



***“The present state of In-situ Wave Data
processing and real-time data transmission
from seabed instrumentation”***

***Torstein Pedersen
Nortek AS***



Real-time Systems

Real-time system =

“Robust, operational method of getting data to shore within a timeframe of validity with a reasonable interval between scheduled service visits”

“Timeframe of validity”:

Winds 5 – 30 min
Currents 30 – 60 min
Waves 60 – 180 min

Bonus options include:

Two-way data telemetry
Change sampling scheme
Poll instrument for data

Continuous power supply
Direct from shore
Solar, wind, etc



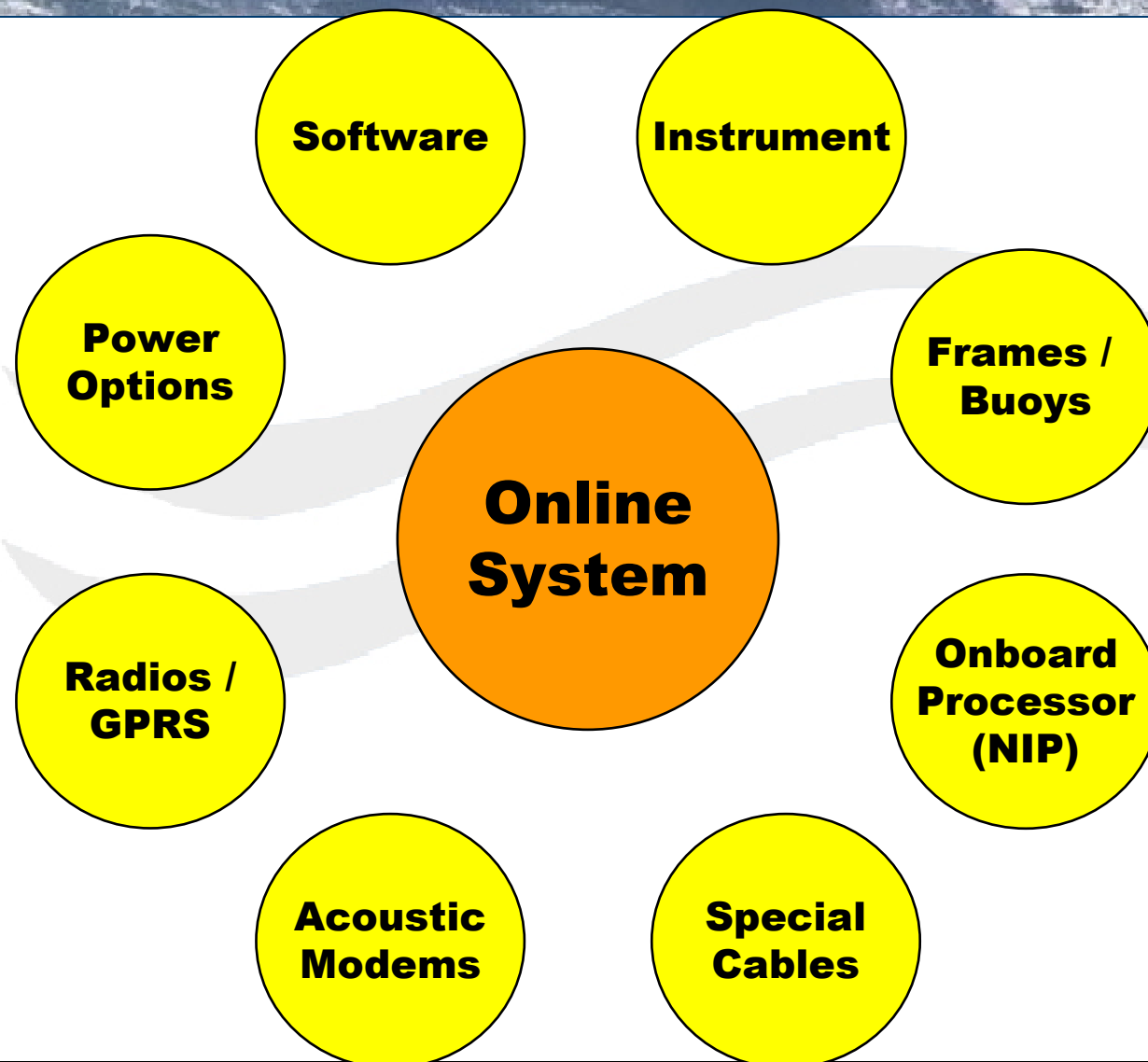
Real-time Systems

Several Options Available:

- **Cabled bottom mount**
- **Surface buoy mount**
- **Underwater modem to shore**
- **Underwater modem to tower**
- **Underwater modem to buoy**
- **Cable to buoy**
- **Subsurface buoy**
- **Platform mount on tower**

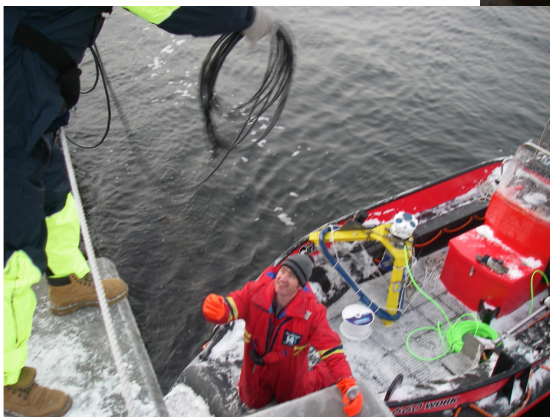


Nortek's Role





Online Group





Data Telemetry and Power

Objective is to provide an overview of available options associated benefits/limitations.

**** Every locations has unique requirements**

Factors defining Telemetry method:

- **Fishing activity**
- **Surface traffic**
- **Range**
- **Hydrographic conditions**
- **Bathymetry**
- **Interference sources**

Tools and possibilities for Interfacing w/ Nortek



Nortek External Power Supplies

4x



50 Wh

Small AA: alkaline/Lithium Ion



165 Wh

Lithium PulsesPlus

540 Wh

Large D: Alkaline



2x

1200 Wh

Lithium metal hydride





Lithium Batteries

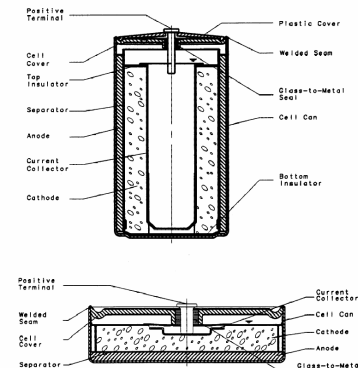
Pulses Plus

**Hybrid combines bobbin type
 Li/SOCl_2 with a capacitor**

**High energy density that
allows for loads periodic high
current draw or pulses**



Same operating life with smaller size for use in GPSlice buoys. Oceantronics' original battery pack (left) used 380 alkaline D cells (54 kg). The new battery pack (right) uses 32 lithium thionyl chloride D cells and four hybrid layered capacitors (3.2 kg).





Doin' it yerself Power Supplies

Considerations:

Minimum voltage 8.5 V

Maximum voltage 18 V

Stiff vs. soft

DC-DC converters min 1.5-2 amp supply



Charge Systems

Solar panel

Regulator

Battery Bank

Panel Orientation

- **Fixed: orient South**
Vertical angle = Latitude

- **Buoy: figure 2-4X panel requirement**
Vertical or on top of buoy



"Standard Kit"



Specifying a Solar Charge System

Battery Bank

Plan for 30 days of no sun (ref. UK)

Sealed gel-cells (little to no "gassing")

Regulator

Avoid damaging batteries

Disconnect panels if batteries reached max

Disconnect load if batteries drop below critical voltage



Specifying a Solar Charge System

Panels

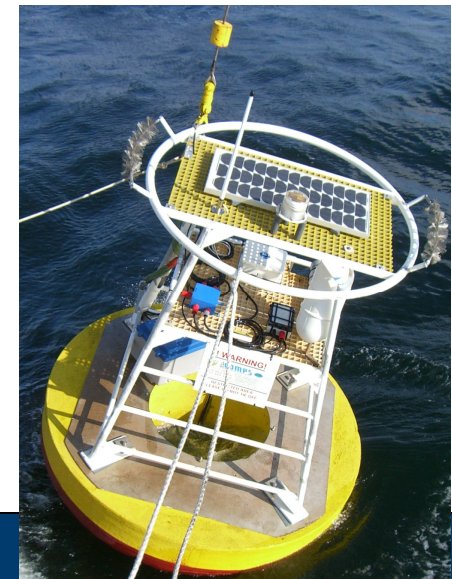
**Estimate lowest Peak Power: Winter
In UK 1-2 hours/day in Jan&Feb (available from
manufacturers)**

**Power consumption per day:
AWAC 1 wave burst/hour => 10 Wh/day
Worst case is 1 hour so 10 Watt panel (buoy 20-
40 W)**

**On land be careful of shading: 1/10 coverage
leads to 1/4 power output loss**

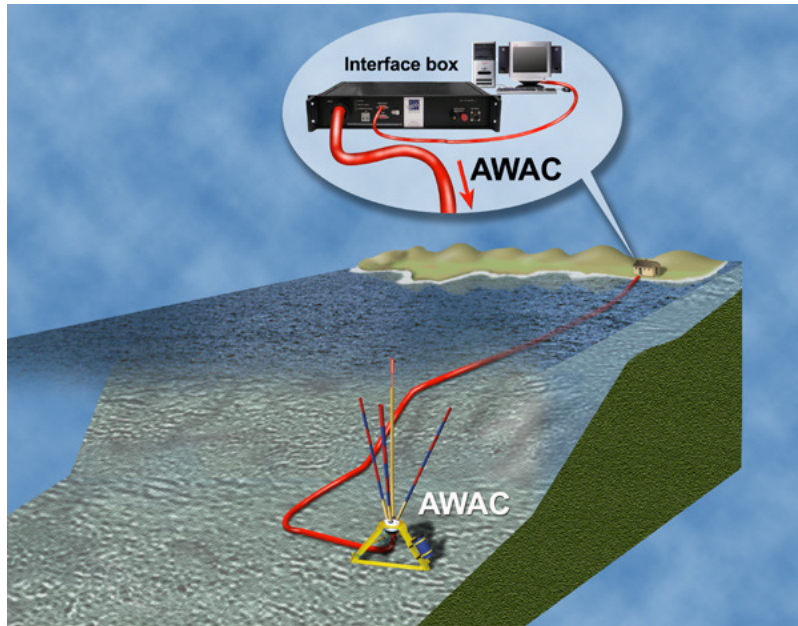
**Types:
Aluminum frame
thin SS (2X price)
Flexible (lower power, more expensive)**

