NAVAL OCEANOGRAPHIC OFFICE

DEVELOPING A CONCEPT OF OPERATIONS FOR MILITARY SURVEYS TO IHO STANDARDS WITHOUT SHORE –BASED STATIONS

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Collection and Processing Assets

- Military Survey Ships (T-AGS) w/HSL
- Fleet Survey Team (FST)
- CHARTS (Airborne LIDAR)
- Underwater Autonomous Vehicles (UUV) / Sea Gliders
- Tethered Vehicles
- Naval Platforms (TTS)
- Satellites
- Maury Library
- High Performance Computing (MSRC)
- National and International Data Exchange Agreements
- Data Warehouse

Outline

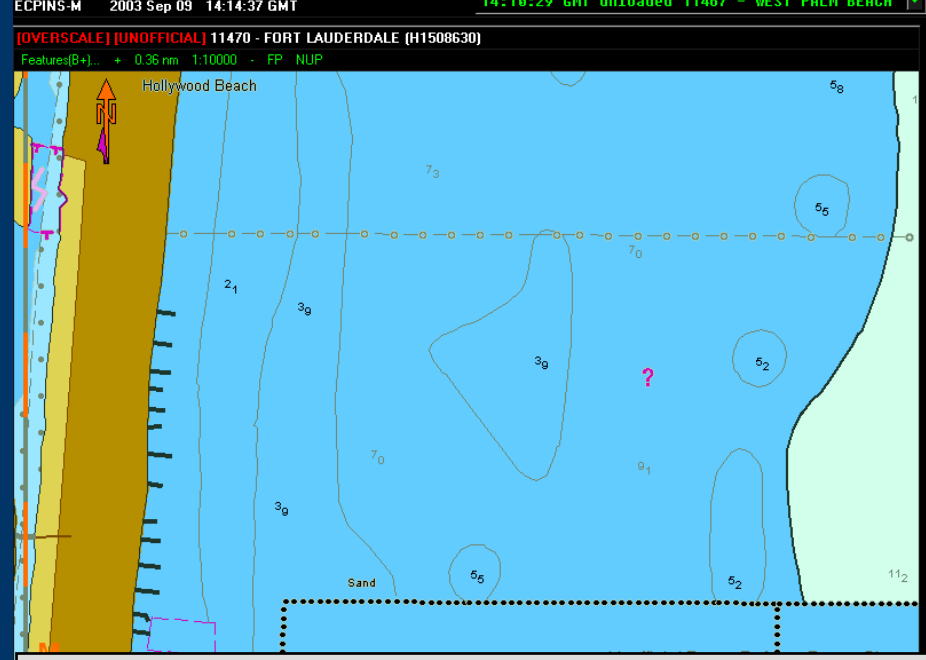
- Introduction
- Why
- How
- Status of Implementation
- Conclusions

Security and Force Protection is a Major Concern Going Ashore

Hydrographic and Geodetic Surveys in Iraq

Quick charting requirements of the Navy cannot wait for traditional tide observation periods to obtain chart datum and tide correctors

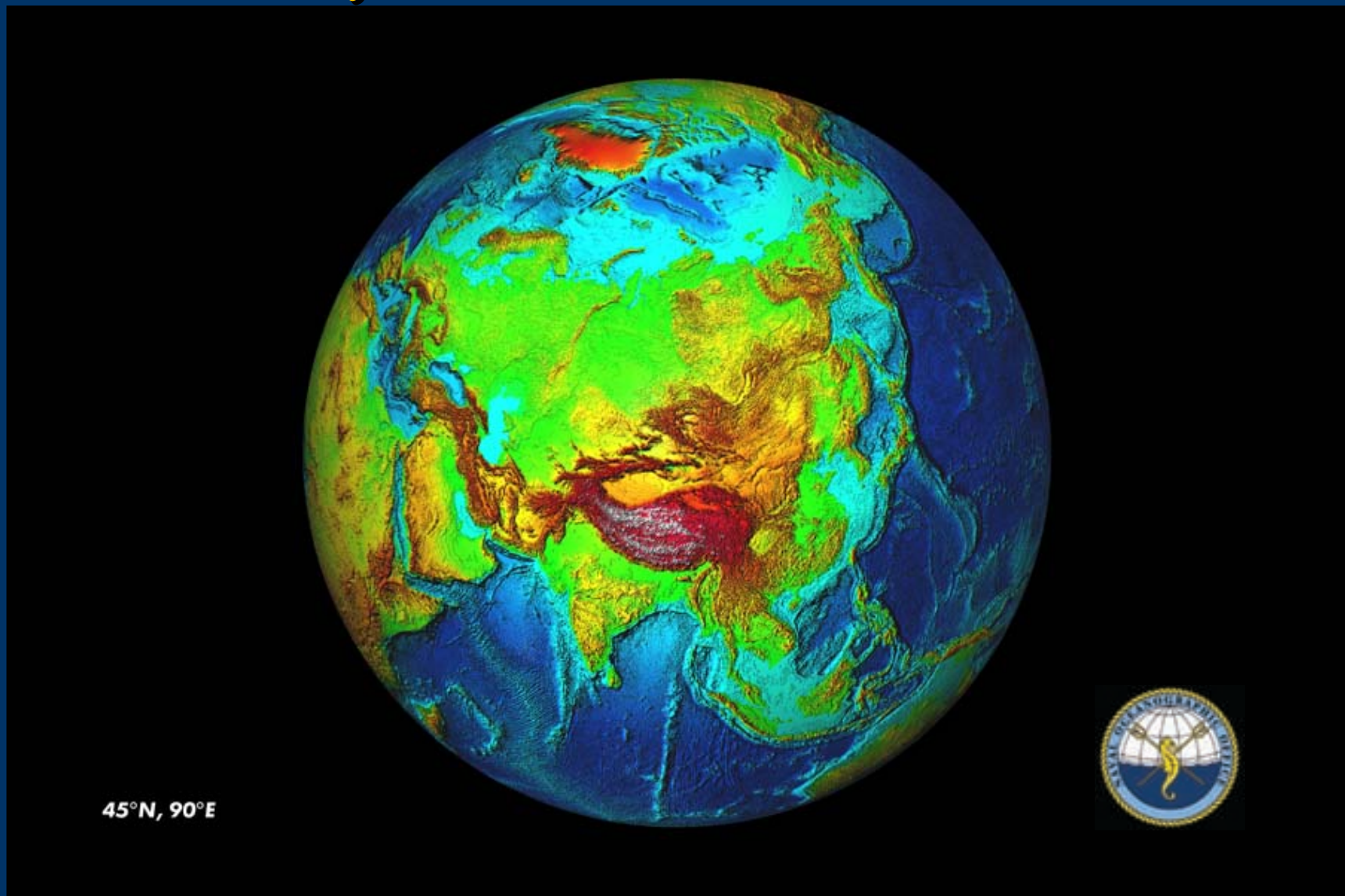
NAVO Enhanced DNC built in 18 hours after data processing. Data collected by CHARTS system in 64 hours. Collection to Processing time ratio was 1:1



