

# AIS 기반 관제의 문제점 보완 및 모니터 화면 개선을 통한 관제향상 방안

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**요약** : 기존 RADAR 기반의 VTS에 AIS를 연계·집약하면서 예측 불가능한 데이터 전송률에도 동일선박으로부터의 AIS 및 RADAR 데이터는 상관관계를 유지하면서 물표에 대한 Tracking이 지속적으로 이루어져야 하지만 AIS 신호 Lost시 RADAR Tracking 자동 전환이 안 되는 경우가 많이 발생하고 있다. 또한 3개의 VTS 모니터 화면에 각각 다른 Scale과 다른 관제구역이 디스플레이 됨으로써 특히 모니터 가장자리 부근의 관제구역은 사각지대로 관제사의 집중도가 떨어질 수밖에 없다. 이러한 문제점들은 관제사의 Traffic Image구성 및 Situational Awareness를 방해하는 요소로 작용하며 사고의 개연성을 높이고 있다. 본 연구에서는 VTS 모니터상의 화면 재구성 방법을 통해서 관제사의 SA를 돕고, AIS-RADAR Tracking 알고리즘 보완을 통한 Target Tracking의 안정성을 확보하고, 교육·훈련을 통해서 AIS특성과 Error현상에 대한 관제사들이 충분히 이해하도록 하여 관제업무의 향상을 기하는 방안을 제시하였다.

**핵심용어** : AIS-RADAR, MMSI, Target Tracking, Correlation, Swiss cheese, Human Error, Auto Acquisition Zone

### 1. AIS사용 관련 한계

**LIMITATIONS ASSOCIATED WITH USE OF AIS**

Although AIS has the potential to greatly enhance VTS operations, the system does have several limitations or potential drawbacks.

- VTS operators may become overly dependent on AIS, and, therefore, may treat the system as a sole or primary means for vessel identification; as a result, they may fail to identify contacts, because all vessels may not be equipped with AIS;
- AIS has the same vulnerabilities as VHF-FM;
- When a AIS unit reaches its saturation point (maximum number of transmission receipts), TDMA prevents overload of the AIS unit by culling transmissions, accepting those closest to the unit and eliminating those furthest away, a feature particularly useful to ships, which must pay particular attention to those vessels in closer proximity; however, this feature could prove detrimental to VTS operations that must service a large area and must give equal priority to areas distant from a VTS AIS site(s); this can however be overcome by better coverage through the addition of more base stations and/or repeaters.
- AIS is not intended to be a general communications means; therefore, to match general communications requirements, mariners and VTS operators should use the appropriate and emerging new general communications technologies.
- Whilst AIS tracks will avoid the great majority of radar shadow effects, the very close proximity of buildings and bridges, sometimes known as the "urban canyon" effect, can degrade the AIS positional information. This is a consequence of inhibiting either the reception of the differential GNSS signal by the AIS station, or the transmission of the subsequent AIS message.

**CAUTION when Mariners use AIS**

- AIS is subject to the vagaries and limitations of VHF-FM propagation.
- Not all ships carry AIS, ex) pleasure craft, fishing vessels and warships etc.
- Government agencies and owners should ensure that watch-keeping officers are trained in the use of AIS, and are aware of its limitations.
- under certain circumstances, may be switched off.
- be aware the accuracy of AIS positional information is the accuracy of the GPS connected.
- Mariners are reminded to periodically check that correct information is being broadcast by their own vessel, particularly position, heading (provided by the ships master gyro) and speed.
- The mariner must always remember that AIS is just one of the several tools available to a watch-keeper, to fulfill their obligations under the Collision Regulations.

In summary, AIS is a valuable navigational aid, one of several on the bridge of a ship. It can assist in the early appraisal and subsequent resolution of a close quarters situation, or of a risk of collision. Initially, detection by AIS alone should be considered in the same way as detection by radar alone, with particular caution being exercised until the AIS information has been verified by other means.

