Requirements Specification Document

The SATIRE System

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1 Project Drivers

1.1 Purpose of Project

The purpose of this project is to develop a new class of Autonomous Underwater Vehicles with supporting marine technology; to effectively, unobtrusively and reliably monitor harbor and coastal areas in order to detect ships, coastal threats, and coastal zone changes. Multiple vehicles that communicate and act together will collectively work towards a desired goal whether for monitoring or to take some form of action. The scope is to develop and test the interaction of multiple AUVs and associated instrumentation to better characterize, observe and monitor the marine environment. The end product of the project will be a fully automated, collection, multi-beam sonar / side-scan sonar / sub-bottom profiler) and sampling (for example, turbidity, temperature, salinity, dissolved oxygen, radioactivity, hydrocarbons, etc.) tools.

This new class of AUV will incorporate various automated sampling devices, instrumentation, and control algorithms allowing them to perform autonomous pre-programmed surveys and sampling. Research at Florida Institute of Technology's Underwater Technology Laboratory is currently underway to implement a unified approach to developing autonomous devices that can remain underwater, navigate coastal regions, collect data, and selectively search for specific physical and chemical spects observed in the coastal environment using neural networks in conjunction with distributed neurons embedded in sensor systems. The three areas currently being investigated are: data classification/reduction, pattern recognition and analysis, and navigation. In addition, neural nets are being investigated using multi-sense analytical data from sensors to be employed as an active component in the navigation scheme. This approach allows the vehicles and sensing systems to use chemical, physical, or biological inputs from the environment to determine the behavior of the vehicle as opposed to or in concert with conventional navigational approaches. The system selectively searches for, discovers, collects information on, and analyzes any undersea "area of interest." Research is also currently underway to develop new collaboration and network communication methods allowing multiple AUVs to work together on a specific task, whether it is a survey or an intervention task. Additionally, through the interaction between the vehicles, the positioning relationship with respect to each vehicle and the general positioning of all vehicles is being researched.

The AUVs will operate autonomously and will periodically transmit, via satellite, pertinent information obtained during its mission via a communications module that ascends and descends to the surface and back to the ocean floor. The AUVs will be capable of being launched from helicopters, ships or from land (i.e., harbors, estuaries) regardless of weather conditions. When multiple AUVs are deployed, each vehicle will communicate with its neighbors to obtain group knowledge of the phenomenon under investigation and this group knowledge will guide future movements and search methods of the vehicles.

1.2 Client, Customer and other Stakeholders

The client for the SATIRE system is Dr. Wood from the Ocean Engineering and Sciences department. This is intended as a two year project, this being the first year. The expected outcome is to develop a prototype of the AUV with basic functionality. This will then be expanded upon by adding the additional suite of sensors, data collection and transmission abilities. The project was proposed by Dr. wood and is intended a means to monitor the safety of harbors and estuaries. The project has received grant funds from the Paul B. Hunter and Constance D. Hunter Foundation. The grant is open ended resulting in $10,000 last year and will be reapplied for again this year.

1.3 Users of the Product

This product is mostly intended for military use but also has other applications and needs for a Clandestine Littoral Node that include environmental sensors complemented by communication links between multiple vehicles and natural history collections. It will provide a baseline against which to measure environmental boundaries and/or changes. This product could be used for observations with information regarding national security, fisheries, or fundamental water related research:

> Military systems require increasingly sophisticated and timely inputs of ocean data to ensure safety of the fleet, optimize performance and precision, and avoid damage to non-military targets. A robust ocean observation system is vital to the success of naval operations.
>
> Tracking of marine ecosystems would show the effects of human activities: (1) increases in the volume of oxygen-depleted bottom water, harmful algal blooms, fish kills, and the incidence of disease in marine organisms; (2) declines in biodiversity and living marine resources; and (3) “successful” invasions of nonindigenous species. Fishing is a multi-billion dollar industry with important impacts on many other economic sectors, and long-term records of fish catch show that fish population and habits change in response to the effects of human activities and environmental conditions.

There are many needs for a underwater AUV that include environmental sensors that are complemented by the ability to communicate with multiple vehicles, and provide a natural history collection to make a baseline for which could be used to measure environmental boundaries and changes.

2 Project Constraints

2.1 Mandated Constraints

2.1.1 Solution Constraints

Description: The product shall be fully autonomous
Rationale: The product is to be marketed as a Subsea Autonomous Traffic Identifying Recon Explorer.
Fit criterion: The vehicle successfully maneuvers to predetermined destination and signals the user.

Description: The code shall be energy efficient
Rationale: The product houses a finite battery with no capabilities to charge
Fit criterion: The product battery lasts X number of days/weeks

2.1.2 Off-the-Shelf Software

We will be using MOOS, which is a Cross Platform Software for Robotics Research as our base when we develop our system.

