TWLWG7
NOAA Presentation

Recent Advances in Technology

4/21/2015

NOAA Development of GPS Buoy for Water Level Measurement

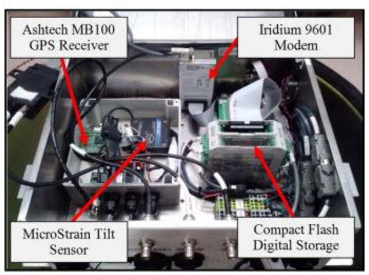
Hydrolevel System Description

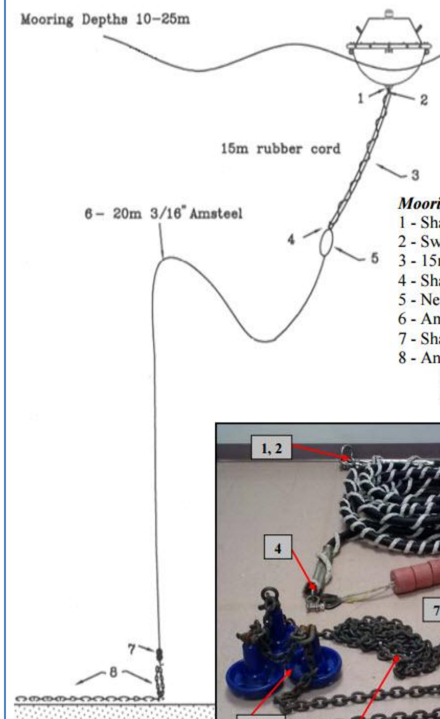
Hydrolevel Buoy
Diameter: 0.6m (25.5")
Weight: 156 lbs.
Telemetry: Iridium (WiFi available)
Sensors: L1/L2 GPS
3-Axis Tilt
Endurance: ~40 days
Nav. Light: Amber, 5 flash every 20 sec

Environmental Constraints:
- Sustained Surface Currents <1 knot
- Sustained Wave Height < 4m
- GPS Baseline <~25km

Assembly/Hardware
- 3/8" AISI stainless steel hull
- 11mm torque wrench
- 12 bolts around equator
- Custom-cut rubber gasket on equator

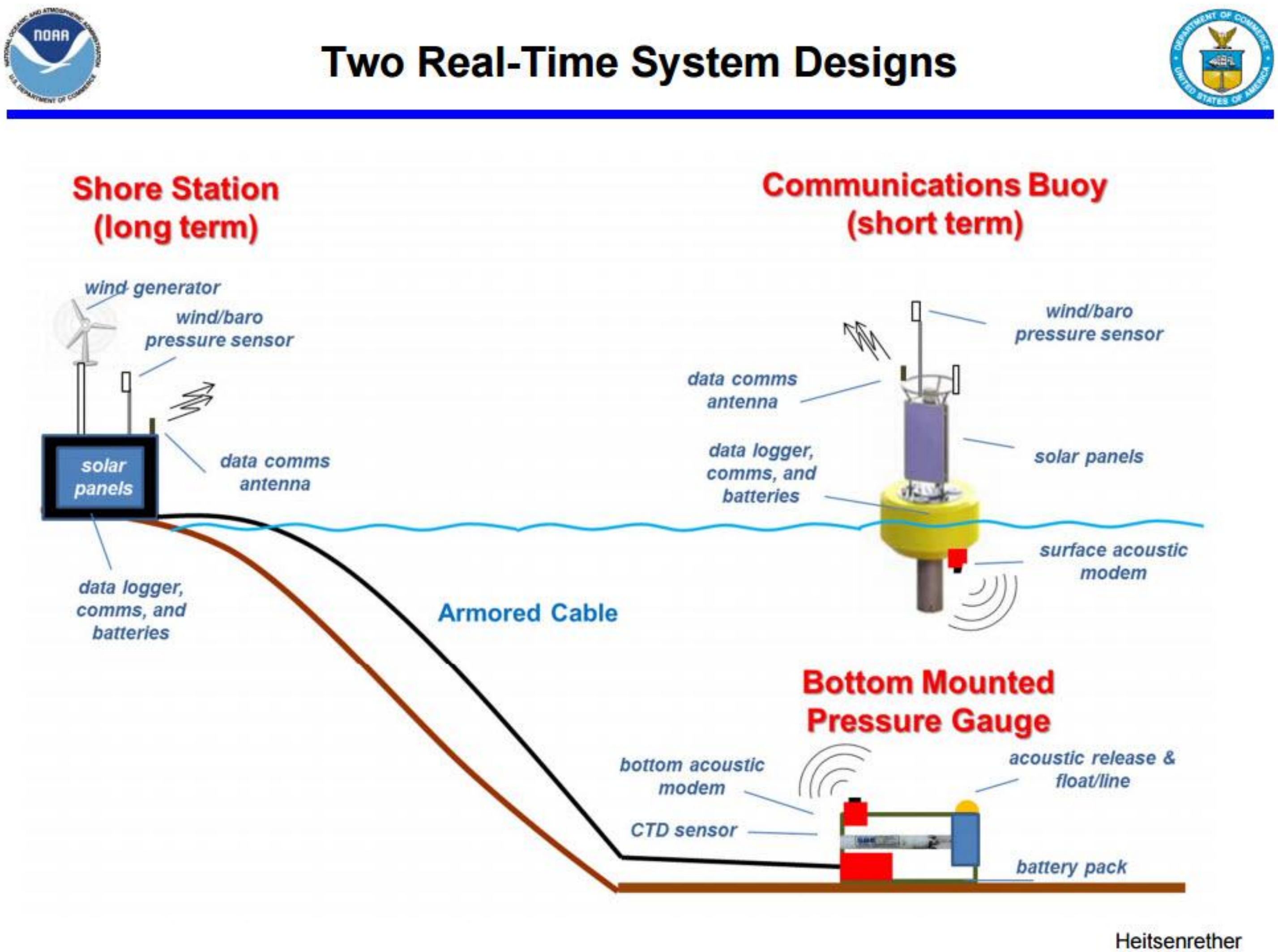
Charging Requirements:
- Two 60 Ah $LiFePO_4$ rechargeable batteries *(included)*
- Standard 120V AC charging
- 60 "D-Cell" Lithium non-rechargeable batteries