IALA Guideline On The Automatic Identification System (AIS)

### 1. AIS사용 관련 한계

**Swiss cheese model Of human error in AIS**

The diagram illustrates the Swiss cheese model of human error in AIS. It shows several layers of defense and safeguard that can fail, leading to an accident route. The layers include:
 

- Defence and Safeguard Layers:** Inadequate regulations on Supervision of AIS information and Training (규정, 절차 미완 및 감독), Undefined standards for AIS design (정해진 표준설계유무 미확), Lack of Training and Management (AIS user certificate, Proper AIS training) (정해진 표준설계유무 미확).
- VTS Operator Actions:** Failure to update information by AIS operator (Check list), AIS training for VTS operator, Surveillance of accuracy of AIS data (VTS operator AIS error 점검 및 기록, AIS error 원인 분석/기록요인, AIS error 원인 분석/기록요인).
- Natural or Intrinsic Hazards:** Limited Windows Of Accident Opportunity.

 An accident route is shown leading to an accident. A note states: "충돌예방을 위한 항행보조장비에서 AIS data에 대한 trustworthiness(신뢰성)이 중요. More encouragement to maintain the data showing on their equipment."

The "Swiss Cheese" model of human error in AIS system, contributing to accident (adapted from the generic model of Reason, 1990, 1997) "Automatic Identification System (AIS): A Human Factors Approach"

### 1. AIS사용 관련 한계

**"Automatic Identification System : A Human Factors Approach"**

**HUMAN ERROR** (slip, lapse, mistake, violation)

- internal factor : 경험과 특성 및 차이 예) skill, experience, task familiarity etc
- external factor : equipment design, installation, task complexity, work environment, organizational factors, operating procedure

Poor performance and transmission of erroneous information by AIS are vital issues on the use of AIS equipment for anti-collision operations.

**Findings**

- MMSI number** : incorrect default MMSI => target swap with sudden and unexpected change of between vessels.
- Vessel Type** : such differentiation would be helpful for visual identification at sea.
- Ship's name and call sign** : Data-mining AIS, left blank, limit to 20 characters => abbreviated ship name etc
- Vessel navigational status** : 동행선 => underway using engine, 기항선 => sailing/ underway by sail, underway using engine, moored, alongside, at anchor 등 잘못 입력, very important information in situational awareness and anti-collision, particularly as it can decide when a ship would be the "stand-on" or "give way" vessel.
- 기타 : Length and beam, draught, Destination and estimated time of arrival... Heading, COG, SOG and Position

**Contrary to intention**, AIS technology actually increases VHF calls between ships for the purpose of collision avoidance. This may cause more violations of the anti-collision regulations and reduce the ability of the COV to take appropriate actions in ample time as required by anti-collision regulation. VHF calls could cause confusion between two ships if they do not agree on specific actions required. The increased potential for local arrangements between ships over VHF may cause more confusion and breach of rules.

**ANALYSIS**

- Active failure : unsafe acts of frontline operators in direct contact with the system such as ship's officers or pilots.
- Latent failure : actions and decisions of those who are indirectly connected with the system, such as managers, designers and rules and procedures makers.

The "Swiss Cheese" model of human error in AIS system, contributing to accident (adapted from the generic model of Reason, 1990, 1997) "Automatic Identification System (AIS): A Human Factors Approach"

### 2. AIS-RADAR 정보/비교

**Pros (+) and cons (-) of ARPA radar and AIS characteristics**

ARPA	AIS
(+) Active detection.	(-) Passive detection.
(-) Effective coverage under 24 nautical miles.	(+) Effective coverage under 40 nautical miles.
(-) Area coverage limited by radar blind and shadow areas.	(+) Full area coverage.
(+) All targets visible.	(-) Only AIS ships visible.
(-) Total target quantity smaller.	(+) Total target quantity larger and reaching 5 times compared with ARPA.
(-) Information simple.	(+) More voyage information
(+) Position accurate.	(+) Position accurate.
(-) Echo various slightly.	(+) Signal stable.

One of major purpose for VTS is to prevent ships from collision, including a ship colliding with a fishing boat or a buoy. Sometimes fishing boats are working in fairway that obstructs ships moving and increases navigational risk. From AIS information these kinds of situations can not be found so that VTS can not sound collision warning to the related ships. Therefore AIS can not replace ARPA radar in VTS operation.