Siemens/Shell/BP





Cabled Bottom Mount



Advantages

- Deployment & sampling not limited by power requirements
- High bandwidth communications
- Direct communication for diagnostic and configuration changes
- Low maintenance
- Can measure waves from bottom mount

Limitations

- Concern for cable damage by recreational boating and fishing activities
- Backup battery should be in place
- Segments and break identification



Cable not without snarls





Offshore Cable

Offshore cable:

8 leads (RS 422)

double jacket

armored

molded connectors

Sync line for NIP on land

\$10/meter

Considerations:

- **Use higher voltage (48V) DC-DC converter and backup battery**
- **Weight the cable**
- **Sements (200-500m)**
- **Strain relief**
- **Finding breaks (time domain reflectometer)**



Taiwan



Cabled Communications

RS 232: Short distances (<50m)

- **Reference to ground**
- **High sensitivity to external noise**

RS 422: Longer distances (<5km)

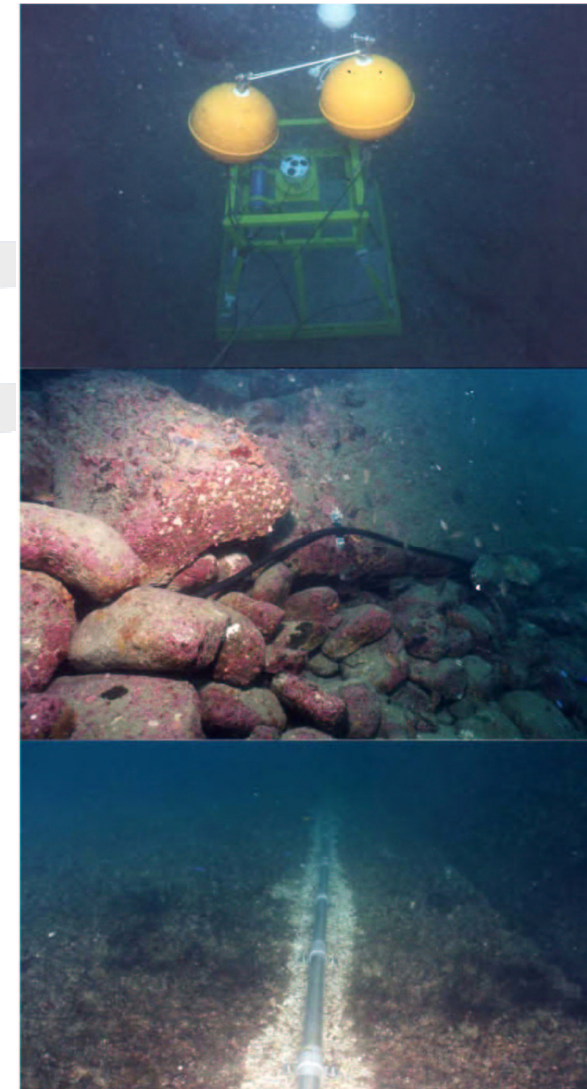
- **Reference to differential**
- **Lower noise sensitivity**

Instrument requirements:

- **Different internal harness**
- **Cable**
- **Converter at PC**

RS485:

- **Not full duplex**
- **Less expensive cables**



基隆港AWCP觀測站水下安裝及海底電纜固定狀況



AWAC Interface Box

**Modem: GSM,
RF, land**

**Lightning
Protection**



AWAC



Modem

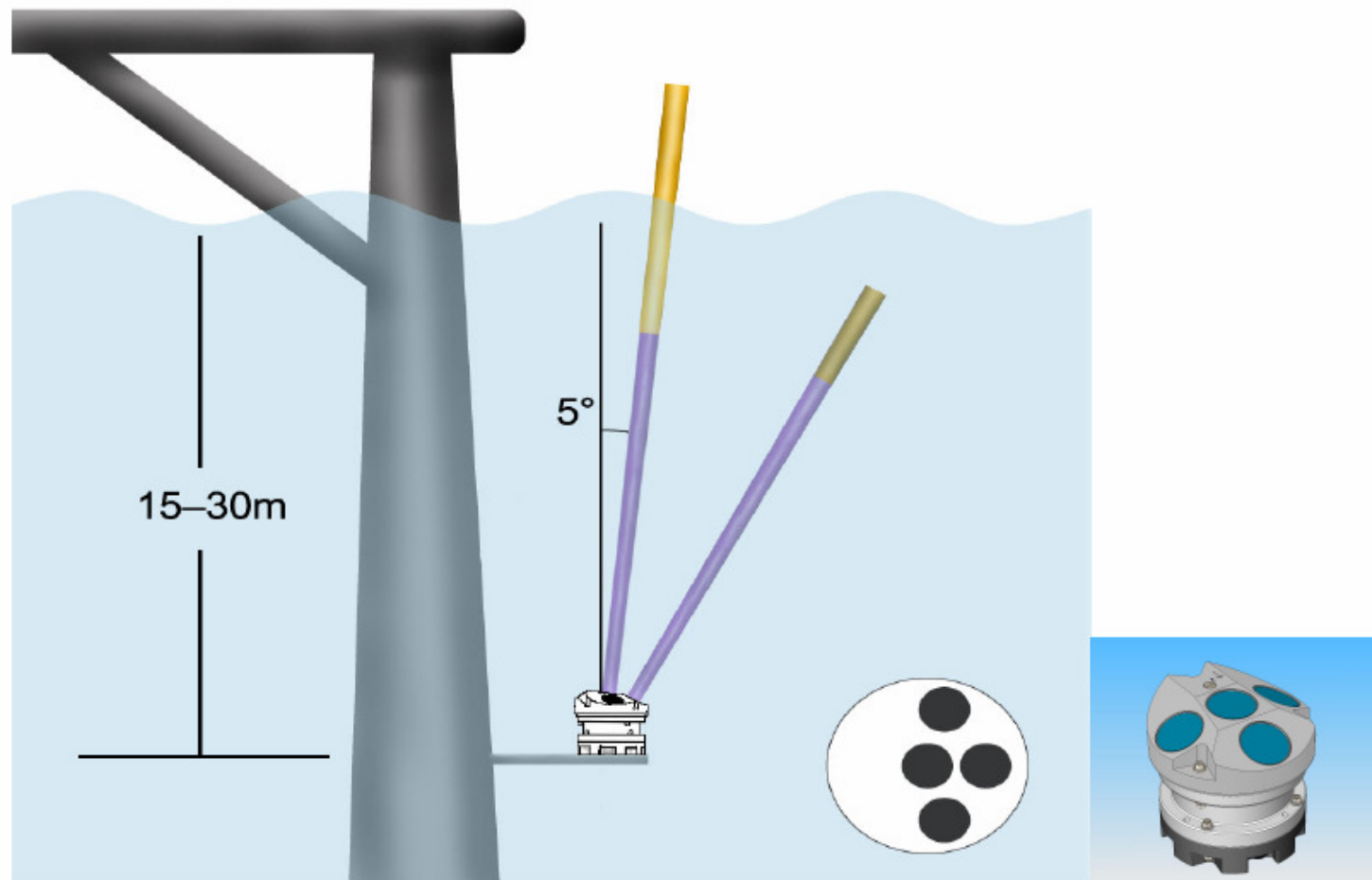
**Backup
Power**

From AWAC

**Network
Power**



Platform Mount - AWAC





Platform Mount - AWAC



**Shell Oil
Gulf of Mexico**



Platform Mount - AWAC



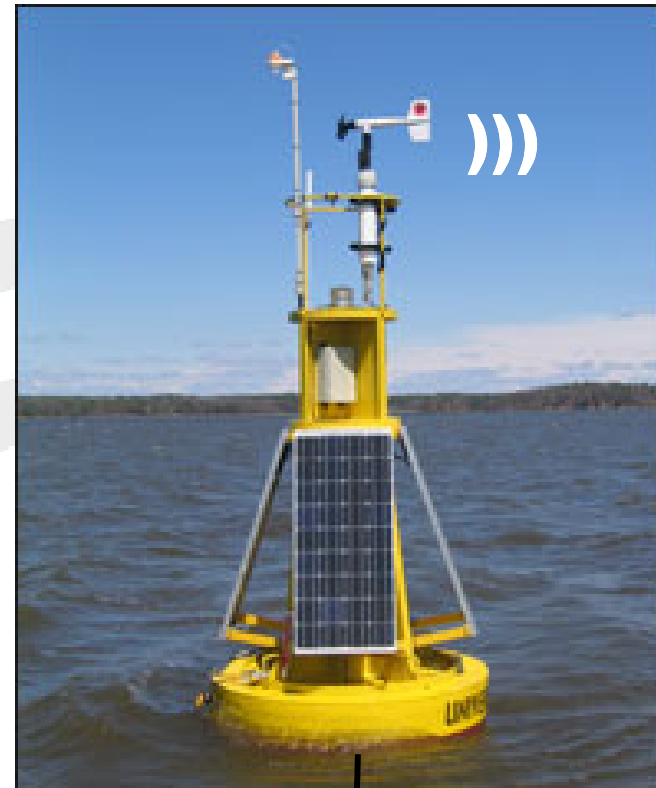
**NDBC
Ambrose Light
Offshore NY Harbor**



