Marine Technology Society
A Unique, Multidisciplinary, Oceans and Marine Network

Admiral James D. Watkins
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Dear Admiral Watkins:

First I want to thank you for the opportunity to testify before the Ocean Commission and also for posing your excellent follow-up questions to that testimony. In the intervening months, we have attempted to address these questions: through the presentation given at the 21 February 2002 Ocean Commission site visit to Ft. Lauderdale, Florida; by six additional testimonies provided by MTS leadership to the Commission; through a number of written submittals sent to the Commission; in addition to some articles that have since been published in response. Now with your work culminating, to aid your staff, we'd like to take this opportunity to gather all this information together into one submittal, along with some final reflections and supporting data to summarize these responses. For completeness, your questions are restated here along with the responses.

YOUR FIRST QUESTION:

1. ***What role, at this point, is industry playing in the development and implementation of an integrated ocean observing system?***

ANSWER:

Attached herewith are:

a. **The Presentation made 21 February 2002 to the Ocean Commission site visit at Nova South East University, Ft. Lauderdale, FL addressing this question.**

b. **An editorial titled, *"Industry's Role in an Integrated Ocean Observing System"*, published in the May 2002 issue of Sea Technology Magazine.**

c. **A paper titled, *"Industry's Role in Implementing an Integrated Ocean Observing System"*, presented 23 October 2002 at the MTS/IEEE Oceans '02 Conference in Biloxi, MS.**

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(Continued)

d. **Excerpts from a Brief describing the National Polar-orbiting Operational Environmental Satellite System (NPOESS)**

e. **Excerpts from a Brief describing Shared System Performance Responsibilities (SSPR) adopted during NPOESS procurement process**

At a recent State Department meeting intended to address Perspectives on International Oceanographic Research that we both attended, I suggested that, in order to succeed in establishing an Integrated Ocean Observing capability, we need to begin doing a better job engaging industry *at this critical early stage*. There, I pointed-out the potential conflicts and apparent contradiction of achieving an "integrated" national asset by the approach currently being discussed. That is, rather than build a national strategy and network topology developed by the best qualified organizations (including industrial firms) in our nation, to instead parse-out the limited annual funds to several different universities and scientific research institutes around the Country (identified as those who are presently engaged in their own experimental systems), each to independently design and deploy separate regional observatories, with the notion to later somehow connect them all together into a monolithic environmental data collection, distribution and communication network.

At that State Department meeting, I offered as an analogous example from which we might derive a more successful model, the recent procurement process for NPOESS (National Polar-orbiting Operational Environmental Satellite System). While NPOESS represents a $4 billion+ initiative, based upon discussions to date, funding for an IOOS could also exceed $1 billion over the next several years, with a sustained annual operating cost of $500 million. More background information regarding NPOESS is included in **Attachment 1 [d].**

Other similarities between IOOS and NPOESS include:

- Both are technology-intensive, *"national, operational networks intended to acquire, receive and disseminate global and regional environmental data*" (quote from NPOESS briefing included in **Attachment1 [d]**).

- Both are "Presidentially Directed" and are to be administered by Interagency Program Offices (NPOESS – NOAA, NASA, DoD).

- Both systems will require development of new types of sensors, will require input and guidance from the nation's "top scientists" in their development and both must reliably, routinely and continuously deliver in real time, accurate environmental data to the scientific community.

Despite the parallels mentioned above and the substantial levels of government funding required for the success of each of these environmental monitoring systems, the industry involvement and paths toward achieving these two similar programs are quite disparate. The path adopted toward achieving NPOESS actually represents some innovative and progressive thinking that might be adapted and adopted to ensure the best possible value and outcome for IOOS. Most notably, the concept of "*Shared System Performance Responsibilities - (SSPR)"* was instituted during the early stages of NPOESS. This was intended to mitigate risk and motivate competition among the nation's leading technology firms, to have them offer their best possible plans for designing, deploying and operating this government-sponsored environmental monitoring capability while still providing them the potential to recoup income commensurate with more lucrative, private-sector commercial pursuits.

Another notable attribute of the NPOESS procurement was a Risk Mitigation Plan that required multiple contracts to be let - *during the proposal process* - to multiple "second-tier" (i.e., not in contention for the main contract) organizations to develop the required sensors. At the same time, those teams competing for the main NPOESS award were required to perform a number of Proof of Concept demonstrations, prior to the Government down-selecting to the winning plan. I will suspend any further discussions of "SSPR" as I am sure that Vice Admiral Lautenbacher and Rear Admiral West are both conversant in this unique procurement approach for NPOESS and either one of them could do a far better job than I of explaining how this might be adaptable to IOOS. I will however, mention again another means of engaging and providing incentives to industry early-on in this process. In **Attachments 1[a], 1[b] and 1[c],** a concept is presented that could portend to effectively double the purchasing power of IOOS funding while ensuring that those best qualified and equipped (academia, industry and government alike) are enlisted early-on and throughout the inception, development, deployment and operational phases of the process.

By analogy, while oceanographic research institutions and universities routinely procure and operate research vessels, they do not attempt to build the ships themselves. Instead, these scientific laboratories are involved in helping to develop a set of *Specifications* that are, in turn, released for competitive bids from naval architects and shipyards. In a similar manner, the scientific community could work with experts (who are already in the business of developing environmental monitoring and communication networks) in writing a set of IOOS Specifications.
These Specifications could serve as the basis for procurement, perhaps with similarities to the NPOESS process, that engages competing teams from an early stage to develop a national network.

The "one-dollar-invested-to-reap-two-dollars-of-product" might work as follows: rather than award dollars to researchers to design and build sensor and communication networks (when they ultimately just want data back from the IOOS), instead award these scientists "Bandwidth Credits" (similar to an Omnet subscription), in dollar increments, based upon a competitive peer-reviewed proposal process. These Bandwidth Credits would be paid (by these researchers) to the operator(s) of the IOOS in return for data delivered to their research institutes. These Bandwidth Credits could only be redeemed by the IOOS operator(s) to the Government for cash. In this paradigm, every dollar spent by the Government results both in a dollar's worth of data as well as a dollar toward paying for the IOOS. Reliability and robustness of the IOOS is ensured, as its operator(s) only receives funding for each valid data bit that passes through it. "Good science" is ensured through the time-honored peer-review process for recipients of the limited Bandwidth Credits, and scientific institutes are allowed to focus upon science rather than trying to design, build and maintain infrastructure. Best value to the taxpayer is ensured by enacting a proven, successful competitive procurement process similar to that developed for NPOESS.

RECOMMENDATIONS:

I. **Task an appropriate organization (an NGO that represents and will work with the nation's marine technology industries and marine science research institutes) to develop a set of IOOS Specifications. Use these Specifications as the basis for an Industry (and nation)-wide Request for Interest (RFI) soliciting interest and ideas for developing and operating an IOOS. The Marine Technology Society (MTS) would be an excellent organization to undertake this IOOS Specifications task.**

II. **Consult with Admirals Lautenbacher and West to see if they agree that an NPOESS-like procurement might be appropriate to ensure that our Country's best and brightest are enlisted early-on to develop this important national asset. If so, establish a procurement office to undertake the process.**

III. **Consider adopting creative funding mechanisms and models, perhaps like some of those discussed here, that will encourage maximum industry participation and ensure maximum value to the taxpayer and scientific community.**

IV. **Provide funding for an Interagency Personnel Agreement (IPA) individual assigned to liaise with the private sector to educate, initiate and perpetuate industrial involvement throughout all phases of an IOOS.**

YOUR SECOND QUESTION:

2. ***What are the most promising areas of technology that should be fostered for economic development and social/environmental well being?***

ANSWER:

Attached herewith are:

a) ***Marine Technology Society State of Technology Reports on: Marine Policy and Education; Ocean and Coastal Engineering; Marine Resources; and Advanced Marine Technology.***

b) ***Current Status, Future Projections and Inventory of Manned Undersea Vehicles, Remotely Operated Vehicles, Autonomous Undersea Vehicles, Sustained Ocean Observatories and Cruise Ships*, a Report Submitted to the US Commission on Ocean Policy, 22 October 2002.**

c) ***November 13, 2001 MTS Testimony to US Commission on Ocean Policy.***

Much of the content of the Reports included as background for this question (and response) is focused upon the current state and inventory of marine technology in this Country. A far more difficult task is to predict the future and thereby make recommendations for critical national investments. One method typically adopted is to evaluate the status of marine technologies in other countries, look for areas in which others are ahead of us, and use this as an indicator to determine where we should increase our own investment and focus. Were this to be the deciding forcing function, one might note **(Attachment 2[b])** that, since three other countries (Japan, France and Russia) all operate manned undersea research vehicles with depth capabilities that considerably exceed anything available in this Country, then this would represent a deficiency driving our investment [however, in this particular example, the most expedient and cost effective means to equilibrate this imbalance may simply be to purchase the MIR submersibles from cash-strapped Russia]. The United States currently leads the world in Remotely Operated Vehicle (ROV) technologies. While the genesis of ROV technology was originally military, its present state of maturity results precisely because these vehicles have, for several decades now, been playing a vital role in some important US industries (petroleum and telecommunications). Autonomous Underwater Vehicles (AUVs) have reached their current state (and our Country maintains a leadership role with AUVs) in large part as the result of US Navy funding (e.g. ONR's Autonomous Ocean Sensor Network – AOSN). While the present level of maturity for AUV technology is approaching that of commercial viability and, at the same time, interest and needs of the US commercial sector are becoming ripe for accepting this emerging technology, additional "bridge funding" by the US Government may be necessary to accelerate this transition. In terms of shear number, there is no doubt that Japan leads the world in successful deployment and operation of sustained ocean observing systems. This is attributable to urgent national security needs, specifically protecting their people from earthquakes and tsunamis. Similarly, national security concerns might accelerate US investment toward establishing sustained unmanned offshore observatories. While there is now, among the science community, a major thrust toward establishing an Integrated Ocean Observing System (IOOS), its possible that very real potential for "Dual Use" opportunities are not being sufficiently sought-out or exploited. With tens of thousands of miles of US coastline, marine technology will play an important role in our nation's homeland defense (See **Attachment 2 [c]**). And while billions of dollars will be spent by the Missile Defense Agency (MDA) attempting to protect our Country against ballistic missiles, our coastlines remain vulnerable to close approach, low altitude cruise missile attack. A network of Coastal Ocean Observing Systems could double as ever-vigilant sentries, listening and watching for any such launches from otherwise unpatrolled expanses of US borders. There is also presently a major effort underway by the US Coast Guard to upgrade a coastal network to support their mission, the National Distress Response System Modernization Program (NDRSMP). Many aspects of the NDRSMP could also support a Coastal IOOS. To date, little if any effort has been made to cross-couple these two efforts.

Perhaps rather than attempting to identify areas requiring future US marine technology investment based upon our status *relative to* the present state of other countries, a more useful – albeit more difficult to define - metric might be to establish in *absolute terms* our nation's (and planet's) immediate and impending needs that might be addressed by advances in marine technology. Two areas that are indisputably global in proportion are human health issues and our nation's (and the world's) increasing energy needs; yet presently, our national funding emphasis does not reflect this absolute importance. The oceans represent our planet's greatest repository of energy, both conventional and alternative. Even in terms of energy derived from petroleum, the oceans lie between us and many of the future reserves that might be tapped. Additionally, vast fields of methane hydrates located on the seafloor may represent substantial future sources during our society's current phase of hydrocarbon dependency. As a nation, we have been complacent to rely substantially upon market-driven forces to deliver the technology advances required to satisfy our energy needs. As long as this is the case, it is absolutely logical for those elements of industry who are investing in this R&D to focus their resources on the endeavors that result in near-term returns to their shareholders. This focus may not always reflect a longer-term national or world-view. When, in the 1970's, our nation began to shun further pursuit of research in nuclear power, our National Laboratories resultantly lost substantial focus and identity. They have since been struggling to "reinvent" themselves variously as environmental research labs and more recently homeland security labs. Perhaps one or more of these Department of Energy laboratories could direct some of their focus and mission toward ocean energy research pursuits.

