A MOOS-based AUV for Magnetic Signature Assessment

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At MOOS-DAWG July 21, 2011

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Motivation

- Influence mines and torpedoes can be triggered by a ship's magnetic field.
- Vessel's magnetic field may be canceled or reduced using
  - Deperming (degaussing)
  - Active cancellation

Pictured:
USS RAMAGE (DDG-61) at Lambert's Point deperming facility near Norfolk, VA
(Robert J. Sitar 10-23-1995)

Motivation

Challenges:

- Optimal field cancellation requires precise measurement.
- Vessel's magnetic “signature” is unique.
- Magnetic signature changes during travel.

Motivation

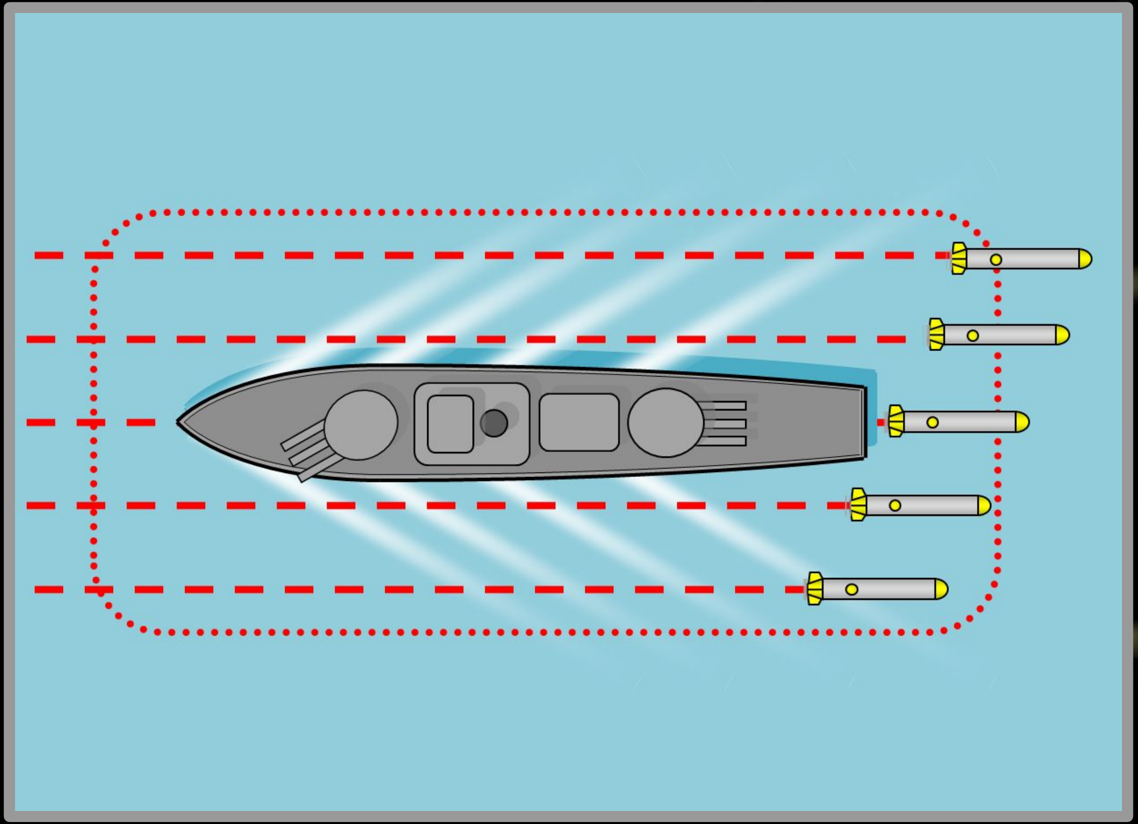
Objective:

A forward-deployable system for magnetic signature assessment

- Scalable to vessel size
- Measurement precision of 100 nT
- Measurement range of 100,000 nT

