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Agenda item [[1]](#footnote-2) 6.2

Technical Domain / Task Number 2 …………………………………

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Analysis on the options for retransmission of SBAS data through VDES

# Summary

IALA G1129 sets out guidance for Marine Aids to Navigation (AtoN) service providers wishing to understand where SBAS information could be used to support the mariner and then how to employ such data for the retransmission of SBAS corrections using MF Radio beacon and AIS. Indeed, the section 4.3 of this document introduces the future work to be done to provide SBAS corrections over other data channels such as VDES.

IALA G1117 provides a VDES (VHF Data Exchange System) overview and considers the possibility to retransmit SBAS corrections with the advantage to use directly the RTCA format, which is independent of the location of the transmitter, either for a terrestrial or satellite transmitter.

Therefore, taking advantage of the work done, and considering also the VDES channels and message types currently defined in ITU Recommendation, this paper proposes an analysis of the options to enable the retransmission of SBAS data through VDES system. This analysis also covers the format(s) in which the SBAS data shall be retransmitted as well as the constraints imposed by using each of them.

Even though this analysis presents some conclusions on the suitability to use one or another option for SBAS data retransmission through VDES, it is understood that there are still some open points (for instance, transmission rate allowed by the different channels, frequency for data provision per message type, etcetera) that would require further analysis and discussion with experts in VDES system and standardization. In this way, the paper requests to IALA Members to support the review of this analysis as well as their future contribution to analyse the open points and gaps (e.g. message type frequency allocation required to meet the SBAS data transmission constraints). Thus, it is the main scope of this analysis to propose the update of the corresponding IALA Guidelines (most likely G1129 and/or G1117) with the main outcomes and resulting mature content.

## Purpose of the document

The main objective of this document is to present the analysis performed and the main conclusions resulted about the (potential) options to enable the retransmission of SBAS data through VDES. The different options presented will be consolidated with the opinions about this work by VDES experts in DTEC and ENG committees while also looking for their support to complete the analysis and the development of the technical material to be included into the corresponding IALA guidelines (most likely G1129 and/or G1117).

## Related documents

* IALA Guideline G1129 – The Retransmission of SBAS Corrections Using MF‐RadioBeacon and AIS. Edition 2.0 December 2017.
* IALA Guideline G1152 – SBAS Maritime Service. Edition 1.0 December 2019.
* IALA Guideline G1117 VHF Data Exchange System (VDES) Overview. Edition 3.0 December 2022
* IALA Recommendation (Informative) R0135 (R-135) The Future of DGNSS. Edition 2.1 September 2020
* ENG17-3.1.2.8 “Retransmission of SBAS data through VDES” input paper.

# Background

Global Navigation Satellite Systems (GNSS) is considered by IMO in [1] as the primary means of obtaining Position, Navigation and Timing (PNT) information at sea. GNSS alone does not meet the most stringent requirements for navigation requiring in this case the use of GNSS augmentation data. In such a way, the traditional GNSS augmentation is based on the marine radio beacon DGPS (Differential GPS) augmentation service, provided by maritime administrations, which improve accuracy while providing integrity for GPS (IALA G1112). Furthermore, being SBAS a satellite-based augmentation it complements the current DGNSS deployed infrastructure (IALA G1129 and G1152) by providing services in water masses not already covered by DGNSS (for instance, EGNOS in Maritimes as per [19]). Additionally, SBAS could be also used as a source of GNSS corrections and integrity information to be retransmitted over the following Maritime Servicer Provider’s AtoN:

* DGNSS stations (maritime radio beacons)
* AIS (Automatic Identification System) stations
* VDES (VHF Data Exchange) data channels

About the first two options, DGNSS and AIS stations, currently IALA G1129 describes in detail the concept to enable the provision of SBAS L1 corrections and integrity information through them as well as it proposes the technical architectures to do so.

For VDES, being the evolution of AIS to overcome the main limitations this later presents, is seen as another option to continue providing the SBAS corrections and integrity (IALA G1117).

As VDES is a new technology already under development and standardization, considering the roadmap presented in DTEC3 ([3]), it is envisaged that its entry into operations would be aligned with the likely entry into service of SBAS DFMC (see Figure 1‑2 in ANNEX A). Thus, it is assumed VDES should facilitate the retransmission of current SBAS L1 corrections but also should additionally allow the retransmission of the forthcoming SBAS L5 corrections (DFMC).

