International trends on the *Integrated Bridge System*

- Regulations and Recommendations of IMO and Classification Societies on the IBS

(Integrated Navigation System (INS))

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1. Abstract

An Integrated Bridge System (IBS) is not an officially defined term but a concept of which integrates on a consol at bridge the primary functions of stand-alone navigational aids and communication instruments or of stand-alone units which are integrated, i.e. ARPA, ECDIS. It aims to enable officers on navigational watch to perform their duty without impairing proper lookout. IBS has been taking shape through a rapid development of navigation and communication systems in relation with bridge configuration, bridge work station and one man bridge operation system.

IBS related matters have been considered for years and is on the agenda of the International Maritime Organization (IMO) for its technical details and safety aspect of possible one-man watchkeeping at night. However, IMO has made it clear that human element should be the key factor in considering IBS and single watchkeeping issue. In the development of IBS, ergonomic element and human psychological aspect have been more emphasized than technical requirements.

This paper refers to documents presented to the IMO and its progress made in various IMO technical meetings on the development of IBS which is perceived as an effective aid to proper bridge lookout and those standards adopted by classification societies on the composition of workstation at bridge in order to identify the international trend on regulating required equipment, function of workstation of IBS, the regulatory review process and technical recommendations related thereto.

2. Development of IBS in IMO

- tracing the course of an IBS wheel along the path of IMO documents

This section provides the historical review in the development of an IBS by tracing the path of the IBS concept as overviewed through a vast amount of IMO documents.

During the course of scrutinizing the relevant IMO information papers, it was the writer's special observation that the IBS matter has been under consideration on the IMO's independent agenda item of one man bridge operation with a close link to not only regulatory acceptability under the STCW, COLREG and SOLAS Conventions but human element perspective. Being aware of the general concern of IMO with regard to the human element, and of the present STCW Convention where one man bridge operation at night is prohibited considerations in the various IMO sub-committees and the MSC have been focused on the safety system of the bridge in carrying out proper lookout and the role of navigational duty simultaneously.

2.1 Consideration in MSC and NAV Sub-Committee

2.1.1 a brief historical overview

In July 1986, the Government of Norway advised the IMO that three advanced ships flying the Norwegian flag had been granted permission to operate with the officer of the navigational watch as the sole lookout "when there is no daylight". The article of the relevant international convention (Equivalents) was used as a legislatory tool for this decision.

Norwegian's such decision called for some debates on the acceptability under the international convention regime. However, it was meaningful that it paved a way for maritime Administrations to pay keen attention on one man bridge operation and therefore various governments submitted position papers to the Maritime Safety Committee and NAV Sub-Committee, one of its subsidiary body with their own analysis of evaluation trials and experiences gained.

The writer could observe that since then, Norway has been in the forefront of the drive to undertake trials and experiments with the officer of the watch as sole lookout.

2.1.2 MSC 55/Inf.4 (dated 19th January 1988) Recommendation for Bridge Design on Sea-Going Ships

This document contains the results of study carried out by a German research company, which dealt with the investigation into the requirements for the realization of one-man manning of ship's bridge at night and accordingly presented a comprehensive recommendations with a purpose of properly taking into account aspects of maritime safety by simplifying the operation and standardizing the bridge design of sea-going ships. Germany frequently used to refer to this study when applying the IBS concept in its submitted IMO documents thereafter.

observations :

1) Here defined were the terms which were translated into main components of a bridge control console.
2) A basic principle of bridge layout was applied as per the activities allocated in each location.
3) It was noteworthy that ergonomic aspects were taken into

