# GPS BREAKOUT SESSION:

# USING RAW NAVIGATION DATA FOR PRECISE POINT POSITIONING (PPP)

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# SHIPBOARD GNSS TO MEASURE TSUNAMI SIGNALS

- Need for subduction zone-wide expansion of a DART-style tsunami warning system.
- Tsunami forecasting capabilities could be improved by ingesting precise shipping fleet GPS positions within a real-time operational framework.
- Band-pass filtered GPS displacement time series supplies wave height and period estimates.
- Real-time precise point positioning (Zumberge, 1997) provides displacement estimates with centimeter-level accuracy, without the need for a reference station. This method results in noise levels of less than 10 cm over the frequency range of interest.
- Synthetic ship height observations is comparable to that derived from the existing network of OBP and GPS buoys (Inazu, 2016)
- Combined use of seafloor pressure measurements coupled with direct sea surface measurements from GNSS will help to better understand the relationship between seafloor deformation and ultimate tsunami wave generation.

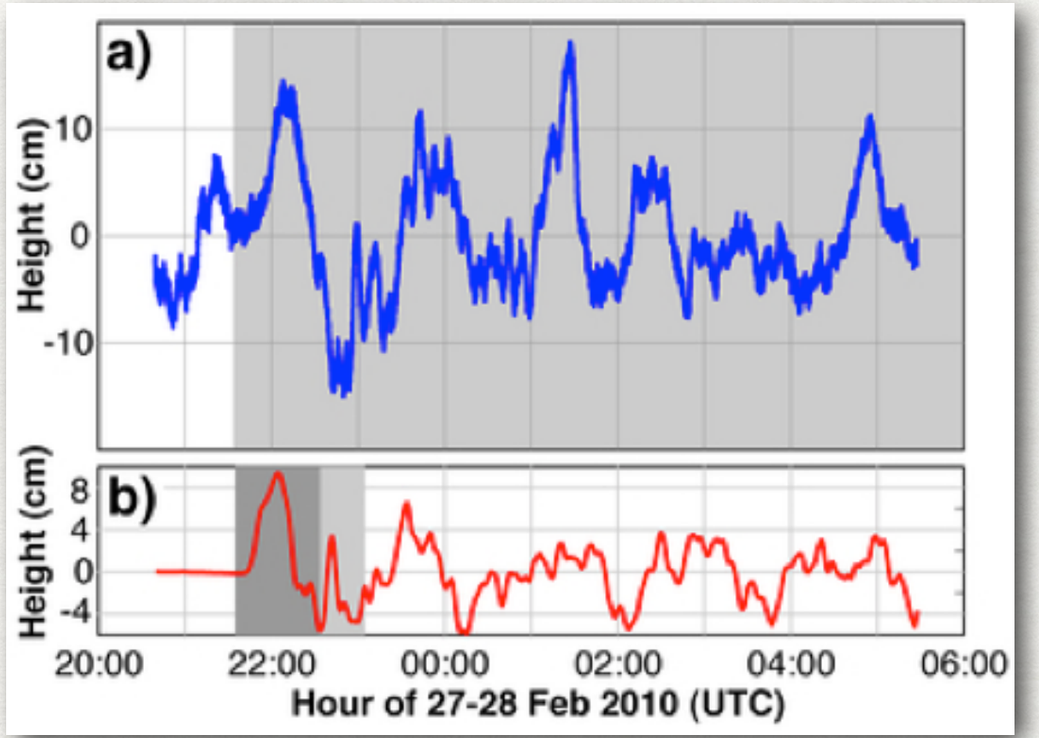
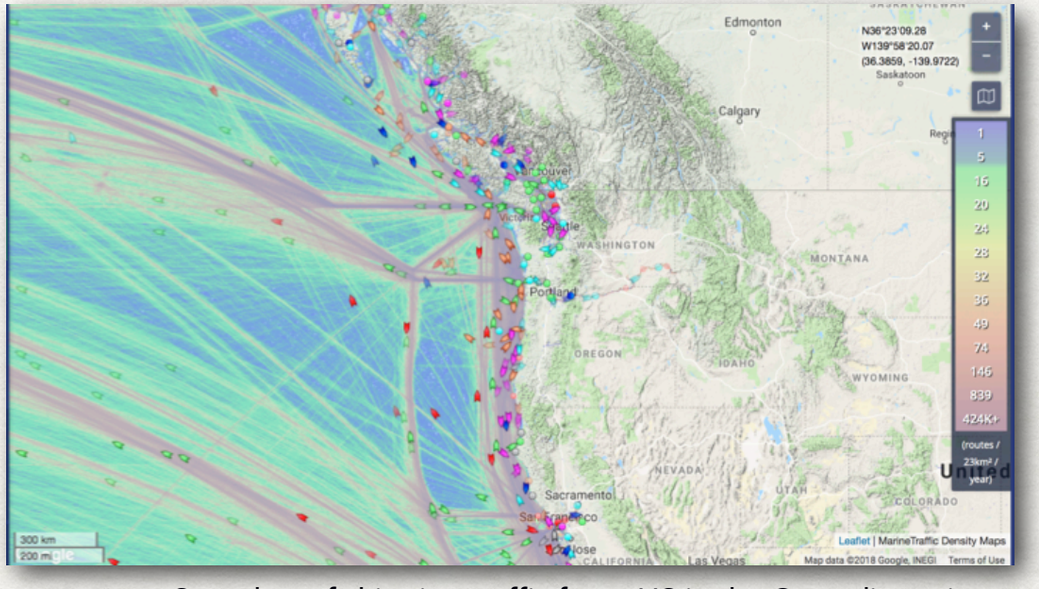


