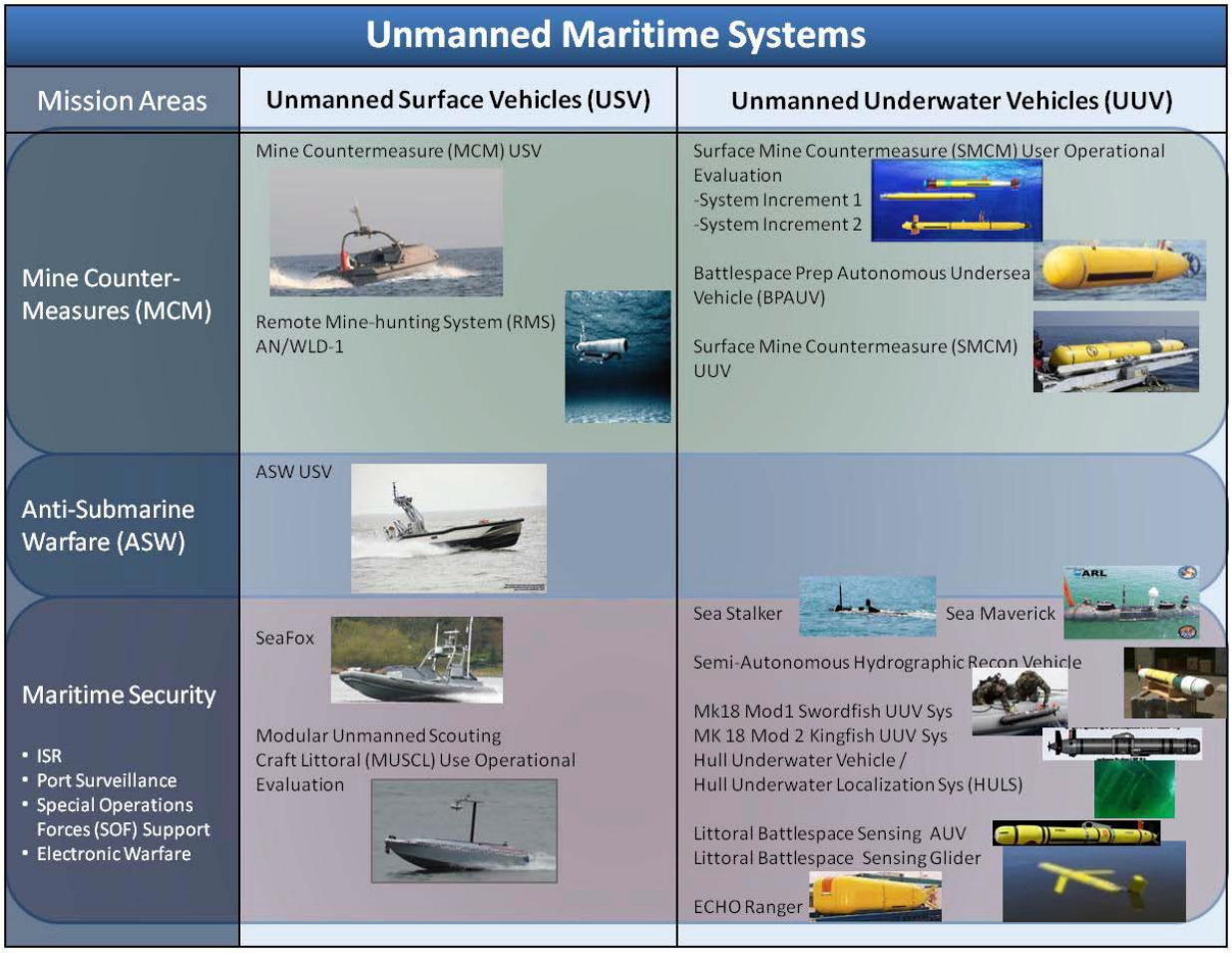
Unmanned Systems Integrated Roadmap FY2011-2036

Unmanned maritime systems (UMS) can be defined as unmanned vehicles that displace water at rest and can be categorized into two subcategories: unmanned underwater vehicles (UUV) and unmanned surface vehicles (USV).

USVs are UMS that operate with near-continuous contact with the surface of the water, including conventional hull crafts, hydrofoils, and semi-submersibles.

UUVs are made to operate without necessary contact with the surface (but may need to be near surface for communications purposes) and some can operate covertly.



The Navy Unmanned Undersea Vehicle (UUV) Master Plan (2004)

Sea Power 21 directs that the Navy will "Use unmanned platforms: Air, Land, Sea, and Undersea for combat and reconnaissance," as well as postulates a host of specific missions (e. g., mine warfare, shallow-water anti-submarine warfare (ASW)) for which UUVs are uniquely suited. Current and future UUV development should continue to focus on facilitating the Navy's high-priority missions.

An "unmanned undersea vehicle" is defined as a:
Self-propelled submersible whose operation is either fully autonomous (pre-programmed or real-time adaptive mission control) or under minimal supervisory control and is untethered except, possibly, for data links such as a fiber optic cable.

Excluded from this definition are towed systems, hard-tethered devices such as remotely operated vehicles, systems not capable of fully submerging such as Unmanned Surface Vehicles (USV), semi-submersible vehicles, or bottom crawlers.

The Unmanned Undersea Vehicle (UUV) Master Plan Update, chartered in December 2003 by the Deputy Assistant Secretary of the Navy and OPNAV N77 (Submarine Warfare Division), expands on the missions and technologies recommended in the Navy UUV Master Plan of April 2000. Using Sea Power 21 for guidance, nine Sub-Pillar capabilities were identified and prioritized:

1. Intelligence, Surveillance, and Reconnaissance
2. Mine Countermeasures
3. Anti-Submarine Warfare
4. Inspection/Identification
5. Oceanography
6. Communication/Navigation Network Node
7. Payload Delivery
8. Information Operations
9. Time Critical Strike

These capabilities were grouped under the four Sea Power 21 pillars: Sea Shield, Sea Strike, Sea Base, and FORCEnet.

FORCEnet (FORCEnet is the operational construct and architectural framework for Naval Warfare in the Information Age which integrates warriors, sensors, networks, command and control, platforms and weapons into a networked, distributed combat force, scalable across the spectrum of conflict from seabed to space and sea to land.

The goal of FORCEnet is to arm US forces with superior knowledge, leading to increased combat power. In pursuit of this goal, FORCEnet will provide a comprehensive network of sensors, analysis tools, and decision aids to support the full array of naval activities, from combat operations to logistics and personnel development. The focused, timely, and accurate data delivered by FORCEnet will help leaders at every level by allowing them to draw on vast amounts

of information and share the resultant understanding. This will increase the joint force's ability to synchronize activities throughout the battle space to achieve the greatest impact.)

The FORCEnet Pillar encompasses the ISR, Oceanography and Communications/Navigation Network Nodes (CN3) missions; however, its reach crosses all pillars.

Intelligence, Surveillance, and Reconnaissance (ISR): The ISR capability will complement and expand existing capabilities, extending the reach into denied areas, and enabling missions in water too shallow or otherwise inaccessible for conventional platforms. This capability will include multi-function systems, operating from a variety of platforms, enabling the collection of critical electromagnetic and electro-optic data.

Oceanography: This capability provides for the collection of hydrographic and oceanographic data in all ocean environments. Ocean survey supports real-time operations as well as intelligence preparation of the battlespace (IPB) for expected operations. Oceanographic data and environmental products are provided in near realtime for tactical support, archived for long-term support, and provided in rapid turnaround mode for operational battlespace preparation.

Communication / Navigation Network Nodes (CN3): This capability will be an enabling undersea component of FORCEnet. CN3 systems will provide connectivity across multiple platforms, both manned and unmanned, as well as navigation assistance on demand. Communication and navigation modules developed as part of this capability will transition into other UUV systems, reducing the overall developmental burden and risk.

SEA SHIELD (Sea Shield will protect our national interests with layered global defensive power based on control of the seas, forward presence, and networked intelligence. It will use these strengths to enhance homeland defense, assure access to contested littorals, and project defensive power deep inland. As with Sea Strike, the foundation of these integrated operations will be information superiority, total force networking, and an agile and flexible sea-based force.)

The Sea Shield Pillar encompasses the Mine Countermeasures, Anti-Submarine Warfare, and Homeland Defense Inspection / Identification missions.