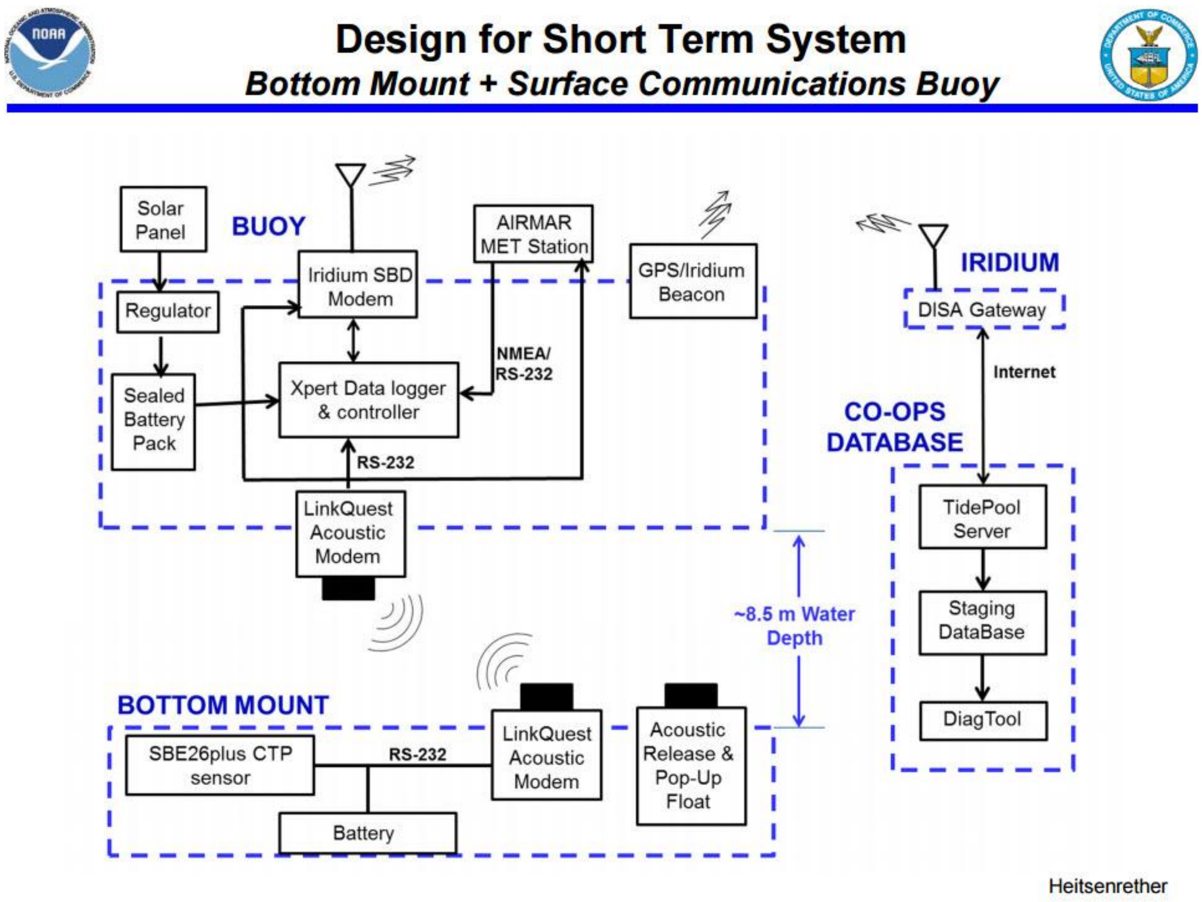


Mooring:
1 - Shackle, (D) ½" SS316
2 - Swivel, 5/8"
3 - 15m rubber shock cord
4 - Shackle, (D) ½" SS316
5 - Net Float
6 - Amsteel, 20m x 3/16"
7 - Shackle, ½" Galvanized
8 - Anchor Chain
8.1 - (3) 8-lbs. mushroom anchors
8.2 - (1) 26-lbs. Danforth anchor

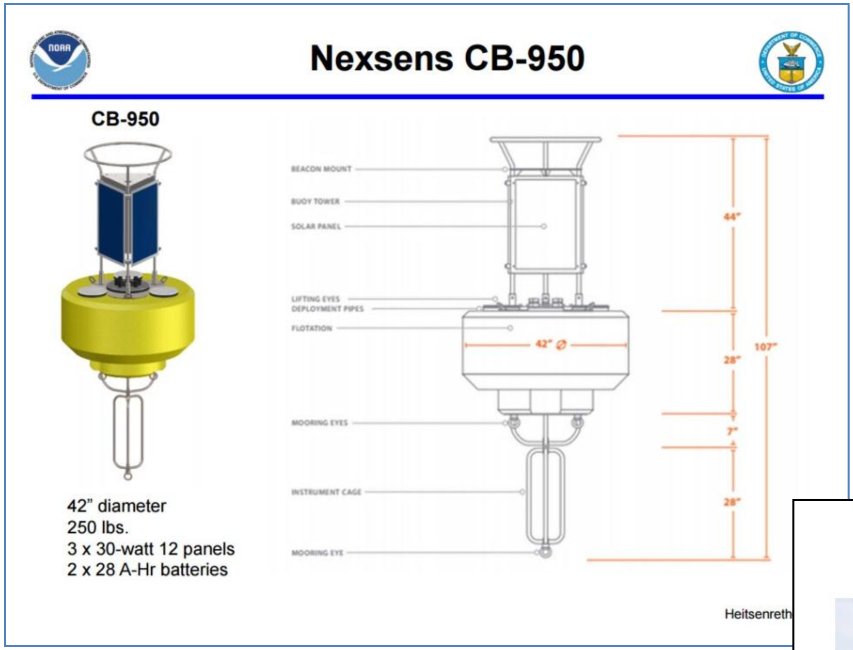
NOAA Real-time Bottom Mounted Pressure Water Level Measurement System

