



SCALING UUV SOFTWARE – DS_ROS, SIMULATION, AND CODE RE-USE

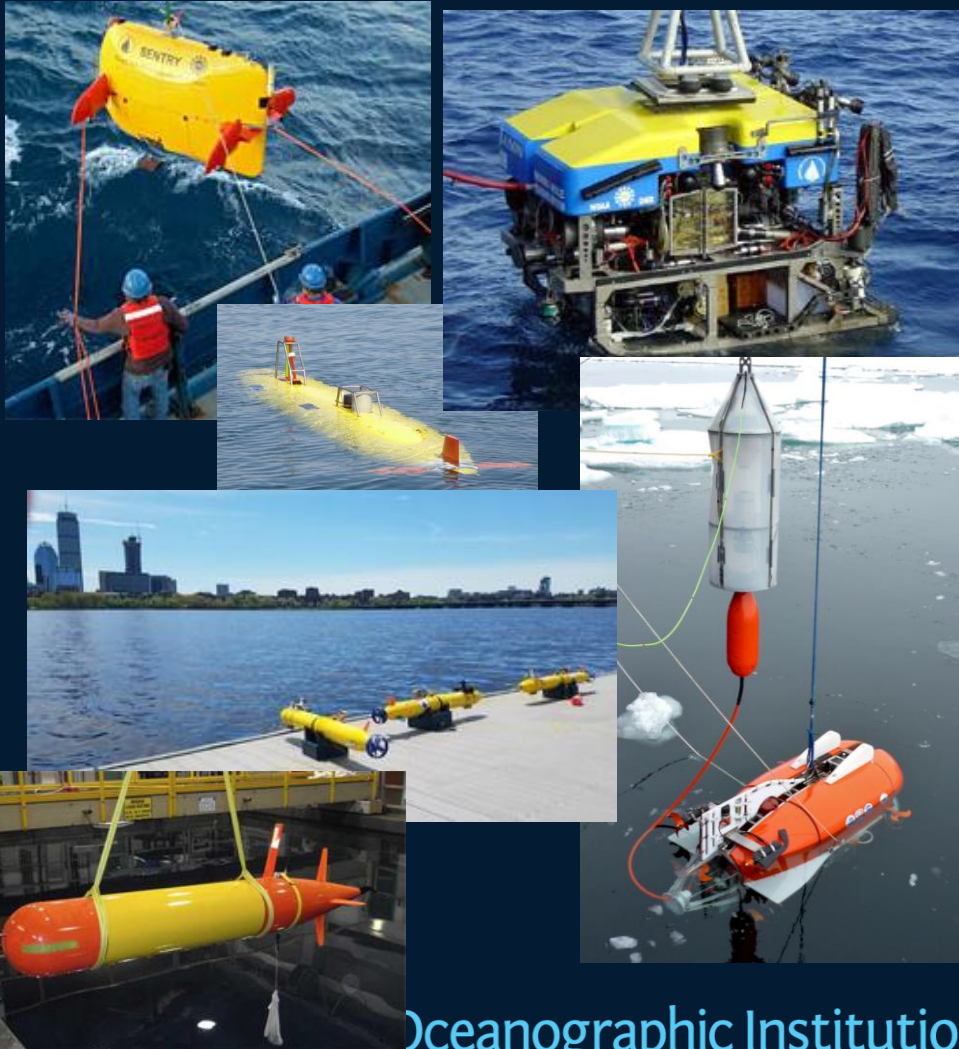
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Dr. Carl L. Kaiser
Woods Hole Oceanographic Institution