Cable to Buoy

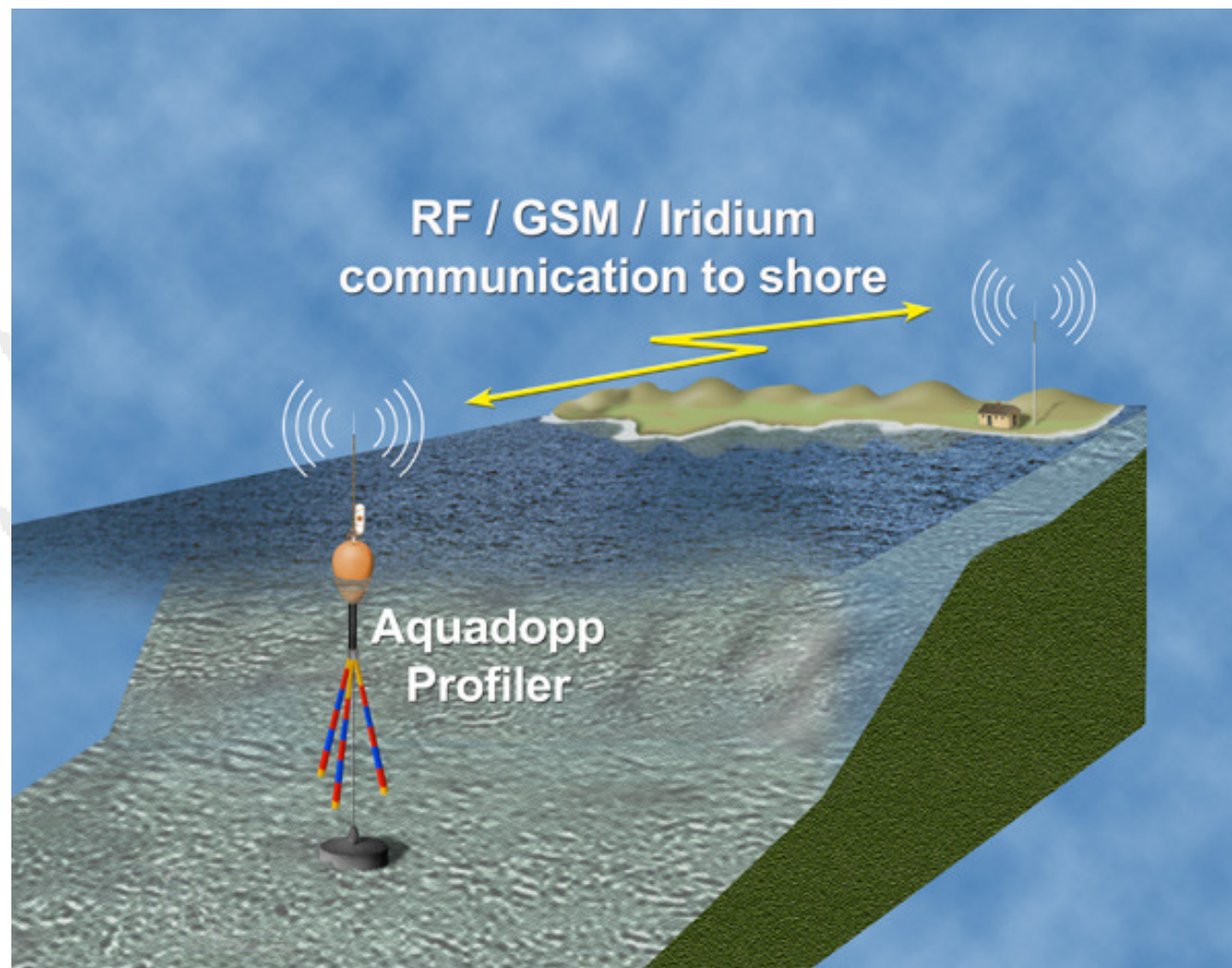
Ru Morrison - <http://www.cooa.sr.unh.edu/buoydata/buoy.jsp>

Cable provides power & data telemetry to buoy controller.



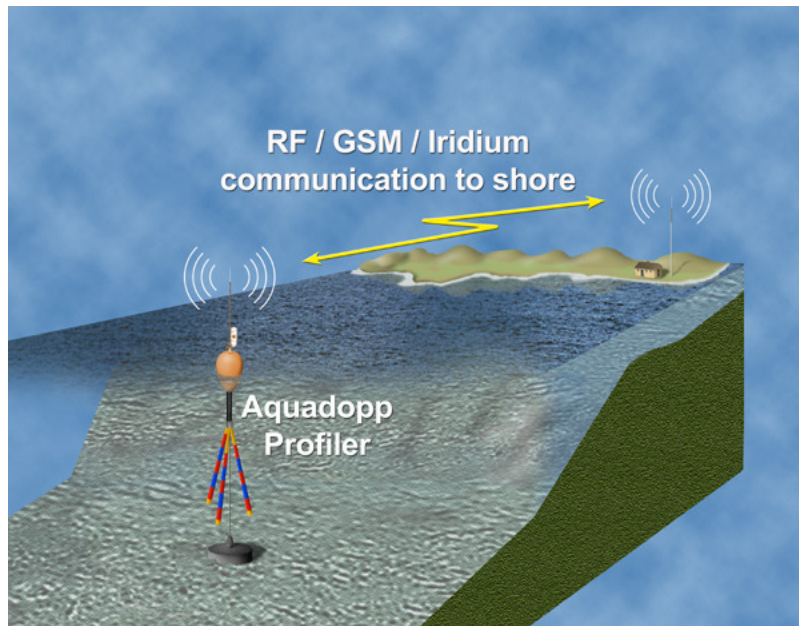


Surface Buoy Mount





Surface Buoy Mount



Advantages

- Does not require divers for deployment or maintenance
- Profile upper portion of water in deep-water applications
- Measure near-surface currents
- High bandwidth telemetry options
- Opportunities for charging batteries with solar or wind

Limitations

- Possible damage by ships, storms, ice & vandalism
- Cannot measure waves from buoys
- RF and GSM coverage difficult at some locations
- Compass calibration possibly necessary



Surface Buoy Options



Coastal Buoy



**Buoy of Opportunity
(ATON)**



Offshore Buoy



Surface Velocity



Offshore Buoy





ATON Application

ATON System:

**Saves cost &
maintenance of own
surface buoy**

**Puts wave & current
data within navigation
channels**





RF Modems

What:

2.4GHz / 900 MHz license free band

Frequency hopping

spread spectrum

Different power levels

Why:

Good Range

Reasonably good bandwidth

Inexpensive

Considerations:

Power vs. range requirements

Antenna selection

Buffer size

Configurable baud rates

Sleep mode power consumption



Satel



Freewave



Maxstream

Less Expense

Range



Antennae

Antenna Gain (fixed vs. buoy)

covers 900MHz supports freq hopping

Fresnel zone/line of sight

Data rate (doubling => 30% less range)

6 dB change power => factor 2 range

Height is everything!!

10m 5x range than 2m

Vertical separation from other antennae

Yagi/Parabolic:

path study/accurate compass



St. Petersburg, FL



GSM/GPRS/CDMA

Established network - Coverage dependent

Dependable

Reoccurring costs but low

GSM used in Taiwan & Norway
- No experience with CDMA

2-way communications



Underwater Acoustic Modem

Underwater acoustic modems provide for the advantages of bottom mounted equipment without requiring long cables for data telemetry

Limitations:

- **Low bandwidth telemetry (must use NIP for waves)**
- **Requires periodic battery replacement**
- **Robust telemetry? (horizontal, shallow water, thermoclines)**



Nortek Acoustic Modem

Benthos Technology

Features:

- Integrated with Nortek products for comms & power
- Special DC/DC converter for single power supply
- Operational & tested





Acoustic Modems

Considerations:

Vertical / horizontal transmission

Test modes – verify channel

Optimum location 1/3 from bottom

Challenges:

Background noise sources:

Sea State, shipping

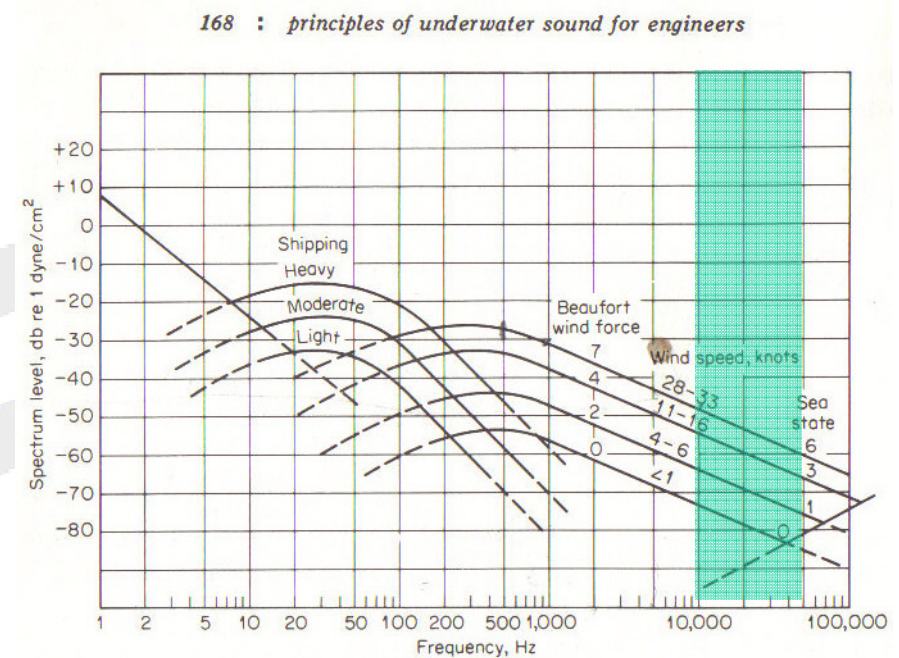
low bandwidth

regular service schedule

depth/range => aspect ratio

Two way challenging - retries

Bubbles



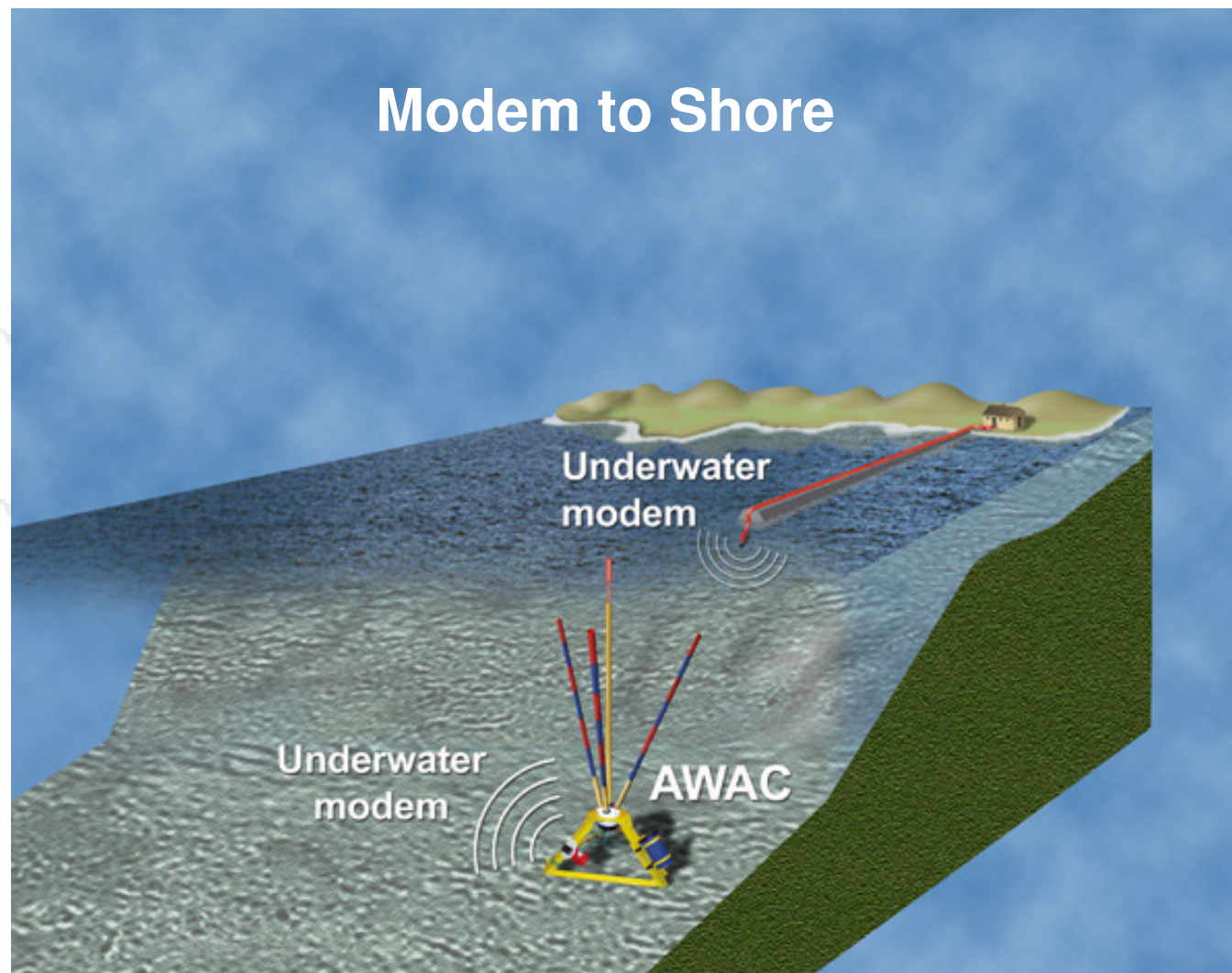
Expectations:

Baud	Range (m)
2400	800
800	1100
300	3000



Modem Applications

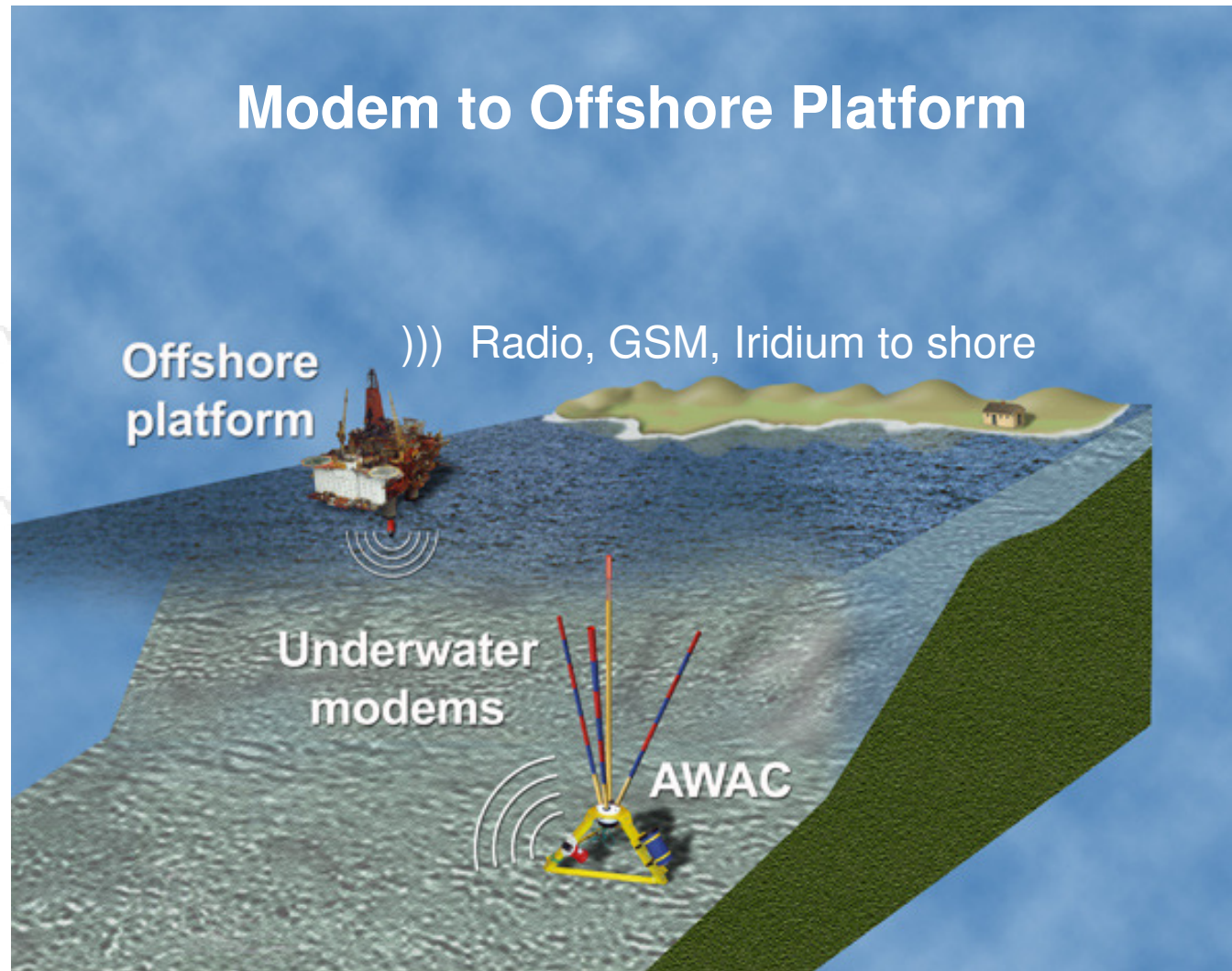
Modem to Shore





Modem Applications

Modem to Offshore Platform

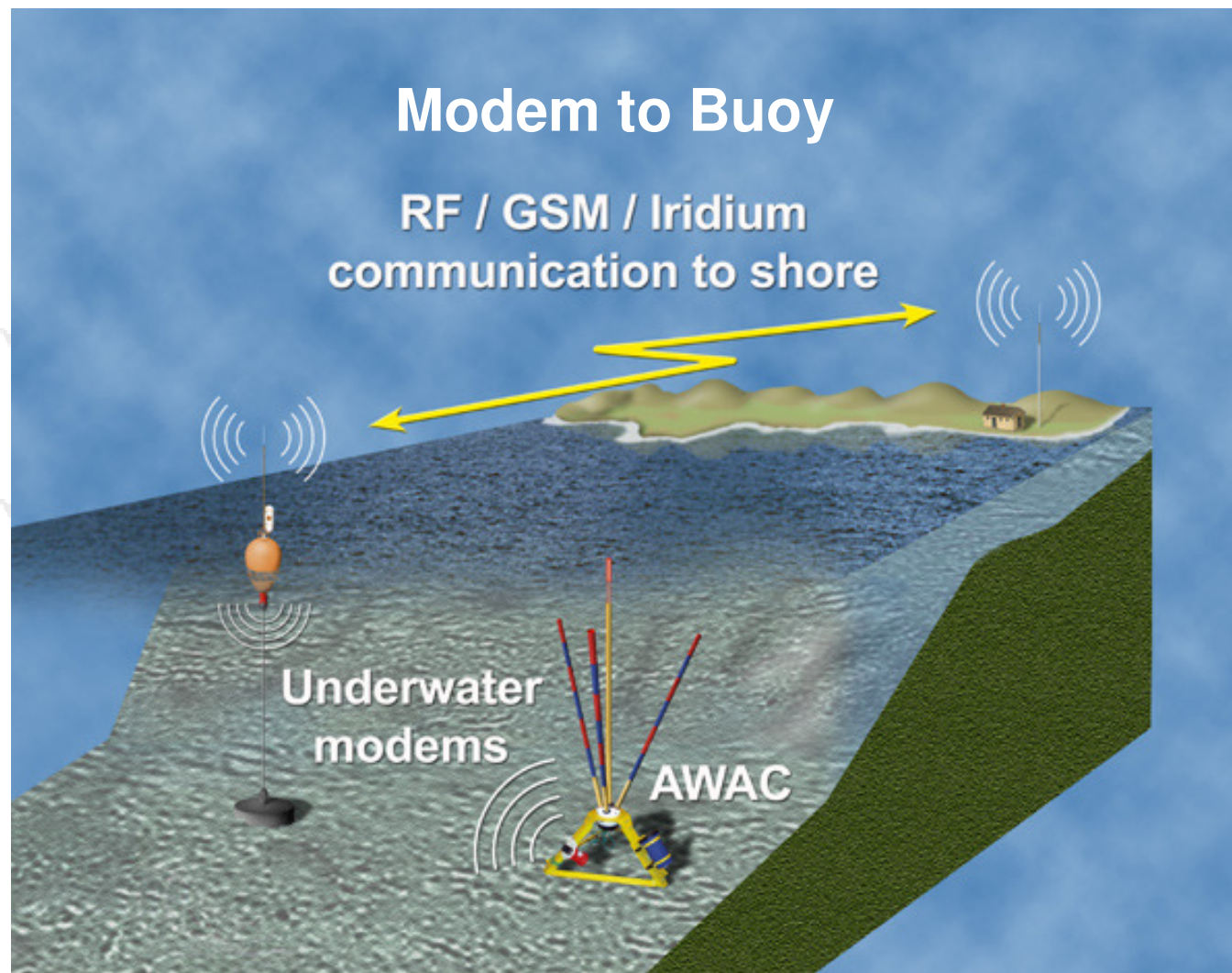




Modem Applications

Modem to Buoy

RF / GSM / Iridium
communication to shore



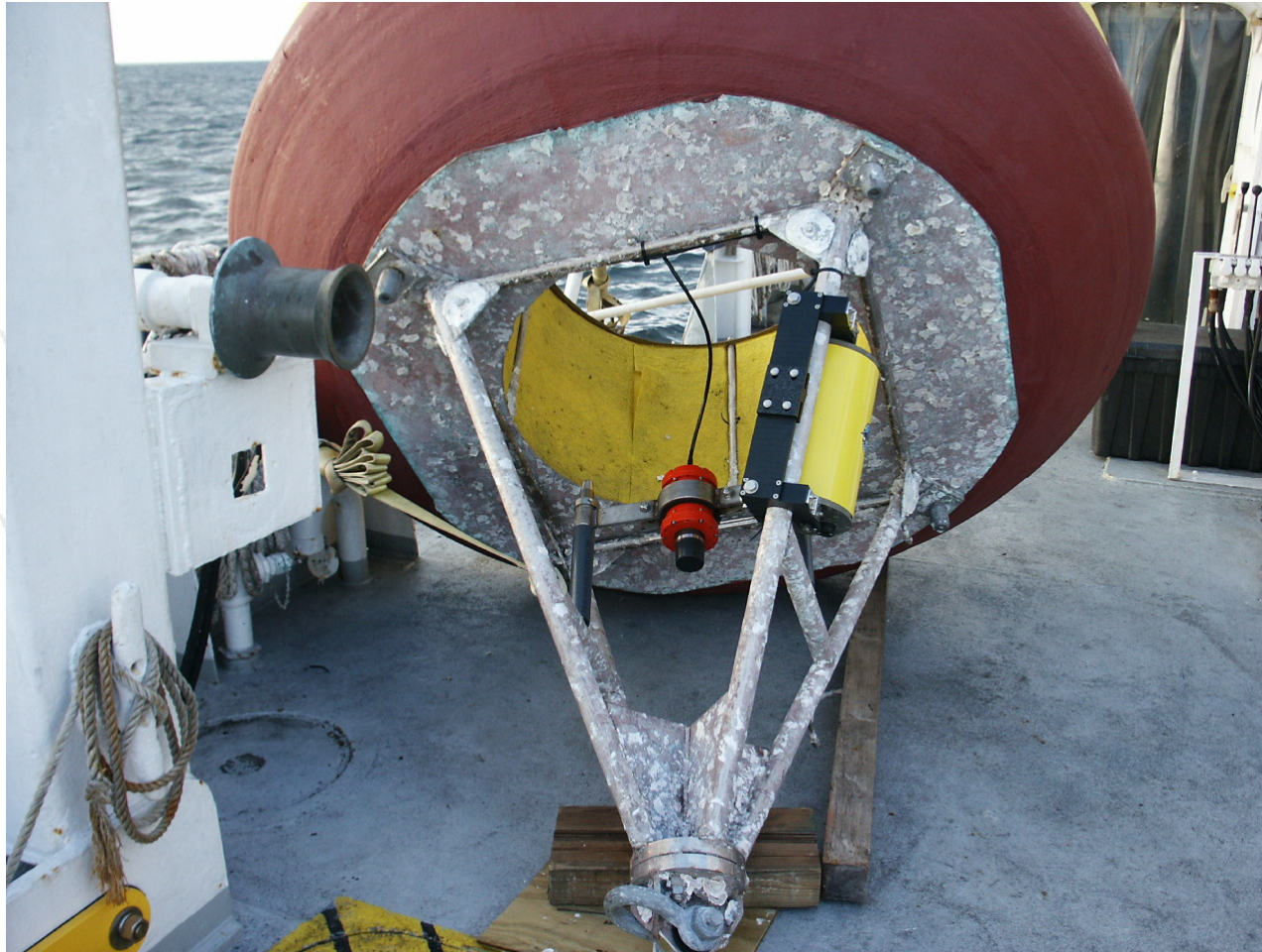


USF - SEACOOs



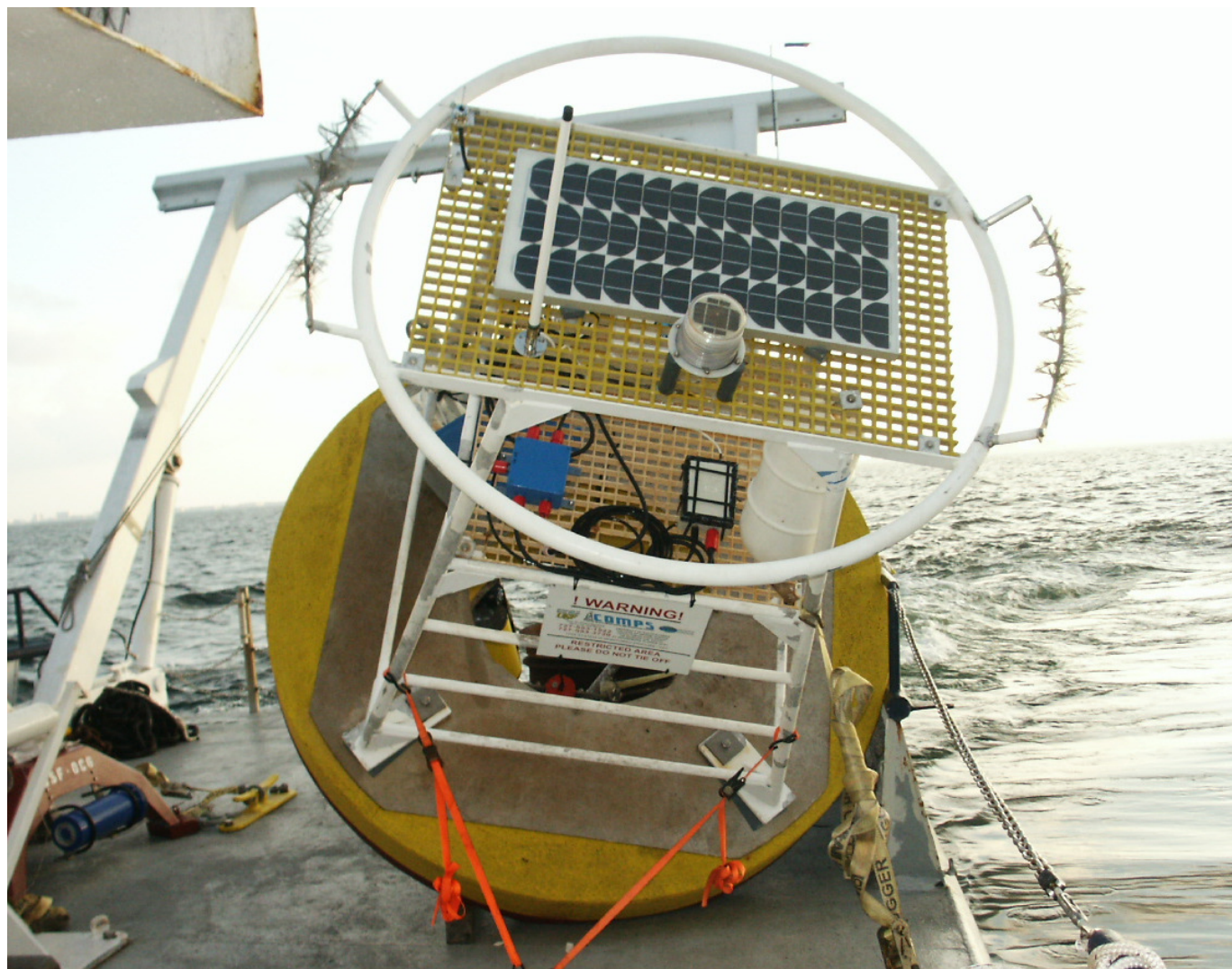


USF - SEACOOS





USF - SEACOOS





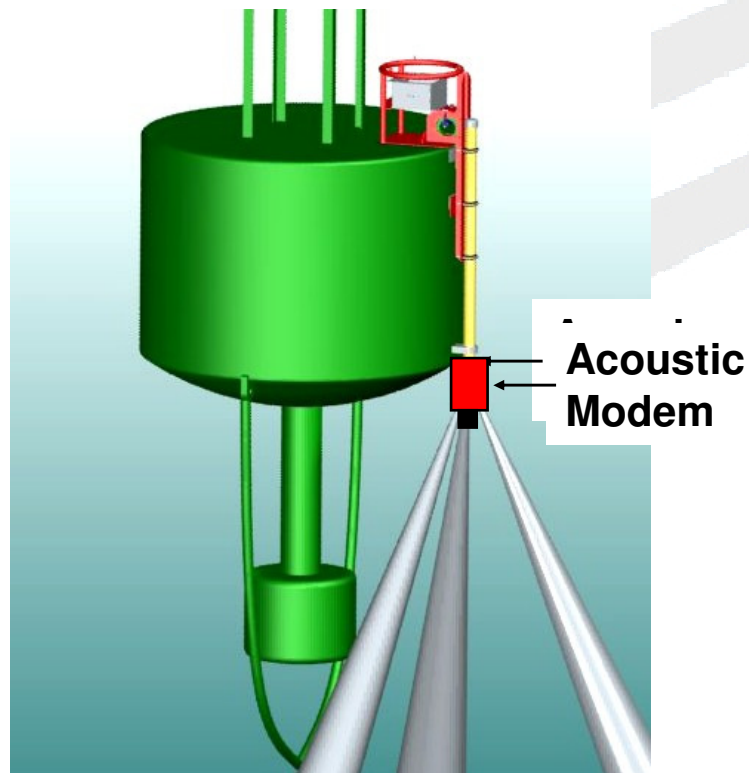
USF - SEACOOS





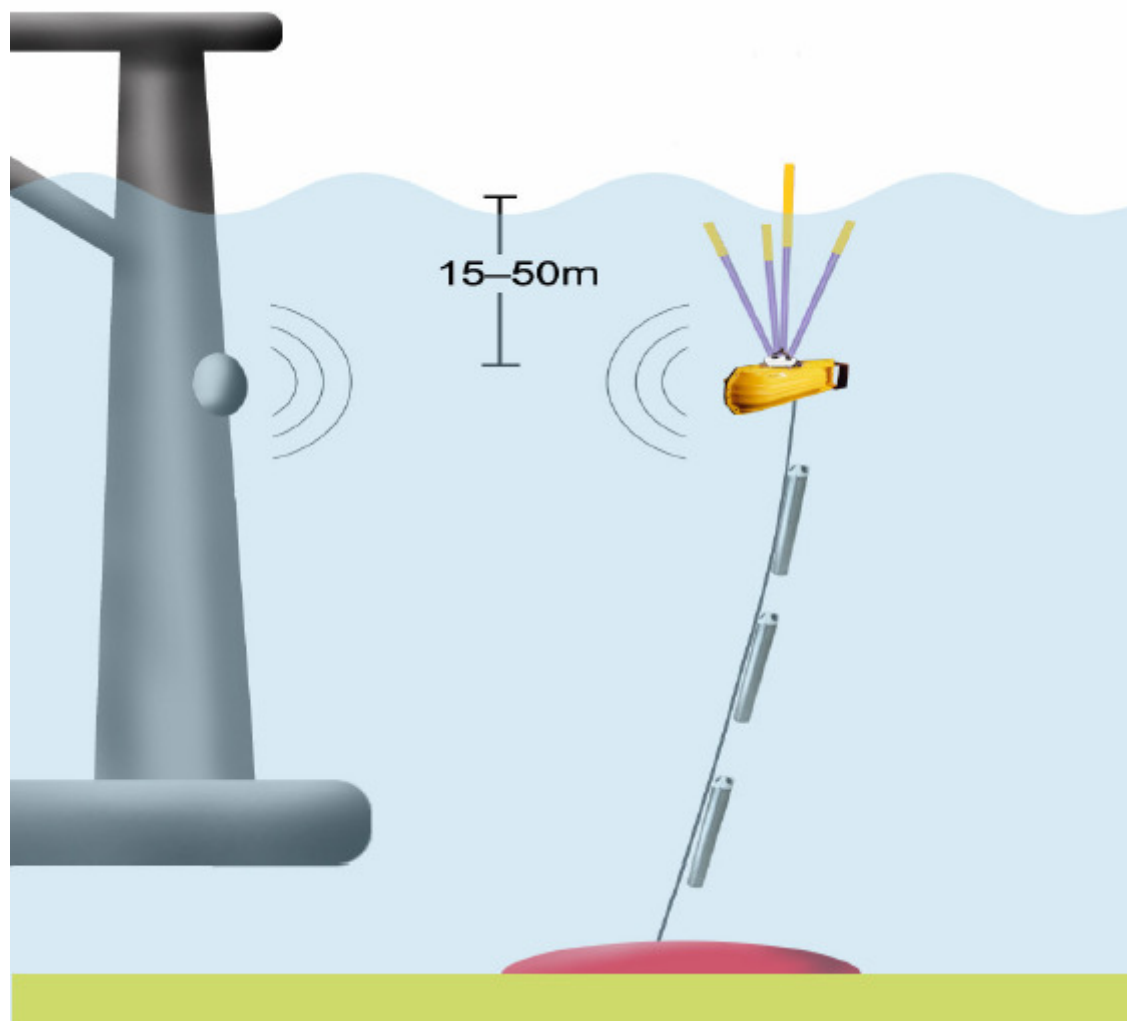
ATON Application

ATON System:
Using “Clamparatus”
system on ATON buoy for
underwater modem





Subsurface Buoy



Deep water locations

SUV processing



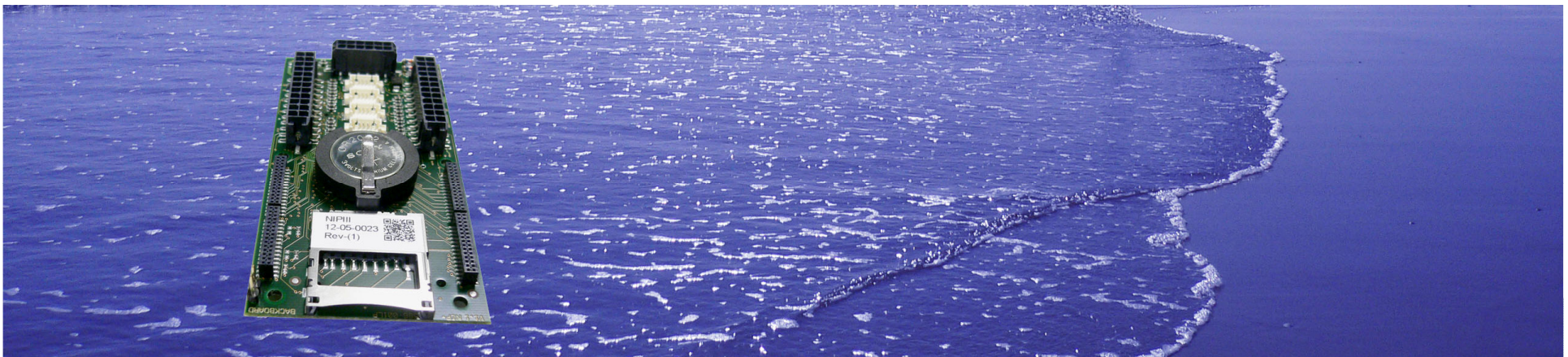
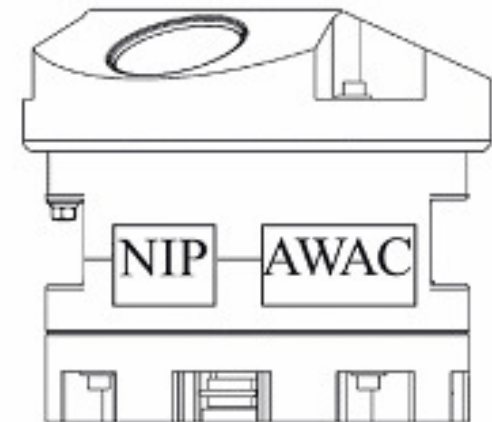
Data Management





NIP - Introduction

- **A wave processing module**
- **An online module**
- **Small computer**
- **Between user and AWAC electronics**





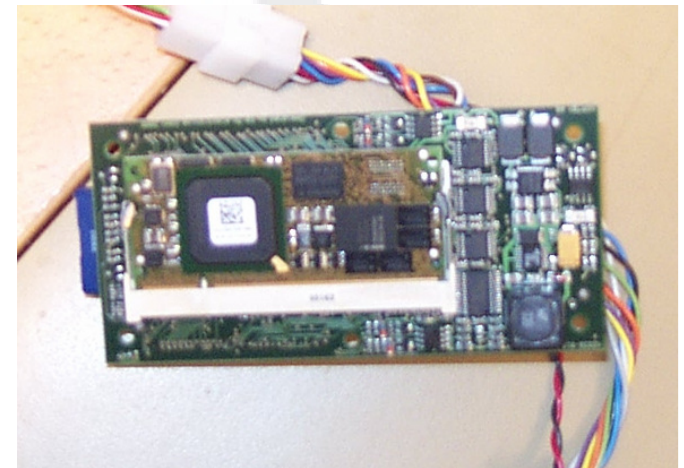
NIP: Functional Description

- **Transforms raw data to wave estimates**
- **Reducing data : ~ 50 kbyte to ~ 100 byte**
- **Available data**
 - Sensor
 - Profile
 - Wave parameters (height, period, direction)
 - Wave spectra (energy, direction)
 - Time series
- **ASCII and binary data**
- **Polled mode or master mode**



NIP: Details

- **Small single board computer**
- **Powerfull processor**
 - Intel XScale PXA 270 at 312MHz
- **Very low power consumption**
 - Sleep : 10mW
 - Active: 650mW
 - Ultra low : 120mW
- **Support for SD-Card**
- **Extra com-port for external device.**





Configuration:

Direct to the AWAC – Raw data
