GUIDELINES
ON
AIS AS A VTS TOOL

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INTRODUCTION

IMO Assembly Resolution A.857(20), Guidelines for Vessel Traffic Services, establishes the following tasks that should be performed by a VTS :

"*A VTS should at all times be capable of generating a comprehensive overview of the traffic in its service area combined with all traffic influencing factors. The VTS should be able to compile the traffic image, which is the basis for the VTS capability to respond to traffic situations developing in the VTS area. The traffic image allows the VTS operator to evaluate situations and make decisions accordingly. Data should be collected to compile the traffic image. This includes:*

1. *Data on the fairway situation, such as meteorological and hydrological conditions and the operational status of aids to navigation;*

2. *Data on the traffic situation, such as vessel positions, movements, identities and intentions with respect to manoeuvres, destination and routing;*

3. *Data of vessels in accordance with the requirements of ship reporting and, if necessary, any additional data required for the effective operations of VTS.*

This IALA Guideline on AIS seeks to identify for the benefit of VTS authorities the ways in which AIS contributes to the achievement of the above tasks.

OBJECTIVES OF AIS

The proper use of AIS enhances the safety of life at sea, the safety and efficiency of navigation, and the protection of the marine environment.

According to SOLAS Chapter V, Regulation 19

AIS shall-:

- *provide automatically to appropriately equipped shore stations, other ships and aircraft information, including the ship's identity, type, position, course, speed, navigational status and other safety-related information;*
- *receive automatically such information from similarly fitted ships;*
- *monitor and track ships; and*
- *exchange data with shore-based facilities.*

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.

In short, the purpose of AIS is :

- to identify vessels,
- to assist target tracking,
- to simplify information exchange, and
- to provide additional information to assist collision avoidance.

DESCRIPTION

AIS is a broadcast communications system, operating in the VHF maritime band, that is capable of sending ship information, such as identification, position, course, speed, ship dimensions, draught, ship type, and cargo information, to other ships and to shore.

It is to be capable of handling over 2,000 time slots per minute per channel and updates as often as every two seconds. AIS uses self-organizing time division multiple access (SOTDMA) technology to meet this high broadcast rate and to ensure reliable operation.

In general, each AIS system consists of the following :

- one multi-channel VHF transmitter;
- two multi-channel VHF receivers;
- one channel 70 VHF receiver for channel management;
- a central processing unit (CPU);
- an internal GNSS receiver for timing purposes and position redundancy;
- interfaces to navigation EPFS receiver, gyro and log and to other on board sensors;
- interfaces to radar / ARPA, ECS / ECDIS, integrated navigation systems and dedicated AIS displays; and
- a BIIT (Built In Integrity Test).

Timing information is derived from an integral global navigation satellite system (e.g., GPS) receiver. Additional information may be broadcasted by the AIS if electronically obtained from shipboard equipment through standard marine data connections (i.e., roll, pitch, etc.).

The effectiveness of AIS may be significantly increased by integrating it into other devices such as electronic chart system (ECS) / electronic chart display and information system (ECDIS) or a radar / automatic radar plotting aid (ARPA).

The AIS station works in an autonomous and continuous mode, regardless of whether it is operating in the open seas or in coastal or inland areas. As prescribed by ITU-R World Radio Conference (WRC97), it has two designated frequencies that are in the maritime mobile band, i.e., VHF-FM channels 87B (161.975 MHz) and 88B (162.025 MHz).

AIS can use both 25 kHz and 12.5 kHz simplex channel bandwiths. When operating with either of these bandwiths the resulting capacity is 2,250 slots/minute at a transmission rate of 9,600 bits/second. When both AIS channels (AIS 1, AIS 2) are used, the reporting capacity is 2 times 2,250 i.e. 4,500 slots/minute.