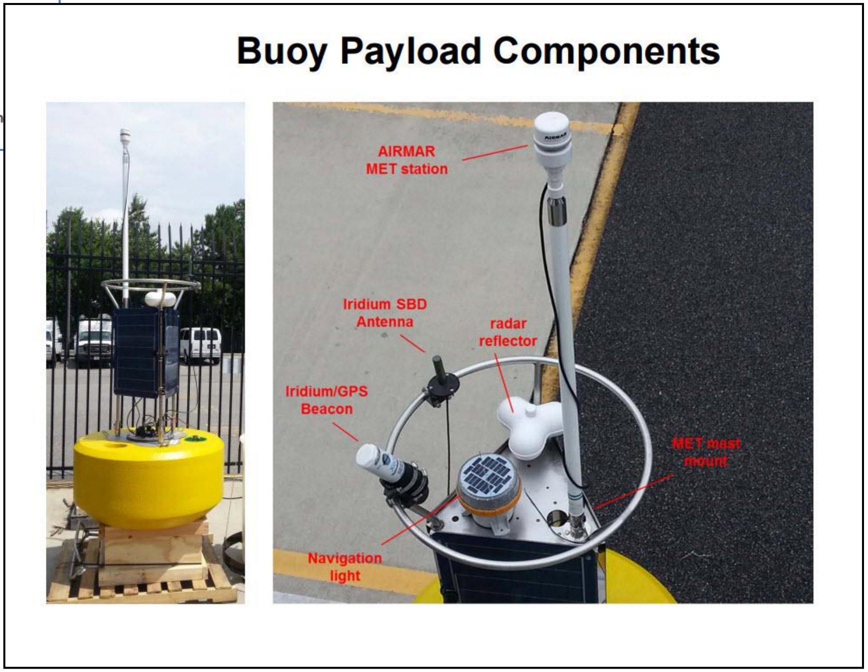


NOAA Real-time Bottom Mounted Pressure Water Level Measurement System



NOAA Real-time Bottom Mounted Pressure Water Level Measurement System

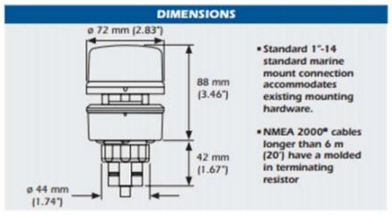




NOAA Real-time Bottom Mounted Pressure Water Level Measurement System

Buoy Payload Components

AirMar 150WX



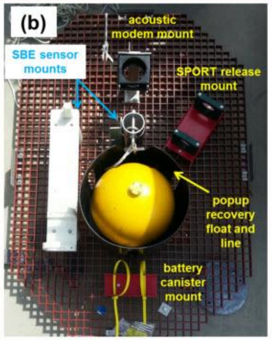
- Internal GPS and compass
- Automatic processing and output of true wind speed and direction
- Air temp and barometric pressure

LinkQuest UWM2000H Omni-Directional

RS-232 data rate:	1500 bits/second
Payload data rate:	300 to 1200 bits/second
Acoustic link:	17.8 kbits/second
Bit error rate:	less than 10^{-9}
Working range:	1200 meters (omni-directional) 1500 meters (narrow beam)
Maximum depth:	2000 meters
Transmit mode power consumption:	2 or 8 Watts
Receive mode power consumption:	0.8 Watt
Sleep mode power consumption:	8 mW
Beam width of transducer:	70 degrees (narrow beam) or 210 degrees (omni-directional)
Operating Frequency:	26.77 to 44.62 kHz