Mine Countermeasures (MCM): The objective of this capability is to find or create Fleet Operating Areas that are clear of sea mines without requiring manned platforms to enter potentially mined areas and to accelerate the MCM timelines. This capability is to operate within the near-term Navy force structure and not adversely impact other warfighting capabilities. It is to provide the least complex and most cost effective solution to the widest range of requirements. The vision is to field a common set of unmanned, modular MCM systems employable from a variety of host platforms or shore sites that can quickly counter the spectrum of mines to enable assured access with minimum risk from mines.

Anti-Submarine Warfare (ASW): This capability focuses on the Task Force ASW “Hold at Risk” scenario, in which a UUV, aided by third-party cueing, monitors and tracks adversary submarine traffic during port egress or through other choke points. The objective of this capability is to patrol, detect, track, and hand off adversary submarines to U.S. Forces using UUVs. A further objective is to perform this function under any rules of engagement and without

taking actions that could inadvertently escalate the conflict. Given the potential access restrictions due to bathymetry or enemy forces, the likelihood that undersea forces may be the only forces available early in the conflict, and the desire to track submarines regardless of the stage of hostilities, the UUV is a leading candidate for the "Hold at Risk" task.

Inspection/Identification: The Inspection/Identification capability will support Homeland Defense (HLD), Anti-Terrorism/Force Protection (AT/FP), and Explosive Ordnance Disposal (EOD) needs. It will be able to perform a rapid search function with object investigation and localization in confined areas such as ship hulls, in and around pier pilings, and the bottoms of berthing areas. As stated in the *Explosive Ordnance Disposal (EOD) Anti-Terrorism / Force Protection (AT/FP) Unmanned Underwater Vehicle (UUV) Mission Requirement Priorities*, the goal is to be able to "rapidly reconnoiter areas of concern (e.g., hulls, port areas, and other underwater areas) and to detect, investigate and localize unexploded ordnance (UXO) objects that impose a threat to military forces, high value assets navigable waterways and homeland security."

SEA BASE (Sea Basing serves as the foundation from which offensive and defensive fires are projected—making Sea Strike and Sea Shield realities. As enemy access to weapons of mass destruction grows, and the availability of overseas bases declines, it is compelling both militarily and politically to reduce the vulnerability of U.S. forces through expanded use of secure, mobile, networked sea bases. Sea Basing capabilities will include providing Joint Force Commanders with global command and control and extending integrated logistical support to other services. Afloat positioning of these capabilities strengthens force protection and frees airlift-sealift to support missions ashore.)

The Sea Base pillar encompasses the Payload Delivery Sub-Pillar Capability.

Payload Delivery: The objective of the Payload Delivery capability is to provide a clandestine method of delivering logistics to support a variety of other mission areas. The missions supported include MCM, CN3, ASW, Oceanography, Special Operations Forces Support, and Time Critical Strike (TCS).

SEA STRIKE (Sea Strike operations are how the 21st-century Navy will exert direct, decisive, and sustained influence in joint campaigns. They will involve the dynamic application of persistent intelligence, surveillance, and reconnaissance; time-sensitive strike; ship-to-objective maneuver; information operations; and covert strike to deliver devastating power and accuracy in future campaigns.)

The Sea Strike pillar encompasses the Information Operations (IO) and Time Critical Strike (TCS) Sub-Pillar capabilities.

Information Operations (IO): The objective of Information Operations is to "exploit, deceive, deter and disrupt our enemies." These operations can use virtually any platform, weapon or means. The UUV capability to operate clandestinely in shallow waters and areas too hazardous for a manned platform make them ideally suited for several IO missions that could not be performed by other platforms. The two IO roles that UUVs seem best suited for are employment as a submarine decoy and use as a communications or computer node jammer.

Time Critical Strike (TCS): This is in the Kinetic Effects portion of the Sea Strike pillar of Sea Power 21. TCS provides the capability to deliver ordnance to a target with sensor-to-shooter closure measured in seconds, rather than minutes or hours. These operations can use virtually any platform, vehicle, or weapon within the battlespace. Launching a weapon from a UUV, or a UUV delivered weapon cache, allows a launch point closer to the target resulting in quicker response time for prosecution. It also moves the "flaming datum" away from high value platforms so that their positions are not exposed.

Develop Four Vehicle Classes

Meeting mission requirements and minimizing cost are the two major considerations that must be addressed when developing UUV acquisition programs. To address the nine Sea Power 21 Sub-Pillar capabilities, this document recommends evolving towards four vehicle classes. This will be achieved through integration of current and future UUV programs. In the long term, this evolution will lead to efficiencies in handling systems, other platform interfaces, and interchange of payloads. The four general vehicle classes identified to address the sub-pillar capabilities are:

The Man-Portable class, which includes vehicles from about 25 to 100 pounds displacement, with an endurance of 10 - 20 hours. There is no specific hull shape for this class.

The Light Weight Vehicle (LWV) class, which is nominally 12.75 inches in diameter vehicles and displaces about 500 pounds. Payload increases six- to 12-fold over the manportable class and endurance is doubled.

The Heavy Weight Vehicle (HWV) class, which is 21 inches in diameter and displaces about 3000 pounds, and provides another factor of two improvement in capability. This class includes submarine compatible vehicles.

The Large Vehicle class will be approximately 10 long-tons displacement and compatible with both surface ship (Littoral Combat Ship (LCS)) and submarine (SSNs with hanger or "plug," and SSGN) use.

ANALYSIS OF VARIOUS MISSIONS/CAPABILITIES

1. Intelligence, Surveillance and Reconnaissance (ISR)

ISR collection has been identified as the number one priority UUV mission, supporting a wide range of other Sub-Pillar Capabilities.

- **Objective**

The purpose of performing ISR missions from a UUV is to collect intelligence data above the ocean surface (electromagnetic, optical, air sampling, weather) and below the ocean surface (acoustic signals, water sampling, ocean bottom equipment monitoring, and object localization) while remaining undetected by the enemy. Specific ISR UUV capabilities would include

persistent littoral ISR, harbor or port monitoring, Chemical, Biological, Nuclear, Radiological, Explosives (CBNRE) detection and localization, surveillance sensor emplacement, battle damage assessment, active target designation, and launch and coordination of UAVs. These capabilities will substantially improve indications and warning.

- **Concept of Operations**

The vehicle is launched from its host platform, most likely a submarine, but possibly a surface ship, aircraft, USV or shore facility. The UUV then proceeds to the designated observation area. Once it reaches its OPAREA, it performs the mission, collecting information over a predetermined period of time; autonomously repositions itself as necessary, both to collect additional information and to avoid threats; and provides a persistent presence in the operating area, gathering data for long time periods, perhaps as long as several weeks. The information collected is either transmitted back to a relay station on demand or when "self cued" (i.e., when the vehicle records a threat change and determines that transmission is necessary). In some cases where maximum stealth mission is required at the expense of real-time or semi-real-time transmission, the vehicle will bring the recorded data back to the host platform or to a suitable area for transmission.

2. Mine Countermeasures (MCM)

- **Objective**

MCM supports all three pillars of Sea Power 21 (Sea Strike, Sea Shield and Sea Base). In support of Sea Shield and Sea Base, the objective of this MCM capability is to find or create Fleet Operating Areas that are clear of sea mines without requiring manned platforms to enter suspected mined areas, and to shorten MCM timelines. Further, this capability is required to operate within the near-term Navy force structure and to operate independently of other warfighting capabilities. The vision for future mine countermeasures is to field a common set of unmanned, modular MCM systems operated from a variety of platforms or shore sites that can quickly counter the spectrum of threat mines assuring access to our Naval Forces with minimum mine risk.

- **Concept of Operations**

The functions of MCM that lend themselves to near-term UUV solutions are minehunting and neutralization. These can be further broken down to the following phases:

• "Detection (D)": the discovery by any means, of the presence of a mine or mine-like object with potential military significance.

• "Classification (C)": the evaluation of an object to determine if it is non-mine like or mine-like.

• "Localization (L)": establishing the precise position of an underwater object relative to a specific geodetic position.

• "Identification (I)": determination of the exact nature of a mine-like object as a mine. Current doctrine specifies visual identification by a diver or camera, but advances in sonar technology may provide adequate capability in the foreseeable future.

