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

Scalable, Adaptive, and Resilient Autonomy (SARA)

1pm
24 February 2020

Brett Piekarski, Ph.D.
Program Manager
Brett.h.piekarski.civ@mail.mil

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Agenda:

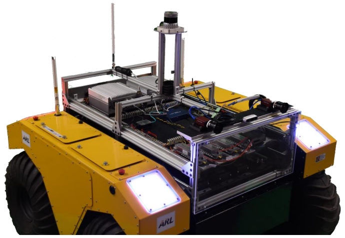
- **Motivation**
- **Sprint Topic Logistics**
- **Technology Sprint Topic Details**
  - **Sub-topic #1: Off-road autonomous "GROUND" maneuver**
  - **Sub-topic #2: Autonomous "AERIAL" maneuver through off-road environments**
  - **Sub-topic #3: Large scale heterogeneous autonomous systems experimentation**
  - **Simulation Environment**
- **Proposal process and details**

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Purpose:

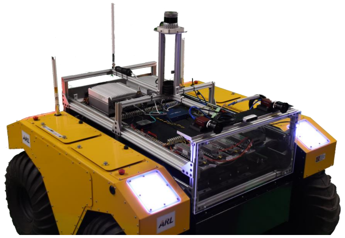
- Develop fundamental understanding and inform the art-of-the-possible for SARA.
- Improve air and ground based autonomous vehicle perception, learning, reasoning, communication, navigation, and physical capabilities to augment and increase the freedom of maneuver in complex and contested environments.
- Realize adaptive and resilient Intelligent Systems that can reason about the environment, work in distributed and collaborative heterogeneous teams, and make optempo decisions.
- Enable Autonomous Maneuver in complex and contested environments.

Off-Road Autonomous Maneuver



SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Off-Road Autonomous Maneuver



Approach:

- Through a series of technology sprint topics executed in annual program cycles the program will develop and experimentally accelerate emerging research in:
  - Autonomous mobility and maneuverability
  - Scalable heterogeneous and collaborative behaviors
  - Human-agent teaming
- Build a comprehensive and cumulative capability exploring and experimentally demonstrating the art of the possible in scalable, adaptive, and resilient autonomy.

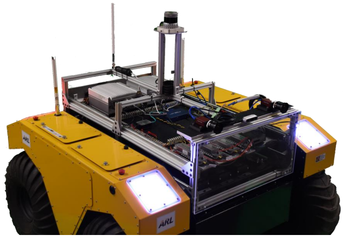
UNCLASSIFIED//Approved for Public Release

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Products:

- 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 collaborative air and ground MUM-T 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.

Off-Road Autonomous Maneuver



SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

SARA sprint topics:

- Will be 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.
- 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.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Place of performance:

- There is no limitation on the place of performance
- On-site collaboration at ARL facilities and with ARL researchers as well as with other seedling Recipients is encouraged.
- It is mandatory that all Recipients participate at bi-annual experimentation events.
    - For SARA cycle #1, the events are planned to take place at Camp Lejeune, NC.
    - The first event will be a coordination event for all seedling Recipients in April of 2020.
    - Seedling awardees will be required to attend a 3 day period during this two week event conducted by ARL to witness testbeds, ARL baseline experimentation, and the ARL autonomy stack in operation.
    - A full two-week experimentation event for all seedling Recipients and ARL collaborative researchers to experimentally evaluate integrated solutions from the seedling Recipients on ARL testbeds and within the ARL software autonomy stack will be held in October of 2020 at Camp Lejeune or an equivalent test site.
    - Future SARA cycles will rotate to different sites depending on the nature of the sprint topic.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

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	15 January 2019
Opportunity Webinar	**24 January 2020**
Deadline for Questions on Funding Opportunity	31 January 2020
Proposals due for Cycle 1	14 February 2020
Cycle 1 Awards	April 2020 (Expected)

UNCLASSIFIED//Approved for Public Release

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Cycle 1 Technology Sprint Topic: Off-Road Autonomous Maneuver. We have focused this announcement (Cycle 1) on "Off-Road Autonomous Maneuver."

Within "Off-Road Autonomous Maneuver," there are three sub-topics:

- **Sub-topic #1: Off-road autonomous "GROUND" maneuver**: focused on how to increase the operational tempo and mobility of autonomous ground systems to traverse increasingly complex off-road environments.

- **Sub-topic #2: Autonomous "AERIAL" maneuver through off-road environments:** Explores how to increase the operational tempo and mobility of aerial autonomous systems to navigate increasingly complex off-road environments such as forest roads, along field edges, and above, through, and under canopy forested environments in order to support ground platforms and dismounted Soldiers.

- **Sub-topic #3: Large scale heterogeneous autonomous systems experimentation:** Develops software infrastructure to orchestrate and manage large-scale air-ground collaborative experiments.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Sub-topic #1: Off-road autonomous "GROUND" maneuver:

- How to increase the operational tempo and mobility of autonomous ground systems to traverse increasingly complex off-road environments.

Assumptions for Sprint sub-topic area #1:

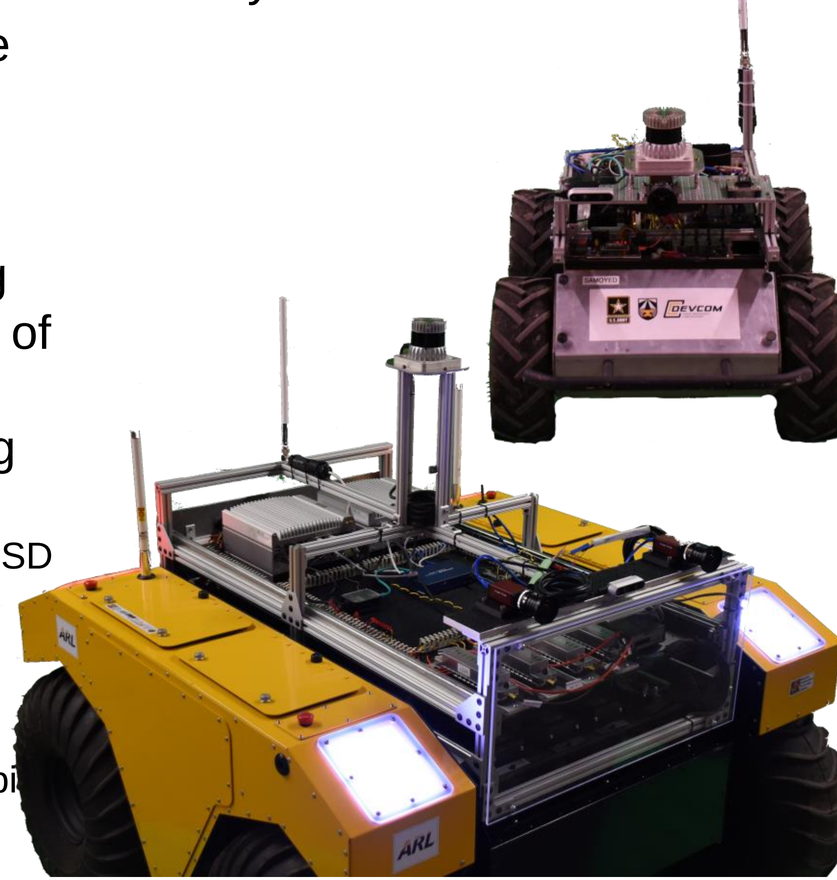
- Single Platform, GPS limited/denied navigation
- Unprepared Terrain – Forest environment
- Point A to B navigation over distances on the order of kilometers with potential for area/zone search at point B
- Ability to operate with and without a stale map a priori
- Not reliant on communication/data feeds to complete a commanded task

