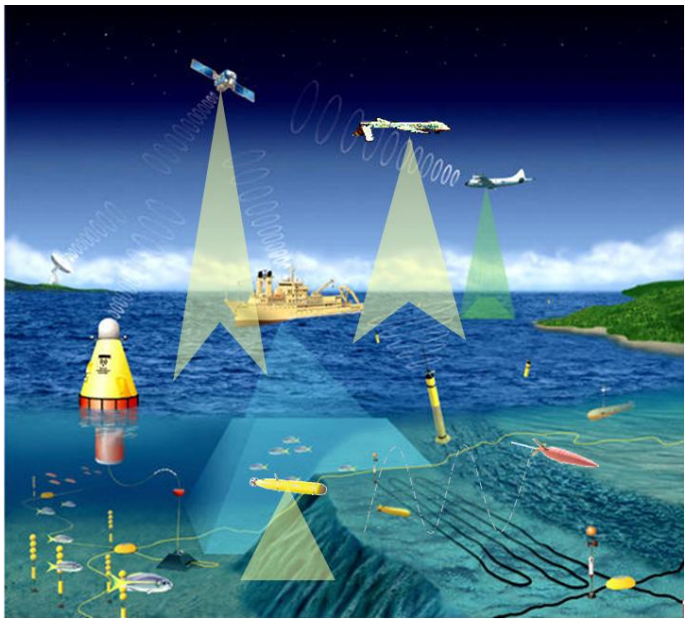
State of the Science FACT SHEET

Emerging Technologies for Mobile Earth Observations

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION • UNITED STATES DEPARTMENT OF COMMERCE

For decades, NOAA has relied on data from satellites to provide remotely-sensed measurements of Earth. Now, emerging autonomous and remotely piloted platform technologies, including **unmanned aircraft systems**, **autonomous underwater vehicles**, *and* **sensors on aquatic species**, *have matured in capabilities and reliability. They offer great potential for cost-effective, operationally feasible, and energy-saving solutions for observing Earth that complement satellite and more traditional in situ platforms. These platforms will be useful for observing missions requiring longer duration, longer range, or access to dangerous or inaccessible areas (e.g., hurricane eye walls, sub-ice oceans). NOAA currently deploys these technologies for individual research, development, and demonstration projects. The potential exists to more fully integrate them into a comprehensive Earth observing system for coasts, oceans, weather, climate, and research missions.*



Comprehensive Earth Observing System. *Autonomous and remotely piloted in situ platforms complement standard ship, aircraft, satellite, and tethered platforms by increasing coverage, assessing remote or dangerous areas, and reducing operational costs. Photo credit: US Integrated Ocean Observing System*

Autonomous Underwater Vehicles

Autonomous Underwater Vehicles (AUV) measure ocean conditions and map ocean features. From solar-powered surface vehicles to Argo floats to propeller-driven submersibles capable of reaching the deepest ocean trenches, AUVs can use sonar to collect data on fish stocks or map the ocean bottom, be equipped to collect water samples during missions, and use other sensors to measure temperature, conductivity, dissolved oxygen, sound, and other parameters. AUVs can be rapidly deployed wherever they are needed, and provide the flexibility to survey inaccessible areas or conduct long duration missions (e.g., up to six months).

Unmanned Aircraft Systems

Unmanned Aircraft Systems (UAS) have the potential to efficiently and safely bridge critical information gaps in data sparse and remote locations of the global environment and advance understanding of key processes in Earth systems. NOAA may be able to use UAS to address mission goals through improved understanding of oceanic and atmospheric exchanges, hurricanes, marine ecosystems, polar regions, wildfires and other hazards, and other environmental and ecological processes, ultimately leading to improved climate and weather predictions and management of marine resources. NOAA is partnering with other civilian agencies, industry, and the academic community to develop UAS operations, systems, and platforms that can be safely deployed, both nationally and globally, to fill observational data gaps with increased efficiency and decreased risk to personnel.

Sensors on Aquatic Species


Photo Credit: D. Costa

Living in the ocean and along coastlines, **marine species** can serve as highly mobile platforms capable of traveling over long distances and through remote, sometimes extreme or inaccessible environments. When outfitted with sensors, vast quantities of environmental and behavioral data can be collected from the habitats they occupy. These data provide important information about ecological interactions, biodiversity, animal behavior, foraging "hotspots", and migration routes, as well as hydrographic information, particularly from areas where traditional forms of such observations are lacking. **Sensors on aquatic species (SOAS)** can be deployed and tracked in large numbers over long periods of time. These observations can provide data for climate, weather, ecosystem, and fisheries models, among other diverse applications. SOAS undergo extensive permitting and review prior to deployment to ensure no animal is harmed.

