VESSEL TRACKING AND IDENTIFICATION 2006
Crowne Plaza St. James Hotel, London
April 24, 2006

# PILOTAGE AND THE AIS PILOT PLUG

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## SUMMARY

*US pilots have considerable experience in the use of AIS as a navigational tool. As experts in directing vessels in confined, busy areas, pilots are in a unique position to assess the value of AIS for enhancing situational awareness and collision avoidance. The predominant use of AIS by pilots in the United States is by importing the vessel's AIS data onto the pilot's carry aboard computer equipment through the vessel's AIS Pilot Plug. Pilots consider AIS information to be particularly valuable when integrated with other navigational technology such as ECDIS and ARPA and displayed through advanced software.*

*AIS technology has limitations, and the potential for inaccurate information exists. Pilots and other mariners should be aware of those limitations – as should shoreside (VTS) users and regulatory authorities. Pilots should receive training both in how AIS works and in how pilots should incorporate AIS into their piloting practices. Some remaining regulatory issues should be addressed before the full potential of AIS as a navigation tool can be realized.*

## Pilot Support for AIS

Pilots in the United States were early supporters of, and participants in, efforts to introduce Automatic Identification System (AIS) technology. This support has extended to all of the potential uses of AIS, including: vessel-to-vessel to assist in collision avoidance, vessel to shore for surveillance and tracking for security purposes, and vessel to shore/shore to vessel as a vessel traffic service (VTS) tool.

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[4] The authors would like to thank Captain Michael Morris, Houston Pilots and Member, APA Navigation and Technology Committee for his assistance in preparing this paper.

In a relatively early example of such support, the American Pilots' Association (APA) was an active participant in a VTS Dialogue Group assembled by the National Research Council in 1997 at the request of the US Coast Guard. The objective of the Dialogue Group was to provide stakeholder guidance to the Coast Guard for a consensus national policy on VTS and other forms of navigational assistance. From the very start of the Group's deliberations, APA member pilots recommended AIS as the base technology for VTS systems. This reflected the pilots' perception that developing AIS technologies could improve safe navigation both inside and outside of VTS areas. In a VTS, AIS could provide accurate vessel information without distracting voice communications.

Indeed, the APA members and a number of other participants expressed their belief that AIS offers the potential to not only reduce voice communications in VTS systems (a common goal of the participants, including the Coast Guard), but, in many places, to avoid a VTS system at all. Much of the information provided to a vessel from a VTS center could be provided directly vessel to vessel through AIS. Underlying this was a general belief that the traditional manned VTS center should eventually become extinct as a vehicle for providing navigational information and assistance.

Joined by shipowner groups INTERTANKO and the US Chamber of Shipping, the APA advocated a two-tiered approach in which the Coast Guard would be responsible for implementing a national AIS/transponder system as the baseline or "basic" navigation support system to supplement traditional aids to navigation. Beyond that, the Coast Guard and local stakeholders could determine if a VTS or other enhanced system of shore-based support should be implemented where necessary, with the condition that the enhanced system should be built upon AIS. The Group eventually adopted a Summary of Guidance that embraced that approach. The major feature of the Summary was its endorsement of "the widespread use of AIS employing Differential Global Positioning System (DGPS) and on-board transponder technologies." These technologies would provide the basis for navigation support services in both VTS and non-VTS areas.

Of course, the pilots' faith in future vessel to vessel applications of AIS as obviating the need for manned VTS systems in other than a few select places involved a measure of forward thinking. An accurate assessment of the value and limitations of AIS in a vessel to vessel mode would not be possible until the widespread carriage of shipborne AIS equipment in the years since the Dialogue Group, prompted primarily by the carriage requirements in SOLAS. Pilots and other mariners have now begun to see enough shipborne AIS equipment to measure the benefits and potential problems with using this technology.