NIP – Processed data

AWAC configuration

Output configuration

Data markers (c,s,w)
End markers
Delimiters

Configuration

Get Set Defaults Done Cancel

☒ Data Collection ☐ Wave Processing ☐ Data Output

Instrument

Frequency: 1 MHz

Current profile

Interval (s): 120

No. of cells: 5

Cell size (m): 1

☒ Waves

No. of samples: 512

Sampling rate: 2 Hz

Interval (s): 480

☐ Acoustic Modem

NONE

☐ High power

Advanced Settings

☒ Sampling

Average interval (s): 60

Blanking distance (m): 0.52

Coordinate system: ENU

Power level: (low) (high)

Speed of sound

☒ Meas. Salinity (ppt): 35

☐ Fixed (m/s): 1525

Analog inputs

Input 1: NONE

Input 2: NONE

☐ Output power

Summary

Assumed duration (days): 30

Estimated depth (m): 20

Horizont. vel. prec. (cm/s): 2.2

Min. wave period (s): 0.9

Min. period direction (s): 3.1

Battery utilization (% of 540 Wh):

AWAC	104
NIP	10.2
Acoustic modem	0
Total	114.2

Configuration

Get Set Defaults Done Cancel

☒ Data Collection ☐ Wave Processing ☐ Data Output

General

General settings

Output Format	ASCII
Profile Cells	1,2,3,4,5
NAN Indicator	NUL
Checksum Type	NONE
Feed Control	NONE
Report Mode	LONG

Markers

Data output

Sensor Data	☒
Current Profile	☒
Wave Estimate	☒
Wave Band	☐

Summary

Assumed duration (days): 30

Estimated depth (m): 20

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AWAC	104
NIP	10.2
Acoustic modem	0
Total	114.2



SeaState: Status

Display Setup:

Instrument config

Last estimates

Terminal Window

SeaState - COM1 - NIP - [Status]

File Edit View Communication Deployment Data Display Window Tools Help