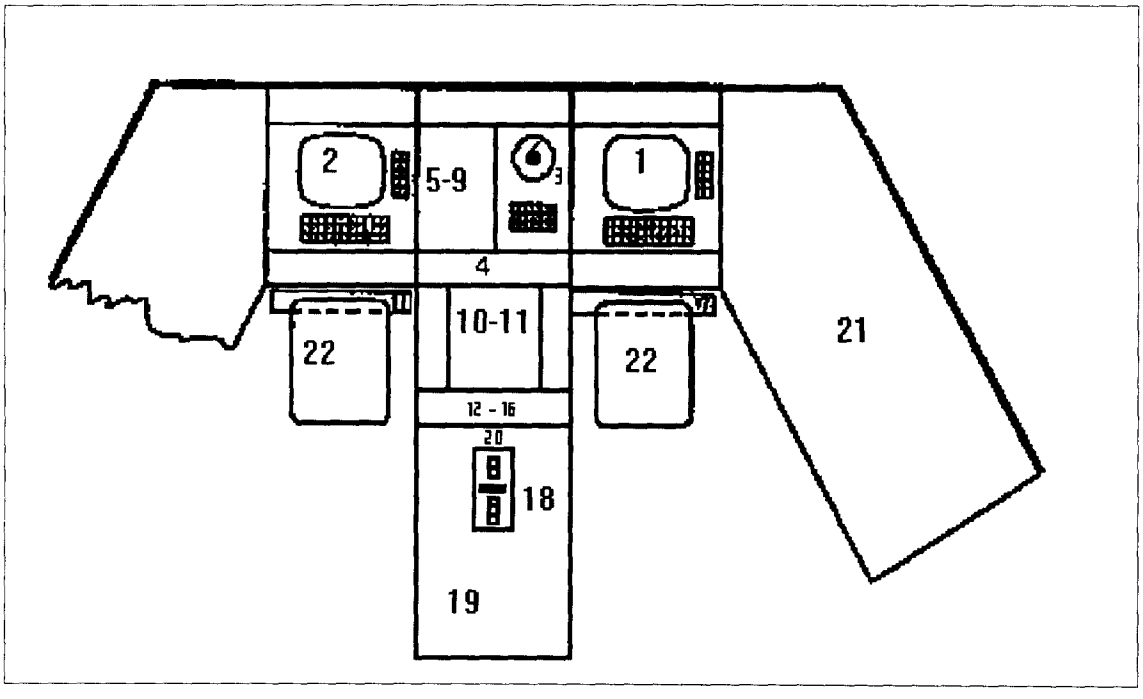
4) Special considerations given to bridge layout :

(1) Bridge configuration : a helmsman's clear horizontal field of vision from the workstation extending outside the forward window is secured.

(2) Bridge arrangement : ● an analysis on every possible activities at navigating and manoeuvring workstation from the angles of decision-making process, cognitive reaction, preception of surrounding stimuli, etc. ● a comprehensive combination of instruments and facilities. ● technical design of a Bridge Control Consoles

Principally, the most favourable co-ordination of instruments and equipment should be explored in such a manner that those various instruments and equipment are located so as to meet the navigator' needs at each workstation.

An example showing the arrangements of instruments in a bridge control console is drawn hereunder :



List of instruments to be installed in console is as follows :

1. radar with ARPA function (rasterscan and daylight properties)
2. radar
3. autopilot with analogous repeater compass indication (possibly separate)
4. manual rudder control device (override tiller) with pump selector switch
5. log and distance indicator
6. rate-of-turn indicator
7. echo-sounding indicator
8. clock
9. main engine / propeller revolutions (may also be mounted overhead)
10. VHF radiotelephone installation
11. internal telephone system
12. general alarm key
13. whistle key and manoeuvring light switch
14. morse signalling light switch / key
15. searchlight switch
16. switch for windscreen wiper and washer, screen heater
17. watch alarm acknowledgement button (floor button)
18. remote control for main engine
19. monitoring system with group alarms and display of aids for decision-making
20. emergency stop for main engine
21. automatic visual position display
22. chair
23. shelf for binoculars, ashtray, coffee cup, space for writing, etc. (to be provided)

Instruments to be mounted overhead :

- rudder angle indicator (trilateral display unit)
- magnetic compass indication

As is readily apparent from the figure, this arrangement combines navigating and manoeuvring workstation and monitoring workstation with the function area "Command" mainly stressed. In order to minimize unnecessary movement in the wheelhouse, and so to increase the opportunity to monitor external events and communications, equipment which is used in sequence should be placed in proximity.

An ideal configuration, as seen from the hi-tech crafts, will provide the navigator seated forward with a good all-round visibility and controls and modern navigational aids all within easy view and arms reach.

2.1.3 MSC 55/25 Final Report (dated 4 May 1988)

A question was raised concerning the permission granted to operate advanced ships on a preliminary and experimental basis, with the officer of the navigational watch acting as sole look-out on the bridge under certain conditions, which was alleged by some nations to be not in accordance with the article V(3) of the 1978 STCW Convention.

