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WORK PROGRAMME

Proposal for a new output to develop minimum Performance Standards for Dual Frequency Multi-Constellation Satellite-Based Augmentation Systems (DFMC SBAS) and Advanced Receiver Autonomous Integrity Monitoring (ARAIM) in shipborne radionavigation receivers

Submitted by Australia, Austria, Belgium, Bulgaria, China, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Kingdom of the Netherlands, New Zealand, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, EC, ICS, IALA and NI

SUMMARY

Executive summary:	This document provides information on the Southern Positioning Augmentation Network (SouthPAN), the joint Australian and New Zealand Government operated Satellite-Based Augmentation System (SBAS) and proposes a new output to develop minimum Performance Standards for Dual Frequency Multi-Constellation Satellite-Based Augmentation Systems (DFMC SBAS) and Advanced Receiver Autonomous Integrity Monitoring (ARAIM) in shipborne radionavigation receivers.
Strategic direction, if applicable:	2
Output:	Not applicable
Action to be taken:	Paragraph 50
Related documents:	Resolutions A.1110(30), A.915(22), A.1046(27); MSC.112(73), MSC.113(73), MSC.114(73), MSC.115(73), MSC.233(82), MSC.379(93), MSC.401(95), MSC.432(98), MSC.449(99) and MSC.480(102); IALA Recommendation R-135 and IALA World-Wide Radio Navigation Plan

Background

1 This document is submitted in accordance with MSC-MEPC.1/Circ.5/Rev.4 on *Organization and method of work of the Maritime Safety Committee and the Marine Environment Protection Committee and their subsidiary bodies* on the submission of proposals for new outputs. It takes into account the High-level Action Plan for the Organization and priorities for the 2018-2023 period (resolution A.1110(30)).

2 Satellite navigation systems are being used by the international maritime community to fulfil carriage requirements for determining position, navigation and time (PNT) according to SOLAS chapter V. IMO is carrying out the necessary tasks required for due recognition of the Global and Regional Navigation Satellite Systems (GNSS/RNSS) as components of the World-Wide Radionavigation System (WWRNS). IMO also develops performance standards for shipborne receiver equipment, for individual GNSS and for multi-system receivers (resolution MSC.401(95)), which includes augmentation systems and Receiver Autonomous Integrity Monitoring (RAIM).

What is SBAS?

3 Sattelite-Based Augmentation System (SBAS) augments signals from navigation satellite systems. It improves the accuracy, availability and reliability of GNSS by correcting signal errors while adding an integrity to GNSS signals, thereby enhancing the safety and efficiency of navigation.

4 SBAS use geostationary and non-geostationary satellites and have continent-wide service areas. SBAS use a set of monitoring or reference stations (whose positions are known precisely) to receive GNSS signals that are processed in order to obtain estimations of the errors applicable to the users (i.e. ionospheric errors, satellite position/clock errors, etc.). Once these estimations have been computed, they are transmitted as differential corrections by means of a SBAS satellite. Along with these correction messages, which increase accuracy, SBAS also broadcast GNSS integrity data, thus increasing the confidence that a user can have in the satellite navigation positioning solution.

5 Satellite-based navigation systems are being used widely by the international maritime community. Today, more than 90% of GNSS receivers on board international ships are SBAS-enabled.*

6 Flag and port States require GNSS equipment to be of an approved type. This requirement is fulfilled when ships' equipment has a type approval certificate, based on an IEC (or similar) test standard. That standard is being developed, with completion expected in 2023.

7 At the present stage, industry does not have the means to test the SBAS functionality of shipborne GNSS receivers against any approved standard. The lack of a SBAS test standard to assess correctness and validity of the position solutions offered by the equipment also limits the possibility to promote reliance on the provided SBAS information in the maritime domain.

Lack of performance standards

8 To date, IMO has recognized several GNSS and RNSS as components of WWRNS. IMO has also developed performance standards for shipborne receiver equipment, for individual GNSS, RNSS and for multi-system shipborne radionavigation receivers (resolution MSC.401(95)). However, there is, up to now, no performance standard for receivers that support SBAS.

9 Resolution MSC.401(95) on *Performance standards for multi-system shipborne radionavigation receivers* was adopted in 2015. It identifies SBAS as an augmentation system for GNSS and RAIM as a mechanism to provide integrity monitoring.