※: COMPARISON BETWEEN ARPA RADAR AND AIS CHARACTERISTICS FOR VESSEL TRAFFIC SERVICES - Journal of Marine Science and Technology, Vol. 14, No. 3, pp. 182-189 (2006) ※인 : Keelung Harbor.

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## 2. AIS-RADAR 정보 비교

### Integration of AIS into existing radar based VTS systems

Radar based VTS systems often differ in the way radar video is handled and processed, prior to presentation of the traffic image. System design and age are thus likely to influence the options for successfully integrating AIS. A full appreciation of those options, together with any consequences, will normally only be possible after consultation with the relevant manufacturers.

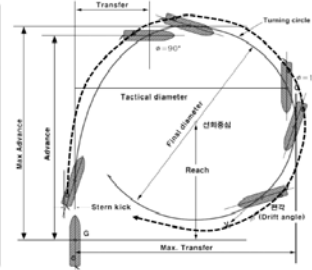
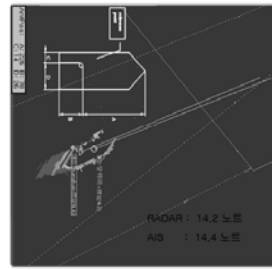
생략.....

AIS data is transmitted at variable rates depending upon vessel speed and manoeuvre. In contrast, radar data is generated at a constant rate as defined by antenna rotation speed.

The integration of AIS into a radar based VTS system thus needs to be capable of achieving and maintaining the correlation of AIS and radar data originating from the same vessel, despite unpredictable variations in data rates. The potential benefits of AIS would be quickly reduced, should the process of integration result in the generation of numerous false tracks.

• Correlation(상관관계) : 한 범선의 변화에 수반되어 다른 범선에서의 변화가 일어나는 경우와 같이 두 범선 사이의 의존성 및 관계.  
- IALA Guideline AIS as a VTS Tool-

## 2. AIS-RADAR 정보 비교



- Raw RADAR Targets은 True positional Accuracy 감소 : 선박위치, 크기, 모양 등에 따라
- RADAR + AIS 상호 보조

— RADAR : 반사파영상  
- - - AIS신호 : GNSS ANT Pos.

## 2. AIS-RADAR 정보 비교



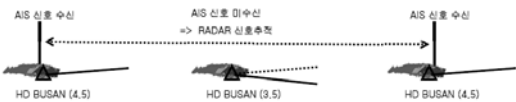
## 2. AIS-RADAR 정보 비교



The attached screen shot clearly shows the difference between the radar-ARPA and the AIS information for collision avoidance. While the ARPA shows a crossing situation the AIS clearly indicates the red to red situation

선속에 따라 정보 update 주기가 결정되는데, 이와 상관관계로 현재 표시되는 정보가 RADAR, AIS 신호로부터 오는지에 따라 VTS에서 보는 Vessel Target CPA추정에 오류발생.

## 2. AIS-RADAR 정보 비교



- 다음 AIS 신호 수신시까지 RADAR 신호를 추적하여 정보를 표시함 (단일 설정된 시간 이상 지연 시 LOST TARGET)
- AIS신호 미수신 구간 동안 : 물표주위에 RADAR 신호 있을 시 물표 이동



- 현재 장비는 AIS의 Heading, course 정보가 많이 차이 날때 정로백터까지 표시 하지 않음
- cf) ATLAS장비는 AIS신호 오류 있어도 그대로 표시하며 관제센터에서는 본선에 정보전달 및 수정요구

## 3. AIS Target lost

Target warning!!! : 많은 warning 표시로 본질 변색

### Processing of information

- If the signal of a dangerous AIS target is not received for a set time:
- a lost target symbol should appear at the latest position and an alarm be given;
- the lost target symbol should disappear after the alarm has been acknowledged; and
- means to recover the data for a number of last acknowledged lost targets may be provided.

If the operation still concentrates on the AIS display and neglects existence of the ship, it will be a seriously critical time. Another problem is that ship equipment in conjunction with AIS, such as GPS or gyro compass, has trouble so that the information delivering to VTS and other ships is incorrect or inaccurate.

### Presentation of information

The presentation of AIS target symbols, except for sleeping or lost targets, should have priority over other target presentations within the display area, including targets from EPA, ATA or ARPA. If such a target is marked for data display, the existence of the other source of target data may be indicated, and the related data may be available for display upon operator command.

