Analysis of capabilities and application characteristic of AIS

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ABSTRACT

This paper compares and analyzes the capabilities and application characteristic between the shipborne AIS and ARPA Radar、AIS base station and VTS Radar, give a brief introduction of the AIS base station network's building and application in China, and give a discussion on the information fusion and technology integrated of AIS and ARPA Radar, AIS base station network and VTS Radar.

1. Background

AIS is an international standard for ship-to-ship, ship-to-shore and shore-to-ship communication of information, including vessel position, speed, course, destination and other data defined by ITU-R Rec. M.1371-1. AIS transmits on 161.975 MHz and 162.025 MHz, as specified by Appendix **18** of the Radio Regulations and by Rec. ITU-R M.1371-1. AIS was originally designed to enhance navigation safety, but its potential as a prime contributor to security quickly became apparent. AIS provides an effective means to monitor the total global marine environment that could affect the security, safety, economy, or environment of an Administration.

On December 6, 2000, the International Maritime Organization (IMO) amended Chapter V of the Safety of Life at Sea (SOLAS) Convention to include an implementation schedule for shipboard AIS carriage requirements. In 2002, in response to the needs of Administrations to improve their security, the IMO accelerated the AIS carriage requirements schedule from a phased approach ending in 2008, to require all vessels over 300 gross tons on international voyages to carry AIS equipment by 31 December 2004.

From Figure 1 we can know that ECDIS has a longer history than AIS, but AIS made a rapid development in recent years

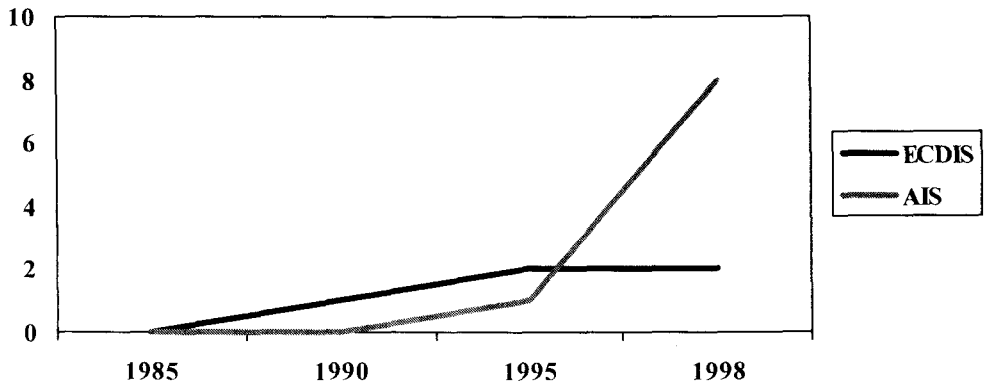


Figure 1 AIS Development Cycle

As we know that ARPA radar plays an important role in the collision avoidance area before AIS's appearance. Since AIS has too much advantage in enhancing navigation safety, especially in collision avoidance area and VTS. So people will ask: can AIS take the place of ARPA Radar in this area?

2. Capabilities and application characteristic of AIS and ARPA Radar

AIS and ARPA Radar all can be used in the collision avoidance area, but they have different capabilities and functionalities.table 1 will give the difference of them.

Table 1 capabilities and application characteristic of AIS and ARPA Radar

	AIS	ARPA
Dynamic object capture	Yes(which AIS installed)	yes
Weather and environment influence	none	have
Radiate route influence	none	have
Collision avoidance information	More	few
Update rate	2s to3min interval	antenna Scan interval 3s
Object position (λ , φ) description and precision	(λ , φ) 1/10000 min (0.1582m)	none
Object position precision	≈15m(DGPS 5m)	≈80m
Relatively motion vector displaying	None	have
Collision estimation and alarm	None	have
Collision avoidance operation	simple	complex
Motion vector update follow with rudder	Fast, about 3s	About 9s
Vector data stability time	real-time	About 3min

2.1 Analyses of capabilities and application characteristic

2.1.1 Advantage and disadvantage of AIS in collision avoidance area

AIS is a system which broadcasts the position, identification and other data of a vessel at sea. AIS is centered around automatic data transmissions regularly (typically every 2s-3 minutes) broadcast by vessels at sea using a dedicated marine VHF.