## AIS as a Navigational Tool in Vessel to Vessel Applications

The promise of AIS for mariners lies primarily in its capabilities for increasing situational awareness and collision avoidance. With the mix of static, dynamic, and voyage-related data transmitted through an AIS signal, a mariner can "see" a target ship's

location, name, size, navigational status, speed and direction, and other useful information. This can eliminate the need to call a vessel on VHF in order to identify that vessel. It can reduce the chances of making a meeting arrangement with the wrong vessel through confusion of VHF communications, and it can identify a vessel that fails to respond to VHF calls and provide needed information about that vessel. Unlike radar, AIS can see around corners (blind bends, mountains, etc.) and is not knocked out by heavy rain. When combined with modern charting systems and navigation software, dynamic data about a vessel through its AIS signal can be used to predict meeting locations.

The capabilities of AIS as a navigational tool, however, cannot be achieved without enhancements to the mandatory equipment. It is well-known that the so-called "Minimum Keyboard Display," the elementary three-line alphanumeric display required by the IMO, has severe limitations as a navigation tool. It is difficult and time-consuming to read. It is often mounted in inaccessible places. It takes a pilot away from essential navigation duties.

For a pilot, some limitations in a vessel's AIS set-up, particularly its display, can be avoided through the use of the pilot's own carry-aboard electronic equipment. Even on vessels with high-quality, integrated AIS-based navigation equipment, the pilot's own carry-aboard equipment may offer significant advantages. Through his or her own equipment, the pilot has a familiar display with data inputs and navigation software best matched to the local conditions. AIS data in this environment has some remaining limitations, however, and pilots need to be aware of these. Nevertheless, many US pilots have decided that the key to maximizing the benefits of AIS for the pilot's job is accessing the data through the vessel's pilot plug and displaying it on their own carry-aboard equipment.

## Pilots' Use of AIS Through the Pilot Plug

### A. Pilot Carry Aboard Units and AIS Pilot Plugs: Background

For many pilots, the value of AIS as a navigational tool is the product of two other pieces of technology: carry aboard electronic units and the AIS pilot plug. The development of each has played an important role in the current use of AIS by pilots.

Pilot carry aboard electronic units first appeared in the United States over 20 years ago. The initial units, developed by pilots, provided position information using Loran–C and showing own-vessel location relative to way points or the channel centerline. As positioning technology evolved since then, the units and the type of information they provide also evolved. The availability of the Differential Global Positioning System (DGPS) was a major breakthrough, offering reliable position information accurate to less than a meter. With DGPS, own-vessel position can be shown on an electronic chart-type display through software loaded with data specific to the particular pilotage area. Increasingly, portable units also provide positioning information

on other vessels through AIS, a radar overlay/underlay, a link to a shoreside VTS center, an internet server-based platform (recognizing other pilot carry aboard units), or some other position information vehicle. They may also have digital communication capabilities that would provide other useful information from external sources.

As pilots in the US and other places in the world gained experience with portable units, they could see the advantages of having a portal to link their carry aboard unit with the vessel's own navigation equipment to draw information such as the ship's gyro heading, rate of turn, and position data. For example, in 1999, the APA Navigation and Technology Committee sent the US Coast Guard a list of ship's information that should be "accessible" by the pilot thorough a connection device. The concurrent development of AIS requirements provided an opportunity to mandate a standard connection device for this purpose. The device became known as the "AIS Pilot Plug."