Another presentation at the November State Department meeting you and I attended implied that some "environmental watch-dog" activist lobbying groups, presently are thwarting scientific experiments aimed at evaluating deep sea carbon dioxide sequestration as a means of dealing with greenhouse gasses. While these groups initially may not be accurately representing public sentiment, misinformation gone unchecked can indeed influence and ultimately sway public perception. As previously mentioned, our Country lost its leadership position in the world in nuclear power generation and fuel reprocessing technology. This was due, in large part, to action (and inaction) resulting from the "irrational exuberance" of the American public in response to disinformation and a lack of education and understanding regarding the potential for a "plutonium proliferation" stemming from breeder reactor technology. We should not risk repeating such a loss of world leadership in strategic technology, by allowing misinformation to stir public hysteria that could hamper good science from being conducted, and that might help us to further understand and curtail anthropogenic global climate change. Government funded education campaigns *("Only You Can Prevent Forest Fires", " This is Your Brain on Drugs"*, etc.) have been effective at raising public awareness about other issues that affect our daily lives. Ocean explorers and filmmakers like Dr. Robert Ballard and James Cameron have and continue to inspire young would-be scientists and adventurers, challenging them to become concerned about the ocean. In order to reach their parents (and grandparents), a more directed, Government-funded campaign might be successful at educating the rest of us about what we can do in our daily lives to improve the state and future of the oceans. The American People need to know, for example, that how they care for their lawns in the nation's heartland may have a direct effect on non-point source marine pollution thousands of miles away.

On a relative (to other nations) basis, the US remains the leader in our efforts (and successes) in discovering from the oceans, compounds that improve human health. In absolute terms, far more can and should be done. The estimated 200,000 to 300,000 ocean species that have been described to date probably represent only a small percentage of those yet to be discovered. A relatively small number of these – primarily algae and invertebrates – has already yielded thousands of novel chemicals, yet only a small percentage of these have been studied for their potential use in human health (Pomponi, 2000). Federal agencies need to emphasize, prioritize and "fast-track" initiatives for marine natural products to ensure support for early phase research that assesses the potential for commercial applications (U.S. Department of Commerce, 2000). In addition to Government funding required to foster these critical early phases, a healthy marine biotechnology industry must exist to carry through with further development, testing and marketing of the products. This industry requires a base of qualified scientists and engineers, most likely trained at those very universities receiving Government funding for marine bioproduct research.

REFERENCES:

Pomponi, S.A., The Oceans and Human Health: The Discovery and Development of Marine-Derived Drugs, Roger Revelle Commemorative Lecture, 9 November 2000.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 2000. President's Panel for Ocean Exploration. Discovering Earth's Final Frontier: A U.S. Strategy for Ocean Exploration. University Corporation for Atmospheric Research.

RECOMMENDATIONS:

I. **Through the standard mechanisms (BAA, et al.) and appropriate agencies (e.g. NOAA, NSF, ONR) designate sufficient funds to foster "bridging" the final transition of AUVs from limited scientific/military mission capability to "technology reduced-to-practice" for reliable commercial applications.**

II. **Establish a liaison between IOOS efforts and Department of Homeland Security, Missile Defense Agency, USCG's NDRSMP effort and others, to ensure that any and all potential "Dual Use" opportunities are identified and exploited at an early phase.**

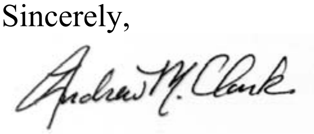
III. **Launch a Government-funded campaign to raise public awareness about the health and status of the oceans, our national priorities therein, and what we as individuals can do to participate.**

IV. **Task one of the DOE National Laboratories to become the lead institution for conducting ocean energy research.**

V. **Through the appropriate Government agencies and programs (NIH, SBIR, STTR, etc) provide funding to foster and support early phase activities of marine bioproducts for human health.**

I hope that you, your fellow Commissioners and staff find this information useful. On behalf of the Marine Technology Society, I want to express our sincere gratitude for the good work you have done and wish you continued success in this important mission.

Sincerely,



Andrew M. Clark, Ph.D.
President

Industry's Role in the *Implementation* of an Integrated Ocean Observing System

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***Abstract* – This paper describes a novel concept of implementing and funding an Integrated Ocean Observing System (IOOS). Rather than fund research institutions to design and build discrete observatories, only later to be integrated into a national network, instead what is proposed is to competitively award bandwidth to those researchers requiring data from offshore observatories. The network itself would be designed, installed, maintained and operated by industry. Initial development costs will be offset both by utilizing existing commercial networks and also by leveraging some other (funded) pending and emergent government initiatives that present opportunities for synergy. Discussed are opportunities to enhance Homeland Security and the USCG National Distress and Response System. Result: realization of an IOOS in a reduced schedule and at a substantial cost savings. Examples of two existing commercial networks are provided.**

I. INTRODUCTION

Through the establishment some thirty years ago of UNOLS (the University National Oceanographic Laboratory System) fleet, the National Science Foundation (NSF) helped to make available to the academic research community a fleet of modern research vessels for exploring the world's oceans. Progress since then in the study of the ocean now warrants that a new system of tools for the conduct of ocean science be developed and made available to the community, namely that of an integrated network of stationary ocean observatories [1]. Interest has heightened in the U.S., particularly since an integrated ocean observing capability was identified as one of the priorities of the Presidential Commission on Ocean Policy. Ocean.US, an interagency coordinating office has been established to serve as the focal point for integrating these emergent ocean observing activities. Ocean.US predicts by the end of this decade, that once deployed, annual operation and maintenance of an integrated ocean observing system will require approximately a half billion dollars [2]. Industry and the private sector have been identified as stakeholders in the reports and proposals addressing these ocean observing initiatives, but usually only as end users and beneficiaries. There is no doubt that a number of industries and enterprises will benefit from the products of an ocean observing system. However, the development, deployment, operation and maintenance of this national asset will similarly benefit from industry's early involvement. A report compiled by the Chairs of the U.S. Global Ocean Observing System (GOOS) Steering Committee [3] identifies one of the critical issues leading to the desired observing system as "exploiting the complimentary interests and expertise of the academic, industrial/private and governmental sectors through appropriate partnerships". Clearly, much of the technology and building blocks that make even a discussion of an integrated ocean observing capability feasible – electro-optical submarine cables, wet-mate connectors and satellite telemetry systems - are derived from industry. But beyond this, there are further industrial avenues to be exploited in the build-out of such a vast and complex system, not the least of which is financing. With some promise of federal funding for a sustained and growing subscribership, a business case may be closed for some substantial up-front commercial investment. Competitive market forces should serve to ensure good service, value, and even decreasing costs as the network expands. Some existing or emerging models exist and are discussed in the following Sections. If the funding being discussed is made available to the oceanographic community in usual the manner, it will likely be disbursed to a number of different competing teams around the country, comprising research institutes and academics. Truly, it is these very researchers, scientists and oceanographers who are those that need the data collected from an integrated ocean observing system in order to verify their models and theories. However, expecting these same researchers and institutions to also undertake the design, construction, installation, implementation, operation, maintenance and perpetual upgrading of both a nationwide as well as a worldwide communications network of the scale and complexity required to satisfy the objectives of an Integrated Ocean Observing System may be neither practical nor fiscally prudent. After all, it is the *data* these researchers require, not the contracts to build a network. A guaranteed half billion dollar annual subscribership over a sustained (decadal) period represents sufficient incentive to attract industrial concerns who are already in the business of building, operating and maintaining maritime data networks. A bank of "data credits" could be established, and awarded to researchers in the customary competitive manner. These credits, in turn, would be exchanged for bandwidth on a commercially operated and maintained network (redeemable by the network operator for cash from the government for bandwidth successfully delivered.)

II. COASTAL VS. GLOBAL

As the result of a number of studies conducted to date, it has been determined that, while the oceans themselves are seamless, for programmatic and political reasons, the approach to establishing an integrated ocean observing capability will be divided into both a coastal and a global effort [4]. Factors including international jurisdiction, the US

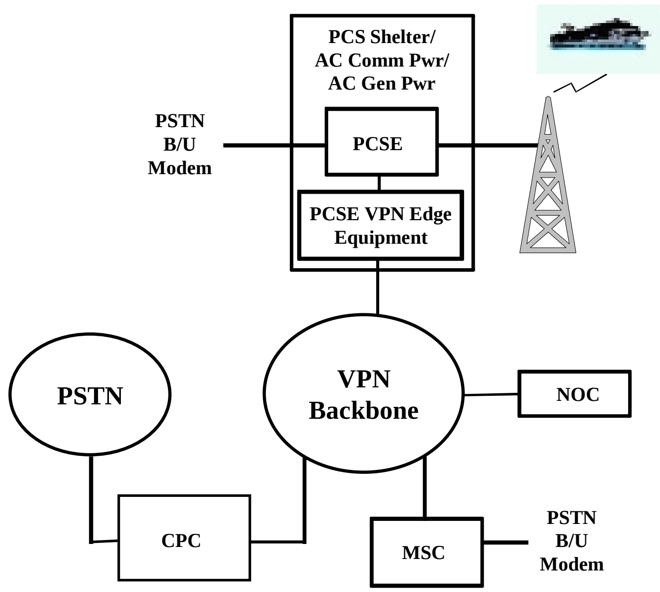
Exclusive Economic Zone (EEZ), federal, state and local governance are all cited as contributing to this bifurcated approach. As it turns out, there are also driving technological factors that warrant separate approaches to a global, verses a coastal, network. Provided they are near enough to shore, data from coastal observation sites potentially might be transmitted back to a central communications backbone via either submarine cable or wireless (RF) line-of-sight techniques as has been done at numerous discreet observatories around the world [5]. However, retrieval of high bandwidth data from open ocean (global) observatories, too far from shore to economically consider dedicated submarine cable, poses a different and substantial technological challenge. To operate a truly global ocean observing system requires a global constellation of communication satellites, globally-distributed earth stations for down-linking their signals, and world-wide distribution of terrestrial back-haul circuits for delivering the data to end users.

A. A Commercial Coastal Communication Network

There exist today myriad industrial firms that manufacture many of the meteorological and oceanographic sensors required for coastal observatories and even several companies that integrate these into buoys, complete with mooring and communication packages for RF line-of-sight telemetry. What does not currently exist, and what would represent a substantial investment, is the shore based infrastructure that would be required to enable deployment of multitudes of these moored buoys into an integrated coastal observing system. An example of a commercial venture analogous to such a network is MariNET™, a VHF-based maritime-band communication system. While the system is designed to provide voice and data telephony for vessels traveling 20 – 50 miles from shore, it serves as an example of a privately financed coastal communication network. The system, or one similar to it, could actually be employed as the backbone for a coastal ocean observing system. The network design ultimately calls for a total of approximately 290, 340-ft tall towers spaced along the coast of the continental U.S. as depicted in Figure 1.

Fig. 1. Final Proposed Build-Out of MariNET™.

HARRIS Corporation has provided MariNET™ the Public Coast Station Electronics (PCSE) comprising the environmentally controlled shelter, communications equipment (RF and DSC controller), antennas, and the Maintenance System Console (MSC). MariNET™ is linked to call centers through a Virtual Private Network (VPN) using Voice Over IP (VoIP) protocol as depicted in Figure 2. The digital radios support all types of DSC messaging. 8 Kbps CELP encoding is used for routine voice circuits while G.711 64 Kbps PCM encoding is used for circuits carrying analog data. Depending upon distance from shore and height of offshore (shipboard) antennae, data rates of 64 kbps to 256 kbps have been demonstrated.



- **Public Coast Stations (PCS)**
- **Virtual Private Network (VPN)**
- **Call Processing Centers (CPC)**
- **Network Operational Center (NOC)**
- **Maintenance System Console (MSC)**
- **Public Coast Station Electronics (PCSE)**

Fig. 2. Terrestrial Backhaul of MariNET™ System.

Historically, regulations governing VHF maritime spectrum have restricted its usage and the ability to offer comprehensive (integrated) services. Spectrum was allocated on a per channel per region basis, eliminating the possibility for any national or supra-regional system as would be required in an integrated ocean observation system. Before the advent of DSC radio technology, data communication was not possible, nor was interconnection with the PSTN (Public Switched Telephone Network) without human intervention (mobile operator assisted). Efforts taken to enable the MariNET™ system will also serve to benefit an integrated costal observing network. In the late 1990's, the FCC changed many of these restrictions and the implementation of IMO and FCC-mandated DSC standards have since effectively facilitated maritime communications.