ckaiser@whoi.edu

The Problem

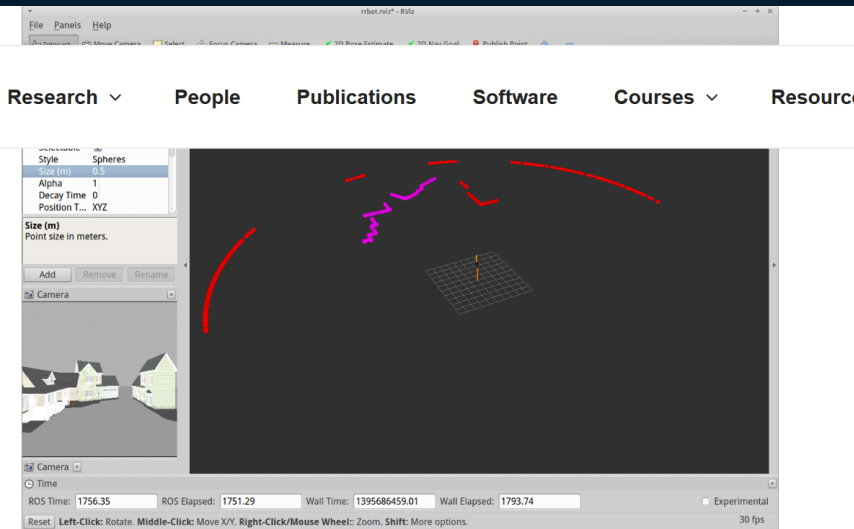
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- Everyone has their own black box code
 - Some are fiscally invested in keeping it black box
 - Some are inertia and “good reasons” just at WHOI 6 major variants and ??? Minor variants
- Navy increasingly wants modular and open
- Pace of Innovation must increase MASSIVLY -> must share and re-use everything but secret sauce (and maybe that)
- Cyber Issues

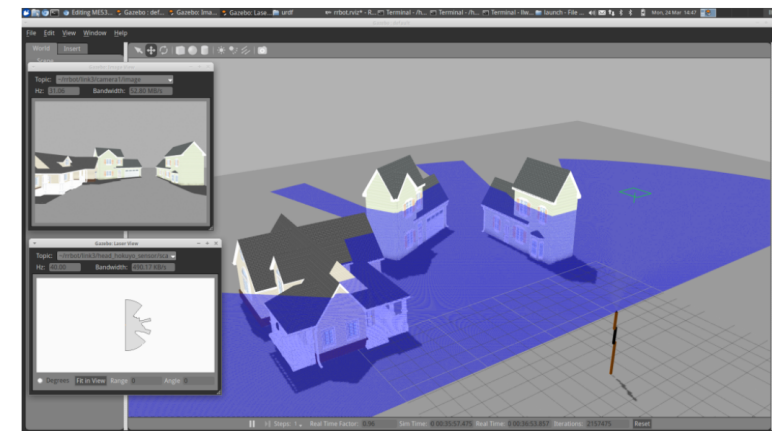
Robot Operating System (ROS)

3



- Robotics Middle Ware
 - Not actually an operating system
 - Manages messaging, build, etc.
 - Massive number of open and variously well maintained libraries
 - Introspection!
 - Core is maintained by well funded organization
 - More than 10,000 users
 - **Students Know it!!!!!!!**
- Gazebo!
- We've created a semi-custom undersea variant that is still backward compatible but solves a lot of undersea problems

shot showing the RRBot camera and laser-scanner sensor data. Click for higher resolution



ds_asio: I/O For the Busy

4

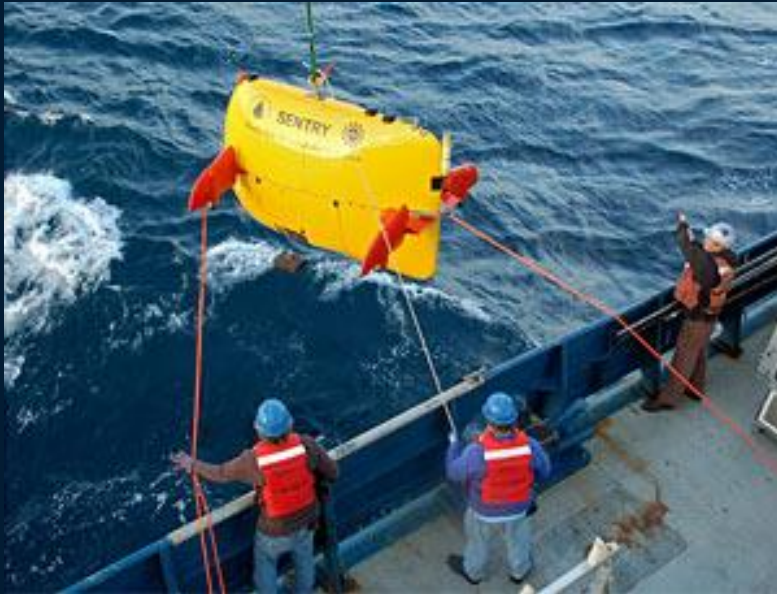
- ❑ Blocking I/O code is a drag
- ❑ Boost::asio rocks, but doesn't support ROS messages
- ❑ Solution (now on bitbucket!):
 - ▣ Execute ROS callbacks in a boost::asio event handler
 - ▣ Make I/O look like ROS callbacks
 - ▣ Instant debug access to ALL serial/UDP connections

```
void MySensor::setupConnections() { // overrides base class method
    addConnection("instrument", // where to look in rosparam
                  boost::bind(&MySensor::parseBytes, this, _1));
}
```

```
void MySensor::parseBytes(const ds_core_msgs::RawData& bytes) {
    // handle here just like a normal topic callback
}
```

