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# An Extended Enterprise Architecture for a Network-Enabled, Effects-Based Approach for National Park Protection—Transitioning Military Paradigms[1]

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**Abstract**

The threats to the national parks in the United States are many and varied. These range from climate changes, animal/fish population cycle variations, invasive species introduction, and cultural affects of indigenous peoples to problems associated with natural disasters, oil spills, land development, criminal enterprises, etc. The United States Department of the Interior National Park Service has issued a Natural Resource Challenge to help preserve the many diverse national parks in all 50 states and U.S. territories. Since the creation of the National Park Service in 1916, it has been charged with caring for, restoring, and protecting a wealth of natural assets without a specific process to handle these varied tasks. According to the National Park Service Action Plan for preserving natural resources, a focused methodology is necessary to achieve this challenge.

Investigating the Wrangell-St. Elias National Park and Preserve (WRST) in Southeastern Alaska as a specific illustration of a complex U.S. national park environment, this paper proposes a solution for national park protec-

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tion in the 21st century via the application of a military-derived network-enabled effects-based approach married with a well defined extended enterprise architecture. The interconnection of planning systems, monitoring sensors, visualization tools, and other information sources will allow for quick reaction to national park threats by enforcement agencies. The combination of thousands of acres of forest and mountains, a remote location, littoral and watershed geography, variable weather conditions, and public and indigenous people's usage makes the WRST an excellent candidate for investigation. This paper further proposes a solution space via system requirements definition and design processes modeled on those in use by some Department of Defense (DoD) agencies. Finally, this paper investigates some command systems in use by forestry agencies and the United States Coast Guard (USCG) that could be used to form an initial realization of a network-enabled, effects-based approach to national park protection.

## Introduction

The threats to the national parks in the United States are many and varied. These range from climate changes, animal/fish population cycle variations, invasive species introduction, and cultural affects of indigenous peoples to problems associated with natural disasters, oil spills, land development, criminal enterprises, etc. The United States Department of the Interior National Park Service has issued a *Natural Resource Challenge* to help preserve the many diverse national parks in all 50 states and U.S. territories. Since the creation of the National Park Service in 1916, it has been charged with caring for, restoring, and protecting a wealth of natural assets without a specific process to handle these varied tasks. According to the *National Park Service Action Plan* for preserving natural resources, a focused methodology is necessary to achieve this challenge.

> For most of the 20th century, we have practiced a curious combination of active management and passive acceptance of natural systems and processes, while becoming a superb visitor services agency. In the 21st century that management

> style clearly will be insufficient to save our natural resources. Parks are becoming increasingly crowded remnants of primitive America in a fragmented landscape, threatened by invasions of nonnative species, pollution from near and far, and incompatible uses of resources in and around parks (NPS1 2008).

The National Park system in the United States represents over 80 million acres of public land spread out over all 48 contiguous states plus Alaska, Hawaii, American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands (NPS2 2008). The overarching goal of the National Park Service as part of their *Natural Resource Challenge* is to maintain the ecosystem integrity of approximately 270 parks that contain significant natural resources. To this end, the National Park Service has established five long term goals for their *National Resource Inventory and Monitoring Program* (NPS3 2008):

1. Biological and geophysical natural resource inventories will be completed and data will be used locally as well as to generate regional and national summaries.

2. Long-term monitoring programs will be in place to monitor ecosystem status and trends over time.

3. Decision support geographic information systems and other field data tools will aid park managers in identifying alternative management actions, assessing trade-offs, and evaluating outcomes.

4. Integrated natural resources inventory and monitoring programs will be integrated with park planning, operation and maintenance, visitor protection, and interpretation activities to establish natural resource preservation and protection.

5. Cooperation with other federal and state agencies to share resources, achieve common goals, and avoid unnecessary duplication of effort and expense will occur.

Of these five goals, numbers 2, 3, 4, and to some extent 5 can be addressed with the proposed network-enabled effects-based approach with a defined extended enterprise architecture. The interconnection of planning systems, monitoring sensors, visualization tools, and other information sources will allow for quick reaction to national park threats. These elements include persistent surveillance systems and sensors, adversarial understanding, environment understanding, and coordination of distributed operations.

Protecting national park assets will require a new way of thinking beyond the traditional methods of national park protection to satisfy these goals if the *National Park Service Action Plan* is to be realized. The problems described by the National Park Service (NPS1 2008) such as invasions of nonnative species, pollution from internal and external sources, and incompatible uses of resources in and around parks have not been adequately addressed according to this source. Most recently, a rapidly growing threat to national park visitors and environment is the increase in illegal drug production on public lands, specifically by Mexican drug cartels bypassing tighter border controls. According to John Walters, the director of the Office of National Drug Control Policy, 75 – 80% of marijuana grown outdoors is on state or federal land (Keen 2008). The Drug Enforcement Agency (DEA) reports more than 4.8 million marijuana-plant seizures at outdoor sites in 2006, and in July and August of 2008, 340,000 plants alone were seized from the Sequoia and Kings Canyon national parks (Keen 2008). In these same parks, the giant sequoia trees may soon die off more quickly due to global warming effects and along the 400 mile Sierra Nevada mountain range, federal land managers have started monitoring wilderness lands to understand how they are transforming (Burke 2008). This same source quotes U.S. Forest Service officials as stating, "Rather than just managing forests for the plants we see growing here today, we're now having to look forward to think about what might thrive there in 100 years."