As the system operates in the VHF radio band, it is capable of communicating within "line of sight". Should the number of AIS stations within line of sight range of a receiving station exceed the frame capacity in terms of slots/minute, the SOTDMA algorithm and the GMSK/FM modulation ensure that the effective radio cell for each AIS station slowly decreases. Transmissions from stations farthest away are suppressed giving priority to those closer to the receiving station.

The overall effect is that, as a channel approaches an overloaded state, the TDMA algorithm produces a progressive reduction of the radio cell size. The effect is to drop AIS reports from vessels farthest from the centre of operations, while maintaining the integrity of the (more important) closer range reports.

However, when using 12.5 kHz channels the communication range is slightly reduced. The size of the radio cell in the 12.5 kHz channel, in an overload situation, shrinks to approximately one half the size compared to that in the 25 kHz channel.

This effect has to be taken into consideration when planning 12.5 kHz channel areas.

AIS DATA

There are different message types including the ship's data required by the IMO performance standards (as well as data necessary for communication management).

The data is autonomously sent at different update rates as follows :

- Dynamic information dependent on speed and course alteration (see Table 1); and
- Static and voyage related data every 6 minutes or on request (responds automatically without user action).

Report Rate of Dynamic Information

Ship's manoeuvring condition	**Reporting interval**
Ship at anchor or moored and not moving faster than 3 knots	3 min
Ship at anchor or moored and moving faster than 3 knots	10 sec
Ship 0-14 knots	10 sec
Ship 0-14 knots and changing course	$3^{1/3}$ sec
Ship 14-23 knots	6 sec
Ship 14-23 knots and changing course	2 sec
Ship >23 knots	2 sec
Ship >23 knots and changing course	2 sec

Table 1

A ship and its messages are identified and allocated by its MMSI number (Maritime Mobile Service Identity).

Except where noted otherwise (i.e., listed as optional or at the discretion of a competent authority or master), under the international standard, the following data will be required to be transmitted by an AIS station :

- Static (manual input)
  - MMSI;

  - IMO number;
  - Call sign and name;
  - Length and beam;
  - Type of ship; and
  - Location of position-fixing antenna on the ship (aft of bow and port or starboard of centreline).

- Dynamic (automatic input)
  - Ship's position with accuracy indication and integrity status;
  - Position time stamp in UTC;
  - Course over ground (COG);
  - Speed over ground (SOG);
  - Heading;
  - Rate of turn;
  - Optional - angle of heel;
  - Optional - pitch and roll;
  - Navigational status (e.g., not under command (NUC), at anchor, etc. - manual input); and
  - Provision must be made for inputs from external sensors giving additional information.

- Voyage Data (at master's discretion or as required by competent authority)
  - Ship's draught;
  - Hazardous cargo (type; as required by a competent authority);
  - Destination and estimated time of arrival (ETA) (at masters discretion); and waypoints
  - Optional - route plan (; field not provided in basic message).

BENEFITS OF AIS

Automatic Vessel Identification

AIS brings to the mariner many benefits. Principal amongst these, as the name implies, is the automatic and immediate provision of vessel identity (MMSI, call sign etc), thereby facilitating rapid radio communication where necessary. This benefit is of equal, if not even greater value to VTS authorities.

Most VTS organisations require vessels to report to the VTS centre on approaching or entering the VTS area. Achieving vessel identity relies on such vessels reporting both identity and location to the VTS centre, and the VTS operator then correlating this information with an unassigned radar track.

The process is time consuming and wholly reliant on the co-operation of participating vessels. It is not uncommon for some vessels to fail to comply with this requirement, thereby creating a potentially dangerous situation, and creating further distraction for the VTS operator. Even where VHF direction finding equipment is fitted, the VTS traffic image is still reliant on vessels reporting identity via VHF thereby permitting the correlation of identity with the radar track identified by DF. AIS will help overcome the safety weaknesses and time consuming procedures, inherent in the present arrangements.

Improved Vessel Tracking

a) Wider geographical coverage.