• "Neutralization (N)": rendering (by external means) a mine incapable of firing on a passing target or sweep.

One central issue relating to the MCM mission is the number of passes a UUV will be required to make before the neutralization step occurs. One advantage to a single C-I-N pass is that it doesn't require re-acquisition of the target. An advantage of separate pass neutralization is that is provides an opportunity for an operator-in-the-loop to put "eyes" on the image of the identified target prior to neutralization.

Two neutralizers were studied: (1) a stationary bomblet that is placed by a UUV and remotely detonated later using an acoustic command, and (2) an autonomous neutralizer in the class of Man Portable UUVs, essentially a small anti-mine torpedo. The autonomous neutralizer would have to be capable of re-acquiring the target.

Neutralization can also be performed using autonomous neutralizers capable of reacquiring the targets and can be transported to the OPAREA by UUV, USV, or UAV. USV delivery is attractive because, for example, four 30-knot USVs carrying 135 autonomous neutralizers each, could deliver their entire payload in four hours. This is well within the time requirements for the overt clearance of the large area mission or the clandestine Littoral Penetration Area.

Ultimately the goal would be a fully automated system such as the C-I-N option, which performs all three steps in a single pass. Reacquisition would not be necessary. The neutralization device would be a bomblet that would have to be effective against bottom as well as volume mines.

Additionally, USVs could be used to ferry search UUVs (whether C-I or C-I-N) to and from their OPAREAs (approximately eight 500-pound displacement vehicles per USV, or one to two 3,000-pound displacement vehicles per USV). This would also be an option for the lane or sea-line of communication (SLOC) clearance missions. These missions are typically not well suited to relatively short-range vehicles, due to their long narrow geometries, and long transits for delivery and extraction. The USV ferry method would allow an entire 200 NM SLOC to be searched by eight LWVs and neutralized by one USV load of 128 autonomous neutralizers. Therefore, two USVs could accomplish the entire mission, while the host platform stands-off at 90 NM.

3. Anti-Submarine Warfare (ASW)

UUVs will complement and extend existing anti-submarine warfare capabilities.

- **Objective**

This capability focuses on the Task Force ASW "Hold at Risk" scenario, in which a UUV, aided by third-party cueing, monitors and tracks the submarine traffic through an adversary port egress or other choke point. The objective of this capability is to patrol, detect, track, and hand off adversary submarines to U.S. forces using UUVs. A further objective is to perform this function under any ROE without taking actions that inadvertently advance the stage of conflict. Given the potential restriction of access due to bathymetry or threat, the fact that undersea forces may be the only forces available early enough, and the desire to track submarines regardless of the stage of conflict, the UUV is a leading candidate for the "Hold at Risk" task.

- **Concept of Operations**

The development of a completely independent, fully autonomous, long-term UUV tracking capability with large area search is not considered to be feasible or practical in the mid-term. Even short of this ideal capability, however, there are several ASW capabilities that UUVs can provide as significant complements to existing ASW forces. For example, focusing on specific areas through which the enemy must pass (as opposed to large area search) is a necessary simplification. This simplification in CONOPs allows relatively simple UUVs (compared to manned ASW assets) to hold an enemy "at risk." UUV applications that complement ASW are addressed below, from technically easiest to most difficult to implement, given these simplifying assumptions.

The UUV is launched and transits into the intercept area—typically a port egress route or choke point–-where it establishes contact with a source of off-board cueing (e.g., other UUVs, a pre-existing deployed sensor field, or other third party source) and monitors that source for cueing. Typically the UUV will maintain its position relative to the cueing sensor in a low-energy "loiter" mode, which will facilitate its ability to remain on station for extended periods. When cued, the UUV takes up position and maneuvers to verify the cue's initial classification. If successful, the UUV reports to its decision authorities. UUV options at this point, from easiest to hardest technically, include:

• Return to cueing barrier in "loiter" mode to wait for the next cue,

• Employ lethal weaponry against the adversary, and

• Employ non-lethal weaponry (NLW) against the adversary.

Establish intermediate-term track of the target while avoiding counter-detection and communicating to its controllers that a track has been initiated, with periodic updates. At the end of the tracking phase (due to handoff, energy exhaustion, or orders from its controllers), the UUV would break contact and transit to a rendezvous location based on the initial sortie plan or

as updated during communication intervals. Later, perhaps after a significant loiter period, the UUV would be recovered or replenished to enable another mission.

Alternate ASW Sub-Pillar options include:

• Having the UUV employ its own autonomous or semi-autonomous sensor field (e.g., Advanced Deployable Systems (ADS), Deployable Autonomous Distributed System (DADS), or Remote Deployable System (RDS)).

• Having the UUV establish a barrier patrol without the benefit of cueing sensors. This option is only appropriate in very restricted choke points, since the UUV's energy availability will not allow it to execute a significant search rate for an extended time period and still maintain adequate reserves for the tracking part of the mission. Options that can mitigate this situation somewhat include use of vehicle-mounted non-traditional tracking (NTT) sensors to enhance effective search rate, and use of NLW to aid its own tracking efforts (and those of others).

ROE and CONOPs development are required to enable some of the options noted above. Specifically:

• Permitting the employment of NLW early in the pursuit, eliminating the requirement for longer-term track, and enabling immediate handoff to other ASW assets.

• Permitting the use of lethal weaponry from the UUV, either semi-autonomously (man-in-loop) or autonomously (UUV makes the decision). In addition to CONOPs and ROE attention, this option would require technical and operational assurances to protect friendly forces operating in the vicinity. Any of the above options–except for the stand-alone search and track option–individually or in combination, can reduce the endurance requirements on the UUV substantially by mitigating the requirement to maintain track of the target submarine for a significant time. These changes would also reduce the complexity associated with UUV autonomy for the tracking mission, but greatly increase the autonomy complexity associated with release of weaponry, lethal or otherwise.

4. Inspection / Identification

- **Objective**

The Inspection/Identification Capability will support Homeland Defense (HLD) and Anti-Terrorism/Force Protection (AT/FP) needs. It will be able to perform a rapid search function with object investigation and localization in confined areas such as ship hulls, in and around pier pilings, and the bottoms of berthing areas. As stated in Commander Explosive Ordnance Disposal Group TWO's letter dated June 13, 2003, *Explosive Ordnance Disposal (EOD) Anti-Terrorism/Force Protection (AT/FP) Unmanned Underwater Vehicle (UUV) Mission Requirement Priorities*, the goal is to be able to "rapidly reconnoiter areas of concern (e.g., hulls, port areas, and other underwater areas) and to detect, investigate and localize unexploded ordnance (UXO) objects that impose a threat to military forces, high value assets, navigable waterways, and homeland security."

Current performance objectives (*Coast Guard Requirements 2004)* for this mission include the following:

Hull Search: 1000-foot ship, 100-foot beam, 50-foot depth in 8 hours

Pier/Harbor Area Search: 1500-foot pier, 50 feet wide, and 100 feet deep in 24 hours

These area coverage rates are approximately three times those currently available with divers and other systems, such as ROVs. UUVs provide a means to address these objectives in a cost-effective fashion, reserving divers and ROVs for the more complex tasks requiring real-time human intervention.

In 2002, the Navy's *Small UUV Strategic Plan* (28 June 2002) delineated three basic mission tasks for UUVs to address: Very Shallow Water Mine Countermeasures (VSW MCM), Surface Mine Countermeasures, and EOD. The Commander, Explosive Ordnance Disposal Group Two issued a letter in June 2003 which provided direction to minimize EOD diver exposure to ordnance hazards through the search-detect-identify-neutralize missions. To this end, three specific UUV missions were identified: (1) rapid hull search and target localization, (2) harbor area search and target localization, and (3) open water search and target localization.

- **Concept of Operations**

The full Inspection/Identification mission is currently outside the realm of UUV operational capabilities. However, a UUV can provide a useful asset to current hull and pier inspection operations, by performing the broader area surveys, freeing divers to concentrate on the more complex areas and designated targets that require real-time human judgment. It is critical that the UUV system be compatible with other systems in use, so that the data may be quickly interpreted and acted upon. A possible operational scenario might be as follows:

1) Deliver UUV system to the operational area
2) Input known data on environment (charts, hull model, etc) into system for UUV mission planning

3) Develop inspection plan

4) Deploy support equipment (navigation transponders, communication relays, etc.)