A number of technologies implemented by this network could also be employed to support offshore data collection sites as would be required in an integrated coastal ocean observation system. A typical coastal station is depicted in Figure 3. Each site supports 24 simultaneous VHF calls that may be used for data transfer, secure voice and vessel location and tracking. Commercial maritime enterprises can utilize the network to provide vessel location and weather information, cargo load/unload information, maintenance schedules, fuel consumption, human resources information, re-provisioning, vessel traffic control, scheduling, and POTS (Plain Old Telephone Service). Voice, analog data and digital data are combined into a single IP stream over Frame Relay between fixed facilities and VPN backbone (CIR = 576 Kbps at PCS). Each PCS has a VPC with up to CIR = 576 Kbps to a Primary CPC and a VPC with CIR = 128 Kb/s to the Backup CPC.

Fig 3. Typical MariNET™ Coastal Station.

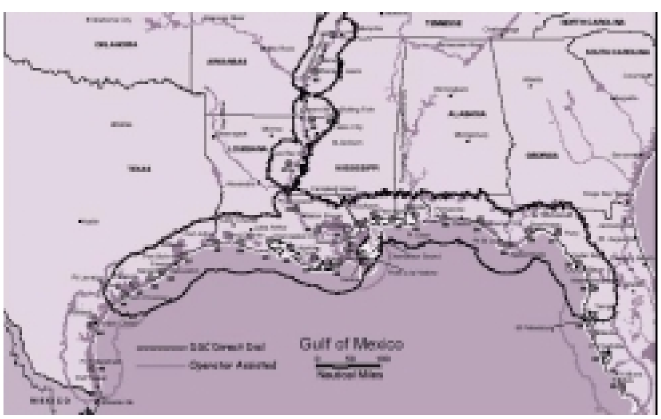


Fig. 4. Presently Installed MariNET™ sites.

In order to establish an integrated coastal observation network, covering the entire coastline of the contiguous continental United States with no-gap overlap would require on the order of 300 towers. To date, MariNET™ has installed a total of 29 towers and shore sites, stretching along the Gulf coast from south of Houston, TX to Tampa, FL and up the Mississippi River to Memphis (Figure 4).

B. A Commercial Global Communication Network

While MariNET™ represents a commercially operated and subscriber-financed coastal (20 - 50 miles from shore) communication network, OceanNET™ is an example of an existing global commercial system, intended to provide broadband communications from sea surface and seafloor sites situated any distance from shore. As with MariNET™, the burden of owning and maintaining the OceanNET™ system resides with its operator (HARRIS Corporation's Maritime Communication Services – MCS) freeing up it's end users to simply become subscribers of a service, as one would with any telephone. Thus, oceanographers need not become maritime operators or communication specialists. The system utilizes the world-wide constellation of INTELSAT satellites and a unique buoy-based, inertially stabilized VSAT (Very Small Aperture Terminal) antenna to provide real time data throughput up to 2 Mbps back to shore.

A mooring cable containing optical fibers and copper conductors provides essentially unlimited power and data throughput to/from the seafloor. Figure 5 depicts the network topology. The components of the OceanNET™ system have been described in detail elsewhere [6]. While moored buoys supporting a coastal (near shore) integrated observing system might generate and store sufficient electrical energy using solar panels and batteries, such is not the case with the offshore component of this global system. For broadband over-the-horizon data telemetry, the substantial amount of electrical energy needed to power the inertial stabilization required to maintain pointing accuracy at geosynchronous satellites in conditions through sea state six requires a pair of onboard 20-kW diesel generators. Despite this apparent complexity, redundant diesel gensets operating on buoys have proven sufficiently reliable to warrant their use for critical life-support systems [7].

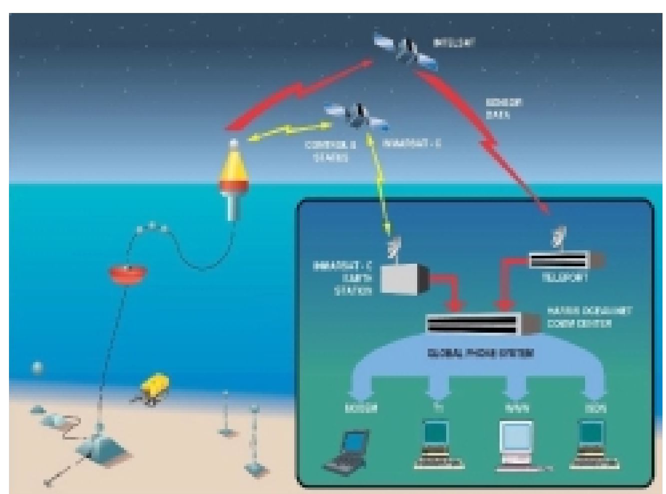


Fig. 5. OceanNET™ Global Observation Network.

Just as with the example of the coastal communication network discussed, operating a network of global observing systems requires substantially more investment than just the offshore stations themselves. Also required is a network of expert-staffed service centers and spare parts depots located strategically around the world so as to limit down-time upon inevitable equipment failures and to minimize maintenance costs, time lost shipping equipment, personnel, clearing customs, etc. Teaming agreements with owner/operators of specialized maintenance, deployment and recovery vessels in the region local to each observatory sites are also necessary.

Fig. 6. Deployment of an OceanNET™ Buoy.

III. WORLDWIDE CONNECTIVITY

As with the coastal network, there are many manufacturers and industrial suppliers of the sensor packages and attendant subsea components and connectors that are necessary for a global ocean observatory. Integration of these into an unattended floating platform is not as straightforward as with a coastal buoy, owing primarily to the substantial size and complexity required for long-term reliable operation. Nonetheless, several oil industry-related firms have undertaken construction of very large and complex moored unmanned buoys, primarily to support subsea well completions and their operation. OceanNET™ may be unique in that its design-purpose is to support scientific sensors and long-term observations. Again, the buoy and subsea sensors at any one observatory site are only a portion of the investment required. Once collected, the data from each site must be processed and delivered to the end user. The satellites employed by Ocean NET™ are part of the INTELSAT network. This constellation of more than 20 satellites provides global coverage in the C-Band frequencies as well as some coastal coverage in Ku-Band. A minimum of three geosynchronous satellites are required to provide global coverage, one in each of the three "ocean regions": Atlantic Ocean Region (AOR), Pacific Ocean Region (POR) and Indian Ocean Region (IOR). In turn, a separate earth station or "teleport" is required in each of these regions of the world with an antenna trained at its respective ocean region satellite. These earth station facilities are manned continuously (24 X 7), as real-time adjustments must sometimes be made at the transmit / receive equipment, components periodically must be replaced and specialists always must be on hand to respond to requests or direction from the satellite operator.

Fig. 7. OceanNET™ Teleport and Network Operations Center.

In order for the network to be integrated, all these geographically-dispersed earth stations must be tied together with high-speed data connections and of course must ultimately be linked to the end user(s) of the data. A network topology as just described will rely upon the services (and service level agreements – SLAs) of multiple international telecommunication providers from multiple different countries, long-term leases of millions of dollars of satellite transponder space, leased trans-oceanic fiber, frame circuits, long-term negotiated international calling rates, not to mention FCC and international telecommunication licenses.

The global network of teleport earth stations described above must, in turn, be connected via high-speed and diversly-routed, redundant links to a Network Operations Center (NOC). The NOC is not only manned 24 X 7, it must be staffed around the clock with subject matter experts who can diagnose and troubleshoot fielded systems remotely, determine corrective measures, evaluate veracity of data being received and perform quality control and archiving. The NOC and AOR earth station for the OceanNET™ system is depicted in Figure 7. It is clear that the infrastructure cost and complexity to establish a globally integrated ocean observing system is substantial and difficult to justify until many sites are up and operating around the world. Indeed, it would not be possible for a commercial venture (e.g. OceanNET™) to provide this global broadband connectivity and back-haul were it not for a substantial base of other maritime data and communications consumers. Data transmitted to and from OceanNET™ observatories is carried over an existing infrastructure that also carries voice, fax, data and Internet traffic from commercial vessels operating around the world. One of the larger stakeholders in this network is the cruise line industry. With some of today's mega-class cruise liners carrying nearly 5,000 passengers and crew and operating multiple Internet cafes, casinos, restaurants and shops along with an internationally diverse manifest of passengers and crew all calling home, these vessels represent the data equivalent of small cities. Moving from one ocean region (and thus satellite) to another, the enterprises operated off these and others of today's commercial fleet have necessitated that the operators of OceanNET™ install, staff, maintain and operate all the infrastructure that is required to support a global integrated ocean observing system.

IV. REGIONAL VS. MONOLITHIC

As described in the previous section, the nature of a global ocean observing capability necessitates prerequisite design, investment, implementation of bilateral agreements and licensing, and build-out of substantial infrastructure and hardware prior to deployment of even the first offshore nodes. Some of the preliminary discussions of how to implement a coastal ocean observing system [2,3] advocate a phased approach wherein regional observing systems would be funded, designed and built, later to be integrated into a national network. Certainly this approach will help to assure that regional concerns are addressed in determining locations of offshore observatory sites and parameters to be measured. Standardization of protocols, data formats and even devices will no doubt help to facilitate the eventual "unification" of regional observatories into an integrated network. However, even in the case of the coastal system, the ultimate goal of an integrated national network will be achieved more quickly and seamlessly by investing some thought, design and funding upfront in addressing the communication backbone.

V. DUAL USE OPPORTUNITIES

Beyond fulfilling the objectives of an integrated ocean observing capability, there are some other critical national needs that an integrated network such as that described here could help to address. Communication (voice and data) coverage out to 20 nautical miles to monitor the international VHF-FM distress frequency, coordinate search and rescue (SAR) operations, communicate with commercial and recreational vessels and to provide Command and Control (C2) for USCG performing safety, law enforcement and environmental protection missions. The existing system, much of which was installed in the 1970s, consists of analog transceivers controlled by regional communication centers [9]. Among the features of the modernized NDRS will be Direction Finding (DF) equipment, Digital Selective Calling (DSC), send and receive data channel at 9.6 Kbps, digitally recorded transmission (voice and data) including time stamp and archiving of provide covered (protected) communications of Sensitive But Unclassified (SBU) information.

Beyond the NDRS modernization program, other maritime enterprises could also benefit from an integrated coastal communication network. Port Authority and safety agencies have burgeoning communication needs. Vessel Tracking Systems (VTS) and Automated Identification Systems (AIS) being implemented in many US ports would benefit from a reliable integrated network. Since 9/11, there has been placed a new emphasis and sense of urgency in directing technology at securing the nation's coastline. No fewer than fifteen different papers at this conference alone are discussing technologies, many involving communication networks, aimed at Homeland Security of coastal and open ocean areas.