AIS data will be received by other AIS units, or by base or repeater stations. Thus where a VTS organisation is fitted with such equipment, it will be capable of receiving both identity and precise location of a vessel at the maximum reception range of the VHF radio communications frequency. As a consequence, it will often permit detection of vessel target well outside conventional radar range. Even where this is not possible due to the need to screen base stations from adjacent VHF interference, extended VTS detection range may be achieved by the installation of additional base or repeater stations connected into a network at much lower cost than radar.

b) Greater positional accuracy.

AIS aims to achieve positional accuracy better than 10 metres when associated with DGNSS correction signals. This compares favourably with radar which as a function of frequency, pulse repetition rate, and beam width will often only achieve positional accuracy in the range 30 to 50 metres.

c) Absence of "radar shadow" areas.

In coastal and harbour waters radar tracking of vessels can be masked, or otherwise affected by the proximity of land and buildings. The resultant "shadow" areas can cause a radar based VTS to lose track, thereby denying the VTS centre the ability to monitor accurately vessel movement at what could be a critical time. The loss of tracking will invariably result in the need to reacquire and re-identify lost tracks, thereby increasing the work load within the VTS centre.

Whilst AIS tracks will avoid the great majority of such effects, the very close proximity of buildings and bridges, sometimes known as the "urban canyon" effect, can cause difficulties for AIS stations in heavily built-up areas. 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.

d) Traffic image accuracy

Vessel tracking can similarly be interrupted when two vessels pass close to one another, with the result that the radar tracking of one contact is confused by the proximity of the other. Importantly, this can result in the identity of one track transferring or "swapping" to the other. Self-evidently, such a situation introduces a potentially dangerous inaccuracy in the vessel traffic image, unless noticed and rectified quickly by VTS operators. Again the consequences of this phenomenon are yet further work for the VTS centre. The more precise tracking associated with AIS has been shown to prevent the incidence of "track swap".

e) Real time manoeuvring data.

Radar based VTS systems will typically provide details of a vessel's course and speed over the ground. Of necessity, this information is historical in that it is calculated from the track made good by a vessel. In contrast, AIS will provide all recipients with certain elements of real time manoeuvring data such as Ships Heading and Rate of Turn. These are derived directly from the vessel navigation systems and are included automatically in the Dynamic Message broadcast by the AIS.

f) Weather effects on tracking performance.

Navigational radar performance is often adversely affected by precipitation as a function of the radio frequency on which it operates. In heavy rain or snow, effective radar tracking is sometimes unachievable, even with the use of modern suppression techniques. VHF radio transmissions on the other hand are not so attenuated. As a consequence a VTS centre is much more likely to maintain an accurate traffic image in adverse weather where that tracking is based on AIS data.

VHF radio transmissions can be affected by atmospheric ducting. In these conditions, VHF reception ranges can be greatly extended. Where such an enhanced reception range brings with it the detection of greatly increased AIS messages, the system will automatically overcome the risk of overloading by ignoring signals originating from vessels at greatest range, and re-using the slots so gained.

g) Provision of more precise navigational advice.

It follows that where a VTS centre is able to receive AIS information from vessels within or adjacent to its area, the quality, accuracy and reliability of vessel tracking will be improved markedly. As a consequence, that VTS centre will be able to provide more precise navigational advice, as and when required, or when deemed necessary. Moreover, the availability of certain real time manoeuvring data within the VTS centre will enable VTS operators to appreciate more rapidly, and in greater detail, actual vessel movement. It should be stressed, however, that this facility alone will not enable a VTS centre remotely to manoeuvre a vessel with safety.

<u>Electronic transfer of sailing plan information</u>

Where AIS is integrated into a VTS system, it becomes possible for vessels and the VTS centre to exchange passage information such as intended way points, provided the appropriate software is available.

Electronic transfer of safety messages.

The facility available within AIS for the transmission of short safety messages makes possible the electronic broadcasting from a VTS centre of local navigation warnings, and similar safety related messages.

