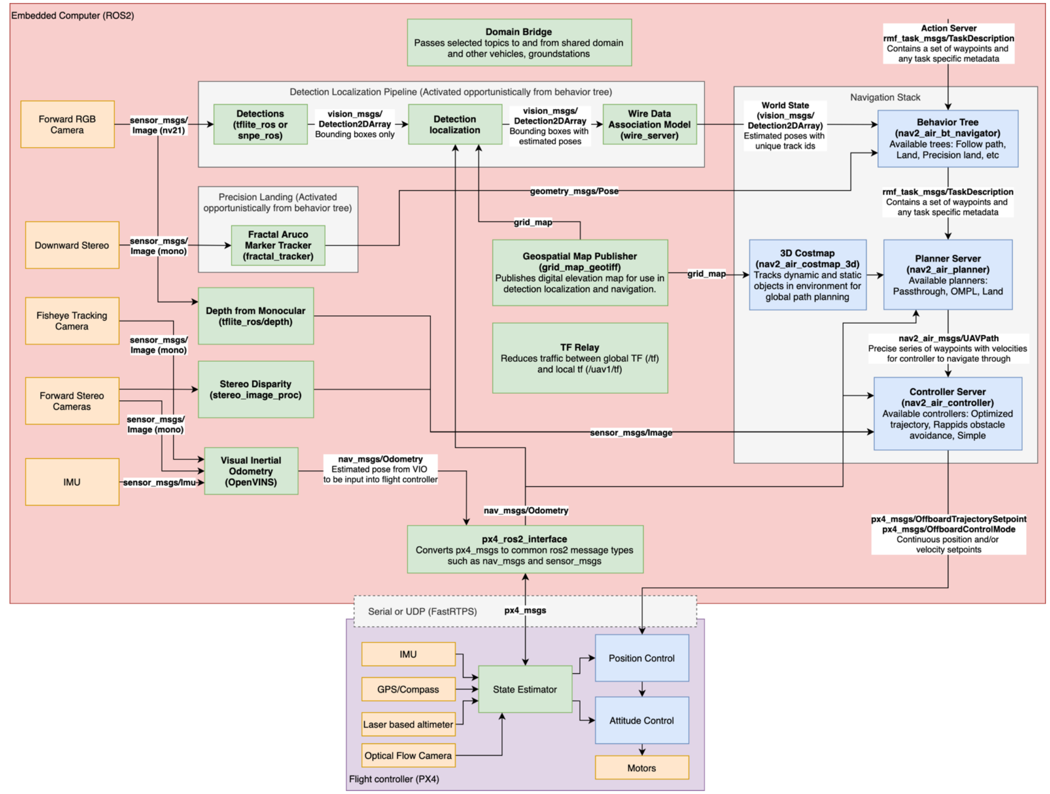




Global Localization: Train neural network to visually recognize location in an outdoor environment

OVERVIEW OF BASELINE AIR AUTONOMY STACK

- **ARL Air Autonomy Stack (MAVericks)**
  - Focal point of ARL air autonomy research
  - Leverages PX4 and ROS2
  - Common simulation environment (Unity)
  - Feature branches documented in Gitlab with merge request reviews for integration into master
- **Core functions**
  - Perception
  - State estimation
  - Localization and mapping
  - Multi-agent communication
  - Simulation



CONTRIBUTING TO ARL AIR AND GROUND AUTONOMY

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Contribution comes in three possible ways:

- Replace an existing algorithm or capability with a newly-developed or already-existing one. Experiments should then be conducted to show improved performance.
- Add an algorithm or capability, either already-existing or newly-developed. Experiments should then be conducted to show augmented capability.
- Modify an existing algorithm or capability. Experiments should then be conducted to show improved performance.

- The baseline ARL Autonomy Stacks will be made available to seedling Recipients as GFE at Award for development purposes.
- Recipients are expected to perform continuous development, integration, experimentation throughout the program.
- Recipients will be given access to a private Gitlab project so that technologies can be integrated into the ARL Autonomy Stacks independent of other Recipients.
- Solutions with restrictive Intellectual Property or non-open architecture solutions will also be considered, but must show a pathway to transition to future Army systems and integration and operation within the ARL Autonomy Stack.