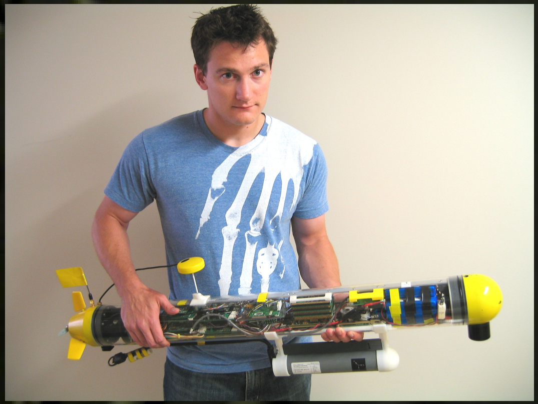
Strategy

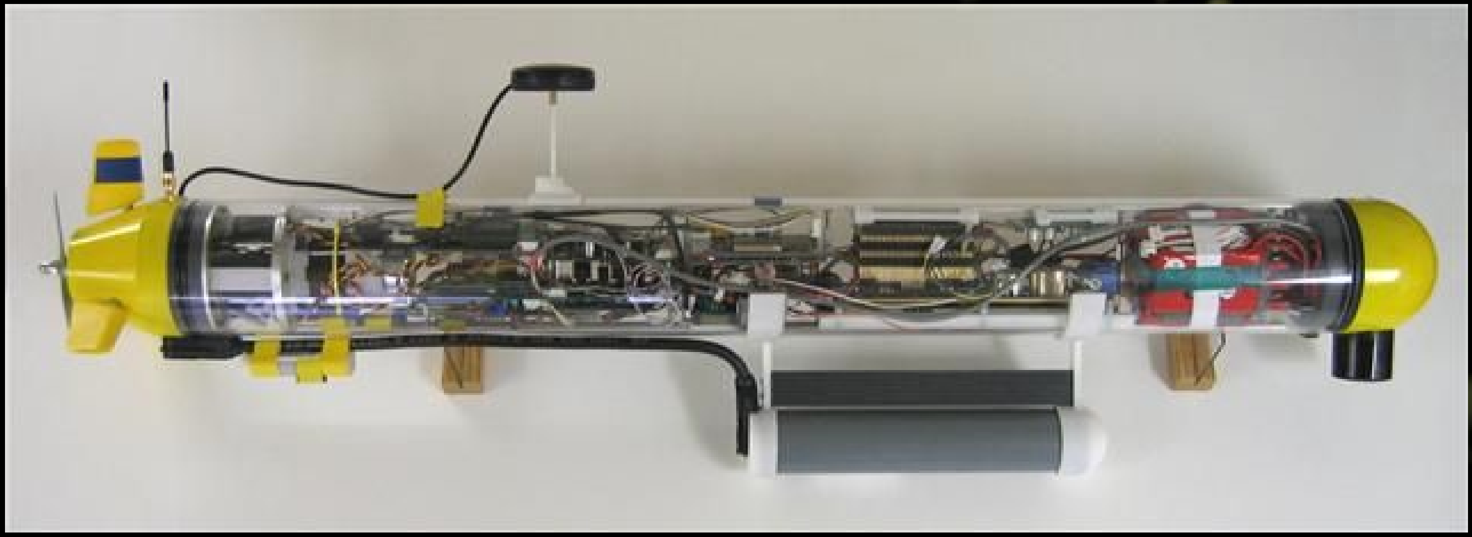
Magnetic signature measurement using multiple AUV's



U of I AUV

- Portable, deployable
- Small magnetic footprint
- Low Cost (approx. $19k USD)
- Collaborative autonomy