2.1.3 Anticipated Workplace Environment

The product will operate without any communication from the user; it must be ready to handle any given situation.

2.1.4 Schedule Constraints

Milestone 1: (Oct 3)

- Collecting information on hardware IO during week of September 4, 2016.
- Investigate and learn to use MOOS starting September 2, 2016.
- Create Requirement Document, start week of September 4, 2016.
- Create Design Document, start week of September 4, 2016.
- Create Test Plan

Milestone 2: (Oct 31)

- Implement, test, and demo GPS navigation controller
- Implement, test, and demo AUV dead reckoning
- Implement, test, and demo motor control

Milestone 3: (Nov 28)

- Implement, test, and demo sensory input
- Implement, test, and demo collision avoidance system
- Implement, test, and demo data transmission

2.2 Naming Conventions and Definitions

SATIRE: Subsea Autonomous Traffic Identifying Recon Explorer

AUV: Autonomous Underwater Vehicle

MOOS: Mission Oriented Operating Suite

AO: Area of Operation

3 Functional Requirements

Req. #	Description	Rationale	Originator	Fit Criterion
1.	The product shall be fully autonomous.	To be able to do all the intended work without any communication from the user.	Client	The vehicle successfully maneuvers to predetermined destination and signals the user.
2.	The code shall be energy efficient.	To be able to survive long runs without recharging the onboard batteries.	Client	Be able to last X days/weeks.
3.	Emergency System	To be able to detect and respond to emergency situations in the event the system is compromised.	Client	Be able to preserve the system and/or collected data
4.	Communicate with other similar AUVs in the AO	A network of AUVs will work together	Client	
5.	Mission Planner	To be able to plan and complete a pre-specified objective.	Client	Given a behavioral script and a GPS point of origin plan and complete the target mission
6.	World Modeler	Generate a model sufficient to navigate the AO	Client	Use MOOS IVP Helm to map the local environment

4 Non-functional Requirements

4.1 Usability Requirements

The System is intended to be autonomous in all functions. User input is intended to extremely limited to non-existent. The system will operate based on an onboard mission planner and world modeler.

4.1.1 Ease of Use Requirements

The product shall be used by people with no understanding of the MOOS program, and possible no understanding of programming in general.

Fit criterion: The hardware team shall be able to deploy the vehicle with ease.

4.1.2 Understandability and Politeness Requirements

The finished software shall hide the complex details from the eye of the user. The finished hardware shall express minimal cost to the customer/user.

4.2 Performance Requirements

4.2.1 Speed and Latency Requirements

The data analysis and management must be capable of collecting data from a suite of internal, external, and scientific sensors in real time.

4.2.2 Safety-Critical Requirements

The system must be capable of operating in an aquatic environment to a depth of 500 feet.

4.2.3 Precision or Accuracy Requirements

Data collection must be accurate and complete throughout operation. The AUV navigation systems must be capable of reaching a target location within a margin or error sufficient to guarantee all sensors will be capable of meaningful data collection in an aquatic environment.

4.2.4 Robustness or Fault-Tolerance Requirements

The system must be able to face potential damage and take appropriate action to preserve the AUV and or the data collected. The system must be capable of operation unattended in potentially hostile environments without detection. The system will have an emergency system to detect and manage faults during operation.

4.2.5 Capacity Requirements

The must have the capacity to house and manage an onboard database for the analysis and collation of collected data during missions.

4.2.6 Scalability or Extensibility Requirements

The system must be open to changes in hardware throughout the development of the AUV and after completion.

4.2.7 Longevity Requirements

The system must be able to operate for an extended period of time without human interactions. It must therefore be as efficient as possible to maximize operational time.

4.3 Operational and Environmental Requirement

4.3.1 Requirements for Interfacing with Adjacent Systems

The system is intended to potentially work in concert with multiple AUV and as such will need the capability to interface and communicate with other instances of the same system through closed communications.

4.3.2 Productization Requirements

The system must be easily shipped, modular and capable of easy interchangeability of scientific modules.

4.3.3 Maintenance Requirements

The System must be modular in design. The system must be deployable by person without expertise in engineering or computer science and operate unattended for the duration of the mission plan.

4.3.4 Adaptability Requirements

The system must be modular in design, and easy to ship, assemble and disassemble. The scientific modules must be easily interchangeable.

4.4 Security Requirements

4.4.1 Access Requirements

The system is intended for use in monitoring harbor and estuary shipping traffic for threats to national security. Access must be strictly controlled throughout operation.

4.4.2 Integrity Requirements

Data integrity must be maintained during operations, with the potential need to erase and or destroy the system in the event of compromise.

4.4.3 Privacy Requirements

All data transmissions must maintain confidentiality. Data transmissions should not be traceable to either the AUV or recipient.

4.5 Off-the-Shelf Solutions

4.5.1 Ready-Made Products

The MOOS system will be the central component of the S.A.T.I.R.E. AUV master control system.