Status of SAMOS/R2R real-time data protocol for UNOLS vessels

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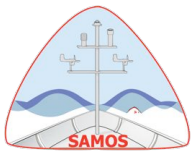
With thanks to other UNOLS operators

RVTEC 2010, BIOS, Bermuda – 15-18 Nov. 2010



http://samos.coaps.fsu.edu

http://www.rvdata.us

Real-time NAV, MET and TSG data acquisition

- Collaborating with R2R, the SAMOS data center is recruiting more UNOLS vessels
  - We focus on the collection, quality evaluation, and distribution of underway meteorological, thermo-salinograph, and essential navigational observations

Primary and secondary parameters for routine data acquisition from Shipboard Automated Meteorological and Oceanographic Systems (SAMOS) on research vessels.

Primary	Secondary (desired if available)
• Observation time (UTC)	• Vessel pitch, roll, and heave
• Latitude	• Photosynthetically Active Radiation (PAR)
• Longitude	• Ultraviolet radiation
• Ship course over ground	• Total Radiation
• Ship speed over ground	• Visibility (from automated sensor)
• Ship heading	• Ceiling (from automated sensor)
• Ship speed over water (fore-aft and along beam components)	• Radiometric Sea Surface Temperature
• Ship-relative wind speed and direction *(as measured by anemometer)*	• Swell and wind wave heights and directions *(if measured by automated system)*
• Earth-relative (true) wind speed and direction *(calculated)*	• Weather, cloud cover, and cloud height *(desired, but not anticipated as automation is unlikely)*
• Earth-relative (true) wind speed	
• Atmospheric pressure	
• Air temperature	
• Moisture (dewpoint temperature, wet-bulb temperature, relative humidity, and/or specific humidity)	
• Precipitation	
• Shortwave radiation	
• Longwave radiation	
• Sea temperature *(both external and at the TSG)*	
• Salinity *(from TSG)*	
• Conductivity *(from TSG)*	

SAMOS

rvdata.us

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NSF NOAA COAPS

Why?

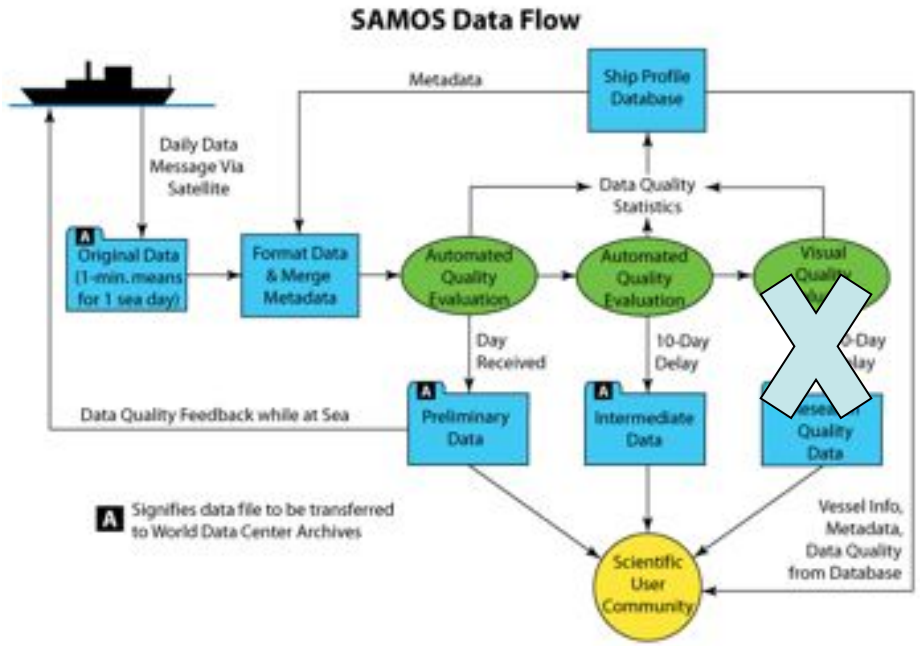
- SAMOS distributes MET/TSG data to a wide range of secondary users
  - Satellite sensor/product developers
  - Air-sea interaction and physical process research groups
  - Atmospheric and oceanic modelers
  - Operational weather centers

- Operator benefits
  - Routine quality evaluation
  - At-sea feedback when problems are detected
  - Decision support for vessels wishing to improve their sensor suites and/or instrument exposure
  - Expanded user community

Transfer Options from RVTEC 2009

- Expand use of original SAMOS data transfer protocol
  - Operator must conduct data reduction
  - Operator must provide data and metadata in desired format
  - Use of NOAA SCS or custom developed code required
- Develop protocol to transfer full sampling rate data from ship to shore (SAMOS 2.0)
  - Operator must provide data and metadata in desired format
  - All data reduction/processing done at SAMOS data center
- Develop “SAMOS box” for installation on UNOLS vessels
  - Plan would have serial feeds enter box, all data reduction done on board, reduced data transmitted to shore
  - No funding available to support this effort.