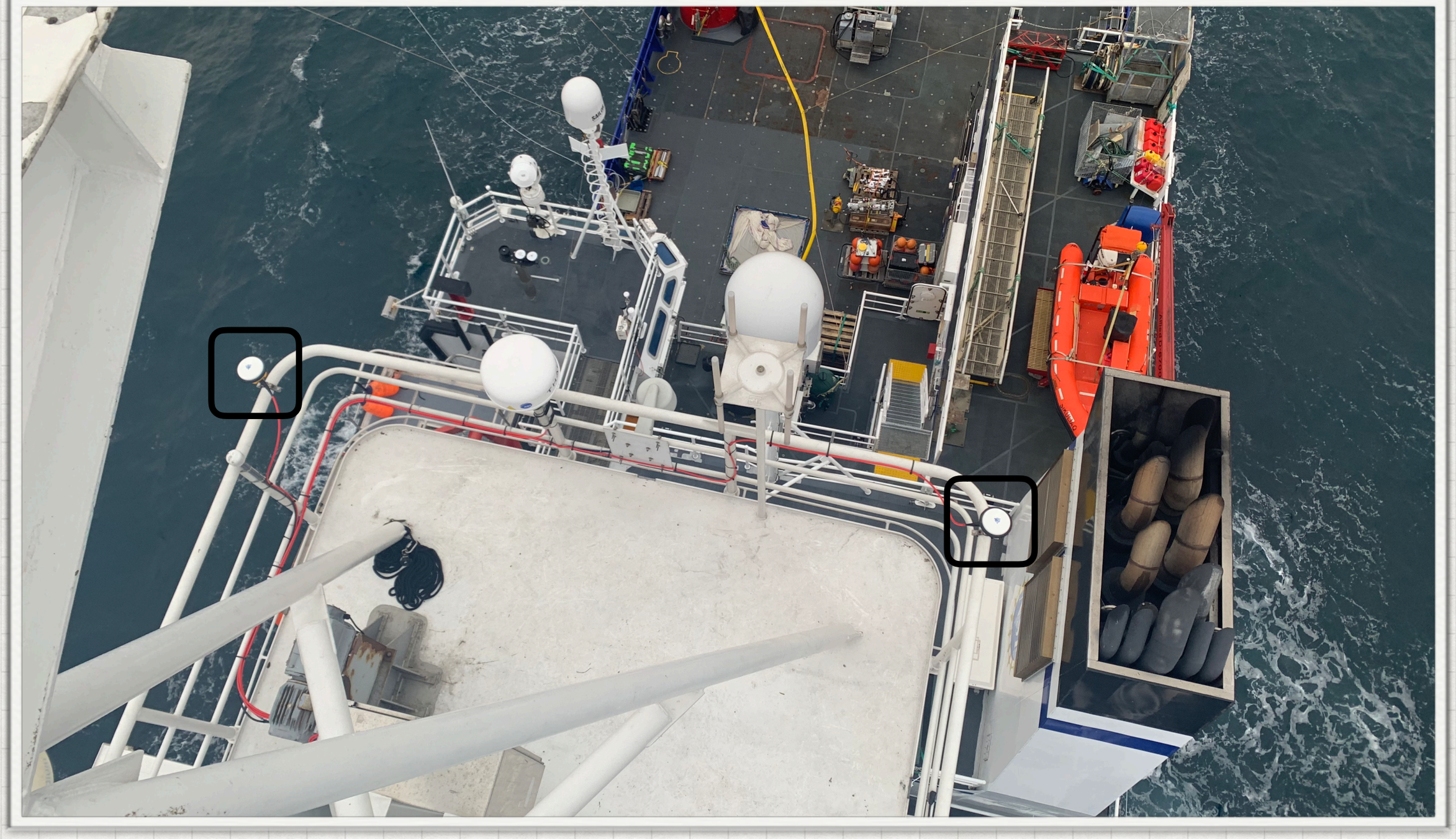

Figure from Foster et al. (2012)




Snapshot of shipping traffic from AIS in the Cascadia region.