## Network-Centric Enterprise and Approaches to Operations

A network-centric enterprise (NCE) as a component of network-centric warfare (NCW) focuses on "the combat power that can be generated from the effective linking or networking of the warfighting enterprise" (Alberts et al. 2002). Although the concept of national park surveillance and protection does not in itself comprise a strict definition of a "warfighting enterprise," many elements of the warfighting problem do apply, such as the need for information at the right place and time, developing a more complete situational awareness picture, and generating the ability to respond quickly to problems as soon as they are detected (such as fires, floods, chemical spills, etc.).

According to Alberts and Hayes, the moniker of Network Centric Operations (NCO) was introduced to emphasize that the principles behind NCW and Network-Enabled Capabilities (NEC) reach beyond purely military environments (2007). One of the impacts of NEC is defined as the "integration of sensors, decision-makers, weapon systems, and support capabilities to enable agility and thus permit commanders to better synchronize effects" (NEC 2005). Farrell relates that "NCO promises to do just that (removing communication and information sharing barriers) by networking people, processes, and assets together, and therefore facilitating shared awareness, common intent, and decision-making required for planning, execution, assessment, and ultimately mission completion." (2008).

Therefore, NCO can characterize any network-centric enterprise via the successful implementation of the following domains (Alberts and Hayes 2007):

- Physical Domain: All enterprise entities are robustly networked, achieving secure and seamless connectivity.

- Information Domain: All participant entities have the capability to access and share information with each other and other enterprise entities as appropriate.

- Cognitive Domain: Each participant in the enterprise has the capability to develop high quality awareness.

- Social Domain: The enterprise has the capability to develop shared awareness and understanding, including that of command intent, across all participants.

## Statement of Purpose

These problems suggest that a requirements and information architecture development approach is needed. Because of the physical scale of many national parks such as the Wrangell-St. Elias National Park and Preserve (WRST) in Southeastern Alaska—especially protected areas with maritime components where diverse activities that occur within a park's boundaries, the application of a *network-enabled effects-based approach* married with a well defined *extended enterprise architecture* will greatly facilitate comprehensive national park surveillance and protection. An effects-based approach (this is equivalent to the more common term—effects-based operations [EBO]) is one that is described as "coordinated sets of actions directed at shaping the behavior of friend, foe, and neutral in peace, crisis, and war" (Smith 2006). A network-enabled organization at its core allows for the rapid exchange of information across communications nodes and provides for both rapid reactive and proactive responses to changes in a surveilled environment. In other words, a high degree of situational awareness is created that will enable rapid response to time critical threats such as poaching and the emergence of forest fires. The extent of the area of concern is theoretically unlimited. Any real limitations are based on the number of sensors available, their types and ranges, the communications and processing capacity in the network, the ability of the network to synchronize information, the availability of decision makers, and the ability to execute toward a desired effect. Here "effect" is consistent with the effects-based approach of directing and shaping behavior as a result of the processing of disparate information sources.

To this purpose, the WRST in Southeastern Alaska is an excellent model for application of net-centric enterprise concepts for monitoring and protection that can be applied to all other U.S. national parks. The WRST consists of 13.2 million acres that includes a coastal region of approximately 1.9 million acres and four mountain ranges. It is shown in figure 1 (Wrangell 2008). The WRST is the largest national park in the U.S. and contains the continent's largest assemblage of glaciers and mountain peaks above 16,000 feet (Hood 2006). Therefore, the goal of this paper is to present a network-enabled effects-based strategy across an extended enterprise to satisfy three to four of the previously listed long term goals of the U.S. National Park Service *National Resource Inventory and Monitoring Program* (NPS3 2008). This can then be used to define the generation of surveillance strategies and plans to protect the WRST national park as a realization of controlling disparate threats to U.S. national parks in general.