Phase I Rollout: Sentry

5



- 9 dives
 - 2 dives lost to HW, ops issues
 - 3 mission-ending bugs
 - 4 successful dives
- All Validation issues
 - Thruster mixing & saturation
 - Sound velocity outlier
 - Integrator windup
 - Poor recovery from unknown RS-232 hardware issue
- Gazebo verification worked
- Abort testing worth it
- Develop operations doctrine

Results: Operations continue

6

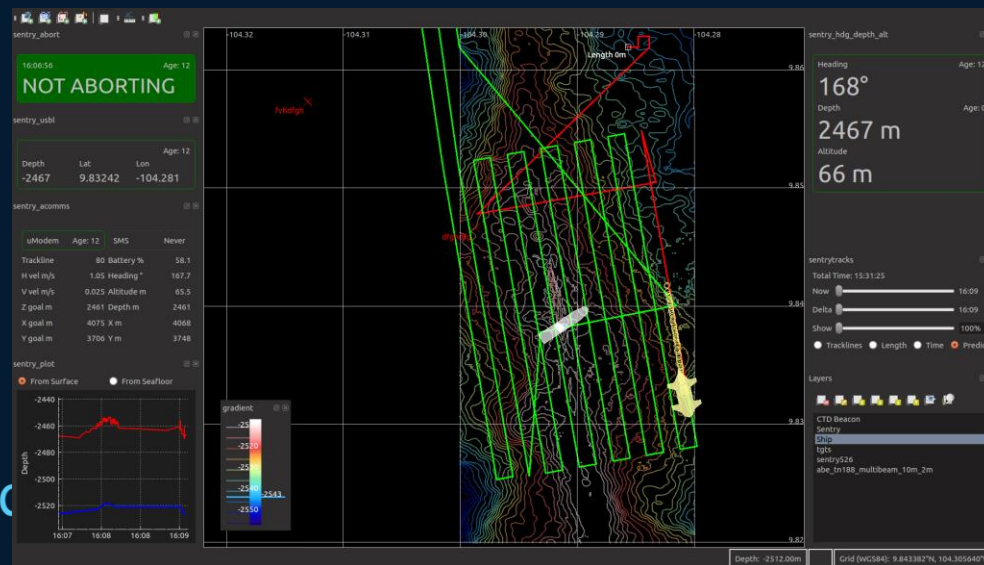
- Post-upgrade:
 - ▣ ~60 dives over 6 cruises
 - ▣ No major software failures
 - ▣ ... some bugs
 - ▣ Crazy new science ideas worked the first time (thanks Gazebo!)

- Phase II: Mission executive
 - ▣ Ongoing



NavG 3

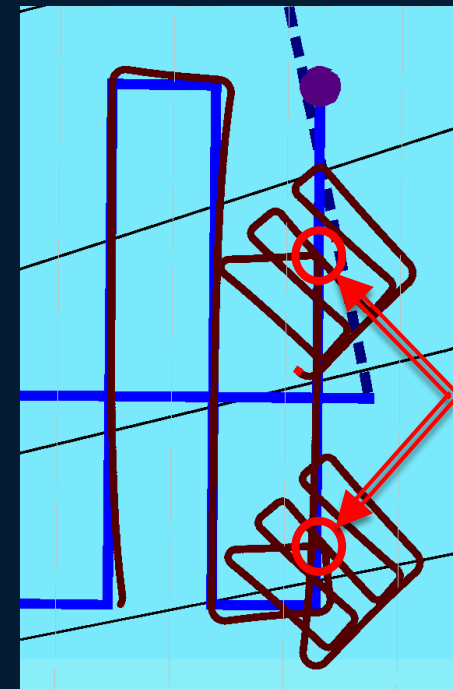
- New vehicle user interface
- Operate your vehicle in the context of your data
- GIS based – co-locate your data, planning, and monitoring
- Plug in based with savable configurations
 - ▣ Science, watchstander, operator, etc