B. The AIS Pilot Plug

An AIS pilot plug is found, or should be found, on every ship with a Class A AIS unit. This is the result of guidelines established by the IMO to accompany the AIS carriage requirement. In particular, the "Guidelines for the Installation of a Shipborne Automatic Identification System (AIS)" state:

> *3.2 Pilot Plug*
> *A pilot input/output port is part of a class A station. A plug connected to this port should be installed on the bridge near the pilot's operating position so that a pilot can connect a Personal Pilot Unit (PPU).*
>
> *The pilot plug should be configured as follows:*
> *AMP/Receptacle (Square Flanged (-1) or Free-Hanging (-2)), Shell size 11, 9-pin, Std. Sex 206486-1/2 or equivalent with the following terminations:*
>
> *- TX A is connected to Pin 1*
> *- TX B is connected to Pin 4*
> *- RX A is connected to Pin 5*
> *- RX B is connected to Pin 6*
> *- Shield is connected to Pin 9*[5]

US Coast Guard regulations, applicable to US-flag and foreign-flag vessels in US waters, provide:

> *The AIS Pilot Plug, on each vessel over 1,600 gross tons, on an international voyage, shall be available for pilot use, easily accessible from the primary conning position of the vessel, and near a 120 volt AC power, 3-prong receptacle.*[6]

[5] IMO SN/Circ. 227.
[6] 33 CFR §164.46.

As requested by pilots and other early proponents, the pilot plug offers the pilot a portal to the vessel's received AIS signals as well as other information, such as the vessel's gyro heading and own-vessel position data derived from the ship's GNSS (GPS/DGPA or GLONASS) antenna and receiver and other equipment. With the plug, the pilot has the opportunity to import into the pilot's portable unit as much or as little of the vessel's own navigation information as the pilot chooses. How much of the vessel's information and sensors the pilot wants to use is perhaps the major factor in the type of portable equipment the pilot will select.

A significant number of the first vessels operating in US waters with AIS equipment had problems with their pilot plugs. On some vessels, the plug was in an inaccessible place, such as under a console or even on the ceiling. In a number of vessels, the plug was located near the chart table or some other place far away from a pilot's normal conning position. On other vessels, the plug was wired incorrectly or even not wired at all.

This situation has improved. An informal survey of members of the APA's Navigation and Technology Committee conducted in the Fall of 2005 suggested that US pilots are finding that approximately 10% of the vessels fitted with pilot plugs have data or technical deficiencies. The deficiencies listed in order of frequency were:

- Incorrect static or voyage data input
- No heading or gyro input
- Incorrect wiring
- Incorrect pilot plug receptacle

The 10% deficiency rate (which includes defects other than in the pilot plug) may seem high, but it is a substantial improvement over the situation that existed only a year or two earlier.

One of the keys to the improving quality of shipborne AIS equipment, including the pilot plug, is enforcement of the US and international standards by the Coast Guard. Pilots are encouraged to report AIS deficiencies, including pilot plug deficiencies, to the Coast Guard, either to the local USCG Marine Safety Office or a web site maintained by the USCG Navigation Center (http://www.navcen.uscg.gov/ADO/ais_form.asp).

There are commercial testers available that can identify problems with pilot plug data output. Some devices can apply system software/hardware solutions that can correct reversed polarity, adjust baud rate, and use a cross-over cable to swap data pairs at the pilot plug While these devices can be useful, the pilot's arrival on the bridge does not always lend itself to quick identification of problems with the pilot plug and easy solutions to those problems.

One potential problem for future consideration would be the pilot plug's durability. The AMP receptacle still faces the test of time. Pilots have expressed skepticism regarding the plug's construction and its longevity. The all-plastic pilot plug

receptacle is threaded at one end to accept attachment by the pilot of a mated all-plastic receptacle. Unless the two mated all-plastic receptacles are aligned correctly, the potential for cross threading exists. The plastic threads on both receptacles could also eventually degrade, and connections will need to be replaced.

Perhaps one of the simplest yet most overlooked issues is the clear identification of the pilot plug. With the numerous receptacles on the bridge, clearly labeling the pilot plug so pilots can quickly identify its location would be helpful.

Ultimately, it is the vessel's responsibility to maintain a properly operating and appropriately located and accessible pilot plug. Flag states and port states should "assist" the ship owners and bridge designers and equipment manufacturers in this effort.

C. Pilot Portable Electronic Units

There are currently three basic options for pilot carry aboard systems capable of displaying AIS data.