# Discussion

## The different SBAS data transmission means

Regarding the provision of SBAS data to final users, this can be supported either by the SBAS system per se and/or other augmentation solutions through two compatible mechanisms:

* Directly through SBAS Signal-in-Space (e.g. EGNOS SoL assisted service to Maritime users (ESMAS)).
* By retransmitting the SBAS data (corrections & integrity information) via terrestrial augmentation systems as DGNSS stations (currently via IALA beacons) and AIS stations and in the coming years through VDES). For this second mechanism, SBAS data can be provided to these stations either via SiS or through internet if available (for instance, EGNOS EDAS service).

In relation to the retransmission mechanism proposed, different implementation models have been already defined for the retransmission of SBAS data, either using IALA DGNSS radio beacons or AIS stations (through AIS Message 17 as it is detailed in IALA G1129). This mechanism presents some advantages as the mitigation of local effects affecting DGNSS stations (e.g. multipath) that could be mitigated.

Complementary, SBAS data could be retransmitted via VDES (VHF Data Exchange System) through AIS channel but also through the new additional ones, ASM and VDE. Indeed, VDES enables the retransmission of data to users through terrestrial means as well as via the satellite segment this system encompasses.

## Options for VDES to retransmit SBAS data

It is not yet defined nor agreed by the Maritime community about whether SBAS augmentation should be provided to the users via VDES and the mechanisms to do it. About the first question, it is identified in the following section some of the potential benefits envisaged when VDES is adopted as an alternative means to provide SBAS augmentation to Maritime users. In regards the second point, it is proposed to IALA members different mechanisms described in ANNEX A which describe how SBAS DFMC augmentation would be provided to end users, notably as per the following two options:

* Through AIS refurbished channel, as part of an “enhanced” AIS Message 17 that would extend the actual one to incorporate the additional SBAS L5 augmentation data (corrections plus integrity information)
* Through the new ASM and VDE channels, identifying a new message (particularised for the channel considered for its retransmission) that would integrate the SBAS L5 augmentation data as well as the SBAS L1 legacy augmentation information.

The analysis is also complemented with the identification of the potential data format adopted to encapsulate the SBAS data into VDES messages to be retransmitted then. As per the conclusions included into the ANNEX A, there are some constraints about the frequency of message retransmission as well as on the message size to ensure the compliance with the integrity requirement (as per [1]). Moreover, it is also identified other limitations because of lack of standardization to convert the SBAS data to the required format.

## Benefits of using VDES to retransmit SBAS data

Regarding the main benefits foreseen of using VDES for retransmitting SBAS augmentation it is considered:

* Navigation solution using SBAS is reliable, resulting in reduced navigation errors with respect to GNSS. Thus, use of VDES to retransmit SBAS data as an alternative means to provide GNSS augmentation will increase the robustness and safety of PNT.
* Retransmission of SBAS data is so relevant in case of SBAS satellites outages (but still SBAS ground segment is working properly and generating augmentation data), obscuration (SBAS satellite signal blocked by natural of man-made obstacles) or reduced visibility of SBAS GEO satellites at high latitudes (above 70º N). Notably, SIS obstruction is particularly likely in canyon areas or near cliffs.
* Jamming/Spoofing resilience: an eventual interference attack in L1 or L5 frequency would have no impact on the SBAS corrections provided through VDES.
* VDES is a technology that it is currently under development and standardisation, so applications that could provide benefits could be defined from the beginning.
* VDES will enable greater bandwidth compared to traditional AIS (Automatic Identification System). It expands data transmission capacity, allowing for higher data rates, improved communication efficiency, and enhanced maritime safety and navigation services. Thus, it could be used to include the provision of SBAS augmentation data for maritime community.

## Way forward proposed

* Review and consolidation of the analysis/conclusions detailed in ANNEX A
* Identification of potential updates to be covered in further analysis.
* Encourage the involvement of IALA experts to support further analysis. It is assumed intersessional work could be required between committees (plan to be defined and agreed among collaborators)
* Liaison among DTEC and ENG committees would be needed to work on this topic in both committees (if needed).
* Mature the technical description of the mechanism(s) to retransmit SBAS data through VDES and its inclusion as part of IALA guideline material (for instance, G1129, G1117…) at the end of 2023-2027 quadrennial plan.
* Discuss on the need of additional workstreams to work on and follow-up, mainly with standardization bodies (IEC, ITU, RTMC…), to complement the technical description of the retransmission means. The required liaison process could be put in place if needed.