* https://www.transnav.eu/Article_Evolution_of_SBASEGNOS_Enabled_Devices_in_Maritime_Lopez,59,1146.html

10 Resolution A.915(22) on *Revised maritime policy and requirements for a future global navigation satellite system (GNSS)* of 2002 foreshadows SBAS and RAIM and their evolutions. It adds, "without augmentation, GNSS accuracy does not meet the requirements for navigation in harbour entrances and approaches or restricted waters". Further, "GPS does not provide instantaneous warning of system malfunction" (annex, paragraph 2.1.1.4). Finally, there is a reference that the resolution should be reviewed periodically (which has, so far, not been conducted). Resolution A.915(22) also states, "augmentation provisions should be harmonized worldwide to avoid the necessity of carrying more than one shipborne receiver or other devices" (annex, paragraph 3.1.3).

11 The International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) describes all elements of an SBAS relevant to maritime Administrations in their Guidelines G1152 (SBAS Maritime Service). It notes test standards for (type approval) do not exist yet, although they are expected to be available in the future (section 5.1).

About DFMC and ARAIM

12 Resolution MSC.401(95) promotes the use of augmentation systems. It mentions that "Augmentation systems use ground-based or space-based transmitters to provide augmentation data to improve accuracy and integrity for specific service areas (such as navigation in harbour entrances, harbour approaches and coastal waters)". Whereas the legacy SBAS is based on a single frequency, e.g. the GPS-like L1 signal (1575.42 MHz), and provides augmentation for GPS satellites only, the Dual-Frequency Multi-Constellation (DFMC) SBAS provides dual-frequency augmentation service for all GNSS constellations (i.e. GPS, Galileo, BeiDou and GLONASS). The DFMC SBAS receiver will need the capability to track both the L5 and L1 signals with the SBAS data (i.e. ephemeris parameters, correction and integrity information) required for the DFMC SBAS service transmitted through the L5 frequency (1176 MHz). The minimum DFMC SBAS capabilities support the same type of operational services as L1 SBAS. DFMC SBAS provides this service in much the same way as L1 SBAS, using corrections broadcasted by geostationary and non-geostationary satellites applied to the GNSS pseudorange augmented by SBAS. DFMC SBAS will offer improved availability, continuity, accuracy, and integrity by using ranging sources with two frequencies to provide ionosphere-free pseudorange measurements.

13 Advanced Receiver Autonomous Integrity Monitoring (ARAIM) is a satellite navigation capability that provides the integrity of highly available, continuous, and accurate GNSS position. ARAIM develops navigation solutions using the same GNSS satellite constellations as DFMC SBAS. ARAIM extends RAIM capability to multiple GNSS constellations, adds a dual-frequency mode and provides additional Integrity Support Data (ISD) through a broadcast channel.

14 ARAIM includes an offline ground monitoring architecture, which provides updates on the nominal performance and fault rates of multiple GNSS constellations. This integrity data is contained in the Integrity Support Message (ISM) that is generated by an offline ground monitoring network and is provided to the receiver by means of GNSS signals. The ISM allows monitoring and updating on a regular basis the performance information over the evolution of the constellation without requiring equipment changes. In this offline architecture, the ISM is not expected to be updated frequently. Both ARAIM and RAIM use the GNSS receiver to determine the satellite position integrity by monitoring the consistency of measurements.

15 The combined use of GNSS, DFMC SBAS and ARAIM is compliant with the user requirements described in resolutions A.1046(27) and A.915(22) for a defined service area, including navigation in harbour entrances, harbour approaches and coastal waters (c.f. EC- funded project ARAIMTOO final report). The ARAIM service complements the

DFMC SBAS one, offering resilience to SBAS satellite outages, which frequently appear at low elevations, and enabling navigation with integrity, outside of the SBAS service areas (i.e. polar regions).

16 Radio beacon Differential GPS (DGPS) meets IMO requirements for accuracy and integrity for maritime navigation in harbour entrances, harbour approaches and coastal waters. However, its coverage is limited to medium frequency (MF) radio ranges and it is a 1990s technology. Australia, Ireland, Japan, the United Kingdom and the United States have discontinued their radio beacon DGPS service. DFMC SBAS and ARAIM is an alternative to DGPS.