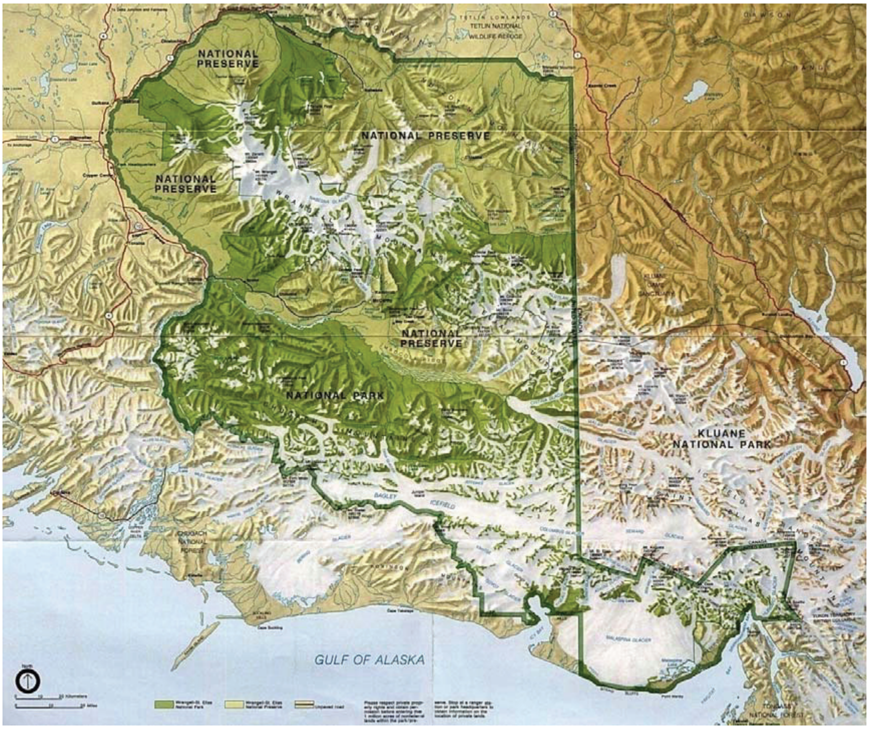


**Figure 1. A map of the Wrangell-St. Elias (WRST) National Park and Preserve.**

*Literature Review*

The concept of using NCO for any sort of natural site protection or monitoring has not been specifically addressed in the literature, although distributed sensing applications have had some treatment in this context as have some systems engineering methodologies. Shepherd and Kumar briefly describe the use of a network of sensors that form a distributed sensor network (DSN) in the Hawaii Volcanoes National Park to measure climate data (2005). Xu performed a survey of sensor network applications that specifically deploy many inexpensive, ad-hoc sensors across a wide area (mimicking military applications) for habitat monitoring and environmental observation (no date). Haskins has described systems thinking as a proper method to bring together diverse stakeholders to discern the attributes of eco-industrial parks, which bear similarities to national park systems (2006, 2007). To this point, Sutherland, et, al. have investigated the significant effects that recreational activities have on drainage basins and soil properties via hiking trail use. (2001).

Some components of the national park landscape discussion in this paper are addressed in the literature, such as the effects of human systems and conservation methods. Hawkins, et al. investigated the restoration of temperate marine and coastal ecosystems and found that rocky shore and seagrass systems were prone to the direct and indirect effects of human impacts (1999). This includes shellfish and seaweed exploitation, point source pollution and oil spills. He suggests that the management of human activities (human systems) is the best approach in terms of conservation as opposed to the restoration of seagrass beds. Human systems and their effect on the hydrology, ecology, geomorphology, and climate and biochemical cycles of land systems are discussed by Liverman and Cuesta (2008). They report that progress has been limited linking socio-economic data with satellite imagery and human activity forecasting for understanding land use dynamics. Clark discusses similar issues for river management (2002). Shoreline management and the problems caused by 21st century relative sea level rise (RSLR) are addressed by Orford and Pethick (2006).

## Understanding NCO Requirements and Process

The problem of WRST enterprise protection and that of national parks in general, is similar to the Defense Advanced Research Projects Agency (DARPA) Information eXploitation Office (IXO) strategic master plan process for United States Marine Corps (USMC) for Expeditionary Intelligence, Surveillance, and Reconnaissance (ISR). A modified process plan for WRST protection is shown in Figure 2.

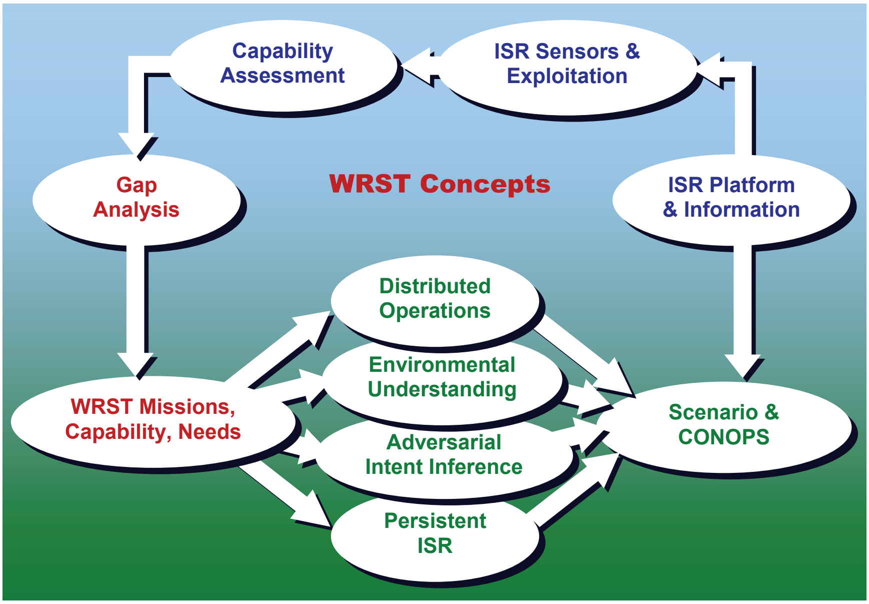


**Figure 2. A National Park Strategic Master Plan Process as applied to the WRST.**

The cyclical process represented begins with Missions, Capability, and Needs which is addressed in the landscape discussion of the WRST problem space. This information feeds advanced concept possibilities like Persistent ISR, Adversarial Intent Inference, Environment Understanding, and Distributed Operations that can be transformed into a Concept of Operations (CONOPS). A CONOPS is used to describe system behavior often via the development of usage scenarios and/or use cases. These components of the WRST concept, as shown in figure 2, should be considered as part of any WRST *enterprise architecture* to develop actionable information.

1. Persistent ISR for a contiguous operational picture: UAV, Autonomous Underwater Vehicles (AUV), satellite tracking, Infrared (IR), imaging, chemical and biological plume detection/tracking, Automatic Identification Systems (AIS), Vessel Monitor-

ing System (VMS), Aerostats, terrestrial/maritime radar, sonar, sonobuoys, Coastal Oceanographic Line-of-Sight (COLOS) and NOMAD buoys, C2 system inputs, etc.

