AUTONOMOUS VEHICLE PROGRAMS AND APPLICATIONS AT SPAWAR SYSTEMS CENTER

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Abstract

Space and Naval Warfare Systems Center-San Diego (SSC-SD) is the Navy's research, development, test and evaluation, engineering, and fleet support center for command and control, communications, ocean surveillance, and the integration of those systems which overarch multiple platforms. This provides a unique perspective for the development of autonomous vehicle applications encompassing all types of systems: air, ground, and undersea. The role of these vehicle systems and their integration is of growing importance as part of the overall need for consistent situational awareness. Not only can they act as sensor delivery platforms, they can also provide a means of communication between a variety of disparate systems, creating a dynamic interoperable connectivity to a worldwide information grid. A variety of autonomous systems and their roles will be discussed including land robots for security, unmanned air vehicles (UAVs) for surveillance, and unmanned undersea vehicles (UUVs) for data collection and communications.

I. Overview

The vision at SSC-SD is to be the nation's pre-eminent provider of integrated C4ISR (command, control, communications, computers, intelligence, surveillance, and reconnaissance) for warrior information dominance. To this end, there are a broad range of missions and programs with autonomous vehicle applications currently being pursued.

A. Missions

To fulfill the SSC-SD missions, it means working across the air, land and sea domains, providing means of information collection and dissemination (Figure 1). Sensor and delivery systems must be developed for surveillance and reconnaissance, communication across multiple media, and handling the wealth of information gathered. To perform these tasks, SSC-SD combines demonstrated expertise in ocean surveillance, ocean engineering, intelligence / surveillance / reconnaissance sensors, navigation systems, and robotics.

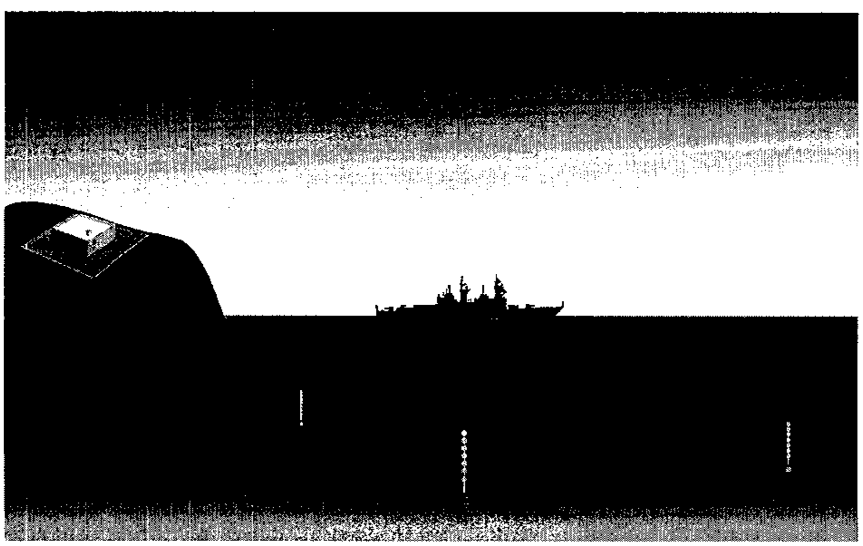

Figure 1: Mission Area Domains

B. Vehicle Roles

Autonomous vehicle systems play a key role in many of these mission areas. They are an effective means of deploying surveillance sensors in air, land, and sea, providing the data required for comprehensive situation awareness and understanding. Various communications modes are facilitated with vehicle systems, be it underwater or over the horizon, providing connectivity without exposing troops or platforms to hazardous situations. Vehicles are also key in cross-platform integration, bringing shore-based data to offshore platforms and vice-versa. Compatible and integrated systems are essential for the continued evolution and performance of these missions.

II. Autonomous Vehicle Systems

To address the varied roles, a wide variety of vehicle systems have been developed at SSC-SD over the past 30 years. These include many teleoperated systems for land, air, and undersea use. As the missions have evolved, so have the technologies, leading to the more capable, autonomous systems described below. Additionally, by virtue of the SSC SD mission, many of the communications architectures by which these vehicles are linked are developed by SSC SD.

A. Undersea

SSC-SD has developed a wide variety of autonomous underwater vehicles over the past 20 years, building on their experience in remotely operated vehicles. Systems such as the CURV, the Nozzle Plug, Mine Neutralization Vehicle, and Advanced Tethered Vehicle have provided a strong technology and application base for advanced system development.