Original SAMOS data exchange protocol



- Current vessels:
  - *Atlantis, Knorr, Oceanus* (Caliope)
  - *Atlantic Explorer, Healy, Polar Sea* (SCS)
  - *Kilo Moana* (UH custom code)
  - 17 NOAA, 2 NSF Polar, 2 Australian vessels

- Data reduction completed on vessels
  - Transmission to data center only includes one-minute averages, true winds, etc.
  - FSU center does not receive higher frequency data
- Transmission are
  - Completed using emails sent via HiSeasNet
  - Once per day (00 UTC)
  - Data can be delayed to reduce transmission cost
- Format is key:value paired ASCII developed by SAMOS

Proposed SAMOS 2.0 Protocol

- Design Requirements:
  - Capture NAV, MET, and TSG data in physical units at the instrument sampling rate on each vessel (upwards of 1 Hz for some systems)
  - Minimize processing of data by vessel operators
  - Use NMEA 0183 standard sentences when possible
  - Capture essential metadata for vessel and instruments along with the data
  - Use machine readable formats that support downstream automation of processing
  - Ensure that data files are “self-describing” (e.g., need no additional documentation to be processed)
  - Interface with relevant developments within the R2R (and other groups)

Proposed SAMOS 2.0 Protocol

- Design requirements (cont.)
  - data transmission will again focus on using satellite comms (HiSeasNet, etc.)
  - data to be sent to a central real-time server at R2R
  - enable data transmission more frequently than once per day
    - (rate minimally 6 hourly for vessels to participate in WMO VOS)

- Data reduction (averaging, true wind calculation) will be done by SAMOS data center prior to quality processing
  - SAMOS will pull data files from R2R
  - SAMOS will harvest and monitor instrument metadata for changes

Proposed exchange format

- Focus of discussion over past year has been on the metadata that are necessary to describe the NAV, MET, and TSG data.
- Two file formats under consideration:
  - CSV
  - XML
- At present, SAMOS data center is willing to accept both CSV and XML formats

Proposed exchange format

Main components:

- Four metadata header groups
  - META_VESSEL - information related to the vessel providing the data
  - META_CRUISE - information related to an individual cruise
  - META_SOURCE - describes the source of the data (talker to destination)
  - META_DATA – describes the content of the data lines

- Each META group is followed by VESSEL, CRUISE, SOURCE, and DATA records containing the values outlined by the META headers

Content
The protocol is designed to include four sections, META_VESSEL, META_CRUISE, META_SOURCE, and META_DATA, each of which contain metadata headers and the corresponding values associated with the header information. For reference, two CSV examples are provided at the end of this document from the OSU data acquisition system. Note that each field has a priority level: required, strongly recommended, recommended, and optional. The required fields are designed to provide continuity between data provided by different vessels. Optional fields can be created to meet the individual operator needs and have no strict naming conventions. In the examples below, optional field names are just suggestions. The blocks and their content include:

META_VESSEL
Required block containing information related to the source vessel for the data. The header line is followed by a corresponding VESSEL data line.

Field	*Field Priority*	*Definition*
Name	Required	Full name of vessel
Call_Sign	Required	Vessel call sign
IMO_Number	Required	Unique International Maritime Organization number for vessel

META_CRUISE
Optional block containing information related to an individual cruise. The header line is followed by the corresponding CRUISE data line. The following field names are suggested by the developers and the META_CRUISE block can be extended by individual operators to include fields desired to define their cruises. The developers envision developing a vocabulary of fields which will be recommended for use by operators to avoid multiple field headings for the same parameter (e.g., Chief_Scientist versus ChSci or ScientistInCharge).