2. Adversarial understanding and intent inferencing: Sea bird poaching, timber harvesting, illegal fishing operations, drug and human trafficking patterns, illegal diving/archeological operations, etc.

3. Environmental understanding: NOAA weather reports, Lloyds maritime databases, tidal information, dynamic water temperature and salinity zone maps, port identification, littoral/land entry barriers, forest cover, fish spawning cycles, migratory bird movements, NOAA prohibited fishing areas, tourist destinations, chemical spills, wastewater release points, commercial maritime vessel traffic patterns, large public events, etc.

4. Coordination and prioritization of distributed operations: Asset availability and dynamic tasking, resource allocation, environmental tempo, multiple user objectives, network centric operations, synoptic assessment, command authority, multi-level security, mission precedence, communication routing and bandwidth availability, etc.

The CONOPS is also influenced by the availability of ISR Platforms and Information which is why the ISR activity terminates in the CONOPS (although this could also be represented as a double arrow implying feedback). This will define the ISR Sensors/Systems and Exploitation needed and the subsequent Capability Assessment. The Capability Assessment provides a key to understanding what can be monitored with a given set of sensors, their availability, and the amount of control that is possible to exert for each source of information. Specifically there are three categories for sensor/source information control (adapted from Gravell, [1998]) that reflect the previous WRST concept list.

- Organic sources (complete local control): These resources include radar, sonar and sonobouys, local sensors of various types, and some vessel identification systems like AIS or VMS, etc. These systems would be considered real-time or near real-time and under direct control from a local national park authority.

- Non-organic sources (within local authority control): These resources can include UAVs, other centralized AIS or VMS systems, aerostats, etc. Additionally, this data could be provided from other stations, multi-use aircraft, etc., within the control (even indirectly) of the local park authority.

- Non-organic assets (beyond control of local authority): These include regional or national assets such as satellite imagery and other C2 system outputs. These C2 systems could include FBI or DHS criminal and terrorist watch lists, NOAA weather information and prohibited fishing areas, etc. These assets are considered to be beyond the control of local national park authorities where various information products can be selected but ultimately all received information can only be accepted or ignored. In other words, no feedback channel is available to request information refinement or initiate a new collection event.

Finally, the compilation of this process leads to a Gap Analysis that will highlight areas that cannot be supported between CONOPS needs/scenarios and available resources/capabilities. This might seem like a linear process, but due to the complexities inherent in a NCO, the problem is both non-static and nonlinear and as a result, there may be multiple modes of behavior that need to be considered and understood. For an NCO gap analysis, referencing Atkinson and Moffat (2005), this includes understanding of the *influence network*. They define this as understanding the landscape entities (actors, sensors, etc.), their authority level, their interactions, and the flow of influence and causality and how these propagate through the system. This is further refined by the work of Sierhuis, et al. (2003) and Acquisti, et al. (no date). Both authors describe using an agent-oriented, activity-based language known as *Brahms*, to model the actions of actors, communication, collaboration, and their interaction. Specifically, a conceptual model is defined for space systems (which involve similar technical challenges to WRST monitoring), that contains the following sub-models (note that these specific sub-models use entities from the WRST landscape discussion in the following section):

- *Agent Sub-model*: This includes the actors in the enterprise. These include government enforcement personnel, criminals, scientists, indigenous peoples, and visitors. Hierarchies can be developed and specifically modeled that includes USCG, NOAA, EPA, and state and federal police for government enforcement personnel, as an example. Hierarchies and their relationships would be built for all agents.

- *Activity Sub-model*: Recurring and unique activities can be modeled based on group membership of the agents. As an example, an activity group can be defined by the interrelationship between the government enforcement personnel and criminals. This can further be broken down to *recurring* and *unique* activities. A recurring activity includes daily aircraft overflights to monitor a specific park region. A unique activity would be the coordination of law enforcement to perform a poaching interdiction.

- *Geography Sub-model*: This includes the entire WRST geographic region as shown in figure 1. This can also be hierarchically broken down depending on the fidelity needed for different groups. For example, the littoral interface between the rivers, ocean, and land areas might need more attention to detail than the individual monitoring points for park personnel. This will reflect the interaction of the groups in the agent and activity models.

- *Knowledge Sub-model*: This model represents what the agents can know about their environment and their ability to perform problem-solving. As an example, conservation personnel can learn about species' migratory patterns and then use the geography model to establish boundaries, the agent model to establish the actors involved, and the activity model to determine relationships between the entities.

## Extended Network Architecture and Systems Approach

Any proposed approach to solve the national park protection problem should define the *extended enterprise architecture* possibilities pertinent to the multi-faceted problem of protecting, in this case, the WRST. The extended enterprise refers to a "business system" that forms the myriad of *value webs* that can affect the WRST and first answers the "who" question of what people and groups are involved. For example, as discussed in the National Park Service commissioned report on the WRST (Hood 2006), the business system for the WRST includes the many scientists, fishermen, local communities, enforcement agencies, tourists and Alaskan natives who are all a part of and derive value from this resource. Envisioning the extended enterprise will allow the linking of the strategic intent of WRST protection to a tactically executable, effects-based solution. The proposed WRST extended architecture considers the following which forms the *landscape* of the problem space:

1. Available sensor information for observing the environment

2. Intelligence information (Human intelligence, e.g., knowledge of criminal enterprises)

3. Sensor and source control (local vs. national vs. strategic assets)

4. Normal maritime traffic and maritime domain awareness (MDA)

5. Known techniques, tactics, and procedures (TTP) of poachers and other miscreants

6. Adversary intent and capabilities

7. Weather events

8. Geologic events and changes

9. Ecological events (sewage and oil spills, etc.)

10. Normal and abnormal cycles in animal and plant populations

11. Cultural affects of indigenous peoples

12. Fishing practices (destructive, subsistence, and otherwise)

13. Effects of run-off, sedimentation, waste water, and marine and agricultural debris

14. Ocean variations (temperature, salinity, etc.) over distance and time

15. Invasive species (plant and animal) introduction and spread

16. Natural and man-made disasters (forest fires, earthquakes, etc.)

17. Tourism

18. Coast Guard presence and capabilities

19. Enforcement and policing capabilities

20. Legal and regulatory agencies and policies (e.g., USC Title 50)

The most irreducible part of an enterprise is the *person*. So in the WRST enterprise, the interaction and collaboration of *human activity processes* should be the first concern. These include activities already detailed such as fishing, monitoring agencies, tourism, research,

search and rescue (SAR), etc. It is here that the relationship of these systems forms the communication and influence paths that exist between them, per an NCO paradigm. This is illustrated in figure 3 which can be considered a high-level operational concept graphic described as an operational view (OV-1 specifically) that is used in the Department of Defense Architecture Framework (DoDAF). This is one of several possible architecture frameworks that can be used. However, the DoDAF structures naturally represent network-based systems and enterprises and allow the decomposition of an NCE into system and technical views that can be used to develop and/or align to requirements, interfaces, and technical standards.

In figure 3, a high-level information interchange between platforms (entities), various sensor systems, command and control (C2) nodes, and their environment is shown. In the same operations area there may be SAR operations commingling with salmon fishing, tourism, wildlife conservation, and any other number of human system activities. The next step in WRST protection, and that of national park protection in general, is then to be able to deploy the right sensors (radar equipped Unmanned Aerial Vehicles (UAVs), National Oceanographic and Atmospheric Administration (NOAA) National Data Buoy Center information, seismic/vibration, etc.) and C2 systems across the thousands of square miles that make up the WRST enterprise in order to effectively monitor its use and health.

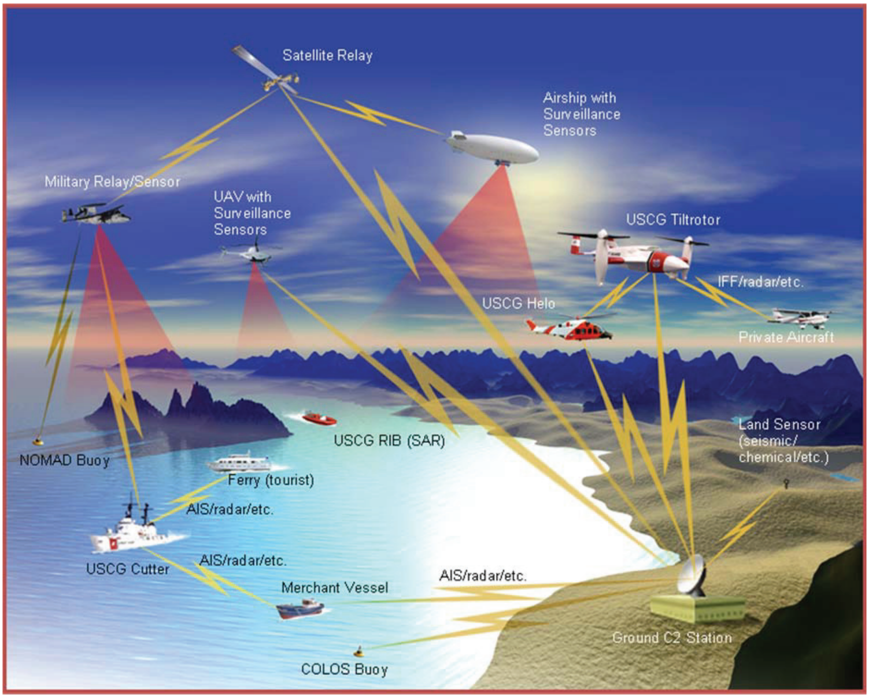


**Figure 3. Operational view of the Wrangell-St. Elias (WRST) National Park and Preserve.**

One solution to the vision of WRST protection across these many dimensions is to generate an integrated domain awareness capability based on a *network-centric oriented model* that will provide highly scalable solutions for maritime and land based security and critical infrastructure protection across the entire WRST enterprise. In short, this architecture supports the generation of *actionable information*, which is simply information that increases knowledge and allows for a decision-maker to act on a choice with minimal uncertainty in a timely manner. This is an especially difficult problem in the use of demand driven sensors such as UAVs and aircraft that cannot stay on-station indefinitely and have relatively high costs associated with their use.

Addressing the dynamic aspects of an NCO, a different frame of reference needs to be generated in order to comprehensively attack the architectural design for the enterprise architecture. This entails a marriage of sorts between a Service Oriented Architecture (SOA), a complete DoDAF design, and the enabling of edge units such as the WRST actors.