Free Swimmer: Two Free Swimmer vehicles were produced by SSC-SD in the Experimental Autonomous Vehicle program, funded by the US Geologic Survey in the early 1980's. As testbeds, they demonstrated a wide variety of advanced concepts and technologies including autonomous pipeline following, supervisory control, autonomous mission planning, neural network controlled sensor, manipulator coordination, expendable fiber optic links, acoustic navigation, and underwater wet-mateable fiber optic connectors. While the free-swimmer vehicles themselves are currently inactive, the technologies developed with them are evident throughout the vehicle community.

Advanced Unmanned Search System (AUSS): The need for a deep ocean search capability drove the development of AUSS, demonstrated in 1992. Unhampered by a physical tether, AUSS uses an acoustic data link for supervisory control of the vehicle. All critical vehicle and mission control loops are closed on the vehicle, allowing autonomous performance of basic mission tasks such as transiting to a given location, hovering, and executing pre-programmed sonar and optical search patterns. Sensor data from the onboard side-looking sonar, forward looking sonar, and electronic still camera is compressed and acoustically transmitted to the surface. At any time, the surface operator may designate a target for closer investigation. If it proves to be a false target, the search may be easily resumed. Designed to operate to a depth of 20,000 feet, the AUSS vehicle is 17' long, 31" diameter, with a cylindrical graphite epoxy pressure hull with titanium hemispherical ends. During its sea tests in 1992, AUSS demonstrated side-looking sonar search at 5 knots, detailed optical inspection, sustained search rates up to one square nautical mile per hour, and operation at a depth of 12,000 feet. The system remains intact and is on standby for any potential requirements.

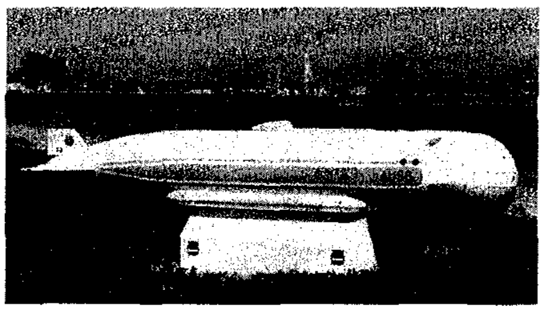

Figure 2: The Advanced Unmanned Search System (AUSS)

Flying Plug: The Flying Plug was developed as a means of transmitting large quantities of data underwater via the expendable fiber optic micro cable. A small vehicle, the Flying Plug is launched from a support platform, paying out micro cable as it goes. Control functions are performed on the host platform via the cable, to maintain vehicle simplicity. The plug homes in on and docks with a reusable Socket autonomously, completing the connection between the host platform and the outside world. The Socket provides both acoustic and optical homing aids, as well as the latching mechanism required for the wet-mate optical connection. After the data transfer is complete, the plug detaches from the socket and may either be scuttled or retrieved for refurbishment. The Flying Plug was demonstrated in 1996 and is a key part of the Distributed Surveillance Sensor Network described below.

