The Next Generation Easy-to-Deploy (ETD) Tsunami Assessment Buoy

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Sumatra Tsunami - December 26, 2004

The Aftermath of the Sumatra Tsunami

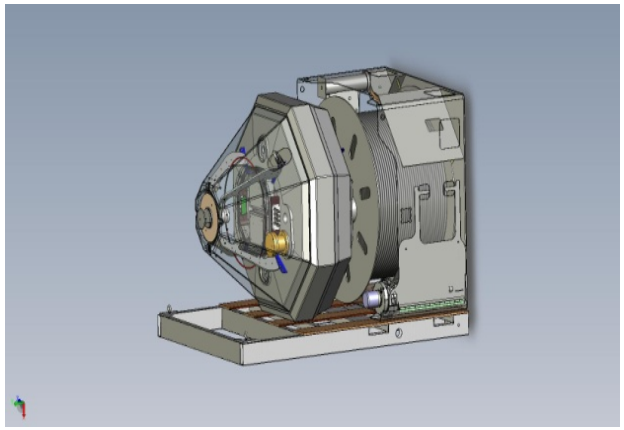
- Demonstrated lack of adequate tsunami warning systems globally
- IOC establishes the IOTWS
- Increasing emphasis in the PTWS
- NOAA upgrades DART I systems to DART II - begins deployment of 39 systems
- DART II system considered the “Gold Standard”
- International interest in DART Technology based systems increases
- SAIC develops STB system and is licensed by PMEL

Development during the Last Five Years

- Pacific Marine Environmental Lab (PMEL) focuses R&D efforts to develop a next generation system

- Goals:
  - Increase endurance while decreasing deployment costs
  - Simplify deployments
  - Eliminate need for traditional large, slow moving ships
  - Incorporate technical and engineering improvements

- ETD DART Prototypes Designed and Produced
  - 15 short-term test deployments
  - Extended tests in Gulf of Alaska, Tasman Sea and Fiji Basin
  - Australia Bureau of Meteorology key partner in the development effort

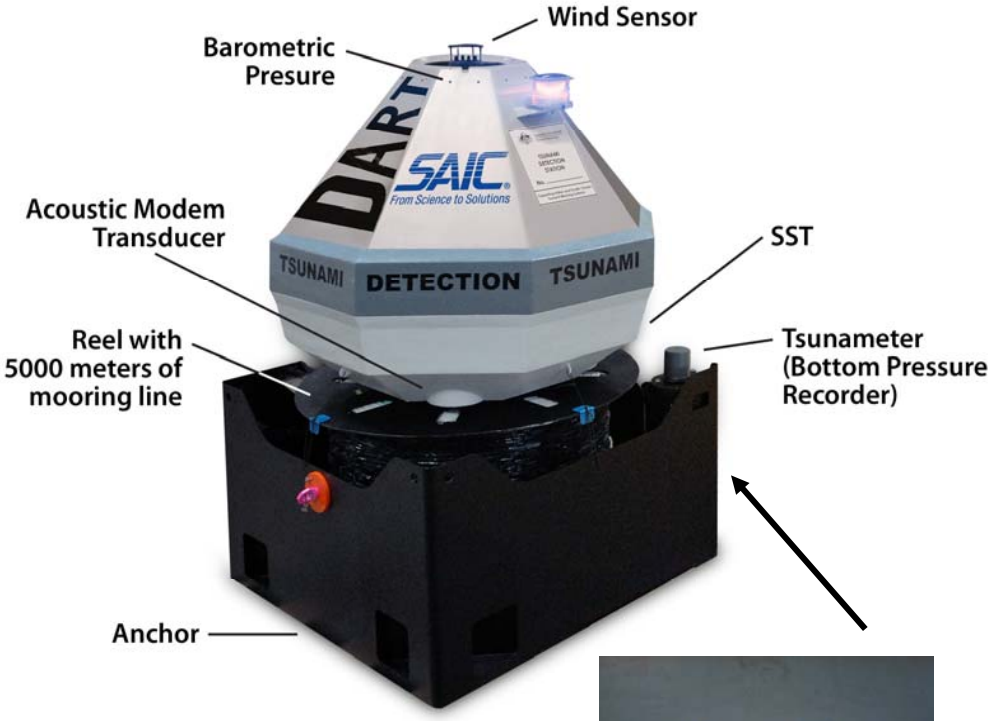


DART® tsunami technology

Easy-to-Deploy (ETD) DART® Anatomy

Common core components with different packaging

- Surface Buoy Subsystem
  - Communications, electronic payload, batteries
  - Low profile reinforced fiberglass over foam hull
  - All internal instrumentation to reduce vandalism
- Bottom Pressure Recorder (BPR) Subsystem
  - Integrated into single high pressure vessel (PV)
  - Mid-frequency omni-directional acoustic transducer
- Mooring Subsystem
  - Self deploying anchor and reel
  - Slack-mooring versus taut-mooring for STB
  - Deployment off small platform by crew with little equipment or experience



