National Data Buoy Center

Presentation

to

The Regional Marine Instrumentation Center (RMIC)

April 13 – 15, 2010

Ralph F. Cambre
Power Systems for NDBC NOOS Stations
NDBC Buoy Systems

**Mooring system**
- Cables
- Floats
- Anchors

**Communications**
- Transmitters
- Antennas
- Position tracking devices

**Power system**
- Batteries
- Solar panels
- Controller

**Payload/data logger**

**Buoy structures**
- Buoy hull
- Mast
- Underwater structures

**Support equipments**
- Radar reflector
- O&I light

**Meteorological Sensors**
- Wind speed/direction
- Air pressure
- Air temp
- Relative humidity

**Ocean Sensors (surface/subsurface)**
- Surface Current
- Surface temperature/salinity
- Current Profiler
- Temperature/salinity Profiler
- Directional & non-directional Wave Measurements
- Other ocean parameters

**Other sensors**
- Bottom Pressure Recorder
- Bottom-mount current profiler

**Other sensors**
- Bottom Pressure Recorder
- Bottom-mount current profiler
40 Years of Development

- Hydrogen fuel cell
- Diesel generators – DC output to charge batteries
- Wind powered generators
- Lead-acid batteries
- Solar panels
- Air-depolarized alkaline batteries
- Lithium DD batteries; primary cells
- Alkaline D batteries; primary cells
- Air-depolarized alkaline; non-magnetic batteries
- Lithium batteries; secondary cells (under study)
- Wave-generated power (future consideration)
Marine Observation Network

NOOSS Buoy and C-Man Stations
Marine Observation Network

Weather Network Buoy Types (113)
Marine Observation Network

C-MAN Stations (49)
Marine Observation Network

Tsunami Buoy Network – DART Buoys (39)

05/27/2009
Marine Observation Network
Tropical Atmosphere Ocean Network – TAO Buoys (55)
Offshore Test Platform – 1970’s & 1990’s
20 miles east of NDBC in the Gulf of Mexico – easy access

Solar Power

Diesel Generator Exhaust

Wind Power

Hydrogen Fuel Cells

Primary and Secondary Batteries
NDBC Prototype Fuel Cells - 1979

Hydrogen generators

Fuel Cell

Water

Capacity: 3.5 KWH
Rate: > 2 Month
Dry Weight: 3-3.5 Kg
Net Weight: 14 Kg

limited capacity, 6 mos., large, cumbersome
Solar Panels

- 1980: Introduced
- **Circa 1975:** Initial Tests
- 1989: Hybrid Solar, *all* stations, Bering Sea to Christmas Island
Solar Panels – monocystaline panels

Kyocera Model KC-50 – currently being used throughout network
  36 cells (designed for self regulating applications)
  Specifications: 50 watts; 3.11 amps, 17.4 volts.
  Open circuit voltage: 21.7 V

Siemens Model M20 – limited stock to support existing stations
  30 cells (designed for self regulating applications)
  Specifications: 20 watts; 1.38 amps, 14.5 volts.
  Open circuit voltage: 18 V

Siemens Model SM55J – limited stock to support existing stations
  36 cells (useful in tropics when efficiency reduced due to panel heating and in cold areas of limited solar insolation.
  Specifications: 55 watts; 3.14 amps, 17.4 volts.
  Open circuit voltage: 21.7 V
800 watts solar—continuous, 24/7
112 12v lead-acid batteries; 229 solar panels
with backup 7.5 kW DC generator inside
FAA Project, circa 1996
3 Meter Buoy Equipment Rack

- ProStar charge controllers
- NDBC power control unit
- Cegasa primary batteries
- Concorde secondary batteries
- Kyocera solar panels not shown
Battery Types Used by NDBC

Primary: non-rechargeable

Model: CEGASA AS10-2 (basic cell used to construct higher voltage packs)
Specs: 1.5V/cell; 1200 Ah; 500mA continuous; 2.0A < 1 min.
4.0A for < 1sec.; 375mAh

Model: CEGASA AS10-2 NM (non-magnetic battery designed for NDBC)
Specs: 1.5V/cell; 1200 Ah; 500mA continuous; 2.0A < 1 min.
4.0A for < 1sec.; 375mAh

Secondary: rechargeable

Model: Sonnenschein A212/85 (dry fit technology)
Specs: 12V, 85Ah, EIC/DIN ratings
Advantages: 5 yr expected life; gel type; won’t leak;; high internal impedance;
Disadvantages: Cost increased substantially, availability.

