USING COMMERCIAL GPS/SOFTWARE FOR MILITARY NAVIGATION

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Abstract

In 2001, the Naval Research Laboratory (NRL) was approached to investigate, develop, and demonstrate software on commercial off the shelf (COTS) hardware to electronically display precise lane navigation information. The navigation information should provide both a primary and an alternative means to guide landing craft drivers through an assigned lane to the beach during an amphibious assault in the presence of mines. Specific needs have been outlined based on input from both the mine countermeasures and the amphibious community. They include:

- Determine Position
- Display Position
- Aid in Controlling Position
- Display Waypoints

The Naval Research Laboratory (NRL) is developing and testing moving-map devices based on commercial hardware and software in an effort to create a variety of platforms that demonstrate such a navigation system. Currently, the Marine Corps plans to implement the Data Automated Communications System (DACT) in the Amphibious Assault Vehicle (AAV) platform, but not all vehicles will receive this system. NRL has obtained a moving map system based on a Compaq Ipaq Pocket PC platform with Pocket Navigator software. Field-testing proved that this combination was very quick and quite accurate. Other hardware that NRL plans to test include:

- DACT
- Laptop computer
- The integrated multifunctional control system used on the AAAV
- Navstar 1000, a new product designed by Navigator PC.

NRL is in the process of developing software to compress different map types and imagery into the Raster Product Format (MIL-STD-2411) (RPF). This will allow bathymetry data, nautical charts, and satellite and acoustic imagery to be loaded on devices that handle standard National Imagery and Mapping Agency (NIMA) RPF data. NRL will also determine a method of loading mission specific overlays, such as threat rings, lane markings, possible mine-like objects, and waypoints.

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Introduction

The U.S. Navy and Marine Corps use several different landing crafts (Figure 1). These landing craft include, but are not limited to:

- Landing Craft Air Cushion (LCAC)
- Landing Craft Utility (LCU)
- Amphibious Assault Vehicle (AAV)
- In the future, the Advanced Amphibious Assault Vehicle (AAAV)

Each of these crafts uses a different method of navigation, with each method having its own advantages and disadvantages. However, all of the existing methods of navigation used by the landing craft drivers to guide them through an assigned lane to the beach during an amphibious assault have proven to be insufficient, and potentially hazardous when there are underwater mines present in the area.

Both the LCAC and the LCU are equipped with a Marconi LN66 navigation system (the LCU may use an SPS-53 instead), but the difficulty with these vehicles lies primarily with vehicle maneuverability, rather than the positioning systems. By definition, the LCAC travels on a cushion of air, making it very susceptible to redirection by both wind and surface currents. NRL is investigating the possibility of incorporating a system that will define trends that will aid in a course adjustment of the LCAC to accommodate the likelihood of such a redirection. The LCU, because of its great size and weight, is not likely to drift off course due to wind or sea currents. A question that needs addressing, however, is related to maneuverability. However, due to the LCU's size, its maneuverability may be limited. A question remains whether the LCU could stay within the confines of a marked lane to shore, negotiate a 180° turn, and sail back out to sea without compromising the safety of the crew and equipment onboard.

The U.S. Marine Corps' AAV and AAAV have entirely different navigational challenges. The AAV currently has no embedded navigational device and must rely on a small portal with a dangerous blind spot to navigate. Although equipped with radio capabilities, weather conditions do not always allow for a crewmember to give direction to the driver because of limited or no line of sight. As stated previously, there will eventually be a few of the AAVs that will be outfitted with the DACT systems, but not all vehicles are scheduled to receive this retrofit. The planned AAAV navigation system will accommodate real-time tactical displays, using both the AN/VSQ-1 Position Locating Reporting System (PLRS) with GPS and a Forward Looking Infrared Radar (FLIR). Although usually very effective in a battlefield environment, the sea spray that the AAAV will encounter during a littoral assault will "blind" the FLIR and render it useless. Also, the initial fielding of AAAVs will not start until 2004, with the entire fielding process not complete until 2012. Although the AAAV will be an invaluable asset, as well as a much needed upgrade from the AAV, there are some immediate concerns that must be addressed while the Fleet is awaiting their new vehicles.

Given that the driver of an AAV has only a small portal through which to navigate a lane, his ability to see any visual cues, such as marker buoys, may be seriously diminished by physical barriers such as sea spray, darkness, fog, and other such factors. Another factor to take into consideration is the extremely intense workload of the crew of a landing craft such as the AAV. The driver has a number of other devices to monitor, as well as a crew of Marines, leaving little concentration to be afforded to an entirely new navigational system. This means that anything new that might be introduced would need to be very easy to read and understand, so that no time is wasted trying to interpret the meaning of a display. A new navigational system should "be capable of conveying critical information concerning navigation … in a manner that is easily interpretable under often stressful conditions" (Lohrenz, et. al.).