# References

1. IMO Resolution A.1046(27) World Wide Radio Navigation System
2. IMO Resolution A.915(22) Revised Maritime Policy and Requirements for a future GNSS
3. DTEC3-11.1 Report of the third Session of the IALA Digital Technologies (DTEC) Committee
4. ITU. Recommendation ITU-R M.2092-1 Technical characteristics for a VHF data exchange system in the VHF maritime mobile band. Ed Sept 2024 as a draft.
5. Recommendation ITU-R M.1371 (02/2014) Technical characteristics for an automatic identification system (AIS) using time division multiple access in the VHF maritime mobile frequency band
6. ITU-R M.823-3 Technical characteristics of differential transmissions for global navigation satellite systems from maritime radio beacons in the frequency band 283.5-315 kHz in Region 1 and 285-325 kHz in Regions 2 and 3.
7. RTCM 10402.3, RTCM Recommended Standards for Differential GNSS (Global Navigation Satellite Systems) Service, Version 2.3
8. RTCM PAPER 108-2018-SC104-1068 - Committee Draft for Comment STANDARD 10402.4 Differential GNSS (Global Navigation Satellite System) Services – Version 2
9. RTCM 10403.4, RTCM Recommended Standards for Differential GNSS (Global Navigation Satellite Systems) Service, Version 3 (November 01, 2024) with Amendment 1
10. ED-259A/RTCA DO-401 Minimum Operational Performance Standard (MOPS) for DFMC SBAS airborne equipment
11. IALA Guideline G1129 The retransmission of SBAS corrections using MF-radio beacon and AIS. Edition 2.0. June 2022
12. IALA Guideline G1117 VHF Data Exchange System (VDES) overview. Edition 3.0. December 2022.
13. ENG18-4.6.1. Liaison Note to IALA – Update of RTCM 10402.3 Standard. 04 April 2024
14. IEC 61108-4 Maritime navigation and radiocommunication equipment and systems – Global navigation satellite systems (GNSS) – Part 4: Shipborne DGPS and DGLONASS maritime radio beacon receiver equipment – Performance requirements, methods of testing and required test results. 2004-07.
15. S3C GNSS RTK Corrections over VDES. 2024-09-24. DOC-20241101
16. DO-229 Minimum Operational Performance Standard (MOPS) for GPS/WAAS airborne equipment
17. GNSS Augmentation using the VHF Data Exchange System (VDES). Jan Šafář, George Shaw & Alan Grant, General Lighthouse Authorities of the UK & Ireland; Hans Christian Haugli & Lars Løge Space Norway; Stig Erik Christiansen, Kongsberg Seatex; Nader Alagha, European Space Agency. AMNAS project (finance by ESA through ESA General Studies)
18. EGNOS Maritime service status and status (ppt), Silvia Porfili, EUSPA. EGNOS Workshop 2024 (Dublin, 13/03/2024).
19. EGNOS Safety of Life assisted service for Maritime users (ESMAS). Service Definition Document (SDD). Issue 1.0. March 2024

# Action requested of the Committee

The Committee is requested to: (Body text)

1. Review the input paper and the analysis/conclusions written down in ANNEX A and ANNEX B.
2. To agree on the way-forward proposed in section 3.4
3. Annex A – MECHANISMS ENABLING RETRANSMISSION OF SBAS DATA THROUGH VDES

# Assumptions

As it will be detailed in following sections, VDES is a new technology developed to cope with the current limitations of AIS. Indeed, rather than an evolution of AIS, VDES is a multi-component system comprising of VDE, ASM and the AIS in the VHF maritime mobile band (156.025-162.025 MHz) providing in this way a variety of means for the exchange of data between maritime stations, ship-to-ship, ship-to-shore, shore-to ship, ship-to-satellite and satellite-to-ship.

Therefore, VDES will still allow legacy AIS services and messages through the AIS channels implemented in this technology such as the current AIS Message 17, identified as the container to retransmit DGNSS corrections in legacy AIS, will still be used. Thus, this AIS Message 17 will still be a valid option to provide SBAS L1 augmentation in VDES. To do so, SBAS L1 wide area corrections in RTCA format [16] are converted into local DGNSS corrections in the corresponding RTCM format [7]) for the corresponding AIS (or future VDES) station which retransmits then to the end user (in accordance with [6]).

On the other hand, VDES is a technology that it is currently under development and standardisation. Indeed, the relevant maritime organizations as IMO and IALA as well as the main standardisation bodies are already working on the required regulation, relevant guidelines and standards. The following roadmap (Figure 1‑1) provides the timeline by when the system could be sufficiently mature to enter into operations and service.