Field	*Field Priority*	*Definition*
Cruise_ID	Recommended	Operator defined cruise identifier
Primary_Investigator	Optional	Name of PI on cruise
Chief_Scientist	Optional	Name of Chief Scientist on cruise
Marine_Technician	Optional	Name(s) of marine technician on cruise
Cruise_Start	Optional	Start time of cruise (ISO 8601)

META_SOURCE
Required block describing the source of the data. The header line will be followed by one or more SOURCE data lines. Multiple SOURCE lines are needed to trace the path from the instrument physically sensing the DATA to the final data file name containing the observations. Although there may be multiple SOURCE lines in the example block, they each contain values for every field in the META_SOURCE header line.

Field	*Field Priority*	*Definition*
Name	Required	Name of data talker
Make	Strongly Recommended	Make of data talker
Model	Strongly Recommended	Model of data talker
Version	Recommended	Software/firmware version for talker
Serial_Number	Required	Serial number of data talker
Location	Required	Location of data talker –The developers envision the location to include an x, y, z coordinate relative to a known and defined reference on the vessel; measurement units (meters strongly recommended) for x, y, z; a descriptive name (e.g., doghouse, mainmast); and an optional survey_reference for the coordinate system (e.g., who conducted the vessel survey and when).
Destination	Required	The receiver of the information from the talker
Calibration_Date	Required	The date of last calibration of the talker
Calibration_Name.#	Required	The name/variable name of calibration value #, where #=1,2,3…
Calibration_Value.#	Required	The calibration value paired with the Calibration_Name.#

Notes:

- The number of calibration_name and calibration_value pairs is talker dependent. For example a Sea-Bird SBE3 has six calibration values with letter names corresponding to the equation to determine salinity from conductivity, temperature, and pressure.
- There will be a discussion of coordinate systems and terminology at RVTEC 2010.

META_DATA
A required block that describes the content of the data lines. The format provided for eight header lines, each which apply to all DATA lines within the file.

Header name	*Definition*
META_DATA_NAME	Used to uniquely name every field in the DATA lines. Currently the only standard name is "Timestamp".
META_DATA_SAMOS_NAME	Desired fields for data that maps to the parameters of interest to SAMOS. Providing this mapping will ease automation of SAMOS data processing. E.g., Wind_Speed in Example 2 would map to PL_WSPD (platform relative wind speed) in the SAMOS convention. This mapping can be worked out during the SAMOS recruitment process.
META_DATA_FORMAT	The format of the fields in DATA. These can be descriptive as for Timestamp in the examples or may simply define whether the data field is alphabetic=alpha, numeric, alphanumeric, binhex, etc.
META_DATA_UNITS	Units descriptors for each field. If left blank, the value is assumed to be unitless (discouraged, if any unit applies please include). Recommend using fully spelled out units. A short controlled vocabulary or UNITS developed at FSU is provided in Table 1. This was developed to fit the UDUNITS convention of the University Corporation for Atmospheric Research (http://www.unidata.ucar.edu/software/udunits/udunits-1/etc/udunits.dat)
META_DATA_REFERENCE_FRAME	Descriptors for the frame of reference for each field in DATA as needed. For example, this would be the location to note that your anemometer zero degree line is pointed towards the bow, that your time is in UTC, or your atmospheric pressure has been adjusted to sea level.
META_DATA_REFERENCE_STANDARD	Relevant reference standards for any DATA field as necessary. For example, time being ISO8601, water temperature being based on ITS-90, etc.
META_DATA_SOURCE	Maps each field in DATA to the respective SOURCE. In some cases, this will not map to a specific SOURCE line, but could be a constant value = 'constant', an equation, or a reference

	(URL) for an equation used to calculate the value (in many cases using the provided Calibration_value.#s.
META_DATA_PRECISION	Alphanumeric or numeric precision value for each field in DATA (as required). May be blank for some fields. Precision value(s) required to be in the same units as listed in META_DATA_UNITS.

The fields contained in these header lines vary in a manner that allows complete description of the contents of the DATA lines. The developers decided upon the following convention. The META_DATA_NAME line is REQUIRED to include a

- Timestamp – ISO8601 convention (strongly recommended), but other convention can be used if defined in META_DATA_FORMAT

followed by any fields necessary to describe the DATA lines.

When the DATA are standard NMEA0183 sentences (Example 1), a description is not required and “Sentence” is used to represent the data string in the META_DATA_NAME header. Note that NMEA0183 is listed as the META_DATA_REFERENCE_STANDARD for the “Sentence” field.