Figure 1. Clockwise from upper left - LCAC, LCU, AAAV, AAV

The space inside these assault vehicles is minimal, only allowing room for a predetermined number of Marines and their equipment. Providing a small, unobtrusive device would decrease the likelihood that the size of this device would hinder normal operations. These assault and landing craft can be very difficult to control. Waves, currents, wind, and the speed of the vehicle can all factor into this challenge. A digital navigation tool may be able to aid a driver in controlling the vehicle by displaying the track that the vehicle has already driven, thereby possibly showing a pattern that would help the driver adjust his steering (e.g., if the craft keeps drifting to the left, then try to stay to the right side of the lane). In order to meet the demands and concerns of both the mine countermeasures and the amphibious communities, NRL is researching a number of different commercial products, as well as developing software to compress different map types and imagery into RPF. Since many of the landing craft vehicles are using a software program called Command and Control Personal Computer (C2PC), which reads RPF images, the development of RPF compression software will enable a variety of image and data types to be converted for use on C2PC.

Approach

Tasks that NRL plans to accomplish are to:

- Determine what navigation information should be displayedCombine this information with precise lane coordinatesDisplay as overlays on an electronic chart

- Determine whether a descriptive picture of the environment (e.g., currents, waves, tides, bathymetry, winds) is beneficial to the AAV / AAAV drivers
- Evaluate how AAV and (later) AAAV drivers respond to these displays

In order to create the best demonstration product with the funding available, NRL decided to use commercial GPS products. The reasons for this decision included:

- Price
- Availability
- Reliability and Accuracy

In a case study performed by the Office of the Defense Standardization Program in 1996, research showed that the "AN/PSN-8 Manpack, an Army developed 17-pound receiver with a unit cost of over $40,000. The father is SLGR (Small Lightweight GPS Receiver). During the Manpack's development, commercial GPS receivers became available. The commercial version most attractive to the military (the SLGR, pronounced "slugger") weighed about four pounds and cost about $4,000 each." This is a large price difference for seemingly similar products. "Until recently, both military and commercial GPS receivers were power hungry, bulky and very expensive." (Vansuch) This is no longer the case.

Commercial GPS systems can be found virtually anywhere in the United States. There are several developers that produce quality systems, and they are available through the manufacturer's web sites, magazine, any marine store, and even in your local Wal-Mart.

With the March 1996 dissolution of the Federal Government's policy of Selective Availability, commercial GPS users now have access to a highly accurate, stable system of satellites, with no limitation or degradation from the government. This ensures reliability that, until recently, has only been available for military use. There is no reason why the Federal Government should not leverage the advancements made by commercial producers. According to NIMA, "A military user of GPS in a differential mode may reach an accuracy of 2 to 7 meters," and "With an established maintenance system, electronic charts used with valid display system will be the navigation method of choice for most mariners."

With GPS systems evolving quickly, and with many different commercial vendors striving to improve their individual products, it would greatly benefit the military branches to take advantage of the commercial development in GPS devices. Lockheed Martin, in an advertisement on their web site, advises, "Over the past 10 years, GPS has evolved beyond its military origins. Not only does GPS provide such service as situational awareness and precision weapon guidance for the military. It is now an information resource supporting a wide range of civil, scientific, and commercial functions – from air traffic control to the Internet – with precision location and timing information.

Today, the military is not the sole technological development force in our country. Rather than civilian companies relying on military development, there has been a turning point, where "there's a lot more we can gain today by looking at commercial technology and figuring out how we can use it for national security needs." (Lyles) In the Gulf War, many pilots relied on commercial GPS to guide them through areas where visibility was extremely low, or nonexistent.

“Without a reliable navigation system, U.S. forces could not have performed the maneuvers of Operation Desert Storm. With GPS, the soldiers were able to go places and maneuver in sandstorms or at night when even the troops who lived there couldn't. Initially, more than 1,000 portable commercial receivers were purchased for their use. The demand was so great that, before the end of the conflict, more than 9,000 commercial receivers were in use in the Gulf region. They were carried by foot soldiers and attached to vehicles, helicopters, and aircraft instrument panels. GPS receivers were used in several aircraft, including F-16 fighters, KC-135 aerial refuelers, and B-2 bombers; Navy ships used them for rendezvous, minesweeping, and aircraft operations” (Aerospace Corporation).

Many of the nation’s military vehicles, including fighter jets, tanks, and amphibious assault vehicles, were not outfitted to support a GPS system when they were designed. For these vehicles, a commercial GPS product would seem most appropriate, as they require little, if any, modification in order to make use of them. In February of 1999, a squadron of A-10 ground support aircraft were outfitted with commercial, handheld GPS receiver from Garmin Corp. This method of implementation provided the “aircraft with GPS capabilities faster and at a lower cost than plans to retrofit the A-10 with military GPS receivers” (Brewin).

Testing and Results

In August 2001, NRL began testing of the Pocket Navigator PC (made by Navigator PC out of Sunrise, Florida), to include the moving map and the GPS accuracy. When comparing the position as read from the GPS/Pocket Navigator with a known fixed point, there were no discrepancies found. The moving map software, loaded onto the Pocket Navigator PC, guided us through a narrow channel of water, such as are located on Cat Island (figure 2), off of the coast of Mississippi, in the Gulf of Mexico.