Tsunameter
(Bottom Pressure Recorder)

DART® Tsunami Technology

ETD DART® Specifications

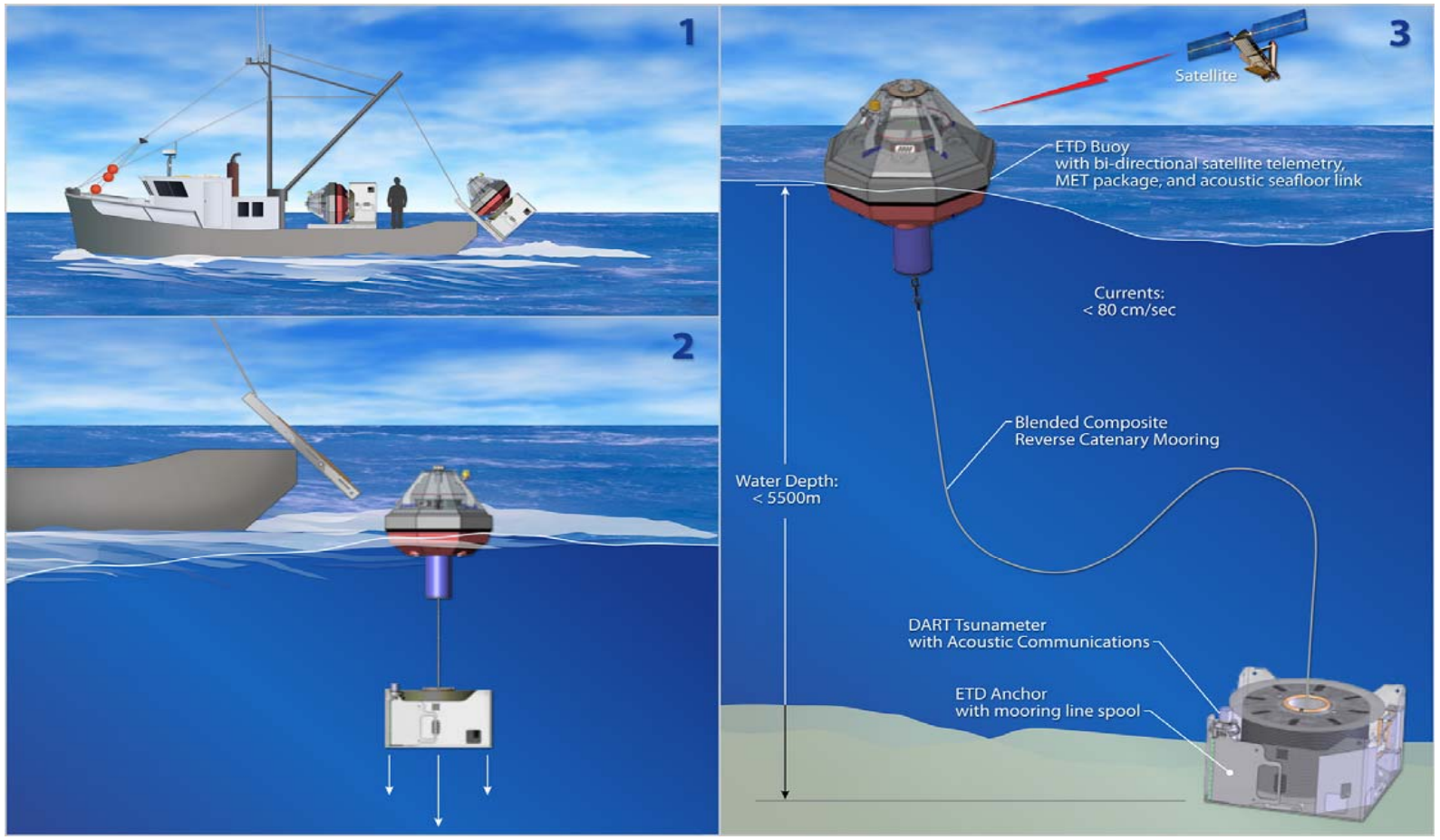
Mandatory Characteristic	Specification
Measurement sensitivity	1 millimeter in 5,000 meters
Sampling interval, internal record	15 seconds
Sampling interval, event reports	15 and 60 seconds
Sampling interval, tidal reports	15 minutes
Two-way end-to-end communications (two channels)	On demand, tsunami warning center trigger
Tsunami data report trigger	Automatically by tsunami detection algorithm
Data flow, BPR to TWC	Less than three minutes after triggered event
Desired Characteristic	**Specification**
Reliability and data return ratio	Greater than 80 percent
Maximum/minimum deployment depth	5,000 meters/1,500 meters
Maximum surface/subsurface currents	Less than 1.5 knots (80 cm/sec)
Deployment conditions	Sea State 6
Nominal system weight	2.5 tons
Deployment vessel	Greater than 60 feet LOA
Operating conditions	Beaufort 9
Theoretical battery life, buoy	Greater than two years
Theoretical battery life, tsunameter	Greater than four years
Maximum status report interval	Less than 6 hours
Maintenance cycle, buoy	Greater than two years; rotation
Maintenance cycle, BPR/Anchor subsystem	Greater than 4 years, total replacement