SOA is a broad topic and much literature is available on this subject. However, in an NCO context, the SOA describes the overall design and structure of the collaborative enterprise environment. The Brahms model that is previously discussed that combines the agent, activity, geography, and knowledge sub-models used in the gap analysis is a way of viewing this. Some enterprise architectures are better than others in regard to how well they are structured and thus how easily data is stored and retrieved, how users interact, how program components communicate with each other, how easily components can be replaced with others, etc. In an SOA, the structures are specifically designed to be a set of loosely coupled "black box" entities orchestrated to deliver a well-defined level of service by linking together business processes. These processes and services interact based on formal definition of their external interfaces (allowing appropriate data to be visible) independently of computing environments, communications methods, security, and physical entities (aircraft, boats, etc.). The NII Net-Centric Checklist provides a comprehensive view of SOA and the entire NCE and should be referenced for complete coverage on the "goodness" of an NCE (OASD 2004).

Complementing the SOA, a process algebra (π-calculus) defining the underlying foundation for business process management (BPM) for enterprises that are comprised of mobile systems is discussed at length by Puhlmann (2008). Dynamic, mobile systems like the WRST enterprise present a new problem to BPM that traditionally has been dominated by static and causal environments. This environmental "space" consists of processes that are either links between processes, or the processes themselves. In the DoDAF OV-1 of figure 3, the links can be seen via the satellite and aircraft relays and ground sensor. Figure 4, modified from work done by Jones (2005), captures the message-based concept of an NCE architecture that could exist on every node that processes more than just local sensor information (at least to some extent) shown in the OV-1. It is comprised of the SOA-based set of service components for sensors, registration, C2, and communications (represented in the yellow boxes). These services execute the WRST concepts of distributed operations, environmental understanding, adversarial intent inferencing, and persistent ISR. Each service relies on defined internal and external message structures to pass information as needed, with examples shown via the labeled messaging arrows.

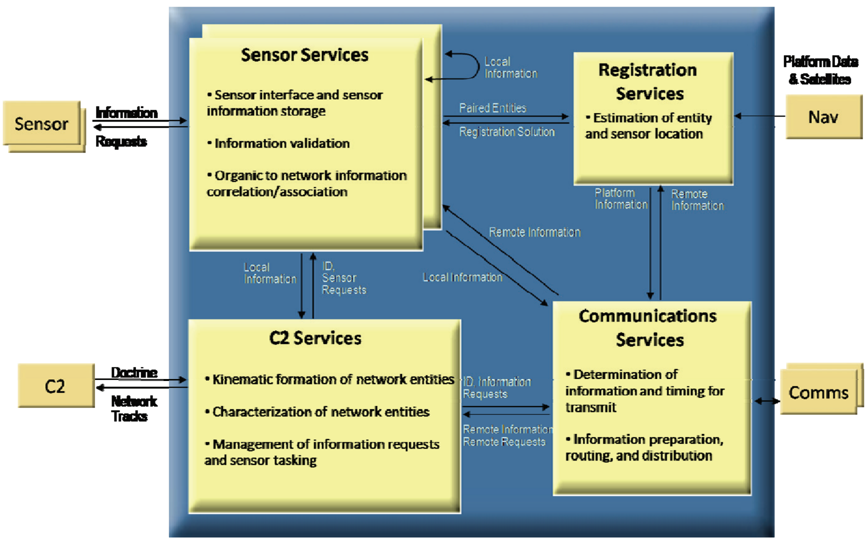


**Figure 4. NCE based functional architecture.**

Pullman has described that "mobile systems are made up of parallel components which communicate and change their structure—thereby overcoming the limitations of static structures" (2008). A dynamic mobile system simulation snapshot is shown in figure 5 (Jones 2005).

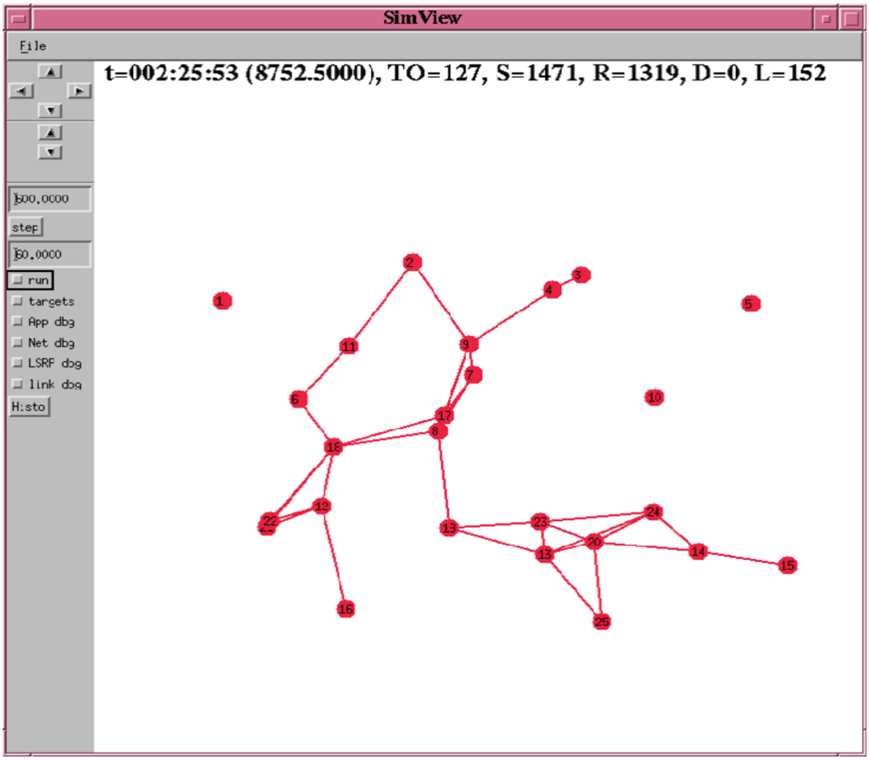


**Figure 5. Simulation of mobile ad hoc network.**

Each numbered node in figure 5 represents a WRST entity (platform) and the red lines show link connectivity per the OV-1 in figure 3. As entities transit in the WRST space, communications links are formed and broken in a dynamic fashion as communications limitations occur, such as range limits and geographical obstructions.