AIS set broadcasts its ship's identity (MMSI) position, course, speed, ship type and rate of turn and other information and incorporates a facility to send short text (binary) messages. All of the information AIS broadcasted is helpful in anti- collision.

Like Radar, AIS works perfectly at night and thick fog. Unlike Radar, because AIS depends on VHF which is neither cut off by intervening cliffs nor confused by sea or rain clutter, AIS offers a huge advantage over Radar in supplying other ships with a continuous, clear information stream.

AIS also have some principal drawbacks in collision avoidance area.

Firstly, not all vessels will fit the AIS transponder compulsively, so own ship can not obtain the information which vessels have no AIS equipment; this is deadly drawback of AIS.

Secondly, AIS depends on GPS (from which both time-slot governance and position-fixing is derived). In the long term these data may be got from other systems including e.g. Galileo, GLONASS and Loran but all are vulnerable in some way.

The third, AIS will include integrity of ships' own data, the information broadcast by a ship may be wrong due to an individual malfunction: receiving stations may have no means of assessing the data received.

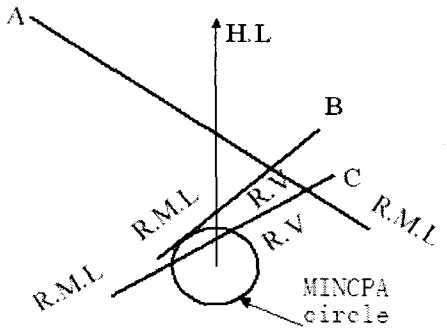
The fourth, a ship may switch off its AIS transmissions at any time.

The fifth, the system is vulnerable to spoofing (transmission of inaccurate or false information) and jamming.

Finally, AIS's antennae must be mounted as high as possible and well separated from other antennae.

2.1.2 Advantage and disadvantage of ARPA Radar in collision avoidance area

ARPA equipment provides for manual or automatic acquisition of targets and the automatic tracking and display of all relevant target information for at least 20 targets for anti-collision decision making. ARPA can give an intuitionistic danger of collision, and it also enables trial manoeuvres to be executed. Moreover, as long as own ship have fitted the ARPA radar, object around will be captured whether AIS equipment is fitted or not.
Figure 2



CPA > MINCPA TCPA > MINTCPA	safe ship A
CPA ≤ MINCPA TCPA> MINTCPA	danger ship B
CPA ≤ MINCPA 0 < TCPA ≤ MINTCPA	very danger ship C

Figure 2 danger of collision,

The ARPA radar also has some drawbacks in anti-collision area. The accuracy of range and bearing is the deadly drawback of ARPA Radar. Moreover, in very busy areas, like harbors, rivers and archipelagos, the need for a high update rate beacon mode AIS is evident. The limitations of the ARPA radar to track ships due to target swapping from a ship to land, beacons, bridges and other ships makes the ARPA capabilities very limited in narrow and congested waters.

3. VTS and AIS base station network development status

3.1 Background

The world's first harbor surveillance Radar was inaugurated in Liverpool, England, in July 1948 and in March 1950,a Radar surveillance system was established at Long Beach, California - the first such system in the United States. The ability of the coastal authority to keep track of shipping traffic by Radar, combined with the facility to transmit messages concerning navigation to those ships by radio, therefore constituted the first formal VTS systems.

With the rapid development of international shipping and harbor, ensuring the navigation safety , more and more VTS was built in recent 30years in China. Since 1978 the fist VTS project startup ,China has built Dalian ,Yingkou Qinhuangdao,Tianjin ,Yantai, Chenshantou, Qingdao, Lianyungang, Changjiang(nan-liu),Shanghai, Ningbobeilun ,Xianmen, Guangzhouhuangpu Shenzhen ,Zhangjiang, Haikou ect. more than17 VTS system, 50 VTS Radar station to enhance the navigation safety.