17 In accordance with the requirements stipulated in MSC-MEPC.1/Circ.5/Rev.4, necessary information for the assessment of the proposal is given below.

Is the subject of the proposal within the scope of IMO's objectives?

18 The proposal aims to enhance maritime safety, covering the gap related to performance standards for augmentation systems, and in particular for SBAS and ARAIM as an alternative to DGPS whose transmission is being discontinued worldwide, and RAIM that is not designed for multiconstellation GNSS.

19 The co-sponsors of this proposal, some of them operating SBAS systems and GNSS constellations enabling ARAIM services, are committed to providing long-term, continuous, stable and reliable services for the users in their defined service area. SBAS and ARAIM can enhance the safety and efficiency of marine navigation. The subject is, therefore, clearly within the scope of the IMO objectives.

How is the proposed item related to the scope of the Strategic Plan for the Organization and how does it fit into the High-level Action Plan?

20 IMO's Strategic Plan (2018-2023) has a key strategic direction (SD 2) to "Integrate new and advancing technologies in the regulatory framework". SD 2 urges the Organization to review existing instruments, to ensure that the application of new technologies to international shipping is conducted in a manner which continues to ensure the highest practicable standards for maritime safety, efficiency of navigation and prevention, and control of marine pollution from ships. The proposed work item will enhance technical, operational and safety management standards contributing to the performance indicator 2.1: proposals submitted to IMO to incorporate new and advancing technologies into the regulatory framework.

Need or compelling need

21 The proposal aims to enhance maritime safety, covering the gap related to performance standards for augmentation systems, as an alternative to DGPS whose transmission is being discontinued worldwide. There is a need for standardization of DFMC SBAS and ARAIM to ensure a provision of integrity mechanism. Without this standard in place, there will be a safety issue because ships will be using signals that are not regulated in a receiver that is not tested for it.

22 Some Member States are facing serious obsolescence issues in their DGNSS radio beacon infrastructure. DFMC SBAS and ARAIM are considered by maritime authorities as a cost-effective complementary technology to provide enhanced accuracy and integrity worldwide in the case of ARAIM, and up-to continental extent for SBAS.

23 As examples of evidence of the need, Australia, Ireland, Japan, the United Kingdom and the United States have discontinued their radio beacon DGPS service. Some of the Member States with this need are co-sponsoring this document.

24 Flag and port States require GNSS equipment to be of an approved type. This requirement is fulfilled when ships' equipment has a type approval certificate, based on an IEC (or similar) test standard. Importantly, though, as it is not currently possible to test SBAS functionality (against an approved standard), maritime community does not know whether receivers supporting SBAS are functioning correctly and whether mariners can rely on the SBAS information.

25 Noting the urgency to provide authorities and manufacturers technical guidance, the IEC is completing the work in order to publish a first test standard for the combined use of SBAS and RAIM by 2023, building on the IEC 61108- 1 GPS test standard.

26 In order to allow for the implementation of a similar approach for multi GNSS constellations, and the adoption of DFMC SBAS and ARAIM as a safety service for the maritime community, minimum performance standards are needed. Considering the above, a new work item is necessary at the earliest opportunity.

27 The evolution of the various GNSS elements towards DFMC is already taking place. As of today, there are four GNSS constellations, which can provide navigation services worldwide and free of charge: GPS, Galileo, BeiDou and GLONASS. The availability of multiple constellations contributes to improving the GNSS position solution and minimizes the risk of having insufficient satellites within a single constellation.

28 Furthermore, States responsible for the GNSS constellations are introducing DF services gradually, such as ARAIM. The use of DF solutions can mitigate vulnerabilities of the GNSS service such as radio frequency interference affecting a single frequency.

29 As a consequence, a number of States and regions also plan to deploy DFMC SBAS services which take advantage of the availability of several constellations and frequencies and ensure a robust and safe GNSS navigation which the maritime sector can benefit from. Operational SBAS systems such as WAAS, EGNOS, QZSS and GAGAN have been providing differential corrections and integrity bounds for the L1 GPS C/A and L1 SBAS ranging signals. All current operational and future SBAS providers (i.e. China (BDSBAS), Republic of Korea (KASS), Africa (SBAS-ASECNA), Australia / New Zealand (SPAN) and Russian Federation (SDCM) have DFMC SBAS in their roadmap.

