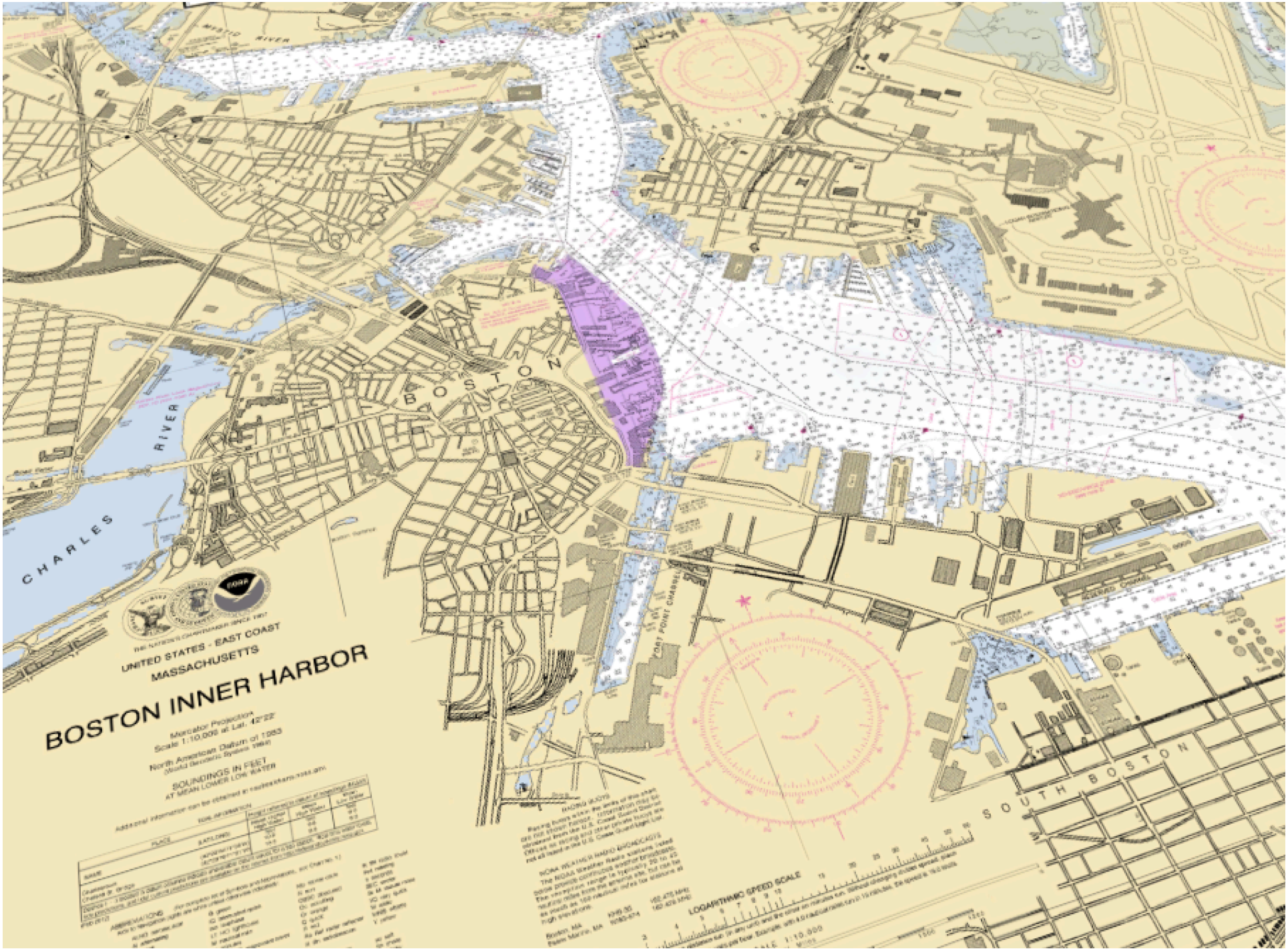
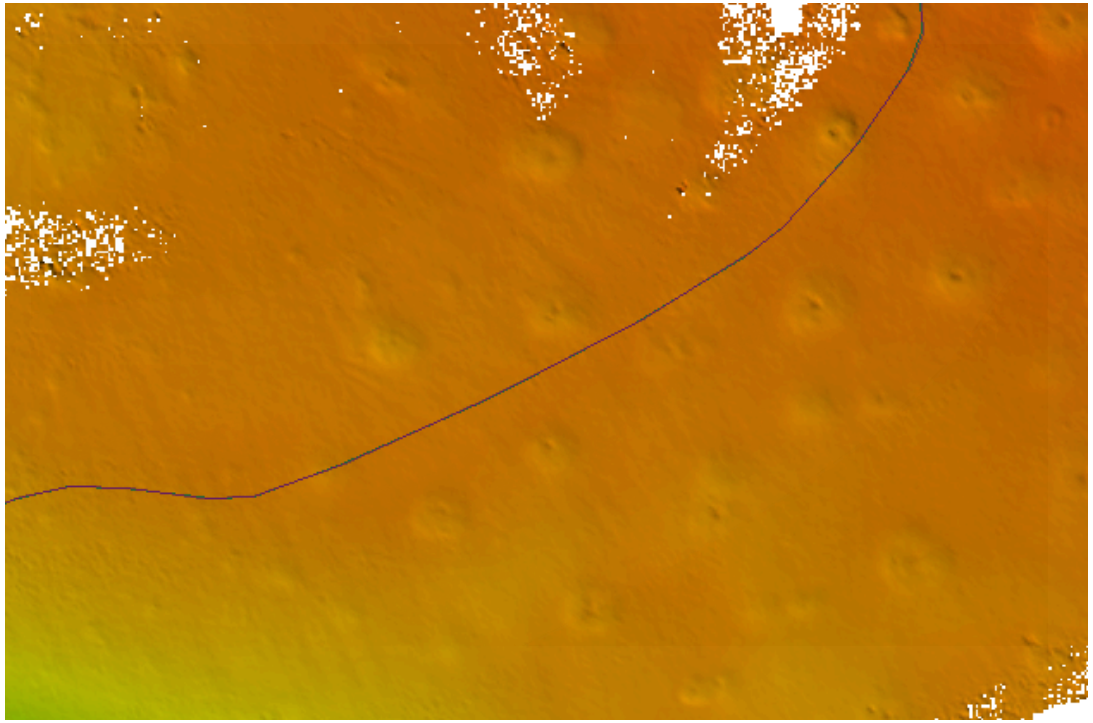
Requirements for an Operational ASV for Hydrographic Survey:

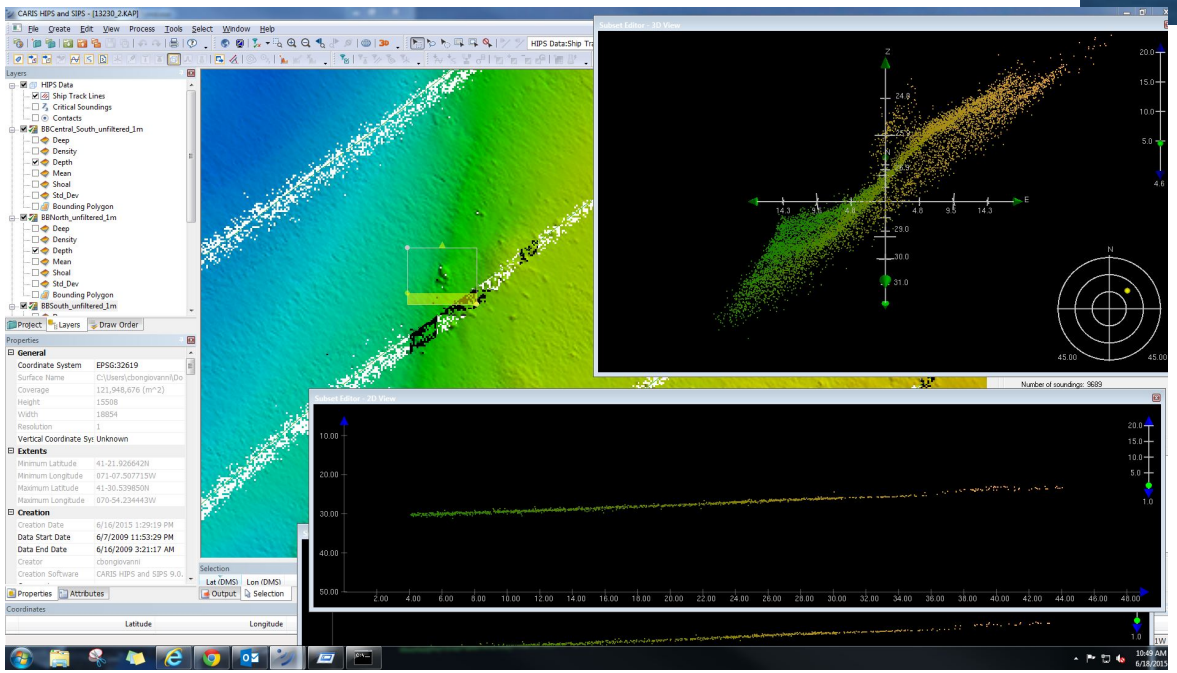
A Rookie's View of MOOS.