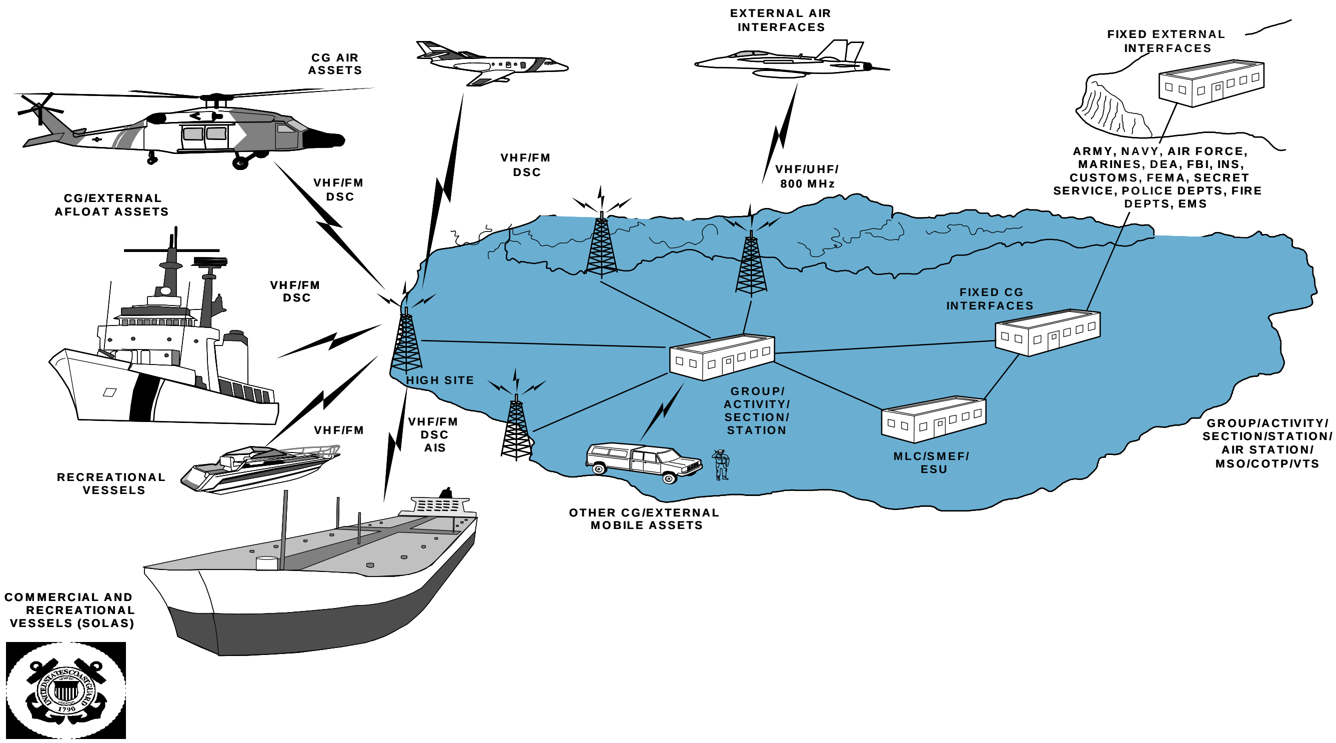


Fig. 8. U.S. Coast Guard's National Distress and Response System.

VI. FINANCING THE NETWORK

Funding to develop, then operate and maintain an integrated ocean observing system has been discussed [2] as a phased affair over a period of 8 or so years, reaching a sustained level on the order of half a billion dollars annually. Discussed in Section V are some other government initiatives, sufficiently related so as, through some form of leveraging, opportunities might exist that could help to both offset some costs and result in a more robust system for both objectives. The two commercial networks discussed (Sections II A and B) are intended to be self-sufficient upon financing through subscribership alone. Figure 9 portrays the percentage and mix of subscribers targeted by the coastal MariNET™ system. An addressable market upwards of 4 million subscribers is estimated, comprising more than 2.5 million recreational vessels and a growing number of commercial vessels with pressure to operate more cost efficiently.

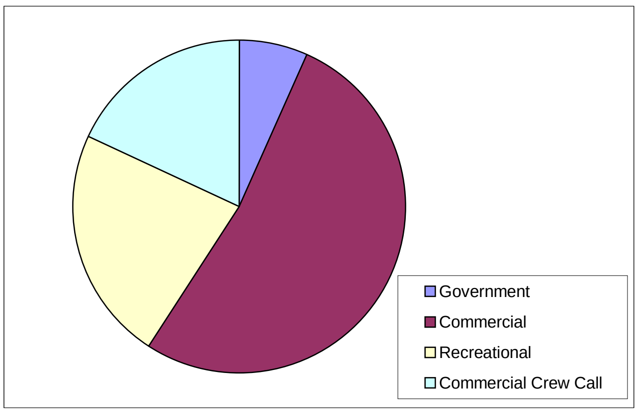


Fig. 9. MariNET Subscribership

At its present rate of subscriber enlistment, MariNET™ has built-out only approximately 10% of its 300 site network to date. Cost to complete the entire network will approach \$100M. The growth of the global commercial network discussed, OceanNET™, is similarly paced by the rate at which subscribers are recruited. To date, only two offshore systems have been completed, both of them adopted as part of the MedGOOS (Mediterranean component of GOOS). One system is deployed and operating off the western coast of Sardinia while the second is undergoing preparation for deployment in the Eastern Mediterranean Sea. The financial case for an over the horizon (global) observing system based upon geosynchronous telecommunication satellite telemetry is clearly portrayed in Figure 10. While a number of commercial satellite systems and services exist that can be used for transmitting back to shore data from the global ocean, in consideration of the continuous requirement to transmit broadband data from ocean observatories they are neither practically nor financially viable alternatives.

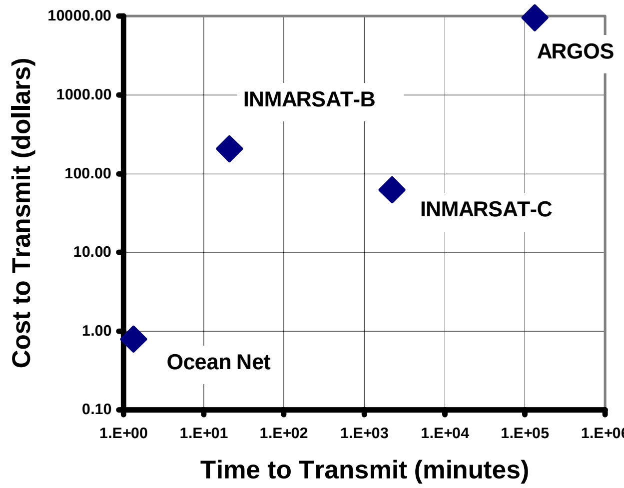


Fig. 10. Cost Vs. Time to Transmit a 10 Mbyte File.

VII. CONCLUSION

Engaging the appropriate industrial players early on in the development of an Integrated Ocean Observing System will help to assure it's timely and cost effective completion. Consideration should be given to competitively awarding to researchers, subscription for bandwidth on an integrated network, commercially built, maintained and operated by industry.

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[2] "An Integrated and Sustained Ocean Observing System (IOOS) for the United States: Design and Implementation", Report from the Ocean.US Workshop, March, 2002.

[3] W. Nowlin and T. Malone, "Toward a U.S. Plan for an Integrated, Sustained Ocean Observing System", National Ocean Research Leadersship Council (NORLC), April 1999.

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[8] "U.S. Coast Guard National Distress and Response System Modernization Project", www.uscg.mil/hq/g-a/nrdsmp/index.htm.

Industry's Role in an Integrated Ocean Observing System

Presented at US Ocean Commission

Florida East Coast Site Visit

21 February 2002

BY

Andrew M. Clark, Ph.D.

President

Marine Technology Society

Question Posed by Ocean Commission:

- **What Role can Industry play in developing and implementing an Integrated Ocean Observing System?**

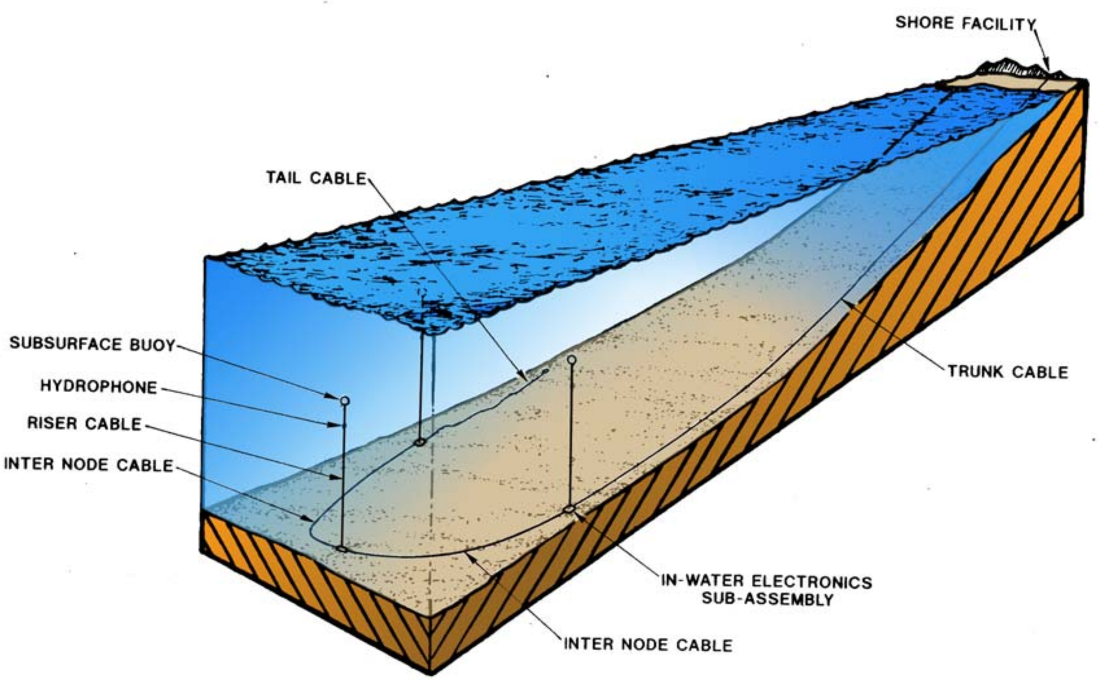
First Some Definitions and Guidelines:

- **An Integrated Ocean Observing Capability would involve Satellite Imagery and Remote Sensing, Real Time data from ships and undersea vehicles in addition to a network of stationary offshore "observatories".**

- **This talk will be limited to addressing only Industry's role with *stationary observatories*.**

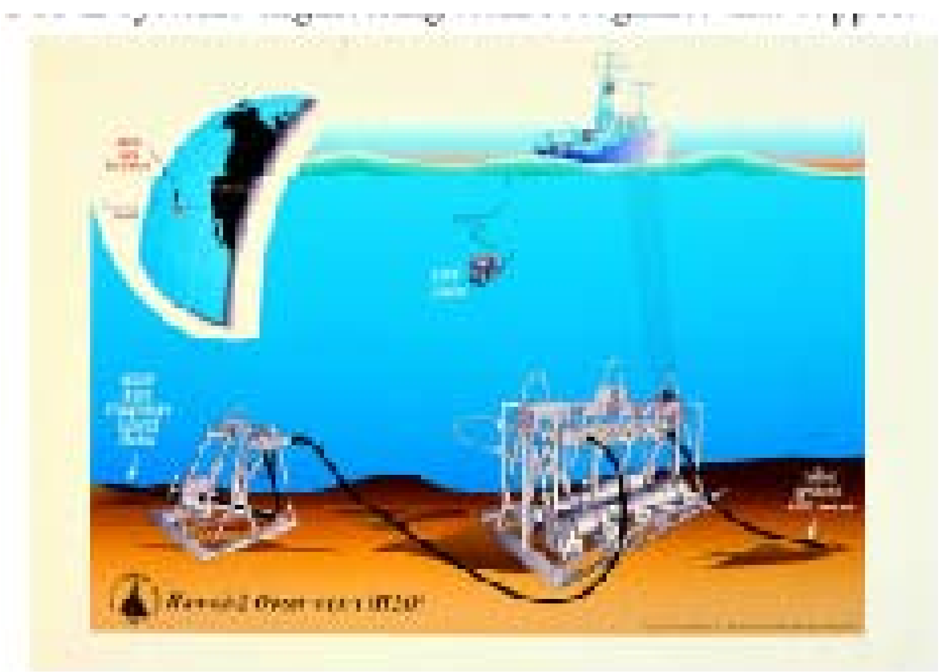
Some Examples of Types of Observatories

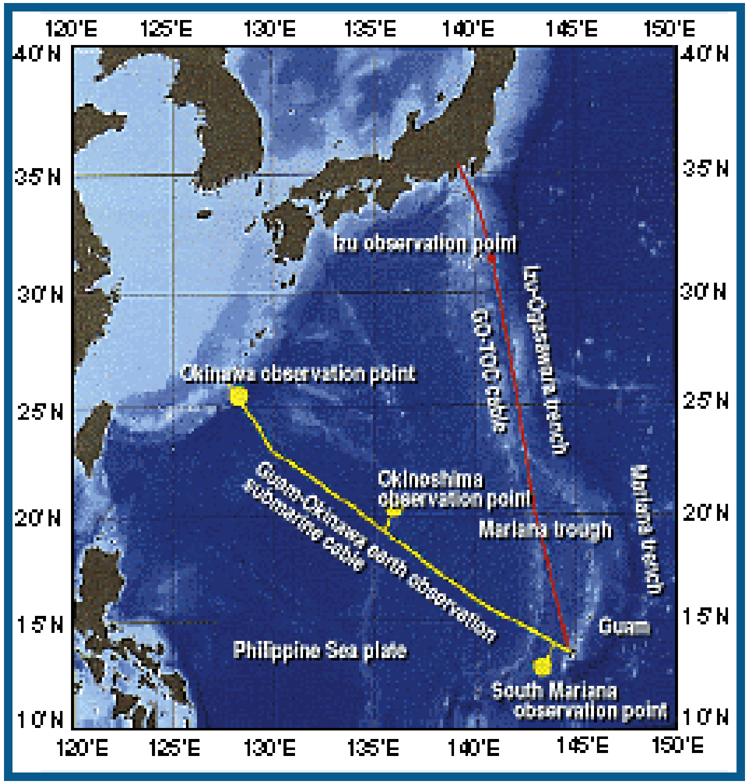
- **Near Shore Sites Lend Themselves to Short, Relatively Inexpensive Dedicated Cable Runs that Power Sensors and Retrieve Data; or to Surface Buoys Utilizing Low-Power "Line of Sight" RF Communications to Telemeter Data Back to Shore**