Some voices were noted that a further investigation over a long period into such factors as fatigue and the socio-psychological effect on ship's personnel on the basis of experiments carried out in various environments and conditions.

Against this expressed concerns, Canada, Germany and Norway proposed a compromise to add in the STCW Convention a new regulation I/5 on "equivalents" in order to allow evolving technologies and procedures.

2.1.4 NAV 36/Inf.4 (dated 18 December 1989)

England submitted a report paper on the conduct of trials of one-man watchkeeping at night in vessels of less than 1,600 grt.

1) A scrutinized insight over the relevant international

convention requirements :

(1) COLREG : "Every vessel shall at all times maintain a proper lookout by sight and hearing as well as by all available means appropriate in the prevailing circumstances so as to make a full appraisal of the situation and of the risk of collision."

(2) STCW II/Reg.1.9

(3) SOLAS 1974/1978 Chapter V/Reg.13 : "All ships shall be sufficiently and efficiently manned."

(4) IMO Resolution A.481(XII) "Principle of Manning"

2) Technical equipment to be fitted with an OMBO ship of 1,600 grt and upwards

(1) Bridge Safety Alarm (watch alarm) : to be linked with auto-pilot and of tamper-proof

(2) Bridge Control of Main Engine

(3) Stabilized radar with reflection plotter (North-up/ Head-up)

(4) 4 window wipers

(5) internal and external communication system

It was noted that England gave valuable appraisals on the status of legal process and technical development at the time in the area of an one-man bridge watchkeeping.

2.1.5 NAV 39/4/14 (dated 12 July 1993)

Following the consecutive groundings and collisions of oil tankers such as those of Shetland Islands, Japan proposed in its submitted paper that the IMO should take an initiative to introduce the installation of a comprehensive safety navigation system for oil tankers into the mandatory requirements of SOLAS 1974 as amended.

It was a common view shared by most maritime nations participating in an IBS formulation that it was surely important to integrate the information on safety of navigation to assist the navigation by human who must make a final decision to control ship.

2.1.6 NAV 40/7/16 (dated 15 July 1994)

Further to the precedent NAV 39/4/14, Japan gave the specifications of an ideal comprehensive safety navigation system.

Japan's proposal advocated : human factor-based safety system, modelling of information, realization of a full automation, co-operation of man-machine, cross checking redundancy.

2.1.7 NAV 40/WP.1 (dated 18 August 1995)

A working group prepared a consolidated analysis of trials conducted in accordance with MSC/Circ. 566, with an assessment of the specific conditions under which the practice of one-man watchkeeping during periods of darkness can and cannot be considered to conform with the principles established in COLREG 1972, 1978 STCW and the relevant IMO resolutions.

At present, this consolidated draft is expected to be a basis for IMO's future works.

From the analysis, the writer may induce that the most important factors to be weighed up in the safety aspect are :

1) Maintenance of the alertness of the solo-watch officer .
2) Full automation of a bridge system capable of reducing workload (assignments).
3) Bridge layout based on the workstation concept.
4) Complete conversancy with the functions, operations and layout of the bridge system, bridge procedure, watch limitation.

2.1.8 NAV 43/Inf.15 (dated 15 July 1994)

In pursuit of the decisions made by Design & Equipment Sub-Committee, Japan carried out experiments for the evaluation of the standard of bridge layout, using a mockup of a bridge.

According to the results of the experiments, the basic concept for standardization of the bridge layout can be summarized hereunder.

1) Efficient performance of operations.
2) No obstruction for lateral movements from wing to wing.
3) Secured working spaces for looking out.
4) Installation of a ARPA radar in close proximity to the console.
5) Integration of alarm switches and indicators in the console.

2.2 MSC/Circ. 566 (dated 1 July 1991) issued by IMO Secretariat

The Maritime Safety Committee approved a provisional guidelines for the conduct of trials in which the officer of the navigational watch acts as the sole look-out in periods of darkness. The Committee urged IMO's member governments that this provisional guidelines should be considered as guidance for uniform application in such trials.

The report forms of the results of trials conducted in accordance with the provisional guidelines, including preliminary progress report, annexed thereto are expected to collect relevant information, evaluate and consequently facilitate deliberations by the Organization on the practice of allowing the officer of the navigational watch to act as sole look-out in periods of darkness.

On the basis of the data collected, the Committee will further consider the details and particulars of the bridge system of this kind.