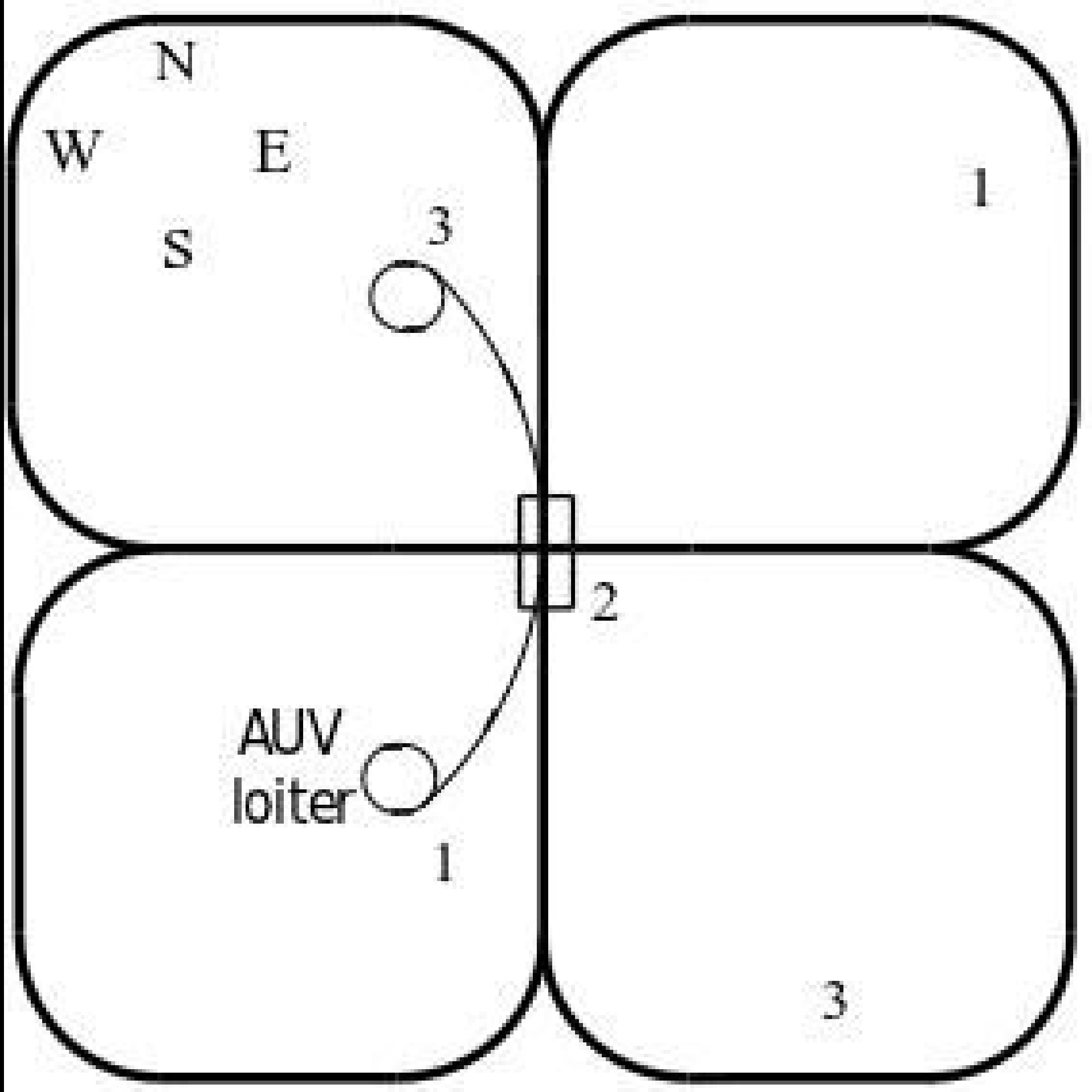




AUV Instrumentation

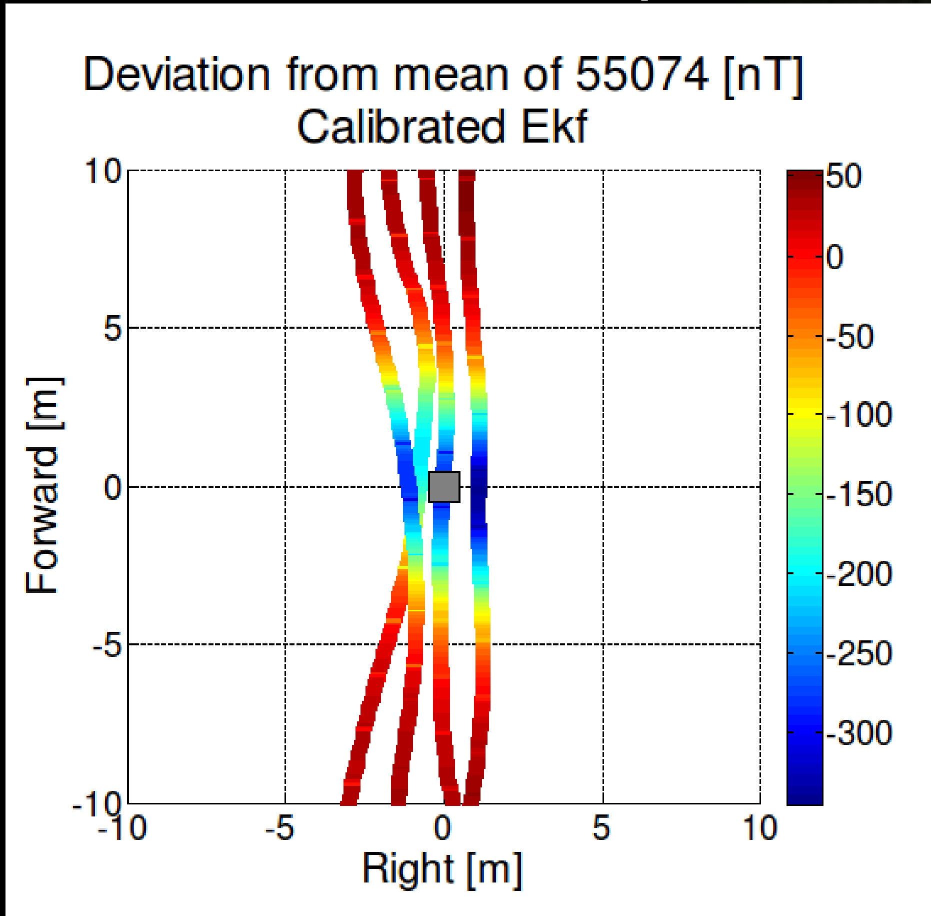
- Billingsly Aerospace triaxial fluxgate magnetometer
- 6-channel, 200 kHz data acquisition system
- Garmin GPS-18x
- Revolution digital compass
- Archangel IMU3
- 900 MHz radio modem
- WHOI Acoustic Micro-modem