ROS-MX

8

- Built on Sentry's 70+ dive/year experience
- Build complex missions from small, testable "Tasks"
- Facilitates high-level autonomy
 - ▣ Inherently run multiple tasks at once
 - ▣ Most standard tasks are resumable
- Plugin-based architecture to seamlessly integrate new vehicles and payloads
- Geospatial graphical mission planner
- Fall 2019

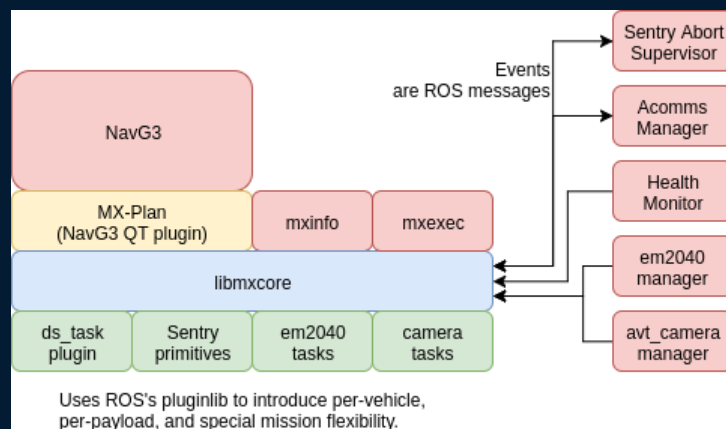


Simulate
target
detection

ROS-MX: An extensible framework for any vehicle

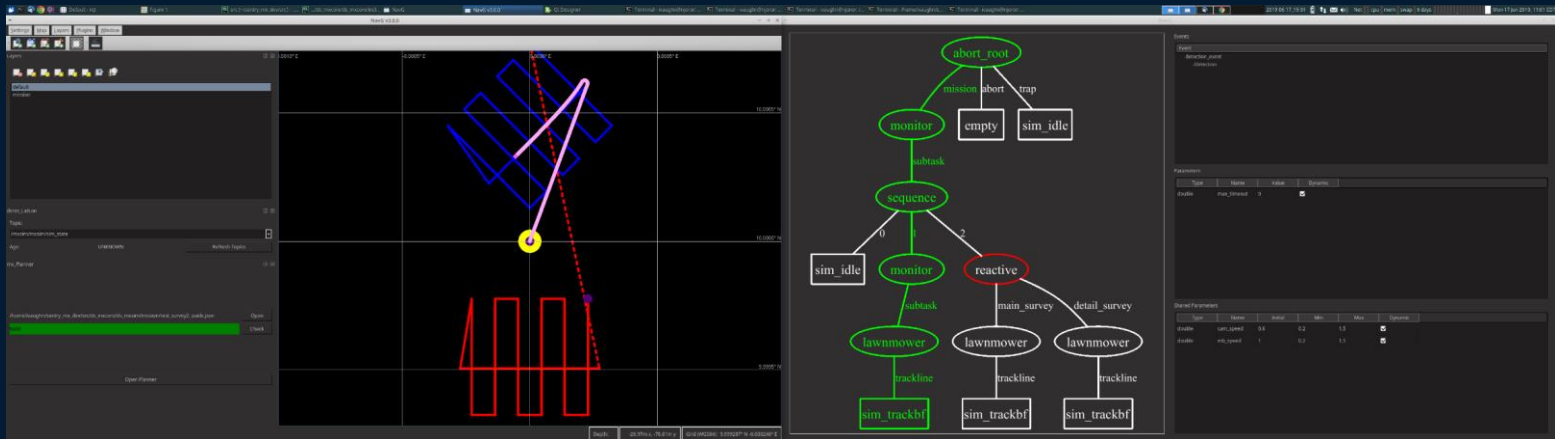
9

- Plugin architecture based on ROS's native build system
- Tasks are simple to write
- Assemble Tasks for your vehicle, payloads, etc from open-source ROS packages
 - ▣ You manage your custom plugins
 - ▣ Only core framework and standard library need centralized management
 - ▣ Seamlessly use open-source and proprietary mission Tasks



