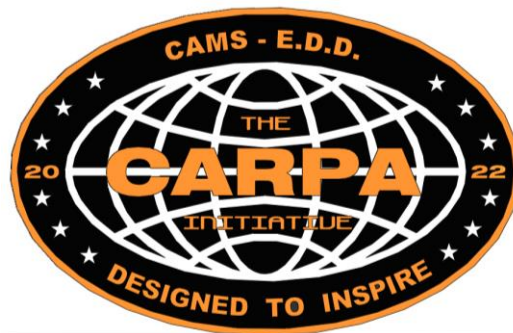


Design Brief  
Request for Proposal  
**2022 CARPA Initiative**

**The Fox and the Hound**

Distributed Autonomous Robotic System  
HeistBOT



J.E. Carpenter  
The CARPA Initiative  
EDD – Periods 3 and 5  
10/25/21

# Proprietary Information

## Executive Summary

The Fox and the Hound Design Challenge is an exercise in stealth and highly ambulatory robotic design. The purpose of the challenge is to design, build and test a semi-autonomous stealthy robotic device, capable of negotiating uneven terrains, running and jumping, in order to complete an obstacle course within timed parameters. Additionally, the two teams will be engaged in a mission challenge, where one team role plays the “fox”, with the intention of using the device to investigate enemy positions and strongholds, retrieve an artifact of importance from the enemy encampment, and escape, evading detection from the opposing team. The other team will role play the “hound”, where the robot must maintain the security of the encampment, and prevent the fox from completing its mission, or to hunt down the fox, terminate its function, and retrieve the captured artifact, returning it to its original location. Each team in turn, will alternate their machines role in the game.

(All future revisions to this document will be highlighted in yellow).

## The Fox/Hound Quadrupedal Mechanisms

The device must be designed with a cylindrically shaped “body” with four legs and uniform interfaces that allow for the transfer of mechanical forces and moments, electrical power and communication throughout the devices.

Requirements of the DARS vessel are hereby defined, but not limited to the following design parameters:

- Each device not to dimensionally exceed 300mm wide, 400mm tall, 600 mm long.
- Each device may not weigh more than 12 Kg.
- The Fox is meant to operate in a covert fashion, therefore, the device must be camouflaged to robotic vision.
- Each device is required to crouch down to a minimum of 300mm tall, and must be able to walk in that state, to be able to enter a 300 x 300mm doorway.
- Each device must be able to run at a speed of 1m/sec.
- Each device must be able to leap over an obstacle that is 150mm in diameter.
- The device(s) must be water resistant.
- The device(s) must be capable of self-righting, in the event it tips over.
- The device(s) must be able to distinguish specified targets in the mission theater.

- Each device must be fitted with end effectors that can pick up, transport, and put down a raw chicken egg, without damaging it (size between medium and jumbo). The end effectors must each have a minimum of three phalanges, complete with interphalangeal joints, in order to pick up and cradle the egg.
- The device must be fitted with a magnetic relay switch that will terminate power to the device, should an external magnet come close enough to the switch. The magnetic relay needs to be mounted at the rear of the vehicle, accessible to the pursuing device.
- Operating time for each device: 1.5 – 2.5 hr. on one charge.
- Batteries must be easily removed and replaced.
- External interfaces to include: battery charging port, 2x USB, 1x HDMI, 1x Ethernet.

### **Mission Constraints – Prohibited Technology**

- Electro Magnetic Pulse (EMP)
- High Voltage Discharge
- Microwave Discharge
- Liquids (oil, water, corrosives)
- Open Combustion (fire, explosives)
- Untethered Projectiles
- Smothering/Entrapment
- Signal Jamming
- Lasers above 1mW
- Wheels
- Flight

## **Project Deliverables**

### **Soft Deliverables**

#### **Company Formation/Organization –**

Students will be organized into teams for this effort. Student teams will be organized into “companies”, with designated tasks, in order to complete the project.

Companies will devise company trademark symbols, to include a name, logos, company letterhead, badges, drawing format sheets and any other identity protocol.

All assignments and deliverables must be on company letterhead. Designated officers shall include, but not be limited to: Project Manager (PM), Deputy Project Manager (DPM), Chief Scientist, Chief Programmer, Chief Financial Officer, Systems Engineer, Test Engineer, Lead Electrical, Mechanical, and Design Engineers, Drive and Articulation Specialties, Media Specialists, Risk Management Officers, Manufacturing and Production disciplines, Mechanical and Electrical Technicians, and Packaging.