BPR = bottom pressure recorder
TWC = Tsunami Warning Center

Improvements to the Standard DART® Design by the Next-Generation ETD DART®

- Deployments made less hazardous in higher sea state conditions
  - Smaller system size and integrated shipping/deployment pallet
  - Faster and less complicated deployment tasks
- Eliminated need for large deployment ship and large skilled crew
  - Ship charter-hire costs significantly reduced
  - Labor costs significantly reduced
- Enhanced vandalism protection
- Increased reliability of the BPR by eliminating wet-mate cables and connectors
- Reduced BPR material costs by eliminating four pressure vessels (both titanium and aluminum)
- Reduced labor costs of overall production
- Potentially reduced lifecycle costs
- Economized operations resulting from ETD design, as compared with traditional requirements (and constraints) for deployment of fixed moorings in the open ocean.

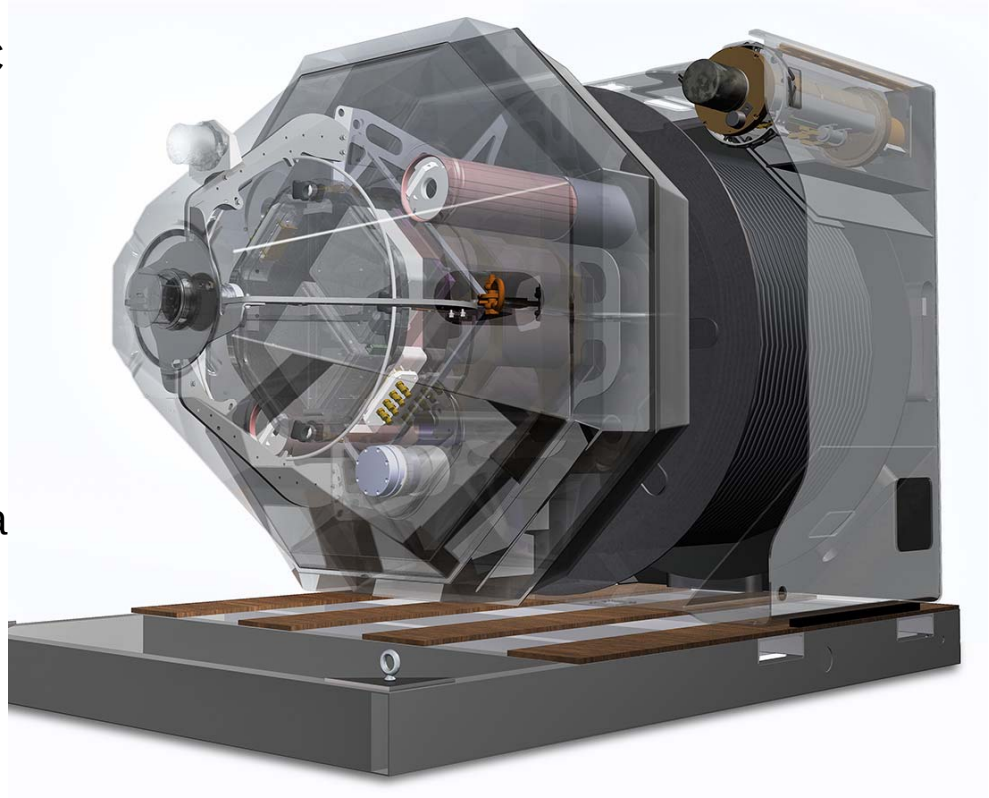
Easy-to-Deploy (ETD) DART Deployment



Next Generation Tsunami Buoy System
Easy-to-Deploy (ETD) DART

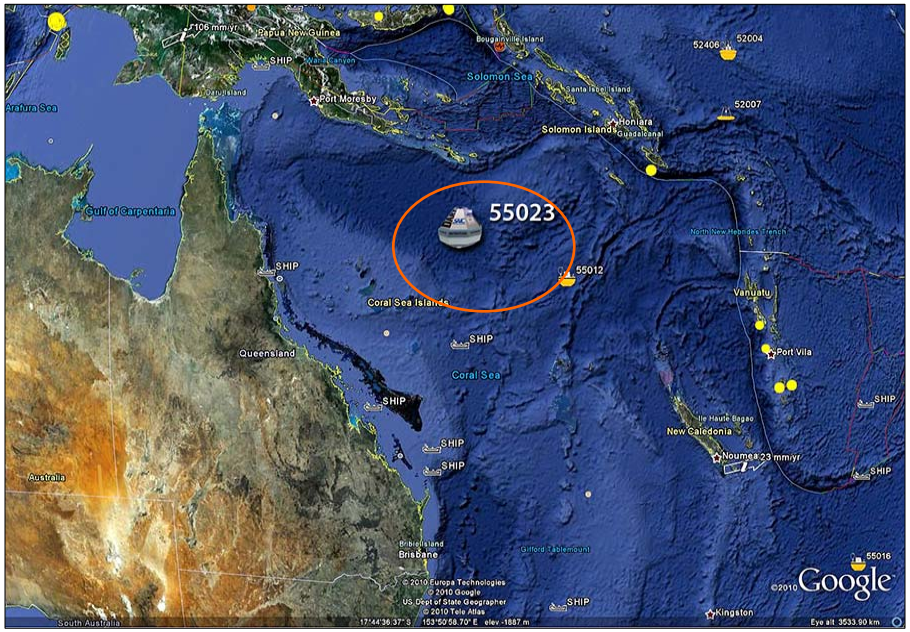
Transition of the ETD DART from Research to Operations