Model: Concorde PVX-1080T (absorbed gas matte technology)
Specs: 12V, 104Ah@24hour rate
Advantages: lower cost; availability
Disadvantages: 1 yr expected life; leaks when damaged; low internal impedance
From D cells to Li Sulfuryl Chloride for TAO Buoys

NEW Li pack: flat discharge curve; higher energy density, small package; higher costs

OLD Alkaline D cells: discharge drops quickly, more cells needed for higher initial voltage, lower energy density, low costs.
Primary Batteries

Battery Technology and NDBC Utilization

Alkaline, sealed, ‘D’ cells, 15 Ahrs per cell:
- used on the 5 separate battery packs on the DART buoys
  - BPR CPU: 170 cells
  - BPR A/M: 180 cells
  - Buoy CPU: 88 cells
  - Buoy A/M: 120 cells
  - Buoy Comms: 105 cells

Alkaline, Mg, air-depolarized, 3 volt cells, 1200 Ahrs per cell:
- when used as backup on solar power buoys:
  2 parallel strings, 5 cells/string, 15 volts @ 1200 Ahrs
- on Hurricane buoys without solar power:
  2 banks of 12 parallel strings, 5 cells /string, 120 cells
- on Alaskan Hi-Rel buoys in extremely cold environments:
  same as for Hurricane buoys but with Super Capacitors

Lithium-sulfuryl chloride  - replaced alkaline cells on TAO buoys
  - future use on 1.3 meter Standard Buoys
Secondary Batteries

Battery Technology and NDBC Utilization

Lead- Acid - currently in use throughout NOOSS network
  - typically, on the 3m buoys:
    2 banks of batteries, 3 parallel batteries per bank,
    12 volts, 624 Ahrs total.

Lithium Fe PO$_4$ - under consideration for certain applications
Super-Capacitors Added Across Battery Bus to Provide an Extra Boost

- Regulated, slow charge between cycles extracts maximum power from batteries as they begin to decline
- Capacitors then provide high power output during data transmission
- Supported a 6m buoy with only primary batteries for 4 years
# Power Budget Analysis

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<thead>
<tr>
<th>Equipment</th>
<th>Connected</th>
<th>AH/Day</th>
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<tbody>
<tr>
<td>ARES Baseline (No Sensors)</td>
<td>N/A</td>
<td>3.46443</td>
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<tr>
<td>Wind Sensor A</td>
<td>1</td>
<td>0.19467</td>
</tr>
<tr>
<td>Wind Sensor B</td>
<td>1</td>
<td>0.15200</td>
</tr>
<tr>
<td>Barometer A (Rosemount)</td>
<td>1</td>
<td>0.26771</td>
</tr>
<tr>
<td>Barometer B (Rosemount)</td>
<td>1</td>
<td>0.25672</td>
</tr>
<tr>
<td>Compass A (Richie)</td>
<td>1</td>
<td>1.48000</td>
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<tr>
<td>Compass B (Richie)</td>
<td>1</td>
<td>1.32000</td>
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<tr>
<td>Sea Temp</td>
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<td>0.06664</td>
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<tr>
<td>Air Temp</td>
<td>1</td>
<td>0.03368</td>
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<tr>
<td>Humidistat</td>
<td>1</td>
<td>0.0896</td>
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<tr>
<td>Continuous Winds</td>
<td>1</td>
<td>0.73611</td>
</tr>
<tr>
<td>O&amp;I Light (13 Hour Cycle)</td>
<td>1</td>
<td>1.26425</td>
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<tr>
<td>TDD</td>
<td>1</td>
<td>0.10128</td>
</tr>
<tr>
<td>GPS</td>
<td>1</td>
<td>0.47333</td>
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<tr>
<td>Photovoltaic Controller * = values estimated from manufacturer's</td>
<td>1</td>
<td>0.96000</td>
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<table>
<thead>
<tr>
<th>Total Requirement for Secondary Battery Charging</th>
<th>1.086</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total ARES Requirement Ah/Day</td>
<td>11.95</td>
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</table>
Solar Powered System Calculator