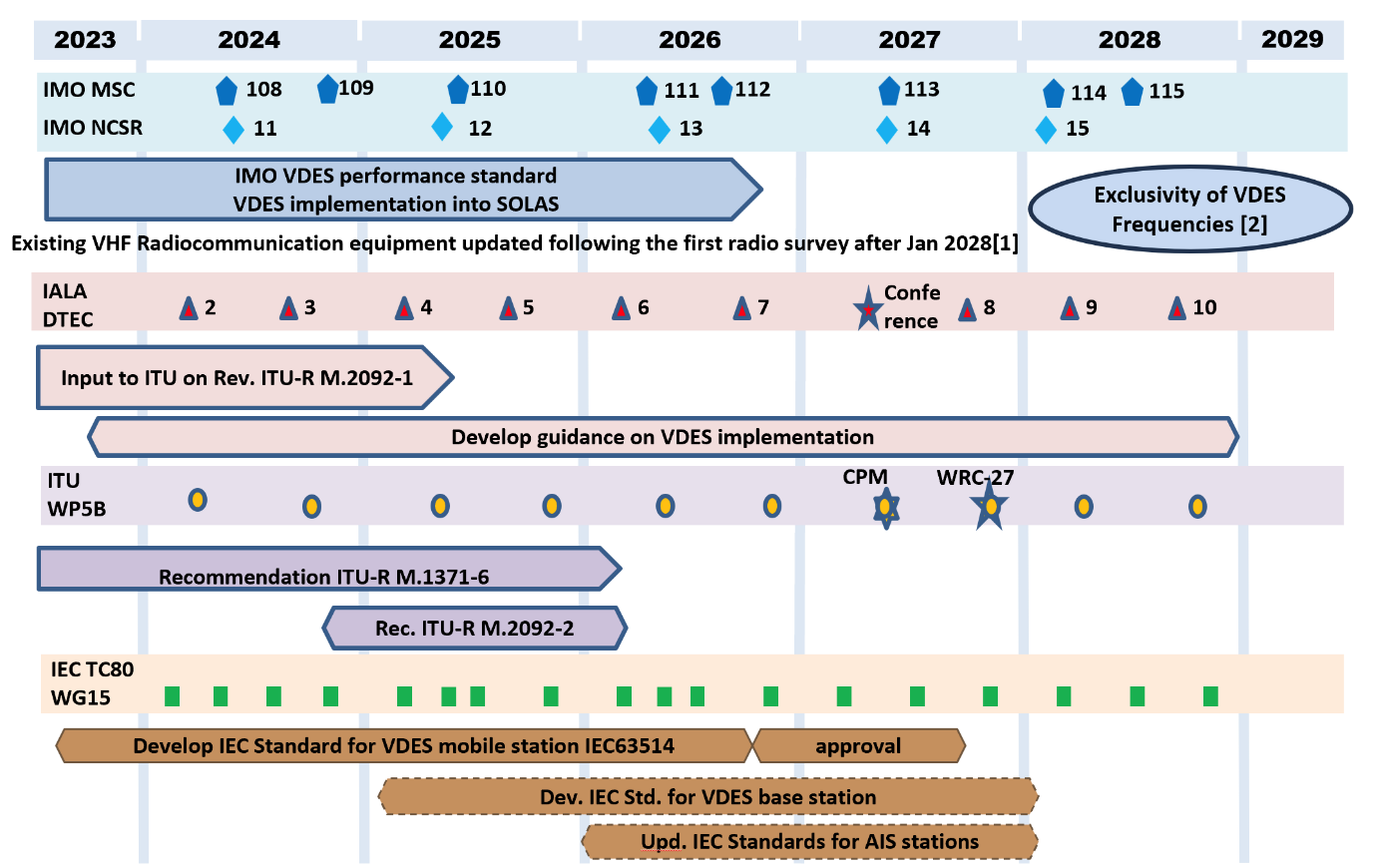


Figure 1‑1 - VDES Roadmap (presented at IALA DTEC3, also included in the report [3])

Additionally, the following Figure 1‑2 introduces the planned entry into operations of EGNOS v3.1 and v3.2, the later one enabling DFMC GNSS augmentation.

