Four Decades of Technology Transitions from Research to Operations at the National Data Buoy Center

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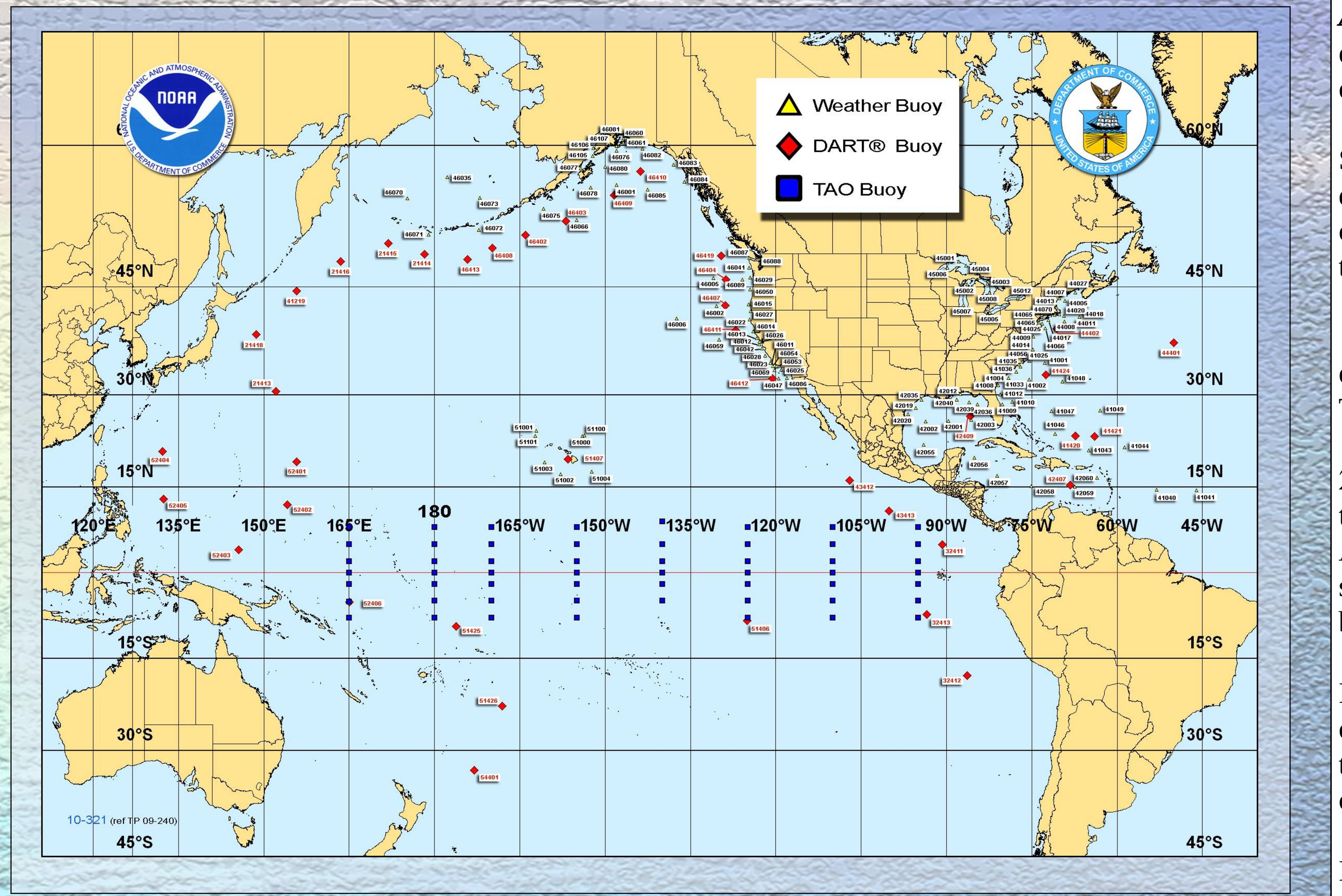


ABSTRACT: Since its inception in 1968, technology transitions have been common-place at the National Oceanic and Atmospheric Administration's (NOAA) National Data Buoy Center (NDBC). As the decades have progressed, the type and character of the transitions have changed resulting in a greatly expanded geographic area of NDBC operations and an increase in the diversity of the measurements. Transitions and improvements have taken into consideration the need of continuity of observations over long-periods for interest to the climate community. While all transitions been successful, they have offered significant challenges to NDBC and to NOAA.

Significant transitions in the 1970s included large-hulled buoys developed by the U.S. Navy, including the 12-m steel discus and 6-m aluminum NOMAD (Navy Oceanographic Meteorological Automatic Device) buoys. In the early 1980s, NDBC transitioned and adapted the 3-m aluminum discus hull developed by the Woods Hole Oceanographic Institution. These 3-m buoys were first moored adjacent to larger buoys or offshore platforms to establish measurement comparability and to determine accuracy in a variety of sea states. Hull correction coefficients were also empirically determined through these comparisons for wave measurements. This practice helped to ensure data continuity as cost-efficient, smaller buoys replaced larger ones and has resulted in a reasonably consistent, long time series record that is of increasing interest in climate change research. The robustness of the systems is evident in that there are 20 stations that have operated nearly continuously since 1980.

