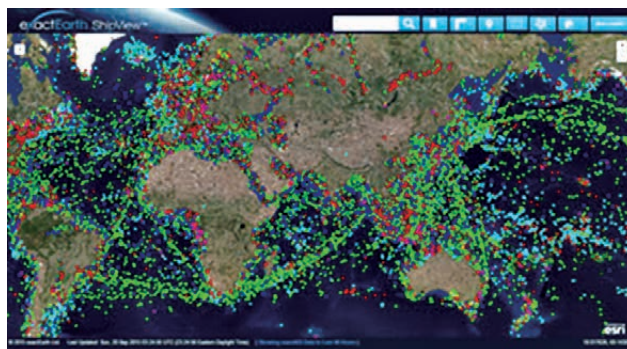
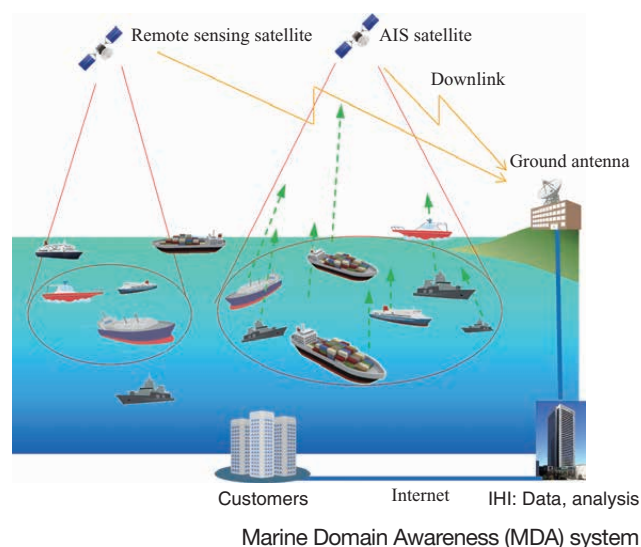


# Track Ships from Space

## Provide safer and optimized marine logistics using satellite AIS

IHI covering a wide range of business areas can contribute to solving problems in various fields using data acquired by satellites in space.

This report introduces applications for using satellite AIS (Automatic Identification System) messages currently focused on as new data.



Global ships tracking captured by AIS ©exactEarth

### Panoramically viewing from space

When viewing the earth from space, the shiny blue sea spreads below. The ratio of the sea to the earth's surface is approximately seven tenths. The vast sea also serves as the artery of world economy, which assumes nine tenths or more of international distribution. We wonder if by panoramically viewing the movements of ships which can also be regarded as pulsing motions, we can respond to needs such as grasping/monitoring global marine traffic, grasping the situation of and enhancing the efficiency of port logistics, and further grasping world economy. From such a perspective, this report introduces activities related to AIS messages focused on as new satellite acquisition data, which IHI is currently working on.

### AIS and its potentialities

AIS is a system having been required to be equipped in IMO (the International Maritime Organization) passenger ships, all ships engaging in international voyages and having a gross tonnage of 300 or more, and all ships not engaging in

international voyages and having a gross tonnage of 500 or more since 2002. Ship information is automatically transceived through radio waves among ships to grasp the movements of nearby ships. The AIS messages include the identification numbers, positions, speeds, courses, and so on of ships under way, and is used to avoid the collision between ships.

Due to the rectilinearity of a radio wave, the AIS messages cannot be transmitted beyond the horizon, and therefore applications other than communication between nearby ships were limited. However, in 2008, a satellite equipped with an AIS receiver was launched to enable the acquisition of AIS signals from ships traveling on oceans, so the situation was completely changed. "AIS data services" is a very promising market whose sales increase by 10% or more every year.

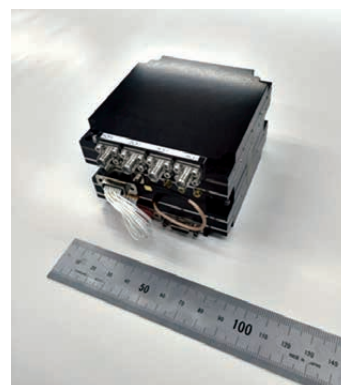
Since the acquisition of the AIS messages by satellites enables the activities of ships on the global ocean to be grasped, the AIS messages are expected to be applied mainly to the following two fields.