Standard NGA DNC for Fort Lauderdale

Enhanced DNC for Fort Lauderdale

Large shelf areas of the planet exist extending well beyond the 12-mile territorial limit



S-44, 5th ed explicitly recommends that depth areas 100m or less be surveyed to Order 1

ORDER	Special	1a	1b	2
Description of areas.	Areas where under-keel clearance is critical	**Areas where the seabed is less than 100 metres** and under-keel clearance is less critical but where features of concern to surface shipping may exist.	**Areas shallower than 100 metres** where under-keel clearance is not considered to be an issue for the type of vessel expected to transit the area.	Areas generally deeper than 100 metres where a general description of the seafloor is considered adequate.
Maximum allowable THU 95% Confidence Level	2 metres	5 metres + 5% of depth	5 metres + 5% of depth	20 metres + 10% of depth
Maximum allowable TVU 95% Confidence Level	a = 0.25 metres b = 0.0075	a = 0.5 metres b = 0.013	a = 0.5 metres b = 0.013	a = 1.0 metre b = 0.023

Tides usually are the major component of the TVU budget

The allowable uncertainties for typical depths for

Order 1a/1b	in 1 to 100 m of water	
		0.50 to 1.39 m allowable
Order 2	in 100 to 200 m of water	
		2.50 to 4.71 m allowable

The typical total tide uncertainties are:

Order 1a/1b	0.20 to 0.30 m	(14 to 60% of TVU)
Order 2	0.50 to 1.00 m	(20 to 40% of TVU)

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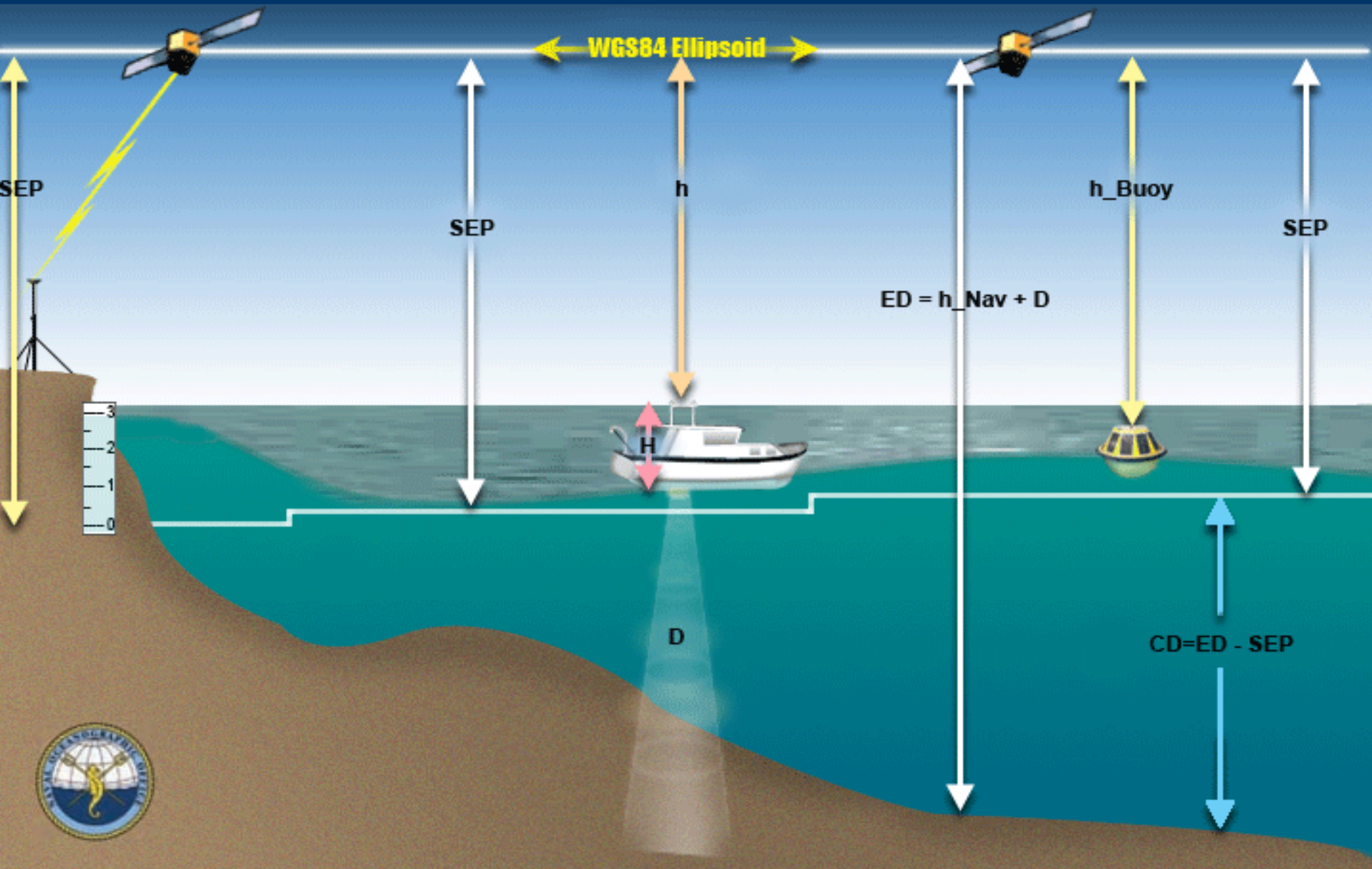
Surveying on the Ellipsoid