TCP Client **Connect** Disconnect Configuration Activate Save Start Stop Download Data

Tasks **Info** **Data**

Shortcuts

- Connect and Get Status: Connect to the instrument and read status and configuration information.
- Start Deployment: Configure the instrument including on-line data processing and start data collection.
- Calibration
 - Calibrate the internal instrument sensors.
 - Calibrate Compass
 - Calibrate Temperature
 - Calibrate Pressure
- System Update
 - Update the instrument firmware and hardware configuration.
 - Update NIPware
 - Update Firmware
 - Update Head
- Show at Startup

Info

Status

- Connected: YES
- Mode: Polled (Scheduler ON)
- State: Idle
- Connection: TCP/IP Client - 127.0.0.1:23 - 20s
- Link: Cable
- Comm logging: OFF
- Log file: --

NIP

- NIP version: 2.14
- Wave version: 3.15
- Build: 03.07.06 (1.1)
- Serial number: 12-05-0024
- Hardware revision: Rev (1)

Hardware

- Instrument ID: WPR 0517
- Firmware version: 1.17

Head

- Head ID: WAV 5201
- Head frequency: 1MHz

Configuration

- Profile interval: 120 sec

Data

Temperature: -6.80 degC
Pressure: 0.00 dbar
Pitch: 0.0 deg
Roll: 0.0 deg
Heading: 90.00 deg
Battery: 15.3 V
Sound Speed: 1425.0 m/s
Analog input #1: 0 counts
Analog input #2: 0 counts
Error code: 0081 (hex)

Current data

Time	Coordinate	East	North	Up (m/s)	Amp (counts)	
20.03.2007 10:13:00						
Cell 1	0.70	0.01	-0.36	33	31	32
Cell 2	-0.25	-0.73	-0.47	33	31	32
Cell 3	0.22	-0.27	-0.36	33	31	32
Cell 4	0.71	-0.44	-0.49	33	31	32
Cell 5	0.60	-0.64	-0.33	32	31	32
Error code	0081 (hex)					

Wave data

Time	Hm0	H3
20.03.2007 10:14:01	0.00 m	0.00 m

Output [Read-only - Terminal commands disabled]