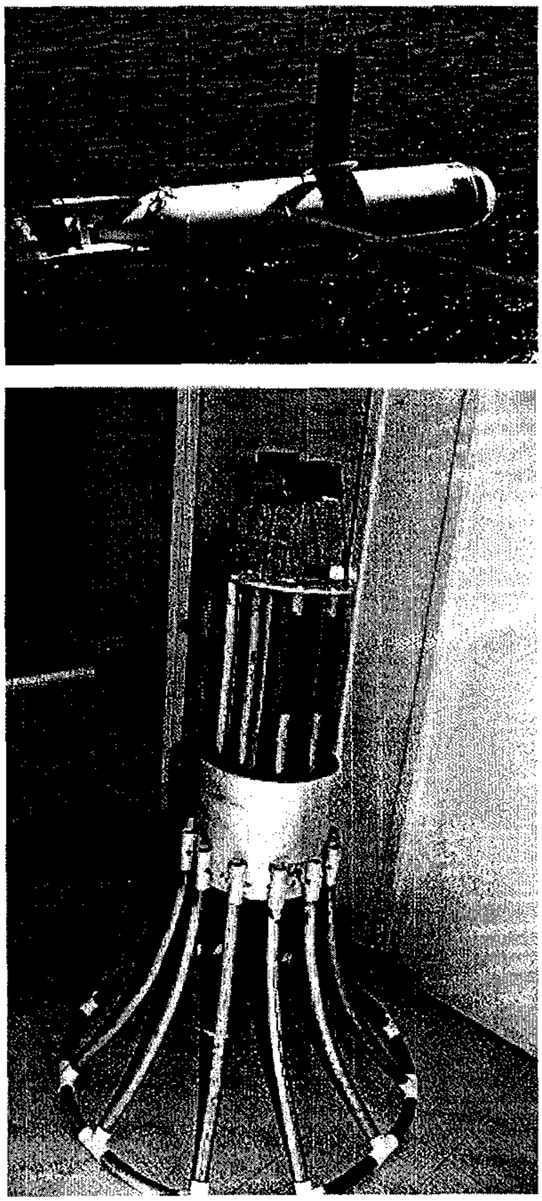

Figure 3: The Flying Plug and Socket

B. Land

In addition to undersea robotics, SSC-SD has played a significant role in ground robotics including the Ground Surveillance Robot, GATERS Teleoperated Vehicle, and the Surrogate Teleoperated Vehicle. Autonomous developments include ROBART I, II, and III, and the Mobile Detection, Assessment and Response System (MDARS). Started in 1988, MDARS provides automated intrusion detection and inventory assessment capability for DOD warehouses and storage sites. The goal is to provide multiple platforms performing random patrols within assigned areas. Separate indoor and outdoor systems are under development. The indoor system is based on the Cybermotion K2A Navmaster mobility base, and the outdoor mobility platform was developed by Robotic Systems Technology. System requirements are similar for both systems: the ability to navigate in a semi-structured environment. Novel features detected by the robot are assessed as to threat level, and appropriate action taken. The human operator is involved only when necessary. The indoor system has been in operation for over 2 years at a beta test facility at Camp Elliot in San Diego, and at a Defense Logistics Agency warehouse in Alabama. Operational fielding of the system is planned for 2000. Key portions of the outdoor system were demonstrated in 1996 and 1997, and development continues.

Figure 4: Interior MDARS

C. Air

Unmanned air vehicle (UAV) systems have also been developed at SSC-SD, starting with the Airborne Remotely Operated Device in the early 1980s. More recently, the Multi-Purpose Security and Surveillance Mission Platform (MSSMP) has been developed to provide a rapidly deployable, extended range surveillance capability. MMSP system requirements include high mobility, operation over low bandwidth tactical radio links, long endurance surveillance capabilities, and the ability for one operator to supervise several systems. Based on the Sikorsky Cypher enclosed-rotor unmanned air vehicle, MSSP carries a sensor package of a visible light video camera, infrared video camera, and a laser range finder, all mounted on a pan and tilt unit. As with MDARS, most sensor processing is performed on board, alerting the human operator only when a target of interest is detected. The system has been successfully demonstrated for several missions including a simulated counter-drug operation in May 1996 and urban terrain reconnaissance support in January 1997.

Current SSC-SD UAV efforts include defining the roles of the imagery dissemination node for Global Hawk flights, supporting the integration of UAVs into Non-combatant Evacuation Operations, supporting the development of a submarine launched UAV, internetting ground sensors and undersea sensors via UAV communications relay, using UAVs to send target track updates to precision targeting stations, and a collaborative US/UK effort to identify how UAVs can help solve the time critical targeting problem in the littoral region.

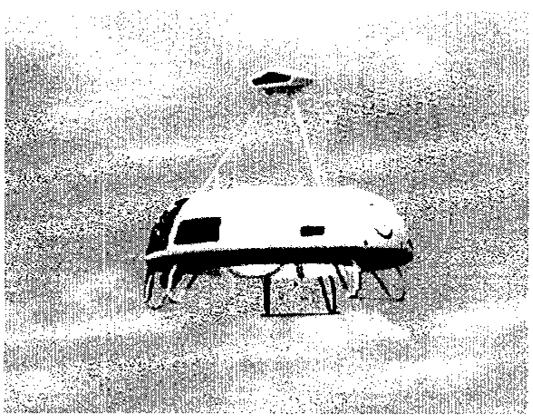

Figure 5 The Multipurpose Security and Surveillance Mission Platform (MSSMP)

III. Integrated Systems- Bringing it Together

The key to any effective system is the integration of the individual parts. Vehicles are just one part of the systems being developed to address C4ISR mission needs.