- Agreement signed between PMEL and SAIC in 2009
- In 2010 SAIC produced first commercial ETD DART for international and domestic requirements
- **ETD DART 1** - deployed in the Coral Sea in August 2010
- **ETD DART 2** - deployed in the Tasman Sea in April 2011
- **ETD DART 3** - awaiting deployment in the IO (south of Bali) in OCT-NOV 2011
- **ETD DART 4** – awaiting deployment in Kuril Islands May 2012
- **ETD DART 5** – in production



Easy-to-Deploy (ETD) DART® Deployment 27 Aug 2010

- Deployment cruise 25-31 AUG 2010
- Location: Coral Sea
- Station: 55023 (CE2)
- Location: 14.803 S 153.585 E
- Depth: 4595 meters



- Weather conditions: winds 20-35 knots; seas 2 - 5 meters
- Deployment Platform: PMG Pride – small general purpose ship
- Deployment Team: SAIC, NOAA PMEL, Australia Bureau of MET

Easy-to-Deploy (ETD) Coral Sea Deployment

- Deploy from small fast ship, tug, or fishing boat
- Rapid deployment
- Gravity induced launch
- Little deck equipment necessary
- Safer deck operations in heavier seas
- Sensitive to oceanographic conditions (currents and depth)
- Recover surface buoy
- Anchor / BPR fire and forget