Some Examples of Types of Observatories

- **Certain Fortuitous Locations May Be Served By the "Opportunistic Re-Use" of Abandoned Telecommunication Cables Donated to the Scientific Community**

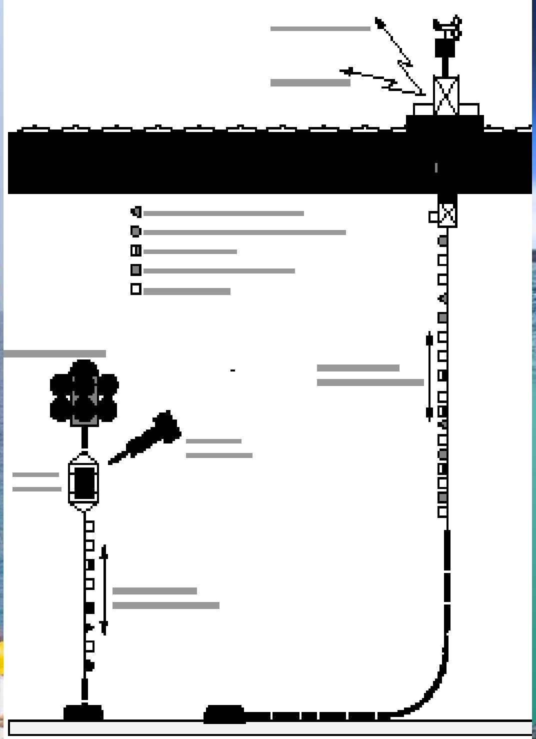




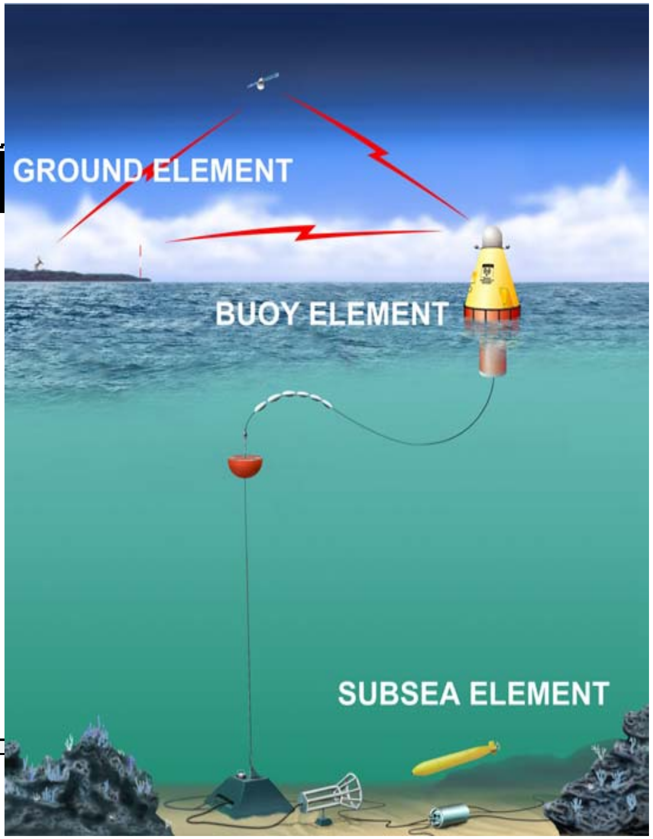
Some Examples of Types of Observatories

- **Seafloor to Sea Surface Data May Be Transmitted in One of a Variety of Means**

Deployable Data Floats



Acoustic Data Modem



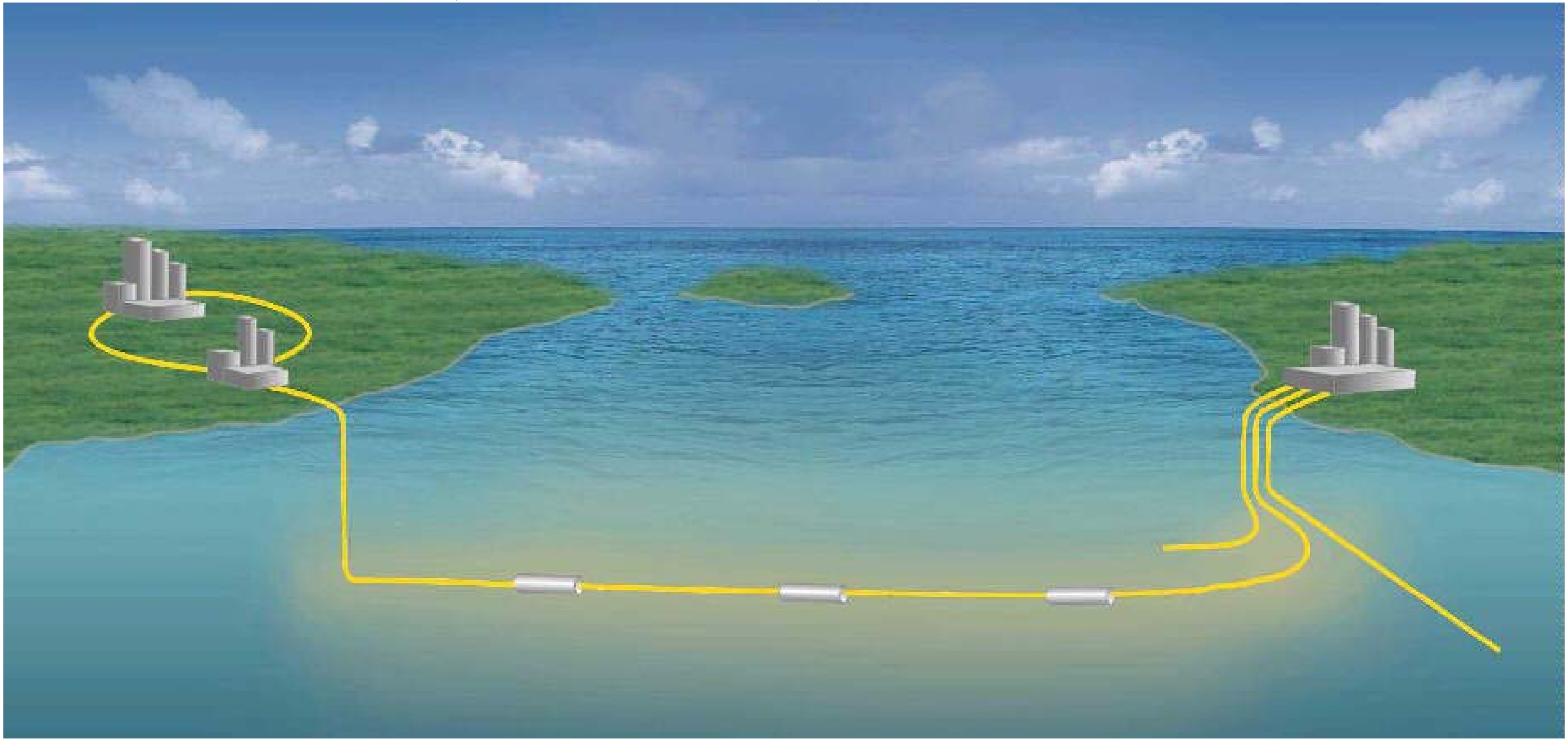
Fiber Optic Data & Power Riser

WHAT IS INDUSTRY'S ROLE?

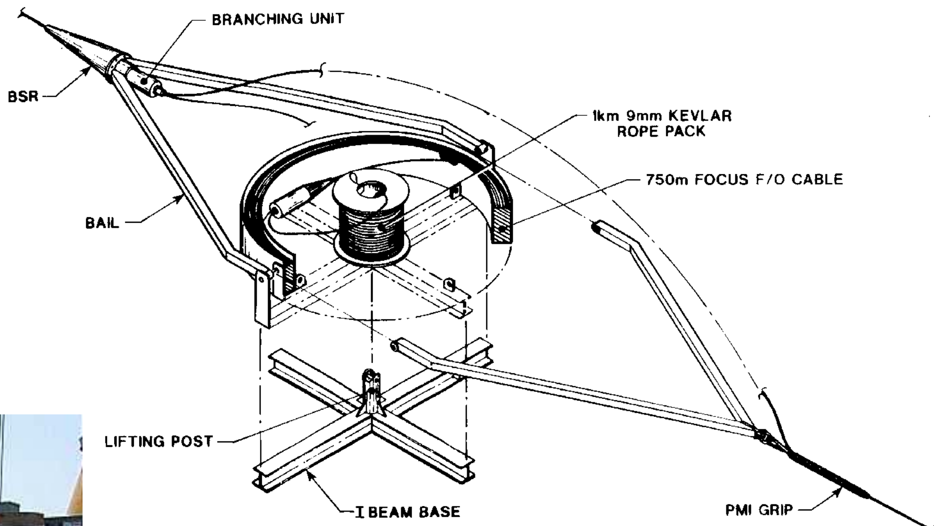
- **Industry has Developed the Tools and Techniques (Enabling Technologies) that Make the Development and Deployment of an Integrated Ocean Observing Capability Feasible.**

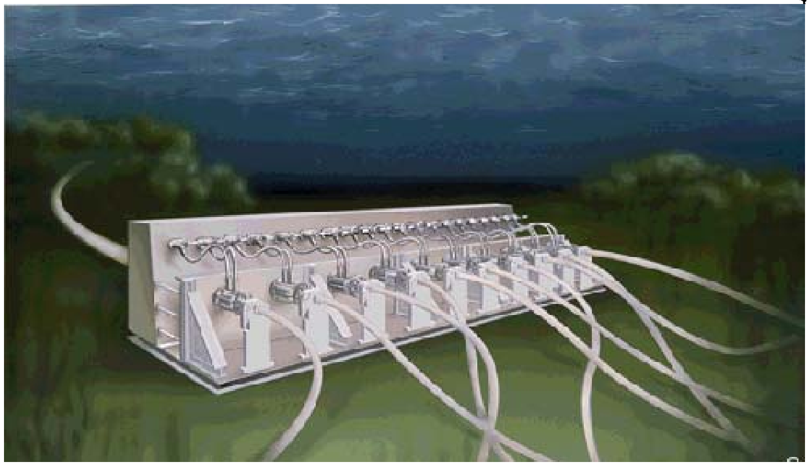
WHAT IS INDUSTRY'S ROLE?