A. Current Efforts

A number of efforts are currently ongoing at SSC-SD looking at the myriad of ways that vehicles can be part of the larger system. Some of these include the following:

<u>Distributed Surveillance Sensor Network (DSSN)</u>: The objective of DSSN is to investigate the applicability of using small, inexpensive undersea vehicles for surveillance applications and submarine connectivity. Autonomous undersea vehicles gather data and periodically dock with undersea stations to dump data, recharge batteries, and receive new instructions. The data is retrieved by way of the Flying Plug described above, providing the critical communications link to the Fleet.

<u>Deployable Autonomous Distributed System (DADS)</u>: This is a suite of autonomous sensors which are designed to provide surveillance options in areas where current capabilities are too costly, overt, slow, and/or limited by the number of manned platforms available.

<u>Autonomous Off-Board Surveillance Sensors</u>: The objective is to demonstrate automated contact reporting from a rapidly deployable surveillance sensor with connectivity to a command center via acoustic and R/F data links.

B. Future

Future systems will see continued integration of sensor and vehicle systems, providing combined coverage of land, sea, and air arenas (Figure 6). As the technologies develop and mature, autonomous vehicles will play greater roles as sensor platforms, aids to communication, and operational entities.

References

For more information on these and other SSC-SD efforts, please consult the web page at:

http://www.nosc.mil/robots/

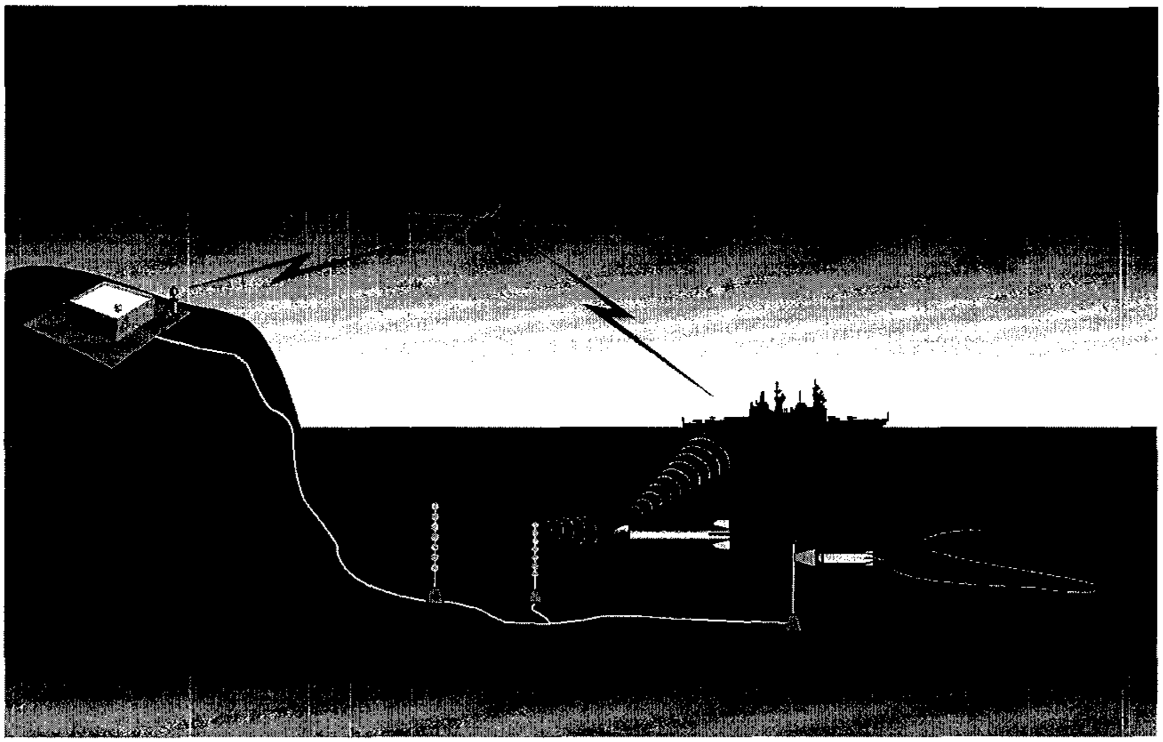

Figure 6: Integrated Autonomous Vehicle Systems can operate across multiple mission areas and domains.