One option is a portable, self-contained ECDIS/AIS system, which is self-powered and typically enclosed in a waterproof case. Inside the case are a PC notebook, an AIS receiver, a DGPS dual antenna/receiver package, and a power source. There is typically no connection to an AIS power plug. All own-vessel and other vessel information is received through the carry aboard system. The system, as well as the other options described below, may include a PDA, which communicates through a wireless LAN with the notebook contained in the case. The benefits of this type of carry aboard system are that the unit is totally self-contained, independent of the vessel's sensors, and offers familiar user interface containing port specific data to the pilot. The weight of a typical such unit averages approximately 8 Kgs (17.64 lbs). This type of system is now considered first generation or pre-first generation. As the quality of shipborne equipment and AIS pilot plugs improves, many pilots have become more comfortable using AIS information derived from the vessel's equipment.

The second, and currently most popular, option is a notebook PC combined with a DGPS antenna/receiver package and pilot plug connectivity. Own-vessel position is derived from the carry aboard DGPS equipment, which is set up outside the bridge. The important gyro heading information is obtained either from dual carry aboard antennas or from the vessel's AIS heading data accessed through the pilot plug. The notebook receives AIS signals for other vessels from the pilot plug. Increasingly, the various components of the system as well as the pilot plug are connected with wireless (WiFi) technology, such as Bluetooth. The carry aboard DGPS antenna/receiver package avoids problems with inferior vessel GNSS equipment or with an AIS/GNSS interface that is not properly configured and could produce inaccurate results for own-vessel position through the AIS signal.

The third option is a notebook PC that receives and incorporates AIS data solely from the vessel's equipment via the pilot plug. As with option 2, above, this vessel data is displayed in a format familiar to the pilot. The navigation software on the notebook interfaces with the vessel's AIS transponder data via the pilot plug to create a display environment providing flexibility and convenience for the pilot without sacrificing the accuracy of the navigation information provided from the vessel. Key benefits of this type of carry aboard unit over options 1 and 2 include, but are not limited to: faster and easier set-up, smaller size and less weight (2-3 Kgs, 6-7 lbs) and reduced cost. Because of this option's total reliance on the vessel's information, possible disadvantages are poor quality, unreliable or defective information from the vessel's equipment, e.g., ship's GPS not calibrated to centerline pivot point, GPS operating on wrong datum, gyro and heading device input faulty, or pilot plug deficiencies. Typically, pilots who elect this option encounter mostly more modern ships with advanced AIS equipment, such as cruise ships.

There are a number of variations, combinations, and accessories available to create systems that differ in some respects from the general options described above. PDAs, for example can be WiFi-linked to a notebook PC, as mentioned above, or possibly even connected directly to a pilot plug to take the place of a notebook PC. Recent software developed for PDA can provide the user with an audible collision danger alert and/or sorted tables based on CPA or TCPA as well as color-coded target icons – all normal AIS safety features available from the Bluetooth connection to the AIS pilot plug.

D. Pilot Carry Aboard Unit – Pilot Plug Connectivity Options

Connection of a pilot carry aboard system to an AIS pilot plug requires hardware not available on the vessel. The pilot has two options: hard link or wireless. The latter is more costly but has a number of extremely valuable benefits to the pilot (and to the bridge crew). In either case, the RS422 signal at the pilot plug must be converted to an RS232 signal. The conversion of the signal is handled by different manufacturers with equipment that varies in size and connection type. USB and serial port connections are commercially available.

Wireless connectivity via Bluetooth has enjoyed success and is purported to have a range of 100 meters when paired with a Class 1 Bluetooth adapter. Wireless connections seem clearly to be the most popular with pilots, combining the mobility of a notebook PC with the pilot plug. As noted previously, pilot plugs are not always found in convenient locations. The freedom wireless connection offers can be a significant advantage depending on bridge layout and design. Because there is no physical connection between the notebook and the pilot plug, there are no wires around which the pilot and the bridge crew have to maneuver.