Heitsenrether

Bottom Mount



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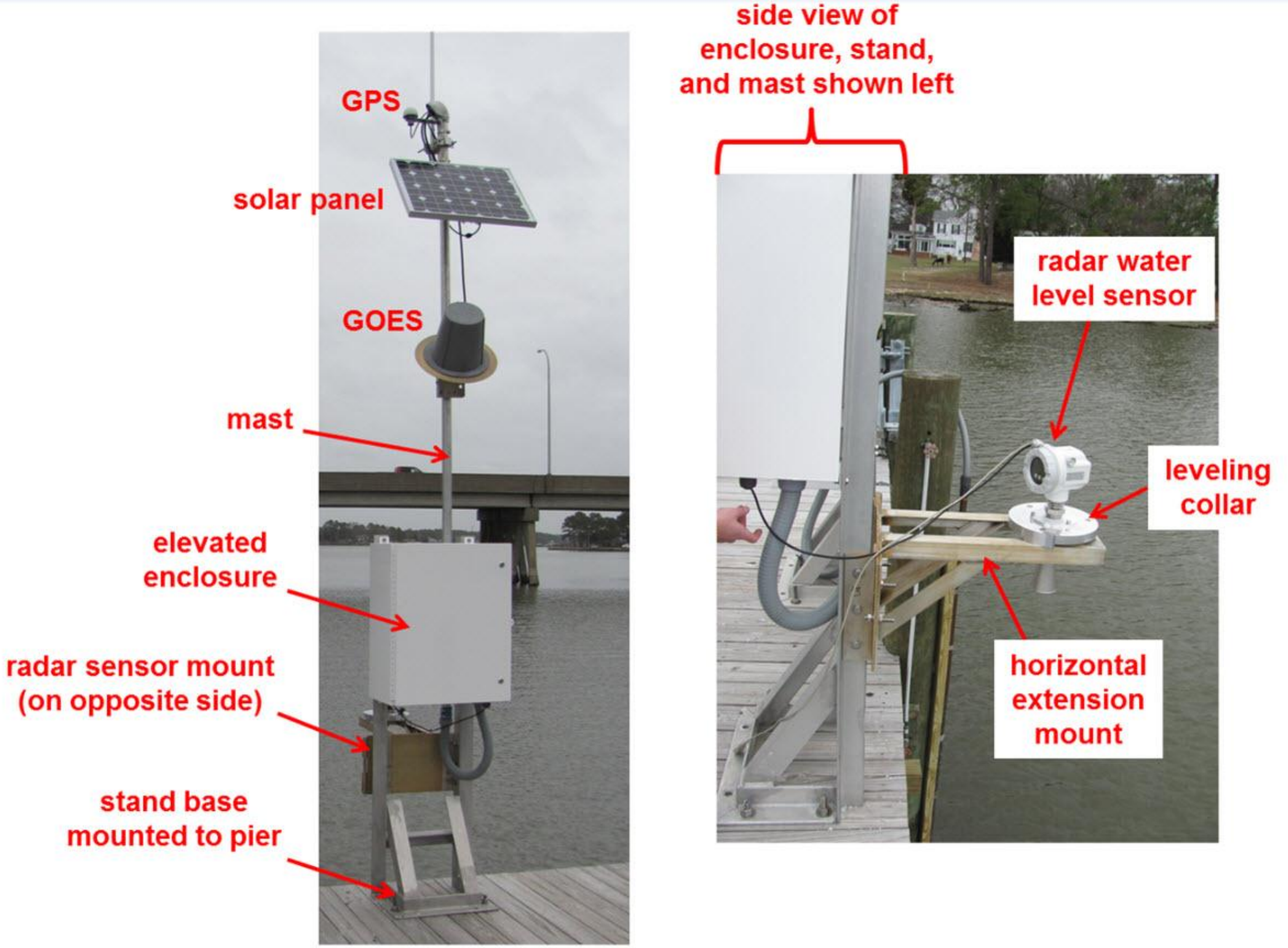