It is anticipated that VTS centres may have the capability to broadcast via AIS local chart corrections to ECDIS fitted ships.

Automatic indication of Voyage Related Information (cargoes, dangerous goods etc)

Vessels are normally required to report to the VTS authority that any dangerous goods are being carried. The AIS voyage related message permits the inclusion and automatic transmission of this information.

Impact on VHF communications

As described earlier, a major benefit of AIS is the consequential reduction of VHF voice messages. This in turn reduces the reliance placed on vessels understanding such messages from a VTS centre and vice versa.

Archiving data

The automatic availability within a VTS centre of AIS data for each vessel facilitates the rapid and comprehensive recording, replay and archiving of data.

System redundancy

By equipping VTS centres with AIS, an alternative method of tracking and monitoring vessel navigation is introduced, thereby improving system redundancy significantly.

Potential for interaction within regional AIS network

Increasing emphasis is being placed on networking VTS centres on a regional basis. Such an arrangement facilitates greater efficiency by making possible the rapid transfer of vessel details between different centres. Adoption of AIS within the relevant VTS centres may contribute toward this process

Improved SAR management

Many marine and VTS authorities are equipping SAR capable units, including aircraft and helicopters, with AIS. The AIS voyage related message permits a vessel to transmit the number of persons onboard. Whilst this is not mandatory for vessels at sea, it can be made a formal requirement in a VTS area. The provision of such details, and the ready identification and location of SAR units greatly facilitates the management and evaluation of any SAR response.

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. For example :

- 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.

INSTALLATION OF AIS INTO A VTS - ISSUES TO BE CONSIDERED

Number/location of base stations/repeaters

In deciding the size, and thus cost, of integrating AIS into a VTS system, a careful study needs to be undertaken to establish practically the number and location of base and repeater stations required to achieve full and reliable coverage of the expected traffic load. Although VHF reception is greatly influenced by antenna location and height, operation in a heavy electronic environment may necessitate the installation of additional base stations in order to reduce susceptibility to interference.

Interoperability with adjacent VTS authorities

Where it proves necessary to use more than one centre, or where a VTS authority involves more than one VTS centre, the method of connecting the component elements into a local network needs to be given careful consideration. In particular, the existence of, or plans for a regional network may necessitate using a local networking solution, which is compatible with national and international networks.

Availability of VHF Communication channels.

Two maritime VHF Channels have been allocated by the ITU for the international use of AIS in its primary ship-to-ship mode. What is not yet certain, is whether additional local channels will need to be allocated to support the operation of VTS within certain congested VTS port environments. The need for such additional channels will be at its most acute where large numbers of vessels navigate within a VTS area, and where the VTS centre has a particular interest in deriving vessel identity at maximum range. As has been described above in the section on the Limitations of AIS, the AIS in an overload situation will discount AIS signals received from the extremity of an area, before those emanating from vessels or craft close to the receiving station.

Availability of national/regional/local DGNSS corrections

In order to monitor vessel navigation with the 10 metre accuracy potentially possible, a reliable DGNSS correction signals will need to be made available to all vessels throughout the VTS area. Such services are provided nationally or regionally in some areas. Where such a service does not exist, a VTS authority may consider providing these corrections itself. It is technically possible to transmit the relevant corrections using the AIS itself.

OTHER ISSUES TO BE TAKEN INTO CONSIDERATION

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.

In many VTS areas, vessel traffic is varied and includes both SOLAS and non-SOLAS vessels. In these circumstances, radar will remain the primary sensor for detecting vessels not fitted with AIS. Economies in infrastructure are therefore unlikely.

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.