5) Deploy vehicle to run programmed path and collect sensor data

6) Monitor real-time or near real-time communication from vehicle containing sensor data content

7) If a target of interest is detected, relay coordinates and any additional information to the dive team or ROV operations team

8) Continue mission

9) Recover vehicle

10) Redeploy as necessary

5. Oceanography

Oceanography includes collection of hydrographic, oceanographic, and meteorological data in all ocean environments. Oceanography supports real-time operations as well as IPB for expected operations. Oceanographic data and environmental products are provided in near real-time for tactical support, archived for long-term support, and provided in rapid-turnaround mode for operational battlespace preparation.

The oceanographic function is described herein as a dedicated set of UUV capabilities. However, all UUVs collect oceanographic data in order to function. Adherence of UUV developers to established standards for data formats would allow efficient use of these data to augment that collected by dedicated oceanographic platforms.

- **Objective**

Oceanography ranges from broad reconnaissance of large littoral undersea areas to detailed characterization of specific battlespace areas collecting high quality, accurately positioned data. There is a need to perform these missions in areas where battlespace dominance has not been achieved. The focus is on the littoral, but a deep-water survey capability is required for bottom characterization to accomplish cable route preinstallation and inspection. The shallow-water littoral region survey is useful in aiding navigation or projecting sensor performance. This type of mission may be best accomplished using small UUVs or gliders.

UUV technology is a force multiplier to manned platforms and is essential to meet critical oceanography requirements. The predominant driver for adopting UUV technology for ocean survey is to increase the timeliness and cost effectiveness with which the fleet can acquire affordable, near real time data at required temporal and spatial sampling densities. Used in conjunction with remote sensors, other ocean data, and models, UUV-acquired data provides warfighters with critically required foreknowledge of environmental parameters such as bathymetry, tides, waves, currents, winds, acoustic propagation characteristics, locations of hazards to navigation, and other objects of interest.

6. Communication / Navigation, and Network Node (CN3)

The Communication / Navigation Network Node (CN3) will be the enabling undersea node of the Net-centric Warfare Sensor Grid. As such, it will serve as the implementation of FORCEnet for UUV applications and forms the interface to the Global Information Grid (GIG). It will provide networked connectivity across multiple platforms and the ability to provide navigation aids on demand. Navigation and communication components developed for this capability will become integral parts of, or support other UUV systems fielded in the future.

- **Objective**

The objective of the CN3 is to provide a low-profile communication and navigation relay function for a wide variety of platforms. As a communications relay, the primary focus is on providing the connectivity to FORCEnet for underwater systems. Links would be established with underwater stations, other platforms, and SATCOM capabilities. The advantages offered by using a UUV include extended standoff distances and greater accessibility. CN3 will provide submerged communications to undersea platforms in areas not otherwise available. Potential users include other UUVs, submarines operating at speed and depth, Special Forces units, and any other application where low-visibility communication is desirable.

As a navigation aid, the CN3 UUV is envisioned as an on-site on-demand reference point for subsea or surface operations. Pre-positioned, either just prior to, or well in advance of planned operations, the vehicles will provide reference beacons (visual, radar, or acoustic) for other UUVs, submarines, SOF, or surface operations. These could take the form of lane designators, undersea mileposts, or supplementing or replacing conventional navigation means. In critical situations, the CN3 UUV could provide an above- or below-water navigation capability equivalent to GPS accuracy without the need for continuous direct satellite communications. CN3 UUVs will also aid less-capable UUV systems, providing a mobile geographic reference system. An immediate application would be a self-deploying navigation transponder for use by SOF vehicle systems.

- **Background**

The CN3 capability is a support function enabling other systems to perform their missions more effectively. These range from providing efficient over-the-horizon navigation beacons for SOF operations to connection with the undersea FORCEnet.

One immediate application of the CN3 would be a self-deploying transponder network to support near-shore SOF and EOD missions; such tasks are now performed with small manned vehicles. Currently, forces in rubber boats deploy the transponder field–putting men in high threat areas. A CN3 UUV could be launched from a safe distance, transit to the operations area using GPS, and then deploy itself as a transponder node for operations. The mission assets could then transit into the area, orient themselves to the network, and perform their mission without the need to expose human operators.

Looking to the future, the growing emphasis on networked systems will require multiple undersea components. UUV systems will be FORCEnet compatible, able to connect with sensor fields, arrays, other UUVs and multiple platforms. The flexibility provided by UUV systems is especially important for mobile, dynamic systems such as submarine communications at speed and depth, operation of UUV swarms, and connection with SOF.

7. Payload Delivery

- **Objective**

The objective of the Payload Delivery Capability is to provide a clandestine method of delivering various payloads to support other mission areas. The missions supported would include MCM, CN3, ASW, Oceanography, SOF Support, and TSC.

- **Background**

Payload delivery is not a mission in itself, but is necessary to support a number of other mission areas. As a payload delivery platform, the UUV would essentially act as an underwater truck. The UUV would provide the energy, navigation, autonomy, and payload deployment systems necessary to support the other missions.

- **Concept of Operations**

The concept of operation for payload delivery depends on the particular mission being supported. Since a payload delivery UUV would be large and would include fairly robust autonomy, navigation, energy, and propulsion, in most cases vehicle recovery would be desired following delivery of payloads. Some of the mission areas and concepts of operation include the following:

MCM: To support the MCM mission, a large UUV would provide the capability of inserting smaller devices into forward areas. It could deploy sensors that would detect mine laying operations, a swarm of smaller vehicles that perform mine reconnaissance, or mine neutralization devices or mine neutralizing UUVs.

Oceanography: To support Oceanography, a large UUV could deploy sensors used to collect long-term oceanographic data. It could also deploy a group of smaller vehicles to survey shallow water.

ASW: To support the ASW mission area, a large UUV could deploy underwater sensor arrays used to detect the passage of enemy submarines. A UUV could also deploy either lethal or non-lethal weapons.

CN3: To support the CN3 mission area, a large UUV could deliver underwater communications nodes or acoustic-to-RF communications transponders. A UUV could also deliver transponders used to provide accurate navigation for other manned and unmanned platforms.

SOF Support: A large UUV could be used to resupply SOF personnel with weapons, food, batteries, fuel, and other supplies. It could also carry transport devices (i.e. motorcycles or all-terrain vehicles (ATVs)) increasing the mobility and operating range of the forces.

Time Critical Strike (TCS): To support the TCS mission, a UUV could deliver an underwater weapons cache or buoyant missile launch capsules that would loiter in place awaiting launch instructions, or the UUV itself could carry the weapons and loiter.

8. Information Operations (IO)

Information Operations (IO) plays a key role in the Sea Strike pillar of Sea Power 21.

- **Objective**

The objective of Information Operations is to "deceive, deter and disrupt our enemies." These operations can use virtually any platform, weapon or means. UUV capability to operate clandestinely in shallow waters and areas too hazardous for a manned platform makes them ideally suited for several IO missions which could not be performed by other platforms. The two IO roles that UUVs seem best suited for are use as communications or computer node jammer and employment as a submarine decoy.

- **Background**

The technology to support IO exists or can be easily leveraged from other sub-pillars. The Navy has long employed submarine simulators as ASW targets. These are considered UUVs. The basic targets had little if any intelligent autonomy, navigating a pre-assigned route while transmitting the acoustic and magnetic signature of a selected submarine.

- **Concept of Operations**

An IO UUV could also be used as a platform to jam enemy communication nodes. The natural stealth and small size of a UUV allow it to operate in littoral areas that would be difficult or impossible for other platforms to reach. This enables the transport of a transmitter and antenna to close proximity of susceptible communications nodes. Injection of false data would be much more difficult, requiring either a reliable communications link with the vehicle or a sophisticated degree of autonomy which would recognize and act on the opportunity to inject the erroneous data. Enhancements in the autonomy and sophistication of UUVs may make this a feasible mission in addition to jamming.

