Since the late 1990s, the use of computers for navigation onboard commercial vessels has steadily increased, particularly when the international S-57 standard electronic navigational charts (ENCs) and the IMO compliant Electronic Chart Display and Information System (ECDIS) become commercially available. In the Straits of Malacca and Singapore, shore-based facilities to monitor ship movement passing through either in transit or calling port have been established. These facilities rely on various modalities of communications (e.g., radar, radio and satellite) and are essentially coordinated by a network of computer systems as in the case for Malaysia and Singapore. Table 1 shows some examples of existing facilities and information technologies in place in the three littoral States.

### Table 1. Some examples of existing facilities and information technologies that are in place along the Straits of Malacca and Singapore for maritime safety and environment protection and management.

<table>
<thead>
<tr>
<th>Facility and Information Technology</th>
<th>Coverage in the Straits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Indonesia</td>
</tr>
<tr>
<td>VTS</td>
<td>v</td>
</tr>
<tr>
<td>Radar System</td>
<td></td>
</tr>
<tr>
<td>ENC</td>
<td>v</td>
</tr>
<tr>
<td>DGPS Broadcast Service</td>
<td></td>
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<tr>
<td>STRAITREP</td>
<td>v</td>
</tr>
<tr>
<td>Ship Routeing System</td>
<td>v</td>
</tr>
<tr>
<td>GMDSS</td>
<td>v</td>
</tr>
<tr>
<td>GIS-based Environmental Database</td>
<td>v</td>
</tr>
<tr>
<td>Pollution Dispersion Model</td>
<td></td>
</tr>
<tr>
<td>Oil Spill Trajectory Model</td>
<td>v</td>
</tr>
</tbody>
</table>

Advancements in information technology have significant impacts on the shipping industry. Many of the important navigational technologies and data are amenable to computerization. Examples are paper charts converted to ENCs, incorporation of some aspects of ship routeing system into ECDIS and audiovisual communications. Many of the newer commercial vessels are equipped with ENCs-ECDIS including integrated bridge system. However, majority of the present world fleet still use paper charts for navigation. The slow adoption of new technologies by the shipping industry is due to several factors among them are capital outlay requirement, training of mariners and limited sea area coverage of current ENCs. In general, however, there is increasing trend towards the use of computers onboard ships for navigation. The developments of maritime safety technologies are generally industry-driven and fairly in adherence to standards and performance criteria (e.g., ISO, IEC, IMO and IHO) unlike the development of information technologies in other sectors and disciplines. Although the process of development of
maritime safety technologies could be considered as quite conservative, there
is less proliferation of systems in various platforms and formats. This can
make data exchange and communication easier among users.

Information technologies on environment management and protection,
especially for coastal and marine areas applications are numerous such as
databases and analytical systems and cater to various sectors and levels.
Development in this field is very dynamic and at times, discordant.
Commercial systems range from simple to complex types and at varying
platforms, formats and prices. There are also numerous in-house systems
developed within academic and research organizations with more focused
applications. Unlike maritime safety technologies, environment management
and protection systems adherence to standards and performance criteria is
less rigorous. This allows for more flexibility to customize some systems to
meet client needs and/or applications. For example, geographic information
systems (GIS) have been applied in the management of coastal areas and
although both vector and raster data types are used, object representations
and specifications are not necessarily the same as defined by S-57 standard.
Generally, the base maps used in GIS are derived from topographic maps
rather than navigational charts.

The Concept of Marine Electronic Highway

The bulk of world trade, in tonnage terms, is transported by ships and
will remain so for many years to come. Economic development in many parts
of the world such as in the Asia-Pacific region will exert tremendous
sustainability pressures on the maritime industry, especially on future energy
demands. Such pressures will have bearing on the aging fleet of the maritime
industry and the ban on single hull tankers, burgeoning coastal populations,
and the need to address marine pollution from land- and ship-based sources
such as oil pollution and garbage. From the maritime industry perspective,
this will require a shift in policy and strategy to improve shipping operations
such as adopting mechanisms and processes that could reduce fuel cost and
insurance premiums, adoption of new technologies and management systems
to enhance safety of navigation and minimize the risk of pollution but ensuring
better commercial performance. From the marine environment management
and protection standpoint, a coherent monitoring and response programme
within a multi-sectoral setting would be needed since marine pollution has
transboundary implications in addition to social, legal and economic
dimensions.