The mid-80s saw the transition of directional wave measurement instrumentation and techniques for heave/pitch/roll buoys using the method of Longuet-Higgins, Cartwright, and Smith (1963). The successes of the previous two decades were carried further in the 1990's by efforts to improve the cost-efficiency, accuracy, and reliability of marine observations. These transitions and improvements allowed for the increase in the number of operational weather buoys from one in 1970 to more than 110 in 2010 and the increase of directional wave measuring buoys from one in 1985 to more than 60 in 2010. These transitions included developing the supporting infrastructure for system and component life-cycle management, quality control, and product generation and distribution.

2003 brought a significant change to NDBC's transition experience – the transition of complete end-to-end systems, developed by NOAA's research facility at the Pacific Marine Environmental Laboratory (PMEL), specifically the Tsunami Detection Network and the Tropical Atmosphere Ocean Array (TAO the climate and El Niño monitoring network). Furthermore, the systems greatly expanded NDBC's operational area from primarily the offshore and coastal waters of the United States to a system of systems that stretches from New Zealand to the Bering Sea, and from the Philippines to east of the Lesser Antilles. The addition of TAO and the Tsunami Detection Network nearly doubled the number of buoys that NDBC operates. Prior to these transitions, NDBC's focus had been on surface meteorological observations, but both systems brought a host of diverse measurement requirements. TAO consists of both surface meteorological and subsurface oceanographic measurements. The Tsunami Detection Network reports on the water-column height derived from measuring the pressure at the sea-floor. Both systems had been deployed by PMEL and provided data for a number of years. The transition strategies were based on preserving the system performance and operations in order to be transparent to existing users.

In 2002, upon the recommendation of a Program Review Team, the NOAA administrator approved the development of a transition plan for TAO. The plan called for a two phase approach and would include technology upgrades to address the aging systems. The first phase was the transfer of data management operations completed in 2006, followed by the at-sea operations in 2007. Because TAO is a climate monitoring system, it brought NDBC into the realm of post-deployment measurements to determine and correct for instrument drift and biases. Presently NDBC is in the midst of the final chapter of the transition and that is the technology upgrade, which is referred to as TAO Refresh. TAO Refresh replaces customized sensors and components with those commercially-available and uses state of the art communications to provide more real-time observations and to guarantee the continuity of the system for climate purposes.

In 2003, NDBC transitioned the six-station Tsunami Detection Network that employed PMEL's award-winning, first generation Deep-ocean Assessment and Reporting of Tsunamis (DART) technology. In 2005, NDBC transitioned the PMEL's patented, second generation technology, and expanded the network from six to 39 stations by 2008. Among the tsunami events that the network provided information for were tsunamis generated by earthquakes in the Kuril Islands in 2006 and 2007, Peru in 2007, Samoa in 2009, and Chile in 2010.

NDBC's long experience with transitions serves as the foundation of future transitions as NDBC enters its fifth decade of operation. NDBC is undertaking significant changes to its data archiving system to meet increased demand for data to support climate studies, and is considering transition to Autonomous Marine Vehicles such as Wave Gliders as ocean observing platforms to augment moored buoys. The vehicles are seen as a means to reduce the length of buoy outages because of the lack of the availability of service vessels, and to augment and or replace buoys to eliminate expensive vessel costs (~$30,000 per day) associated with the deployment and recovery of buoys.


10-m Hull (NDBC)

3-m Aluminum Discus Hull from WHOI

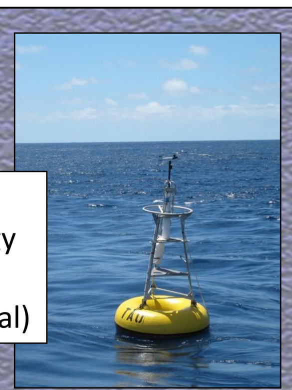
Directional Waves from Buoys

Acoustic Doppler Current Profiles

DART I from PMEL

TAO from PMEL

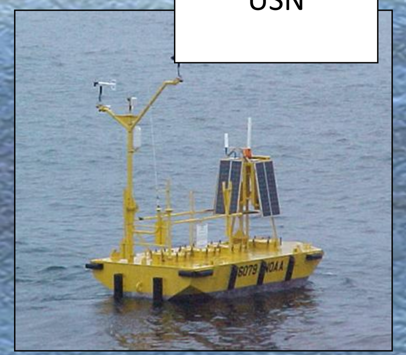
TAO Technology Refresh (Commercial)