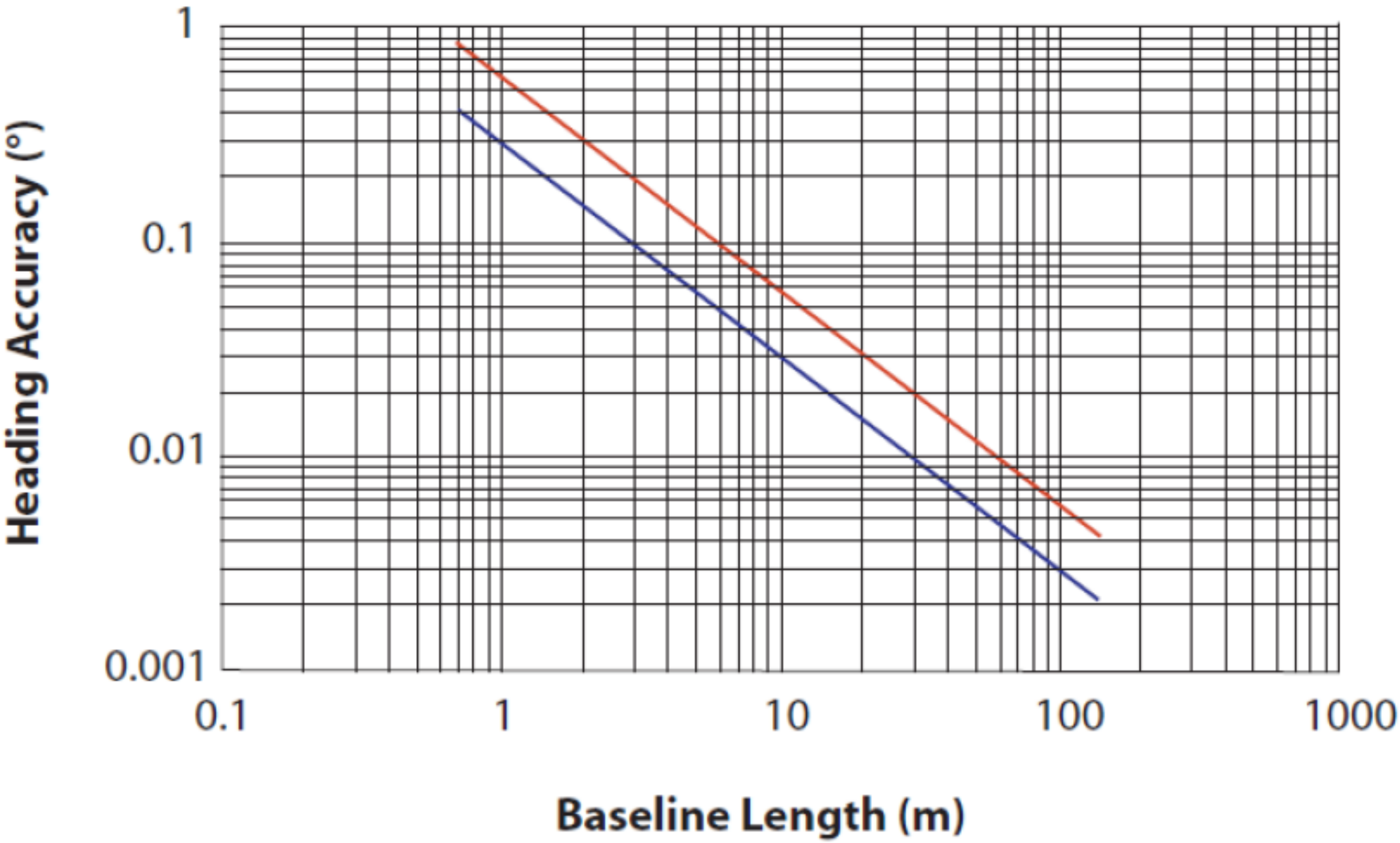
# ANTENNA INSTALLATION

## 90 DEG AZIMUTH OFFSET / 3.6 METER VECTOR LENGTH

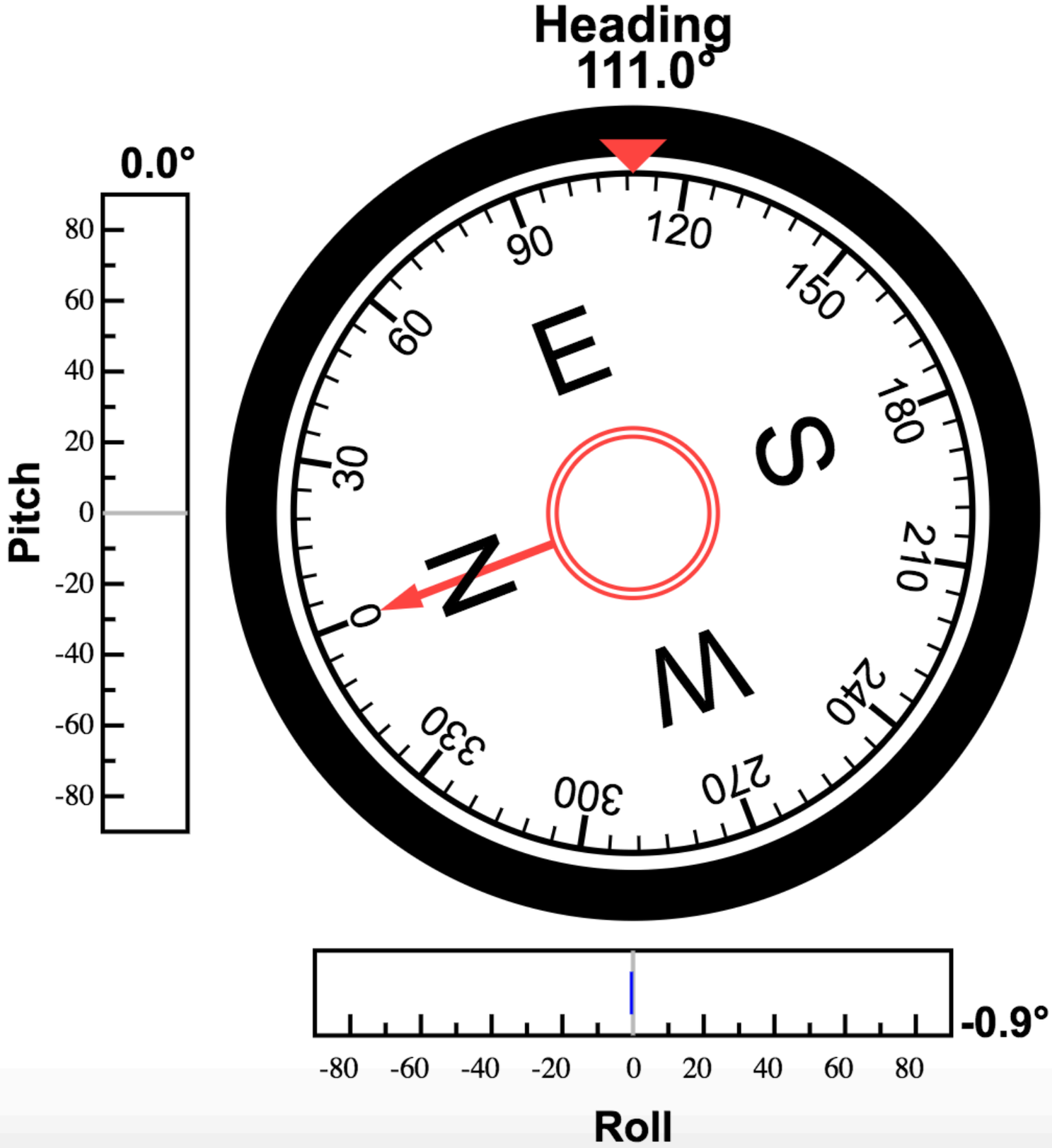


# EXPECTED HEADING ACCURACY

## MULTIPATH EFFECTS, VEHICLE FLEXING, CORRELATED ERRORS



# ATTITUDE DISPLAY




**Status:** Solution Available (Fixed Solution)

**Heading:** 111.010°
**Roll:** -0.900°
**Vector Length:** 3.350 m
**MRMS:** 0.006 m
**BRMS:** 0.004 m

# PROGRAMMING DATA OUTPUTS

| Type | Port | Name | Input | Output<br>Primary Antenna | Output<br>Secondary Antenna |
|---|---|---|---|---|---|
| **Serial** | **A<br>(115200bds)** | **A** | **-** | **-** | **-** |