The interface of the pilot plug to pilot carry aboard units in most applications is successful and offers immediate beneficial results. Soon after arriving on the bridge, the pilot unit is up and running, and valuable navigation information is available to the pilot in a format that is familiar to the pilot and well-suited to the demands of the pilotage

waters. Compatible pilot plug technology is growing quickly with new versions of hardware, software, and firmware becoming available all the time. In many cases, pilots beta test and apply the new pilot plug technology. Pilots are in a unique position to offer valuable feedback to developers.

## AIS Displays on Pilot Carry Aboard Systems: Benefits and Challenges

A major advantage of a pilot's carry-aboard notebook PC is that it has software that meets the pilot's specific needs and displays AIS and other information in a way that is most useful to the pilot. The typical navigation software on a pilot carry aboard utilizes S-57 (vector) charts and displays own-vessel position (via either a pilot's DGPS package or the vessel's DGPS through the pilot plug) and all AIS targets acquired by the ship's AIS receiver. Other vessels displayed on the screen will have name flags and COG/Speed. By zooming in on a particular vessel, the footprint of the vessel can be seen. The pilot can call up information on that vessel on its icon or check any other vessel by pulling up the traffic window.

Most AIS-based navigation software programs used on pilot carry aboard units operate in a Windows environment. This allows the pilot to, for example, move the COG/SOG/HDG/ROT window wherever the pilot wants to put it and resize the window as desired. The software provides speed, heading, TTG to any waypoint, DGPS quality indicators, cross track error and meeting points. The meeting point feature indicates where own vessel will meet the target vessel along their respective routes. The software constantly updates; so a speed change by a target vessel can be detected instantly. Filtering is available through the choice to activate or deactivate sleeping targets (acquired by ARPA) or vessels in one or more specified categories of navigational status as entered manually by the vessel's crew or by selecting CPA/TCPA parameters. This is, in essence, a basic filtering technique used by pilots depending on the level of integration and the system available. Most of the newer navigation software programs available offer a wide range of additional features and capabilities such as picture-in-picture, electronic bearing lines, history trail, and predictor.

Even the newest and most refined navigation software on pilot carry aboard units has the potential to display erroneous AIS information, either on own vessel or another vessel. This problem also exists with shipboard displays. The most commonly cited errors occur with incorrect static, status, and voyage information entered (or sometimes not entered) by the vessel's crew. Another error encountered with unfortunate frequency is inaccurate vessel position. A vessel's AIS processor/controller normally uses the vessel's "external" or primary GNSS equipment for transmitting and receiving position information. As a result, vessel position in an AIS signal is only as good as the transmitting ship's GNSS equipment. In some cases that equipment is considerably older than the AIS or is of inferior quality. Even on vessels with high quality DGPS equipment, the interface with the AIS may not be configured properly or have some other problem that results in erroneous position information. Pilots have reported instances in which their own-vessel position transmitted by the AIS signal is a significant distance

away from the actual position as shown by the pilot's own DGPS equipment. These are similar to the well-known accounts of AIS signals showing vessels on the landward side of docks or on downtown streets or somewhere else far from their actual position. Pilots and other mariners must recognize that position accuracy derived from AIS alone is somewhat limited. VTS authorities and other shore-based AIS users should also recognize this limitation.

This inaccurate position problem can be significantly lessened by combining AIS with radar/ARPA. In fact, pilots consider AIS on radar/ARPA, which is being seen on newer ships, as substantially enhancing the situational awareness and collision avoidance benefits of AIS. It improves tracking and identification and provides the ability to cross-check radar and AIS information. Consistent with this view of the pilots, the IMO has mandated that beginning July 1, 2008, all new radar installations must be able to display AIS targets according to standards set by the organization.[7] This should be a significant advance in the use of AIS as a navigational tool.