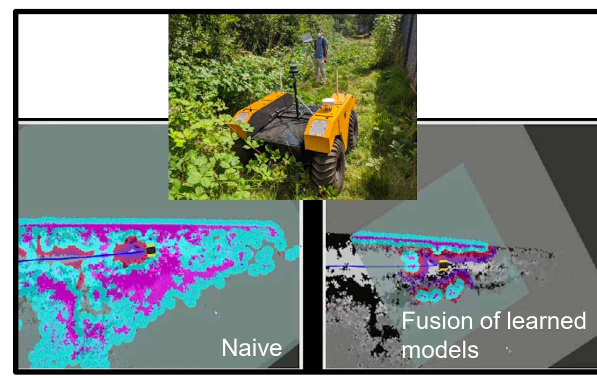
DEVELOPMENT & INTEGRATION APPROACH

- **ARL Autonomy Stack is a git <u>monorepo</u>**
  - Repository is one big catkin workspace (collection of packages built and deployed together)
  - Cons: repo is big and takes a long time to build
  - Pros: everything is at-hand

- **Master branch**
  - Always works (only updated through vetted merge requests)
  - Moves rapidly, no point-releases

- **Project branches**
  - Individual efforts (bugfix, feature, research project) branch from master
  - Goal is no long-running branches – everything aims to merge to master eventually

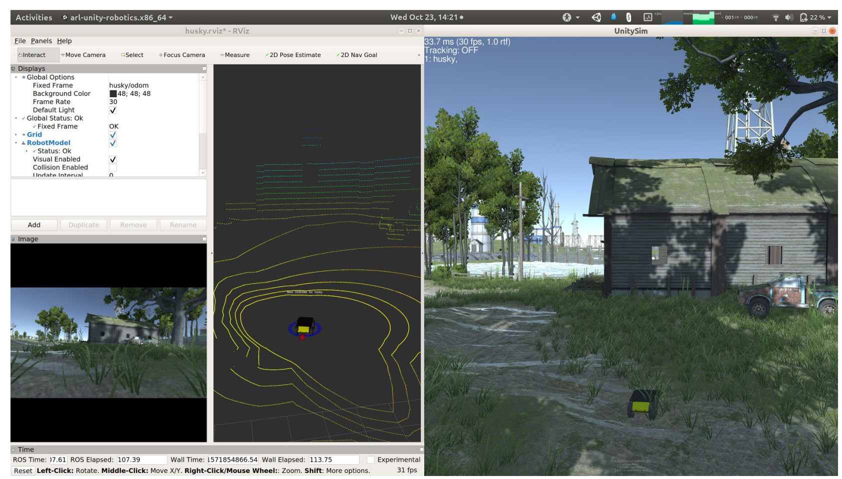
- **Experiment packages**
  - Individual experimental efforts keep configuration/settings/tools within a dedicated package
  - Stack design is intended that experiment packages are small deltas from standard configuration



ARL GROUND SIMULATION TESTBED

ARL Autonomy Stack has an "opt-in" package for a Unity-based perceptual and physics simulation

- **ROS Interface**
  - Spawn robots, sensors, environment
  - Receive sensor data on hardware-compatible topics
  - Send actuation commands to simulated platform
- **Platforms**
  - Clearpath Husky
  - Clearpath Warthog
  - Polaris MRZR
- **Sensors**
  - IMU
  - Cameras
    - RGB
    - Depth
    - Semantic segmentation
    - Object detection
  - 3D LIDAR