30 The creation of an IMO performance standard for DFMC SBAS and ARAIM services will also ensure a simpler and cost-efficient transition to the upcoming DFMC GNSS scenario. The introduction of DFMC SBAS and ARAIM is backward-compatible with current GNSS services and for all fielded shipborne receivers. However, the equipment needs to be upgraded to benefit from the enhanced services that will be offered.

Analysis of the issues and implications involved, having regard to both the costs to the maritime Industry, as well as the associated legislative and administrative burden, at global level, including an assessment of its practicability, feasibility and proportionality

31 SBAS service provision is funded entirely by SBAS service providers (some of which are co-sponsors of this proposal), encompassing all development, implementation and operating costs, and is compatible with other satellite-based augmentation systems. Thus, the deployment of the DFMC SBAS and ARAIM services are not expected to impose direct costs on the maritime industry. The administrative burden to the Organization and to the Member States will be minimal.

32 The text above justifies the practicability and feasibility of the proposal. Additional tests will need to be established to increase safety and reliability of the implementations done by manufacturers. The additional costs are covered by the benefits (next section), which makes this proposal proportional.

33 A completed checklist for "identifying administrative requirements and burdens" in accordance with MSC-MEPC.1/Circ.5/Rev.4 is provided in annex 1.

Benefits that would accrue from the proposal

34 The combined use of DFMC SBAS and ARAIM will result in enhanced performance in terms of accuracy, availability, and integrity, and provide resilience of the Position Velocity and Timing (PVT) solution compared to using a standalone augmentation system.

35 DFMC SBAS and SBAS L1 provide an augmentation service, meeting the requirements as outlined in resolution A.1046(27). The co-sponsors believe that the combined use of DFMC SBAS and ARAIM will further enhance the safety and efficiency of navigation for mariners compared to the available SBAS L1 services. DFMC SBAS and ARAIM will be offered as a complement to DGNSS radio beacon infrastructure to enhance the safety of navigation in ocean, coastal waters, harbour entrances and approaches, which is not possible with standalone GNSS.

36 The DFMC SBAS service offers many advantages when compared to the legacy SBAS service in terms of availability, accuracy and integrity.

.1 Availability:

.1 DFMC SBAS enables the provisioning of an SBAS service in regions of active ionosphere, the enhanced service mitigates the effect where the availability of an L1 SBAS service would otherwise be low;

.2 the DFMC SBAS design addresses the limitations of the L1 SBAS service to augment multiple constellations; and

.3 the use of an additional frequency in DFMC SBAS provides additional resiliency to radiofrequency interference (RFI) on L1.

.2 Accuracy:

.1 DFMC SBAS enabled receiver can select a good set of ranging sources from multiple constellations to improve the geometry (Dilution of Precision) of the GNSS satellites used in the position solution.

.3 Integrity:

.1 DFMC SBAS provides higher reliability and improved integrity schemes at ranging level.

37 The ARAIM service comprises several major advantages compared to the legacy RAIM such as higher reliability and integrity schemes. ARAIM has the ability to dynamically enhance the integrity of data, allowing an improved availability and continuity of service. ARAIM expands the ability to monitor multiple fault cases (i.e. common mode and multiple independent failures), unlike RAIM.

38 The development of an IMO performance standard and the associated IEC test standard will help national maritime authorities to optimize and recapitalize their DGNSS radio beacon infrastructure, enabling the possibility to invest in those areas that are especially critical from the safety of navigation perspective, and complementing the service with DFMC SBAS and ARAIM, which will provide enhanced accuracy and integrity.

Do adequate industry standards exist?

39 No IMO performance standards exist for shipborne receiver equipment that supports DFMC SBAS or ARAIM.

Scope of the proposal and output

40 The scope of the proposal and requested output is the development of minimum performance standards for shipborne receivers that support DFMC SBAS and ARAIM.

41 The output proposed is specific and focused on the development of a standard for receivers.

42 The output is measurable, in the sense that once the standard is in place the output is achieved.

43 The fact that some Member States are developing these new technologies makes the output achievable and realistic.

44 The output is expected to be completed in one biennial period (post-biennial).

Human element

45 The proposal is consistent with IMO's objectives and takes into consideration the human element guidelines and principles contained within resolution A.947(23), in an effort to minimize the impact on the role and workload of the Officer of the Watch. The completed human factors checklist from MSC-MEPC.1/Circ.5/Rev.4 is set out in annex 2.