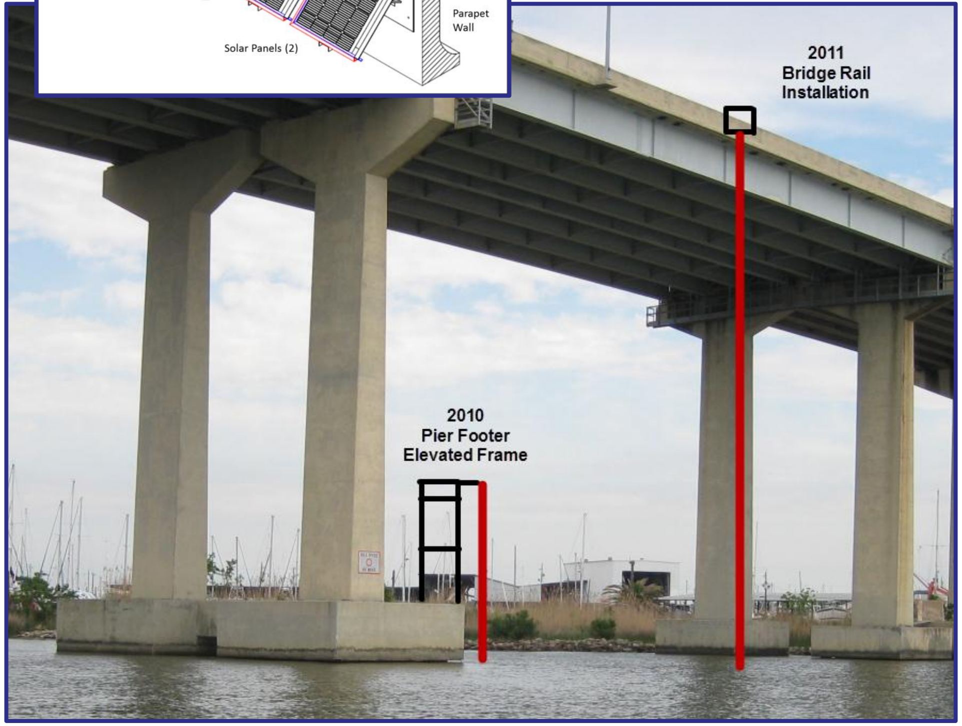
NOAA Real-time Bottom Mounted Pressure Water Level Measurement System