| Serial | B<br>(115200bds) | B | - | NMEA-GGA(1 Hz)<br>NMEA-HDT(1 Hz)<br>NMEA-VTG(1 Hz)<br>NMEA-ZDA(1 Hz)<br>NMEA-ARR(1 Hz) | - |
| Serial | F<br>(115200bds) | F | - | - | - |
| USB serial | - | U | - | - | - |
| Internal Radio | D<br>(38400bds) | D | - | - | - |
| Bluetooth | - | C | - | - | - |
| Bluetooth | - | H | - | - | - |
| Bluetooth | - | T | - | - | - |
| UDP | 255.255.255.255:53140 | I | - | NMEA-GGA(1 Hz)<br>NMEA-GLL(1 Hz)<br>NMEA-HDT(1 Hz)<br>NMEA-VTG(1 Hz)<br>NMEA-ZDA(1 Hz) | - |
| UDP | 255.255.255.255:53141 | J | - | RTCM-1006(Pending) | - |
| IBSS/NTRIP/DirectIP | - | P | - | - | - |
| IBSS/NTRIP/DirectIP | - | Q | - | - | - |
| Memory | USB Device | M | - | ATOM-ATR<br>ATOM-NAV<br>ATOM-RNX-0(1 Hz)<br>ATOM-OCC | ATOM-ATR<br>ATOM-RNX-0(1 Hz) |
| Session | #1 | S | - | ATOM-ATR<br>ATOM-NAV<br>ATOM-RNX-0(1 Hz)<br>ATOM-OCC | ATOM-ATR<br>ATOM-RNX-0(1 Hz) |
| Session | #2 | N | - | ATOM-ATR<br>ATOM-NAV<br>ATOM-RNX-0(1 Hz) | ATOM-ATR<br>ATOM-RNX-0(1 Hz) |

# RAW DATA RECORDING

## Memory

| | | |
|---|---|---|
| **Internal Memory :** | **0% (3 Files)** | 6.6 GB |
| **Log Files Memory :** | **4% (10 Files)** | 52.5 MB |
| **USB Device :** | **21% (192 Files)** | 59.1 GB |