When a standard NMEA sentence is not used, all fields of the corresponding DATA line MUST be defined (Example 2).

Example 1: OSU Starboard GPS

```
META_VESSEL, "Name",       "Call_Sign", "IMO_Number"
VESSEL,      "R/V Wecoma", "WSD7079",   "076044390"

META_CRUISE, "Cruise_ID",       "Primary_Investigator", "Chief_Scientist", "Marine Technician", "Cruise_Start"
CRUISE,      "w1010c_moum",     "Jim Moum",             "Jim Moum",        "Dave O'Gorman",    "2010-10-24T03:00Z"

META_SOURCE, Name, Make, Model, Version, Serial_Number, Location, Destination, Calibration_Date, Calibration_Name.1, Calibration_Value.1,
Calibration_Name.2, Calibration_Value.2, Calibration_Name.3, Calibration_Value.3, Calibration_Name.4, Calibration_Value.4, Calibration_Name.5,
Calibration_Value.5, Calibration_Name.6, Calibration_Value.6
SOURCE, "xmltocsv_v2.0.generic", "Oregon State University", "Serial", "27 Oct 2010", , mizuki, gnss_starboardsuite_gps.csv, , configuration file, /usr/local/etc/
suds/sensor_gnss_starboardsuite_gps.yaml, configuration date, 2010-10-25, , , , , , , ,
SOURCE, DataStorm_gnss_starboardsuite_gps, Oregon State University, Serial, S1.0.7, 02-04-A3-42-02-06, gnss_starboardsuite_gps, xmltocsv_v2.0, ,
IP_Address, 10.240.158.108, , , , , , , , , ,
SOURCE, gnss_starboardsuite_gps, Garmin, GPS 17-HVS, , MARTECH_GPS_001, "0,0,0", DataStorm_gnss_starboardsuite_gps, None, , , , , , , , , , , ,

META_DATA_NAME, Timestamp, Sentence
META_DATA_SAMOS_NAME, ,
META_DATA_FORMAT, YYYY-MM-DDThh:mm:ssZ, alpha
META_DATA_UNITS, year-month-dayThour:minute:decimal_secondZ, ASCII
META_DATA_REFERENCE_FRAME, UTC,
META_DATA_REFERENCE_STANDARD, NTP, NMEA0183
META_DATA_SOURCE, DataStorm_gnss_starboardsuite_gps, gnss_starboardsuite_gps
META_DATA_PRECISION, 0000-00-01T00:00:00.001,
DATA, 2010-10-28T22:59:59.747Z, "$GPGSV,3,3,12,30,53,233,49,05,54,082,49,10,19,043,44,29,78,318,51*77"
DATA, 2010-10-28T22:59:59.838Z, "$GPVTG,202.0,T,183.9,M,003.3,N,0006.2,K*79"
DATA, 2010-10-28T23:00:00.208Z, "$GPGGA,230000,4726.4098,N,12223.3120,W,2,10,0.8,7.2,M,-17.5,M,,*72"
DATA, 2010-10-28T23:00:00.338Z, "$GPGSA,A,3,,16,25,21,31,02,12,,30,05,10,29,1.4,0.8,1.2*30"
DATA, 2010-10-28T23:00:00.476Z, "$GPGSV,3,1,12,51,33,159,45,16,08,326,44,25,43,199,39,21,35,250,47*72"
DATA, 2010-10-28T23:00:00.623Z, "$GPGSV,3,2,12,31,11,279,44,02,18,066,41,12,16,171,42,18,02,200,30*74"
DATA, 2010-10-28T23:00:00.768Z, "$GPGSV,3,3,12,30,53,233,49,05,54,082,49,10,19,043,44,29,78,318,51*77"
DATA, 2010-10-28T23:00:00.860Z, "$GPVTG,203.1,T,185.0,M,003.4,N,0006.2,K*71"
DATA, 2010-10-28T23:00:01.190Z, "$GPGGA,230001,4726.4089,N,12223.3125,W,2,10,0.8,7.2,M,-17.5,M,,*76"
DATA, 2010-10-28T23:00:01.303Z, "$GPGSA,A,3,,16,25,21,31,02,12,,30,05,10,29,1.4,0.8,1.2*30"
DATA, 2010-10-28T23:00:01.448Z, "$GPGSV,3,1,12,51,33,159,45,16,08,325,43,25,43,199,38,21,35,250,46*76"
```