Clearly, the sustainability of the maritime industry and the need to
ensure clean seas will require a coordinated and collaborative effort among
key stakeholders at local, national and international levels, that is, among the
public and private sectors, the industries, marine/coastal resource
management bodies/groups and NGOs, etc. This is particularly important in
highly congested and confined sea lanes that have high biodiversity such as
the Straits of Malacca and Singapore. A key determinant that ensures such a
coordinated and collaborative effort would be effective is the availability and management of up-to-date and reliable marine information.\(^1\)

Traditionally, management of information utilize by the maritime industry, particularly relating to navigation and emergency response is almost exclusive. The advancement in information technology and enhanced Internet connectivity are breaking barriers in the way information is used by the maritime sector but a large part is still focused on local and autonomous applications. As shown in Table 1, the Straits of Malacca and Singapore are well equipped with the latest in information technology compared to similar sea lanes elsewhere. Thus, the deployment of information systems in more mature applications such as in a marine electronic highway could lead to the integration of maritime safety technologies with marine environment management and protection systems resulting in improved performance, new capabilities and innovative applications.

The marine electronic highway (MEH) is envisioned to be a regional network of marine information technologies linked through the ENCs-ECDIS. The availability of differential global positioning system (DGPS) with accuracy between 1 and 5 meters provides the enabling technology to enhance the navigational accuracy of ENCs-ECDIS, especially in congested and confined waters.

Although the MEH is still conceptually being defined, some of the basic components can be outlined. From the technical standpoint, the MEH will have two components, namely maritime safety, and environment protection and management. Within maritime safety, three categories are recognized, namely, safety of navigation, precision navigation and emergency response. Precision navigation would be the backbone of the marine electronic highway upon which all the technological platforms would be integrated commencing with the ENCs-ECDIS (Fig. 1). Precision navigation consists of onshore, sea-based and ship-based facilities from which information and data flow into the network. The wide adoption of digital technology in the shipping sector will bring about enhanced precision navigation, for example the use of transponders such as an automatic identification system (AIS) and onboard access to the Internet.

With AIS, real time information can be automatically provided to and/or received from appropriately equipped shore facilities or other ships such information as the ship’s identity, type, position, course, speed and

\(^1\) In the context of this article, marine information is a broad collection of diverse types of information associated with activities in the coastal and marine environments such as shipping, fishing, coastal and marine management, marine conservation, maritime crime prevention, marine pollution response and prevention, etc.
navigational status. With enhanced AIS, hydrographical and oceanographic data (e.g., currents and depth, tides, visibility and sea state) including weather information can be transmitted and/or received which can greatly ease ship movement in restricted or congested waterways as well as during inclement conditions (e.g., improving the situational awareness of mariners). Currently, AIS is mainly used for exchange of basic ship information. However, future development could include other relevant information such as weather data. Thus, information flow could be real time, forecast, archive data, and monitoring/time lag data. The presence of a network of meteorological centres such as SEACAMP could provide higher resolution local weather conditions or forecast rather than a regional one that could be transmitted through the AIS allowing mariners to evaluate the weather hazard conditions along their route.

For environment protection and management, four categories can be identified that have bearings on the marine and coastal environments, namely environmental monitoring, protection and management, emergency response and risk/damage assessment. Currently, the technologies being utilized for environment protection and management are numerous with varying data formats. However, integrated systems are already in the market such as GIS linked to DBMS, statistical packages, remote sensing and, numerical models, etc., providing a wide range of applications including 3- and 4-D modelling. The latter can be useful in the marine environment where the seabed, water column and surface can be modelled such as on spill incidents associated with semi-buoyant heavy fuel oils or salvage operations. An example of a GIS-DBMS application in the Malacca Straits is the Straits of Malacca Environmental Information System (SMEIS).

System integration between maritime safety technologies and environmental information systems must never interfere with precision navigation. Thus, the flow of information among the various systems (e.g., data exchange, retrieval, storage, data translation, broadcast or online access) at various locations (at sea, onboard a ship or in a shore-based installation) must be properly regulated so that interference, poor reception and tampering could be minimized. Fig. 2 shows some of the possible system integration in the MEH and the flow of information from various platforms. Some of the issues affecting system integration that will be considered in the
action plans are security of online transactions, communication traffic, access costs, and protection against cyber crimes, among others.