#### **Critical Design Reviews/Team Member Participation**

There will be (5) Critical Design Review (CDR) periods, where the major deliverables will be graded. There will be a designated winning team for each CDR. The team that amasses the most points during the CDRs will be awarded the “contract” and determined to be the overall winner for the 2022 CARPA Initiative Design Challenge. The five CDRs are: 1) SPS Proposal Document and Presentation in front of a distinguished panel of judges, 2) Proof of Concept (POC) Document and prototype/benchmark demonstration in front of a distinguished panel of judges, 3) First Article/Technical Data Package (TDP), 4) Mission Theater Demonstration, 5) Product Showcase/Open House. Three of the CDRs (1,2,5) will require oral presentations. Company Teams are expected to dress in a business professional manner for all presentations. All team members are expected to participate in all oral presentations, speaking to their particular/assigned expertise. All students will be assessed a “participation effort” for each CDR, which will be used as a multiplier against the total numbers of points earned for each CDR, thereby formulating the individual team member grades. For example, if a team member is assessed a participation value of 70% effort and a CDR is worth 200 points, the individual member would receive 140 points for their effort toward that particular CDR. There will be no “blanket” team grades. Participation is very important towards a team member’s grade. Participation values shall be determined solely by the instructor. Input shall be provided by the Project Managers for each team, in regard to team member participation during off campus gatherings. The Industry Partners and attendees of the first two oral presentations will have input to the grading scheme.

## **Tentative Dates for the five CDRs:**

**CDR #1 System Performance Specification and Presentation – 12/08/2021**

**CDR #2 – Proof of Concept and Presentation/Demonstration – 02/02/2022**

**CDR #3 – First Article/TDP/Test Requirements – 04/27/2022**

**CDR #4 – Mission Performance Date – 05/25/2022 - 06/01/2022**

**CDR #5 – EDD Expo/Documentary Film/Presentation – 06/02/2022**

**Additional due dates are found within the document.**

**Proposal Document** - Company teams shall provide a Systems Performance Specifications (SPS), or “Proposal” document, in response to the CARPA Request for Proposal (RFP). The SPS will outline the company’s proposed solution to the challenge, and all of the work that will be performed to complete the mission. The SPS shall include: a title page, index, mission overview, an executive summary, company organization chart, job descriptions, engagement management procedures, approach, scope of the work performed, risks and assumptions, year-long schedule, itemized budget and an approval section. The SPS will be reviewed by the customer and will either be approved or rejected. In the case of a rejection, the company will have an opportunity to provide a revised document. The SPS effort shall also include a PowerPoint Presentation, to be presented in a closed setting to the customer and a panel of professional people. This is CDR #1, and is due by the first grading period, date to be 12/08/2022, as scheduled.

**Engineering Notebook** – Every Team Member is responsible for contributing to and maintaining the content of the Engineering Notebook (ENB), for the life of the Project. The Chief Scientist will coordinate the ENB for the project. Publications will be in charge of publication of the book. Notebooks shall follow the ENB protocol, outlined in IED.

**Team Portfolio** – Both teams shall submit a project portfolio to extend for the life of the project, in the form of a digital video documentary (Due CDR 5). Portfolios will become part of the Trade Expo exhibit. Documentaries are the property of the CARPA Authority and may not be published without CARPA approval. All media will be provided by the end of the school year. The video documentary is expected to be 10 minutes in length and must encompass all aspects of the design solution and student experience. A 2-3 minute “infomercial” video showcasing the project/product is due for the proposal presentation (CDR 1).

**Work Breakout Structure Diagram** - Company Management shall provide a Work Breakout Structure diagram, subject to review, showing the perceived tasks, and assigned personnel. Techniques for developing the WBS will be discussed in class. **(Due by CDR 1).**

**Schedule** – Company Management shall provide an updated schedule (in MS-Project format), *once a month* to the Customer. The schedule shall include a legend of the symbology used (CDR 1).

**Budget** – Company Management shall provide an itemized, updated budget once a month to the Customer. The budget is the responsibility of the Chief Financial Officer (CFO). **Due (CDR 1).**

**Proof of Concept (POC)** – Company teams shall provide a Proof-of-Concept presentation and demonstration, showing the ability to communicate, download and execute a software program/command; demonstrate the modular design, and articulation of multiple configurations. The Proof of Concept will be performed for the customer in a closed setting. A PowerPoint presentation and appropriate documentation is required. Digital models may be used in lieu of actual hardware, provided that it can be demonstrated to be easily provided in the build and test phase. If the two teams cannot demonstrate a command of the required technology for the project, the class will revert to the standard PLTW EDD curriculum for the spring semester.