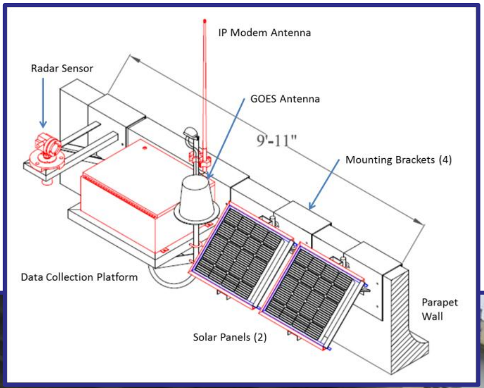
System Deployed Sep 3, 2014

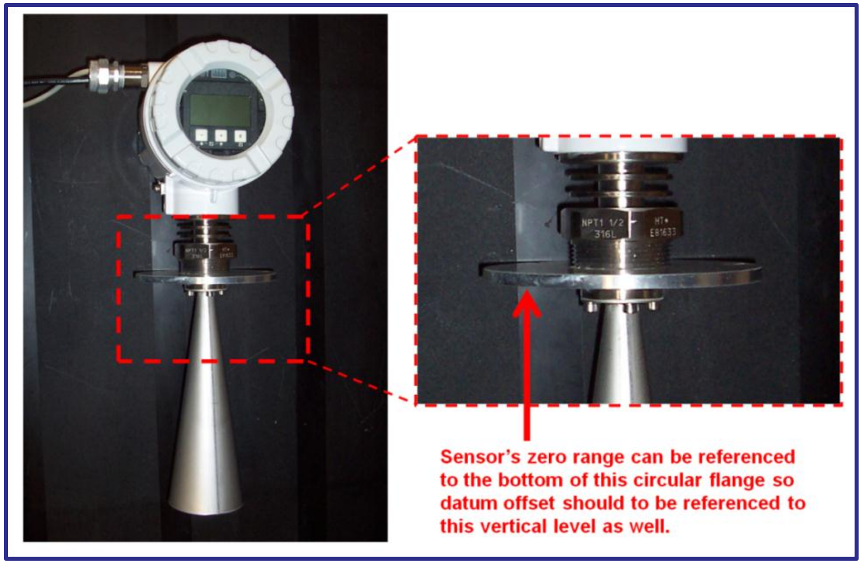
Microwave Water Level (MWWL) Short –Term Gauge Installation

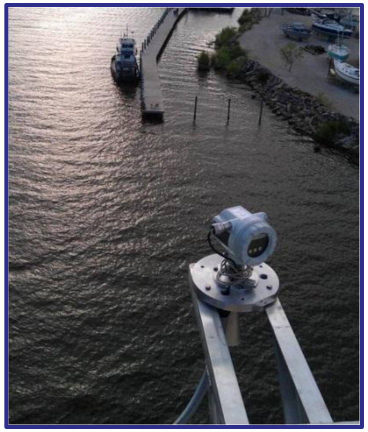


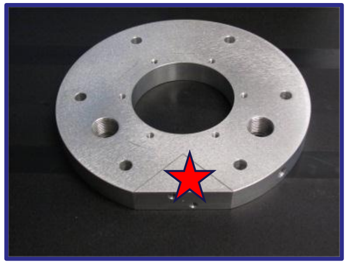
Storm Surge Project Installations











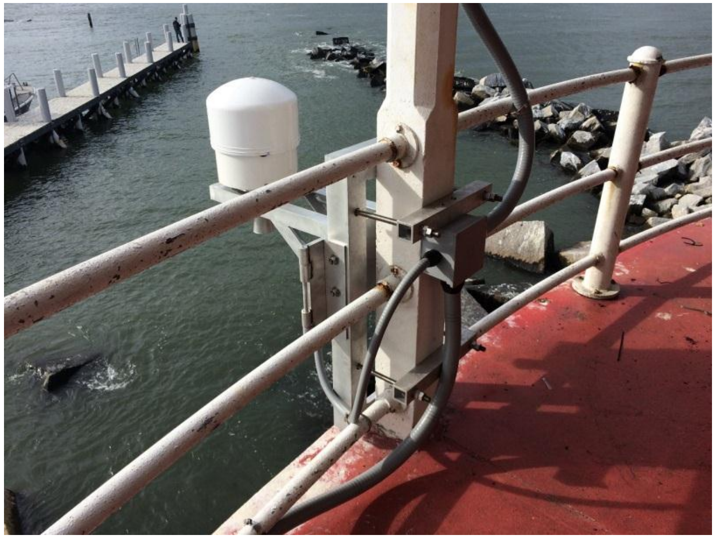
Credit: Tom Landon and Robert Heitsenrether