The integration of the maritime safety component with the environment protection and management technologies will be the foundation of the marine electronic highway. This technical integration will be built from the perspective of end-users and their requirements and is one aspect of the MEH system. It will include new technologies, applications and management approach. Sustainable financing mechanisms, obligations associated with accession or ratification of international conventions, protocols, agreements and treaties, legal, institutional and administrative arrangements and political considerations are the non-technical aspects of the MEH that will have to be identified, assessed and integrated into the system.

The Marine Electronic Highway Project

The need and justification for an enhanced information technology system in the Straits of Malacca and Singapore such as a marine electronic highway (MEH) to address navigational safety and transboundary marine pollution issues was initiated by the Global Environment Facility (GEF) pilot phase project entitled, GEF/UNDP/IMO Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas in 1996. Among the forums organized by the Regional Programme where the concept of a marine electronic highway in the East Asian Seas was discussed, were the Regional Conference on Sustainable Financing Mechanisms - Public/Private Sector Partnerships in November 1996 and its annual Programme Steering Committee Meetings since 1996.

In 1997, the Strategic Ventures Corporation (SVC), a private company based in Canada completed a pre-feasibility study for the World Bank on the South East Asia MEH that focused primarily on the public sector stakeholder community. This was followed in 1998 by a contract from the International Finance Co-operation (IFC) on a feasibility analysis of the MEH with an emphasis on the private sector stakeholder communities. The inputs of both the World Bank and IFC studies underpinned the PDF Block B Application prepared by the GEF pilot phase project

In the ensuing years, a number of forums had examined the MEH concept, enhanced navigational safety and other issues such financial, legal and institutional mechanisms for the management of marine pollution and the Straits of Malacca and Singapore as a whole. Other issues on navigational safety that will have direct bearing on the MEH had also been covered in meetings of the Tripartite Technical Experts Group for the Malacca Straits and in conferences organized by the Institute of Policy Studies in Singapore and IMO.

In October 1998, a regional workshop was held in Singapore, entitled The Marine Electronic Highway: Bridging Navigational Safety and Marine Environment Management. The workshop determined that the technical
feasibility of electronic navigational charts (ENCs) for enhanced navigational safety and efficiency was already well established. It suggested that the efforts in the development of the MEH should be focused on the environmental aspects and benefits of the technology including the technical issues on the integration of ENCs and environmental information systems.

While the general outline of the MEH had been discussed in various forums and the major users (e.g., shipping companies, oil spill responders, environmental agencies), there are other aspects that need to be considered:

- Who will be other users of the highway and what are their needs?
- What technologies and services currently available among the three littoral States that will meet the needs of identified users?
- What new technologies and services will be required and how will they be packaged as part of the MEH?
- Who will provide these new technologies and services?
- What mechanisms will allow these technologies and services to operate efficiently and profitably within the marine electronic highway network?
- What are the financial implications of such technologies and services?

Essentially, the components of the Malacca Straits MEH will consist of physical infrastructure, hardware and software, processes and resources focusing on both navigational safety and transboundary marine pollution prevention. The system will also include economic, legal and institutional mechanisms that will allow it to be fully functional, efficient and sustainable but at the same, public welfare (safety and health) is not compromised.

**Project Objectives**

The Regional MEH Project will have three phases:

**Phase 1** - a prototype system in the Straits of Malacca and Singapore;

**Phase 2** - Network construction in priority waters from the Straits to Japan; and

**Phase 3** - Completion of the entire network with emphasis on oil and gas transportation routes.
The MEH Project will commence with a PDF Block B Grant Request prior to the implementation of Phase 1 and will be completed within a one-year period. This will be followed by the refinement of the Project Brief and the development of a project document to implement the first phase MEH. The timeline of the MEH Project is shown in Fig. 3.

The objective of the PDF Block B Grant is to reach consensus amongst interested stakeholders on the development and implementation of a regional MEH, which is to gather support for the implementation of Phase 1 as well as to collect additional information necessary to effectively plan the second phase, and to conduct an early analysis of a potential third phase. As for Phase 1, its developmental objective is to implement, through an “appropriate institution” a regional MEH, commencing in the Straits of Malacca and Singapore, which will be an essential tool for marine pollution prevention, marine pollution control, marine environmental planning and management, as well as safety of navigation. The World Bank is the implementing agency with the International Maritime Organization as the executing agency of the PDF Block B Grant.