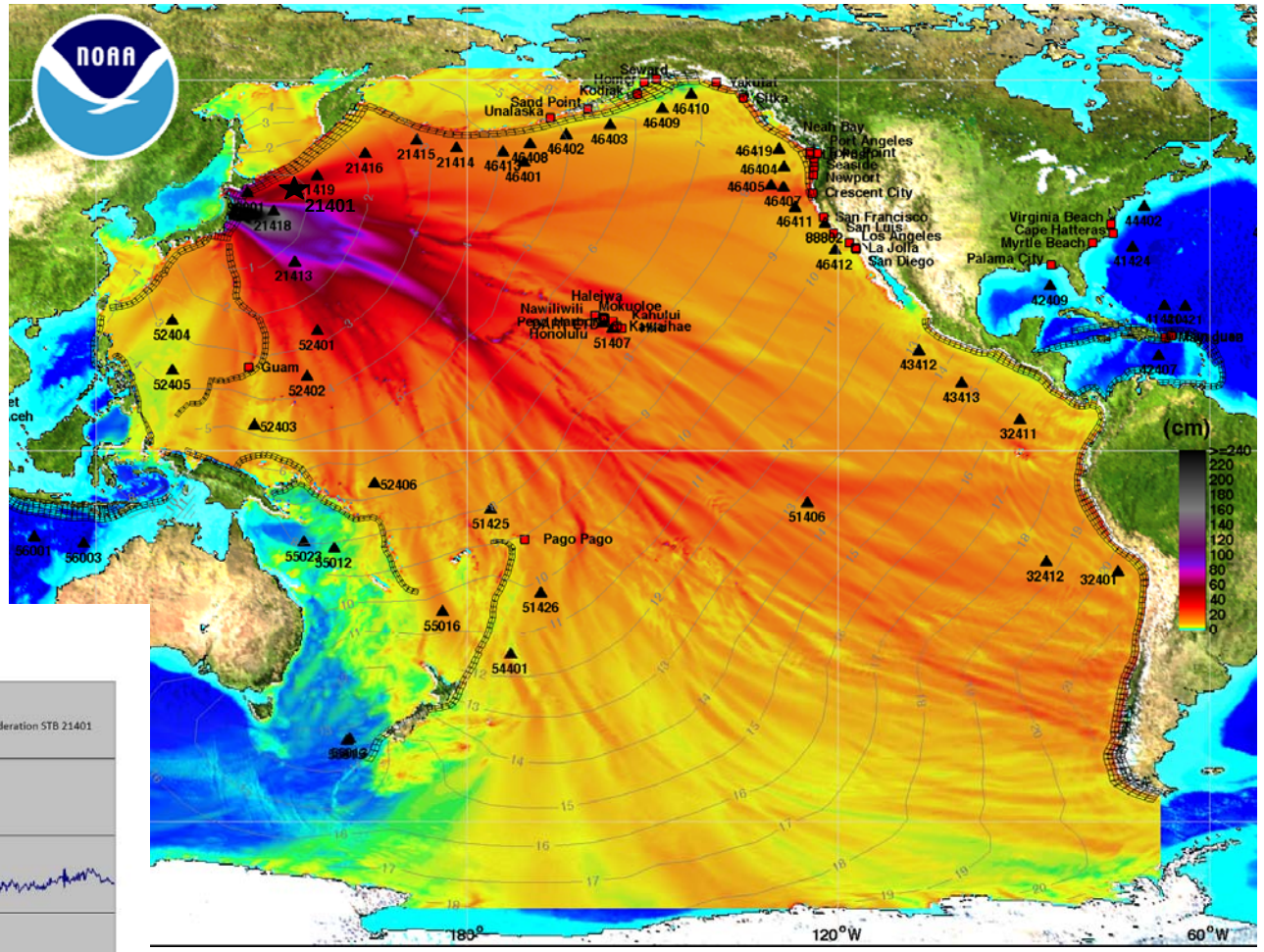
Honshu Tsunami, 11 March 2011
Russian Federation Buoy Provides Critical Data

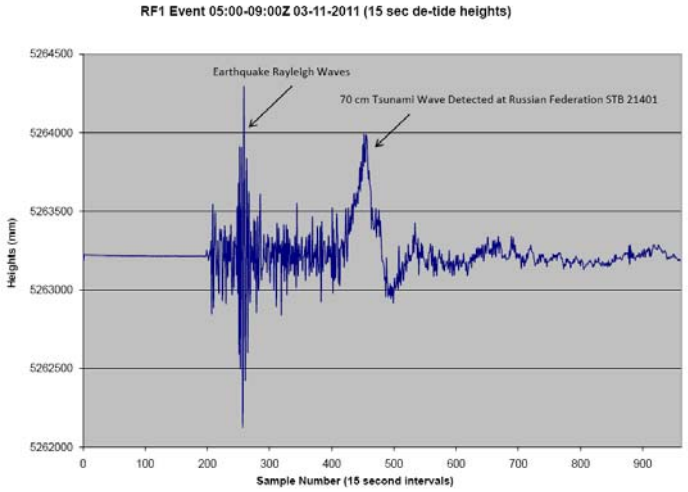
- Generated by a Mw 9.0 earthquake at 05:46 UTC, 130 km (80 miles) E of Sendai, Honshu, Japan