NavCom Technology SF-2050R GPS Receiver

Rear View

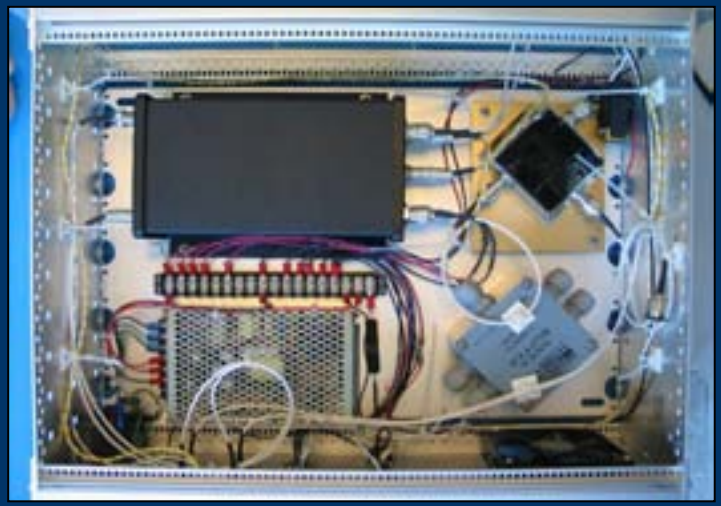
Operating Options

RTK - Limited to tests only

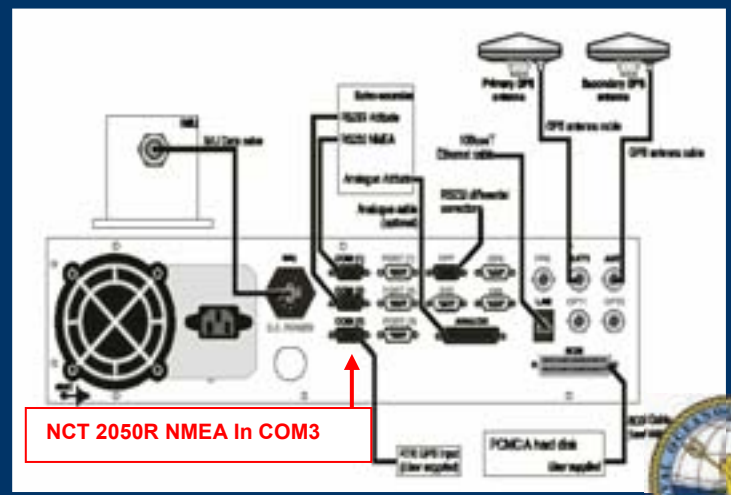
PPK – Limited by baseline length

RTG – 30 cm VU, 2 sigma