An Industry Capable of Designing and Deploying Point-to-Point Submarine Power and Communication Cables is Well Established (Over 100 Years)

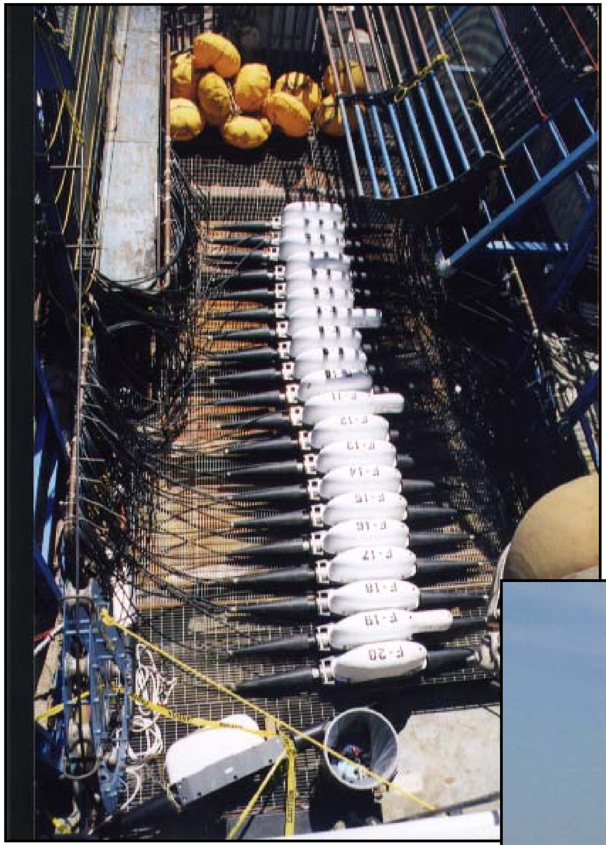


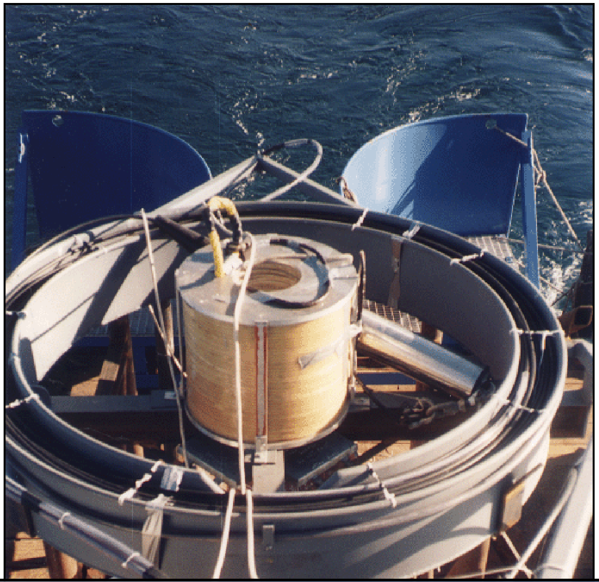
But Recent Advances in Subsea Connectors, Branching Units and Junction Boxes...



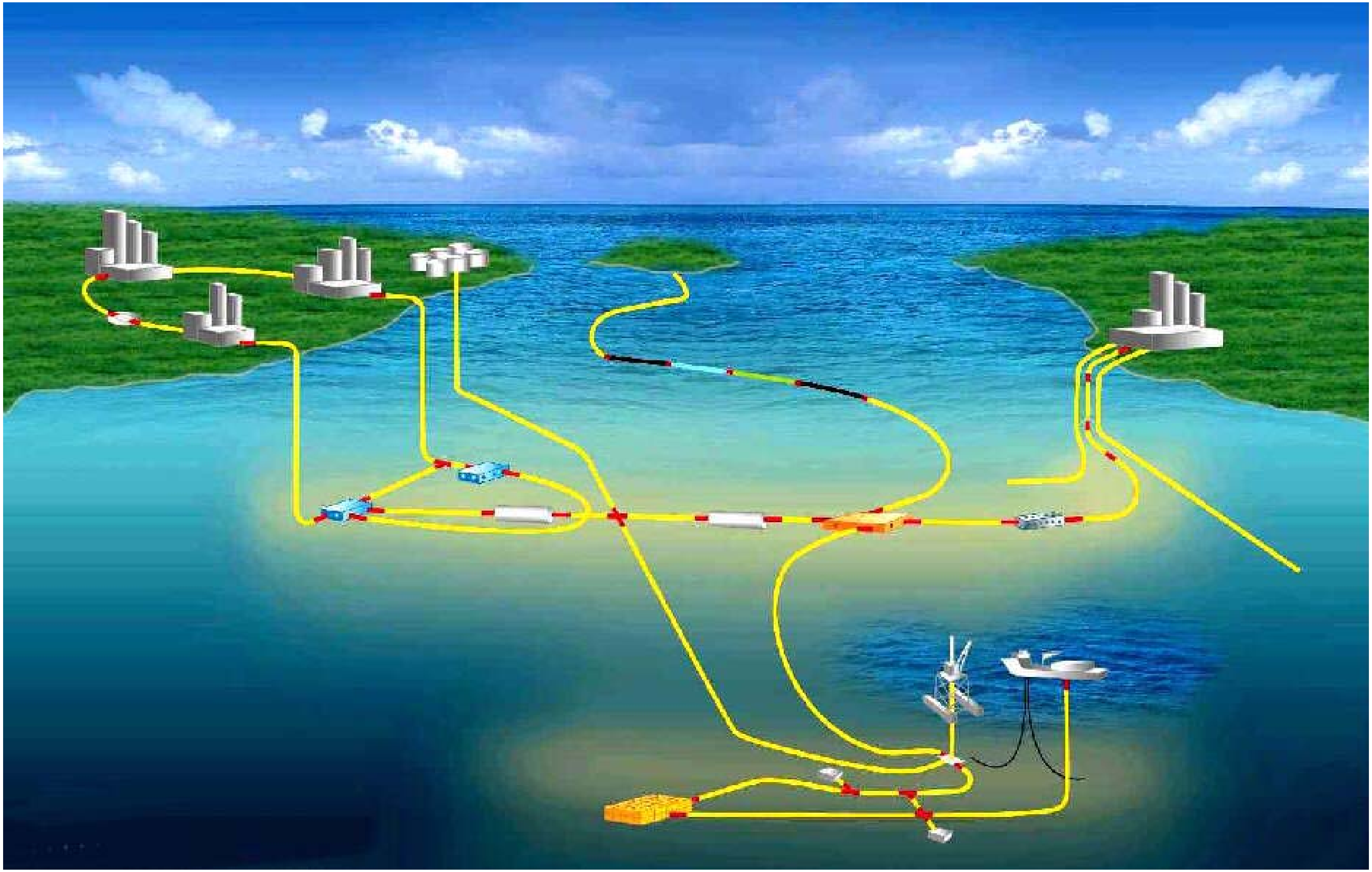


…and Developments in Cable Lay Technology...





…Can Now Facilitate Complex Subsea Networks

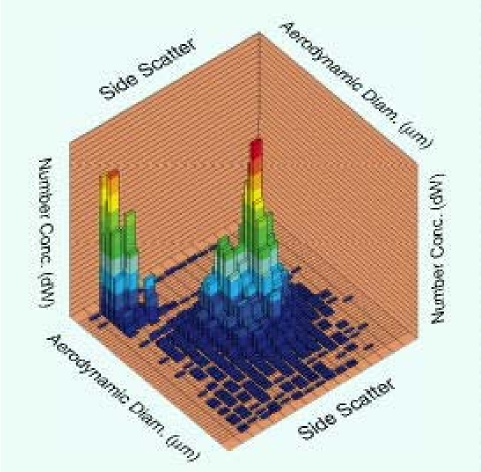


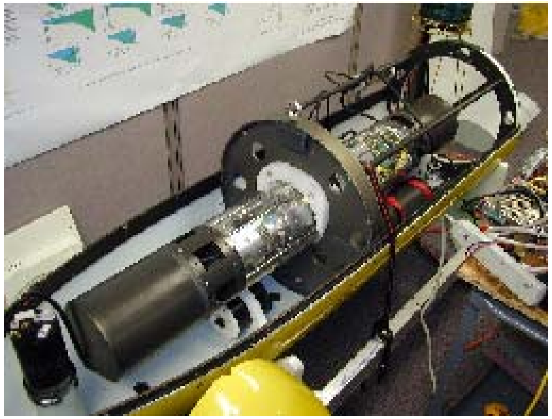
WHAT (ELSE) IS INDUSTRY'S ROLE?

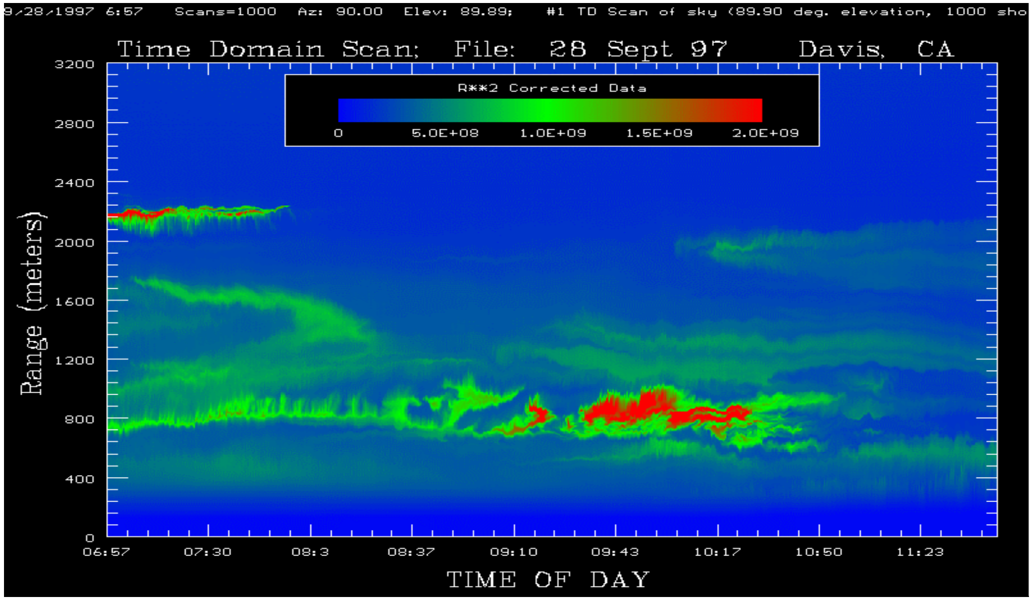
In Addition to Providing the Means to Deploy a Complex Data Collection and Telemetry Network, an Entire Industry has Sprung-Up to Develop Sophisticated Sensors Capable of Long Term Monitoring of a Variety of Oceanographic and Atmospheric Parameters, Among Them:

- Water Temperature
- Conductivity
- PH
- Current Velocity
- Wind Velocity
- Spectrometry
- Seismicity
- Air Temperature
- Salinity
- Dissolved Oxygen
- Rainfall
- Wind Direction
- Pressure
- U/W Video
- Light
- Trace Metals
- Pollutants
- Etc...

Subsea and Atmospheric Sensors

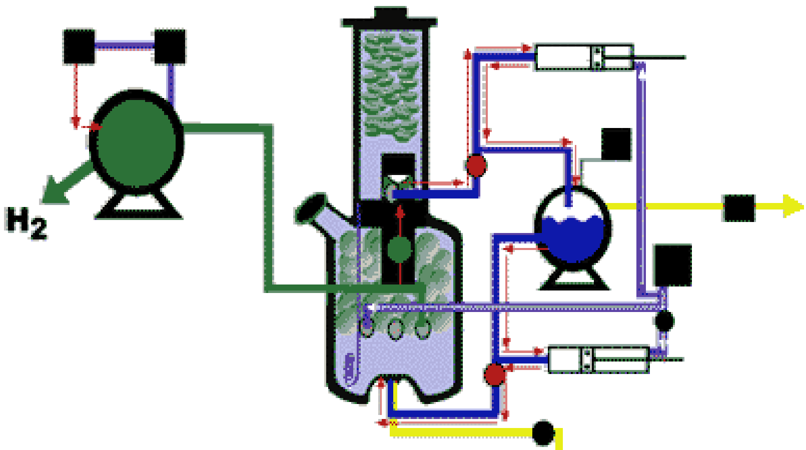






Other "Building Blocks" from Industry...