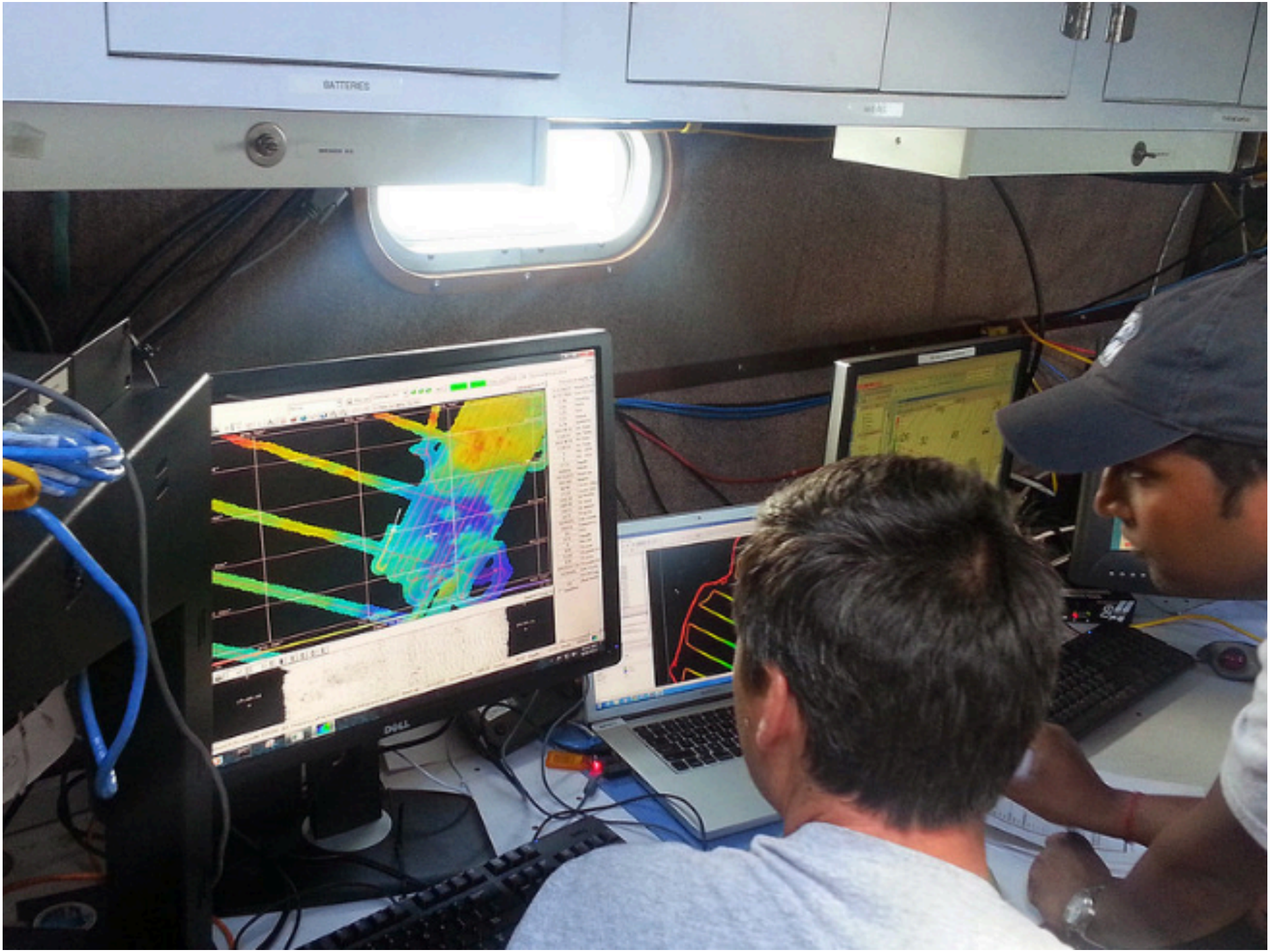
Val Schmidt
Center for Coastal and Ocean Mapping
University of New Hampshire
July 22, 2015

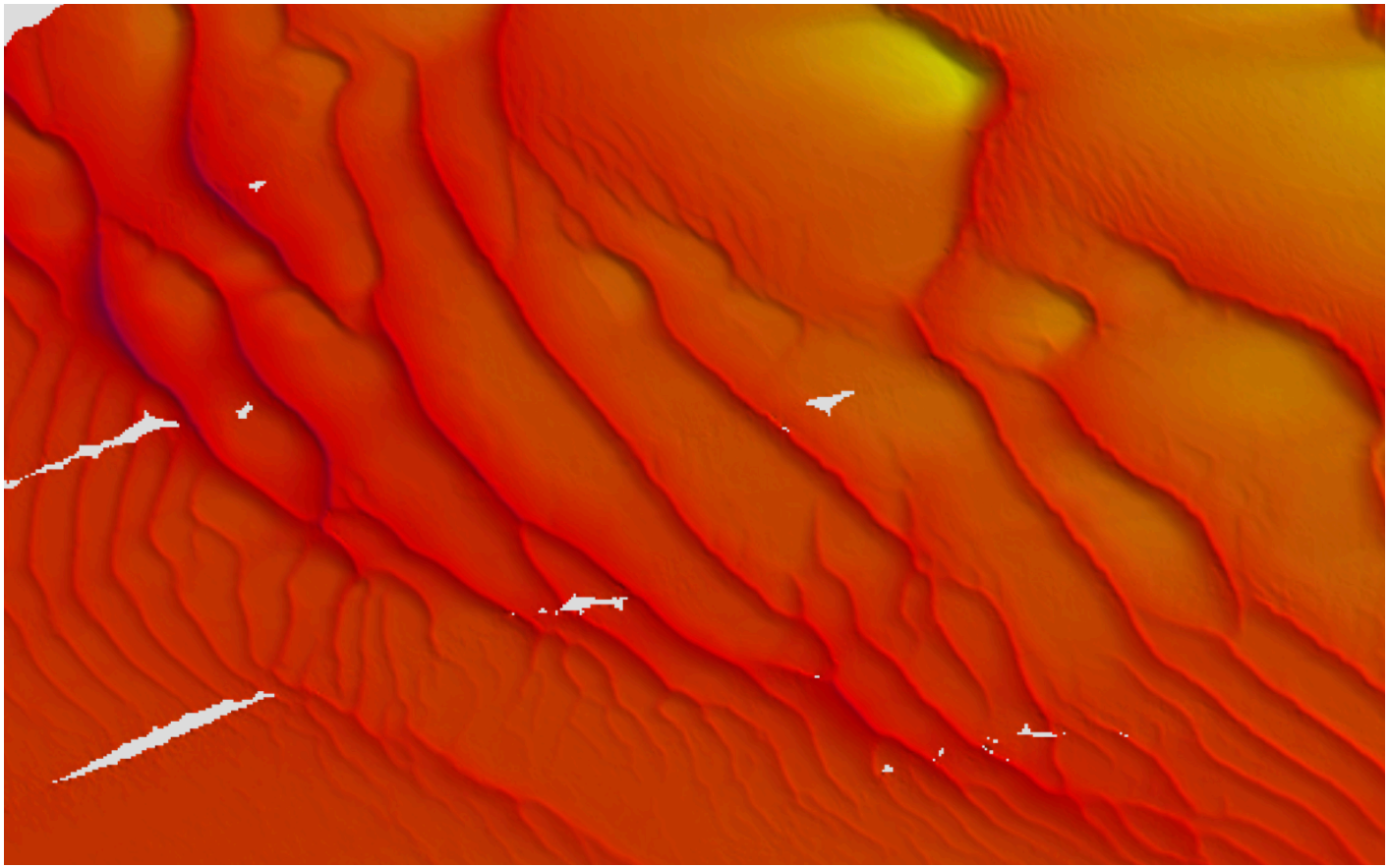

CHARLES RIVER
BOSTON
SOUTH BOSTON
UNITED STATES - EAST COAST
MASSACHUSETTS
BOSTON INNER HARBOR
Mercator Projection
Scale 1:10,000 at Lat. 42°22'
North American Datum of 1983
(World Geodetic System 1984)
SOUNDINGS IN FEET
AT MEAN LOWER LOW WATER
LOGARITHMIC SPEED SCALE

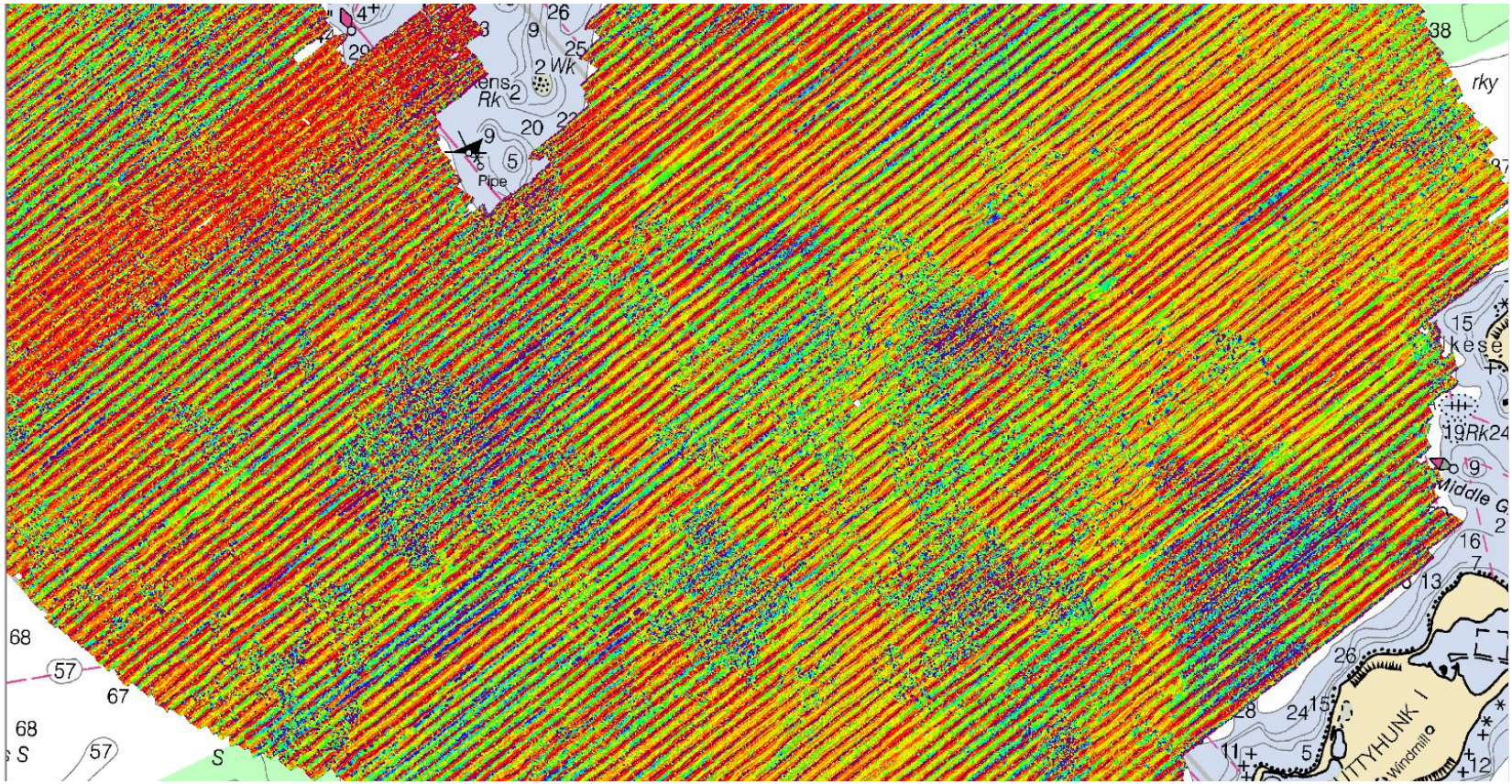



applanix
POSMV


CARIS HIPS and SIPS - [13230_2.KAP]
File Create Edit View Process Tools Select Window Help
Layers
HIPS Data
Ship Track Lines
Critical Soundings
Contacts
BBCentral_South_unfiltered_1m
Deep
Density
Depth
Mean
Shoal
Std_Dev
Bounding Polygon
BBNorth_unfiltered_1m
BBSouth_unfiltered_1m
Project
Layers
Draw Order
Properties
General
Coordinate System EPSG:32619
Extents
Creation
Data Start Date 6/7/2009 11:53:29 PM
Data End Date 6/16/2009 3:21:17 AM
Subset Editor - 3D View
Subset Editor - 2D View
Number of soundings: 9689
Selection
Coordinates
Latitude
Longitude