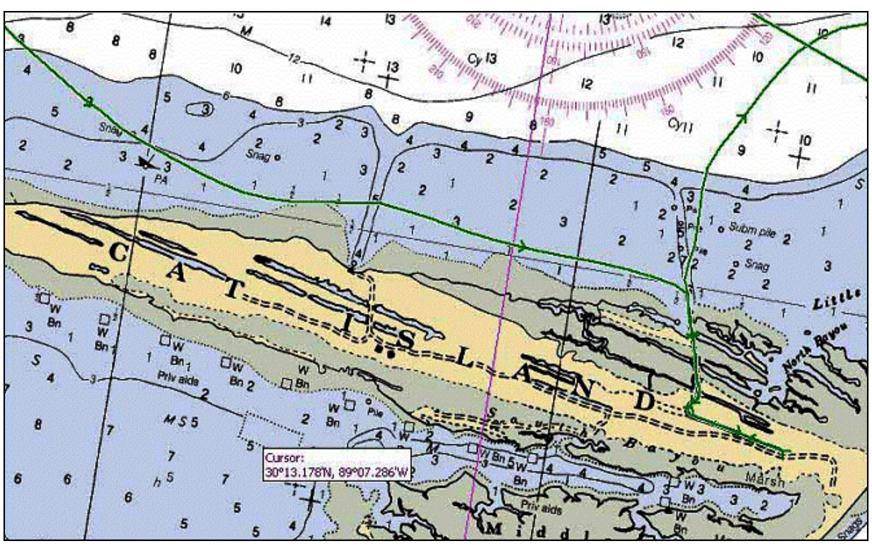

Figure 2

The Pocket Navigator PC achieved an accuracy that is well capable of guiding any AAV/AAAV driver through precise lanes, as our lane width was approximately 15 meters (figure 3). Some difficulties were encountered, however. These include:

- Small screen is difficult to view under rough conditions
- Difficult to remove/use stylus pen for marking on screen
- Hard drive storage space limited
- Battery life is limited to 2-3 hours

To eliminate the problem with battery life, we may want to consider a DC adapter, such as that which might be used in a cigarette lighter of a vehicle. We also suggest using a larger screen, possibly mounted, to monitor position and waypoints, as well as an upgrade to allow for greater storage capacity.

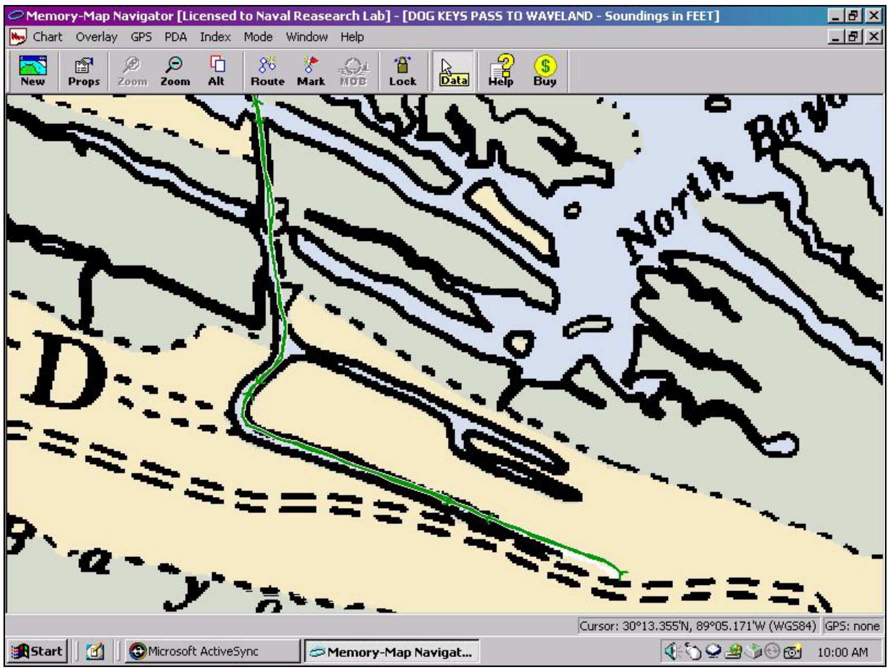

Figure 3

Summary

The Naval Research Laboratory has set out to investigate, develop, and demonstrate software on commercial off the shelf (COTS) hardware to electronically display precise lane navigation and an alternative means to guide landing craft drivers through an assigned lane to the beach during an amphibious assault in the presence of mines. During this process, through research and testing, we have determined that, because of the price, availability, and reliability of today's commercial devices, these tools seem to be the most advanced and reasonable to use for our project. The available commercial software is compatible with all NIMA and NOAA charts, and is very simple to load with mission specific data. For these reasons, we have come to the conclusion that the use of commercial GPS software and receivers is the most cost-effective and reliable route to achieve our goal.

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