AUV Measurement Pattern

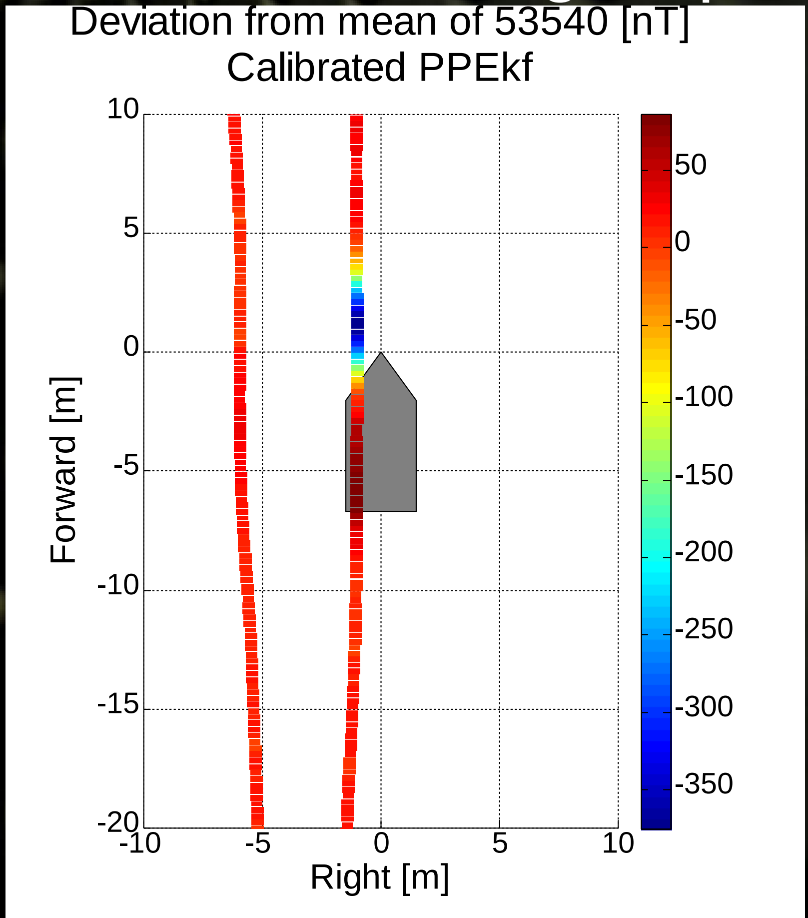


Measurement Results

Multi-AUV measurement of 448 Am^2 source anchored at fixed position



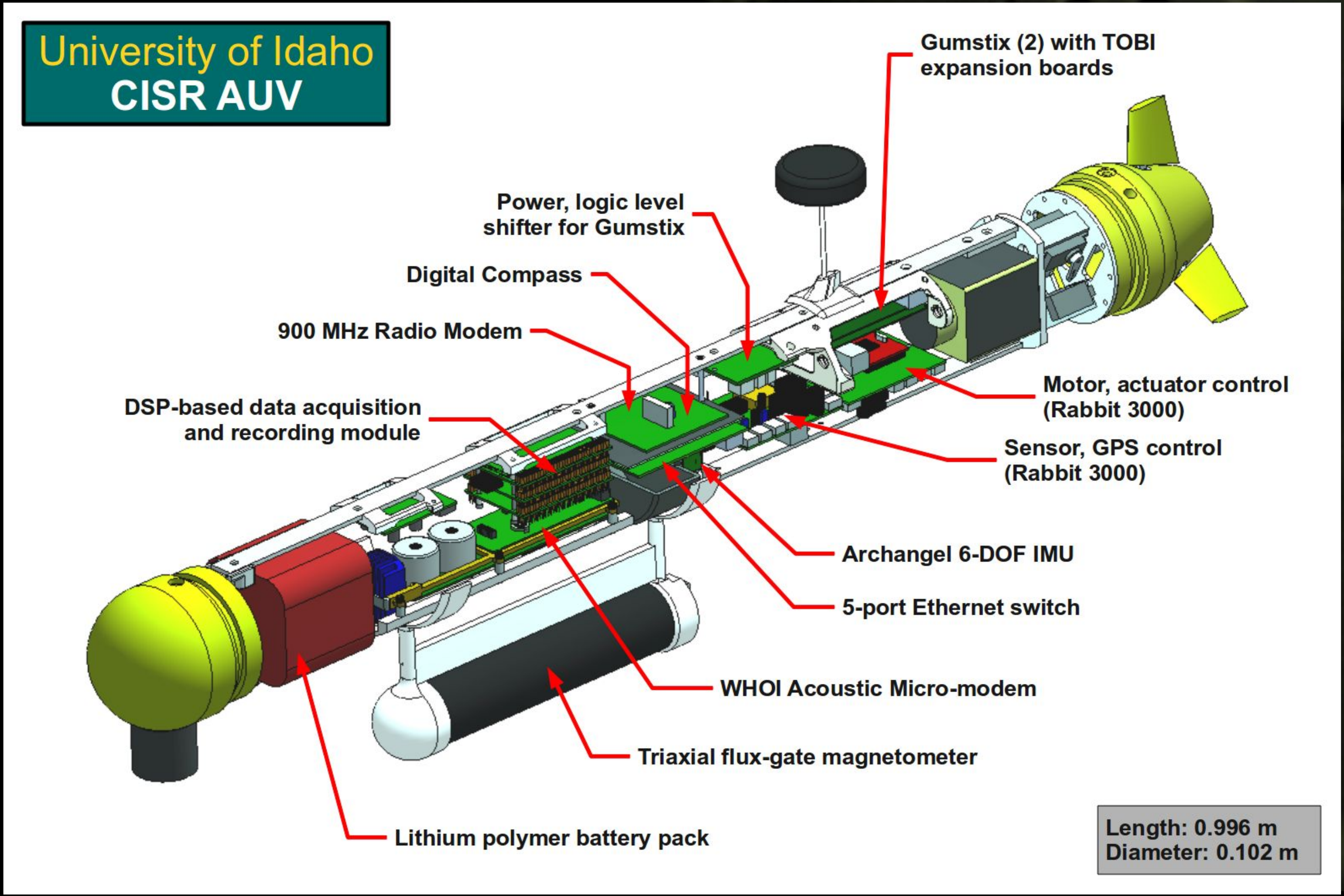
Single-AUV measurement of 135 Am^2 source attached to bow of a moving ship