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

ARL Testbed(s): Development can be done on performer platforms, but the bi-annual experimentation events will be done on ARL provided platforms and with solutions integrated into the ARL autonomy architecture and autonomy software stack.

Ground testbeds include both a small and large platform, an ARL modified Clearpath Robotics Husky and Warthog respectively.

- The Husky is approximately 1 m^3 with a maximum speed of 1.0 m/s while the Warthog is approximately 2 m^3 with a maximum speed of 5 m/s.
- Both platforms are equipped with the following baseline compute and sensor payload:
    - Two (2) Intel i7 computers with 16GB RAM, 1TB of SSD storage, and NVIDIA GTX 1660 GPU
    - LIDAR: Ouster OS-1 Lidar (64-beam)
    - IMU: Microstrain 3DM-GX5-25
    - RGBD Camera: Intel Realsense D435i
    - High Resolution Cameras: AVT Manta G-507C Gigabi Ethernet
    - Hardware Time Synchronization: Masterclock GMR1000 providing PTP server to LIDAR and cameras, PPS signal to IMU



SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

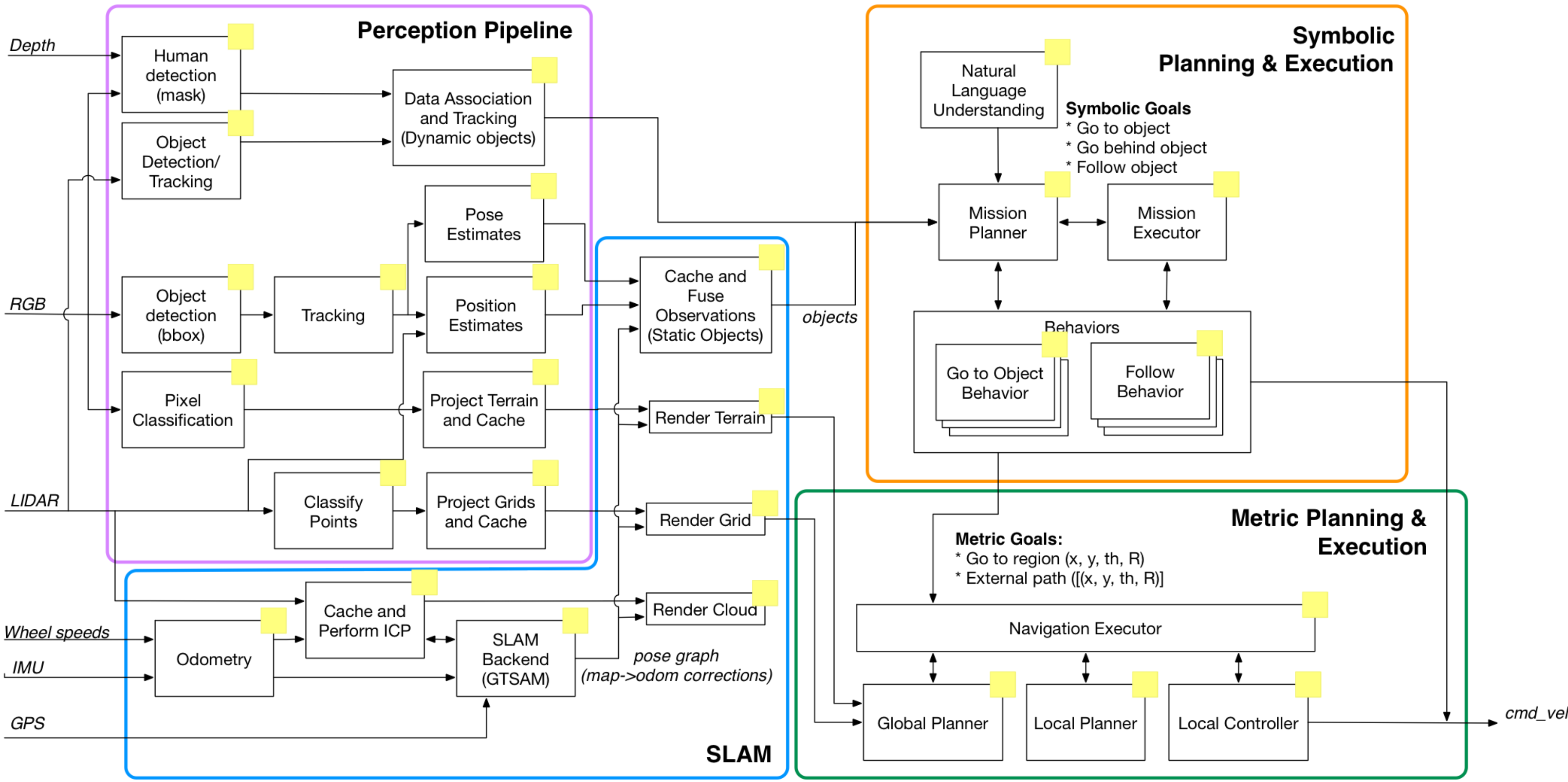
ARL Ground Autonomy Software Stack:

- 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 standard frame conventions
- 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.