Use of electronic charts

VTS systems have traditionally used a diagrammatic representation of the geographical and hydrographic features of the relevant area as the background to the traffic image. The accuracy of such representations, however, is not suitable for precise navigation. With the advent of electronic charts, there are clear benefits to be gained by using such charts as the background to the traffic image. By so doing, vessel navigation may be monitored, and advised, in relation to precise charted features. In VTS systems not fitted with electronic charts, such advice can only be given in relation to radar detectable features, such as coastline or navigational buoys, or as depicted on existing VTS display diagrams.

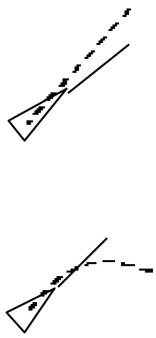
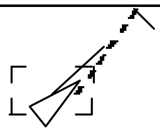
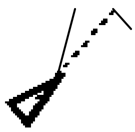
Where reliance is to be placed on electronic charts for this purpose, it is important that they are issued by an approved hydrographic office, accurate, and up to date. It is anticipated that VTS authorities may be able to broadcast local chart corrections to suitably equipped (ECDIS/ECS) vessels and to issue navigational warnings electronically using AIS.

In confined waters, it is likely that VTS operators in monitoring vessel manoeuvres will occasionally have need to reduce the scale of their displays. In such circumstances, it will be important that the electronic chart acting as the background to the traffic image, is capable of showing increasing levels of survey detail, as operators reduce the scale on their displays. This will only be possible where the electronic chart is compiled from source survey data, rather than from an existing paper chart. In these circumstances, it will also be important that the charted location of radar sites is accurate to a maximum of 10 metres, if errors between radar and AIS generated tracks, which will be all the more obvious at reduced range scales, are to be avoided.

IHO Standard S52 defines the standards for symbols and colours on official electronic charts. Four variations of the basic colour scheme are available. These colour schemes, whilst optimised for navigation in varying light conditions on the bridge of a vessel, may not be suitable for VTS purposes ashore, particularly where operators are required to study a display constantly for long periods.

Choice of VTS Symbols

The following table shows the choice of AIS symbols allocated for use onboard vessels.

AIS target	Symbol	Description of symbol
AIS target (sleeping)		An isosceles, acute-angled triangle should be used with its centroid representing the target's reference position. The most acute apex of the triangle should be aligned with the heading of the target, or with its COG, if heading information is not available. The symbol of the sleeping target may be smaller than that of the activated target.
Activated AIS target		An isosceles, acute-angled triangle should be used with its centroid representing the target's reference position. The most acute apex of the triangle should be aligned with the heading of the target, or with its COG, if heading information is not available. The COG/SOG vector should be displayed as dashed line starting at the centroid of the triangle The heading should be displayed as solid line of fixed length starting at the apex of the triangle A flag on the heading indicates a turn and its direction in order to detect a target manoeuvre without delay A path predictor may also be provided
Selected target		A square indicated by its corners should be drawn around the target symbol.
Dangerous target		A bold line clearly distinguishable from the standard lines should be used to draw the symbol. The size of the symbol may be increased. The target should be displayed with: vector, heading and rate of turn indication. The symbol should flash until acknowledged. The triangle should be red on colour displays.
Lost target		A prominent solid line across the symbol, perpendicular to the last orientation of the symbol should be used. The symbol should flash until acknowledged. The target should be displayed without vector, heading and rate of turn indication.

Recommended AIS Target Symbols

- If colour fill is used no other information should be masked or obscured.
- Base stations may transmit information on targets tracked by other means. If these targets are displayed they should be presented using symbols clearly distinguishable from the symbols above.
- –Further symbology for special situations will be developed

These symbols may be found to be unsuitable for VTS purposes, for two reasons. First, those selected to represent AIS tracks may need to be accommodated logically within an existing framework of symbols. Second, VTS centres will often have need to represent visually on the traffic image, a much wider range of information than is necessary onboard a vessel. For example traffic management may necessitate the use of symbols which depict different types and sizes of vessels. Alternatively, it may be necessary to show which vessels have pilots embarked, and which do not.