## Recommendations Citing Existing Programs and Capabilities

Environmental monitoring command centers are realized in some areas for natural disaster detection and resource allocation. As an example, the National Interagency Coordination Center (NICC) is a U.S. Forest Service run national network of eleven centers for wildfire fighting support based in Boise, Idaho (NICC 2008). Wildfire containment represents one of the clearest needs for quick detection and localization of an initial event, such as those caused by lightning strikes, in order to effectively apply resources to battle these fires. The frequent California wildfire problem represents the need for rapid coordination of information for effects-based needs. According to Enkoji (2008), the Northern California Geographic Coordination Center, which is a part of the NICC, is charged with "calculating fire movements, monitoring weather, and trying to pinpoint where the next trouble spot will ignite so that they can marshal the nation's air and ground resources." Fire managers then decide where to move air tankers, fire fighters, or where to drop smoke jumpers. Some aspects of these fire fighting operations are automated and information-based, such as the use of satellite monitored remote weather stations and infrared imagery. However, most aspects of fire fighting remain manually intensive.

Considering the fire protection problem, the complete coordination of sensors, the inclusion of additional sensor information such as local networked lightening strike detectors, predictive pre-staging of fire fighting equipment, and dynamic resource re-planning could also be included. Further, the NICC capability could be tied in with other centers and systems not related to fire detection so that its information and capabilities are available as part of a more diverse national park protection landscape. To this point, the NICC has a geographic coordination center for the state of Alaska, the Alaska Interagency Coordination Center (AICC). The information coordination capabilities of the AICC would be necessary for WRST effects-based NCO. If the WRST were to experience a major earthquake (since 1889, Alaska has experienced ten earthquakes with a magnitude greater than 8.0 on the Richter scale [NPS4 2008]), then resources normally used for fire fighting could be more easily applied to disaster recovery with a NCO paradigm. Additional capabilities that should be a part of this extended enterprise also include the need to coordinate all WRST activities with a dynamic surveillance planning system which will allow an efficient means to respond quickly to changes in the WRST.

One example of a system that employs elements of a network-enabled, effects-based, extended enterprise architecture that could be applied to a national park-like problem is being initiated by the USCG. Figure 6 shows a snapshot of the prototype software visualization tool SemPar VIEW built by Lockheed Martin used in the USCG District 1 (Boston) operations area which encompasses Northern New England. SemPar VIEW supports a web-based application for creating and sharing information across a network establishing a tactical situational awareness picture for multi-mission applications such as fisheries monitoring, commercial maritime traffic identification, law enforcement, etc. The SemPar VIEW visualization has the ability to ingest multiple data sources (e.g., AIS self-identification information, radar, NOAA VMS fisheries data and feeds from UCSG sources) and combine the inputs to display a single situational awareness picture of events (LM 2007).

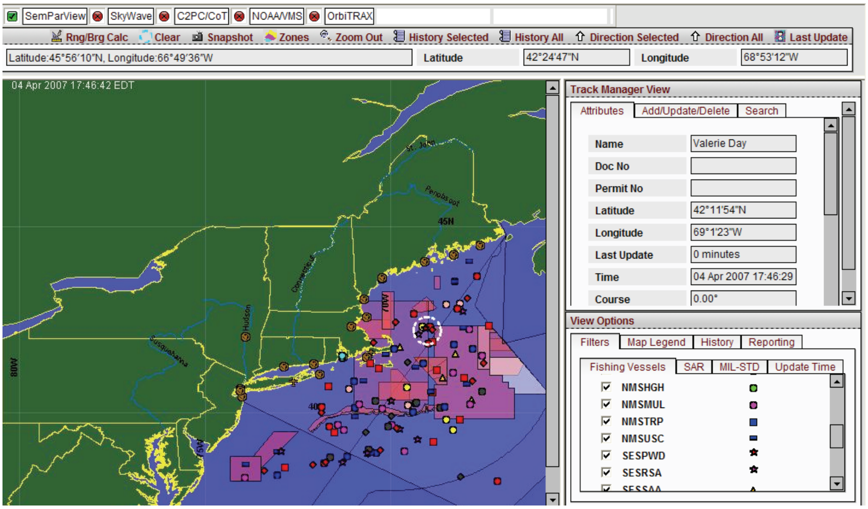


**Figure 6. USCG District 1 Maritime Situational Awareness Display.**

Figure 6 illustrates some of the varied types of information that can be displayed to generate situational awareness. For the future, these types of capabilities are a start of a way of realizing the WRST enterprise and that of the national park system in general. Many other initiatives undertaken for MDA and other homeland security applications can be applied to this problem. The Athena project built by Raytheon is designed to look for suspicious behavior in the maritime domain through a variety of sensors and open source intelligence sources (Raytheon 2006). Maritime security programs such as the DARPA IXO Predictive Analysis for Naval Deployment Activities (PANDA) also hold promise to help identify suspicious maritime behavior. This includes whether a commercial vessel has been hijacked by pirates or terrorists (Moore 2005), among other behaviors.