PPP – 15 cm VU, 2 sigma

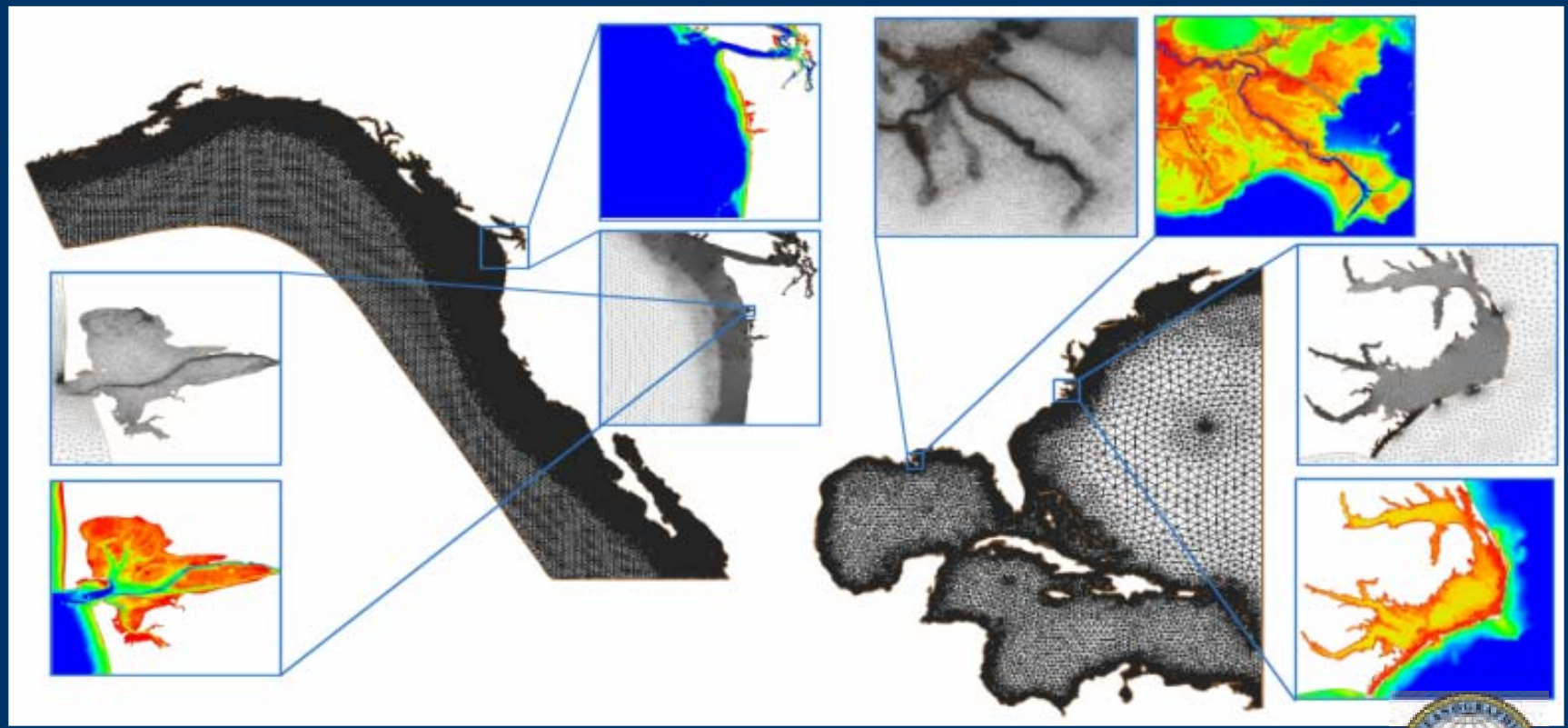


Top View



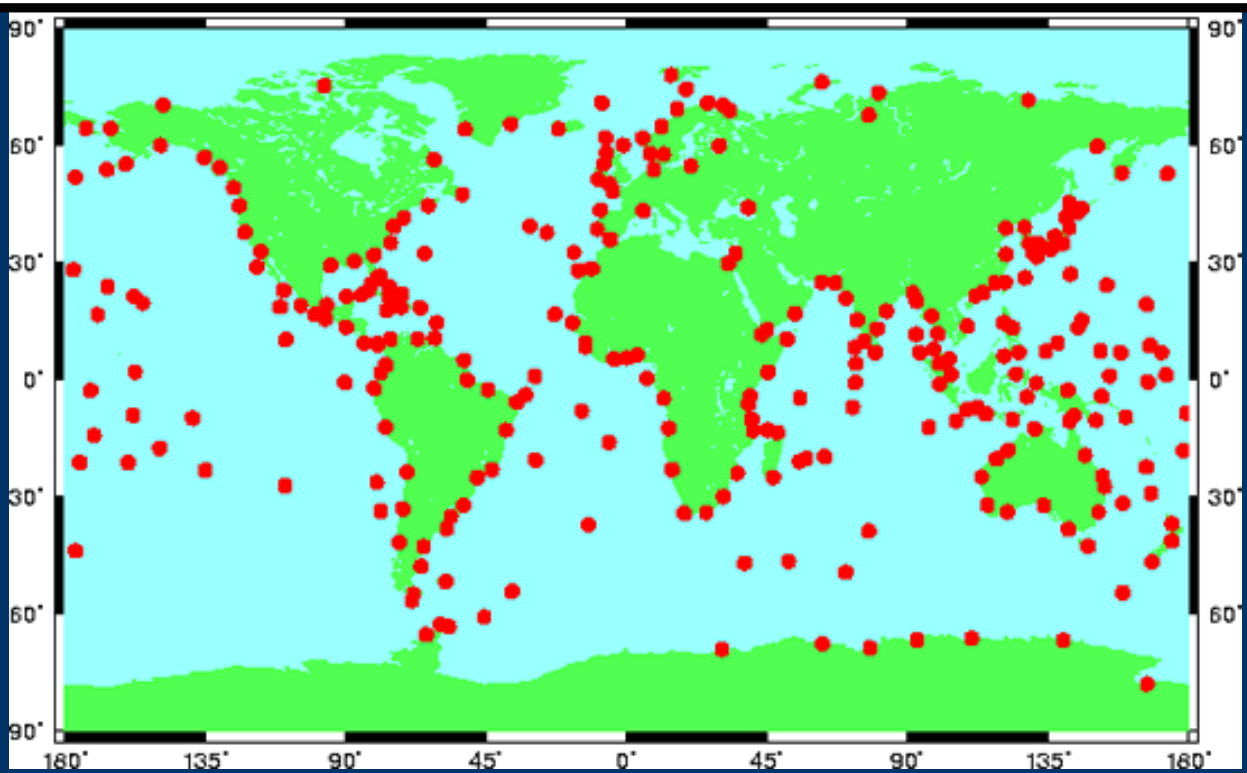
Schematic View

NAVOCEANO Tide Analyst program uses ADCIRC Model to predict tides referenced to MSL