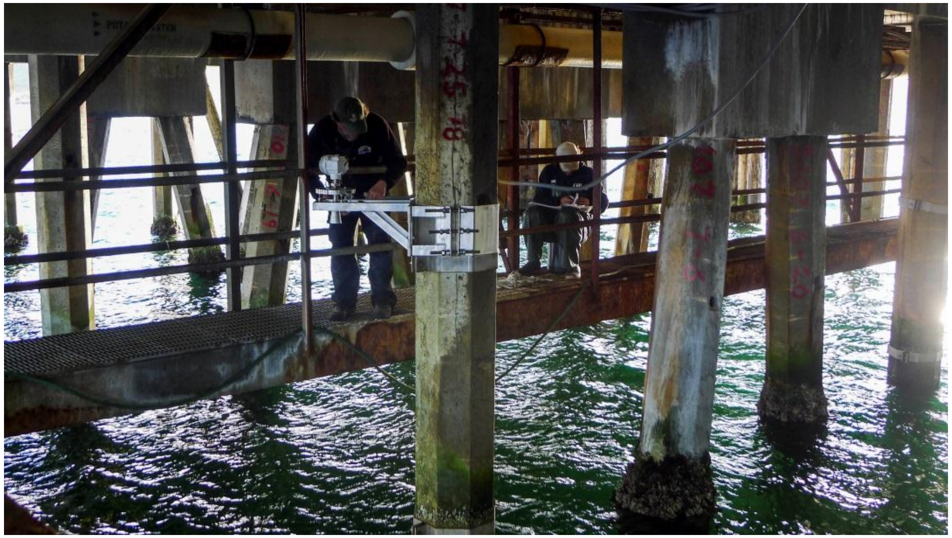
Recent Field Installations at Long-term Stations

8452944 Conimicut Light, RI : side –by-side with Acoustic System for comparison

8454049 Quonset Point, RI

Recent Field Installations





8555889 Brandywine Shoals Light, DE

9461380 Adak, AK

Peer-reviewed reports for MWWL transition

NOAA Technical Report NOS CO-OPS 075

Water Level and Wave Height Estimates at NOAA Tide Stations from Acoustic and Microwave Sensors

Joseph Park

Robert Heitsenrether

William V. Sweet

June 2014

U.S.DEPARTMENT OF COMMERCE
Penny Pritzker, Secretary

National Oceanic and Atmospheric Administration
Dr. Kathryn Sullivan, NOAA Administrator and Under Secretary of Commerce for Oceans and Atmosphere

National Ocean Service
Dr. Holly Bamford, Assistant Administrator

Center for Operational Oceanographic Products and Services
Richard Edwing, Director

http://tidesandcurrents.noaa.gov/publications/NOAA_Tech_075_Microwave_Water_Level_2014_Final.pdf

Integrating VDatum Tide Model Harmonic Constituents with Onshore Observations to Improve Tide Correctors in Chesapeake Bay

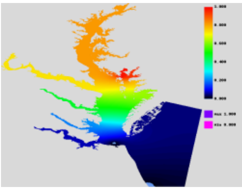
Lijuan Huang[1,2], David Wolcott[2], Lei Shi[3,4], Jindong Wang[3,4] and Edward P. Myers[4]

1. The Baldwin Group, Inc 2. NOAA/NOS/Center for Operational Oceanographic Products and Services (CO-OPS) 3. Earth Resources Technology, Inc 4. NOAA/NOS/Office of Coast Survey, Silver Spring, MD 20910

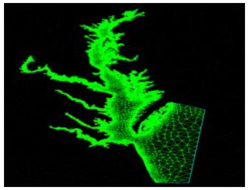
The National Ocean Service's Center for Operational Oceanographic Products and Services (CO-OPS) provides tide support for hydrographic and shoreline mapping survey operations conducted by the Office of Coast Survey and the National Geodetic Survey.

Tidal Constituent and Residual Interpolation (TCARI)

TCARI is a method of computing water level correctors to reference hydrographic sounding to Chart Datum (MLLW) or other tidal datums by interpolating harmonic constituents (HCs), tidal datum elevation relationships, and water level residuals from water level gauge observations.

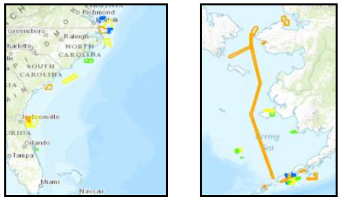


Bishops Head Residual Weighting percent



Grid for Chesapeake Bay

Challenges with using the TCARI method to calculate water level correctors include a lack of observations, a complex tidal regime and providing coverage in offshore regions



Hydrographic survey areas

Method for incorporating HCs from high resolution hydrodynamic tide models into TCARI grids

1. Develop a database of HCs from Advanced Circulation tide models used in VDatum (www.vdatum.noaa.gov)
2. Select HC data points from the database to fill the gaps between observed data points
3. Use both the observed and modeled data for the TCARI interpolation

Input Data

A. Observed station data
B. Raw VDatum tide model HCs
C. Corrected VDatum tide model HCs (The modeled HCs adjusted to match observations)