Submarine decoys could be used in several different scenarios. A simple decoy could be used to transit an area known to have enemy ASW forces or sensors. It could transit a pre-programmed path designed to attract attention and enemy response. A more sophisticated vehicle could be designed to react to prosecution, becoming evasive and perhaps gradually lowering its acoustic signature and causing the prosecuting forces to lose contact. It could then go dormant for a period of time and then repeat its decoy action. These submarine decoys could be used to pulse enemy ASW forces causing them to expend effort that would otherwise be used to endanger friendly submarines. In addition, these decoys could be used to cause the enemy to alter its plans, perhaps deciding not to sail its ships from an area thought to be in danger from the spoof submarine.

9. Time Critical Strike

Time Critical Strike (TCS) is in the Kinetic Effects portion of the Sea Strike pillar of Sea Power 21. TCS provides the capability to deliver ordnance to a target with sensor-to-shooter closure measured in seconds, rather than minutes or hours. These operations can use virtually any platform, vehicle, or weapon within the battlespace. Launching a weapon from a UUV, or a UUV delivered weapon cache, allows a launch point closer to the target resulting in quicker response time for prosecution. It also moves the "flaming datum" away from high value platforms so that their positions are not exposed.

- **Objective**

The objective of TCS is to deliver kinetic effects weapons against multiple targets of interest within extremely short periods of time. The capability to operate clandestinely in shallow waters and areas too hazardous for a manned platform, and to loiter clandestinely for extended periods of time, makes UUVs ideally suited for certain aspects of the TCS mission. The two TCS roles that UUVs seem best suited for are as a delivery platform for leave-behind weapon caches and as a remote weapon launch platform for close-in attack against time-sensitive targets.

- **Background**

TCS is one of the lower priority missions for UUVs. An autonomous weapon launch capability is controversial, and man-in-the-loop control of weapon launch will be required for the foreseeable future. However, UUVs can provide low-risk, high payoff augmentation to strike missions, providing an ability to clandestinely deliver weapons to close-in launch points. The TCS mission was ranked as moderately suitable for UUVs. When viewed as a specialized "Payload Delivery" mission where the payload is a missile, the TCS mission was kept on the list of recommended UUV sub-pillar capabilities.

UUVs could provide TCS capability using several different CONOPS. The first scenario involves missile launch from the UUV. In this scenario, the vehicle is launched from a platform of opportunity, either a surface ship or submarine, and transits to a predetermined launch point. The UUV anchors or loiters in the area awaiting the launch command. When commanded, the UUV either:

• Launches the missiles while submerged, similar to an SSBN or SSN,

• Surfaces to launch the missiles,

• Or releases a buoyant missile capsule that floats to the surface and launches the missile.

When all missiles are launched, the UUV transits to a recovery point for refurbishment and reloading.

The submerged launch option is not highly recommended because of the complexity of the vehicle systems required, i.e. floodable launch tubes, trim and ballast systems, and reliable

underwater communication systems as well as a sea-adapted missile. All options in this scenario place the burden of the operation on the UUV.

The second scenario is similar to the first, except that the UUV surfaces to launch missiles. This avoids the complexities of submerged launch and communications. The UUV would anchor or loiter in the launch area with an antenna on or above the surface awaiting a launch order. When alerted, the UUV could raise a higher bandwidth antenna to receive any new targeting information. When ordered the vehicle would surface and launch its missiles under the control of a remote operator.

The third scenario involves a UUV that carries the missiles as a deployable payload. The UUV is launched from a platform of opportunity outside of the battlespace. The vehicle transits to a predetermined location where the weapon cache is deployed. The weapon cache rests on the bottom or floats on the surface until commanded to launch missiles. The UUV returns to the host for another weapon cache module. This scenario places the burden of the operation on the deployed weapon cache. The UUV is simply the delivery truck.

THE NAVY UNMANNED SURFACE VEHICLE (USV) MASTER PLAN (2007)

The Unmanned Surface Vehicle (USV) Master Plan was chartered by the Program Executive Officer for Littoral and Mine Warfare (PEO (LMW)). It provides the guide for USV development to effectively meet the Navy's strategic planning and Fleet objectives and the force transformation goals of the Department of Defense (DoD) to the year 2020. Plan development was built on the results from Workshops conducted at the Naval War College and the Fleet ASW Training Center in late 2004 and early 2006, respectively, with major analysis, synthesis, and development efforts being conducted by a USV Master Plan Core Team.

The USV vision is:

To develop and field cost-effective USVs to enhance Naval and Joint capability to support Homeland Defense, the Global War on Terror, Irregular Warfare, and conventional campaigns. USVs will augment current and future platforms to deliver enhanced steady-state and surge capability to help deter the enemy at the regional, transnational, and global levels. USVs will be highly automated to reduce communication/data exchange requirements and operator loading. They will deploy and retrieve devices, gather, transmit, or act on all types of information, and engage targets with minimal risk or burden to US and Coalition Forces.

The latest strategic plans show the Fleet structure in 2020 to be mainly comprised of Guided Missile Destroyers (DDG) 51/DDG(1000), Littoral Combat Ships (LCS), Attack Submarines (SSN), and Combat Logistics Force (CLF) class ships. It is expected that over twenty percent (20%) of our 2020 Surface Fleet hulls will be LCS, the first ship class fielded with a significant portion of its warfighting capability tied to reconfigurable “Mission Modules”. Many of these Mission modules have unmanned vehicle systems as primary or contributing components.

Unmanned Undersea Vehicles (UUVs) were considered the main workhorses of the mine clearing effort during Operation Iraqi Freedom in 2003.

THE USV DEFINED

To clearly focus this plan on the required missions the following definitions were used in the plan:

• Unmanned - Capable of unmanned operation. Can be manned for dual use or Test and Evaluation (T&E). Has varying degrees of autonomy.

• Surface Vehicle - Displaces water at rest. Operates with near continuous contact with the surface of the water. Interface of the vehicle with the surface is a major design driver.

For the purposes of the Plan, the following definitions are germane relative to USV autonomy:

• Manual – Man in loop continuously or near-continuously.

• Semi-autonomous – Some vehicle behaviors are completely autonomous (e. g., transit to station, activate sensors). Vehicle refers to its operator when directed by the operator or by its own awareness of the situation (e. g., for permission to fire).

• Autonomous or Fully Autonomous – The vehicle governs its own decisions and makes its own decisions from launch point to recovery point.

Most operations will likely be some combination of these three modes.

CRAFT TYPES

Many hull and craft types were examined since a major design driver is the interface of the USV with the sea surface.

(1) Semi-submersible Craft

(2) Conventional Planing Hull Craft

(3) Semi-planing Hull Craft

(4) Hydrofoils

(5) Other Craft types

MISSIONS

As a result of the analyses performed during development of this Master Plan, seven high-priority USV missions were identified that support the Joint Capability Areas (JCAs). The seven missions, in priority order, are:

• Mine Countermeasures (MCM)

• Anti-Submarine Warfare (ASW)

• Maritime Security (MS)

• Surface Warfare (SUW)

• Special Operations Forces (SOF) Support

• Electronic Warfare (EW)

• Maritime Interdiction Operations (MIO) Support

VEHICLE CLASSES

These seven USV Joint Capability Area missions can be accomplished in three standard vehicle classes and one non-standard vehicle class:

• The “X-Class” is a small, non-standard class of systems capable of supporting SOF requirements and MIO missions. It provides a “low-end” Intelligence, Surveillance, Reconnaissance (ISR) capability to support manned operations and is launched from small manned craft such as the 11m Rigid Inflatable Boat (RIB) or the Combat Rubber Raiding Craft (CRRC).

• The “Harbor Class” is based on the Navy Standard 7m RIB and is focused on the MS Mission, with a robust ISR capability and a mix of lethal and non-lethal armament. The “Harbor Class” USV can be supported by the majority of our Fleet, since it will use the standard 7m interfaces.

• The “Snorkeler Class” is a ~7m semi-submersible vehicle (SSV) which supports MCM towing (search) missions, ASW (Maritime Shield) and is also capable of supporting special missions that can take advantage of its relatively stealthy profile.

• The “Fleet Class” will be a purpose-built USV, consistent with the handling equipment and weight limitations of the current 11m RIB. Variants of the Fleet Class will support MCM Sweep, Protected Passage ASW, and “high-end” Surface Warfare missions.

A discussion of the 7 missions follows.

