Pulling into port

Shipboard technology is matched and sometimes surpassed by the sophisticated new technologies being used in ports and terminals to aid the smooth and safe navigation of incoming vessels. Paolo Amadio of American technology company Lockheed Martin traces the journey of a laden tanker into port

Companies that depend on vessels to transport their goods to market continue to be concerned with the safety of the waterways which their ships traverse. With more and more vessels passing through the world's narrow straits, it is more important than ever to ensure the safety of the world's busiest waterways.
A typical oil tanker can cost up to $50,000 a day to operate. That means that companies want to load and unload oil as quickly and safely as possible to minimise the cost of transporting it to market.
There are several types of information technology (IT) and sensors available today to help increase the efficiency of port and maritime shipping operations. While they all have their own important roles in vessel traffic management, it is important to note that in order to optimise efficiency and security, technology and sensors must be integrated to provide reliable, real-time information and decision-support data during any critical stage of maritime oil transport.
Vessel traffic management systems should integrate existing technologies into one seamless system and be open to accommodate future needs. Each system works together with the others to offer a complete picture of the port and surrounding waters.
To understand what kinds of port technologies are available today and how they might work together it is useful to examine a scenario of an oil tanker approaching and docking at an oil terminal.

Approaching the Port
When the oil tanker is within approximately 45 nautical miles of the marine oil terminal, it is in the transmission range of the Automatic Identification System (AIS) . The AIS transponder, which is onboard the vessel, automatically transmits - both ship-to-ship and ship-to-shore - using Self-Organized Time Division Multiple Access (SOTDMA) communications over VHF radio links. Ship position reports provided by the AIS transponders are automatically passed to the Vessel Traffic Management Information System (VTMIS) workstation at the Vessel Traffic Centre (VTC) through communication with the R30 Universal AIS base station transponder.
Likewise, ship-to-ship reports are implemented using the same SOTDMA communications. Sophisticated software is configured on each AIS to provide advanced navigational assistance and optional display of important environmental data. The AIS provides an electronic chart to plot own-ship position and course as well as position and course information from other AIS transponder-equipped vessels, including monitoring of all surrounding transponder targets and their available information such as position, speed and course.
AIS reports from ship-based transponders are received and processed by VTMIS 'expert software' to ensure that all safety and regulatory rules of the waterways are enforced. This function is automatically performed by the VTMIS using the operational (e.g., vessel position, speed, course) and physical (e.g., ship size, draft, cargo, etc.) vessel data reported by the AIS. The VTMIS will therefore establish whether the ship will violate any given navigation rule, forecast possible safety problems, and monitor, in real-time, the approach of the vessel.
In this hypothetical case, the vessel AIS sends a message to the VTC for an Estimated Time of Arrival (ETA) at 9:00 AM. The VTC acknowledges the AIS