When it is required for a VTS Centre to transmit a psuedo-AIS target to an AIS/ECDIS fitted vessel, it will be necessary for the information to be transmitted in terms that will be recognised by the receiving vessel.

AIS AND AIDS TO NAVIGATION (AtoN)

A further application of AIS is as an AtoN. When positioned at a significant geographic point or danger to navigation, an AIS station can provide information and data that would serve to:

- complement or replace an existing AtoN;
- provide identity, state of "health" and other information such as real time tidal height, tidal stream and local weather to surrounding ships or back to the appropriate shore authority;
- provide the position of floating aids (primarily buoys) by transmitting an accurate position (based on DGNSS corrections) to monitor that they are "on station";
- provide information for performance monitoring, with the connecting data link serving to remotely control changes of AtoN parameters or switching in back-up equipment;
- provide longer range detection and identification in all weather conditions, and possibly to replace radar transponder beacons (RACONS);
- provide information on all AIS fitted traffic passing within VHF range of the site.

The remote control and monitoring of aids to navigation has been developed primarily to enable service providers to ensure that aids and supporting systems are functioning correctly and where required to organise maintenance.

Until now, there has been no simple and universal method of communicating such information. The introduction of AIS presents an opportunity to provide such information to service providers and mariners, using internationally standardised and recognised equipment, message protocols and frequencies.

The operation and performance of aids to navigation can be monitored or controlled using an AIS data link as the interface with the service provider. It is possible to have an AtoN transmit its identity, operational status and other information such as real time wave height, tidal stream and local weather to ships nearby or to the service provider. Buoys that can transmit an accurate position, perhaps based on DGNSS, can be monitored to ensure that they are on station. Performance monitoring, remotely changing operating parameters, and activating back-up equipment are also made possible by the use of AIS.

AIS for Meteorological and Hydrological information

Another application, which is expected to be widely used is the transmission of meteorological and/or hydrological data. Where such an application is intended for international use, the message format will be registered by IALA prior to being made available to system manufacturers. This will facilitate the correct presentation of the information on systems from different manufacturers.

Options for implementing this application include:

- Connecting sensors to a local AIS-unit, which then broadcasts the relevant information.
- Several sensors can be connected to a shore station network via a data communication system. Information can then be broadcast as required.
- A sensor can be co-located with an AtoN equipped with AIS. The AIS-unit can then be used to broadcast both the AtoN information and meteorological and/or hydrological information using separate messages.

The information to be broadcast will depend on the operational requirement and the availability of measuring and processing equipment. Examples include :

- Wind speed, average and gust values
- Wind direction
- Water level
- Water temperature
- Air temperature
- Current speed and direction at different depths
- Tide information

Such data permits the presentation of real time information at receiving stations, including onboard ships within VHF range.

PERSONNEL AND TRAINING

For information on personnel and training, refer to model courses V103-1, V103-2, V103-3 and its associated task book and V103-4.

SHORT TERM ACTION BY VTS AUTHORITIES

AIS equipment is to be implemented as a mandatory carriage requirement under SOLAS Chapter V for newly constructed vessels from 1 July 2002 and progressively thereafter to other vessels by
1 July 2008.

VTS authorities therefore need to consider as matter of priority whether they intend integrating AIS into their VTS system. As the previous paragraphs will have demonstrated, the inclusion of AIS into a VTS system significantly enhances the precision and reliability with which AIS equipped vessels may be monitored, and thus enhances safety.

AIS also has the potential to improve efficiency in vessel traffic and port management. The degree to which this potential may be realised will vary depending on the operational circumstances. It is for each VTS authority to make that assessment.

In order to avoid a situation whereby AIS fitted vessels incorrectly believe that a VTS authority is receiving data being transmitted via the AIS, all VTS authorities will need to publish by appropriate means their status in respect of AIS. Where applicable, the date on which they intend to incorporate AIS should also be promulgated well in advance.

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