Key Activities and Outputs

The PDF Block B MEH Project identified 6 key activities to achieve its objective as shown in Table 2.

Table 2. The activities and expected output of the PDF Block B MEH Project.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Activity Description</th>
<th>Expected Output</th>
</tr>
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<tbody>
<tr>
<td>Activity 1</td>
<td>Start-up phase and setting up a Steering Committee</td>
<td>Steering Committee established, recruitment of consultants, reports of two Steering Committee Meetings</td>
</tr>
<tr>
<td>Activity 2</td>
<td>Organization of two national workshops and consensus building</td>
<td>National MEH Action Plans developed, reports of two national workshops</td>
</tr>
<tr>
<td>Activity 3</td>
<td>Development of an Action Plan for the regional MEH, with a first phase in the Straits of Malacca and Singapore</td>
<td>Regional MEH Action Plans developed,</td>
</tr>
<tr>
<td>Activity 4</td>
<td>Organization of a regional workshop to develop agreement on the regional Action Plan, the implementing strategy and the first phase of the Project</td>
<td>Report of the plenary regional workshop; Review of the draft Regional MEH Action Plan and GEF Project Brief</td>
</tr>
<tr>
<td>Activity 5</td>
<td>Formulation of the GEF Project Brief</td>
<td>Initial draft GEF Project Brief reviewed at the regional workshop</td>
</tr>
<tr>
<td>Activity 6</td>
<td>Approval and endorsement of GEF Project Brief by the GEF National Focal Points</td>
<td>Refined GEF Project Brief as approved by the Steering Committee and endorsed by the GEF National Focal Points</td>
</tr>
</tbody>
</table>
Strategies and Approach

The MEH Project will have three key elements, namely, maritime safety, environment protection and management, and sustainable financing (Fig. 4). Within maritime safety, precision navigation constitutes the backbone of the marine electronic highway. Four key issues are fundamental to the advancement of the MEH technology to a first phase demonstration in the Straits of Malacca and Singapore, namely:

1. **Information technology**, and specifically the integration of existing technologies and capacities within the three littoral States with new and innovative technologies while focusing on the specific needs of users within the three countries as well as other users of the Straits;

2. **Socio-economic benefit** to the governments, industry/private sectors, and the civil societies in general as a consequence of the proposed MEH technology;

3. **Financing mechanisms/investment potential**, and the establishment of interagency, intergovernmental and inter-sectoral partnerships as vehicles for successfully developing, financing, constructing and operating the MEH as a self-sustaining, revenue-generating enterprise in the Straits; and

4. **Institutional arrangements**, with agreement among participating parties on the administrative, legal, financial and operational aspects of a “managing tool”, which will be responsible for implementing the first phase MEH project in the Straits.

To achieve the objective of the PDF Block B and pave the way for the implementation of the first phase MEH in the Straits of Malacca and Singapore, several strategies and approaches are envisaged.

Stakeholders Participation and Partnership

The ultimate success of the MEH Project as a whole entails building consensus among relevant and interested stakeholders at the local, national and regional levels. One of the mechanisms to involve relevant and interested stakeholders such as the governments of Indonesia, Malaysia and Singapore, the private sector including technology/data providers and users, user States and relevant international bodies is the establishment of a steering committee at the national and regional levels.
Each country would have a role in defining the MEH technology and the existing/available systems and capacities that would contribute to the MEH development including potential uses and users as well as the benefits that will accrue and obligations required. The establishment of an inter-sectoral and inter-ministerial body such as a National Steering Committee can galvanize and coordinate such efforts. Additional institutional arrangements would be the establishment of a lead agency and a National Focal Point.

At the regional level, the Project Steering Committee is established composed of the National Focal Points, the GEF/World Bank and IMO. Other potential members are from the private sector (i.e., technology providers and users), shipping industry and special bodies like the Tripartite Technical Experts Group and from the user States. Observers from interested institutions and organizations are invited to participate in its technical sessions. It is envisaged that over time, certain private sector groups will be members of the Project Steering Committee from which a “managing tool” will emerge.

Aside from providing a technical description of the MEH, the Action Plan for a regional MEH will include an estimate of investments and operating costs, assessment of the economic impacts potentials and market sector analysis (i.e., users, their needs and willingness-to-pay), among others. Apart from the design of the “managing tool”, proposals will be prepared to include an implementation plan, an operational plan, and an evaluation of incremental cost and identification of co-financing. The participation of user States in the development of the MEH, particularly as regard sustainable financing would take into account the provisions of Article 43 of the UNCLOS since part of the Straits of Malacca and Singapore is an international sea lane.