MOOS-based AUV Design

- Legacy U of I AUV
- Generation 1 MOOS AUV
- Current work (Generation 2)

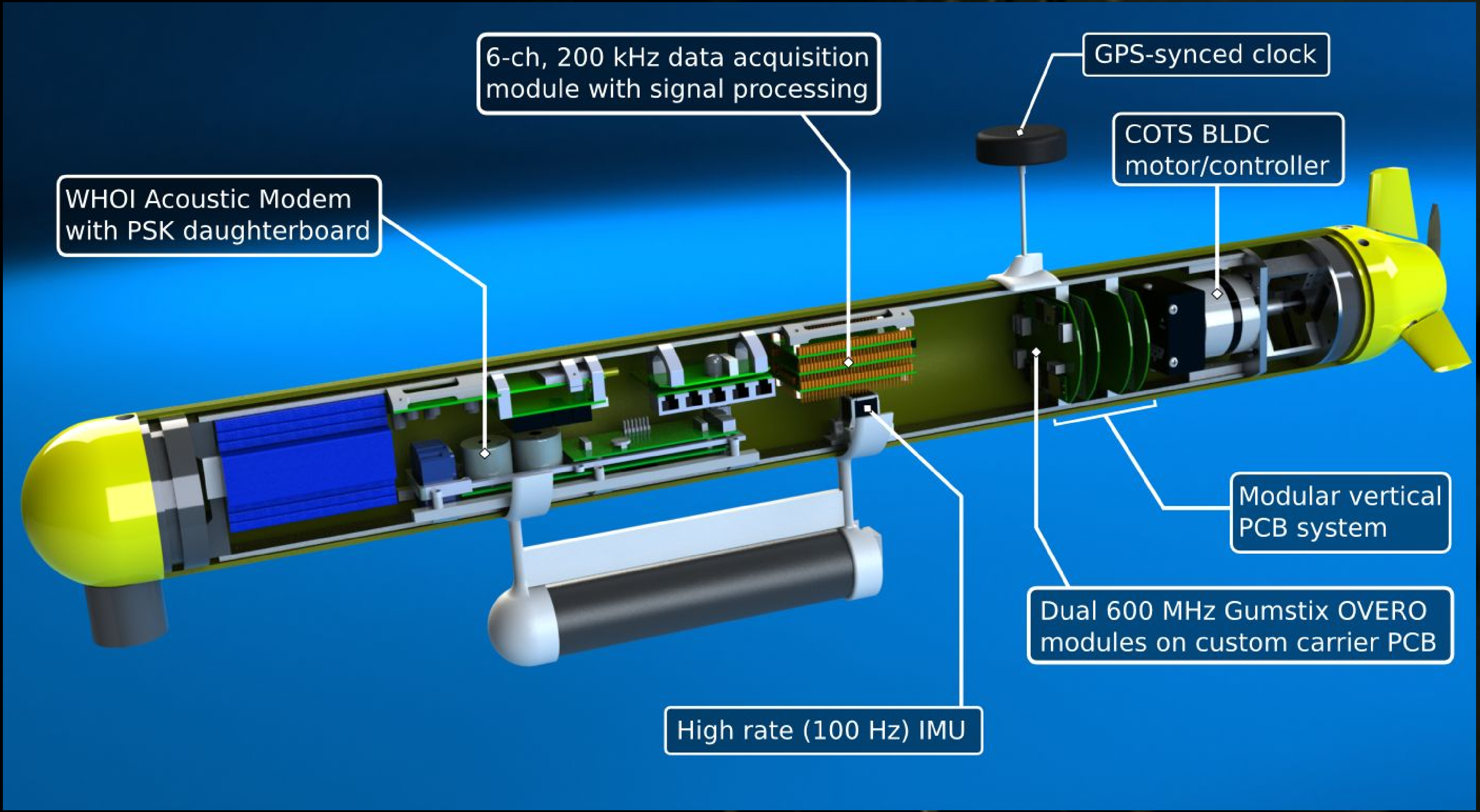
Gen.1 MOOS-based AUV