Example 2: OSU Sonic Anemometer

```
META_VESSEL, "Name",       "Call_Sign", "IMO_Number"
VESSEL,      "R/V Wecoma", "WSD7079",   "076044390"

META_CRUISE, "Cruise_ID",       "Primary_Investigator", "Chief_Scientist", "Marine Technician", "Cruise_Start"
CRUISE,      "w1010c_moum",     "Jim Moum",             "Jim Moum",        "Dave O'Gorman",    "2010-10-24T03:00Z"

META_SOURCE, Name, Make, Model, Version, Serial_Number, Location, Destination, Calibration_Date, Calibration_Name.1, Calibration_Value.1,
        Calibration_Name.2, Calibration_Value.2, Calibration_Name.3, Calibration_Value.3, Calibration_Name.4, Calibration_Value.4, Calibration_Name.5,
        Calibration_Value.5, Calibration_Name.6, Calibration_Value.6
SOURCE, "xmltocsv_v2.0.generic", "Oregon State University", "Serial", "27 Oct 2010", , mizuki, anemometer_mainmast.csv, , configuration file, /usr/local/etc/
        suds/sensor_anemometer_mainmast.yaml, configuration date, 2010-10-21, , , , , , , ,
SOURCE, DataStorm_anemometer_mainmast, Oregon State University, Serial, S1.0.7, 02-04-A3-42-02-08, anemometer_mainmast, xmltocsv_v2.0, ,
        IP_Address, 10.240.158.118, , , , , , , , , ,
SOURCE, anemometer_mainmast, Gill, Wind_observer_II, , , "0,0,0", DataStorm_anemometer_mainmast, , , , , , , , , , , , ,

META_DATA_NAME, Timestamp, Start_string, Wind_Direction, Wind_Speed, Speed_Units, Speed_of_Sound, Sonic_Temperature, Status, Checksum
META_DATA_SAMOS_NAME, , , , , , , , ,
META_DATA_FORMAT, YYYY-MM-DDThh:mm:ssZ, alpha, numeric, numeric, alpha, numeric, numeric, alpha, binhex
META_DATA_UNITS, year-month-dayThour:minute:decimal_secondZ, , degrees, knots, N=knots, meters/second, celcius, 00=okay,
META_DATA_REFERENCE_FRAME, UTC, , bow of ship, , , , , ,
META_DATA_REFERENCE_STANDARD, NTP, , , , , , , ,
META_DATA_SOURCE, DataStorm_anemometer_mainmast, anemometer_mainmast, anemometer_mainmast, anemometer_mainmast, anemometer_mainmast,
        anemometer_mainmast, anemometer_mainmast, anemometer_mainmast, anemometer_mainmast, anemometer_mainmast
META_DATA_PRECISION, 0000-00-01T00:00:00.001, , 1, , , , , ,
DATA, 2010-10-28T22:00:00.051Z, A,028,008.49,N,+342.72,+018.45,00, 0A
DATA, 2010-10-28T22:00:01.051Z, A,032,008.60,N,+342.62,+018.28,00, 00
DATA, 2010-10-28T22:00:02.051Z, A,030,008.31,N,+342.77,+018.54,00, 09
DATA, 2010-10-28T22:00:03.051Z, A,031,008.12,N,+342.77,+018.54,00, 09
DATA, 2010-10-28T22:00:04.050Z, A,032,007.88,N,+342.77,+018.54,00, 06
DATA, 2010-10-28T22:00:05.050Z, A,036,007.97,N,+342.62,+018.28,00, 03
```

```
<?xml version="1.0" encoding="utf-8"?>
<datafile>
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    <call_sign>WCE5063</call_sign>
    <imo_number>7604300</imo_number>
    <coordinatesystem>
      <xPositive>Starboard</xPositive>
      <xOrigin>Centerline</xOrigin>
      <yPositive>Forward</yPositive>
      <yOrigin>Fantail</yOrigin>
      <zPositive>Up</zPositive>
      <zOrigin>Plimsol</zOrigin>
      <MeasurmentUnits>Meters</MeasurmentUnits>
    </coordinatesystem>
  </meta_ship>
  <meta_cruise>
    <cruise_id>EN-488</cruise_id>
    <principle_investigator>Ned Edwards</principle_investigator>
    <chief_scientist>Michael Dutton</chief_scientist>
    <marine_technician>Marine Tech</marine_technician>
  </meta_cruise>
  <meta_data>
    <talker>
      <make>Garmin</make>
      <model>GPS 17N</model>
      <serial_number>R-231.2</serial_number>
      <location>
        <x>2.0</x>
        <y>42.0</y>
        <z>7.1</z>
        <description>Pilothouse roof</description>
      </location>
    </talker>
    <timestamp>
      <format>yyyymmddThhmmss.sssZ</format>
      <units>year|month|day|T|hour|minute|decimal_seconds|Z</units>
      <reference_frame>UTC</reference_frame>
      <source>
        <make>Symmetricom</make>
        <model>GPS-XL</model>