Command: rd stop

```
NUL: 0 00 0 00 0 00051B
C 20 03 07 10:13:00 1 0 704 0 012 -0 358 33 31 32 0 704 89 0 0081
C 20 03 07 10:13:00 2 -0 249 -0 734 -0 465 33 31 32 0 775 198 7 0081
C 20 03 07 10:13:00 3 0 218 -0 268 -0 357 33 31 32 0 345 140 9 0081
C 20 03 07 10:13:00 4 0 712 -0 439 -0 490 33 31 32 0 836 121 7 0081
C 20 03 07 10:13:00 5 0 596 -0 643 -0 328 32 31 32 0 877 137 2 0081
S 20 03 07 10:13:00 -6.8 0 000 0 00 0 00 90 0 15 3 1425 NUL NUL FFB1 0081
W 20 03 07 10:14:01 0 00 NUL 0 00 0 00 180 0 NUL NUL 0 00 NUL NUL NUL 271 08 NUL
NUL: 0 00 0 00 0 00051B
C 20 03 07 10:21:00 1 0 634 -0 745 -0 294 33 31 32 0 978 139 6 0081
C 20 03 07 10:21:00 2 0 090 -0 215 0 022 33 31 32 0 233 157 3 0081
C 20 03 07 10:21:00 3 0 502 -0 114 0 014 32 31 32 0 515 102 8 0081
C 20 03 07 10:21:00 4 0 275 -0 028 -0 012 33 31 32 0 276 95 8 0081
C 20 03 07 10:21:00 5 0 779 -0 135 -0 202 32 31 32 0 791 99 8 0081
S 20 03 07 10:21:00 -6.8 0 000 0 00 0 00 90 0 15 3 1425 NUL NUL FFB1 0081
W 20 03 07 10:22:01 0 00 NUL 0 00 0 00 180 0 NUL NUL 0 00 NUL NUL NUL 271 08 NUL
NUL: 0 00 0 00 0 00051B
C 20 03 07 10:29:00 1 0 634 -0 745 -0 294 33 31 32 0 978 139 6 0081
C 20 03 07 10:29:00 2 0 345 -0 559 -0 135 33 31 32 0 657 148 3 0081
C 20 03 07 10:29:00 3 0 246 0 128 -0 174 33 31 32 0 277 62 5 0081
C 20 03 07 10:29:00 4 -0 501 -0 308 -0 412 33 31 32 0 588 238 4 0081
C 20 03 07 10:29:00 5 0 008 -0 585 -0 229 32 31 32 0 585 179 2 0081
```

Nortek AS For Help, press F1

OK Connected Recording to: C:\Data\NIP\Radius\Untitled Comm Logging OFF



SeaState : Last Update

SeaState - COM1 - [Last Update]

File Edit View Communication Deployment Data Display Window Tools Help

COM1 Connect Disconnect Configuration Activate Save Start Stop Download Data

Start Data Recording OFF Scheduler OFF Time to next: 00:57:14

Tasks

Shortcuts

- Connect and Get Status: Connect to the instrument and read status and configuration information.
- Start Deployment: Configure the instrument including on-line data processing and start data collection.
- Calibration: Calibrate the internal instrument sensors.
 - Calibrate Compass
 - Calibrate Temperature
 - Calibrate Pressure
- System Update: Update the instrument firmware and hardware configuration.
 - Update NIPware
 - Update Firmware
 - Update Head
- ☒ Show at Startup

Last Data

Sensor data

Time: 22.12.2002 15:00:00

Temperature: 10.16 degC

Pressure: 0.00 dbar

Pitch: 0.7 deg

Roll: 1.5 deg

Heading: 115.60 deg

Battery: 11.3 V

Sound Speed: 1486.2 m/s

Analog input #1: 0 counts

Analog input #2: 0 counts

Error code: 0000 (hex)

Current data

Time: 22.12.2002 15:00:00

Coordinate	East	North	Up (m/s)	Amp (counts)
Cell 1	0.34	0.81	0.00	133 129 131
Cell 2	0.34	0.88	-0.01	111 108 109
Cell 3	0.39	0.88	0.00	100 96 97
Cell 4	0.39	0.90	0.00	89 85 85
Cell 5	0.42	0.94	-0.00	80 73 76
Cell 6	0.45	0.96	-0.00	69 64 67
Cell 7	0.45	1.01	-0.01	63 58 61
Cell 8	0.47	1.01	0.01	56 52 54
Cell 9	0.46	1.03	-0.01	49 46 48
Cell 10	0.48	1.05	-0.01	44 41 43
Cell 11	0.51	1.05	-0.00	39 36 37
Cell 12	0.51	1.08	0.00	34 30 33
Cell 13	0.48	1.03	-0.00	32 27 29
Cell 14	0.54	1.06	-0.00	37 26 29
Cell 15	0.73	0.93	0.01	68 38 61
Cell 16	1.05	1.00	0.01	97 82 83
Cell 17	0.85	1.12	-0.01	32 37 25
Cell 18	0.70	0.67	-0.29	19 20 19

Error code: 0000 (hex)