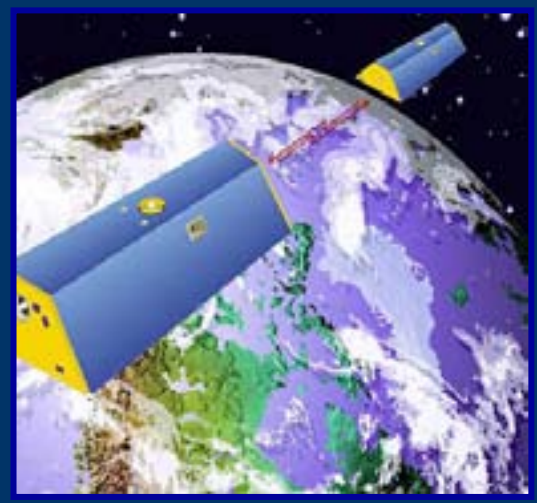
Tide Analyst uses reference tide stations to compute a grid of Zoo values

GLOSS tide stations around the world, many provide data on-line



Tide Analyst can reference ADCIRC tide levels and Zoo to the ellipsoid using EGM 96

NGA Earth Gravitational Model 2008



CHAMP and GRACE

- **satellite gravity missions, 100x improvement in the accuracy over EGM 96**

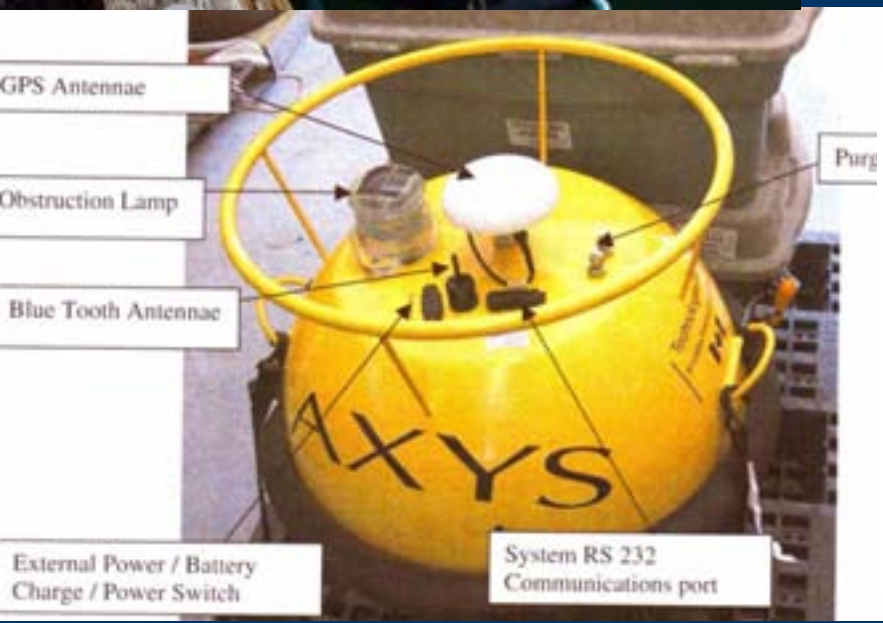
- **Higher-resolution model of the gravitational field and geoid**
  - **5’ x 5’ resolution**
  - **15 cm global RMS for geoid**

Size: 0.9 m Weight: 200 kg

Power: four 100 amp-hour batteries and ten 6-watt solar panels

GPS: NCT 2050G dual freq and INMARSAT C for corrections

Telemetry: Iridium or Bluetooth



Size: 0.6 m Weight: 58 kg

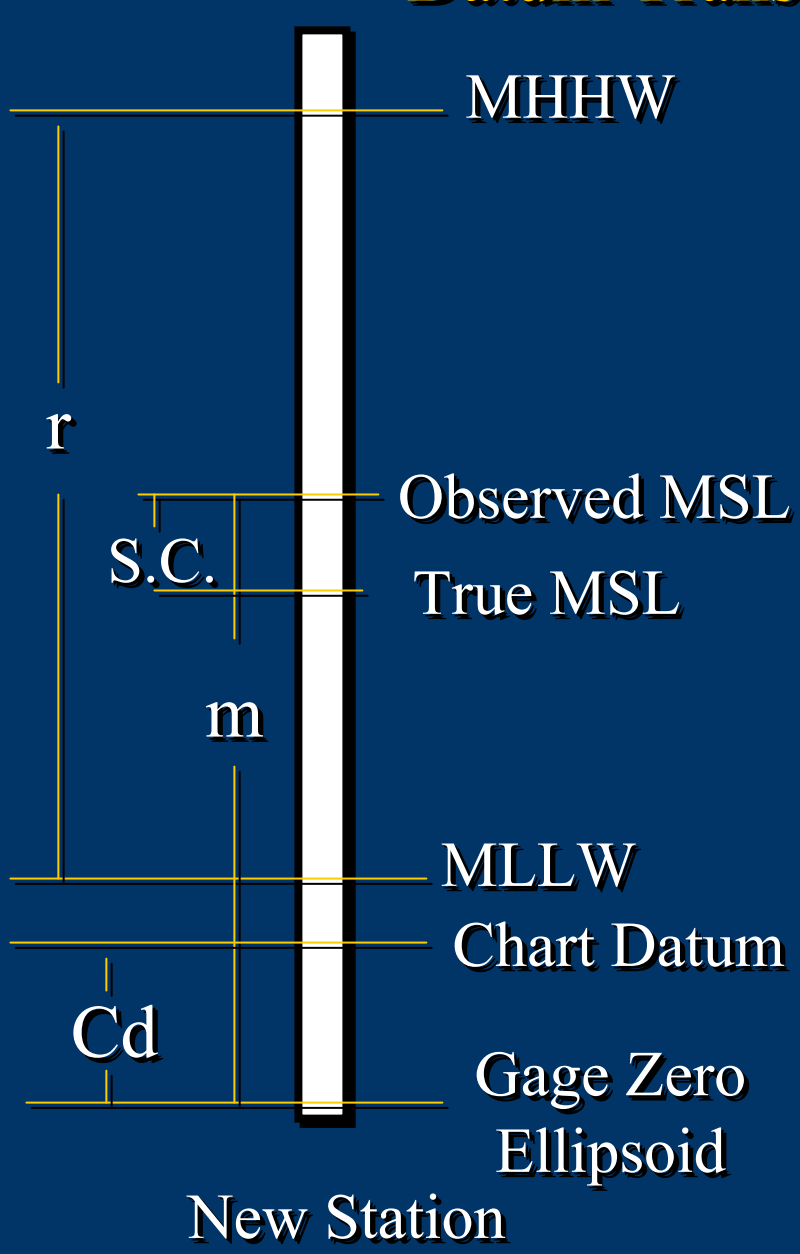
Power: four tiers lithium thionyl chloride battery packs