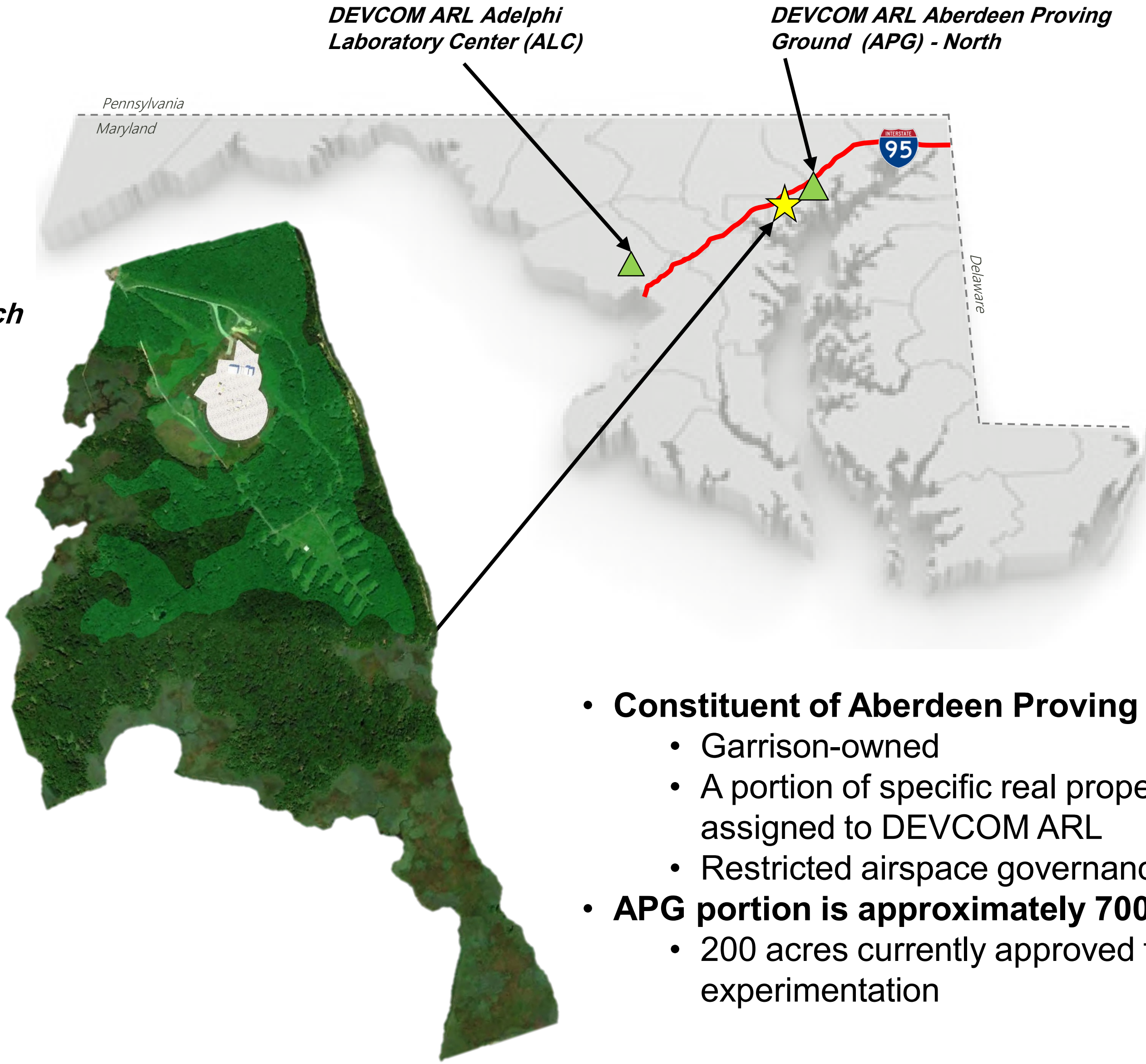
EXPERIMENTATION ACTIVITIES

- **On-site collaboration at ARL facilities and with ARL researchers, as well as with other seedling Recipients, is strongly encouraged**
- **Research outcomes in this program must, at the very least, be demonstrated in situated experimentation events**
  - Place of performance for SARA Cycle 3 is the Robotics Research Collaboration Campus (R2C2) at Graces Quarters, Aberdeen Proving Ground, Maryland
  - Experimentation events are expected to nominally last for one week
  - Leading up to each event, Recipients will commit their algorithms to the ARL Ground and/or Air Autonomy Stacks
  - Recipients should plan on at least 2 trips to the ARL Robotics Research Collaboration Campus Graces Quarters Facility during the seedling period of performance
  - Recipients are expected to perform continuous development, integration, experimentation, and learning at their own facility as-needed throughout the program
  - The number of visits that Recipients can make to the ARL R2C2 Graces Quarters facility is only limited by availability of ARL personnel, testbeds, and the facility