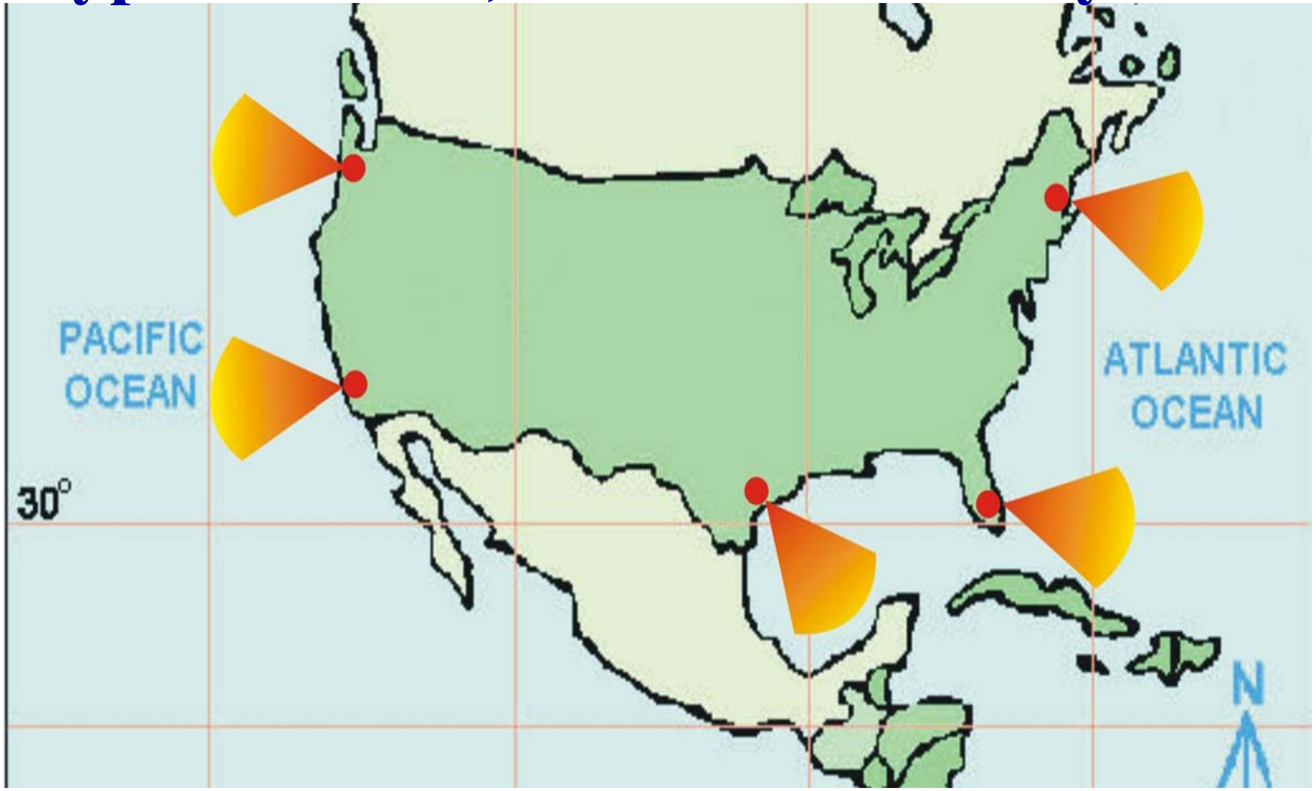
Emerging Fuel Cell Technology



High Bandwidth Satellite Telemetry Buoys for Real Time Data Transmission Back to Shore from "Over the Horizon"

…But How Can this All Be Integrated Into a *Single System?*

The Typical Model, "Fund it and They Will Build"



May Result in Several Functioning but Disjoint Stand-Alone Observatories...

Another Potential Model Toward Fostering an "Integrated" System...

The "Build It and They Will Come" Approach:

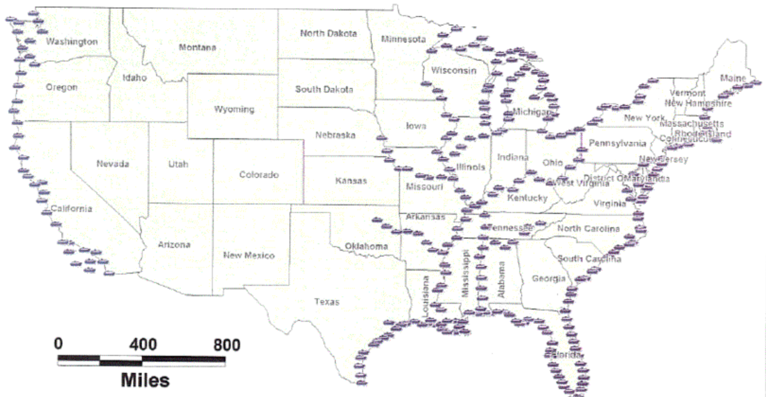
Theory: If a Demand Exists, Industry Will Create the Supply.

Demonstrate to Industry that a subscriber-base exists, and "incentivize" them to invest in the infrastructure to service it

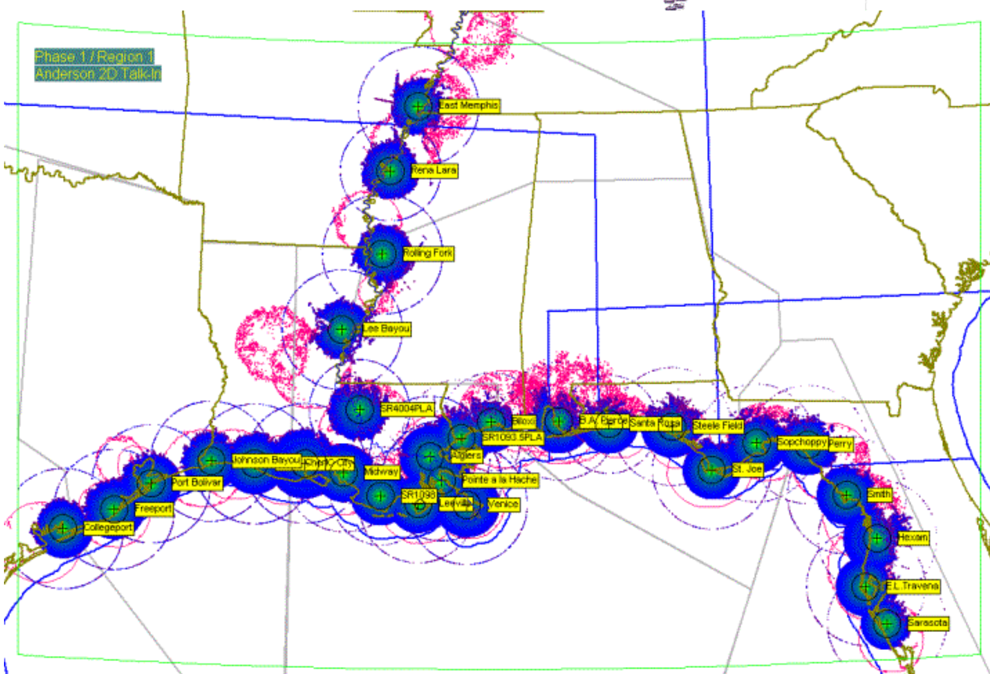
A multi-year commitment of funding for Bandwidth (verses funding to build observatories) made available to the research community might provide such an incentive

The level of funding identified for such a Bandwidth Bank each year would dictate the extent of the network and the speed at which it is built.

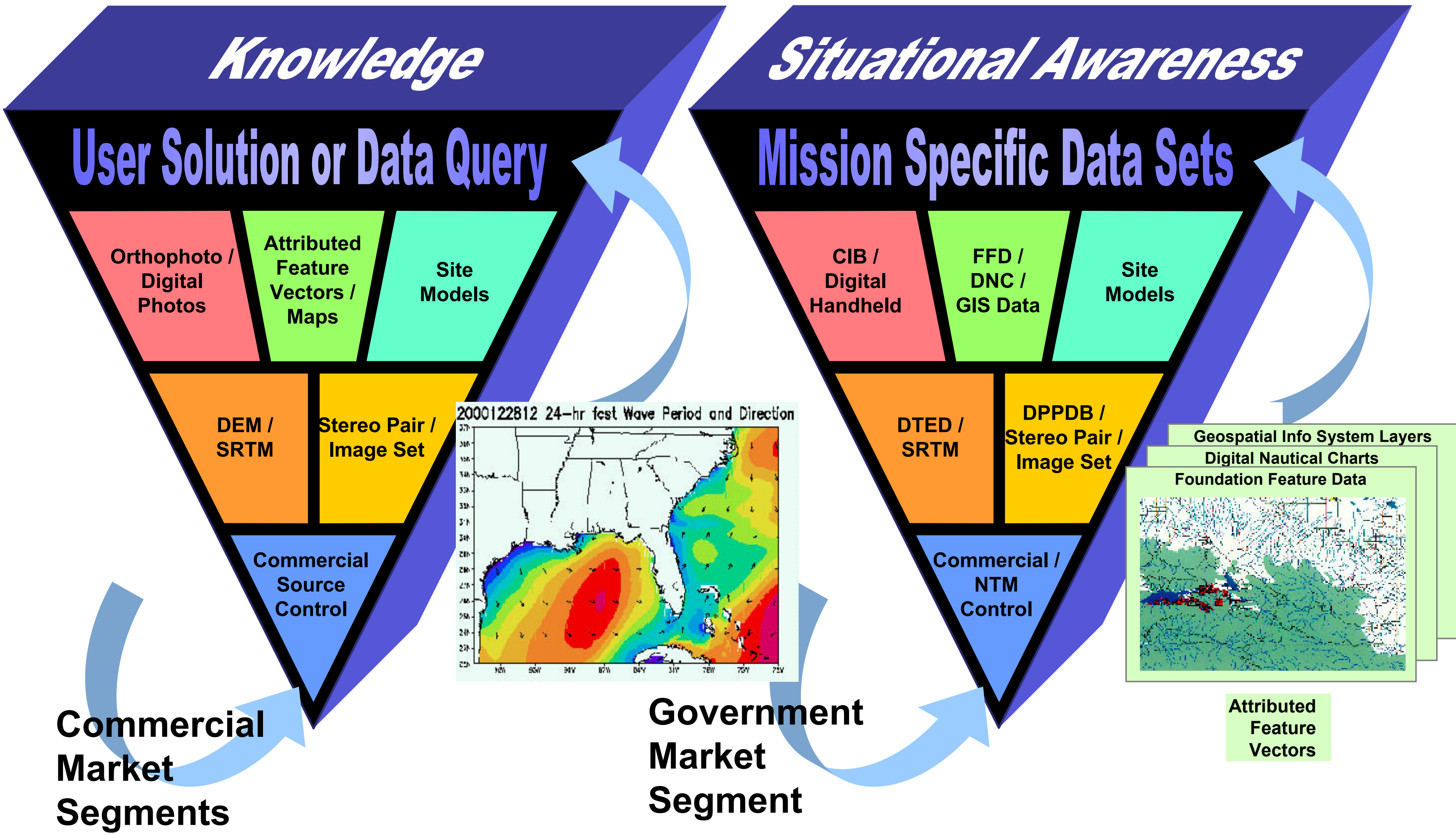
Examples of Industry Built / Operated Systems



- **Users (Boaters) Subscribe**
- **RF Towers provide Line-of-Sight Coverage 20 - 50 miles offshore**