Network of AIS Base Stations is the most reliable method of using AIS technologies. The AIS Network guarantees coordinated operation of all the AIS base stations, absence of collisions and effective use of VHF

data link and data communications channels in a given area. AIS Network systems can solve problems common for the given area in a centralized manner, e.g., transmission of DGNSS corrections via VHF data link, or work with AtoN.

Because of the advantage of the AIS base station network, most of country in the world has built the networks one after another. There are more than 14 countries or region which has built it. They are Norway, Sweden, Finland, Singapore, (west) Malaysia, Australia, Portugal, Canada, Japan, turkey, South Africa, Unite Sates, Hong Kong of China, China etc. Most of the countries above are in the base station network building and basic application stage. A few countries are in network application stage.

Thus, AIS will become an important supplement to existing communication systems. In general, data received via AIS will enhance the quality of the information available. AIS is an important tool :- for increasing situational awareness of the traffic situation among all users, and- for optimizing traffic flow without incurring significant additional burden on users.

3.2AIS base station network's programming and current status in China

3.2.1 Programming

The network programming is set down by shanghai MSA and Shanghai traffic design institute under the MSA of ministry of communications of China in 2004. According to the programming, 122 AIS base stations, 22 local area networks, 3 local ASM and 1 national ASM will be constructed in china. It costs 4 hundred million Yuan to build the whole AIS network in china.

3.2.2 Current status

There are 4 networks built in the past 3yeasrs in China ,they are Changjiang river Mouth network, Zhujiang river Mouth network, Bohai Bay network and Qiongzhou Strait network. A distribution of each network is showed as below:

Changjiang river Mouth network

The whole system includes: 4 AIS base station, 1 local area network surveillant center and 1 relay station, the detail is showed in Figure3.

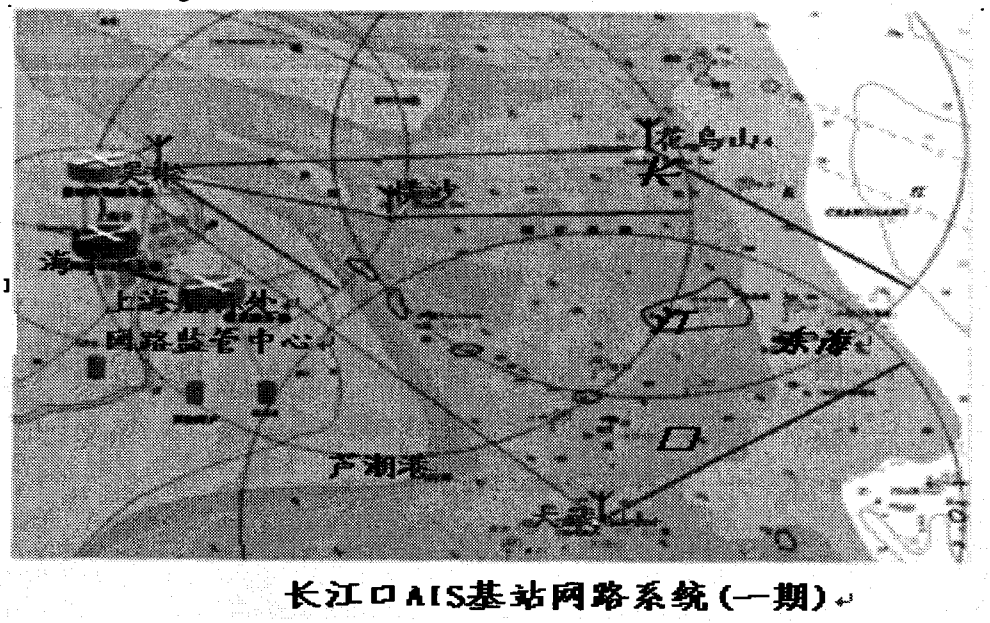


Figure3 Changjiang river Mouth network

Zhujiang river Mouth network

The whole system includes: 4 AIS base station, 1 local area network surveillant center and 7operation terminal on ECDIS, the detail is showed in Figure4.