        <serial_number>45623</serial_number>
      </source>
    </timestamp>
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      <value_delimiter_hex>,</value_delimiter_hex>
    </dataSentence>
    <dataSentence>
      <id>$GPVTG</id>
      <value_delimiter_hex>,</value_delimiter_hex>
    </dataSentence>
  </meta_data>
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  <data time="20101104T145557.609Z">$GPVTG,255,T,270,M,000.0,N,0000.0,K*79</data>
  <data time="20101104T145557.875Z">$GPGLL,4129.4215,N,07125.2967,W,185557,A*34</data>
  <data time="20101104T145557.953Z">$GPVTG,255,T,270,M,000.0,N,0000.0,K*79</data>
```

```
</datafile>
```

```
<?xml version="1.0" encoding="utf-8"?>
<datafile>
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    <call_sign>WCE5063</call_sign>
    <imo_number>7604300</imo_number>
    <coordinatesystem>
      <xPositive>Starboard</xPositive>
      <xOrigin>Centerline</xOrigin>
      <yPositive>Forward</yPositive>
      <yOrigin>Fantail</yOrigin>
      <zPositive>Up</zPositive>
      <zOrigin>Plimsol</zOrigin>
      <MeasurmentUnits>Meters</MeasurmentUnits>
      <Description></Description>
    </coordinatesystem>
  </meta_ship>
  <meta_cruise>
    <cruise_id>EN-488</cruise_id>
    <principle_investigator>Ned Edwards</principle_investigator>
    <chief_scientist>Michael Dutton</chief_scientist>
    <marine_technician>Marine Tech</marine_technician>
  </meta_cruise>
  <meta_data>
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      <value_delimiter_hex>,</value_delimiter_hex>
      <field>
        <samos_name>SamosRelativeWindDirection</samos_name>
        <format>numeric</format>
        <units>degrees</units>
        <reference_frame>Relative to bow</reference_frame>
      </field>
      <field>
        <samos_name>SamosIndicator</samos_name>
        <format>alpha</format>
        <units>R=relative,T=true</units>
      </field>
      <field>
        <samos_name>SamosRelativeWindSpeed</samos_name>
        <format>numeric</format>
        <units>knots</units>
```

```
    </field>
    <field>
      <samos_name>SamosIndicator</samos_name>
      <format>alpha</format>
      <units>K=knots</units>
    </field>
    <field>
      <samos_name>SamosIndicator</samos_name>
      <format>alpha</format>
      <units>A=valid</units>
    </field>
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      <model>05103</model>
      <serial_number>80131</serial_number>
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        <x>12</x>
        <y>40</y>
        <z>15</z>
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      </location>
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      <units>degrees</units>
      <reference_frame>Relative to bow</reference_frame>
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      <format>alpha</format>
      <units>R=relative,T=true</units>
    </field>
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```

```
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        <serial_number>80132</serial_number>
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          <x>-12</x>
          <y>40</y>
          <z>15</z>
          <description>Top platform, Port</description>
        </location>
        <calibration>
          <cal_date>2010-01-12</cal_date>
        </calibration>
      </source>
    </dataSentence>
  </meta_data>
  <data time="20101104T162220.859Z">$PSMWV,90.1,R,12.2,K,A*48</data>
  <data time="20101104T162220.875Z">$PPMWV,87.1,R,10.4,K,A*3A</data>
  <data time="20101104T162221.859Z">$PSMWV,91.2,R,11.6,K,A*48</data>
  <data time="20101104T162221.875Z">$PPMWV,89.9,R,10.1,K,A*3A</data>
</datafile>
```

Discussion Topics

- Operator preference for adopting CSV vs. XML
- Vessel coordinate systems – for sensor location metadata
- Use of controlled vocabularies