BATTERIES
DELL




Wk
Rk
Pipe
rky
Middle G
Rk
Windmill
57
68
67

AUV Hydrographic Bootcamp 2014

Engineering Hydrographic Surveys

August 3–8, 2014 (Sunday–Friday) • New Castle, NH

A Collaboration Between

The Center for Coastal and Ocean Mapping (CCOM) at the University of New Hampshire

&

The Coastal Sediments, Hydrodynamics and Engineering Laboratory (CSHEL) at the University of Delaware

with support from HYDROID, Inc. and NOAA's Office of Coast Survey

QPS leidos caris DCF Subsea

SUBSTRUCTURE HYDROID A KONGSBERG COMPANY Black Laser Learning


ROLL
PITCH
HEADING
TIMING
SOUND SPEED
TIDES ARAP
RAISE
SOURCE
IMU
IMU
IMU
IMU, PPS
GPS, USBL, IMU, DVL
GPS, USBL, IMU, DVL
CTD, Probe (UAV)
Engineering
EM3002
Metric
0.005°/hr
1σ
Data: 0.4m
RTK: 0.01-0.02m
USBL ?
IMU: ?
DVL: 0.004°/s or 0.4m
Fixes: 0.02%
How good is your engineer?
Sonar Sensor Dependence on Data + angle


NH 9672 BK


Agenda
Rest of Week:
Monday: Uncertainty Evaluation. Patch Test Missions.
Tuesday: Experimentation Missions
Wednesday: Production Missions
Thursday: Demos/Data Processing
Friday: Wrap up and review.

Autonomous Surface Vessel Operational Requirements

- 2-4 m vessel.
- Seaworthy.
- 10-12 hour endurance.
- 500W+ Payload.
- >5 nm telemetry.
- Backseat driver capability (MOOS/ROS)

Autonomy Basics

- Waypoints.
- Line following.
- Survey patterns.
- Closed loop control.
- System Health and Fault response.
- Extremely Robust.
- Sailor Proof.

Autonomous Surface Vessels

Clearpath Robotics
"Kingfisher"

Teledyne
Oceansciences
"Z-Boat"

Hydronaulix
"EMILY Boat"

ASV Global
"C-Worker"

Pending Teledyne Oceansciences Collaboration

EMILY Project – Damian Manda

ASV Global

- ~4 m length
- Diesel Jet Drive
- 48 Hrs at 6 Knots (288nm)
- 1500 W electrical payload
- Radar
- AIS
- FLIR and Color Cameras
- Integration with MOOS/ROS
- Sea-chest with retractable sonar mount.

ASV Proposal P571 to the University of New Hampshire

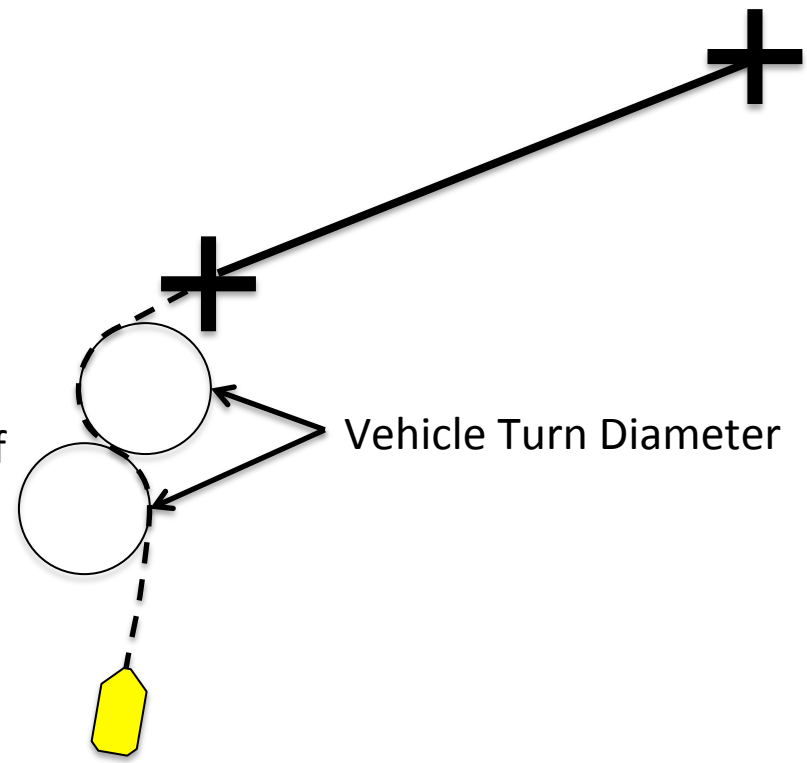
Models

Episodic Handoff	Total Handoff
Mission Component	MOOS Component
Mission Component	MOOS Component
Mission Component	MOOS Component
MOOS Component	MOOS Component
MOOS Component	MOOS Component
Mission Component	MOOS Component

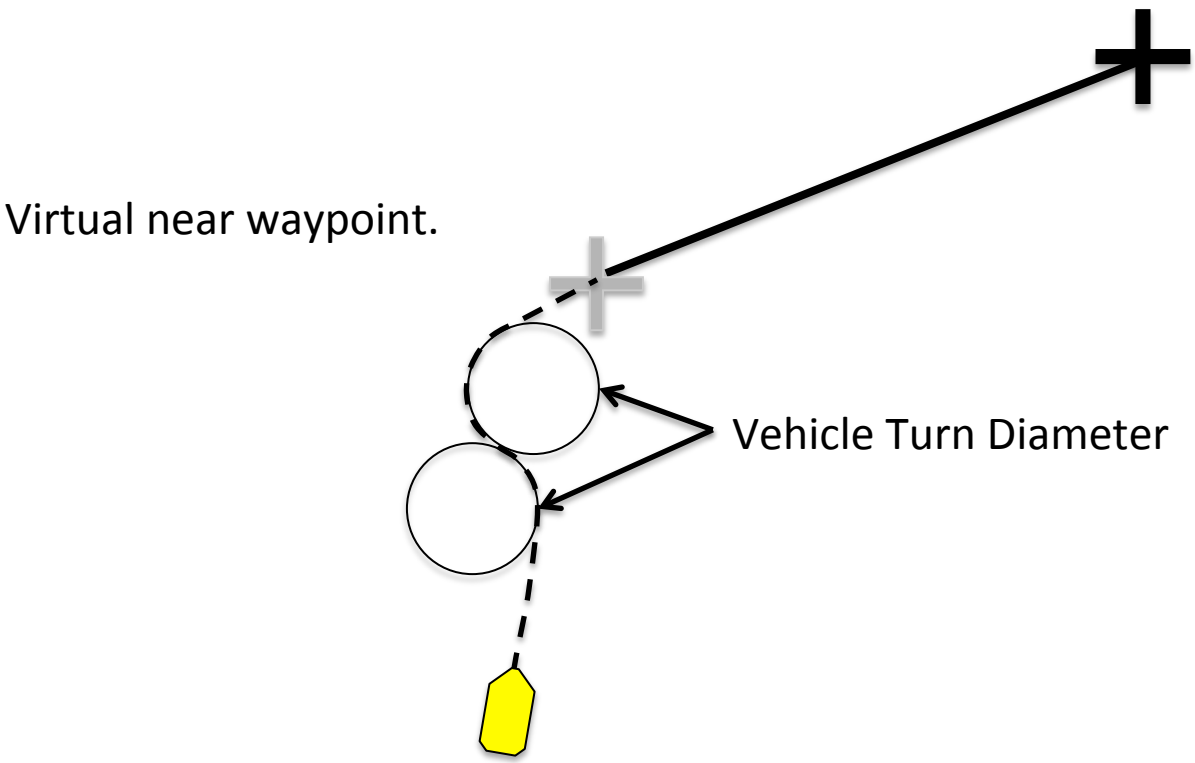
Trackline Following For Survey

Minimizes across-track distance.