UNCLASSIFIED//Approved for Public Release

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

ARL Ground Autonomy Software Stack



SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

ARL Ground Autonomy Software Stack:

The existing ARL autonomy software stack provides an implementation of the architecture described in previous charts and will be provided as GFE to seedling recipient. 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).

UNCLASSIFIED//Approved for Public Release

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Contributions to the existing architecture come in three possible ways:

- Replace an existing algorithm (i.e., node) with one that maintains the same input/output specifications. Experiments should then be conducted to show improved performance.
- Add an existing algorithm or capability to the existing system. Experiments should then be conducted to show augmented capability.
- Replace an existing capability (i.e., cluster of nodes) such that aggregate input/output specifications are maintained. Experiments should then be conducted to show maintained end-to-end performance and augmented capabilities.

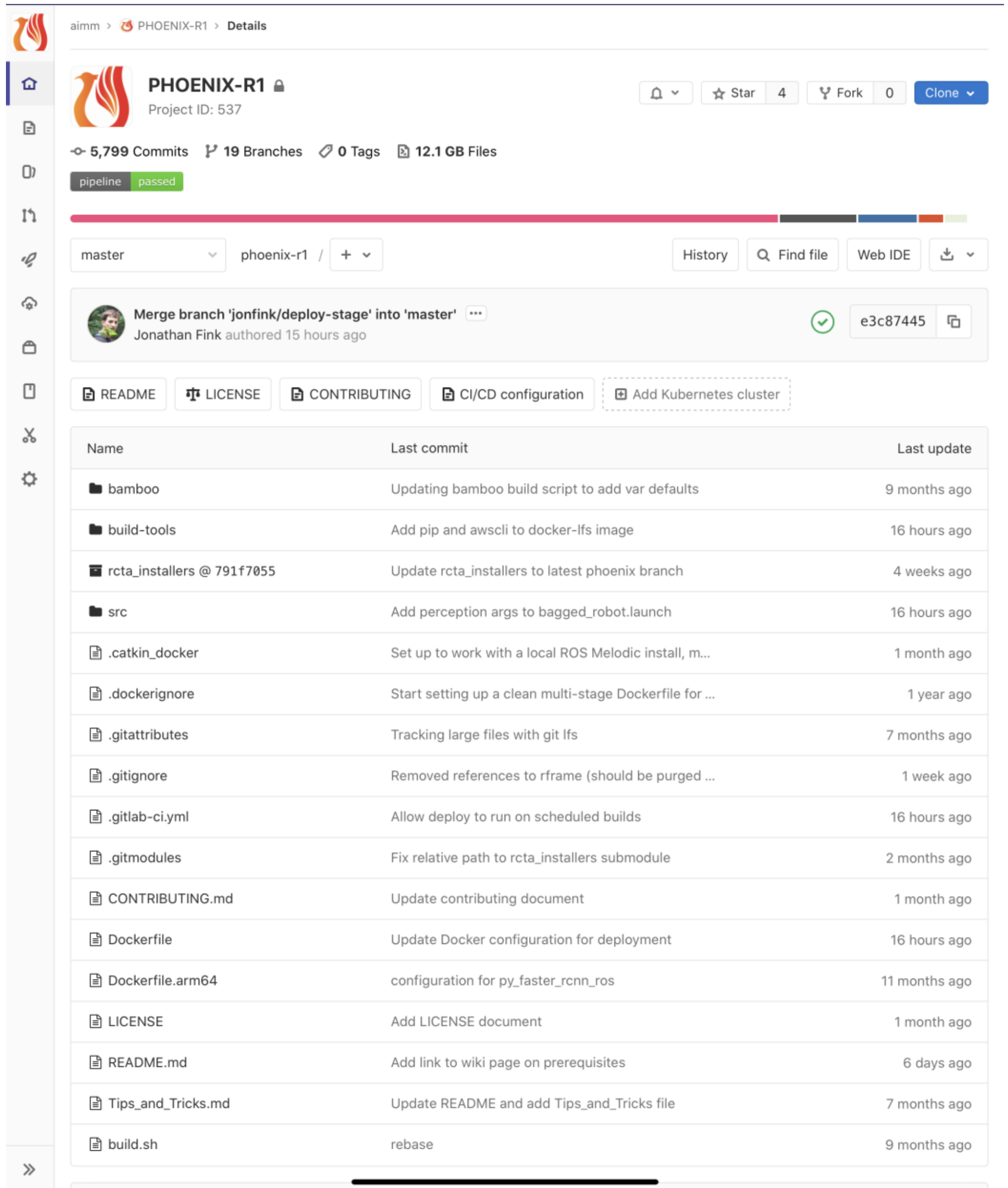
To support this collaborative and cumulative engagement and environment, software code developed under the SARA program will be added to the ARL Autonomy Stack Repository for use by current and future ARL and sprint performers. Performers will be given access to a private Gitlab project so that SARA technologies can be integrated into the baseline ARL Autonomy Stack through a feature-branch methodology including pull requests, code review, and automated testing.