It should be emphasized that this guidelines, being the sole guidelines approved by IMO, outweighed other related information papers and as such its details attract our observation.

2.2.1 Bridge Layout and Instrumentation - its principle -

1) bridge design, bridge configuration, arrangement of consoles and equipment location should be user-oriented.
2) easy accessibility of all relevant instrumentation from the workstation.

The writer's comment :

In ergonomics, this can be graphically suited a spatial operational sequence diagrams which visually depict the actual sequence of operation overlaid on a pictorial representation of the work space.

3) efficient surveillance, manoeuvring, the field of vision from a workstation
4) the field of vision in conformity with the guidelines on navigation bridge visibility as specified in MSC/Circ.403 which was later introduced in new regulation 22 of Chapter V of SOLAS 1974 as amended.
5) navigator's activities necessary to secure the safety of navigation
6) the lighting required on the bridge
7) An OMBO ships should in any case be equipped with the following :
   .1 Bridge Safety System
   .2 ARPA
   .3 electronic position-fixing systems

.4 gyro compass system
.5 automatic steering system
.6 speed log system
.7 echo sounding system
.8 whistle control system
.9 internal and external communication systems

8) In addition, the following instruments may be recommended for the benefits.
.1 automatic graphical position display
.2 an appliance for recording VHF calls
.3 a paging system and means of acknowledgement
.4 a rasterscan daylight-viewing radar
.5 a NAVTEX or EGC receiver, as appropriate for automatic reception
.6 a sound reception system

9) Collision warning system is to be installed in order to safeguard against the risk of collision

10) Grounding and Off-track warning system is to be installed in order to safeguard against the risk of grounding

11) relevant qualifications and additional responsibilities of the officer of the navigational watch

2.3 Further developments in STW and DE Sub-Committees, and MSC.

2.3.1. STW 26/8 (dated 1st March 1994)

England presented in this paper the results of sea trials for the vessels equipped with a Bridge Safety System, the main functions of which were to alert the navigator against

any prevailing risk and to monitor the human responses.
The writer's view on this paper is that :

1) It is envisaged that this instrument will act as a complementary means to alert the navigator of the watch under an Integrated Bridge System scheme.
2) however, humans' fatigue factors were not brought into consideration in the design and the harmonization of ergonomic aspects with psychological aspects.
nevertheless, the visualization of a bridge safety system was of a functional approach to the ultimate IBS with the emphasis on practical application rather than concept itself.

2.3.2 DE 38/11 & DE 38/Inf.3 (28th October 1994)

With a result of activities of a working group under the chairmanship of Japan, a draft guidelines for the standardization of the layout of essential instrumentation on the bridge and in the engine room was developed.

Having compared it with the previously made proposals and recommendations, the writer found no significant differences.

2.3.3. MSC 65 (9~17 May 1995)

The Committee considered the draft MSC Circular on requirements for solo watchkeeping during periods of darkness prepared by the NAV Sub-Committee at its fortieth session and the amendments thereto proposed by the STW Sub-Committee and a proposal of several nations to approve the draft MSC Circular. The Committee decided, following the United States's proposal, not to approve the aforesaid draft MSC Circular; and trials with the officer of the navigational watch acting as the sole look-out in periods of darkness should be discontinued in the

future. Even though delegations supporting solo watchkeeping during periods of darkness pointed out all the ships involved were specially fitted with technically advanced facilities to render solo watchkeeping safe and had had trouble free operations during the trials and officers on board such ships were of the opinion that safety had improved, the Committee decided to prepare a draft MSC Circular to submit to the next 66th session of MSC to the effect that :

.1 the Committee has concern at the impact on safety of navigation if solo lookout at night was allowed to continue in the future ;

.2 the Committee revokes MSC/Circ. 566 ; and

.3 the Committee recommends that trials with solo lookout in periods of darkness should be discontinued.

2.3.4 1995 STCW Conference (26 June ~ 7 July 1995)

STCW Convention, STCW Code and STCW-F Code do not contain any provisions on training of officers in charge of the navigational watch who would be authorized to carry out solo watchkeeping during periods of darkness. Such proposals have been rejected as the majority of delegations expressed the view that a solo look-out at night should be prohibited.