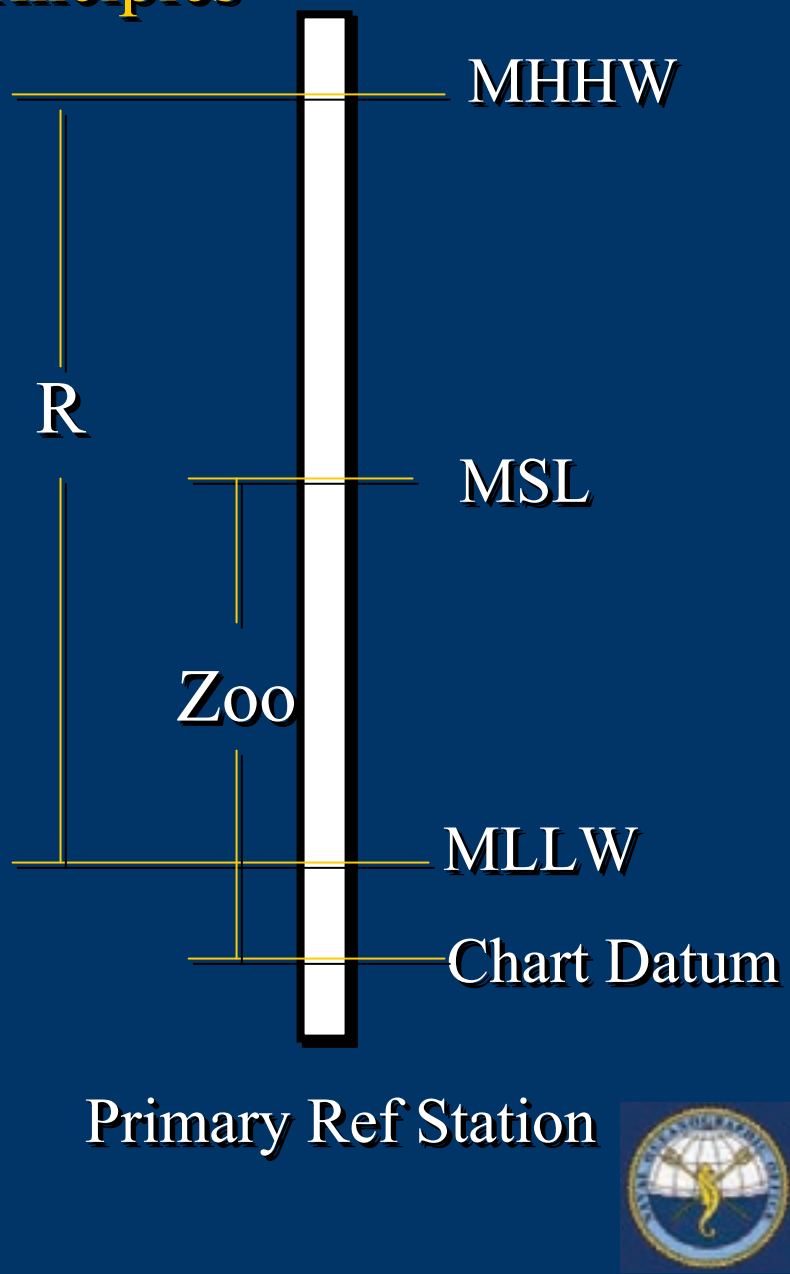
GPS: NCT 2050G dual freq and INMARSAT C for corrections

Telemetry: Iridium or Bluetooth

TRIAXYS Mini-GPS Buoy

Datum Transfer Principles





Patricia Bay, B.C. Buoy Test, 21 Jun – 10 Jul 2005

$r/R = (m - S.C. - Cd)/Zoo$

$Cd = m - S.C - Zoo\ (r/R)$

$-21.2 = -18.79 - 0.0 - 3.1(3.02/3.88)$

diff to ellipsoid	CHS Tide Gage (m)	P&TB (m)	Difference (m)	Vancouver Observed
MHHW (m)	-17.64	-17.57	0.07	4.65
MLLW (m)	-20.55	-20.59	-0.04	0.77
Range	2.91	3.02	0.11	3.88
MSL (m)	-18.78	-18.79	-0.01	3.1
Chart Datum (m)	-21.076 -2.296	-21.20 -2.41	-0.12	N.A.