Refinement of the MEH concept

The concept of what is a marine electronic highway, its composition and operating mechanisms are at the present time, rather fragmentary. It is the major task of the PDF Block B Grant to define the technical specifications of an MEH for the Straits of Malacca and Singapore.

Action Plans, GEF Project Brief and Workshops

The development of the technical description of the MEH and its financial components as well as the legal and institutional arrangements will be dealt with in several levels. At the national level, each littoral State will identify and describe all the mechanisms already in place in the Straits of Malacca and Singapore that are within their territorial jurisdiction covering maritime safety and environment protection and management such as technologies/infrastructure, regulating instruments, capacity, budgetary allocation, management systems, operation and maintenance modalities, among others.
In addition, gaps and constraints including benefits derived from them will also be quantified. The level of interagency co-ordination and cooperation as well as system integration will be critically assessed to determine the technical, legal, institutional, financial and management barriers and how to overcome them.

Potential technologies and mechanisms to enhance maritime safety and environment protection and management will also be identified and assessed including gaps and constraints to system integration (e.g., data compatibility and quality), operation (e.g., transfer, retrieval and use), management, maintenance (e.g., update and quality control) and sustainability.

For the regional MEH, similar approach in the development of the national MEH will be carried out. However, additional considerations will be placed on the existing/available regional infrastructure and mechanisms, contributions of user States and international bodies including obligations, constraints and gaps arising from Article 43 of the UNCLOS and other international instruments.

**Multisectoral Team of Experts**

Three national action plans (Indonesia, Malaysia and Singapore) and a regional action plan will be developed based on the above-mentioned processes. A multisectoral team of experts recruited for the Project together with a Project Manager will be tasked to develop the action plans in closed consultation with the governments and the Project Steering Committee. The regional Action Plan will also include an implementation and operational plan for the first phase and an initial implementation plan for the second phase.

Review, validation and refinement will be carried out on each of the action plans at the national and regional levels through workshops. Two national workshops will be undertaken by the Project while a third one will be organized by Singapore. The national workshops will have the following purposes:

- Communicate and refine the concept of the MEH;
- Identify potential uses in navigational safety and in marine pollution control and prevention;
- Develop a national MEH operation definition and a national action plan that will include a co-ordinating mechanism;
- Develop an improved regional MEH operation definition; and
- Create awareness and support for the first phase of the MEH in the Straits.
Under the regional workshop, review and assessment will cover the regional Action Plan as well as the first draft of the GEF Project Brief. The GEF Project Brief details the strategy, outputs, activities, coordination mechanisms, implementation schedules and partnership requirements to develop, construct and operate the Regional MEH with a first phase in the Malacca and Singapore Straits. It also provides a general overview of the activities for the next stage of the MEH Project leading to the implementation of the first phase regional MEH including work schedule, expected outputs and project monitoring and evaluation process. The regional workshop will outline and develop a consensus on the first phase of the regional MEH and formulate an implementation plan that will assist the stakeholders in addressing and overcoming any gaps and barriers associated with the construction and operation of a full-scale MEH system.

**Status of the MEH Project**

On 7 November 2000, the World Bank approved, in principle, the PDF Block B Grant. Start up activities was initiated by IMO such as the holding of consultative meetings with relevant government agencies in the three littoral States of Indonesia, Malaysia and Singapore, establishment of country organizational framework and preparations for the first Project Steering Committee Meeting and the recruitment of project personnel. A Letter of Agreement was signed on 12 March 2001 between the World Bank and IMO to implement the PDF Block B Grant.

In 19-20 March 2001, the first Project Steering Committee Meeting was held in Putrajaya, Malaysia. The meeting achieved the following:

- the Project Steering Committee was firmly established;
- firm commitments from the governments of Indonesia, Malaysia and Singapore to the MEH Project were assured;
- Terms of Reference of the Project Manager and three Technical Consultants were approved;
- Initial review of the curricula vitae of candidates for the Project Manager and the three Technical Consultants was carried out; and
- Work plan has been agreed.

Recruitment of the Project Manager and Technical Consultants has been completed and the implementation of the remaining five project activities is underway.

Jp APRIL 2001