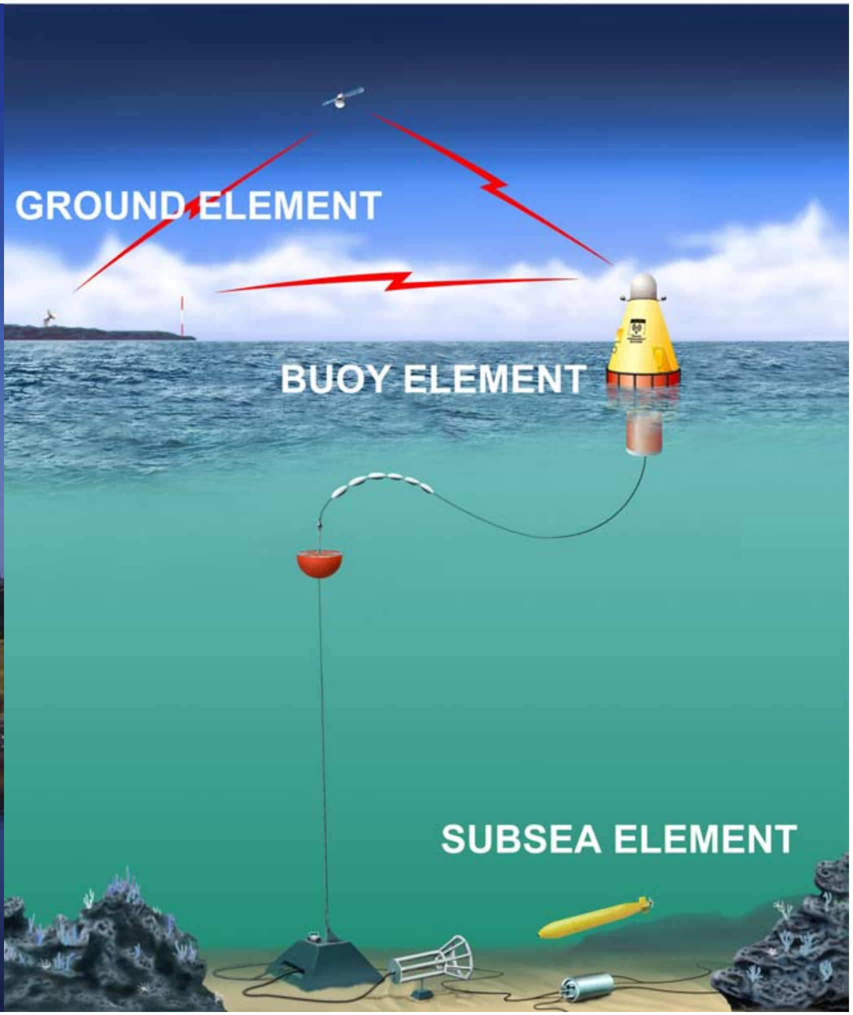


Examples of Industry Built / Operated Systems



Examples of Industry Built / Operated Systems

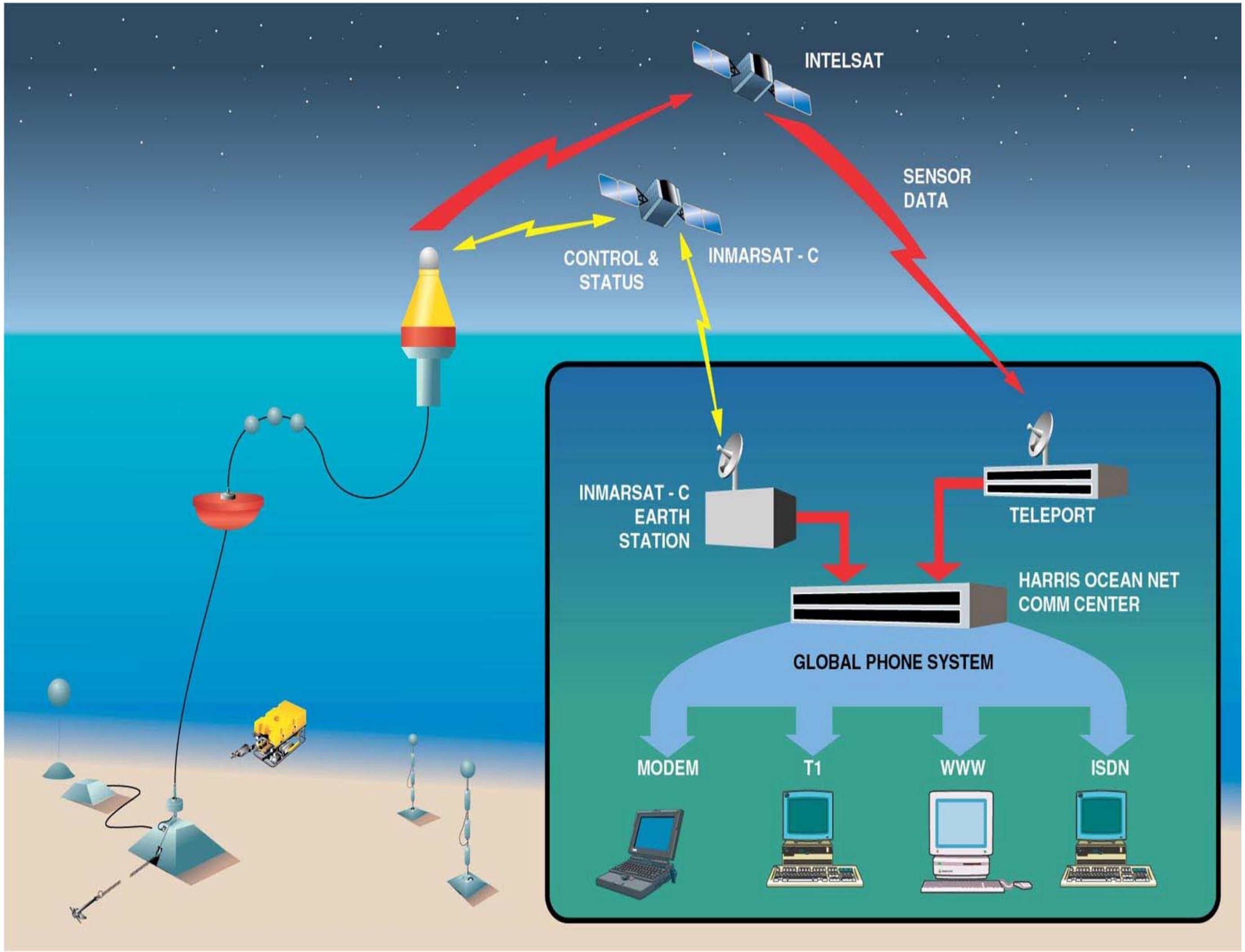
- **Observatory is Deployed and Maintained by Commercial Operator**
- **Users (Researchers) Subscribe for Bandwidth**
- **Scientific Subscribers Need not Also be Marine Operations /Communications Experts**



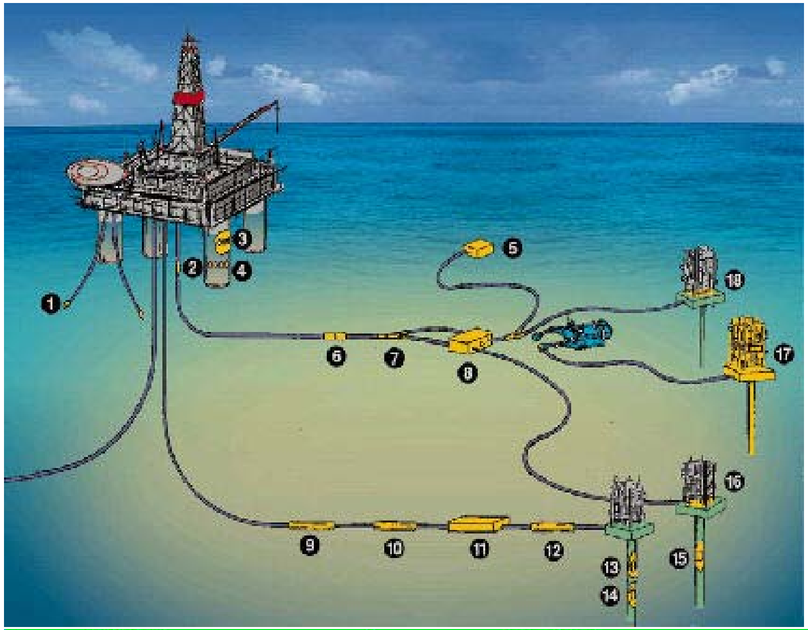
Examples of Industry Built / Operated Systems

World-Wide Infrastructure for Transmitting Data To/From Ships at Sea Already Exists

This Network is Now Also Employed to Deliver Seafloor and Sea Surface Data to Institutes and Universities on Shore

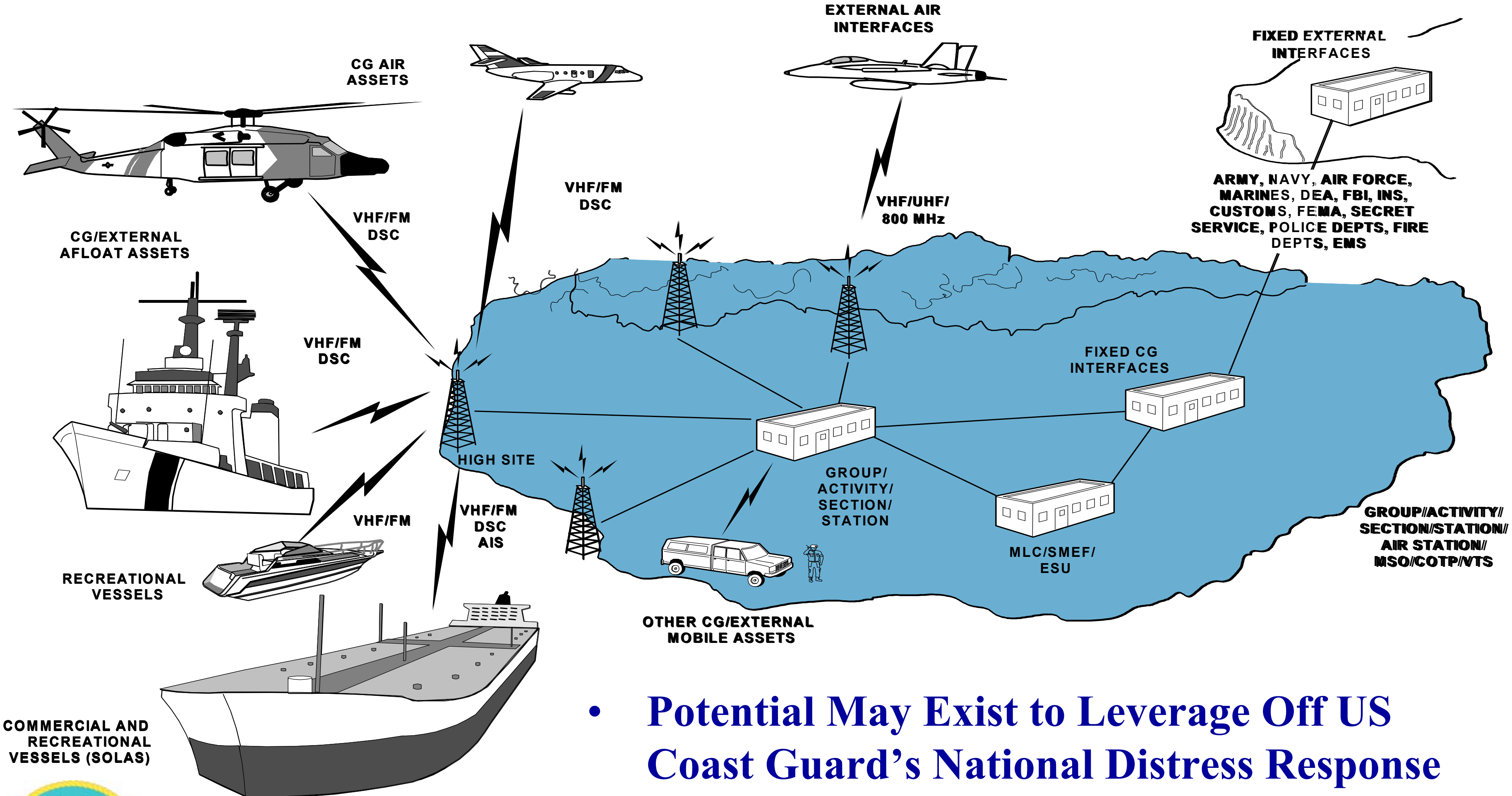


Opportunities for Dual Use
(and shared expense)



- **Networks Supporting Oil & Gas Industry Might Be Expanded to Also Collect Oceanographic Data**

Opportunities for Dual Use (and shared expense)



- Potential May Exist to Leverage Off US Coast Guard's National Distress Response Modernization Project (NDRSMP) and/or Pending Homeland Defense Investments

SUMMARY

- **Industry has Developed Many of the "Building Blocks": *Sensors, Cables, Connectors, Buoys, Broadband Telemetry Systems*, that are required for an Integrated Ocean Observing Capability as well as the Infrastructure and Capability to Deploy it.**
- **Provided with the Expectation of a Sufficient Demand, Industry Might Respond by Developing the Infrastructure of a Truly Integrated Ocean Observing Capability Funded by its Subscribers**
- **Competition and Market Forces Should Drive this Process to Ensure a "Faster, Better, Cheaper"and Continually Upgraded System**

Deployment of Ocean Net Observatory