Urgency, priority and target completion date

46 DFMC SBAS and ARAIM are expected to be operational worldwide starting in 2028. To ensure there is an IEC test standard in place by then, the following timeline is foreseen. An IMO performance standard should be finalized by 2026, following which work on an IEC standard can commence, to be completed by 2028.

47 Based on the compelling need, the development of this performance standard is proposed as a high-priority work and should be addressed as soon as practicable within the working arrangements of the Organization. Taking into consideration the timeline for service provision explained above, the work is then proposed to be executed in the post-biennial period.

Committee and/or subsidiary body essential to complete the work

48 The work should be assigned to the Sub-Committee on Navigation, Communications and Search and Rescue (NCSR).

Estimation of the number of sessions needed to complete the work

49 It is estimated to complete the work in two sessions of the NCSR Sub-Committee.

Action requested of the Committee

50 The Committee is invited to consider this proposal and include it in the post-biennial agenda of the Committee, assigning the NCSR Sub-Committee as the associated organ, with the aim to conduct the work in the 2024-2025 biennium.

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ANNEX 1

CHECKLIST FOR IDENTIFYING ADMINISTRATIVE REQUIREMENTS

This checklist should be used when preparing the analysis of implications required in submissions of proposals for inclusion of outputs. For the purpose of this analysis, the term "administrative requirement" is defined in accordance with resolution A.1043(27), as an obligation arising from a mandatory IMO instrument to provide or retain information or data.

Instructions:

(A) If the answer to any of the questions below is **YES**, the Member State proposing an unplanned output should provide supporting details on whether the burdens are likely to involve start-up and/or ongoing cost. The Member State should also make a brief description of the requirement and, if possible, provide recommendations for further work (e.g. would it be possible to combine the activity with an existing requirement?).

(B) If the proposal for the unplanned output does not contain such an activity, answer **NR** (Not required).

(C) For any administrative requirement, full consideration should be given to electronic means of fulfilling the requirement in order to alleviate administrative burdens.

	NR	Yes
1. Notification and reporting? Reporting certain events before or after the event has taken place, e.g. notification of voyage, statistical reporting for IMO Members, etc.	☑	□ Start-up □ Ongoing
Description of administrative requirement(s) and method of fulfilling it: (if the answer is yes)		
2. Record keeping? Keeping statutory documents up to date, e.g. records of accidents, records of cargo, records of inspections, records of education, etc.	☑	□ Start-up □ Ongoing
Description of administrative requirement(s) and method of fulfilling it: (if the answer is yes)		
3. Publication and documentation? Producing documents for third parties, e.g. warning signs, registration displays, publication of results of testing, etc.	☑	□ Start-up □ Ongoing
Description of administrative requirement(s) and method of fulfilling it: (if the answer is yes)		
4. Permits or applications? Applying for and maintaining permission to operate, e.g. certificates, classification society costs, etc.	☑	□ Start-up □ Ongoing
Description of administrative requirement(s) and method of fulfilling it: (if the answer is yes)		
5. Other identified burdens?	☑	
Description of administrative requirement(s) and method of fulfilling it: (if the answer is yes)		

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ANNEX 2

Checklist for considering and addressing the human element

This checklist consists of five questions as follows:

.1 questions 1 to 4 are risk-based questions intended to identify risks from the implementation and operation of new outputs; and

.2 question 5 is a list of measures for addressing the human element.

	1 **Question**	2 **Yes/ No**	3 **IMO references**	4 **Considerations**	5 **Instructions**
Workload			*Other relevant references may be added* *Strikeout references that are not relevant*	*If answer to question is "yes" identify considerations. If answer is "no" make proper justification*	*Identify how human element considerations should be addressed in the output*
1	**Does the "output" affect workload?**				
1.1	**On board, especially in the already intensive phases of the voyage and port operations to:**	*No*	*Revised guidelines for the operational implementation of the International Safety Management (ISM) Code by Companies* (MSC-MEPC.7/Circ.8) *Guidelines on fatigue* (MSC.1/Circ.1598) *Principles of minimum safe manning* (resolution A.1047(27)) *Guidelines for the investigation of accidents where fatigue may have been an issue* (MSC/Circ.621)	*The use of a GNSS receiver with DFMC SBAS / ARAIM in shipborne radio-navigation receivers has no impact on the workload of maritime operations.*	