UNCLASSIFIED//Approved for Public Release

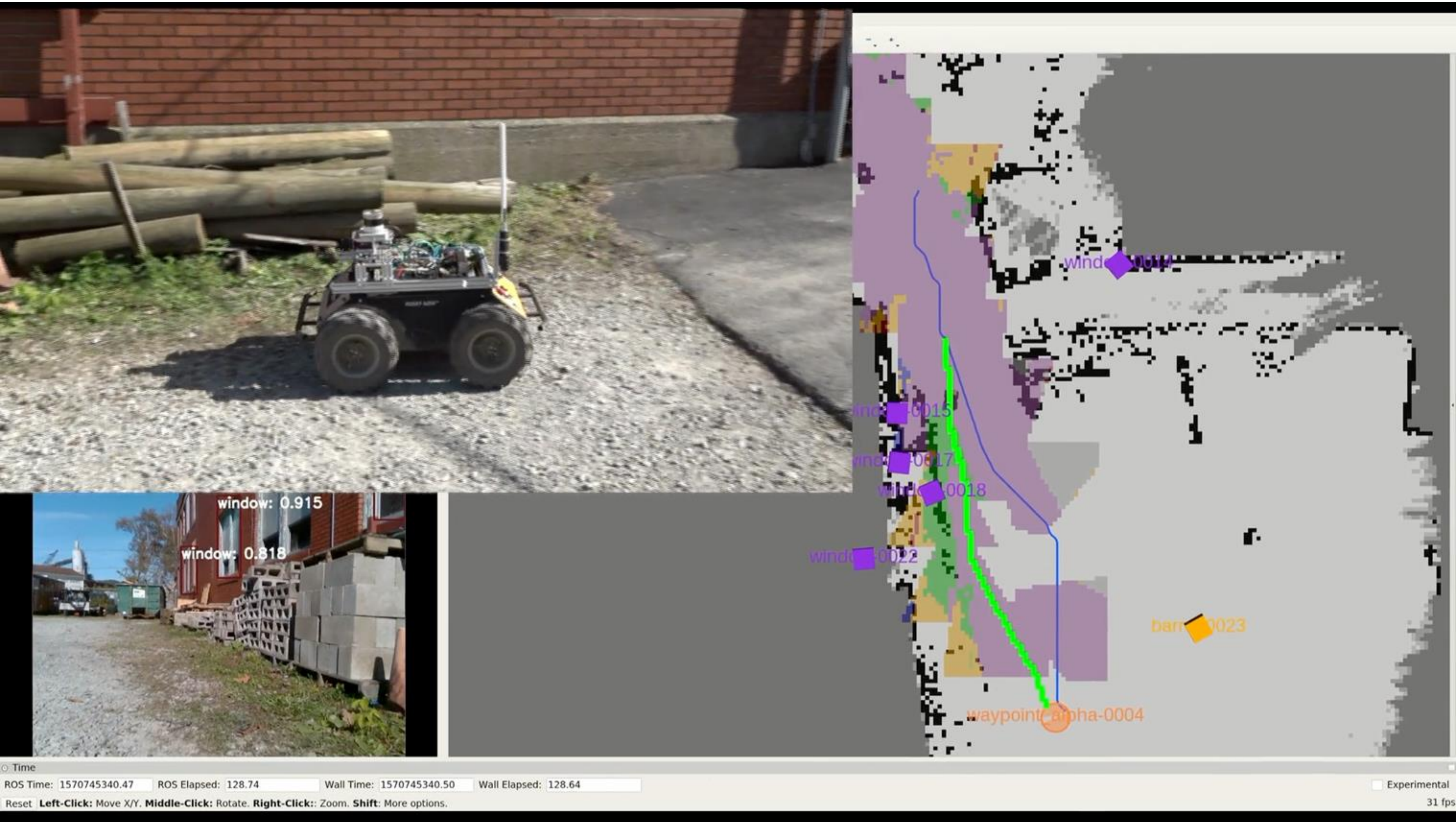
SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

ARL Ground Autonomy Software Repository (Phoenix):

- Monolithic git repository
- Catkin workspace
- Ubuntu 18.04 / ROS Melodic
- Rosdep used to track system dependencies (standard and custom)
- Docker-based development encouraged
- Feature-based branching model, pull requests, automated builds, and code review
- Private gitlab hosting



ARL's Autonomy Stack implemented on Husky Platform At RCTA Capstone



ARL's Autonomy Stack implemented on Husky Platform At RCTA Capstone

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

A few representative images of expected testing environments, actual testing will involve other sites and more terrain features.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Topics of interest for Sprint sub-topic area #1 include but are not limited to:

- Integrated AI/Reasoning approaches focused on reasoning about objects in the environment for natural object detection and characterization and to solve navigation problems including negative and water hazards.
- Techniques for improved semantic perception, decision making, and adaptive behaviors for fully autonomous maneuver and terrain aware navigation through off-road environments.
- Ability to perceive and follow paths through forested environments.
- Ability to perceive and follow large scale, possibly unstructured, terrain features like tree lines.
- Development of a persistent world model and the ability of RAS to learn & adapt navigation planning and behaviors.
- Algorithms focused on reducing reasoning, planning, and processing time to increase operational speed in moderate off-road conditions (off road trails, field transverse, sparse forest with limited underbrush, etc).

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Topics of interest for Sprint sub-topic area #1 include but are not limited to:

- Algorithms and methods to increase understanding, terrain modeling, and path planning for slow-speed complex terrain traversability assessment and 2.5 D Planning through complex terrain (complex terrain with positive and negative obstacles such as rock fields, ditches, fords, heavily forested areas with underbrush, etc).
- Algorithms for increased resiliency in terrain aware navigation to include robustness to wide variations in environmental conditions.
- Algorithms that can detect, reason about, and plan in the presence of dynamic objects.
- Methods for increased state awareness and reduced uncertainty in navigation planning for off-road maneuver.
- 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 resulting in verifiable autonomous behaviors.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Metrics:

- Recipients will be expected to integrate their solutions onto ARL testbeds and into ARL's autonomy stack for the experimental events.
- At these experimental events, Recipients, using the ARL testbeds and autonomy stack, will conduct autonomous maneuvers per the assumptions above and their performance will be evaluated against the baseline ARL platform and autonomy stack performance (as measured during the first **Bi-Annual Experimentation Event)** and criteria 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 manned system, a single tele-operated ground RAS, and the baseline ARL autonomy stack at the start of the sprint.
  - Complexity of terrain traversed based on number, density, and type of obstacles.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

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

- How to increase the operational tempo and mobility of autonomous aerial systems to traverse increasingly complex off-road forested environments.

Assumptions for Sprint sub-topic area #2:

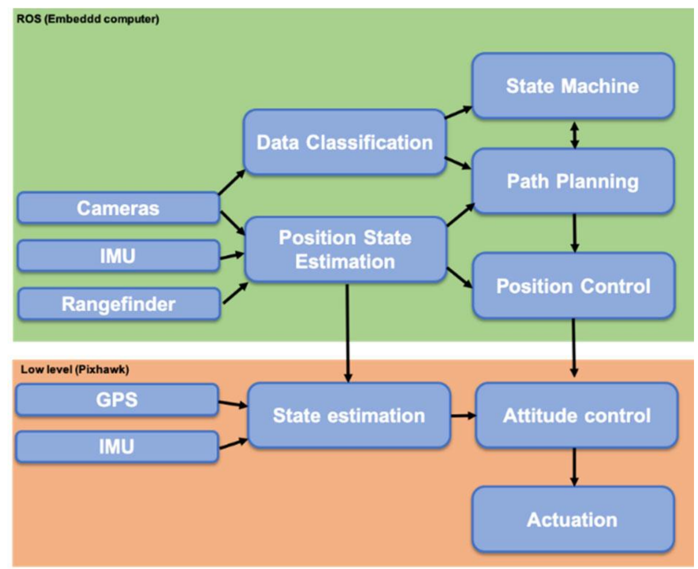
- Single Platform, GPS-intermittent/denied navigation
- Unprepared Terrain – Forest environment
- Point A to B navigation over distances on the order of kilometers with potential for area/zone search at point B
- Ability to operate with and without a stale map a priori
- Not reliant on communication/data feeds to complete a commanded task
- Development can be done on performer platforms, but the bi-annual experimentation events will be done on ARL provided platforms and with solutions integrated into the ARL aerial autonomy architecture and autonomy software stack as defined below.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Air Vehicle Testbed: Small Quadrotor