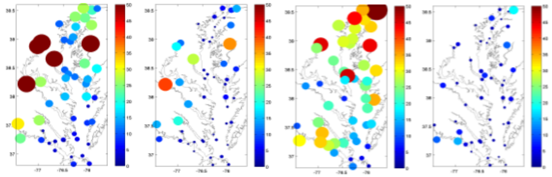
Evaluation of Modeled HCs

Root Mean Square Error (RMSE)

$$A_e = \left(\frac{1}{2\pi}\int_0^{2\pi}(A_m\cos(\phi-h_m)-A_o\cos(\phi-h_o))^2\,d\phi\right)^{\frac{1}{2}} = \left(\frac{A_m^{\,2}}{2}+\frac{A_o^{\,2}}{2}-A_mA_o\cos(h_m-h_o)\right)^{\frac{1}{2}}$$

Relatively RMSE

$$\text{Relative RMSE (\%)} = \frac{A_e}{A_o} \quad (2)$$



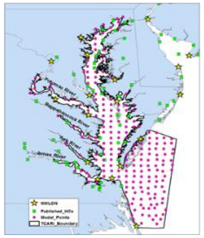
(a) (b) (c) (d)

The relative RMSE for the M2 (a, b) and K1 HCs (c, d) where (a) and (c) include Vdatum modeled HCs and (b) and (d) include corrected VDatum HCs (using jackknifing)

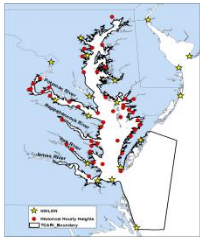
Integration of Modeled HCs with Observations

Three TCARI grids were generated for Chesapeake Bay using

1) 59 stations with published data sets (Direct Interpolation, **DI**)
2) 59 published data sets and 202 VDatum tidal model HCs (Model Blended, **MB**)
3) 59 published data sets and 202 corrected HCs at the locations as MB (Model Blended Corrected, **MBC**).



(e)



(f)

(e) Published HCs stations (green square and yellow star), modeled HCs location (pink dots), and TCARI domain (black line outlined polygon) for integration; (f) Location of historical hourly height data

Results

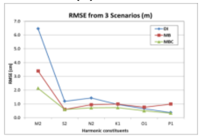
A total of 47 HC sets generated from historical data were used for validation and comparison. The RMSE and relatively RMSE were calculated using Equation 1) and 2) were summarized in table (a) and (b) and plotted in Figure (g) and (h).

Average RMSE (cm)	M2	S2	N2	K1	O1	P1
DI	6.5	1.2	1.4	1.0	0.7	0.4
MB	3.4	0.06	0.9	1.0	0.8	1.0
MBC	2.1	0.6	0.7	0.7	0.5	0.3

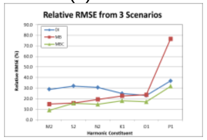
(a)

Average Relative RMSE (%)	M2	S2	N2	K1	O1	P1
DI	28.8	31.9	30.6	24.8	23.0	36.8
MB	14.9	15.8	19.2	22.5	23.6	76.6
MBC	8.9	15.5	14.5	18.0	17.0	31.6

(b)

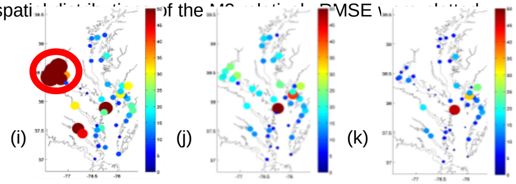


(g) Average RMSE



(h) Relatively RMSE

The spati… of the … RMSE …

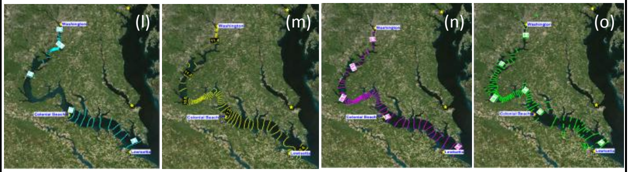


(i) (j) (k)

Relative RMSE for M2 Constituent at stations with working HC i) DI , j) MB, k) MBC. The red circle area is Potomac River

Potomac River

The inclusion of model points was able to make the HWI contours from TCARI interpolation to be more consistent with the hand drawn co-tidal lines.



HWI lines exported from l) DI, m) MB, n) MBC and o) hand drawn based on historical datums

Conclusion and Discussion

The integration of model points in the TCARI interpolation improves results and reduces error. An effort is needed to identify locations where this tool will provide a critical improvement to tide reduction. Operationally the potential improvements must be weighed against the additional effort involved with the application of this method.