- First wave arrived at NOAA DART® Buoy 21418 in approximately 25 minutes,

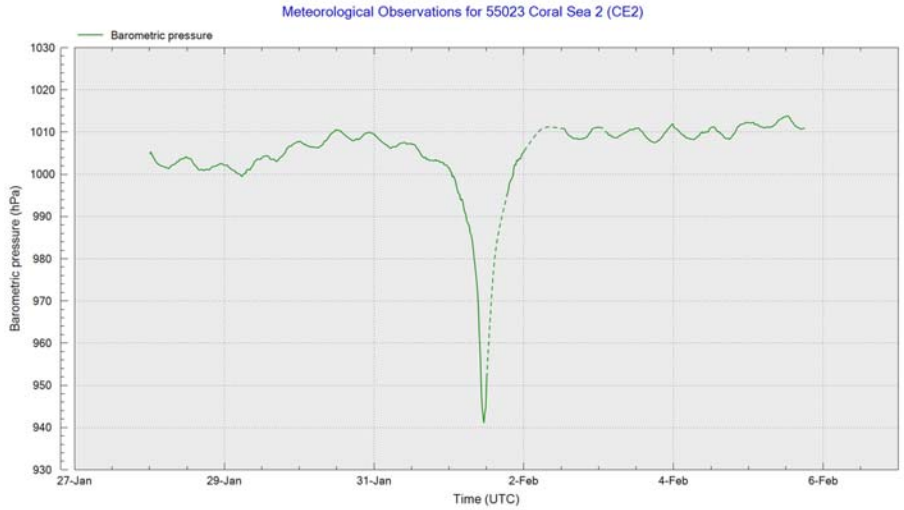
Arrived at FERHRI Russian Federation STB Buoy 21401 in approximately 56 minutes (800 km)

Russian Federation STB data used with DART® data to provide accurate Forecast results using MOST Model