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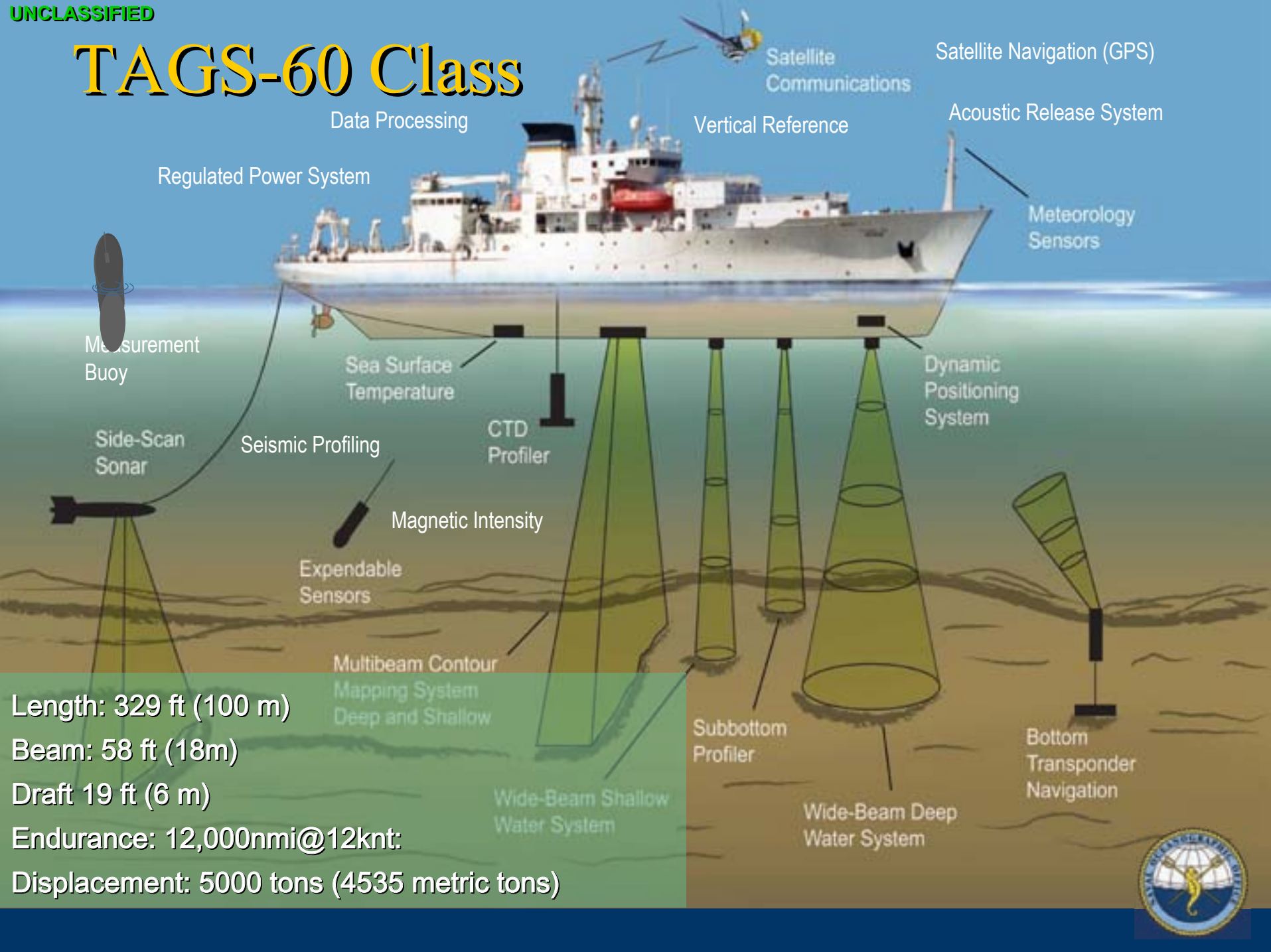
UNCLASSIFIED

TAGS-60 Class



Length: 329 ft (100 m)

Beam: 58 ft (18m)