## Files

**Internal Memory** ○ **Log Files Memory** ○ **USB Device** ◉

**Select filter:** All Files (**)

/

| Name | Size | Modification Date |
|---|---|---|
| **SanDiskSecureAccess** | | 2019-07-12T10:20:56Z |
| RunSanDiskSecureAccess_Win.exe | 15.3 MB | 2019-07-12T10:21:02Z |
| **.Spotlight-V100** | | 2019-07-12T10:21:06Z |
| G7520A19.279 | 48.6 MB | 2019-10-06T23:59:42Z |
| G7520A19.280 | 142.7 MB | 2019-10-07T23:59:42Z |
| G5527A19.188 | 4.3 MB | 2019-07-12T10:21:08Z |
| G5527B19.188 | 44.5 MB | 2019-07-12T10:21:28Z |
| G5527A19.189 | 153.6 MB | 2019-07-12T10:22:34Z |
| G7520A19.190 | 86.9 MB | 2019-07-12T10:23:10Z |
| MPS865_95527_190050429.par | 174.0 KB | 2019-07-12T10:23:10Z |
| 5527189a.19d.Z | 16.6 MB | 2019-07-12T10:23:18Z |
| 5527189a.19g.Z | 27.0 KB | 2019-07-12T10:23:18Z |

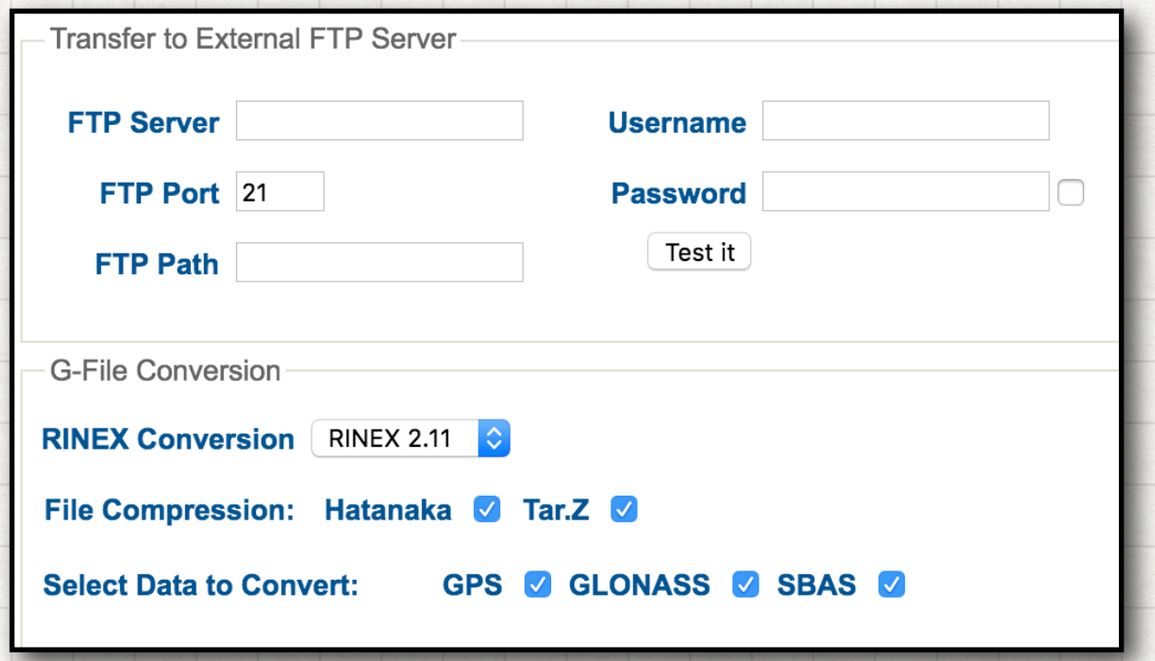
# HIGH QUALITY RAW DATA TO MEET REFERENCE STATION APPLICATIONS

## Precise positioning performance

### Real-Time Accuracy (RMS)

1 2

- Real-Time DGPS Position:
  - Horizontal: 25 cm (0.82 ft) + 1 ppm
  - Vertical: 50 cm (1.64 ft) + 1 ppm
- Real-Time Kinematic Position (RTK):
  - Horizontal: 8 mm (0.026 ft) + 1 ppm
  - Vertical: 15 mm (0.049 ft) + 1 ppm
- Network RTK [3]:
  - Horizontal: 8 mm (0.026 ft) + 0.5 ppm
  - Vertical: 15 mm (0.049 ft) + 0.5 ppm