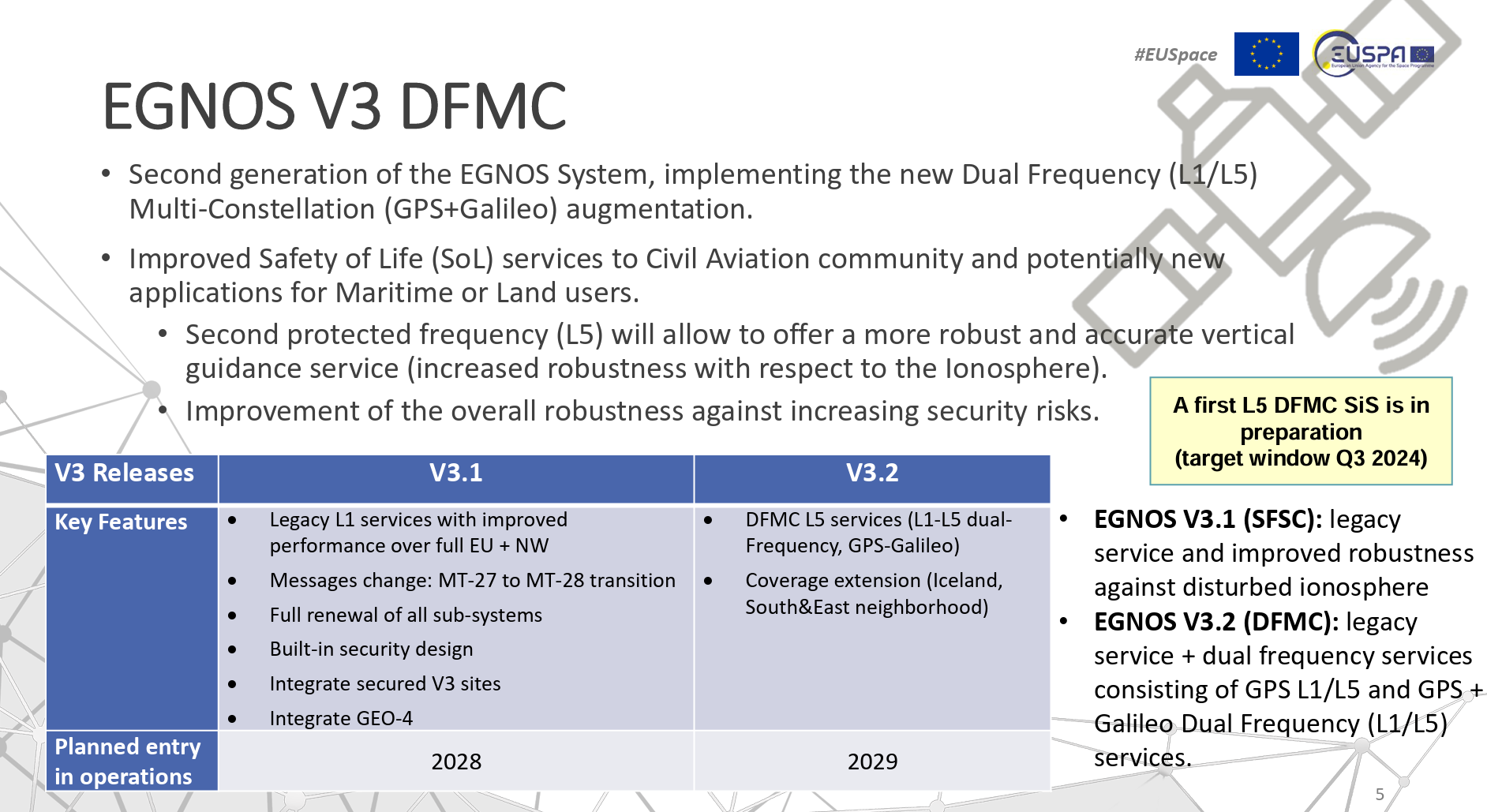


Figure 1‑2 – EGNOS v3 Roadmap (presented at EGNOS Workshop 2024 by EUSPA [18])

Then, taking into account the expected timeframe where this technology could enter into operation, which more or less is aligned with the EGNOS v3.2 DFMC initial operations, VDES should therefore consider the evolution of SBAS from the current L1 legacy service (indeed currently provided in Maritime by ESMAS) to the L1 plus L5 dual frequency multi-constellation (DFMC) services that would be introduced in the late 2020’s (most likely by 2029 as per the Figure 1‑2). In this way, it is understood VDES could adopt this future SBAS DFMC such as the new corrections and integrity information to be broadcast via SBAS L5 (SBAS DFMC will keep providing legacy SBAS L1) could be retransmitted through VDES channels and messages (see Figure 1‑3).