ARL quadrotors are able to navigate without GPS and avoid obstacles, as well as perceive their environment and recognize objects of interest. The flight control functionality is organized as shown in the following diagram:

- 0.25-2 kg vehicle
- 5-15 min flight time
- PX4-based autopilot with GPS and RC receiver
- Ventral optical flow and laser altimeter
- NVIDIA TX2 processor board, Intel NUC or equivalent.
- Onboard EO (1280x1024) and IR(640x480) global and rolling shutter cameras



Vehicle architecture

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Flight Software Stack:

- The ARL flight software is ROS and PX4 based, and is source controlled using GIT. The repository itself contains the ROS workspace and PX4 software, with multiple public and private ROS modules forming most of the functionality. It also contains docker and robot profiles for aid in building the software on embedded targets. The goal for the repository is that the same software can be built installed either on a desktop for software in the loop simulations or on the appropriate embedded target.

Organization and notable packages:

  - communication – Macros for communication with PX4 flight controller
  - control – Path planning and position control
  - descriptions – URDF files that describe the air vehicles
  - drivers – PX4, realsense
  - executives – Python based state machine for high level control
  - launch files – System wide files for running software
  - perception – Fiducial marker recognition and image classifiers
  - simulation – Gazebo and Unity based simulation tools

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

ADDITIONAL POTENTIAL PLATFORM – COLLABORATIVE WITH MIT

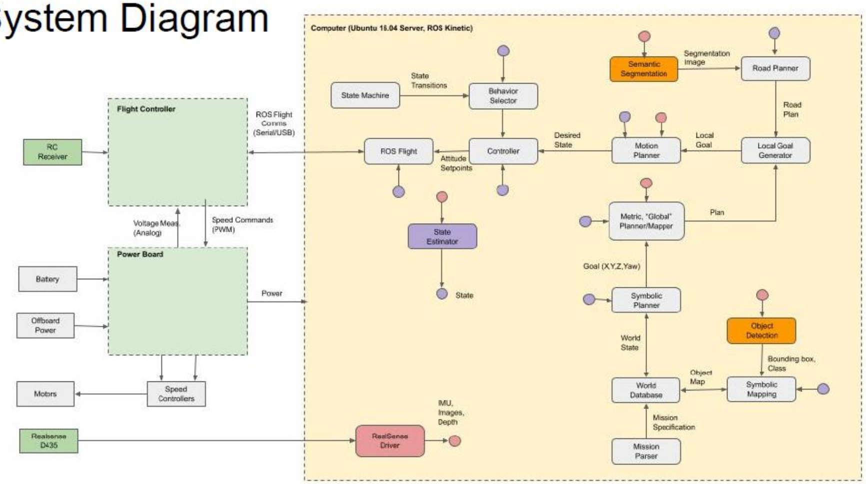
Platform Configuration:

- Weight: 1.87 kg
- Prop Size: 9.5”
- Motor-to-motor distance: 361 mm
- Battery Voltage: 4S (14.8V)
- Flight Time: 8 min.
- No DJI Parts
- Compute Platform: Intel NUC7i7
- 12V and 5V @ 2A power outputs
- Intel RealSense D435 RGB-D Camera
- OpenPilot CC3D Revo flight controller
- Hot swap battery support

Current Platform Capabilities:

- GPS-denied navigation (stereo VIO)
- Fast flight in cluttered, unknown environments
- Object recognition (cars, people, doors)
- Object localization
- Autonomous exploration
- Dense 3-D occupancy mapping
- Visual semantic segmentation
- Waypoint navigation
- Proximity-based velocity planning