2.4 Results of the 41st session of NAV Sub-Committee (18 ~22 Sept. 1995)

The 41st session of the IMO Sub-Committee on the Safety of Navigation (NAV) was held from 18th to 22nd of September 1995. Among the agenda items were included the standardization of essential bridge and engine room instrumentation, ergonomic

criteria for bridge equipment and revision of SOLAS Chapter V in association with the development of performance standards of an integrated navigation system.

The progress made in NAV 41 will be transferred to next NAV 42 for further refinement and subsequent submission to MSC 67 in late 1996.

.1 Ergonomic criteria for bridge equipment

Germany provided a list with a description and examples for software ergonomic design criteria such as suitability for the task, self-descriptiveness, controllability, conformity with user expectations and error tolerance.

When this agenda item was on the table, delegation of the Republic of Korea proposed to consider stimulus and reaction matters as well as tracking task capability in the framework as prepared by Germany. For this, Germany showed its positive response to Korea's proposed additional criteria with its consent expressed and included these criteria in that framework.

.2 Rule-making on an integrated navigation system

A draft text of SOLAS Chapter V provided a legal basis for installation of integrated navigation systems by specifying that the carriage requirements of each essential navigational instrument as per ship's tonnage may also be complied with by installation of integrated navigation systems which meet the general functional requirements and in addition the following specifications :

(i) integrated navigations systems shall meet the functional requirements of the primary stand-alone units or equivalent functions as specified by the Organization.

(ii) in case of failure in the integrated system it shall be possible to operate the primary functions separately.

※ Most participants stressed the importance of this primary functional requirement.

(iii) the stand-alone units which are integrated shall meet the minimum system performance requirements as specified by the Organization.

(iv) the integrated navigation system shall meet the performance standard* adopted by the Organization.

※ The International Electrotechnical Commission (IEC) volunteered to develop a performance standard for submission to next 42nd session of the sub-Committee.

After consideration at length, the working group synopsized the above into two paragraphs only as shown hereunder, while leaving the installation of integrated navigation systems optional irrespective of ship's size ;

- para.(1) Equipment performing the functions in this regulation, forming part of an integrated navigation system should be also so arranged that failure of one sub-system does not effect any other sub-system.
- para.(2) In case of failure in the integrated system it shall be possible to operate the primary functions separately.

.3 Introduction of new navigational instruments into SOLAS Chapter V

- Introduction of new navigational instruments into the carriage requirements of the revised draft text of SOLAS Chapter V was discussed as follows.

(1) Sound Reception System

A sound reception system is an acoustic electronic navigational aid for picking up sound signals at a position outside

the bridge, and relaying them to a loudspeaker or some form of warning device inside the bridge. The primary functions required are the capabilities of receiving incoming sound signals from all directions and of reproducing incoming sound signals acoustically and optically inside the bridge.

The issue of sound reception systems has been raised, mainly in response to the introduction of enclosed bridges and one man bridge operation.

According to paragraph 17 of MSC/Circ.566, Administrations should consider the need and benefits of a sound reception system. Rules 5 of 1972 COLREG requires that every vessel at all times maintain a proper look-out by sight and *hearing* to make a full appraisal of the situation and the risk of collision.

In pursuance of these regulatory requirements and for safety reasons, the Sub-Committee decided to include a functional requirement which reads that "all ships shall be fitted with means to enable the watch officer to *hear* sound signals from other ships."

(2) Voyage Data Recorder (VDR)

After debates, the Sub-Committee, while supporting the concept of a voyage data recorder, came to the conclusion that it was somewhat premature to mandate the carriage of such equipment before detailed specifications are available. However, it is expected that when necessary specifications are available then consideration will be given to require a voyage data recorders on ships in the near future.

(3) Global Positioning System (GPS)

Concerns were expressed that the current SOLAS

requirements are to some extent left behind the rapid development of radionavigational aids. According to the research investigation on the use of GPS worldwide, confidence in this system is remarkably high, with about 80 % of users showing positive response in the use of this system.

The draft regulation to this effect reads that "all ships, and cargo ships of (300) gross tonnage and upwards should be fitted with means suitable for use throughout the intended voyage to continuously establish and update their position by automatic means and this system should be provided with a reserve source of energy.

3. Requirements of Classification Societies

3.1 Class Requirements

As far as "navigation" matters are concerned, most leading classification societies (usually represented by eleven members of IACS) have been dependent upon the requirements as laid down in the international conventions rather than to explore innovative solutions on the reason that the navigational matters are out of classification societies's domain. However, some societies are providing special feature notations regarding ship automation and/or remote control functions like UMS,MO,UMA etc. for unattended machinery space(s) and CCS (Centralized Control Station), and ICC(Integrated Computer Control).