Many reported AIS signal errors are the result of incorrect static information entered in a vessel's AIS, as noted above. For example, an incorrect MMSI number, even one that is off by only a single digit, can cause "target swap" in which a vessel's name or location can be affected by another vessel within the range of the AIS. This and similar problems are a reflection of the fact that AIS is a complex system that relies on various inputs, user interface, and knowledge. Human error manifests itself in flawed static and voyage data transmissions. These inputs are not typically the pilot's responsibility, although most pilots will bring such deficiencies to the attention of the Officer of the Navigational Watch. The real concern lies in the effect of these transmitted data errors in navigational decisions on the vessel.

## AIS Training Needs for Pilots

Training considerations for pilots' use of AIS through their own carry-aboard equipment and the vessel's pilot plug parallel the considerations that have existed for some time with respect to pilots' carry aboard equipment. There are two types of training for AIS, both of which are equally important.

One is training to gain knowledge and understanding of AIS: its operating principles, the correct interpretation of displayed data, and information limitations. Such training would be similar to what is outlined in the IMO's Model Course in the Operational Use of AIS but should ideally be specifically adapted to the pilot's use of AIS. At least one training center in the US has already installed pilot plugs in its electronic navigation simulator cubicles and is planning on installing a plug on its full mission bridge simulator. That center offers a one-day (7 hours) course in AIS for pilots, as well as a 5-day (35 hours) course designed to provide ship's crews with proficiency in the use of AIS as an electronic navigational aid in watchkeeping. This training in AIS

[7] Resolution MSC. 192(79). See also, SN/Circ.243, "Guidelines for the Presentation of Naviagtion-Related Symbols, Terms and Abbrevations."

should supplement training in the use of the pilot's particular carry-aboard unit and pilot plug connection device.

The other type of valuable AIS training for pilots is in bridge resource management training that addresses how pilots should incorporate AIS information into their piloting practices. Again, this should be designed specifically for pilots using AIS on their carry aboard units. This training should recognize that AIS is merely one information resource and navigation tool. The pilot should consider how this resource is to be used, and possibly shared, in a way that maximizes the performance of not only the pilot but the bridge team as well.

## Regulatory Issues for Pilot Use of AIS

In order to obtain the full benefits of AIS, there are some regulatory issues that still need to be addressed. There are two in particular that have recently been of concern to the APA and US pilots. Given the established navigation safety value in "seeing" other vessels with AIS, the AIS carriage requirements should be expanded through national or international regulations. The US Coast Guard, for example, announced last October its intention to broaden the range of vessels required to carry AIS in US waters. As originally announced, this expansion would extend the AIS carriage requirement in US waters to fishing vessels over 65 feet as well as passenger vessels carrying more than 50 passengers and towing vessels of more than 26 feet and 600 horsepower operating in all US waters. That rulemaking has been delayed and put on a slow track because of opposition from the fishing, towing, and passenger ferry industries as well as other ship operating groups. US pilots, however, would strongly support such an expansion. It is important that pilots and other mariners be able to "see" these vessels with AIS. These smaller vessels still present a navigation hazard for larger vessels and, at least in the case of fishing vessels, are precisely the vessels that are most likely to not respond to VHF communications.

Another regulatory issue that has arisen, at least in the US, is with a number of AIS vessels that do not have heading input to the AIS unit and through the pilot plug. On many vessels with no or incorrect heading transmissions, the problem appears to be with a digital converter fitted on an old heading device to allow it to interface with the newer AIS equipment. This requires a fixed offset to be set at the converter, and sometimes this is done incorrectly by the installation engineer or is changed by the ship's crew. Some vessels have other problems supplying heading for the AIS. Other vessels simply have no heading input to the AIS equipment. Whatever the problems, there exists some confusion about international and national heading input requirements. Without going into the details of the conflicting interpretations of the requirements, this should be clarified and a heading input requirement clearly established and enforced.