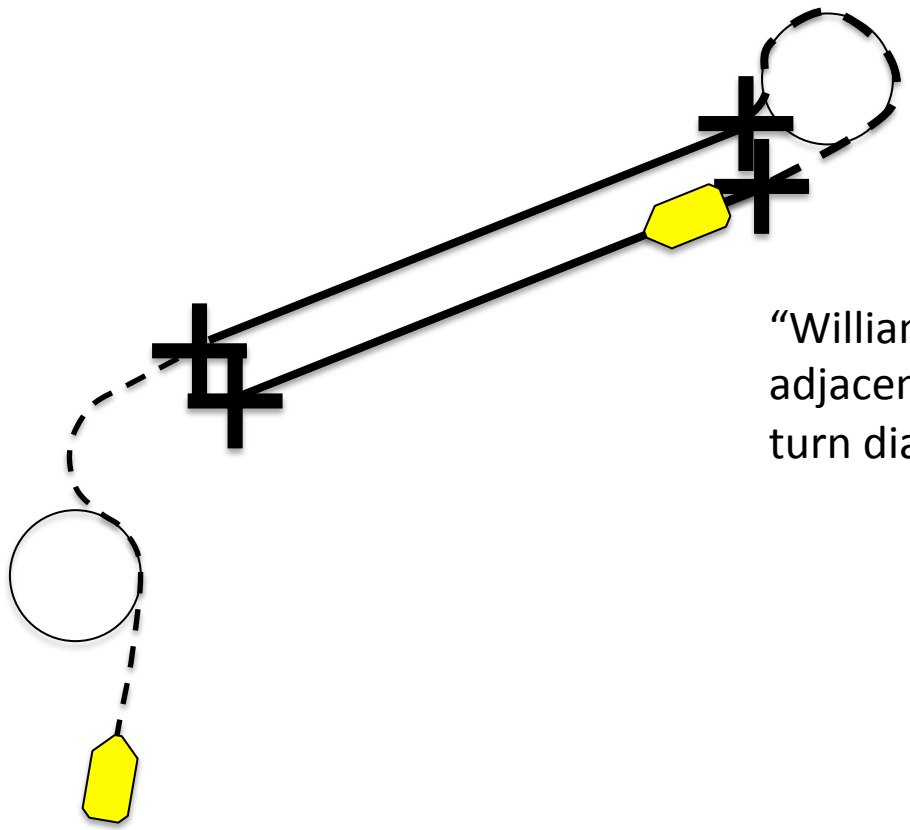
Heading is matched along with arrival of first waypoint.



All Waypoint Following is Trackline Following

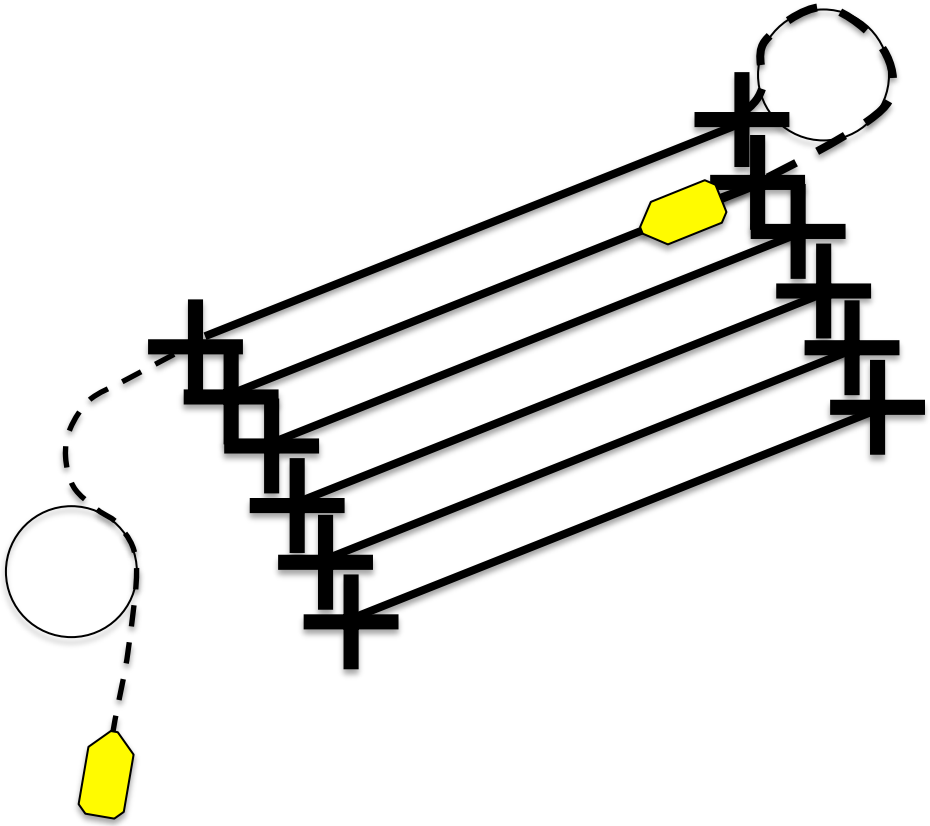


Williamson Turns

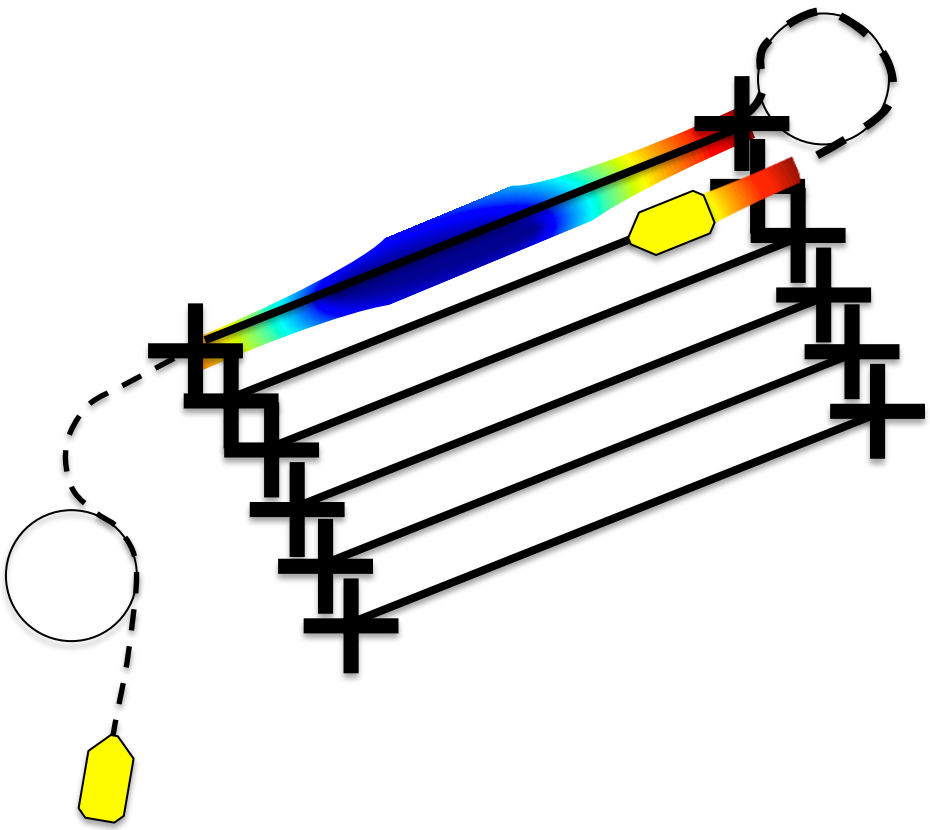


"Williamson Turns" when adjacent lines are within turn diameter.

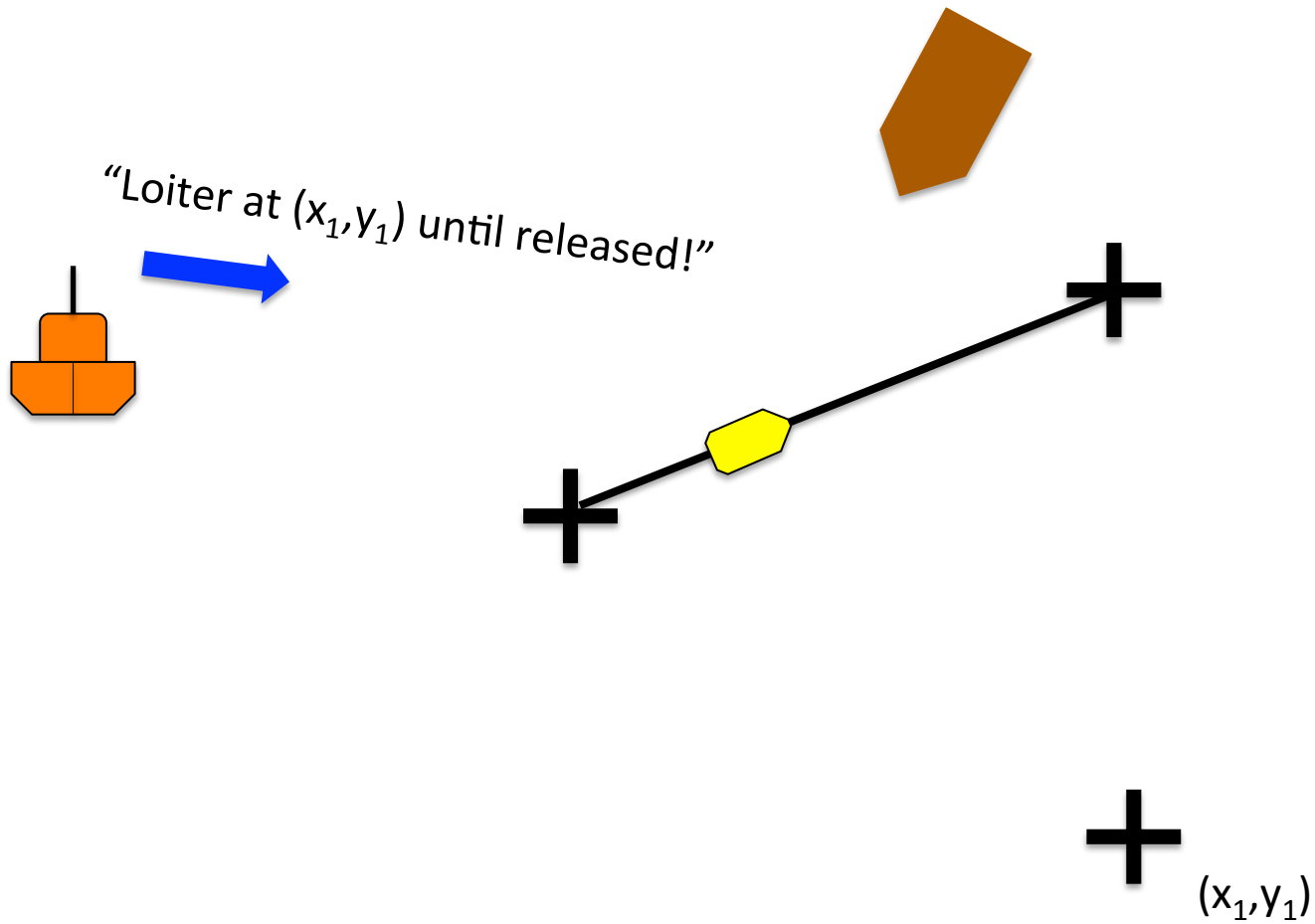
Lawnmower Surveys



Lawnmower Surveys



Ability to interject mission behaviors.