One is ship position recognition for responding to the need to know the current positions of ships for some purposes such as marine situation monitoring. The other one is to

Dynamic data	Static data	Voyage related data
<ul style="list-style-type: none"> <li>· Position</li> <li>· Time</li> <li>· Heading</li> <li>· Speed</li> <li>· Course</li> <li>· Navigation status (at anchor, etc.)</li> <li>· Rate of turn</li> </ul>	<ul style="list-style-type: none"> <li>· MMSI/IMO name</li> <li>· Name Call sign /Name</li> <li>· Overall dimension</li> <li>· Type of ship</li> <li>· Reference of position</li> </ul>	<ul style="list-style-type: none"> <li>· Draught</li> <li>· Dangerous goods</li> <li>· Destination</li> <li>· Estimated time of arrival (ETA)</li> <li>· Safety related information</li> </ul>

(Note) MMSI : Maritime Mobile Service Identity code

### What is AIS messages?



Spaceborne AIS receiver

respond to the need to grasp the entire flow of ships (distribution). By using the AIS messages, each shipping company can grasp the entire flow including not only their own ships but the other companies' ships.

IHI had paid attention to the potentiality of the satellite AIS from early on, and in 2013, started the AIS data services. IHI had also worked on the development of an AIS receiver capable of coping with the interference among AIS signals, which was a problem when a satellite acquired an AIS signal, and the development of a demodulation system as well.

The AIS data services are currently provided by IHI Jet Service Co., Ltd. (IJS). In cooperation with exactEarth (eE) of Canada, the No. 1 company in the field of the satellite AIS data services, IJS is consolidating a position as an "AIS data services" provider. In addition, IHI is advancing the development of an IHI's original AIS receiver system, and aiming to provide the AIS messages with good quality even in areas where it is difficult to acquire AIS signals due to signal interference, such as the East China Sea and the Mediterranean Sea.

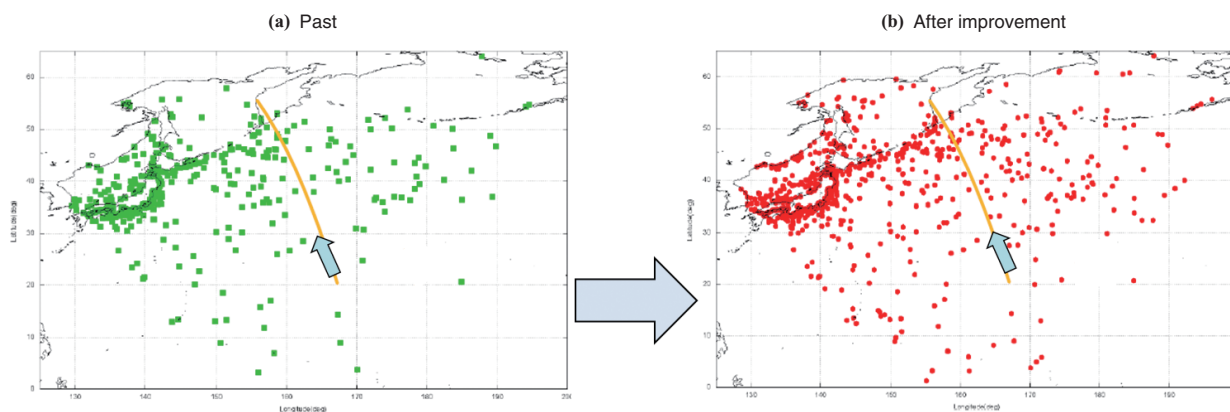
### Development of AIS receiver system

The problem occurring when a satellite receives AIS signals is the difficulty of receiving the signals due to signal interference when a given area has quite a heavy volume of ship traffic.