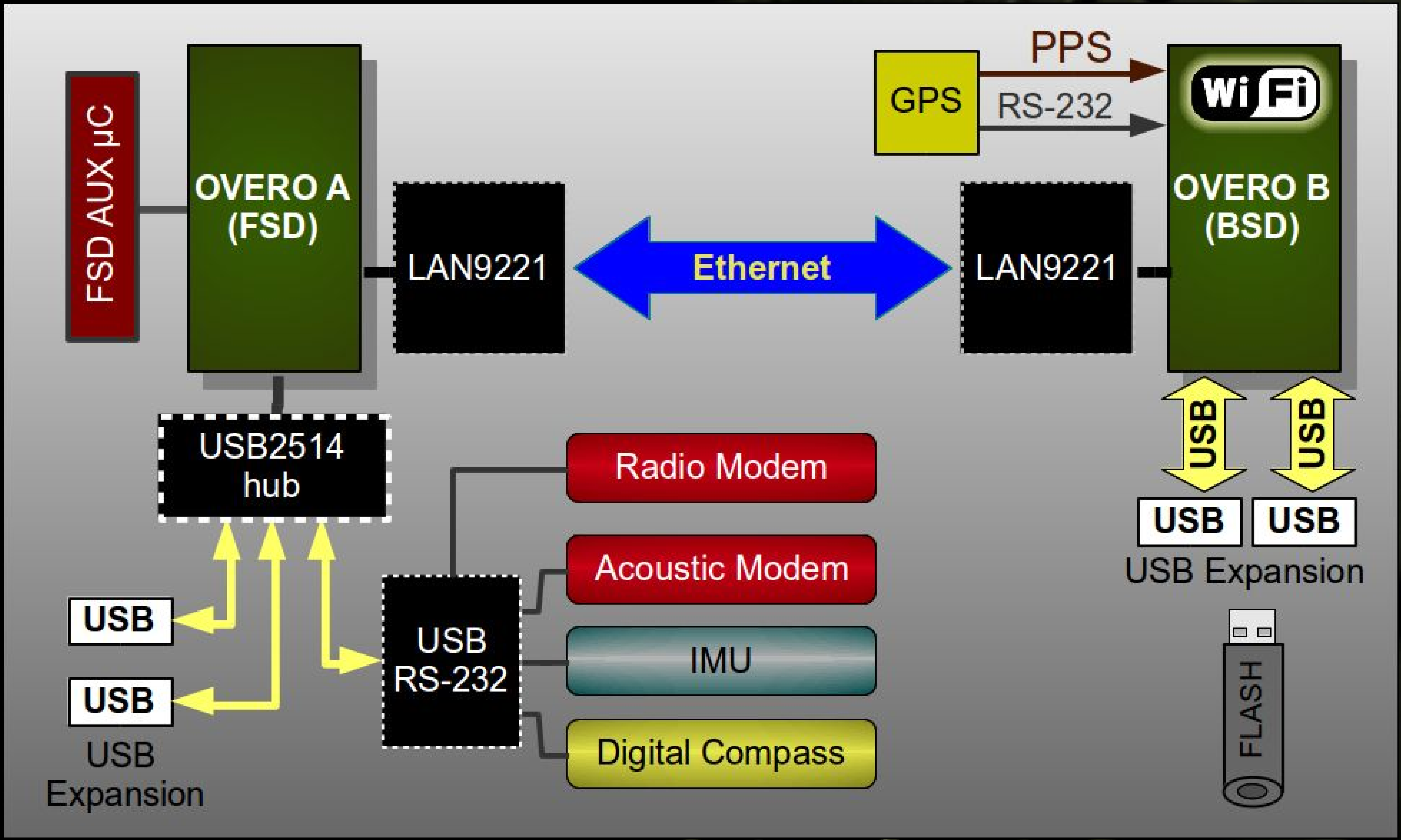
Gen.2 Design Objectives

- Reduce power consumption
- Eliminate redundancies and bottlenecks
- Hardware extensibility
- Streamlined integration