1970 1975 1980 1985 1990 1995 2000 2005 2010

12-m Discus Hull from USN

6-m NOMAD Hull from USN

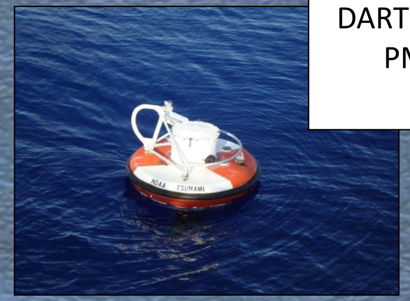


Satellite Telemetry (Commercial/ Govt)

Buoy Technology for Coastal Stations (NDBC)

Humidity Sensors (Commercial)

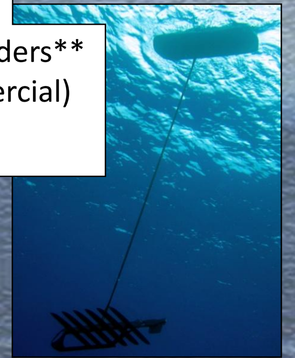
GPS Locations (Commercial)

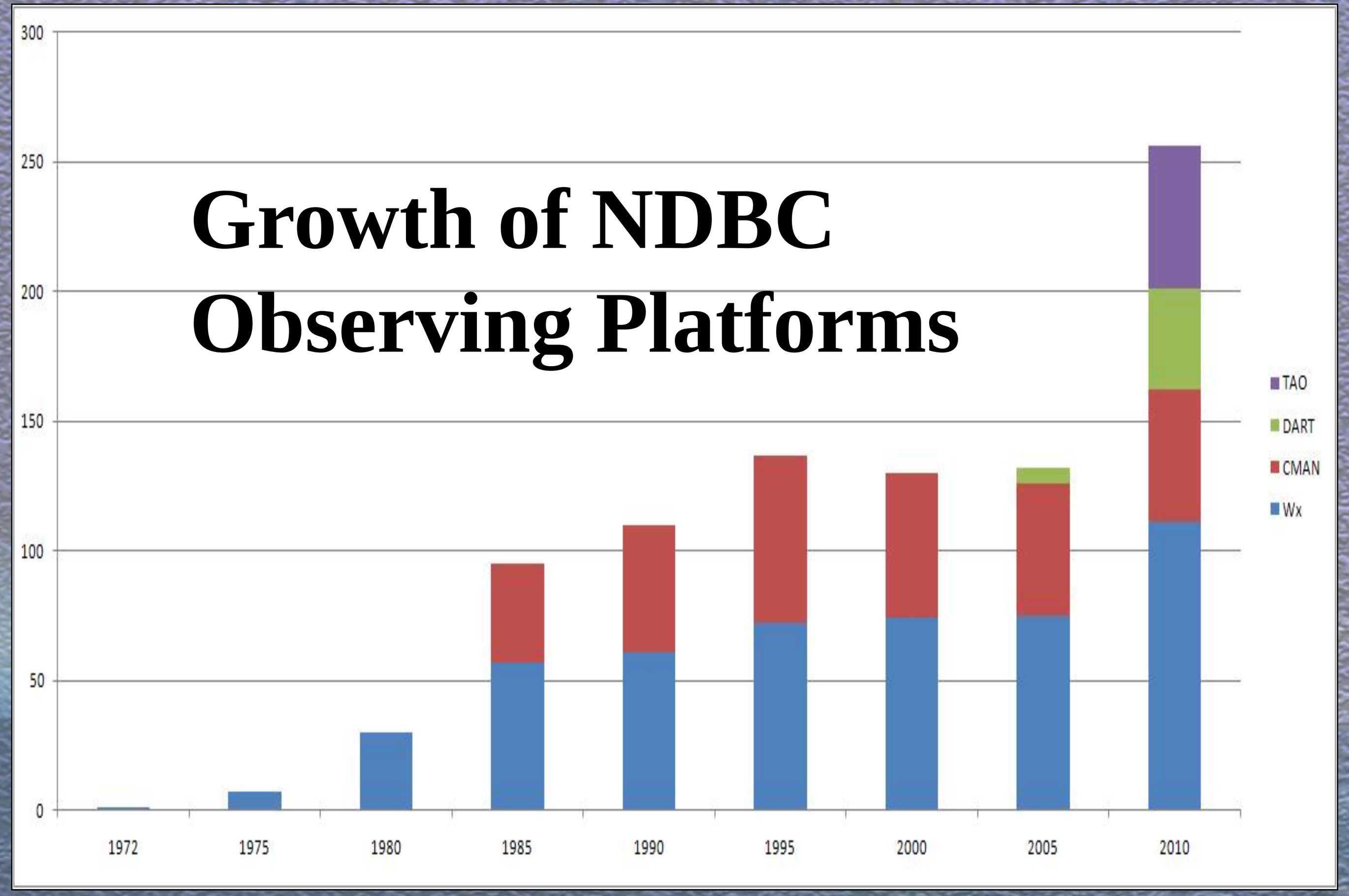


DART II from PMEL

DART Network Completed

Wave Gliders** (Commercial)





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11-078 (NDBC TP) 01-2011 AMS 91

**Wave Glider photo courtesy of Liquid Robotics, Inc.