Wave data

Time: 09.12.2002 13:02:01

Hm0: 2.72 m

H3: 2.58 m

H10: 3.26 m

Hmax: 4.16 m

DirTp: 39.1 deg

SprTp: 40.1 deg

MeanDir: 51.2 deg

UT: 1.0

Tm02: 5.1 s

Wave & Current Direction

Wave & Current direction

Wave Height (Hm0): 2.72 m

Current at 12.4m: 0.34 m/s

Current at 22.4m: 0.34 m/s

Current at 32.4m: 0.34 m/s

Current Profile

Current profile

Height above seabed (m): 0 to 30

North velocity (m/s): -2 to 2

East velocity (m/s): -2 to 2

NUM: 138.0

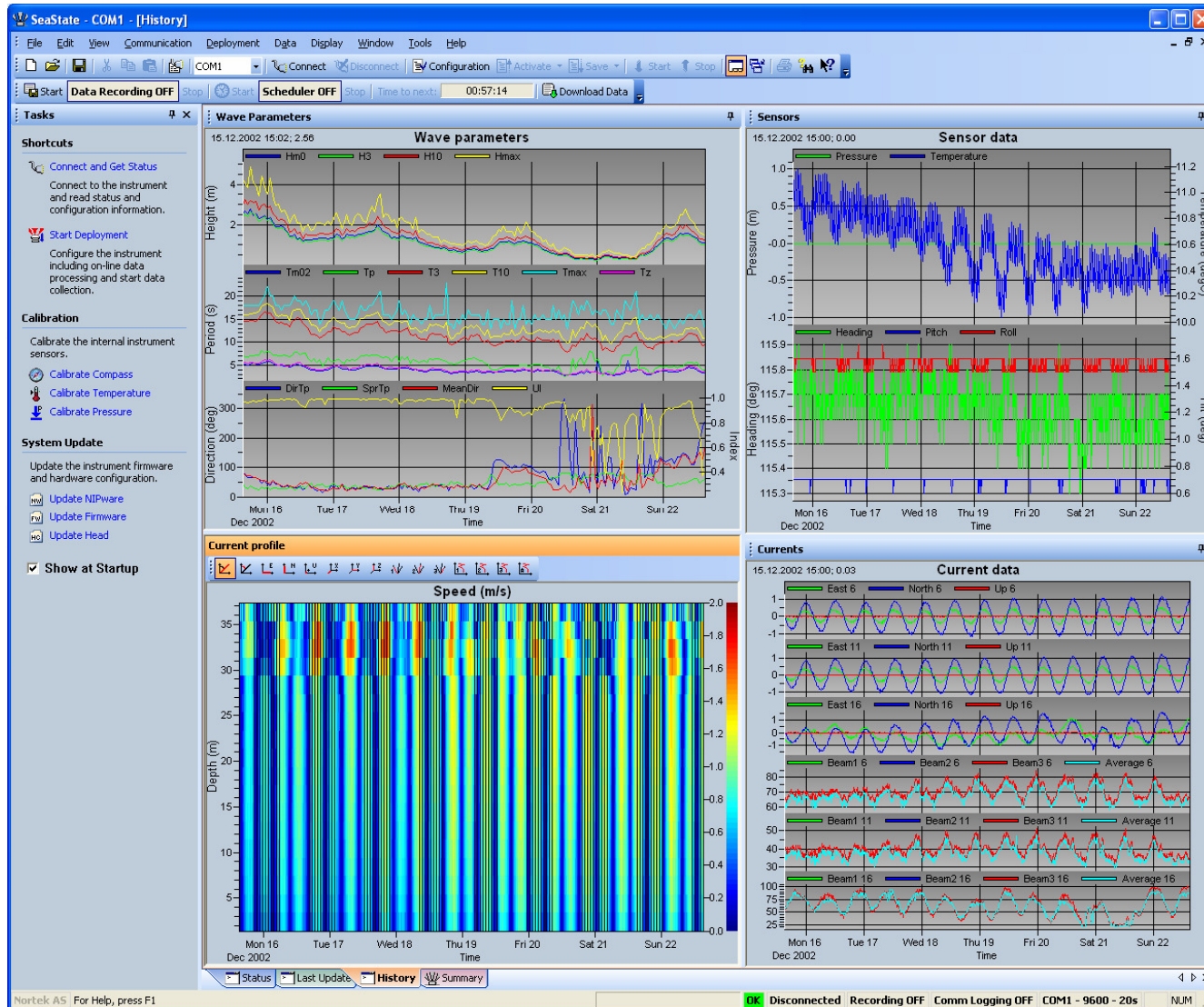
Status: Last Update History Summary

Nortek AS For Help, press F1

Disconnected Recording OFF Comm Logging OFF COM1 - 9600 - 20s

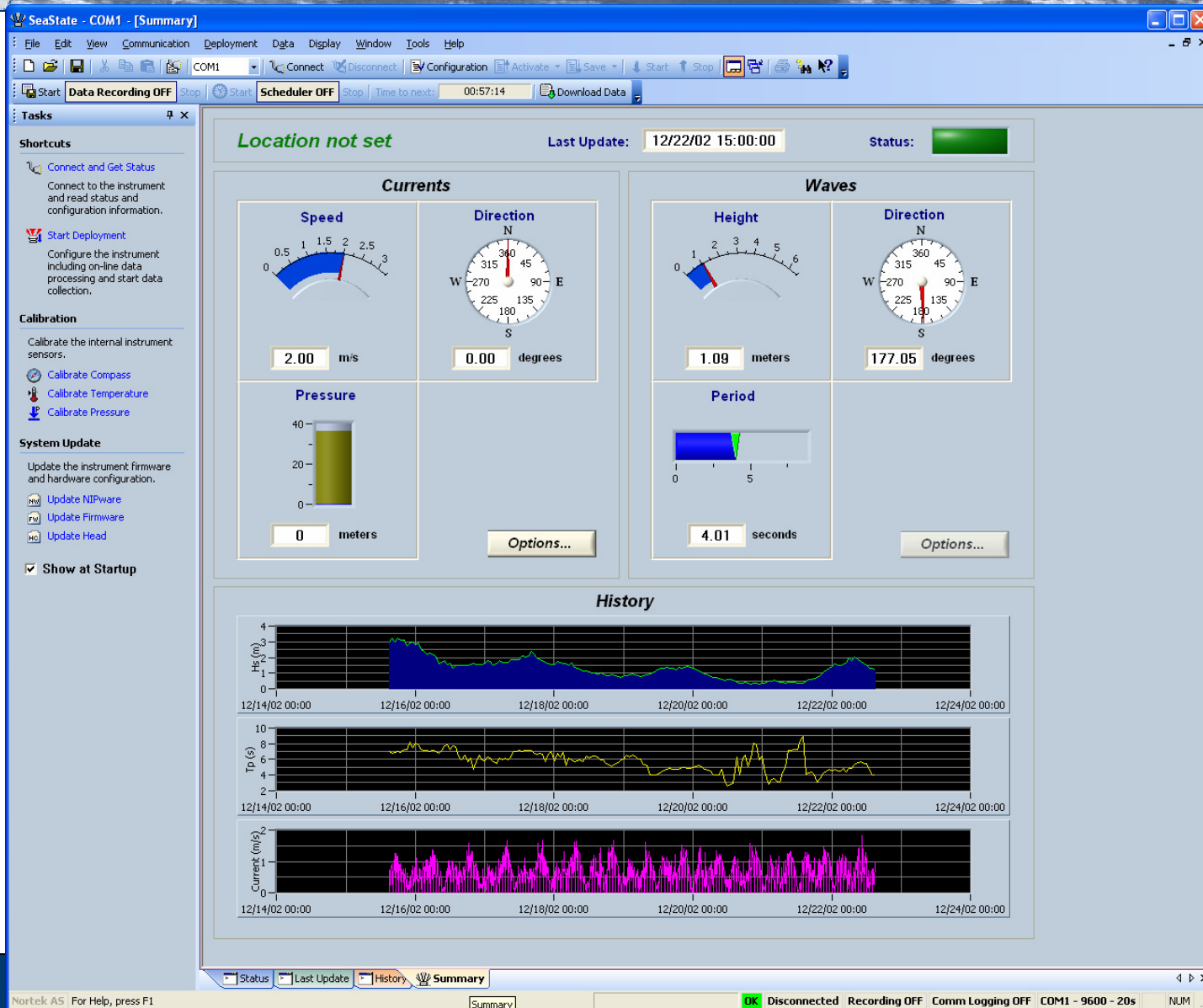


SeaState: Historic View





SeaState: Operator View



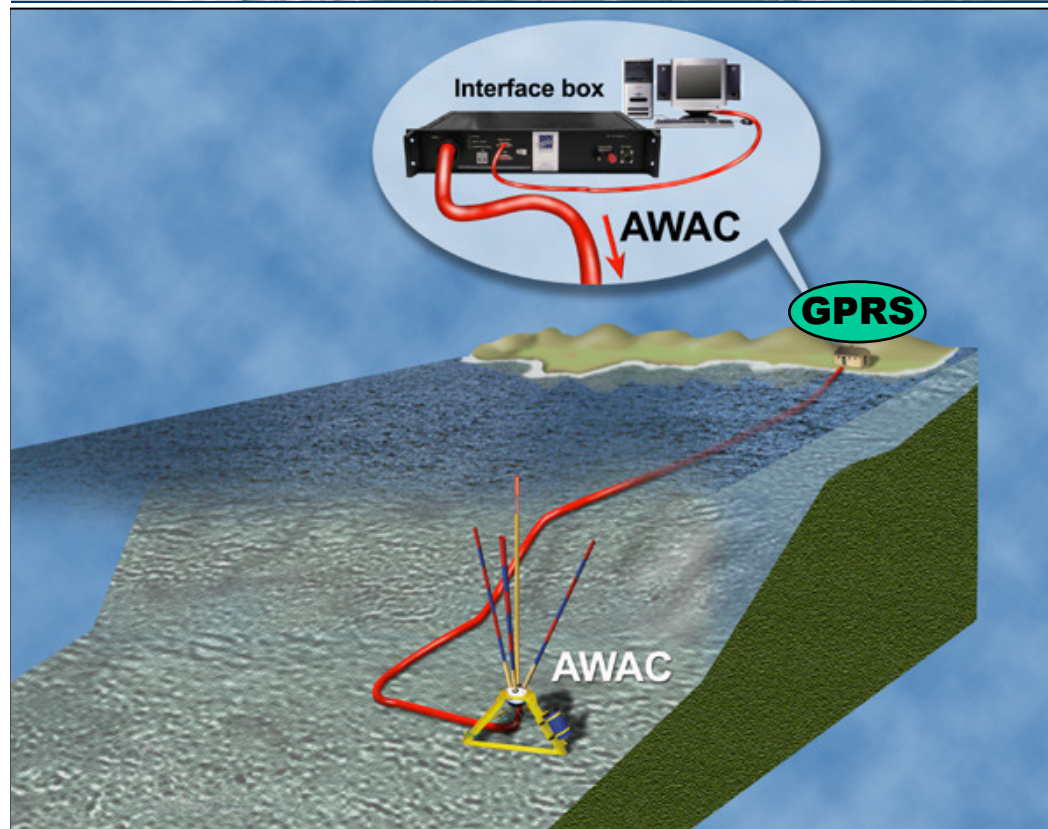


Steilene Test Site





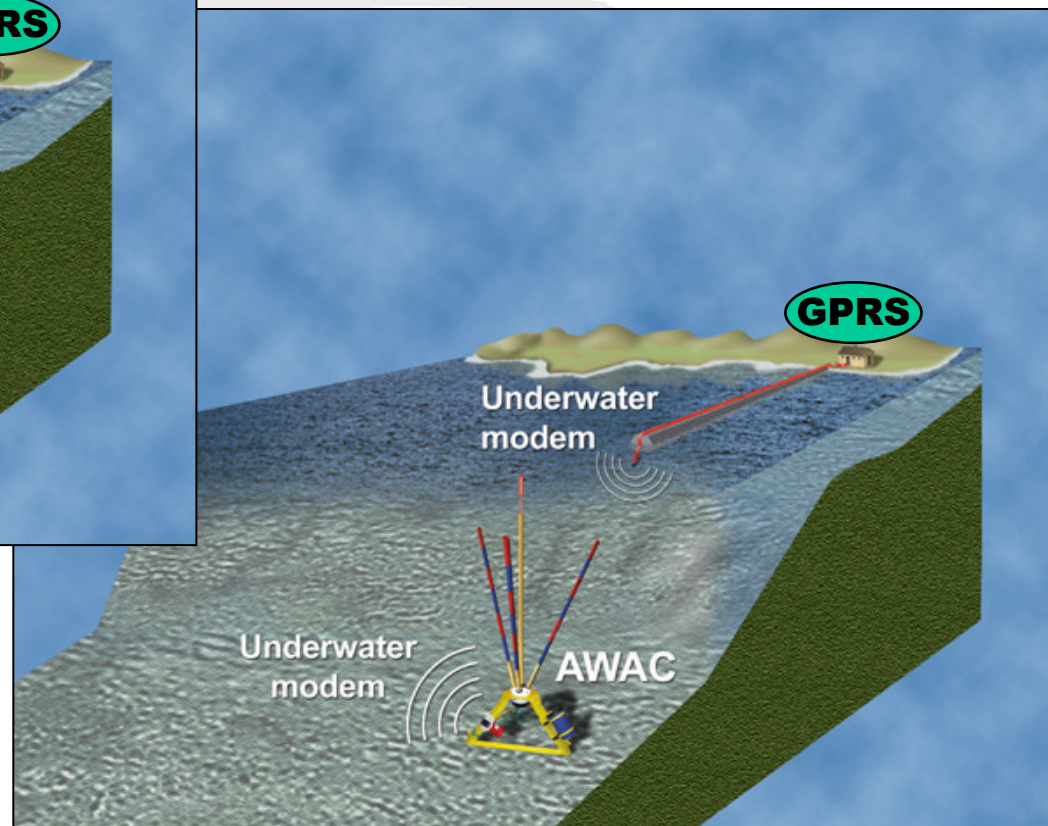
Steilene Test Site



Specified IP address

Mobil Provider

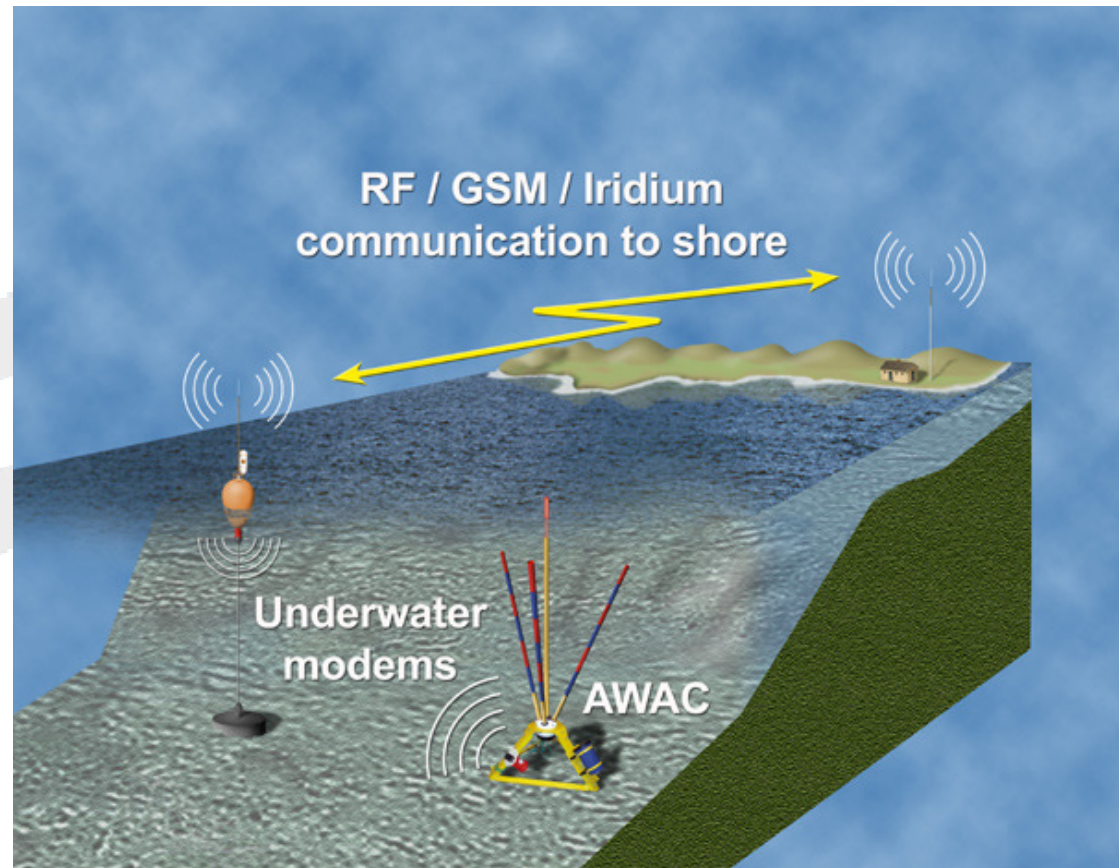
GPRS



Steilene



Steilene Test Site: Next Phase



Steilene



Thank You