- **SIEMENS SOLAR PROGRAM**
- **INSOLATION DATA LOCATION:** SAN FRANCISCO LAT:37.62 DEG N LONG: 122.38 DEG W
- **GROUND REFLECTANCE:** 0.07 (B)  **SYSTEM VOLTAGE:** 12 VDC;  **AVG. LOAD:** 20 AH/DAY
- **SELECTED SYSTEM DATA**
  - **VOLTAGE LOSSES:** 0.5 V. THROUGH CABLE, 0.7 V. ACROSS Standard DIODE.
  - **TILT ANGLE:** 60.0 DEGREES  **MIN. DAYS OF AUTONOMY:** 3.8 (JAN)
  - **MAX. PWR. CURRENT:** 6.1 A.  **MIN. BATT. TEMP:** 9.0 C.
  - **MAXIMUM POWER:** 106.1 W.  **TOTAL STORAGE:** 101.0 AH
  - **M55 3.05 A. @ 17.4 VDC**  **CONCORDE 101 AH, 12 V.**
  - **1 (S) X 2 (P) = 2 TOTAL**  **(S) X 1 (P) = 1 TOTAL**
  - **NOTE:** ARRAY TO FACE TRUE SOUTH.

- **SYSTEM DESIGN ANALYSIS** (BASED ON 90 % OF RATED OUTPUT)
  - **MONTH**  **LANG**  **LANG OUTPUT**  **LOAD**  **CAPACITY**
  - JAN 192 346 22.7 20.0 100.0 %
  - FEB 274 404 26.3 20.0 100.0 %
  - MAR 395 455 29.3 20.0 100.0 %
  - APR 521 469 29.7 20.0 100.0 %
  - MAY 604 453 28.3 20.0 100.0 %
  - JUN 645 445 27.4 20.0 100.0 %
  - JUL 649 464 28.8 20.0 100.0 %
  - AUG 574 480 30.2 20.0 100.0 %
  - SEP 473 498 31.8 20.0 100.0 %
  - OCT 333 452 29.3 20.0 100.0 %
  - NOV 223 383 25.1 20.0 100.0 %
  - DEC 174 335 22.0 20.0 100.0 %

- **PERFORMANCE DEPENDENT ON WEATHER CONDITIONS AND ADEQUACY OF INSTALLATION AND MAINTENANCE.**
Wind Generators – Prototype Tests

C-MAN Station – tested at Newport, OR in 2002-2003

Ampair Pacific 100
100 watt output
Deployed: December 2002
Supplemented solar power system but long-term problems anticipated

Rutland 913
200 watt output
Deployed: December 2002
Damaged by high winds and removed

6-meter NOMAD Buoy – prototype designed; never built
Deemed to be too dangerous to personnel while conducting service visits
Power Regulators for Solar & Wind

SOLAR – photovoltaic controller, used throughout the network

**Morningstar, Model ProStar PS-30M**
- Supports 3 battery types: Gel, Sealed, Flooded
- Low Voltage Disconnect/Reconnect: 11.4/12.6V
- Constant Voltage Regulation: 14.1V
- High Voltage Disconnect: 15.2V

WIND Generators – charge/load controller

**XANTREX, Model Trace C-40**
- Incorporated in Newport, OR  C-MAN station test design
Other Power Regulation Used

DC and AC Charging of Secondary Batteries

DC-DC Converter, Power-One Model XWS 1212

Used to maintain Secondary Batteries from Primary Batteries.
Output Power rated at 150 watts.
Output Voltage set for 13.2 VDC

A/C Battery Charger, Interacter Inc. Model II

Used where commercial A/C power is available; C-MAN stations.
Ratings: 12VDC, 10A
Five-stage, fully automatic charger.
Connects directly to batteries.
NDBC Power System – Generic Configurations

NDBC POWER SYSTEM

- Optional

Solar Panel System
- Secondary Battery-Charging System
- System Load
- Primary Battery-Backup System
NOOSS 1.3 meter Standard Buoy
One Buoy, Three Configurations

-- One integrated system vs three independent systems
- Reduces long-term maintenance cost
  Will use primary air-depolarized, non-magnetic batteries to eliminate requirement to spin the buoy to correct compass readings for directional waves.
  Presently testing a design to use solar panels and secondary lead-acid or rechargeable Li batteries to extend servicing period
- TAO buoys may only require solar panels and super capacitors
Power System Problems Experienced

- Destruction by Wildlife – Seals/Birds
- Collisions with ships
- Vandalism – private/commercial fishermen
- Icing – Northern Latitudes
- Limited Solar Insolation
- Overcharging Batteries
- Primary Batteries Depletion
- Single-Point Component Failures
Thank You

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