ARL Experimentation Location

DEVCOM ARL ROBOTICS RESEARCH COLLABORATION CAMPUS (R2C2) LOCATION

DEVCOM ARL Robotics Research Collaboration Campus (R2C2)



- **Constituent of Aberdeen Proving Ground (APG)**
  - Garrison-owned
  - A portion of specific real property has been assigned to DEVCOM ARL
  - Restricted airspace governance
- **APG portion is approximately 700 acres large**
  - 200 acres currently approved for experimentation

R2C2 RESEARCH ENABLING CAPABILITIES

Key Facility Capabilities

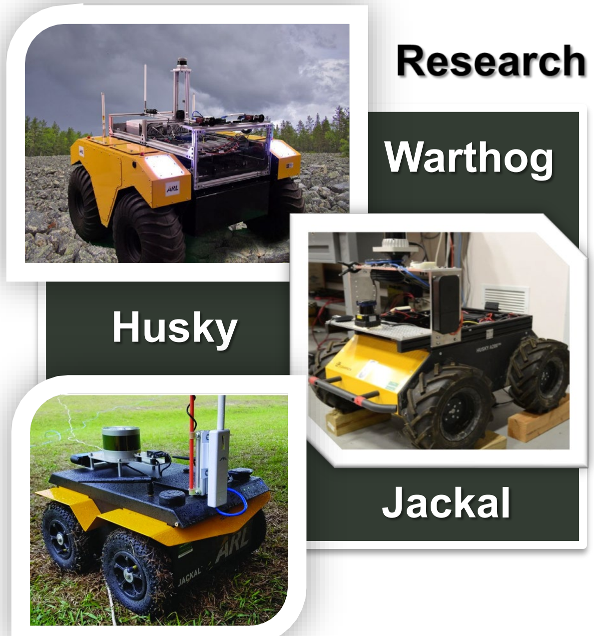
- Collaboration and conference space
- Interconnected outdoor ground and aerial systems testing areas
  - Natural wooded and open terrain
  - Small Multi-Terrain Course
  - Simulated Urban Environment
- Indoor motion capture flight space
- Support infrastructure for extended duration and remote fielded experimentation
- Machining, electronics customization and repair shops
- Ruggedized laboratory space for customization, staging, research and development
- Classified communications capabilities

R2C2 RESEARCH ENABLING CAPABILITIES (CONT.)

Key People and Platform Capabilities

- High fidelity models
- Complex engineered, modular hardware and software packages
- Dedicated personnel performing integration, engineering, experimentation support and maintenance

Research Fleet



Digital Model

Support Personnel

GRACES QUARTERS IN FALL / WINTER

A few representative images of expected environments…

GRACES QUARTERS IN SUMMER / SPRING

Proposal Process and Details

(Copied from the FOA)

SPRINT 3 PROPOSAL INTENT

- Funding will be provided to selected Recipients under a cooperative agreement (CA). The Cycle 3 period of performance will be a 12-month seedling effort followed by a possible 36-month option.
- Multiple awards are expected. Total number of seedling Recipients and funding per Recipient will vary from year-to-year at the discretion of the Government and based on available funding.
- Proposals are to be bid commensurate with level of effort proposed. A total of $2.5M is expected for all proposals to be awarded, not per proposal.
- Proposals must address a minimum of one sub-topic but can address more than one sub-topic within this amended special notice.
- Proposals must address one or more, but need not address all, of the assumptions and challenges listed within each sub-topic within this special notice. Proposals are also not limited to assumptions and challenges listed
- The Government also reserves the right to negotiate with an Applicant to re-scope their proposal or optional proposal technical focus, period of performance, and associated costs in order to maximize the available program funding, balance of research topics across the program, and overall impact to the program.

SPRINT 3 PROPOSAL INTENT (CONT.)