*Potential for Future Work*

The WRST preservation concept is an excellent opportunity to realize systems solutions for the pressing problem of the protection of varied ecosystems across all national park systems. Various studies need to be initiated including those to determine the types and availabilities of sensors needed to cover the expanse of this area, availability of communications networks, human interfaces to be developed, and integrated dynamic planning mechanisms, to name a few. If work toward this network-centric, effects-based solution is successful, then a variety of similar applications exist. These include applications to other national parks and organizations, waste disposal, water treatment facilities, and United Nations peacekeeping and monitoring missions among others.

One of the most pressing political debates in the US over the next several years will continue to be whether to explore and drill for oil in the coastal plain of the Alaska Arctic National Wildlife Refuge. While this specific issue does not affect the WRST directly since this refuge is in North Central Alaska, the concerns for this possible enterprise would also call for an extended enterprise architecture for a network-enabled effects-based approach. For example, according to the U.S. Fish and Wildlife Service if the coastal plain of the Arctic National Wildlife Refuge were developed, the associated infrastructure of pipelines, roads, and other structures would present a significant impact on virtually all indigenous species in the area. One example out of hundreds is the effect of possible drilling on the Porcupine Caribou herd. Effects would be seen via a reduced amount and quality of forage available during and after calving, restricting access to important coastal insect-relief habitats, exposing the herd to higher predation, and alter their ancient migratory pattern (U.S. Fish and Wildlife Service 2001). Hundreds of other fish, mammal, bird, and vegetation effects would also have to be monitored to measure impacts if exploration is ultimately allowed in the same way WRST activities could be monitored.

## Summary & Conclusions

The 3.2 million acre WRST national park presents a most unique challenge to surveil, understand, and protect. The *National Park Service Action Plan* has clearly set forth that the ad-hoc approach the National Park Service has taken over most of the 20th century is insufficient to protect the natural resources and ecosystems of the approximately 270 U.S. national parks that contain significant natural resources in the 21st century (NPS1 2008) (NPS2 2008). Of the five long term goals cited in the National Resource Inventory and Monitoring Program (NPS3 2008), four can be addressed via the proposed *network-enabled effects-based approach* married with a well defined *extended enterprise architecture*. These include:

- Long-term monitoring programs to monitor ecosystem status and trends over time

- Decision support geographic information systems and other field data tools that will aid park managers in identifying alternative management actions, assessing trade-offs, and evaluating outcomes

- Natural resources inventory and monitoring programs integrated with park planning, operation and maintenance, visitor protection, and interpretation activities to establish natural resource preservation and protection

- Cooperation with other federal and state agencies to share resources, achieve common goals, and avoid unnecessary duplication of effort and expense

A literature review has shown that an initial approach to networked systems and sensors has been used in a few applications, but no overall systems-based design has been applied to this problem (Haskins 2006). To answer this deficit, a process plan and architecture example for WRST protection is proposed. Specifically, a *solution space* *via a system requirements definition* that links WRST mission capability and needs with the development of a CONOPS, ISR sensors and platforms, and capability assessments via persistent ISR, adversarial intent inferencing, environmental understanding, and distributed operations is proposed. The linking of national park protection with an adaptive "systems thinking" approach is what really comprises the solution space for the WRST as its environment changes, much like an organism adapting to its environment (Checkland 1999).

Some prototype systems and existing information centers are described that can form the basis for this design. These include the NICC with its established centers around the country to provide wildfire fighting support; the SemPar View prototype which uses networked information to support USCG operations such as fisheries monitoring, commercial maritime traffic identification, and law enforcement; and the Athena and PANDA programs that promise to help identify suspicious maritime behavior with possible extensions to other domains.

Building upon prototype situational awareness developments for military and homeland security applications and other complementary technologies will allow the subject approach of this paper to be defined for the WRST and national park systems in general. This approach provides a method to understand all of the WRST activities, needs, susceptibilities, and needed resources that will result in a robust family of systems solution. It is also consistent with the military's NCW/NCO paradigm shift that emphasizes knowledge generation through networked information sharing as the future of military operations.

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**List of Acronyms and Abbreviations**

AICC – Alaska Interagency Coordination Center

AIS – Automatic Identification System

AUV – Autonomous Underwater Vehicle

BPM – Business Process Management

C2 – Command and Control

COLOS – Coastal Line-of-Sight

CONOPS – Concept of Operations

DARPA – Defense Advanced Research Project Agency

DEA – Drug Enforcement Agency

DHS – Department of Homeland Security

DoDAF – Department of Defense Architecture Framework

DSN – Distributed Sensor Network

EBO – Effects Based Operations

FBI – Federal Bureau of Investigation

INCOSE – International Council on Systems Engineering

IR – Infrared

ISR – Intelligence, Surveillance, and Reconnaissance

IXO – Information eXploitation Office (part of DARPA)

MDA – Maritime Domain Awareness

NICC – National Interagency Coordination Center

NOAA – National Oceanographic and Atmospheric Administration

NCE – Network Centric Enterprise

NCO – Network Centric Operations

NCW – Network Centric Warfare

OV – Operational View

PANDA – Predictive Analysis for Naval Deployment Activities

RSLR – Relative Sea Level Rise

SAR – Search and Rescue

SOA – Service Oriented Architecture

TTP – Techniques, Tactics, and Procedures

UAV – Unmanned Aerial Vehicle

USCG – United States Coast Guard

USMC – United States Marine Corps

VMS – Vessel Monitoring System

WRST – Wrangell-St. Elias National Park and Preserve