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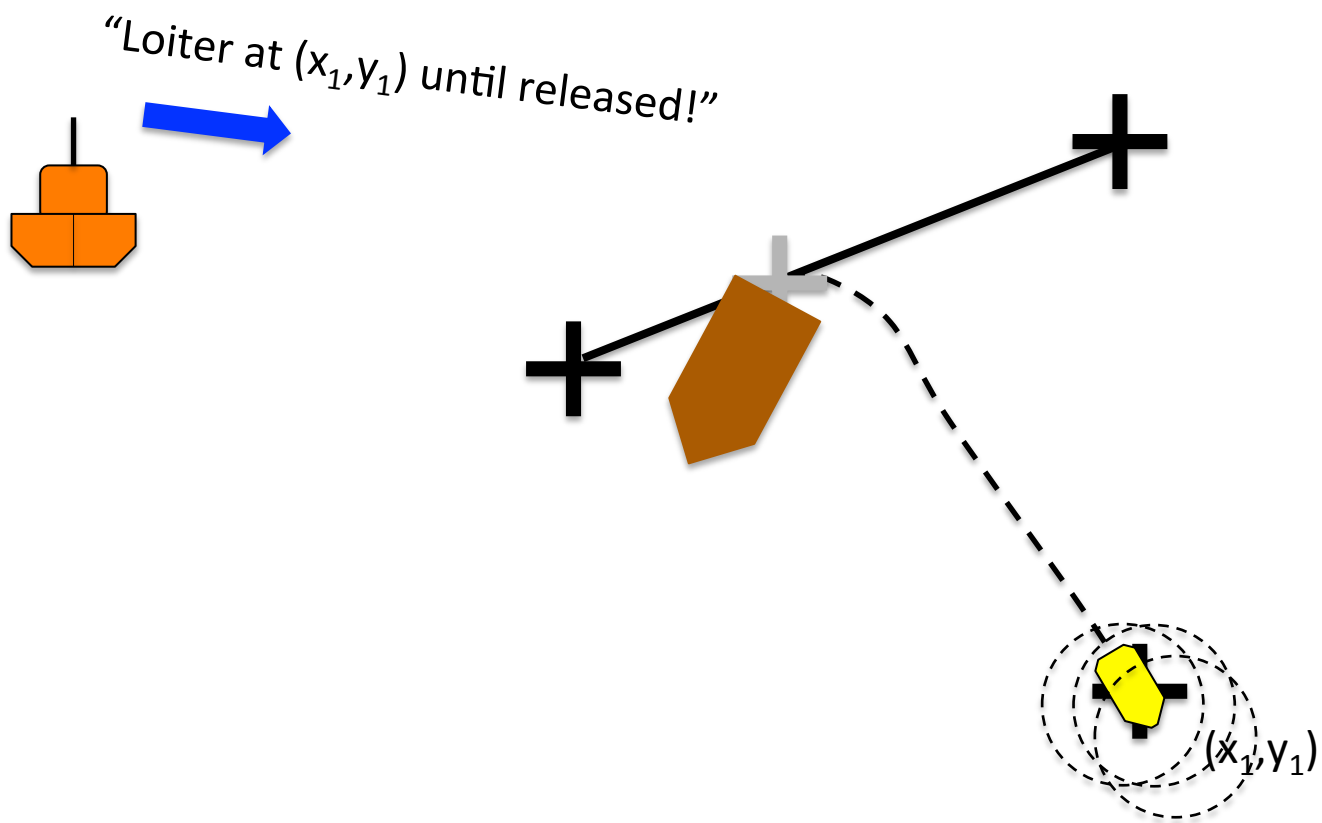
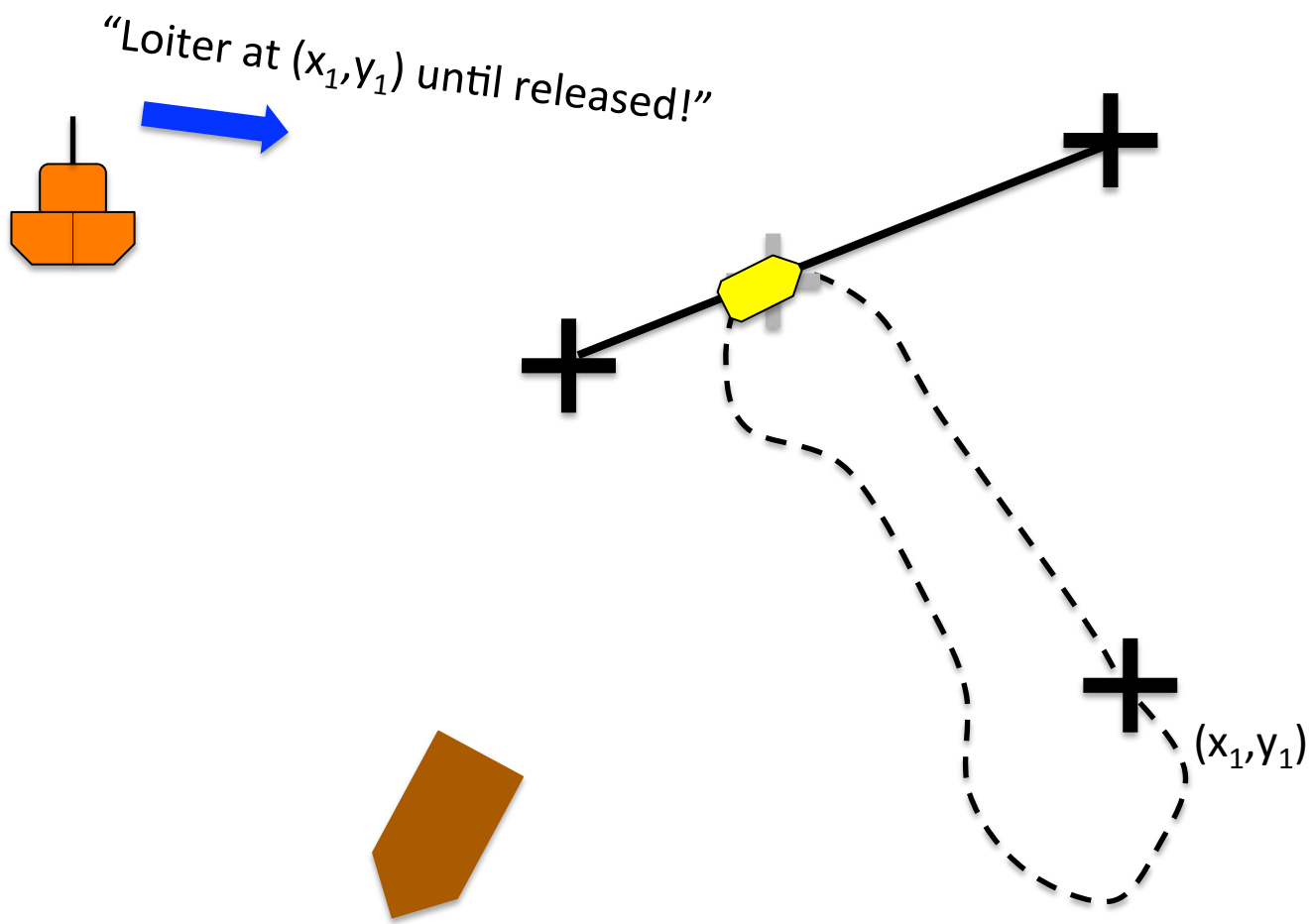
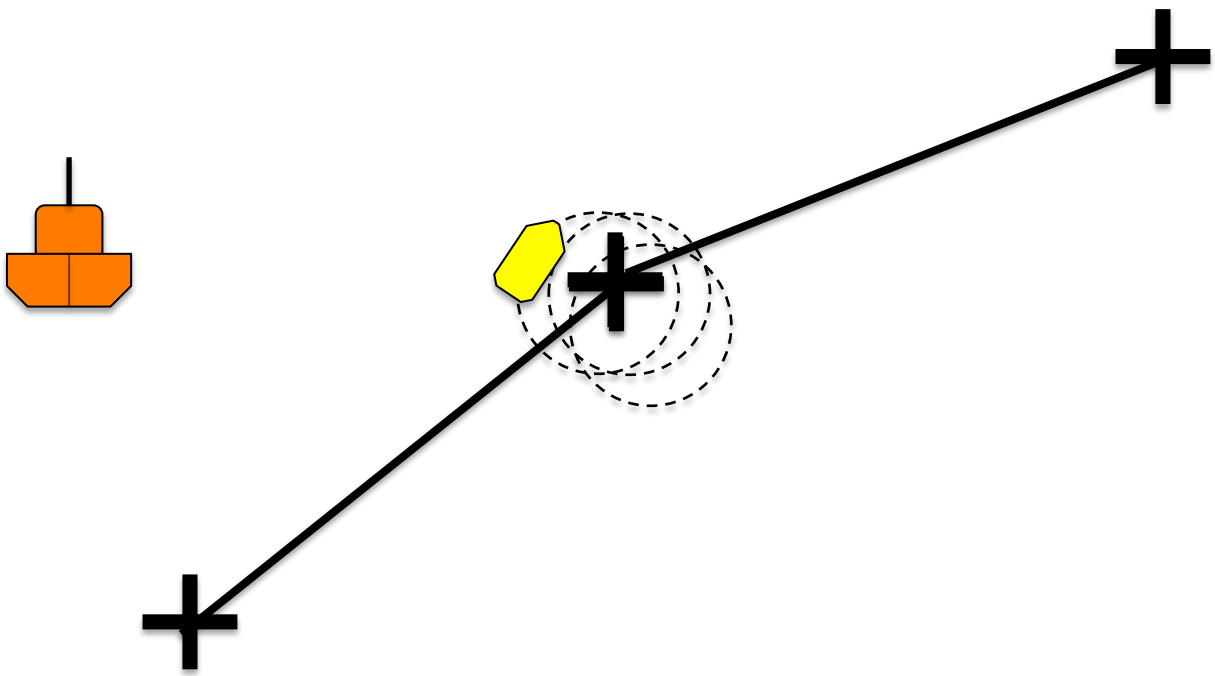