- The Recipients of a “seedling” CA are then eligible for consideration to receive funding for a single optional extension of up to 3 years at the conclusion of the seedling project.
- The success of this multidisciplinary effort will require meaningful collaborative partnerships between government, academia, and industry to advance the science. Proposals must address the intellectual property (IP) approach, how the approach will foster collaboration with ARL and other SARA Recipients, and how the proposed solution will further advance the state-of-art of open source or ARL/government owned autonomy solutions.
- Innovation in open architecture hardware design/selection and algorithm implementation are of high interest, as these approaches can lead to significant decreases in size, weight, power and cost. Solutions with restrictive Intellectual Property or non-open architecture solutions will also be considered, but must show a pathway to transition to future Army systems and integration and operation within the ARL Autonomy Stack.

PROJECT NARRATIVE ON GRANTS.GOV

Chapter 1: Technical Component – Seedling Year.

- Will not exceed 10 pages, utilizing one side of the page.
  - Proposed Effort (approximately 4-5 pages)
  - Proposed Experimentation Participation and Collaboration Development (approximately 1-2 pages)
  - Participant roles, qualifications and bio-sketches (approximately 2 pages)
  - Proposed timeline (approximately 0.5-1 page)

Chapter 2: Technical Component – Option Years

- Will not exceed 4 pages, utilizing one side of the page.
  - Proposed Effort (approximately 2-4 pages)

Chapter 3: Cost Component.

- Chapter 3 does not have a page limitation
- Must include a budget for the seedling year, as well as a budget for the Option Years as applicable

Proposals are due in Grants.gov by 5:00pm (local time in North Carolina, USA) on 21 April 2023

APPLICATION REVIEW / EVALUATION INFORMATION (ABBREVIATED)

Factor 1: Scientific Merit and Relevance: Evaluation of this factor will concentrate on the overall scientific and technical merit, creativity, innovation, and flexibility of the proposed research in light of the current state-of-the-art of tactical behaviors for multiagent systems-relevant scientific topics, and the expected outcomes based on the timeline of execution.

Factor 2: Research Plan and Plan for Collaboration: Evaluation of this factor will concentrate on the Applicant's strategies, plans and experience in fostering collaborative research and managing collaborative research programs as set forth in this FOA.

Factor 3: Experience and Qualifications of Scientific Staff and Junior Investigator Development: Evaluation of this factor will concentrate on the qualifications, capabilities, availability, proposed level of effort, and experience of both the Applicant's key research personnel (individually and as a whole), their relevant past accomplishments, and their ability to achieve the proposed technical objectives.

Factor 4: Cost. While this area will not be weighted, evaluation of this area will consider cost realism, cost reasonableness, and affordability within funding constraints. The Government may make adjustments to the cost of the total proposed effort as deemed necessary to reflect what the effort should cost.

PROPOSAL REVIEW AND SELECTION PROCESS

- Proposals are expected to be evaluated by a group of qualified scientists and managers from the Government.
- Proposals that are timely and in compliance with the requirements of the FOA will be evaluated in accordance with merit based, competitive procedures.
- The Government will make award to the Applicant(s), whose proposal conforms to this FOA and offers the most-favorably rated proposal(s) based on the evaluation criteria.
- The Government reserves the right not to make an award should no acceptable Proposal be submitted.
- The Government also reserves the right to negotiate with an Applicant to re-scope their proposal or optional proposal technical focus, period of performance, and associated costs in order to maximize the available program funding, balance of research topics across the program, and overall impact to the program resulting in the development of an annual program plan to cover the optional research to be performed and the period of performance of that research.
- At the end of Cycle #3, the decision to exercise option periods of any Seedling awards remains at the discretion of the Government.

CLOSING NOTES

- Nothing in this presentation or discussed during the webinar supersedes the FOA for purposes of proposal preparation.
- Any changes to the FOA will be issued as amendments.
- Continue monitoring grants.gov for changes at https://www.grants.gov/web/grants/view-opportunity.html?oppId=323682
- Any additional questions can be submitted through the SARA e-mail address usarmy.apg.devcom-arl.mbx.sara-cra@army.mil
- Responses to non-proprietary questions received will be posted to the SARA program for the benefit of all interested parties. All clearly identified and marked proprietary questions submitted will be responded to via an individual email response, not posted to the SARA program website (https://www.arl.army.mil/business/collaborative-alliances/current-cras/sara-cra/)
- Last day to submit questions is 7 April 2023