System Diagram



SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

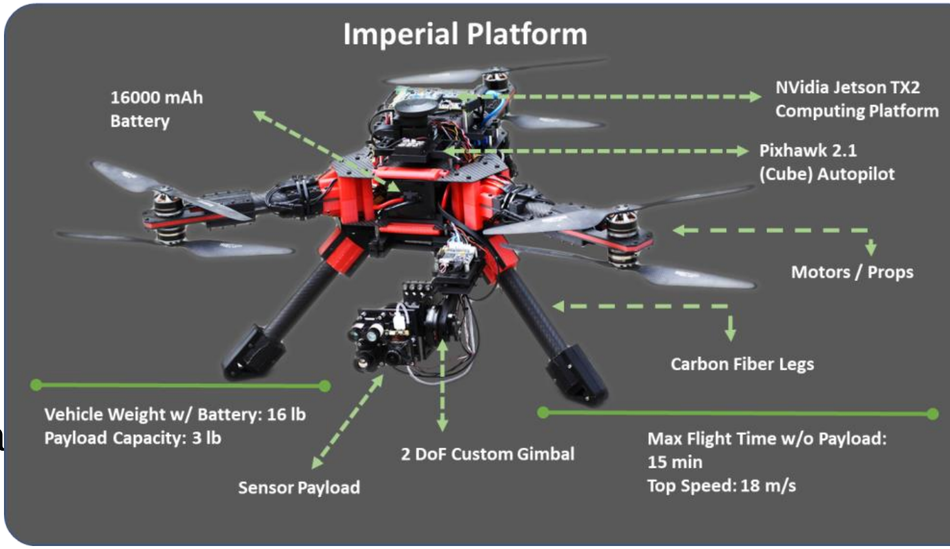
ADDITIONAL POTENTIAL PLATFORM – COLLABORATIVE WITH MIT

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

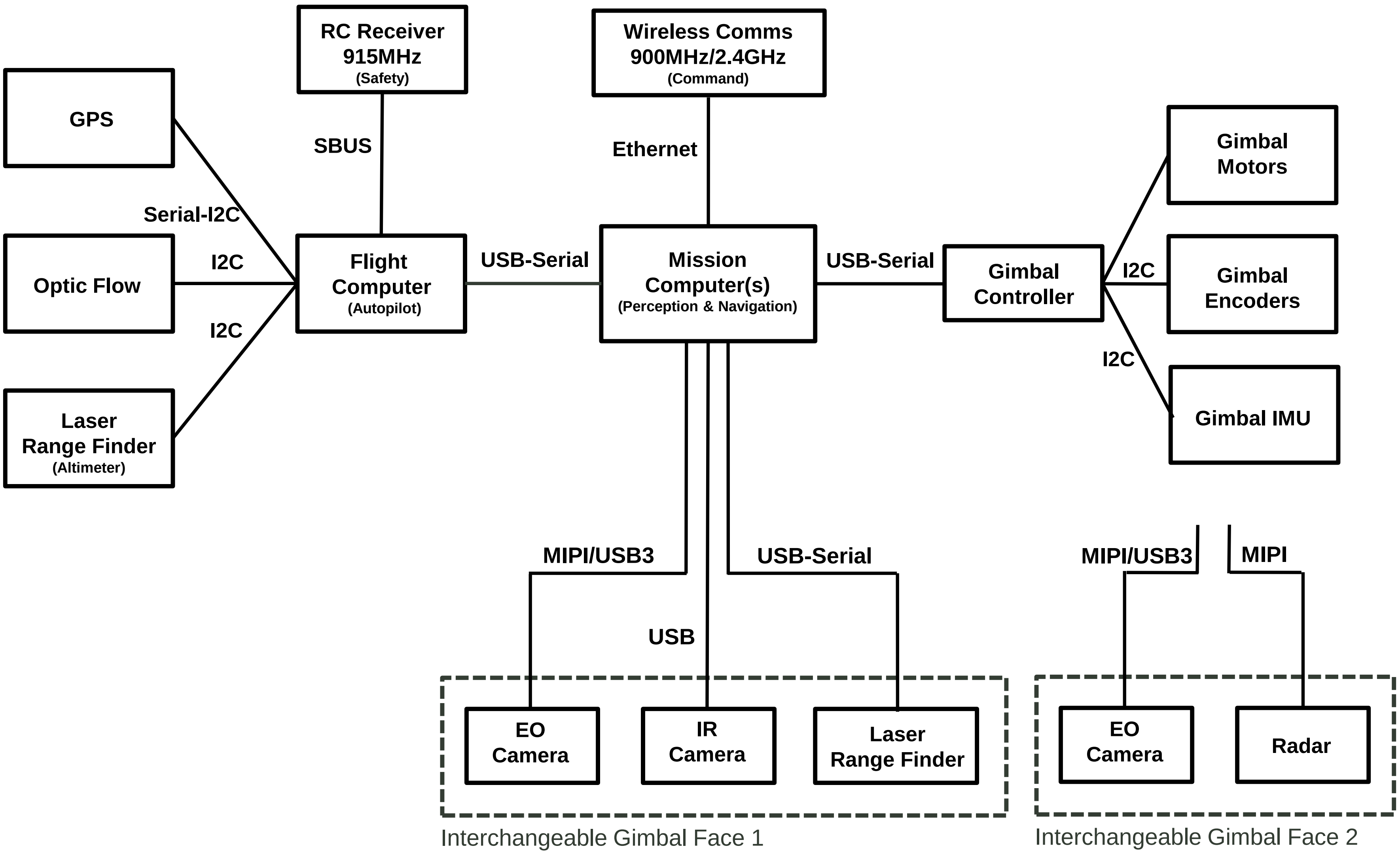
Large Multirotor Vehicle

- 6 – 9 kg vehicle
- ~16-18" prop size
- 10-30 min flight time
- 15-35 W embedded computer such as: Intel NUC, Nvidia Jetson TX2 or Xavier
- Onboard cameras for VIO and object detection such as intel realsense T265 and D435i, Flir Boson, and machine vision imagers (e.g. IDS ueye).
- Optional planar LIDAR
- Optional high resolution IMU such as Vectornav v100
- Pixhawk derivative flight controller
- RC receiver
- Downward facing distance sensor such as a ToF or Lidar based sensor
- GPS

Example "Large" Multirotor



SYSTEM ARCHITECTURE



VIDEO

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

ADDITIONAL POTENTIAL PLATFORM – COLLABORATIVE WITH UNIVERSITY OF PENNSYLVANIA

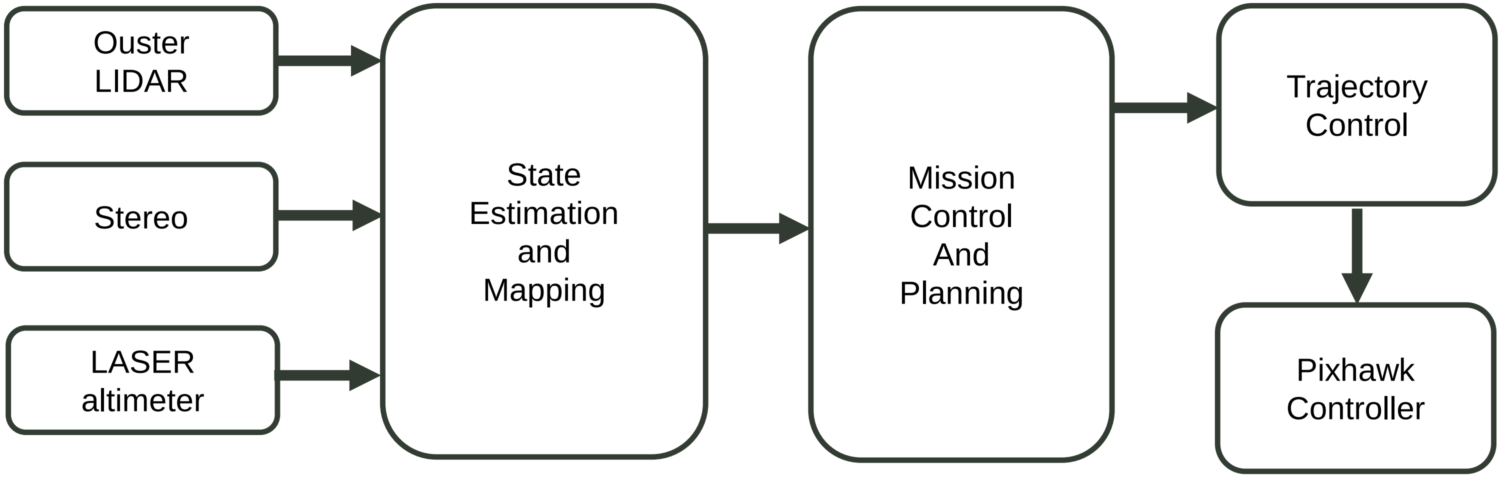
- Design Objectives
  - A bottom up redesign that avoids DJI components
  - Support for longer mission times on the order of 30 minutes
- Design Features
  - Custom designed low weight, low drag carbon fiber frame
  - Reconfigurable design supporting a range of arm lengths and propeller configurations
  - Open source pixhawk flight controller
  - Supports a range of computational modules including Quad Core Intel NUC and NVIdia Xavier modules
- Sensor Suite
  - Ouster LIDAR Unit
  - Multinocular stereo system (Open Vision Computer v3.0)
  - Laser altimeter
  - GPS receiver – (for ground truth measurements)
- Capabilities
  - Autonomous navigation over GPS denied areas using vision and lidar based odometry
  - Autonomous navigation outdoors amongst buildings and trees based on lidar mapping.
  - Support for vision and lidar based semantic segmentation
  - Ability to communicate with other agents via WiFi.