1. MINE COUNTERMEASURE (MCM)

MCM mission requirements are driven by the Fleet's need to rapidly establish large, safe operating areas, transit routes (Q-routes) and transit lanes. These areas are typified by long Sea-Lines of Communication (SLOCs), offshore Fleet Operating Areas (e.g., Carrier Operating Areas (COAs), Amphibious Operating Areas (AOAs)), and Littoral Penetration Areas (LPAs) (e.g., Assault Breach, Port Break-in, and Ship-to-Objective Maneuver (STOM)).

The lexicon of mine countermeasures includes the following terms and their definitions:

“Detection,” “Classification,” “Localization,” “Identification,” and “Neutralization” are as defined in the UUV section.

• "Reconnaissance": That phase of the exploratory objective designed to make a rapid assessment of the limits and density of a minefield.

• "Search": the use of sonar or divers to detect and classify mines or mine-like objects.

• "Hunting": the act of searching for mines. Hunting operations can also include marking and neutralization of mines.

• "Breaching": breaking through a minefield, thereby opening a clear path or channel.

• "Clearance" or "clearing objective": removal of detectable mines from an assigned area. Since it is generally impossible to guarantee that all underwater mines have been detected and cleared, a goal is assigned to coincide with a percentage of risk that a potential number of mines remain.

• "Sweeping": the act of towing mine countermeasures gear intended to actuate mines by generating a ship-like signature, or mechanically cutting mooring cables of moored mines.

• "Jamming": overwhelming an influence-activated mine's sensors with external influences, such as noise or a strong magnetic signature, thereby masking a passing ships signature and causing the mine to not detect the passing vessel.

• "Signature": the characteristic pattern of a ship's influence as detected by an influence sea mine (such as magnetic signature, acoustic signature, pressure signature).

USVs, along with UUVs, will have an important role in the conduct of MCM as they are particularly well suited for the 'dirty - dull – dangerous' tasks that MCM entails. They provide persistence, which permits significant mine hunting and sweeping coverage at lower cost by multiplying the effectiveness of supporting or dedicated platforms. Additionally, they provide the potential for supporting an MCM capability on platforms not traditionally assigned a mine warfare mission.

In the near term, USVs will contribute to search operations by towing a variable depth sensor that has the ability to detect, classify, and identify mines in the environment. This information derived can be processed in near real-time when the operator is in close proximity, or can be post-mission processed when the system operates at long range.

In the future, USVs may also deploy and retrieve multiple UUVs that will perform the search functions, instead of or in addition to towing sensors. This approach provides for very high area coverage rates through the use of many search assets in parallel, as described in the UUV Master Plan Update 2004.

Future USV systems will deploy UUVs to gain the advantage of higher area coverage rates through multiple, simultaneous operations, without the need for additional operators.

The ultimate goal is to have a fully automated system which performs all four steps (detection, identification, localization, and neutralization) in a single pass, making reacquisition unnecessary.

Three neutralization systems approaches are envisioned within the Neutralization Concept of Operations:

1) A Remotely Operated Vehicle (ROV)-type neutralizer that is automatically deployed by the USV and is self-propelled to the mine. Its camera will provide a positive visual ID prior to it

receiving a firing signal, at which point it will launch a neutralizing sub-munition. This system may be based upon present ROV-type airborne neutralizing systems.

2) A stationary explosive charge that is placed by a UUV which has been delivered to the mine danger area and deployed by a USV transporter. The charge is remotely detonated later using an acoustic command or a timing mechanism. The cost of such charges, which already exist in the mine clearance community, would likely be significantly less than the more sophisticated autonomous neutralizers, but somewhat more difficult and risky to place accurately.

3) An autonomous neutralizer in the class of a Man Portable UUV--essentially a small anti-mine torpedo--ferried by the USV to the mine danger area and deployed. This UUV system would self-deploy to the mine. This option could also used be for 'Q-Route' lanes or SLOC-clearance missions. The USV ferry method could potentially allow for rapid search and neutralization by a small number of USV's loaded with autonomous neutralizers.

- **MCM UUV DELIVERY**

While not a separate mission, there are two methods of executing the MCM sub-missions discussed above that make use of subordinate UUVs, notably MCM Search and MCM Neutralization.

2. ANTI-SUBMARINE WARFARE (ASW)

It is vitally important that the U.S. Navy be able to achieve and maintain access to all the world's littorals at the times and places of its choosing. In view of the increasing submarine threat from our potential adversaries, it is critical to establish and maintain a highly effective ASW capability. Current ASW techniques are effective in most cases, but there are several factors that point to USV taking on a complementary ASW role in the future:

• Most of the threat submarines which the U. S. Navy will face in the foreseeable future will be conventional (diesel-electric) and designed for local or regional coastal defense. As such, they will have reduced open-ocean transit and magazine (payload) requirements and can be much smaller than U.S. submarines.

• This factor, in combination with local knowledge of near-shore bathymetry, will allow them to operate more easily in shallower waters. It is likely that these submarines will be able to submerge near their homeports and outside the reach of U.S. Forces and make their way to offshore U. S. operating areas.

• The number of submarines that may be 'surge' deployed near-simultaneously by our adversaries mandates a force multiplier to enhance the efforts of existing ASW assets.

Some standard nomenclature:

• "Hold at Risk"– monitoring submarines that exit a port or transit a chokepoint.

• “Maritime Shield”– clearing and maintaining a large Carrier or Expeditionary Strike Group (CSG or ESG) operating area free of threat submarines.

• “Protected Passage”– clearing and maintaining a route for an ESG from one operating area to another free of threat submarines.

USVs offer significant force multiplication for ASW operations in the Maritime Shield and Protected Passage scenarios, in that they can perform the ASW mission at some level of autonomy. This provides a layer of ASW defense-in-depth for the manned surface group, while freeing the manned combatants for other duties, as well as reducing risk to the manned platforms that would otherwise have been conducting the ASW mission themselves. While offering some advantages in the Hold at Risk scenario, particularly if an overt U. S. presence is desirable, the USV’s limited stealth make them generally less ideal candidate vehicles in this category.

In all cases, USVs can serve as offboard sensors or sources, extending the range of detection and effect without increasing risk. The manned host platform can serve as the mother ship for a fleet of vehicles, providing the decision-making capabilities while remaining out of harm’s way.

In the Maritime Shield scenario, USVs can provide major force multiplication for existing ASW forces. By establishing stand-off submarine surveillance barriers without escalating the level of conflict or placing manned vehicles at risk, USVs in the Maritime Shield scenario can greatly enhance the ability of the Task Force Commander (TFC) to achieve and maintain access, independent of the state of hostilities. In addition to using third-party sensors and cueing assets, or using platform sonars as sources for multi-static prosecution, the USV may also be tasked to plant its own supporting sensor field (e. g., sonobuoys).

USVs can also provide force multiplication for existing ASW forces in the Protected Passage scenario, although the inherent speed of advance inherent in this scenario places greater requirements on the USV. By establishing a submarine-free corridor without placing manned vehicles at risk, USVs in the Protected Passage scenario can greatly enhance the ability of the TFC to move his forces at will, independent of the state of hostilities, while freeing manned assets for other duties (e.g., missile defense for the High Value Units (HVUs)). As in the Maritime Shield case, USVs may use third-party sensors and cueing assets in addition to their own organic sensors.

- **ASW CONCEPTS OF OPERATIONS**

The development of a completely independent, fully autonomous, long-term USV tracking capability with large area search is not considered to be feasible in the immediate future. Even short of this ideal capability, however, there are several ASW capabilities that USVs can provide as significant complements to existing ASW forces. For example, focusing on searching specific areas in which U. S. naval forces will be operating (Maritime Shield) or through which they will pass (Protected Passage) is a simplification in CONOPs objectives which allows relatively simple—compared to manned ASW assets—USVs to create a credible deterrent to threat submarine incursions. USV applications that complement ASW are addressed below, from technically easiest to most difficult to implement, given these simplifying assumptions.

- **MARITIME SHIELD**

In a maritime shield scenario, the surface group has been assigned an operating area, and it is desired to have USVs maintain an ASW barrier around its perimeter. USVs are deployed in a line around the perimeter and are equipped with sensors. The nature of these sensors is not specified, but will probably be monostatic active (e. g. dipping sonar). A multi-static arrangement with sources aboard either the manned platforms or some of the USVs, with passive receivers on the rest, is another reasonable option.