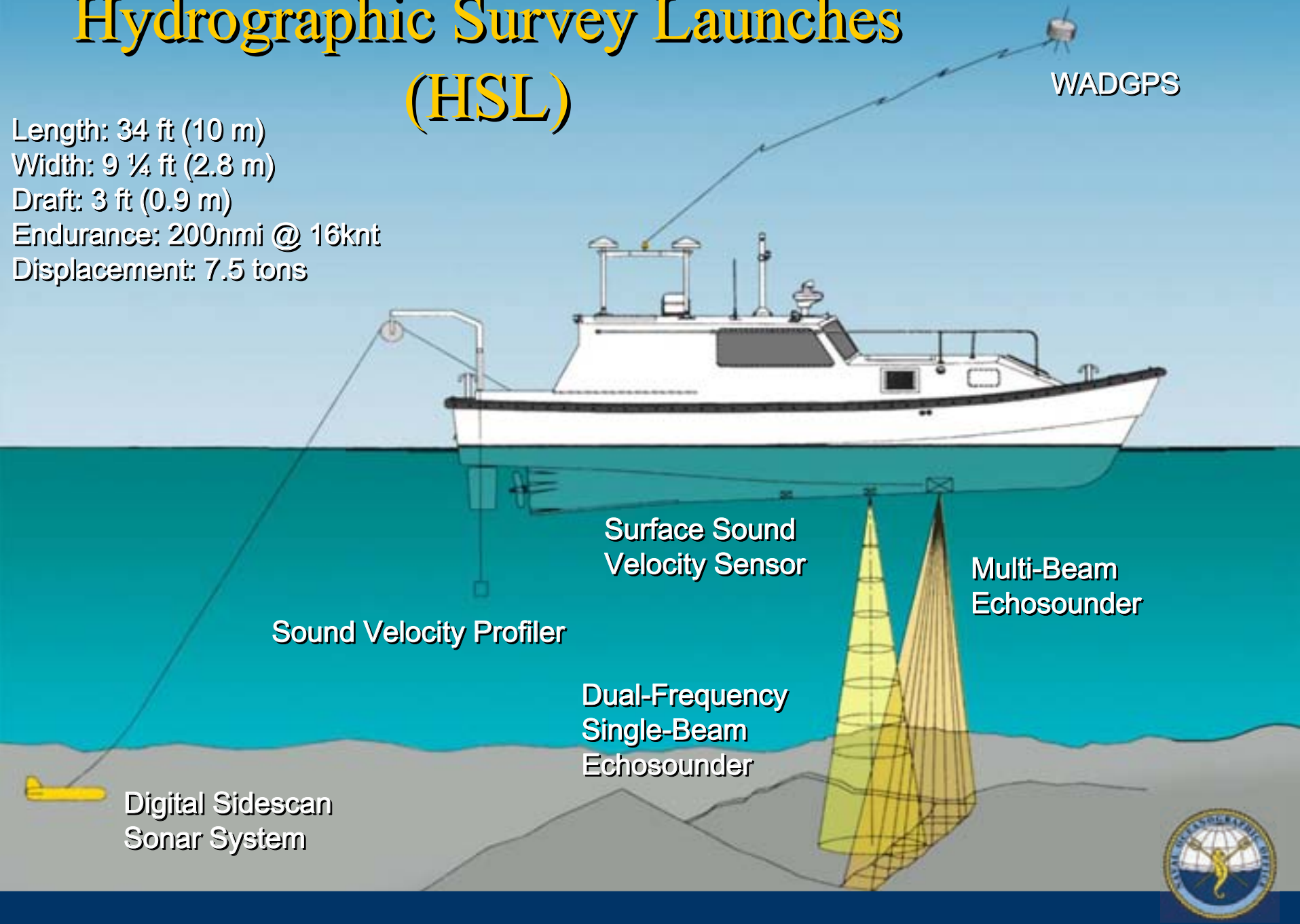
Draft 19 ft (6 m)

Endurance: 12,000nmi@12knt:

Displacement: 5000 tons (4535 metric tons)

Hydrographic Survey Launches (HSL)

Length: 34 ft (10 m)
Width: 9 ¼ ft (2.8 m)
Draft: 3 ft (0.9 m)
Endurance: 200nmi @ 16knt
Displacement: 7.5 tons



Four- phased Implementation of KGPS and RTG 3-D Positioning Aboard T-AGS Survey Ships

Phase 1

- Real-time data logging in ISS-60 to include GPS raw observables from both the Applanix POS/MV with L1 and L2 enabled, and the NavCom SF-2050R GPS at 5 Hz for ship and 10 Hz for launch operations.
- Lever arm corrections are done within the POS/MV.
- Surveys in real time will continue to use predicted tides with heave, squat/settlement, and draft updates applied in real time.
- Testing planned Apr – Sep 08.

Four- phased Implementation of KGPS and RTG 3-D Positioning Aboard T-AGS Survey Ships

Phase 2

- Implement Post-Processed Point Positioning (PPP) which uses final clock and ephemerides and converged Kalman Filter states.
- Updates to the Sonar Analysis and Area Based EditoR (SABER) software used to post-process multibeam. SABER will create water level corrector files providing ellipsoid to chart datum separation with heave, squat/settlement and draft removed. SABER TPE will be updated to track vertical components.
- Scheduled completion is Sep 08.

Four- phased Implementation of KGPS and RTG 3-D Positioning Aboard T-AGS Survey Ships

Phase 3

- Use POS/MV data with L1 and L2 enabled to provide vertical control in real time.
- Real-time integration requires the ISS-60 be modified to properly populate the $GPGGK message sent to the Kongsberg Seafloor Imaging System, so the ellipsoidal height field is populated in the GSF files.
- Positions will be refined in post time with NavCom GPS observables and PPP software
- Scheduled completion is Sep 09.

Four- phased Implementation of KGPS and RTG 3-D Positioning Aboard T-AGS Survey Ships

Phase 4

- Obtain vertical control directly from the NavCom.
- Positions can to be refined in PPP.
- Lever arm corrections are done within ISS-60 instead of POS/MV.
- Pre-survey, a predicted separation grid model will be created using EGM 2008 and used during surveys in lieu of predicted tides and zones.
- Scheduled completion is Sep 09.

Conclusions

Developing a Concept of Operations for Military Surveys to IHO Standards Without Shore-Based Stations

- **Navy IHO Order 1 hydrographic surveys can be conducted without access to shore stations.**

- **Hydrographic surveys tied to WGS-84 ellipsoid avoid the need for real-time tides.**

- **The relationship of local chart datum to the WGS-84 ellipsoid can be determined from buoys, published and on-line tide station data, and tide and gravity models.**

- **Final chart products can be built as soon as SEP is known.**

- **Three-dimensional positional accuracy should prompt a review of how bathymetric measurements are processed, archived, and presented.**

Questions:

Developing a Concept of Operations for Military Surveys to IHO Standards Without Shore-Based Stations

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