message and uses the AIS connection to advise the vessel to increase its speed by five knots to benefit from high-tide in the port that will occur from 6 to 8 AM.
How does the VTC operator know this and how can the ship captain know how much he can carry and still leave two feet clearance throughout the entire route? The answer relies on the use of an Under Keel Clearance (UKC) system that utilises a series of underwater sensors to determine the real-time and the forecasted clearance between a given vessel and the bottom of the channel at several locations.
The UKC system provides a very accurate measurement of the predicted water depth under keel for the entire route, often in the range of ±10 cm for each individual vessel. The calculation is based on real-time measurements and vessel models. It integrates port geography, sail plans, bathymetry, weather, tide, current and vessel squat and provides now-cast and forecast for the planned route. The operator only needs to input the vessel parameters, which include shape, trim and draft, desired time to leave and sail plan, including speed, while allowing for notional situations. In this way the VTC operator will be able to determine that this particular laden oil tanker needs a certain amount of draft to dock and unload, which will only be available between 6 and 8 AM. Moreover, the UKC graphical display will indicate 'green', 'yellow' and 'red' portions of the route to better guide the vessel.
The system mathematically takes into account the tides, the vessel's size and expected cargo load to determine the best time for loading and/or unloading material. This increases the efficiency of the docking operation, which is extremely important to the companies that operate the vessels.
When the oil tanker comes within approximately 25 nautical miles of the port, the VTC's BOLD radar system BOLD begins to detect the ship. The VTC operator now can use the integrated data-base feature of the VTMIS to make a positive correlation between the AIS signal, radar track and database information. All these data are then 'fused' together to provide an unequivocal and clear picture of the incoming vessel, display information about her bearing and speed and keep track of all her operational and physical database information.
The VTC operator will be notified whether the incoming oil tanker needs pilotage to enter the harbour. If this is required, the operator will then update the VTMIS database, which is made immediately available on the port's Intranet website. This function is accomplished through specialised software called GIMNAUTE. Through GIMNAUTE the pilot, freight agent, shipowners and others can easily access updated information about the current traffic in the port and monitor, in real-time, the status of a particular load/unload operation or the location of a vessel (anchorage, berthing, etc.). The database integrity is maintained by the VTC whereas the external user normally accesses the Intranet page through a dedicated password.
GIMNAUTE also allows the actual VTC radar scenario to be displayed on the web.
A modern VTMIS must be capable of securing the safety of navigation and be ready to handle unexpected situations. We assume, for example, that two hours before the vessel is scheduled to enter the port, VTC operators are notified that there is another vessel in the area on fire about 10 nautical miles from the main entrance of the port channel. The VTC operator promptly uses the software functions embedded in the VTMIS to dispatch appropriate search and rescue teams and equipment and create a 'safety zone' around the distressed ship. This new emergency situation is immediately broadcasted through the AIS and traditional radio communication. All the ships with an AIS transponder will receive graphic and text data about the location of the vessel on fire and the location and extent of the safety zone which the VTC operator has created. In this way, the incoming oil tanker can now safely re-plan its entry manoeuvre and still be able to make it to port in time to unload.

Preparing To Dock
At approximately 5 nautical miles from the port, the pilot will make his rendezvous with the ship. The pilot was able to time his operation thanks to the prompt data

received through the VTC and GIMNAUTE. Moreover, the pilot carries with him a Pilot Carry Aboard Package (PCAP) system, which will help him during the approach. This specialized unit is a lightweight package that consists of a small laptop outfitted with dGPS and RF links. Using the PCAP the pilot can be constantly aware of all the navigation activities in and around the port. Moreover, he can communicate electronically with the VTC by exchanging textual and graphical data. The PCAP increases the pilot's 'situation awareness' and provides valid information to safely guide the oil tanker to her docking station.

Docking The Vessel

The pilot and the captain of the vessel now begin to dock at the port for unloading. They use the Laser Docking System (LDS) to approach the dock or the mooring buoy. The LDS is a highly accurate system that utiliSes a laser inferometer - the same technology used by NASA to dock satellites into space shuttles - to support the docking operations of large ships in the safest and timeliest manner possible. LDS has been proven to enhance safety and reduce the docking operation time by at least 40 percent. LDS-processed information is made available to the pilot and the captain over hand-held terminals.

As the vessel begins to unload oil, the oil terminal may use a Mooring Stress Monitoring System (MSMS) to monitor the mechanical integrity of the mooring system and the oil valves, which are normally subjected to stress due to oil tanker drifts. An excessive and uncontrolled mechanical stress may generate failures resulting in considerable economic and environmental problems.

In addition to the technologies mentioned in the above scenario, there are several new technologies being explored. The International Maritime Organisation (IMO), for example, is pursuing the possibility of long-range AIS so that ships at sea can communicate with each other as well as with ports halfway around the world. The long-range version of AIS would incorporate satellite technology, which is already in use on some larger ships and vessel traffic systems.

Another technology that is being tested experimentally allows the ship's captain or harbour pilot to use retinal imaging and a 'wearable computer' to navigate through narrow straits in difficult conditions, such as limited visibility. The virtual reality concept would require pilots to wear a special mask or eyeglasses to navigate through foggy or nighttime conditions.

Modern IT already offers several state-of-the-art solutions to support the management and safe navigation of oil tankers and large commercial vessels. However, integration of these sensors and systems is key to a proper utilisation of the processed data and to ensure a rapid return on investment.