The USVs are launched and transit to the barrier area where they form a moving perimeter barrier and monitor that barrier for submarine incursion. The “gaps” in the USV sensor barrier are determined by the distance between the vehicles minus their combined sensor ranges. Patrol speed of the USVs should be such that the gaps are covered in the time it would take an intruder submarine to cross the barrier. USV options at this point, from easiest to hardest technically, include:

• Report contact and respond as directed by the controlling manned platform,

• Autonomously maneuver to optimize and maintain contact, singly or in concert with other USVs, or

• Autonomously maneuver to track and prosecute the target with non-lethal or lethal weaponry.

- **PROTECTED PASSAGE**

In a protected passage scenario, the surface group has been tasked to move from one operating area to another, and it is desired to have USVs maintain a moving ASW barrier in front of the surface group. In the simplest employment scheme, USVs equipped with sensors are deployed in a line abreast such that their sensors overlap or ”touch” and in sufficient number to cover the entire transit corridor width. The nature of these sensors is not specified, but will probably be active (e. g. dipping sonar), since multi-static arrangements are not expected to be optimal in a moving-barrier scenario.

Options in the event of contact on a threat submarine, from easiest to hardest technically, include:

• Report contact and respond as directed by the controlling manned platform,

• Autonomously maneuver to optimize and maintain contact, singly or in concert with other USVs, or

• Autonomously maneuver to track and prosecute the target with non-lethal or lethal weaponry.

- **WEAPON EMPLOYMENT CONSIDERATIONS**

In the case of lethal or non-lethal attack, a key consideration is time delay between the initial contact and weapon release. Undersea contacts are typically characterized by an Area of Uncertainty (AOU), which is an elliptical area the size and shape of which are determined by target, acoustic propagation, sensor, and processing characteristics. This AOU expands when contact is lost at a rate directly related to: (1) course and speed uncertainty at time of contact loss, and (2) likely target behavior. For example, the AOU for an active target submarine which was poorly characterized initially (ex: solid bearing and range but poor or no derived course and speed) and is assumed to have been 'spooked' by active prosecution will expand much more rapidly than a well-characterized passive sonar target who is unaware of prosecution and maintains patrol routine.

ROE and CONOPs development are required to enable some of the prosecution options, which fall into three basic categories:

• Manual – USV reports contact information, the man in loop evaluates contact and gives specific order to fire. This may include specific weapon presets.

• Semi-autonomous – USV processes contact information and calculates its own best firing options, man in loop has "veto" power or positive control, but is not provided with significant corroborative information from the USV.

• Autonomous – USV makes its own contact and fire decisions, conceptually similar to a mine. In addition to CONOPs and ROE attention, each increasingly autonomous weapon option would require increased technical and operational assurances to protect friendly forces operating in the vicinity.

3. MARITIME SECURITY

Maritime Security (MS) consists of securing U.S. or allied domestic ports, and protecting ship and maritime infrastructure (piers, docks, anchorages, warehouses) at home and abroad against the spectrum of threats from conventional attack to special warfare to specifically targeted terrorist attacks. MS mission effectiveness stems directly from good situational awareness (SA) and the ability to do something about it. The "MS" mission rubric, therefore, includes persistent Intelligence, Surveillance and Reconnaissance. In the context of this plan, MS also incorporates elements of the Port Security Services (PSS) mission and of the Global War on Terror (GWOT). Maritime Security represents a fundamental USV mission and is essential not only for the traditional purpose of intelligence collection and threat deterrence, but also as a precursor and enabler for essentially all other missions.

Possible MS USV missions include:

• Strategic and tactical intelligence collection: Signal, Electronic, Measurement, and Imaging Intelligence (SIGINT, ELINT, MASINT, and IMINT)

• Chemical, Biological, Nuclear, Radiological, and Explosive (CBNRE) detection and localization (both above and below the ocean surface)

• Near-Land and Harbor Monitoring

• Deployment of leave-behind surveillance sensors or sensor arrays

• Specialized mapping and object detection and localization

• Non-lethal and lethal threat deterrence

• "Riverine" operations, such as monitoring civilian boat traffic on inland waterways for threat personnel movements, contraband or threat weaponry smuggling, and similar undesirable activities.

The USV Maritime Security missions are: (1) to collect intelligence data above the ocean surface (e. g., electromagnetic, optical, air sampling, weather) and below the ocean surface (e. g., acoustic signals, water sampling, oceanographic or bathymetric info) and (2) deter enemy attacks on established U. S. and allied positions and material, including ships, while (3) keeping manned platforms out of harm's way. Specific Maritime Security USV capabilities would include persistent littoral ISR, harbor or port monitoring, Chemical, Biological, Nuclear, Radiological, Explosives (CBNRE) detection and localization, surveillance sensor emplacement, Battle Damage Assessment, and active target designation. Non-lethal technologies (i.e. paint ball designators, water cannons) can be used to deter or designate threat forces. Lethal systems including guns and/or rockets could be employed to establish a more threatening posture.

- **MARITIME SECURITY CONCEPT OF OPERATIONS**

The vehicle is launched from its host platform, a surface ship or shore facility. Once it reaches its OPAREA, it performs the mission, collecting information and or deterring aggressive actions over a predetermined period of time. The USV autonomously repositions itself as necessary, both to collect additional information and to avoid or intercept threats and provide a persistent presence in the operating area, perhaps for several weeks. The information collected and actions taken are either transmitted back to a relay station on demand or when "self-cued" (i.e., when the vehicle records a threat change and determines that transmission is necessary). In most cases, the vehicle will be in real-time or near real-time communications with the host platform and can provide information as desired, as well as receive updated instructions from the host platform.

This ready availability of communications for Command and Control and Intelligence (C2I) transfer is considered to be one of the major advantages of a USV in this scenario, as opposed to a stealthier UUV. For most USV ISR missions, it is assumed that near real-time communications are available and will be used to support the mission via "reach-back" (i. e., transfer of raw data to a remote processing center for analysis). This approach places much less onus on vehicle information processing and autonomy, and relieves some serious information security issues associated with vehicle-borne intelligence processing. In some cases where a maximum stealth mission (which will necessarily be conducted by a semi-submersible (SS)) is required at the

expense of realtime or near real-time transmission, the vehicle will bring the recorded data back to the host platform or to a suitable area remote from the Area of Interest (AOI) for transmission.

Additional options for the MS mission include active response to detected entities. The range of responses ranges from warnings (e. g., a loud-hailer challenge), through marking (e. g., paint ball or radio tag) to actually engagement (e. g., gun, missile, or torpedo). Some of these options overlap with other missions in this plan at this point, such as SUW or MIO.

4. SURFACE WARFARE (SUW)

The Surface Warfare capability is very similar to some aspects of the MS mission as discussed in the preceding section, but also incorporates the engagement of more difficult threats in relatively open ocean as well as in the littorals. MS mission systems and technologies are heavily relied upon to support surface warfare missions and payload support; providing situational awareness as well as 'friend or foe' identification. The SUW capability will require a larger craft and higher speed (≈30-40 kts) capability.

- **SUW OBJECTIVE**

The purpose of performing SUW mission support by a USV is to provide the ability to engage targets through the use of lethal and/or non-lethal weapons while protecting or keeping manned platforms out of harm's way. SUW USV capabilities will provide force multiplication, all-source Battle Space Awareness (BSA) and act as an integral component to Sea Shield.

- **SUW CONCEPT OF OPERATIONS**

The following are summaries of example Concepts of Operations in the SUW mission area. While not exhaustive, this list should provide a feel for the spectrum of SUW related operations in which USVs can play an important role.

• Coastal Patrol/Homeland Security/Port Security (example) - The USV is launched from its host platform, a surface ship or shore facility and proceeds to the designated patrol area. Once it reaches the area, it performs the mission: patrolling the area, monitoring and addressing or interrogating 'threats' as appropriate, repositioning itself as necessary, either with man-in-the-loop direction or autonomously, and providing a persistent presence in the operating area.

• SOF Support (example) - The vehicle is launched from its host platform, a surface ship or shore facility. Once it reaches the area, it provides SOF mission support by: performing ISR operations and reporting any penetrations into the area, repositioning itself as necessary, either with man-in-the-loop direction or autonomously, and providing a persistent presence in the operating area. If its area is penetrated, it may have the ability to engage, providing additional opportunity for SOF relocation/extraction.