**Technical Data Package (TDP)** – Companies shall provide a complete technical data package, on company formatted sheets, to include all assembly, fabrication, altered item, and source control drawings for all hardware provided. Drawings shall be prepared in accordance with (IAW) ASME-Y14.100.M. Dimensioning and tolerancing shall be IAW ASME-Y14.5M-2009 or later. Drawings to be Level II (best commercial practice). Documents to be made available to the teams.

**Test Schedule and Procedures** – Company shall provide a test schedule and test procedures for the system, subject to customer review. Test procedures will be introduced in the SPS document and then updated for the POC document/prototype. All environmental test specifications to be per MIL-STD-810.

**Computer Program** – Company shall provide copies of all computer programs used by the robotic mechanisms, on some form of removable media, preferably a flash memory device, that can be easily readable by the customer. Companies must also provide a text copy of the software used, as well.

**User Manual** – Company teams shall provide a comprehensive user manual to show an end-user how to use the developed technology (Due CDR 4).

**Professional Input/Survey** – Companies shall conduct consumer surveys and solicit input from industry, to devise and develop a series of most desired tasks for the quadrupedal adaptive vehicle/device. From these surveys, the company teams shall derive a Product Specification Document (to be included in the company portfolio), subject to approval by the customer (Due CDR 1).

**Engineering Management Protocol** – Company teams shall hold periodic meetings in the form of In Process Review (IPR), and Periodic Process Review (PDR) meetings. IPRs should be held weekly within the “company”; PDRs shall be conducted with the Customer on a monthly basis. The Critical Design Review (CDR) represents major grading periods, and will be conducted by the customer. It is the responsibility of the company teams to schedule and conduct In Process Review (IPR) and Periodic Design Review (PDR) meetings. The IPRs should not last longer than 10 mins.

**Mission Performance** – The graded completion for the StealthBOT Project will consist of a performance demonstration of the completed tasks. This will occur in a controlled environment during CDR 4. Any special interfaces required for the demonstration must be approved and will be provided by the customer. The winner of the competition will be the team, who scores the most points on the scoring rubric. Teams will also be graded on simplicity of operation, as well as the design of the system.

**Participation** – Each student will be graded on his/her participation on the project. The student may or may not be made aware by the instructor, when this grade is being recorded. For each CDR, PMs will provide “employee” assessments, during week-end, or extra-class meetings/workdays. The PM is **not** responsible for the assigned participation grade. That responsibility rests **solely** with the instructor. The perceived percentage of effort for each student on a task will be multiplied against his/her participation effort for that particular CDR/grading period. Once each semester, the team will have an opportunity to provide input as to the performance of the administrative personnel.

**Open House/EDD Expo** – Company teams shall perform all or part of the mission scenario in front of a live audience, to include CARPA Alumni, teachers and industry professionals during the EDD Expo/Open House (CDR 5). Company teams are responsible for providing a presentation to the audience, and for setting up a “trade show booth”, to display their solutions to the invitees. The Documentary is expected to be completed by that date and shown during the exposition, during Open House.

**Due: June 02, 2022**

## **Hardware Deliverables**

**The Fox/Hound Robotic Device** – Student teams will collaborate on the design and build of a quadrupedal robotic device, capable of traversing over or through its intended environment, which may include but not be limited to: sod, dirt, rocky grade, sand, water, gravel, carpeting, linoleum, concrete, asphalt, raised obstacles or trenches.

The device must have built in interfaces/sensors to collect empirical environmental data. The device is expected to be equipped with stereoscopic robotic vision, which can also provide a live video feed of the robots' environment. The Fox must exhibit the ability to run at a speed of 1m/sec, and be able to jump over a 152mm cylindrical obstacle. The device must be able to right itself, in the case of a fall. The device must be able to crouch down to walk through a 300mm x 400mm rectangular opening. The device must be able to recognize, pick up, and transport a standard sized chicken egg, and deliver it to a pre-specified location, without damaging it. The device must be no taller than 400mm, no wider than 300mm, and no longer than 600mm. It must not weigh more than 12 Kg., or exceed a volume of 72,000 cubic cm. (subject to penalty). The device must carry a rechargeable battery as a power source which includes a port which would allow for the recharging of the system with conventional electrical source. The device must have a run time between 1.5 – 2.0 hours. The device must have (in the rear) a 25 mm disc, which conceals a magnetic relay that will interrupt power to the device, should a strong magnet be placed near it, effectively terminating the device. The device may be camouflaged to detection by the opposing device, and may deploy countermeasures to evade capture. **Due date: 05/25/2022.**