	1 Question	2 Yes/ No	3 IMO references	4 Considerations	5 Instructions
1.1.1	Operations including navigation, cargo and engineering	*No*		*The use of a GNSS receiver with DFMC SBAS / ARAIM instead of legacy GNSS receiver with RAIM is transparent to mariners.* *If anything, the enhanced accuracy and availability of DFMC SBAS / ARAIM with respect to legacy SBAS could reduce the workload of maritime operations.*	
	Maintenance of the ships structure and its equipment	*No*		*The maintenance of a GNSS receiver with DFMC SBAS / ARAIM receiver is analogue to the maintenance of legacy GNSS with RAIM equipment.*	
1.1.3	Onboard administration in support of the ships' management systems	*No*		*No impact*	
1.1.4	Onboard administration related to regulation involving flag States, classification societies, port State and other bodies such as charterers and port authorities	*No*		*No impact*	
1.1.5	Increased workload or time pressure on personnel if involved in implementation of changes prior to the implementation date	*No*		*No impact*	
1.2	**Ashore, in a manner that would affect the ships operation to:**	*No*		*No impact*	
1.2.1	Companies' administration	*No*		*No impact*	
1.2.2	Flag State, port State and classification societies administration such that certification and other processes are compromised or delayed	*No*		*No impact*	

	1 **Question**	2 **Yes/ No**	3 **IMO references**	4 **Considerations**	5 **Instructions**
Decision-making			*Other relevant references may be added* *Strikeout references that are not relevant*	*If answer to question is "yes" identify considerations. If answer is "no" make proper justification*	*Identify how human element considerations should be addressed in the output*
2	**Does the "output" impact decision-making on board the ship?**				
2.1	By confusion with existing requirements and regulations	*No*		*The creation of an IMO performance standard for DFMC SBAS / ARAIM prevents any confusion in terms of requirements.*	
2.2	By changing responsibilities as laid out in the ISM Code	*No*		*No impact*	
2.3	By creating complexity in its implementation and/or in the safety management systems	*No*		*The standard will prevent any confusion in terms of decision making on board the ship.*	
2.4	By requiring increased mental effort, such as the need to find, transform and analyse data or result in the need to make judgements based on incomplete information	*No*		*The use of GNSS with DFMC SBAS / ARAIM instead of legacy GNSS with RAIM is transparent to mariners.*	
2.5	By limiting the time available to establish situational awareness, decide, communicate (possibly across time zones) or check	*No*		*No impact*	
2.6	By increasing reliance on judgement and administrative controls to manage major risks such as oil spills and collisions	*No*		*No impact*	

	1 **Question**	2 **Yes/ No**	3 **IMO references**	4 **Considerations**	5 **Instructions**
Living and working environment			*Other relevant references may be added* *Strikeout references that are not relevant*	*If answer to question is "yes" identify considerations. If answer is "no" make proper justification*	*Identify how human element considerations should be addressed in the output*
3	**Does the "output" affect the living and working environment?**		*Guidelines on the basic elements of a shipboard occupational health and safety programme* (MSC-MEPC.2/Circ.3) *Guidelines on fatigue* (MSC.1/Circ.1598)		
3.1	By interfering with existing arrangements for abandonment, fire-fighting and other emergency plans or procedures	*No*		*The implementation of DFMC SBAS / ARAIM is limited to its installation in the shipborne radio-navigation receiver, no impact on living and working environment.*	
3.2	By introducing new materials that could create an explosion, fire, environmental or occupational health risk	*No*		*The implementation of DFMC SBAS / ARAIM is limited to its installation in the shipborne radio-navigation receiver, no impact on living and working environment.*	
3.3	By introducing new high energy sources such as high-voltage, high pressure fluids	*No*		*The implementation of DFMC SBAS / ARAIM is limited to its installation in the shipborne radio-navigation receiver, no impact on living and working environment.*	
3.4	By affecting access or egress and causing lack of ventilation in working spaces	*No*		*The implementation of DFMC SBAS / ARAIM is limited to its installation in the shipborne radio-navigation receiver, no impact on living and working environment.*	
3.5	By affecting the habitability of accommodation spaces due to noise, vibration, temperatures, dust and other contaminants	*No*		*The implementation of DFMC SBAS / ARAIM is limited to its installation in the shipborne radio-navigation receiver, no impact on living and working environment.*	