Gen.2 MOOS AUV Design



Gumstix Integration



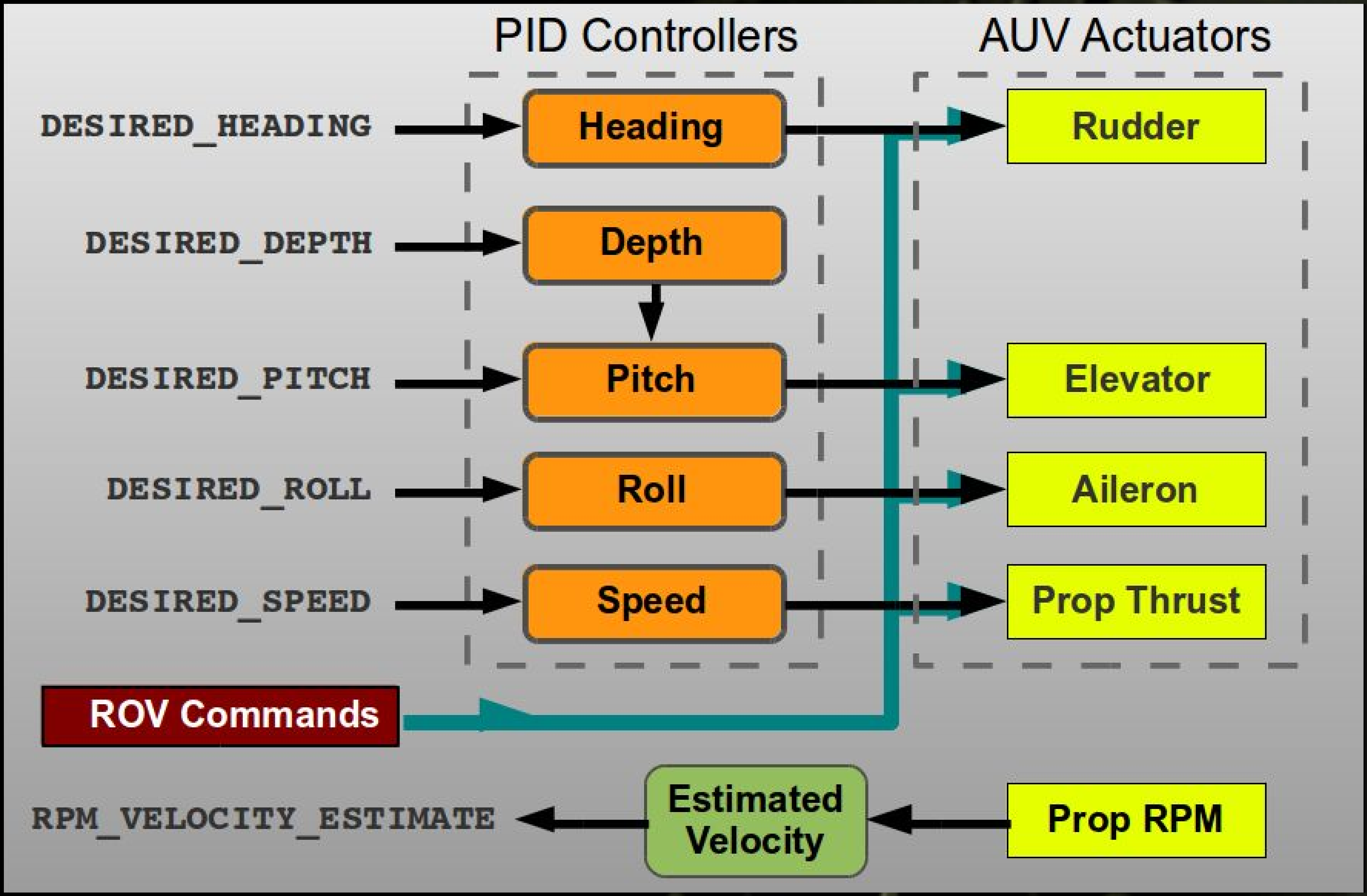
MOOS Software

- MOOS Instruments
- FSD MOOS interface
- Navigation, support applications
- IvP Behaviors

MOOS Instruments

- iArchangelIMU
- iWhoiMicroModem
- iRevolutionCompass
- iYellowSubDAQ
- iRadioModem

Front-side controller



libYellowSubNav

U of I AUV core navigation library

- EKF Base class and derived classes
  - VehicleEKF, SyncVehicleEKF
  - ShipEKF
- Acoustic Navigation classes
  - LBLPositionEstimator, LBLBeacon
- Unit tests for module verification

pVehicleEKF

Estimates current AUV position

Combines:

- GPS, compass, acoustic navigation, IMU, pressure sensor, prop RPM

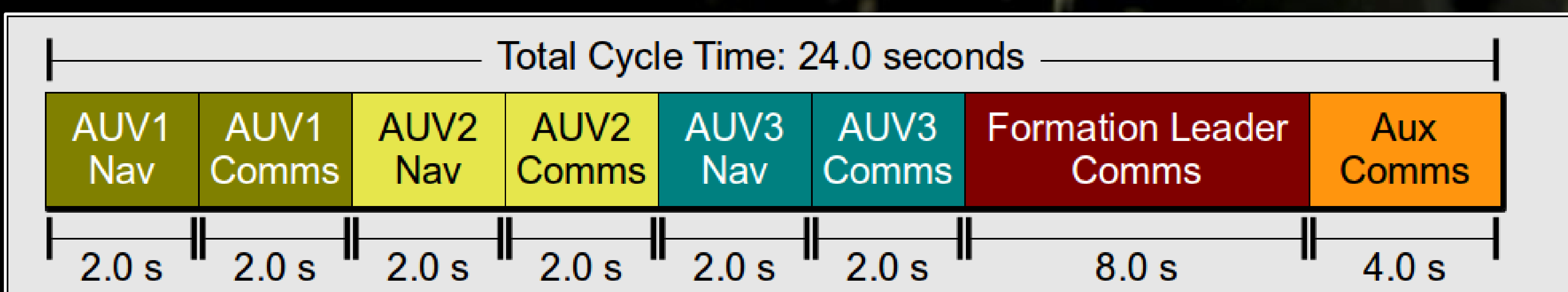
Publishes:

- Local Grid (East, North) location
- Speed
- Bias-compensated yaw

pAcousticCommsAgent

Implements acoustic TDMA control

- Utilizes GPS time synchronization of AUV's
- Text file based configuration of time slots
- Active time slot may *conditionally* publish to one (or more) MOOSDB variables
- Runtime re-configurable



pMissionMonitor

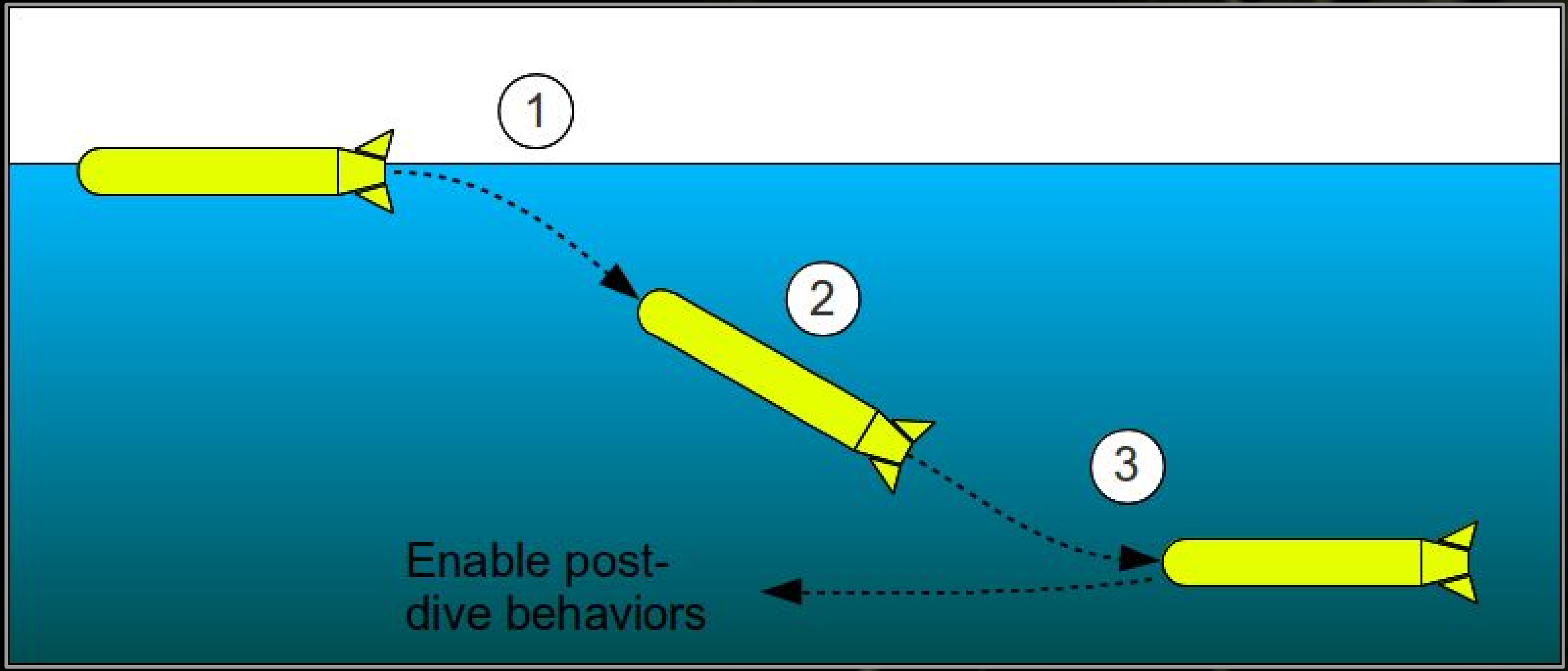
Monitors vehicle safety conditions

- Monitor target objects “enforce” logical conditions imposed on MOOSDB variables.
- If monitor conditions evaluate “FALSE”, one or more variables are published to the MOOSDB.
- Operational even when pHelmIvP is suspended
- Configuration via text file using Behavior-like syntax
- Runtime re-configurable

IvP Behaviors

BHV_ReverseDive

- Implements 3-stage sequence enabling the positively-buoyant U of I AUV to dive aft-first.



IvP Behaviors

BHV_YellowSubReBalance

- Produces objective function in speed, pitch domains
- Used when U of I AUV travels at water surface.

Acknowledgements

Office of Naval Research

Magnetic Signature Assessment System using Autonomous Underwater Vehicles (AUVs)

Phase 1 (N00014-08-1-0779)

Phase 2 (N00014-09-1-0711)

Phase 3 (N00014-10-1-0883)

Acknowledgements

“Autonomous Underwater Vehicle Navigation using Moving Baseline on a Target Ship”

Amanda Folk, Benjamin Armstrong, Eric Wolbrecht, Håvard Fjær Grip, Michael Anderson, and Dean Edwards

Proceedings, IEEE OCEANS 2010 Seattle, WA

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