Pictured configuration 3.7kg total
110cm wingtip to wingtip on diagon

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

ADDITIONAL POTENTIAL PLATFORM – COLLABORATIVE WITH UNIVERSITY OF PENNSYLVANIA

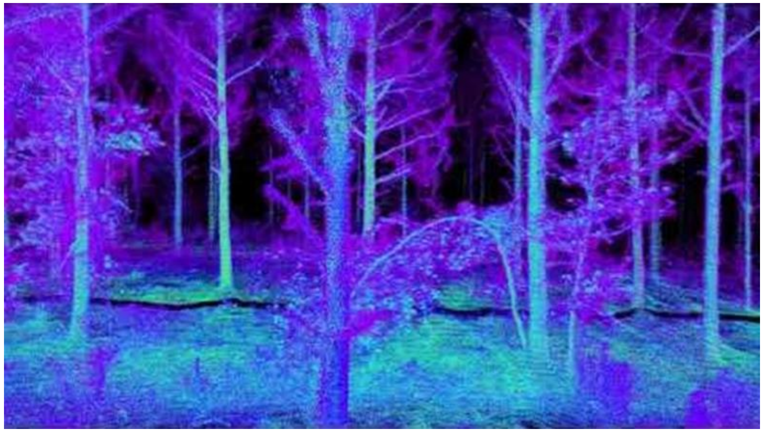
High Level System Architecture



Software architecture composed of modules built using ROS so that components can be reused and replaced as needed

TEST FLIGHT THROUGH FOREST

RECONSTRUCTED POINT CLOUD



UNCLASSIFIED//Approved for Public Release

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Topics of Interest for Sprint sub-topic area #2 include but are not limited to:

- Parsimonious methods to perceive obstacles at a sufficiently large range to adjust speed and course accordingly, including particular consideration for EO/IR fused monocular vision as a modality and thin obstacles such as wires, vines, and branches.
- Ability for perception and navigation methods to operate in a wide range of lighting conditions, to include night operation.
- Methods for incorporation of GPS-intermittent/denied operation in forested environments, leveraging vision and/or other signals of opportunity, to include required considerations for robustness and resilience needed for closing the loop onboard a UAV in a variety of environments.
- Ability to incorporate and fuse vision-based odometry algorithms intended for low altitudes (< 20 m) with alternative methods intended for moderate altitudes (20-400 m) based on absolute positioning leveraging onboard maps/databases.
- Usage of on-board radar fused with inertial sensing for odometric estimation and fusion of on-board radar with EO/IR sensing for small target and obstacle detection or visual/inertial/radar odometry.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Topics of Interest for Sprint sub-topic area #2 include but are not limited to:

- Ability to perceive and follow large scale, unstructured, terrain features (e.g. paths through forests, tree lines).
- Architectures to support dynamic re-allocation of computing resources between subroutines, running within the Robot Operating System (ROS), based on changing task/mission context and on-demand information requests.
- Algorithms that can detect, reason about, and plan in the presence of dynamic objects, including the ability to track, geo-localize, and maneuver relative to objects.
- Methods for incorporation of dynamic/real-time and onboard learning supporting object detection and maneuver behaviors.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Metrics:

- Recipients will be expected to integrate their solutions onto ARL testbeds and into ARL's autonomy stack for the experimental events.
- At these experimental events, Recipients, using the ARL testbeds and autonomy stack, will conduct autonomous maneuvers per the assumptions above and their performance will be evaluated against the baseline ARL platform and autonomy stack performance (as measured during the first **Bi-Annual Experimentation Event)** and criteria 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 manned system, a single tele-operated UAS, and the baseline ARL autonomy stack at the start of the sprint.
    - Complexity of environment traversed based on number, density, and type of obstacles.
    - Flight distance, speed, number of maneuvers, or mean time between failure (MTBF) (missions per crash) for UAS platforms.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Sub-topic #3: Large scale heterogeneous autonomous systems experimentation:

- Software infrastructure to orchestrate and manage large-scale air-ground collaborative experiments.
- Management of execution, runtime monitoring, configuration, and version-control and validation of emergency stop functionality and other safety measures.
- Replicating these complexities across large-scale multi-agent experiments, including concerns such as vehicle deployment and battery management, only compounds the challenge and deters reproducible experiments.

Assumptions for Sprint sub-focus area #3:

- Up to one priority ground platform, one non-priority ground platform, and two air platforms will need to be controlled and coordinated.
- Systems will need to operate over unprepared forest environments at distances of kilometers and urban environments over 100s of meters.