AIS was originally developed on the assumption of the communication among nearby ships, and therefore to prevent the signal interference, automatically groups nearby ships to transceive signals. When a satellite at an altitude of several hundred km receives AIS signals, it receives the AIS signals from many ship groups simultaneously, so interference occurs. This makes it difficult for a satellite to acquire AIS signals in a sea area where many ships are under way.

IHI set, as follows, the design concept of a satellite AIS receiver system whose acquisition rate was improved by minimizing factors causing a reduction in acquisition rate of the current satellite AIS receiver system, and developed it.

- (1) The spaceborne AIS receiver is set as a "sampling receiver" adapted to convert an AIS radio wave in orbit into the most faithful possible digital waveform signal. An increase in waveform restoration accuracy enables an improvement in AIS signal acquisition rate to be expected on one hand, and on the other hand, an increase in sampling rate increases a data amount, which may place a burden on communication resources from a satellite to the ground. Therefore, the receiver is provided with a sampling rate reduction function for very low-density areas, such as the Pacific Ocean where there is little traffic.
- (2) For the demodulation system for separating a signal from a waveform, algorithm based on the assumption of



Improvement in acquisition rate by developed demodulation system

AIS signal interference is developed. Installation on the ground enables future expandability to be ensured.

The spaceborne AIS receiver developed together with MEISEI ELECTRIC CO., LTD. achieved a reduction in size to approximately  $8 \times 8 \times 6$  cm. The receiver can also be equipped in a very small satellite called a 3U CubeSat of a 3U size ( $10 \times 10 \times 30$  cm) recently focused on because of its low launch cost. In addition, the receiver is very small, and can therefore be easily equipped in a small gap inside a middle-sized satellite as well.

The comparative verification of the developed demodulation system was performed. As a result, a signal was restorable even under the presence of interference, and the ship signal acquisition rate was improved by two times.

We will continuously vigorously proceed with preparation for performing the on-orbit verification of the developed very small spaceborne AIS receiver and demodulation system in combination.

## Application to MDA

In the past, it was difficult to find out a ship traveling across the open ocean. However, the advent of the satellite AIS enabled the positions of ships on the sea to be easily grasped by, in space, acquiring AIS signals transmitted by the ships, and served as a trigger for the recent development of Maritime Domain Awareness (MDA) for grasping the movements of ships.

Basically, ships traveling across the open ocean must always transmit their AIS signals, but there are some exceptions. For example, if a fishing vessel in a fishery keeps transmitting a signal, the fishery is known by other fishing vessels, and is therefore permitted to stop transmitting the signal. Also, public vessels such as warships are permitted not to transmit their AIS signals. On the other hand, unidentified ships intentionally turning off their AIS signals are also present. Finding out such ships traveling turning off their AIS signals

and providing real-time AIS capable of constantly acquiring AIS signals are the problems of MDA.

The constant acquisition will be achieved by 2018 using 58 earth orbiting satellites by eE for which IJS became a distributor.

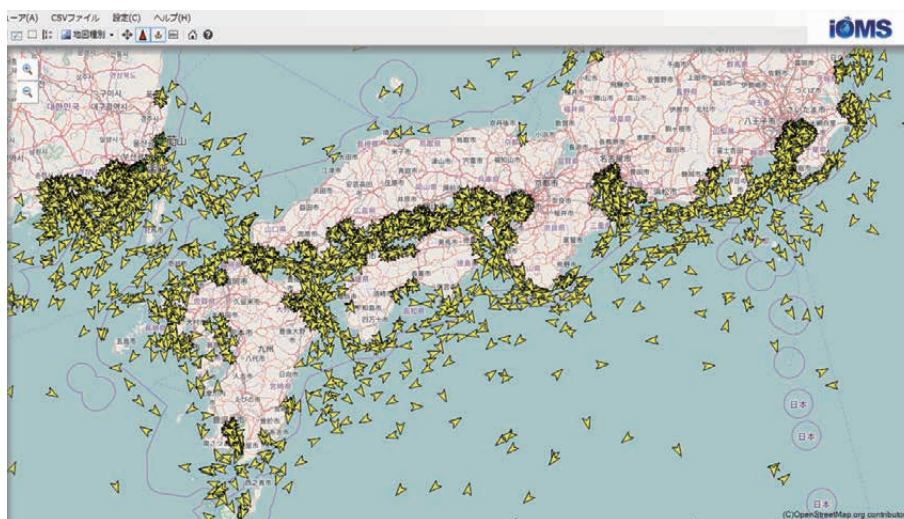
Since fishing vessels and unidentified ships are thought to transmit their AIS signals when departing from their ports, by providing the real time AIS, places where signals are stopped can be recognized as suspicious sea areas, and patrol vessels or other such ships can be dispatched as necessary.