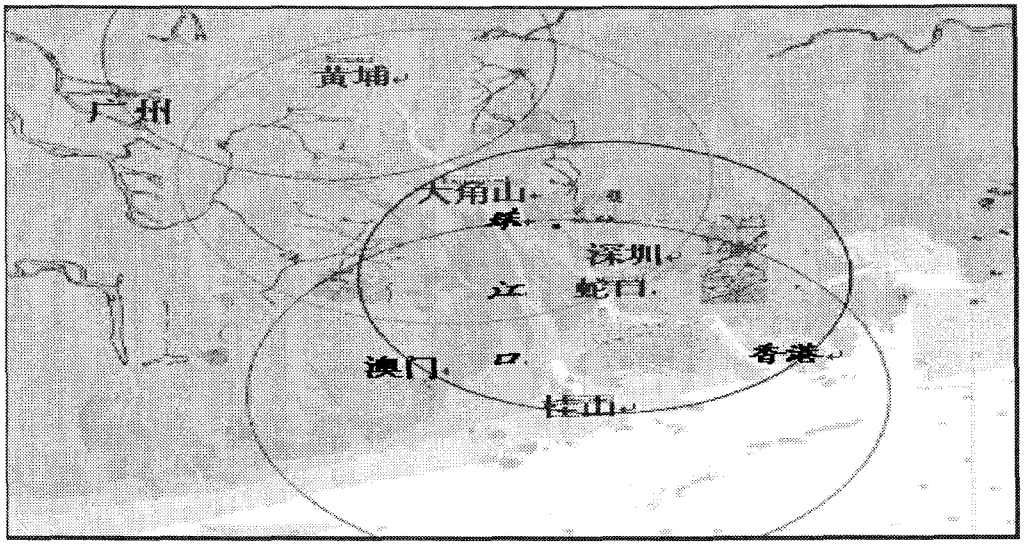


Figure4. Zhujiang river Mouth network

Bohai Bay network

The whole system includes: 4 AIS base station, 1 local area network surveillant center and 2 local area network surveillant sub center .the details is showed in Figure5.

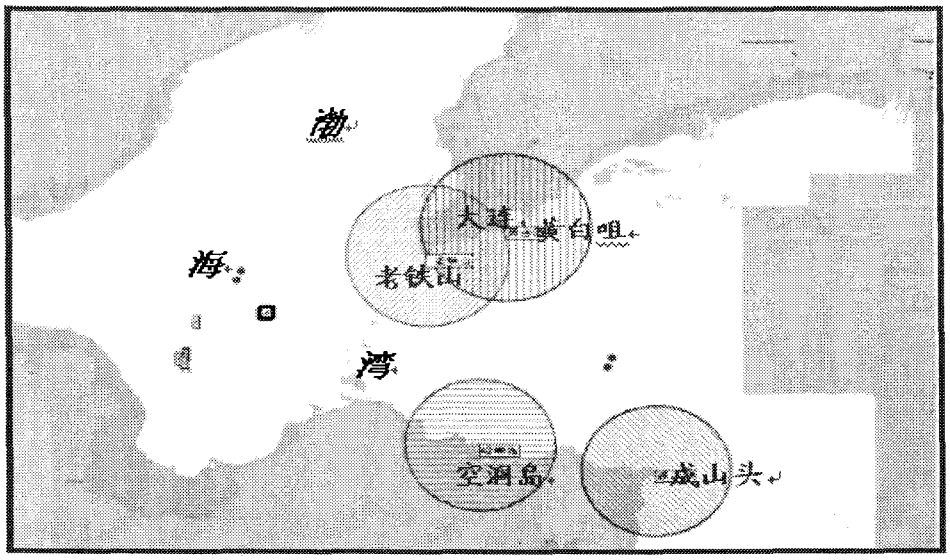


Figure5 Bohai Bay network

Qiongzhou Strait network

The whole system includes: 3 AIS base station, 2relay station,1 local area network surveillant center. the details is showed in Figure6.