One society has a notation regarding BRS(navigation bridge systems) and BRS1(accident prevention systems).

Ships with class notation "ICC"

The control and supervision of functions such as the following are to be carried out by an integrated computer control systems ;

- propulsion and auxiliary machinery
- cargo and ballast systems
- navigation equipment

In addition, the design features for computer hardware, local area networks and software are to be complied with adequate requirements. It is noteworthy that it provides specifications of "Operator Interface" for the ships of "ICC" notation.

Ships with class notation "BRS" and "BRS1"

The society provides rules for bridge layout & bridge working environment, navigational equipment and accident prevention system.

These rules include specific provisions of :

filed of vision, windows, bridge working environment, external sound signals, bridge safety system and alarm and warning transfer system.

3.2 IACS Unified Requirements

IACS developed the unified requirements for one man bridge operated ships (UR on OMBO). The framework of the UR is shown below :

Part A - General

1. Application
2. Operational assumptions
3. Regulations, Guidelines, Standards 4. Definitions

Part B - Technical Requirements

1. Bridge layout
2. Bridge instrumentation and controls
3. Equipment design and reliability
4. Tests and surveys

This UR was developed in conjunction with the one man bridge operation system of IMO and intended to apply to a classed ship where OMBO trial is carried out.

4. Related matters for consideration

4.1 GMDSS

Ships are required to install the GMDSS equipment in accordance with the enforcement of the 1988 SOLAS amendments and the relevant domestic regulations related thereto depending on the size and function of the vessel. Some of this legislation has already been put into force, while worldwide effective GMDSS legislation is in the process of coming into force with complete compliance scheduled for 1 February 1999 (for new ship 1 February 1995).

It seems to be indispensible to find a common link between the GMDSS configuration and an integrated bridge system. As GMDSS equipment is already mandatory, it would be cost effective to shipowners and convenient to vessel operators if all the prerequisite equipment are consolidated into IBS. Various studies and experiments conducted by leading maritime administrations showed that no major technical problems exist with the integration of the GMDSS equipment into an integrated

bridge system.

4.2 Ergonomic considerations

As it is so called, the term *ergonomics or human factors engineering* can be translated into *designing for human-oriented* in a single word.

The current interest in human factors arises from the fact that technological developments have focused attention on the need to consider human factors in such developments of engineering field. In a sense, the goal of human factors is to guide the applications of technology in the direction of benefiting humanity. Still there are a variety of provinces we have to step forward.

Having examined the development of recommendations and standards in IMO, the writer found it important that ergonomic considerations advocate the research investigating not a single factor individually such as workspace design or human responses but the interaction of more than two factors. Applying each recommendation individually in isolation with other factors may result in unnecessary large ranges of interference or unfavourable interactions among them. Further considerations may include the necessity to combat the monotony of a solo watch at night, which requires the presence of other means of a lookout as an emotional support.

5. Summary

The technical and operational requirements for one-man bridge operations caused considerable debate at the IMO forums. During the debates, there was a consensus that the bridge design should enable the officer of the watch to perform his or her normal duties as well as to maintain a proper lookout. The bridge should be designed such that the field of vision should be in accordance with the regulation 22-1 of Chapter V of 1994 amendments to SOLAS 1974.

Makers should also consider the benefits of the more sophisticated equipment including ARPA, automatic graphical position display, paging system, rasterscan daylight-viewing radar, recording of VHF calls, and a NAVTEX receiver for automatic reception etc.

Putting together all the views expressed so far, the writer wishes to make the point that in the development of an IBS, consideration must be given to pure technical research, ergonomics, human factors, bridge visibility and together with psychological effect, noise & vibration and surveillance & monitoring system individually and collectively.

Closing remarks

The writer has tried to keep a scholaric and pragmatic approach jointly to this investigation, with overall review of the related discussions in IMO forums.
In spite of this attitude, a quick glance at this report seems to

this writer that there are plenty of rooms where the presentation may be quite narrative, but it is the writer's cherished desire that this presentation will be used, or referenced for those who are seeking to pioneer the new horizon of the Integrated Bridge System aboard.

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