Obstacles to Applying these Technologies

- Many UAS applications (e.g., severe weather research) will require improved access to national airspace. The Federal Aviation Administration (FAA) has been tasked by the U.S. Congress to develop a roadmap for increased use of UAS in national airspace. In the meantime, the FAA accepts applications for Certificates of Authorization from public operators such as Federal agencies and state universities.
- Various proprietary AUV and UAS systems have been developed, each with unique hardware and software systems requiring separate training and certification to operate. The Department of Defense is pushing for interoperability standards for UAS, but AUV standards for vehicle classes, parts, command, control, sensors, and data streams are lagging.
- Some autonomous and remotely piloted observing platform technologies developed through Department of Defense investments may not be easily transferred to civilian applications. All platforms should be properly evaluated for appropriate civilian applications based on national and international regulations for safety, airwave frequency interference, export control, and international traffic in arms.
- SOAS technology is constantly evolving to address ongoing challenges: long duration sensor attachment; overall sensor size, battery duration, and instrumentation packages; and sensor and data retrieval.

Integration into Agency Operations

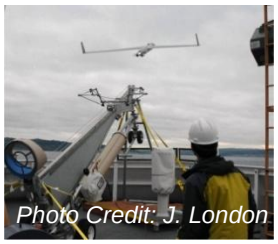
Numerous autonomous systems are being investigated by NOAA and other agencies for their potential to meet data collection needs. NOAA's unique observing requirements may require autonomous systems designed to meet a particular need, while some systems may meet the needs of multiple agencies. To increase efficiency of using these systems, NOAA, with our partners, should promote common training, equipment maintenance, data standards, and lifecycle infrastructure.

Recent Research Applications

- **Weather and air quality:** NOAA and NASA have jointly demonstrated the long range and endurance potential of high altitude UAS with the first science flights of the Global Hawk flown from the NASA Dryden Flight Research Center in California. Studies include observing dust plumes from the Gobi Desert traversing the Pacific Ocean, polar weather of the Arctic, and the genesis, intensification, and dissipation of tropical cyclones in the Eastern Pacific, Atlantic, and Caribbean. Partnership with the U.S. Customs and Border Patrol has provided real-time imagery from the Predator UAS to supply new information for real-time situational awareness for NOAA river forecasters during the 2009 and 2010 flooding of the Red River. These new capabilities will improve the understanding and prediction of high impact weather systems with previously unavailable real-time information. (UAS; ESRL; AOML; NWS)
- **Polar and marine observations:** NOAA has deployed small UAS from both land and ship to demonstrate the potential to collect high resolution spatial and temporal information on sea ice, glaciers, and ecosystem conditions. The low noise levels produced by some UAS may enhance their use for monitoring marine wildlife and illegal fishing activities. (UAS; ESRL; PMEL; AFSC; SWFSC; CINMS)
- **Ocean acidification**: Powered by wave and solar energy, the wave glider surface vessel is being adapted in collaboration with OAR's Pacific Marine Environmental Laboratory to monitor physical and chemical parameters important for ocean carbon and ocean acidification.
- **Narwhals tracking ocean data in the Arctic**: Sponsored research in 2006-07 used tagged narwhals to measure oceanic conditions below the Arctic ice pack. Future efforts aim to increase deployment of acoustic and satellite tags and the receivers that communicate with and transmit data from tagged animals in the field. (OER)
- **Understanding animal movements and behavior**: Researchers at Southwest Fisheries Science Center are collaborating with the Tagging of Pacific Pelagics program to understand the environmental basis for movements and behaviors of large pelagic animals in the North Pacific.
- **Coral, fish, and mussel surveys**: NOAA's Northwest, Alaska, and Pacific Islands Fisheries Science Centers and the Office of Marine Sanctuaries are using AUVs to map coral reef habitats and monitor reef and bottom fish populations on the Pacific coast, while NOAA's Great Lakes Environmental Research Laboratory is deploying AUVs to monitor invasive mussel populations.
- **Water quality, fisheries management, model validation**: The National Ocean Service uses profiling gliders to detect *Karenia brevis* toxins in the water, and the non-Federal partners of US IOOS® operate 80 gliders on a variety of missions funded by NOAA, ONR, NSF, and state agencies.
- **Hydrographic survey support**: NOAA's Office of Coast Survey uses AUVs in operations to support its nautical charting mission, marine incident and post-hurricane response, and port security surveys.

For more information see:

http://uas.noaa.gov
http://explore.noaa.gov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