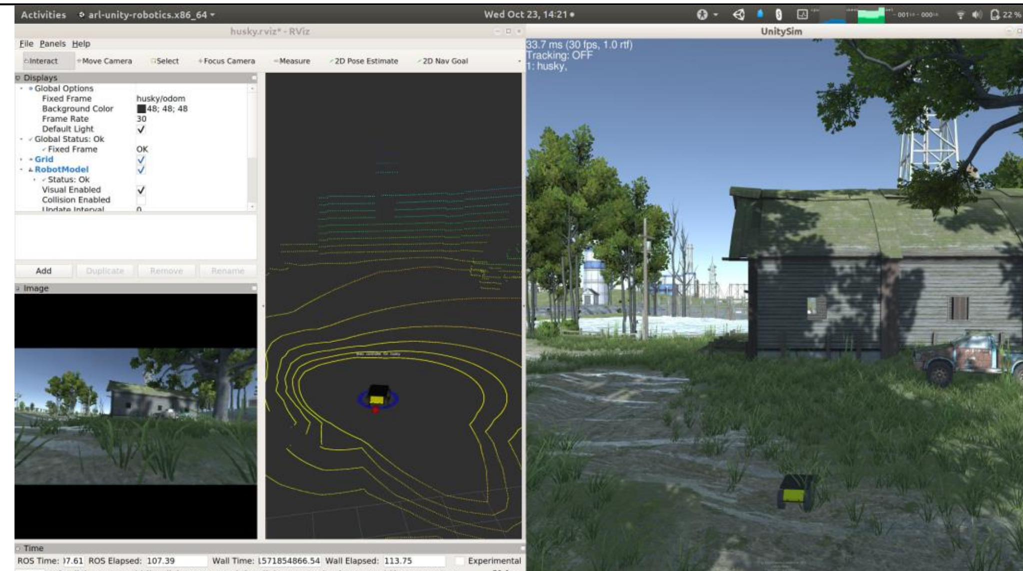
SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Topics of Interest for Sprint sub-topic area #3 include but are not limited to:

- Software to support multi-agent field experimentation to include management of execution, runtime monitoring, configuration, and version-control and validation of emergency stop functionality and other safety measures.
- Software and experiment infrastructures that support these challenges and provide real-time experiment monitoring are of interest.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

DEVCOM ARMY RESEARCH LABORATORY



ARL Simulation Testbed(s):

- Unity-based simulation
- Lightweight wrapper to ROS (send sensor data, receive actuation commands, spawn models in simulation)
- Relies on Unity physics (NVIDIA PhysX)
- Sensors:
  - RGB Cameras
  - Depth Cameras
  - 3D LIDAR
  - IMU
  - Wheel speed/torque
- Platforms:
  - Generic Quadrotor
  - Clearpath Husky
  - Clearpath Warthog
- Multiple environments available
- Performers will be given access to ARL's simulation environment.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Proposal Intent:

- Funding will be provided to selected Recipients under a cooperative agreement (CA). For the first cycle the period of performance will be nine months.
- 1st year CA awards are described as the “seedling” project.
- 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 $3M is expected for all proposals to be awarded, not per proposal.
- Proposals can address one or more of the sub-topics within this special notice.
- Proposals should address one or more, but need not address all, of the areas of interest identified within each sub-topic within this special notice.
- ARL reserves the right to negotiate with an Applicant to re-scope their 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.
- While sub-topic #1 is a priority, subtopics 2-3 are of high interest and ARL reserves the right to adjust the balance of research across the three sub-topics based on merit of proposals received and potential impact to the overall program and advancing the state-of-the-art.

UNCLASSIFIED//Approved for Public Release

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

- The Recipients of a “seedling” CA are then eligible for consideration of a single optional extension of up to 3 years at the conclusion of the “seedling” project.
- Proposals should also include descriptions for optional extensions of their proposed seedling effort for consideration in the optional period of performance.
- The success of this multidisciplinary effort will require meaningful collaborative partnerships between government, academia, and industry to advance the science. Proposals should address their intellectual property (IP) approach and how their approach will foster collaboration with ARL and other SARA Recipients, and how their solution will further advance the state-of-art of open source or ARL/government owned autonomy solutions.
- Proposals that include innovation in open architecture hardware design, selection and algorithm implementation leading to significant decreases in size, weight, power and cost will be a priority. 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 software stack.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

Chapter 1: Technical Component.

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

Chapter 2: Optional Technical Component.

- 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.

Proposals are due in grants.gov by 3:00pm (local time in North Carolina, USA) on 14 February 2020.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

APPLICATION REVIEW / EVALUATION INFORMATION

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 SARA-relevant scientific topics, and the expected outcomes based on the timeline of execution. The scientific merit will be evaluated with regard to the specific research areas (e.g., a topic of interest within a sub-topic) to be addressed in this annual Funding Opportunity. Evaluation of this factor will also concentrate on the long-term relevance of the proposed research and the likelihood that the proposed research will address scientific challenges and research barriers facing the Army and commercial sectors.

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. Evaluation of this factor will include evidence of previous successful collaborative efforts, plans for participation at the SARA Bi-annual Experimental Events, the Applicant's commitment and plans for collaboration within the program and the synergistic value of the collaborations among researchers and government scientists, as well as approaches to data/coding/model sharing and transition of products that create collaborative potential amongst government, academic, and industry partners.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

APPLICATION REVIEW / EVALUATION INFORMATION

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. Key personnel are expected to be substantially and meaningfully engaged in the research and the proposed level of effort for key personnel reflected in the proposal should be commensurate with and demonstrate such engagement. The extent to which the Applicant's proposed facilities and equipment will contribute to the accomplishment of the proposed research will be evaluated, including the nature, quality, relevance, availability, and access to state-of-the-art research facilities and equipment.

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. These adjustments will consider the task undertaken and approach proposed. These adjustments may include upward or downward adjustments to proposed labor hours, labor rates, quantity of materials, price of materials, overhead rates and G&A, etc.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

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 the Funding Opportunity that 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 #1, the decision to exercise option periods of any seedling awards remains at the discretion of the Government.

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

- Nothing in this presentation or discussed during the webinar supercedes the FOA for purposes of proposal preparation.
- Any changes to the FOA will be issued as amendments.
- Please continue to monitor grants.gov
- Any additional questions can be submitted through the SARA website https://www.arl.army.mil/sara/sara-questions-answers/
- Last day for questions 31 January 2020

SCALABLE, ADAPTIVE, AND RESILIENT AUTONOMY (SARA)

DEVCOM ARMY RESEARCH LABORATORY

Questions?

UNCLASSIFIED//Approved for Public Release