ROS-MX: Graphical Planner

10



- Built on NavG geospatial situational awareness platform
- Point-and-click interface for building complex, reactive missions
- Graphical representation of how mission elements interact (right)
- Seamless integration with real-time operations for monitoring

Multi-objective optimization with ROS

11

- 🔗 Use ROS-MX for state, mission planning, etc.
- 🔗 Port most useful functionality of IvP to ROS, for use with ROS-MX
 - + **Fuse safety and mission objectives (e.g. obey obstacle avoidance, COLREGs, min altitude, etc. while still completing mission).**
 - + Build complex behavior by combining objectives (e.g. broadside acoustic behaviors combined with waypoint approach to improve passive acoustic data quality).
- 🔗 Winter 2020

Building a Community – Present

12



- October 2018 – Workshop at WHOI – 78 participants, 30 odd organizations
- Moving up the hierarchy
 - ▣ Common message types
 - ▣ Module re-use
 - ▣ Common Class Hierarchy
 - ▣ Common Code Base
- Requires Release and Adoption Strategy

Current and Near Future Use

13

- Sentry
- Jason/Alvin 2019
- Remus 100 backseat
- Remus 600 Backseat Fall 2019
- Using on several ONR research vehicles
- NUWC Keyport thinking about use
- Talking with RIPTIDE about possibilities

Supporting Multiple Platforms

14

- How do you keep from branching?
- How do you perform V&V?
- Release Schedule
- Adoption
- Code Patches
- Configuration

Verification and Validation

15

- Validation can be address much better* in automated test
 - ▣ Adopt industry best practices
 - ▣ Unit tests are easy, but functional and regression tests are hard once you go past basic control
 - ▣ Requires Canonical Data Sets – We have them
 - ▣ Hardware in the loop Simulation
 - ▣ Eventually have to sea test, but can cut testing dramatically and even do in parallel or online
- Verification is hard in a cross platform sense
 - ▣ Perhaps collaborative organization (e.g. ROS-i at SWRI)

* Of course all simulations are doomed to succeed and hours in the environment are required to refine technology We seek to change the slope of the line especially for feature adds

Simulation and Online Testing

16



- Google leads the way
 - ▣ They drive 3M mi/yr in real vehicles
 - ▣ They drive 2.5B mi/yr in virtual vehicles
- Google has really got finding everything that can be found in simulation down to an art!
- We can and are building on that

Digital Underwater Test Center

18

- Need to build the underwater equivalent of CarSim (of course affordable)
 - ▣ Easy to import new data
 - ▣ Growing library of anomalies
 - ▣ Separate layers – perception, control, driving, physics, etc
 - Most important layers are not flight dynamics
 - ▣ Functional and Regression Testing
- We're building elements of it now, but how do we fund a comprehensive effort?
 - ▣ Navy?
 - ▣ Consortium?
 - ▣ Foundation?

Making ROS real for Defense

19

□ Issues

□ Code Control

- Gitlabs + DFARS network

- Classified – similar but still being worked out

□ Cyber Security

- Ros M (US Army TARDEC)

- www.rosmilitary.org

□ Code Sharing ???



Upcoming Workshops

20

- Sept 4/5, 2019 – UUV Missions and Tools to Enable Development – NUWC Division Newport – formal announcement next week. SECRET level only.
- ??? Fall 2019/Winter 2020 – Open conference? Interest?

Involvement

21

- Code:
 - <https://bitbucket.org/whoidsl/>
 - Needs tutorials, docs, reference design
 - Jump on board if you're interested
- Workshop 2.0 ?? – Fall 2019 – would need sponsors
- Jumpstarting – sim environment is probably highest value – pondering proposal avenues
 - Consortium / ROS-i model?
- Come visit us or we can come visit you