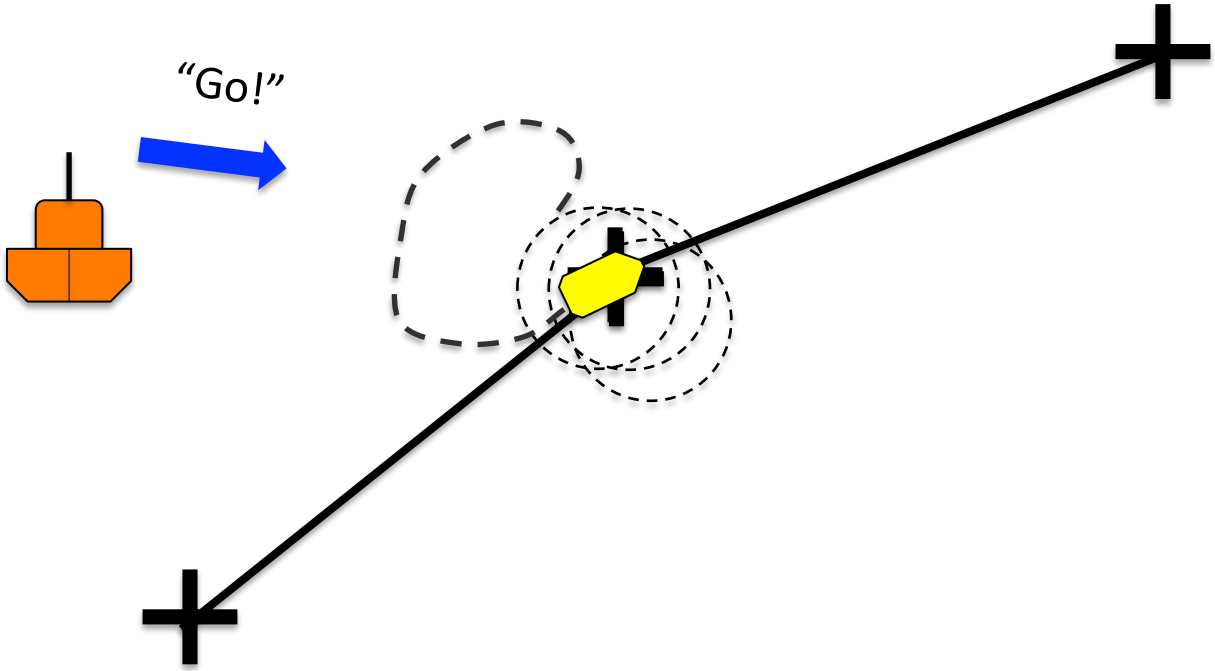
Ability to interject mission behaviors.



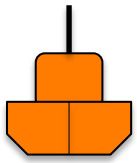
Triggered Mission Components

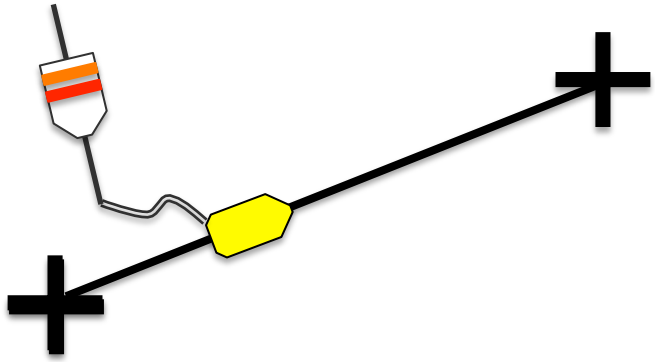


Triggered Mission Components



Closed Loop Control





- Behavior timeouts.
- Positive response to control surface and thrust commands.

Integrated Sensor Mission Planning

Goal:
Each sensor shall have the ability to take some action at the start/ end or each mission component. (behavior?)

(e.g. power on/off, (re)set config, start logging, stop logging, etc.)

```
//--------    FILE: alpha.bhv   -------------

initialize   DEPLOY = false
initialize   RETURN = false

//-----------------------------------------------
Behavior = BHV_Waypoint
{
  name      = waypt_survey
  pwt       = 100
  condition = RETURN = false
  condition = DEPLOY = true
  endflag   = RETURN = true

  idleflag  = WPTING = idle
  runflag   = WPTING = running
  endflag   = WPTING = end
  inactiveflag = WPTING = inactive

  UPDATES   = WPT_UPDATE
  perpetual = true

               lead = 8
        lead_damper = 1
              speed = 2   // meters per second
       capture_line = true
     capture_radius = 5.0
        slip_radius = 15.0
             points = 60,-40 : 60,-160 : 150,-160 : 180,-100 : 150,-40
             repeat = 100

    visual_hints = nextpt_color=yellow
    visual_hints = nextpt_vertex_size=8
    visual_hints = nextpt_lcolor=gray70
    visual_hints = vertex_color=dodger_blue, edge_color=white
    visual_hints = vertex_size=5, edge_size=1
}
```

An example

```
<asl:lawnmowerpattern width="750.00" angle="0.00"
crossangle="90.00" spacing="2.00" alternation="1.00" count="4"
name="Lawnmower_5tow">
  <asl:location>
    <asl:lat>
      <asl:deg>38</asl:deg>
      <asl:min>22.896</asl:min>
      <asl:hem>N</asl:hem>
    </asl:lat>
    <asl:lon>
      <asl:deg>74</asl:deg>
      <asl:min>12.897</asl:min>
      <asl:hem>W</asl:hem>
    </asl:lon>
  </asl:location>
  <asl:run-devices>
    <asl:device>
      <asl:name>flntu</asl:name>
      <asl:required>0</asl:required>
    </asl:device>
    <asl:sidescansonar>
      <asl:range>10</asl:range>
      <asl:frequency>HIGH</asl:frequency>
      <asl:rangedelay>0</asl:rangedelay>
      <asl:required>0</asl:required>
    </asl:sidescansonar>
    <asl:camera>
      <asl:required>0</asl:required>
    </asl:camera>
    <asl:device>
      <asl:name>aanderaaoxygen</asl:name>
      <asl:required>0</asl:required>
    </asl:device>
  </asl:run-devices>
  <asl:speed-rpm>600</asl:speed-rpm>
  <asl:bottomtrack>2.30</asl:bottomtrack>
</asl:lawnmowerpattern>
```

lawnmowerpattern

location

run-devices

sidescansonar

camera

An example

```
<asl:lawnmowerpattern width="750.00" angle="0.00"
crossangle="90.00" spacing="2.00" alternation="1.00" count="4"
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  <asl:location>
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      <asl:hem>N</asl:hem>
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    <asl:lon>
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      <asl:hem>W</asl:hem>
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  <asl:run-devices>
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      <asl:name>flntu</asl:name>
      <asl:required>0</asl:required>
    </asl:device>
    <asl:sidescansonar>
      <asl:range>10</asl:range>
      <asl:frequency>HIGH</asl:frequency>
      <asl:rangedelay>0</asl:rangedelay>
      <asl:required>0</asl:required>
    </asl:sidescansonar>
    <asl:camera>
      <asl:required>0</asl:required>
    </asl:camera>
    <asl:device>
      <asl:name>aanderaaoxygen</asl:name>
      <asl:required>0</asl:required>
    </asl:device>
  </asl:run-devices>
  <asl:speed-rpm>600</asl:speed-rpm>
  <asl:bottomtrack>2.30</asl:bottomtrack>
</asl:lawnmowerpattern>
```