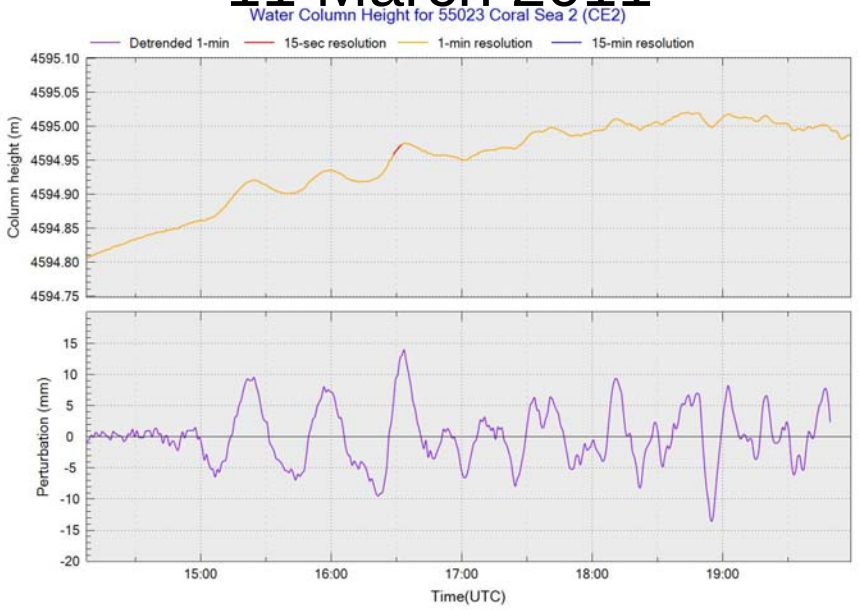


Easy-to-Deploy (ETD) DART Operating in the Coral Sea

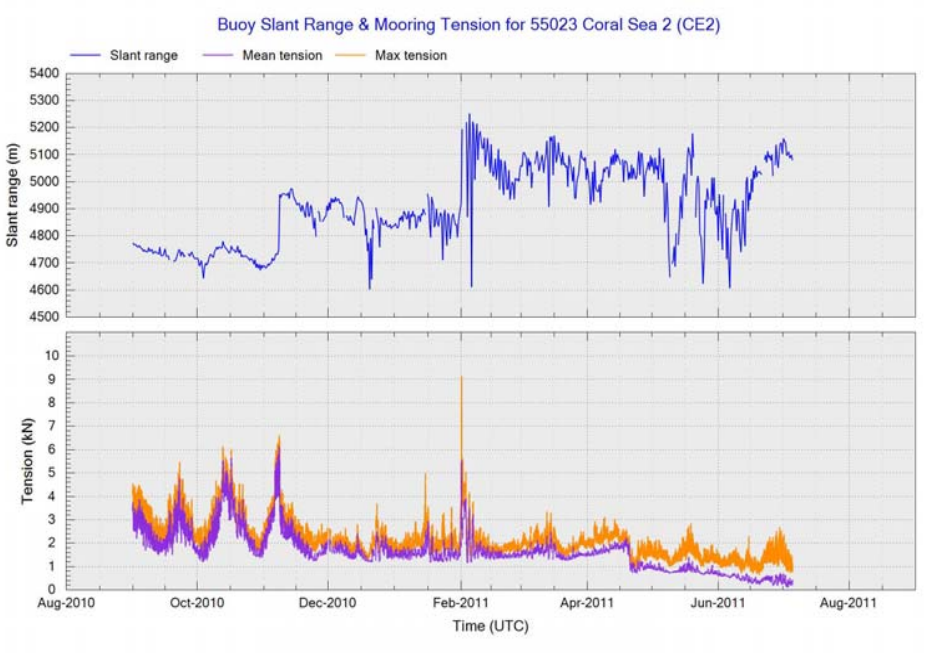


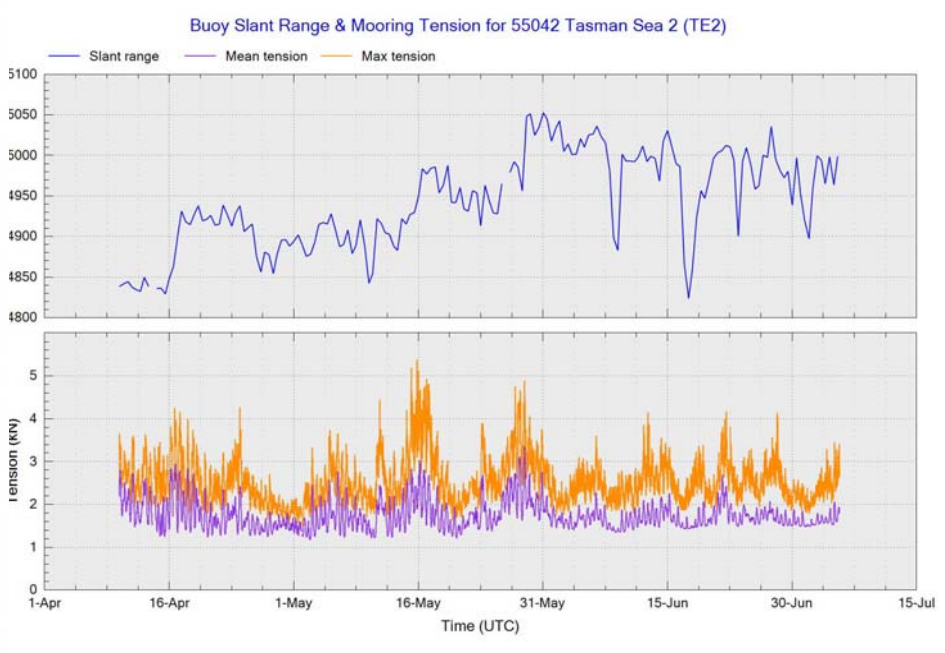
Super-Cyclone Yasi
Barometric Pressure
1 February 2011

Honshu
Tsunami Wave
Detection
11 March 2011



ETD DART Buoy Slant Range and Mooring Tension for the Coral and Tasman Seas





Coral Sea Station 55023

Tasman Sea Station 55042

Flexible Solutions, to Many Applications:

- Ocean Observations
- National Defense
- Homeland Security
- Other Applications

19 STB and ETD DART Systems as of September 2011

Customers include:

Russia **Chile** **China**

India **Australia** **Thailand**

Merci

Special Thanks to:

Pacific Marine Environmental Lab
Australia Bureau of Meteorology
SAIC International Tsunami Buoy Team