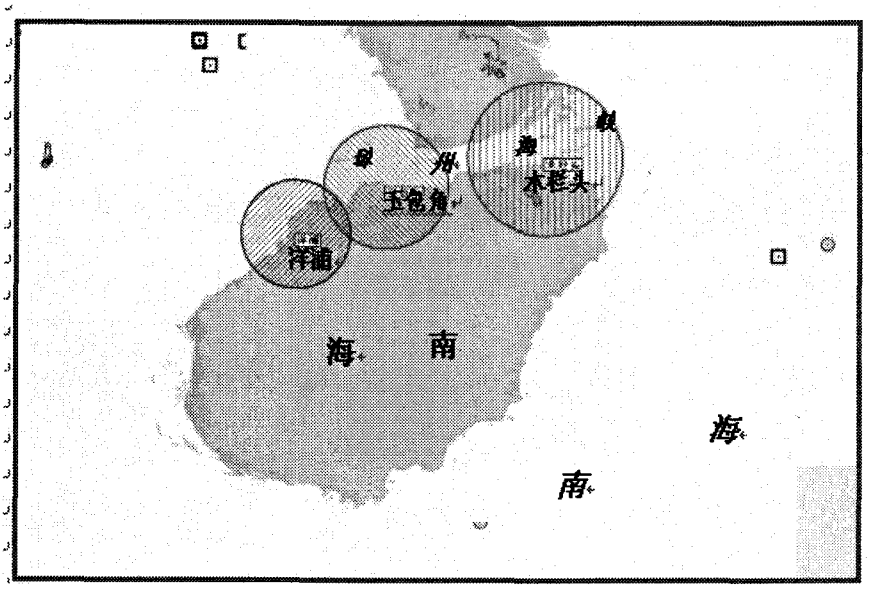


Figure6. Qiongzhou Strait network

The second stage of the network:

According to the programming, there are 4 AIS base station and 1 local area network surveillant center which will be built in North Zhejiang Province and 3 AIS base station, 1 local area network surveillant center in South Zhejiang Province. 5 AIS base stations and 1 local area network surveillant center will also be built in Fujian Province. There are 4 AIS base station and 1 local area network surveillant center which will be built in South Taiwan Strait .Moreover, 1 AIS base station and 6 AIS base stations will be built in Lianyungang port and Hainan Province

4. Capabilities and application characteristic analysis of AIS base station and Radar in VTS

4.1 limitation of Radar in VTS

Before AIS, VHF-DF and Radar is used to identify the vessel by the operator. It will cost more time and the information obtained which is limited, with the increasing density of vessels in port, it will bring more difficulty in the operation.

Radar data processing system is used in most of VTS. Because of the limitation of the radar signal, the detection ability will be restricted by the weather and environment, and the range and azimuth resolving power is also restricted. This will not only bring on the restriction of the object capturing and tracking, but also the resolving power and reliability directly. So object echo signal resource is the bottle-neck of the data processing technology in VTS.

4.2 advantage of AIS base station network in VTS

AIS is an additional source of navigational information. AIS supports, but does not replace navigational systems such as Radar target tracking in VTS.

In general, AIS tracking offers the following significant benefits:

. highly accurate information;

. provided in near real-time;

. capable of instantaneously presenting target course alterations;

. not subject to target swap;

. not subject to target loss in clutter;

. not subject to target loss due to fast maneuvers, and;

. ability to 'look' around bends and behind islands.

In addition, AIS can:

. 'look' behind the bend in a channel or behind an island in an archipelago, to detect the presence of other ships and identify them;

. predict the exact position of a meeting with other ships in a river or in an archipelago;

. know which port and which harbor a ship is bound for;

. know the size and the draft of ships in the vicinity;

. detect a change in a ship's heading almost in real time;

5. Conclusion

The AIS system that will be brought into effect can improve shipping security for its more accurate information of target position and target identification. But it can not replace Radar in collision avoidance and VTS. Making use of the fusion of Radar and AIS data should be a new trend in the navigation technology

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