- IALA guideline -

### 3. AIS Target lost

- ①
- ② H D BUSAN (0.0)
- ③ H D BUSAN (0.0)
- H372283000 (0.0)

**AIS 신호 최신험 주기**

Ship's Dynamic Conditions	Nominal Reporting Interval *
Ship at anchor or moored and not moving faster than 3 knots	3 minutes
Ship at anchor or moored and moving faster than 3 knots	10 seconds
Ship 0-14 knots	10 seconds
Ship 0-14 knots and changing course	3 1/2 seconds
Ship 14-23 knots	6 seconds
Ship 14-23 knots and changing course	2 seconds
Ship > 23 knots	2 seconds
Ship > 23 knots and changing course	2 seconds

- Target tag pop-up, 관제사 Target 정리 및 가능 설정에 시간소요
- AIS신호 Lost되기 前 / 後에 RADAR신호 Tracking으로 자동전환 필요
  - ① Re-identification 하는데 시간소요...
  - ② Target tracking source 표시 예) dGPS, R4, R8 (R4:가덕도, R8: 지세포)

### 4. VTS 관제 화면 재구성

Scale이 달라서 CPA 추정등 선박동향패턴 예측하기 어려움

### 3. AIS Target lost

before

after

- ① 6분정도 AIS Failure ( 2012.06.02 14:22~14:28 발생)
- ② 움직이는 물표의 60%정도만 auto radar tracking으로 전환됨  
그리고 speed zero인 선박은 모두 lost target 됨

※ RADAR 신호가 존재하여 Tracking이 가능(화면 상단 신호 RADAR LAND MASK, 가덕도 RADAR는 신호가 없는 상태)

### 5. Auto Acquisition Zone 활용등

Auto Acquisition area for detecting the vessel with no AIS, out of service, switch off ..

### 3. AIS Target lost

#### Contingency Plan for AIS System Failure

- **RADAR Tracking 자동전환**  
=> AIS Tag(선명, 목적지 등)내용 그대로 RADAR Tag에 표시
  - ① 레이더 video신호 항상 표시되도록 안전성 확보 필요
  - ② 두개 이상 radar site로부터의 영상신호를 overlap할 때 Azimuth 조절이 안되는 경우 물표들 분리 개선을 위해 Land Mask 사용시 주의  
예) 한쪽 레이더 down되어도 다른 레이더가 cover할 수 있도록 유지
- **VOC에 replay 기능 또는 de-briefing 활용**  
=> AIS 시스템 다운되기 바로 전의 물표 정보 활용하여 직접 레이더 물표 Acquire 및 입력
- 다른 dual system 이용 : 현재 실행 AIS장비 고장시 ATLAS정보 활용함.

마산 VTS  
ATLAS

실행 VTS  
Norcontrol

부산 VTS  
Norcontrol

1회선연결

### 6. 결론

- 현재 VTS 시스템은 AIS신호에 대한 의존도 높음 AIS 신호의 신뢰성 미흡, 미탐재, 고장의 경우를 고려하여 RADAR 신호 관리 철저 필요
- AIS Target Lost시 자동적으로 RADAR tracking으로 안정적으로 전환필요 (선박speed zero 경우도 고려)
- AIS-RADAR 신호에 포함된 Error 특성을 감안하고 신호도에 근거한 가중치를 반영 전시함으로써 관제사의 상황인지와 판단을 도울 수 있어야 함
- AIS Error 관제사 교육 및 AIS Failure 상황 발생 대비 Contingency Plan 수립
- 관제사가 선박동향패턴 분석과 예측을 전체 VTS화면에서 효율적으로 할 수 있도록 모니터 화면 개선
- 인접 VTS VHF 이용 할 수 있는 Network구성
- AIS symbol 활용으로 선박의 종류 및 크기를 자동 생성하여 효율적 관제로 개선 (일부 적용 중이며 전체시스템으로 확대필요)
- Auto Acquisition area의 오류를 수정 보완하여 실제 적용 될 수 있도록 시스템 개선 후 적용함으로 No AIS 신호 선박에 대한 관제의 효율성 향상