**Packaging** – Student teams will devise an easily transportable packaging system for their robotic device, which will protect the device during transport. This could simply be a secure strap, to easily transport the device. **Due date: 05/25/2022.**

**Accessory Components** – The student teams will provide any “accessory” components required for the device to perform its function during CDR 5. Any component or accessory which attaches to the device during the execution of a designated task must be provided by the team.

**Due date: 05/25/2022.**



## The Mission

Both Avenir Innovations and Vesta Technologies have been tasked with the design, build and demonstration of a semi-autonomous stealthy robotic device, capable of negotiating uneven terrains, running and jumping, in order to complete an obstacle course, within timed parameters. The robotic system will be comprised of two ambulatory robotic devices, each playing a specific role during the mission competition. One machine will play the role of the “Fox”, a “heist” robot which must locate, retrieve and escape with an artifact of great value, and other will play the role of the “Hound”, a predatory pursuit robot, designed to secure the mission theater, and to pursue and terminate the function of the Fox HeistBOT, retrieving and returning the stolen artifact to its original location, without damaging it.

The other team will play the role of the “Hound”, where the robot must maintain the security of the encampment, and prevent the fox from completing its mission, or to hunt down the robotic “fox”, terminate its function, and retrieve the captured artifact, returning it to its original location. Each team will in turn, assume both roles, during the mission challenge.

## Parameters/Requirements

- 1.0** - Each team will enter the mission theater simultaneously, from opposite entry points. The Hound device must be any closer than 22'-0" to the “henhouse” when the fox enters the henhouse, and may only begin the pursuit, when the fox device is clear from the opening, upon exit from the henhouse. The Hound may not block the door, not interfere with the fox, while it is inside the henhouse.
- 2.0** – Empirical data must be collected, concerning the environment of the encampment inside the mission theater.
- 3.0** – The robotic devices can weigh no more than 12Kg., nor be longer than 600 mm, wider than 300mm, or taller than 400mm, nor violate a volume of 72,000 cubic cm, without penalty. The penalty assessed will be based on the percentage of overage. If the device is 10% over its target weight, then a penalty of 10% will be assessed against the device. Neither robot may have on-board weaponry, but the fox may employ the use of countermeasures, to evade capture.
- 4.0** – No kit parts (VEX, FRC, AndyMark, etc.) may be used, with the exception of gears and motors, without prior CARPA approval.
- 5.0** – GFE (Government Furnished Equipment) may be provided by CARPA for the project. Said equipment is not “disposable” and must either remain as part of the design build, or be returned in the state in which it was provided. Any GFE that is checked out, but not used during the mission scenario must be returned/replaced

by the team it was issued to.

- 6.0** – Both teams are limited to an initial budget of \$3000.00. Any additional use of funds must be approved by the CARPA Authority. Any fundraisers or project grants, must be procured according to the ASB rules of club conduct.
- 7.0** - The HeistBOT device must be able to enter the mission theater and subsequent “henhouse”, but must not disable, destroy, or otherwise interfere with the encampment features in any way.
- 8.0** – HeistBOT must be designed to be an autonomous robotic device. If the robot must be “manually driven”, then it must be by wireless commands.
- 9.0** – Both HeistBOT devices must complete an obstacle course, within three days of the scheduled competition in order to compete in the mission challenge.

**Due: 05/25/2022**

**The CARPA Initiative has commissioned the build of the two robotic devices, so *all* parts and *all* associated components, software, and developed technology, are the property of The CARPA Initiative, to be used at its discretion, at the end of the year.**

### **Approvals**

Rules, Conditions, and Requirements are subject to change by the CARPA authority. All changes will be discussed in class, and be presented to the company teams in writing.

## Approvals

---

Project Manager – Red Team

Date

---

Project Manager – Blue Team

Date

---

Chief Scientist – Red Team

Date

---

Chief Scientist – Blue Team

Date

---

CARPA Authority

Date