lawnmowerpattern

location

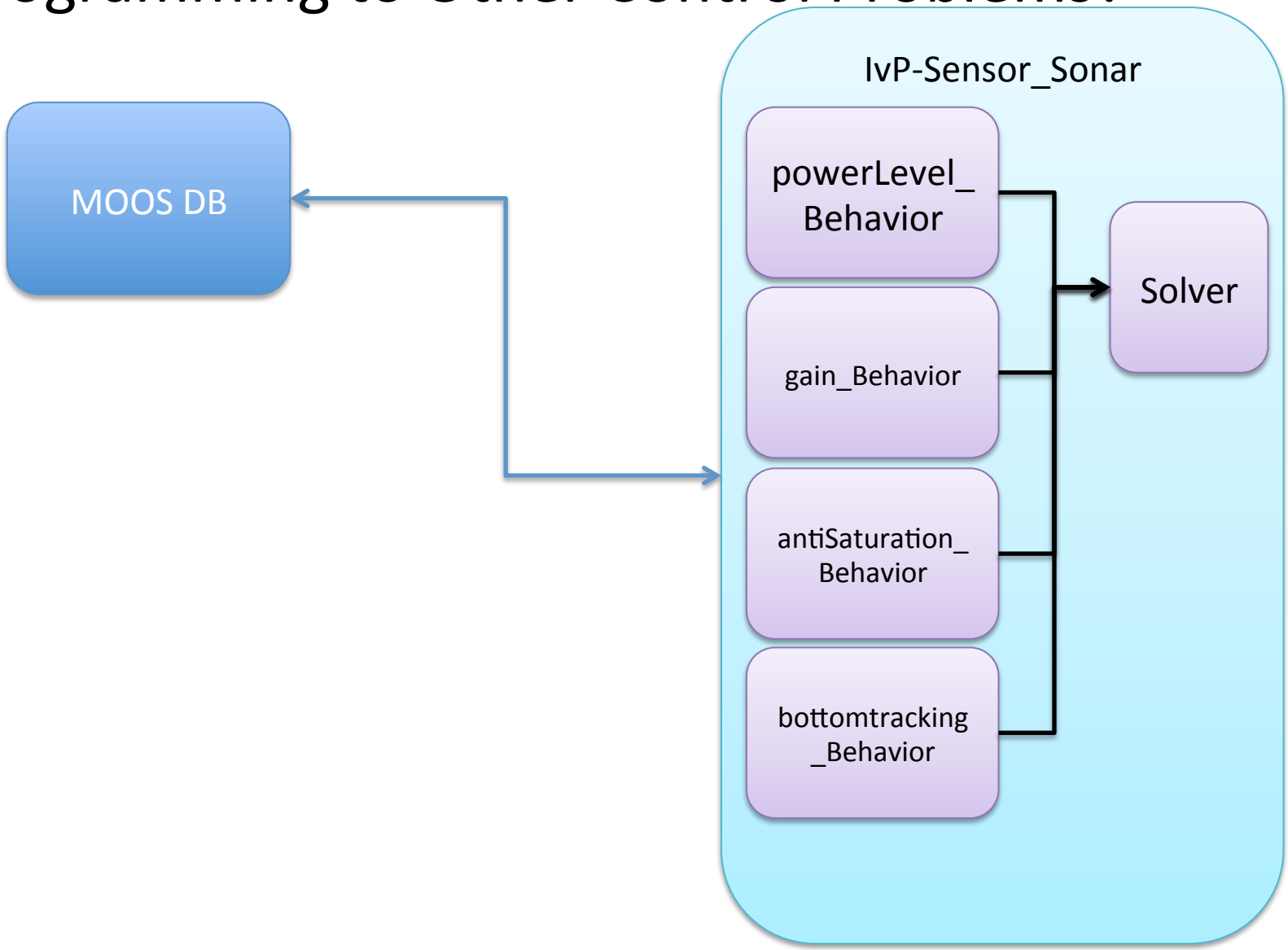
run-devices

sidescansonar

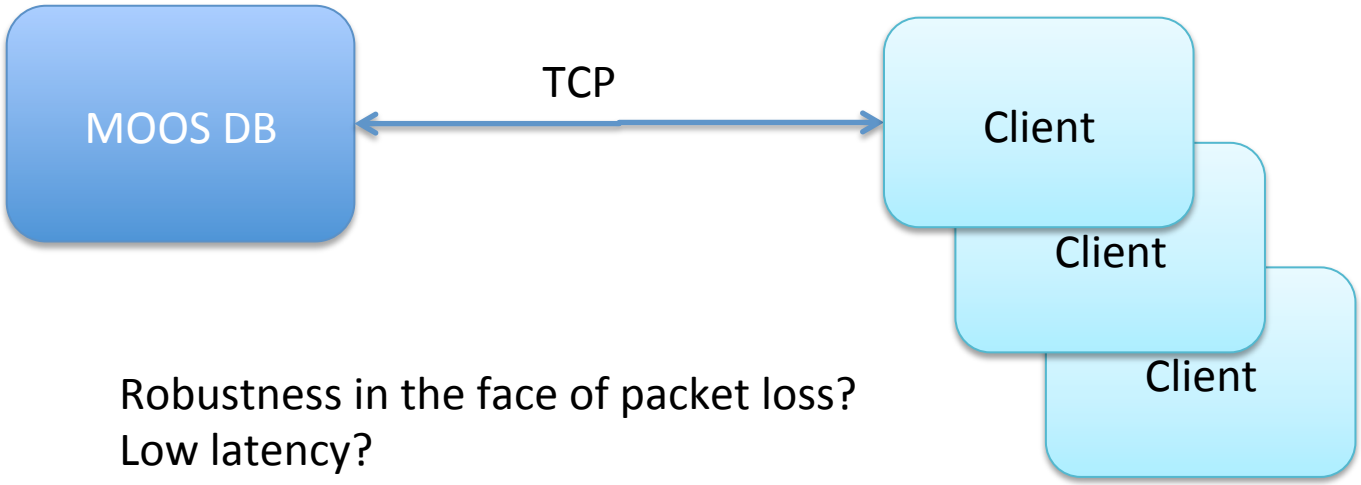
camera

I don't (yet?) understand the model in MOOS and IvP that makes this easy.

Could we apply the methods of Interval Programming to Other Control Problems?



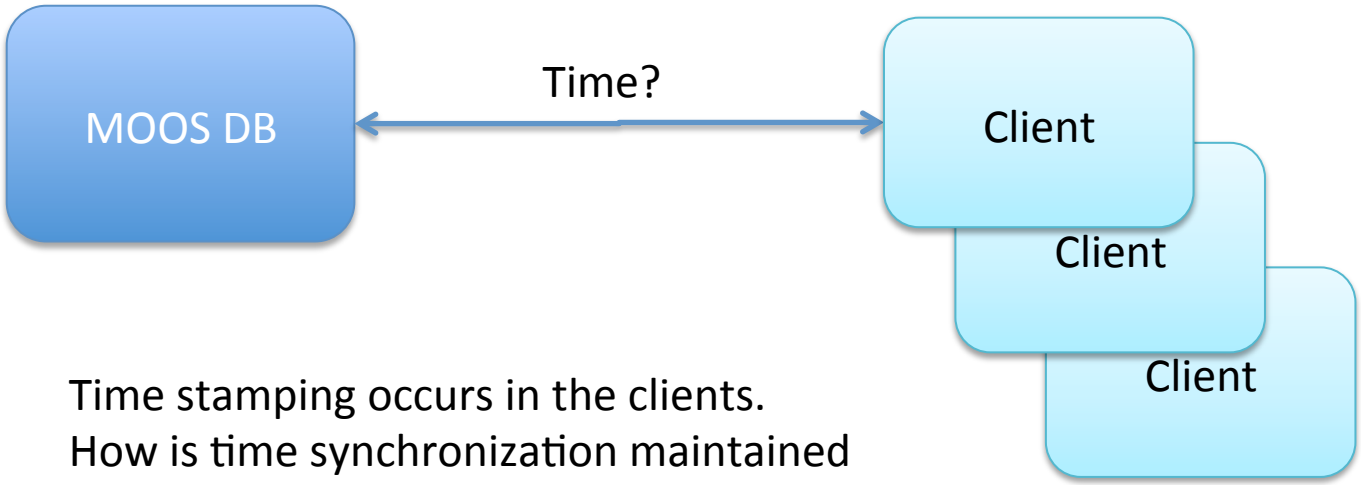
MOOS and IvP Autonomy Q's



Robustness in the face of packet loss?
Low latency?

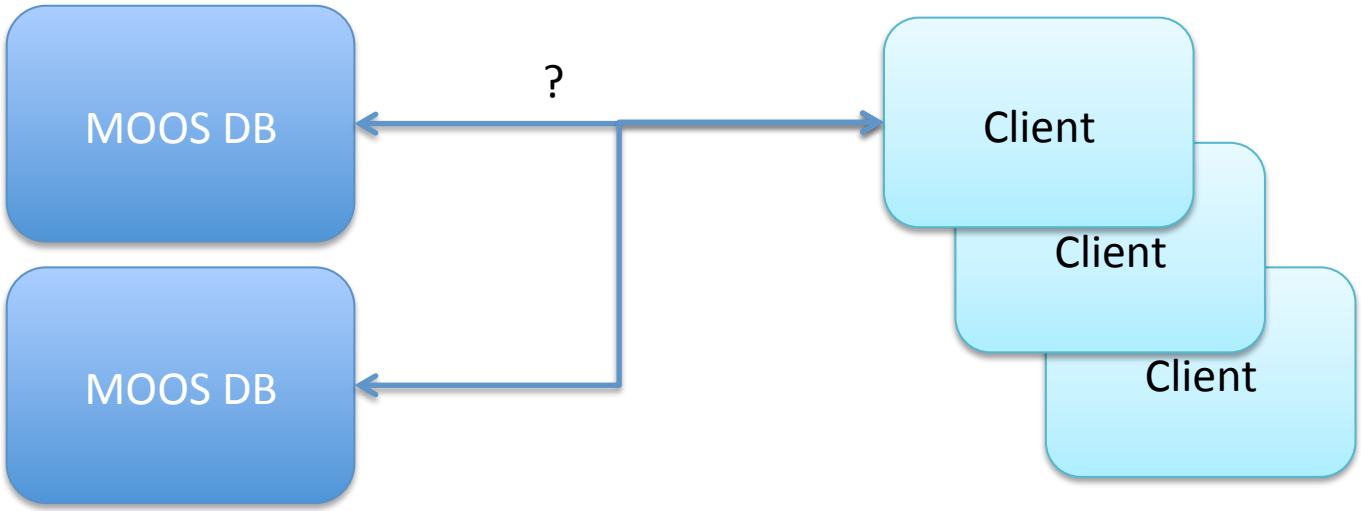
Is UDP more appropriate?

MOOS and IvP Autonomy Q's



Time stamping occurs in the clients.
How is time synchronization maintained
if clients are distributed?
To what level?

MOOS and IvP Autonomy Q's



Is Redundancy Needed?

Data Logging

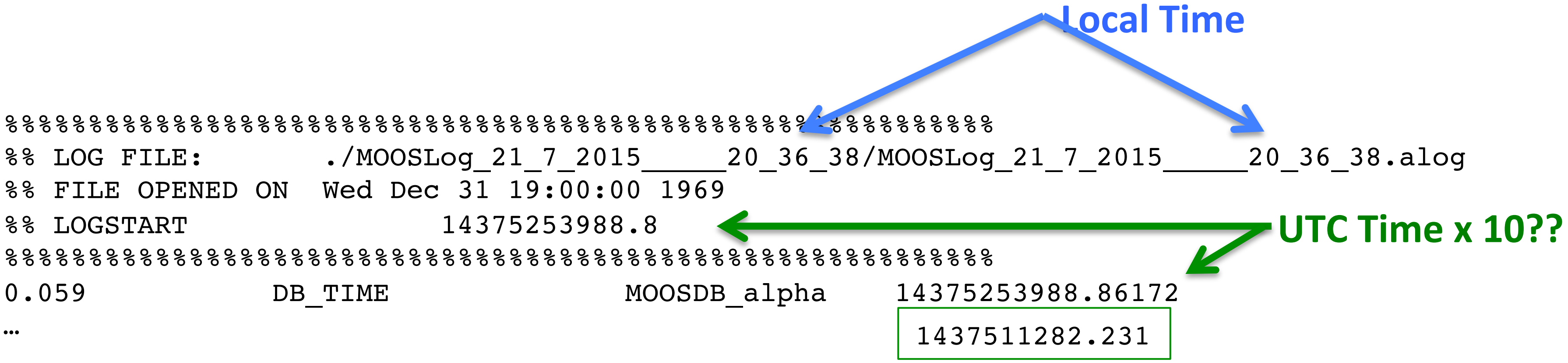
ONE BIG LOG FILE +/-

- Facilitates “replay” of logs

- Makes looking at any one log or log type hard.
- File rotation?
- Does logging from MOOSDB facilitate logging everything, or logging different parameters at different rates?