| Identity | |
|---|---|
| Receiver Type | **MPS865** |
| Serial Number | **5751R95527** |
| Ethernet MAC Address | **00:09:66:02:18:82** |
| WiFi MAC Address | **A8:1B:6A:8F:34:99** |
| Firmware Version | **3.74** |
| Firmware Date | **2019-02-28** |
| U-Boot Version | **0.14** |
| Linux Version | **4.1.15 #1026 SMP Apr/Thu/MSK** |
| PMU Version | **1.6** |
| SL | **SS83V19** |
| PVT | **SP83V17** |
| DSP | **SC83V17** |
| HTML | **SH83V16** |
| WS | **SW83V07** |
| Modem Version | **PHS8-P VER: 03.001 IMEI: 358625053701027** |
| Internal Radio Version | **XDL V02.02(3)** |
| Antenna Database Version | **8.36** |
| RINEX Converter | **2.05 ( GPP.DLL V3.1.32.1 / rdc.lib 2, 1, 1, 0 )** |

**Geofencing:** Worldwide
**Firmware Warranty Date:** 2020-05-09

| Option | | Installed |
|---|---|---|
| GPS | N | ✓ |
| GLONASS | G | ✓ |
| Galileo | O | |
| BeiDou | B | |
| L2 Frequency Tracking | Y | ✓ |
| L5 Frequency Tracking | Q | |
| L6 Frequency Tracking | T | |
| 2Hz Output Rate | 2 | |
| 5Hz Output Rate | 5 | |
| 10Hz Output Rate | 6 | |
| 20Hz Output Rate | W | ✓ |
| 50Hz Output Rate | 8 | |
| RTK Rover | J | |
| RTK Base | K | |
| Flying RTK | F | |
| RAIM | I | ✓ |

| Option | | Installed |
|---|---|---|
| Data Recording | R | ✓ |
| DUO Mode | D | ✓ |
| 3D-attitude | E | ✓ |
| L-Band | L | ✓ |
| GPRS Modem | M | ✓ |
| WiFi Module | U | ✓ |
| IRNSS | H | |
| Dithered RTK 30/30 | 3 | ✓ |
| Dithered RTK 7/2 | 7 | |
| Dithered RTK 10/10 | d | |
| CenterPoint RTX | C | |
| RangePoint RTX | P | |
| ViewPoint RTX | 4 | |
| FieldPoint RTX | 9 | |
| RTX RAM | 1 | ✓ |
| Embedded Caster | c | |

# VESSELS OF INTEREST

## WHO WANTS IN? *A MIX OF SHIP TYPES WOULD BE IDEAL*

- Several PIs are particularly interested in the **Cascadia** region, so vessels that operate regularly in the **Pacific Northwest**.
- There is great interest in offshore **Alaska**, so Sikuliaq remains a good vessel to support those studies.
- **Hawaii** is also in a good location for detecting tsunami signals of interest.
- Ships that are restricted to the Atlantic Ocean would not be as high a priority.
- Global-class vessels with expeditions anywhere in the Pacific Ocean.
- By having a mix of ship types, we can evaluate the signal quality from the different platforms.

# ARCHIVING & R2R DISTRIBUTION

## CAN IT BE A STANDARD DATA PRODUCT?

- Using the same GNSS receiver dedicated to this raw GNSS data recording would streamline the process.
- Raw G-files can be submitted with no additional processing steps. Do we leave it to the data miners to address RINEX conversion?
- These would be considered “hosted” systems, therefore we expect the group of geophysical PIs (led by Anne Sheehan) to assist with QC.
- Is anyone here from R2R? What do you think?