• SUW Engagement (example) - The vehicle is launched from its host platform, a surface ship or shore facility. Once it reaches its area, it patrols the area and monitoring or for 'threats' as appropriate, repositioning itself as necessary and provides a persistent presence in the operating

area. If its area is penetrated it has the ability to engage. Each of these steps may be under the direct control of a human operator (man-in-loop), semi-autonomous (e. g., human verification and permission to fire on a USV-perceived valid target), or completely autonomous.

5. SPECIAL OPERATIONS FORCES (SOF) SUPPORT

USVs supporting SOF missions will require unique capabilities in addition to those being addressed in support of the more conventional mission areas addressed in this Plan; e. g., MS, and SUW. This section will discuss unique capabilities.

SOF units require support for conducting missions involving unconventional warfare, counter-terrorism, reconnaissance, direct action and foreign internal defense, among others. SOF roles are typically those in which the aim is to achieve disruption by "hit and run" and sabotage, rather than more traditional "force on force" combat. Other significant roles lie in providing essential intelligence from close to or among the enemy, and increasing roles in combating terrorists, their infrastructure and activities. Due to the variety of missions and related environments that SOF can be called upon to operate in, SOF-Support USVs will also be required to cover operational environments from coastal to riverine. Each environment presents unique challenges to effective and reliable operation.

- **SOF SUPPORT OBJECTIVE**

The two primary purposes of using USVs to support SOF missions are: (1) ISR (standard and non-standard sensors), and (2) transportation and material support.

- **SOF SUPPORT BACKGROUND**

In the ISR role, USVs can provide persistent coverage and effective support for SOF mission areas that would preclude conventional platforms, providing early warning and maintaining a perimeter in areas of high risk to personnel. Many mission scenarios utilizing small arms as well as other lethal and non-lethal weapons could be effectively performed by USVs. In this sense, this mission area bears a lot in common with the MS mission.

USVs can also effectively provide mission support in high-risk areas or where hazards to navigation or personnel preclude conventional CONOPS. USVs could be launched from a safe standoff distance, transit to the area of interest, and return with or transmit subsets of the data collected. Other options include planting stand-alone sensor packages, dropping off advance or real-time resupply packages (ammo, food, fresh water, batteries), and providing maritime diversion, distraction, or deception in support of the SOF mission.

- **SOF SUPPORT CONCEPT OF OPERATIONS**

Riverine ISR

Due to the size and likely clandestine nature of the operations, small, low-observable (LO) USVs will be required. Although perfect stealth in a physical, floating, and mobile object is not

realistic, there are technologies and techniques available to minimize vehicle observables. SOF personnel aboard a larger manned riverine craft launch a man-portable USV when entering an area of contention. The USV proceeds covertly to the area to be investigated in support of the mission and reports that data back to the operators in real time. Alternately, due to mission restrictions, it can collect the data and returns to the manned platform. Operating in this manner, the USV is essentially serving as a round-the-bend ISR platform.

Insertion/Extraction of SOF Personnel and/or Equipment

Serving as a logistical support asset, larger USVs could provide SOF with an alternative to utilizing manned platforms for these purposes. USVs could be pre-positioned and lie in waiting for the appropriate time to provide support.

Other Missions

U.S. SOF are legendarily innovative in adapting the systems and equipment at hand to fit emergent mission needs and environment. The modularity inherent in USVs can be a great asset in support mission innovation.

6. ELECTRONIC WARFARE (EW)

USVs have broad application to Joint and Naval Warfighting requirements supporting Conventional Warfare, Irregular Warfare and Homeland Defense through strategic use of EW and Information Operations (IO). This capability is synergistic with the Maritime Security Mission.

- **EW OBJECTIVE**

The objective of this capability is to use USVs to provide a means of deception, jamming, and warning of electronic attack. USVs can provide a persistent and effective capability with significant range, endurance, and capacity for large payloads and power generation.

- **EW CONCEPT OF OPERATIONS**

The specifics of the Electronic Warfare mission are classified; it is a subset of IO and closely related to Intelligence, Surveillance and Reconnaissance (ISR). Many technologies exist to enable this mission area. For example, it could be possible for a USV to generate false targets for deception in support of anti-ship missile defense, initiate a denial of service, or instigate spoofing, local area network jamming, and other disruptive IO missions. For example: In support of a CSG, ESG or Surface Strike Group (SSG), a USV could be equipped with a False Target Generator (FTG) and be used in a counter-targeting or Military Deception (MILDEC) role.

In a related application in the same scenario, the USV is used as a picket ship for that same Strike Group. The USV is equipped with an Electro Optics/Infrared (EO/IR) sensor on a retractable/extendable mast with receiver(s) in the body of the vehicle capable of conducting passive spectrum detection and threat warning for the battle group. That same USV, given the

appropriate repeater and/or transponder device, could be used within the CSG/ESG/SSG to aid in force Anti-Ship Missile Defense (ASMD). An economic advantage of using the USV in this role is that the repeater and/or transponder are reusable assets whereas some of the other options are not. An added benefit of using the USV in an ASMD role is that it can be used as an automated remote platform to augment the LCS Platform in a hostile environment, allowing the LCS to perform its primary missions.

Additionally, a USV can provide an extended jamming capability. Size and power of the jammer vs. capabilities of the USV will determine the overall mission capabilities and limitations. For example, a high-power jammer mounted on a large USV could be used in an expeditionary role to provide electronic screening, masking, or deception prior to a beachhead being penetrated by Special Operations Forces (SOF). Concurrently, that same USV mounted with an EO/IR/Laser capability could provide a tactical advantage when used in a Target (ship or aircraft) Illumination or Anti-Terrorism/Force Protection (AT/FP) role. Smaller jammers with directional high-gain antennas could be used in a relatively covert manner near hostile shores, airfields or chokepoints. Roles include communications jamming or deception, a Global Positioning System (GPS) jamming or in a Maritime Improvised Explosive Device (MIED) defeat role.

Another application for the SSV would be the USW application of an underwater generator that generates false screw rates or similar ship sounds, to simulate false surface ships or submarines or mask real ones.

7. MARITIME INTERDICTION OPERATIONS (MIO) SUPPORT MIO SUPPORT OBJECTIVE

MIO is traditionally defined as activities by naval forces to divert, disrupt, delay, or destroy the enemy's military potential before it can be used effectively against friendly forces. Preemptive protective measures can protect not only maritime assets, but also ground forces by disruption of sea-based lines of supply to the enemy. For MIO in this context, emphasis is on vessel boarding, search, and seizure capabilities.

Commander Naval Surface Force (CNSF) has communicated a strong requirement to the Chief of Naval Operations (CNO) for MIO on the LCS reference (l). Due to the increased threats associated with the GWOT, plans have been formulated to conduct sustained MIO with the augmentation of personnel on the LCS. MIO is by definition a manned mission. The MIO role of USVs is to enhance situational awareness in support of the manned mission. In general, this MIO effort would require a small USV system that would support a boarding party by investigating the threat vessel at the waterline and below. Potential support payloads for this role include ISR, EO/IR, CBRNE, Weapons of Mass Destruction (WMD) detectors, ROVs, UUVs, and UAVs.

- **MIO SUPPORT CONCEPT OF OPERATIONS**

The following example scenario should provide a flavor of USV MIO support missions. It is not intended to be prescriptive or limiting, since each MIO situation is likely to have its own unique characteristics and requirements.

The USV will provide ISR support to the manned 11m RIB performing MIO. The USV will support the MIO mission by providing a capability to detect a threat through a variety of devices and sensors to enhance situation awareness. Examples:

• USV approaches a potentially hostile ship ahead of the manned RIB to help gage reaction ("draw fire")

• USV approaches and monitors the far side of an interdicted vessel from the manned MIO boat, to check for cargo jettisoning, fleeing personnel, etc.

• The USV uses sensors (ROV/UUV) to check for below-waterline oddities such as trapdoors, moon pools, or hidden cargo compartments and "drop tanks".

• USV uses special sensors to search for unusual phenomena (e. g., CBNRE traces, large numbers of personnel in "cargo" holds).

In these ways using a USV may reduce the need for manning in support of MIO, and should improve the operation's effectiveness. In conjunction with the USV, launching and recovering an UAV could provide additional monitoring of suspicious objects or behaviors during the MIO mission, similar to that noted above, except from an aerial perspective.