Data Logging

Time Stamping???



Local Time

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% LOG FILE:       ./MOOSLog_21_7_2015_____20_36_38/MOOSLog_21_7_2015_____20_36_38.alog
%% FILE OPENED ON  Wed Dec 31 19:00:00 1969
%% LOGSTART               14375253988.8
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
0.059           DB_TIME              MOOSDB_alpha    14375253988.86172
…
```

UTC Time x 10??

1437511282.231

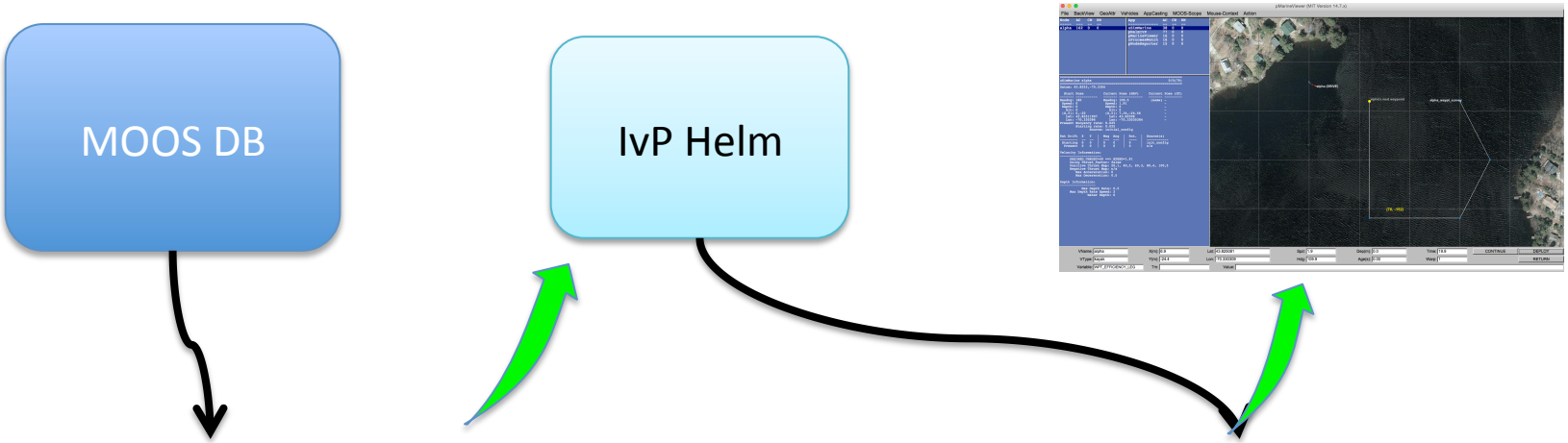
Security

Does it make any sense, at this level, to implement it?

Shared keys between MOOS clients?
SSL?

What's the performance penalty?
What's the risk?

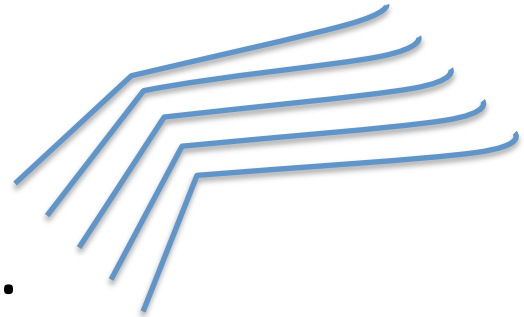
Configuration Blurred?




```
LatOrigin  = 43.825300
LongOrigin = -70.330400
```

```
visual_hints = nextpt_color=yellow
   visual_hints = nextpt_vertex_size=8
   visual_hints = nextpt_lcolor=gray70
   visual_hints = vertex_color=dodger_blue, edge_colo
   visual_hints = vertex_size=5, edge_size=1
```

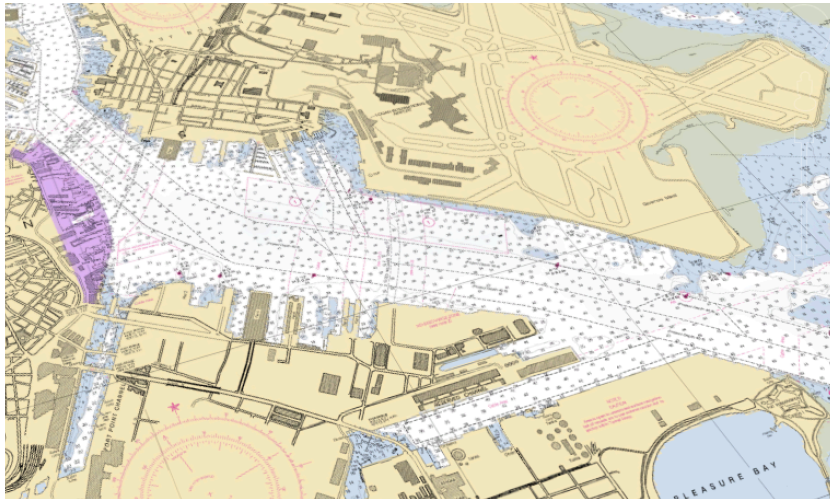
Adaptive Survey



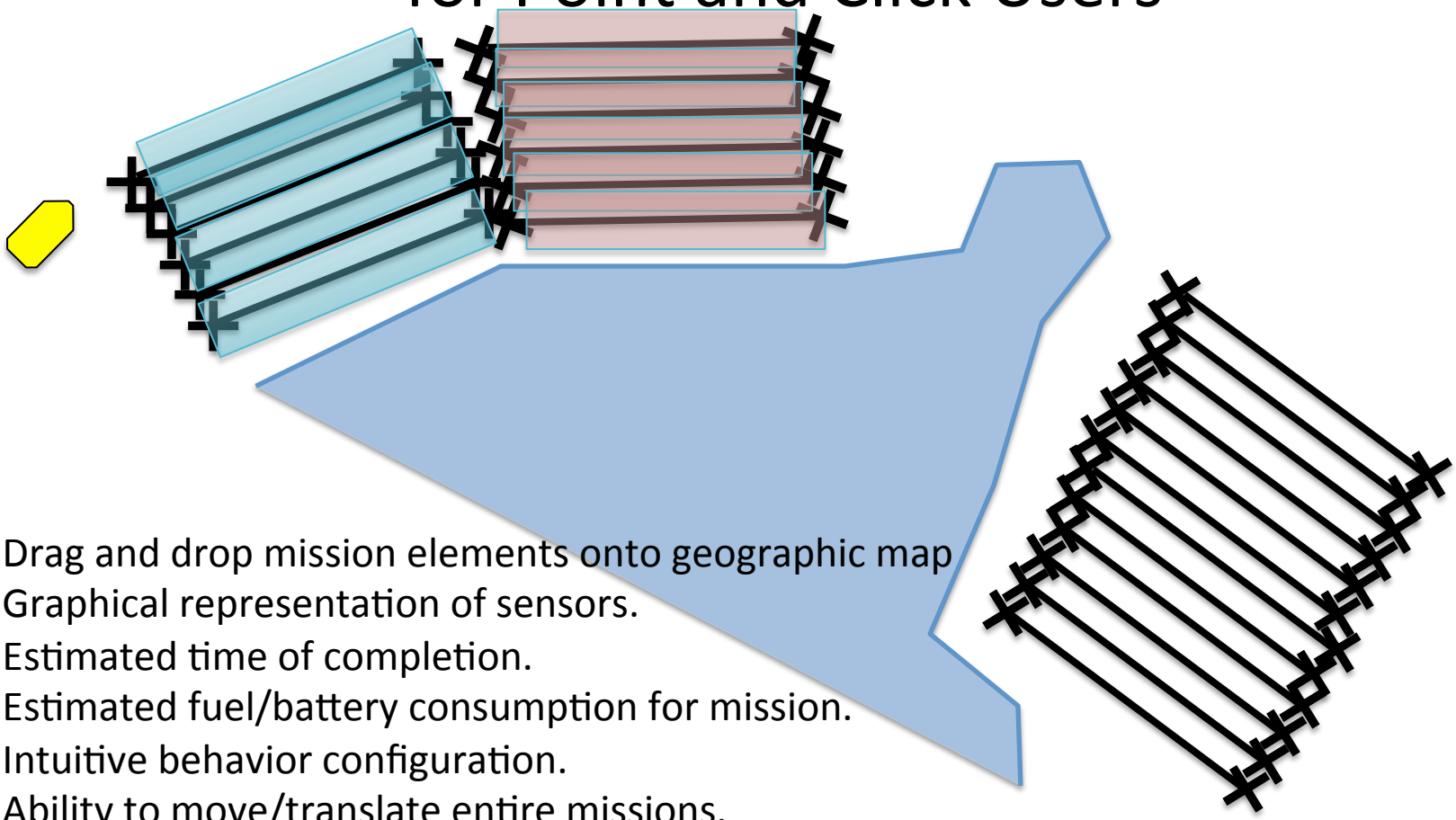
- Contour Following.
- COLREGS - Mariner thinking.
- Data quality and coverage monitoring.
- Foul weather operations.
- Object avoidance.
- Collision avoidance.
- Anticipatory Control w waves and currents.

Think like a Mariner

- Read the chart!
- Know the weather.
- Anticipate traffic.
- Know the Coast Pilot



Usability and Mission Planning for Point and Click Users



Drag and drop mission elements onto geographic map
Graphical representation of sensors.
Estimated time of completion.
Estimated fuel/battery consumption for mission.
Intuitive behavior configuration.
Ability to move/translate entire missions.
Ability to quickly model and illustrate mission to prevent errors.

Questions