On the other hand, a ship not transmitting an AIS signal from the start, such as a warship, can be found out by a satellite radar (Synthetic Aperture Radar: SAR). In general, when attempting to view a wide area with SAR, resolution deteriorates. Therefore, technology for detecting a ship while monitoring the widest possible area with low resolution is required. Accordingly, IHI fully utilized image analysis technology to develop technology capable of detecting a ship of a size equal to or less than resolution. Further, technology capable of identifying the class of a detected ship is also under research.

MDA becomes increasingly important for Japan as an island country in terms of marine resources maintenance, islands security, and so on. IHI is contributing to Japan's MDA by means of real-time AIS messages delivery and SAR image analysis together with IJS.

## Big data analysis

Another feature of the AIS messages is capable of acquiring ship information including not only the position and speed of a ship but the name, class, destination, and so on of the ship independently of affiliation. As compared with a conventional situation where a shipping company or an operation control company uses dedicated communication services to track the movements of their own ships, by using the AIS messages, an information amount drastically increases, and the



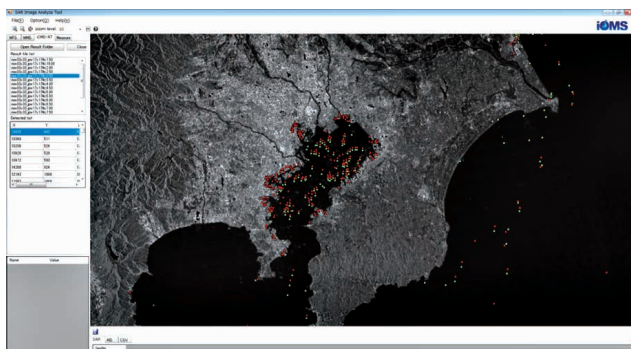
©exactEarth

eE's satellite group covering entire earth

movements of ships including the other companies' ships can be grasped. When focusing on each single message, the movement of a specific ship can be tracked.

Together with Niigata Power Systems Co., Ltd. (NPS), we are currently examining the application of AIS messages to maintenance services for marine engines using the feature enabling the tracking of the movement of a specific ship. The orderer of an engine and a ship owner who is the end user of the engine are often different, and a ship is also often resold. Therefore, grasping and tracking the position of a ship is a problem in the aftermarket. If it is possible to grasp information and operational information on a ship mounted with an NPS engine by estimating an operating time using AIS messages, product maintenance can be timely proposed to the customer of the ship, and also the stable and safe operation of the product can be provided to the customer.

Meanwhile, it is also expected to forecast marine distribution, the congestion degree of a port, and so on by macroscopically grasping AIS messages to perform big data analysis. We think we would like to also use AIS messages for proposal of solutions to port efficiency enhancement and port optimization in combination with a port distribution-related IHI's product family, port cranes, automated guided vehicles, automated warehouses, and so on.



Ship detection results based on SAR image  
(Green dots represent ships detected by SAR  
and red represent ships by AIS)



Tracks of individual ships (Example)

## Toward problem solution from space

We will work on solving marine and distribution problems such as, in addition to grasping the movements of ships, marine monitoring, ship maintenance services, port distribution, and so on by tracking ships from space using the AIS messages as new satellite acquisition data.

Further, we will support solving customers' problems by linking a wide range of IHI's activity area to data obtained from space.

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