	1 **Question**	2 **Yes/ No**	3 **IMO references**	4 **Considerations**	5 **Instructions**
Operation and maintenance			*Other relevant references may be added* *Strikeout references that are not relevant*	*If answer to question is "yes" identify considerations. If answer is "no" make proper justification*	*Identify how human element considerations should be addressed in the output*
4	**Does the "output" affect the operation and maintenance of the ship, its structure or systems and equipment?**		*Revised guidelines for the operational implementation of the International Safety Management (ISM) Code by Companies* (MSC-MEPC.7/Circ.8) *Guidelines for bridge equipment and systems, their arrangement and integrtions (BES)* (SN.1/Circ.288) *Principles of minimum safe manning* (resolution A.1047(27)) *Issues to be considered when introducing new technology on board ships* (MSC/Circ.1091) *Guideline on software quality assurance and human-centred design for e-navigation* (MSC.1/Circ.1512) *Guidelines for the standardization of user interface design for navigation equipment* (MSC.1/Circ.1609)		

	1 **Question**	2 **Yes/ No**	3 **IMO references**	4 **Considerations**	5 **Instructions**
4.1	By introducing equipment that the user may find difficult to operate or maintain or may be unreliable	*No*		*The use of a GNSS receiver that supports DFMC SBAS / ARAIM instead of legacy GNSS with RAIM is transparent to mariners. Reliability of the DFMC SBAS / ARAIM position solution will be established as part of the new IMO performance standard.*	
4.2	By introducing new and/or novel technology, or technology that changes the role of the person	*No*		*The outcome of DFMC SBAS / ARAIM technology is similar to the outcome of legacy GNSS with RAIM. As such, it does not introduce novel technology or changes in the role of a person.*	
4.3	By introducing requirements for new competencies and roles	*No*		*No new roles associated with the use of DFMC SBAS / ARAIM receivers.*	
4.4	By overloading existing infrastructure such as power generation and ventilation systems	*No*		*No impact on shipborne infrastructure, implementation limited to the radionavigation receiver.*	
4.5	By poor integration with existing systems and controls	*No*		*Integration with existing systems and controls is analogue to the implementation of legacy SBAS receivers.*	
4.6	By introducing new and unfamiliar operations/procedures	*No*		*The use of a DFMC SBA\S / ARAIM does not necessarily imply new operations or procedures, although the increased accuracy and availability could allow so.*	
4.7	By introducing new and unfamiliar operating interfaces?	*No*		*No new interfaces need to be added.*	
4.8	By introducing risks to the ship during any modifications required prior to the implementation date of the output	*No*		*No impact*	

	1 **Question**	2 **Yes/ No**	3 **IMO references**	4 **Considerations**	5 **Instructions**
Measures to address the human element			*Other relevant references may be added* *Strikeout references that are not relevant*	*If answer to question is "yes" identify considerations. If answer is "no" make proper justification*	*Identify how human element considerations should be addressed in the output*
5	**Does the "output" require changes to:**		*Shipboard technical operating and maintenance manuals* (MSC.1/Circ.1253) *Revised guidelines for the operational implementation of the International Safety Management (ISM) Code by Companies* (MSC-MEPC.7/Circ.8)		
5.1	Training	*Yes*		*Training may be necessary for mariners to get used to DFMC SBAS / ARAIM terminology, and possibly on how to handle reversion from DFMC SBAS / ARAIM to legacy GNSS with RAIM equipment under specific circumstances.*	
5.2	Practical skill development and competences	*No*		*No impact*	
5.3	Operating, management and/or maintenance procedures	*Yes*		*The use of DFMC SBAS / ARAIM could introduce new operational procedures.*	
5.4	Information/manuals for operation and maintenance	*Yes*		*The use of DFMC SBAS / ARAIM could introduce new operational procedures.*	
5.5	Spares outfit	*No*		*No impact*	
5.6	Occupational safety Requirements including guarding and PPE	*No*		*No impact*	
5.7	Shore support	*No*		*No impact*	

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