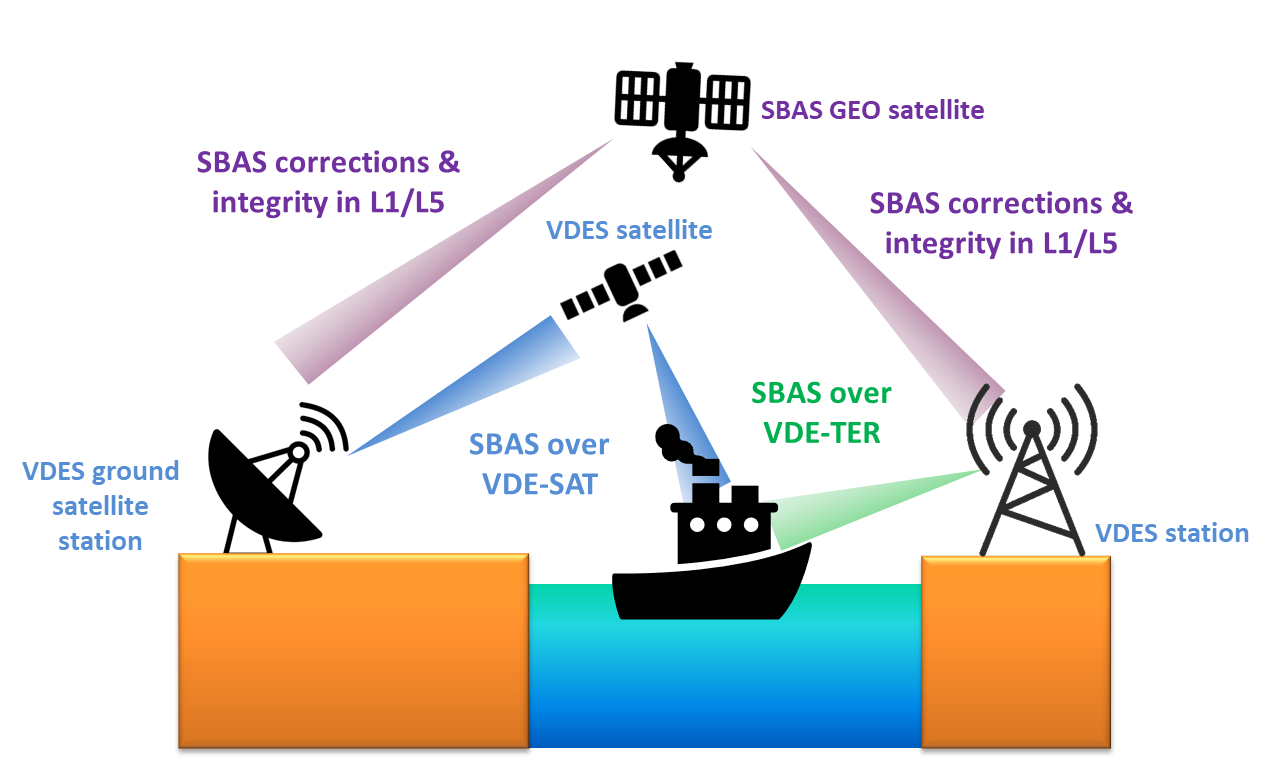


Figure 1‑3 – Concept for SBAS corrections retransmission over VDES

At this point, it is not yet defined nor agreed by the Maritime community about whether SBAS DFMC augmentation would be provided to the users via VDES and the mechanisms to do it. About the first question, this will be treated at IALA in conjunction with the presentation of the mechanisms described through this document to enable the retransmission of SBAS correction through the VDES. Indeed, in regard this second point, it is proposed the following alternatives to respond to the question on how SBAS DFMC augmentation would be provided to end users:

* Through AIS channels, as part of an “enhanced” AIS Message 17 that could be extended to incorporate the additional SBAS L5 augmentation data (corrections plus integrity information)
* Through the new ASM and VDE channels, identifying a new message (particularised for the channel considered for its retransmission) that would integrate the SBAS L5 augmentation data as well as the SBAS L1 legacy augmentation information.

These two options have been initially analysed as potential mechanisms to enable the retransmission of SBAS messages in this ANNEX A. Thus, this analysis addresses the status of the standards (some of them still in draft version and pending on being internationally accepted, approved and published), which describe the VDES technology, to identify the channels and messages that could be used to retransmit the SBAS L1 and L5 corrections. The analysis is also complemented with the identification of the potential data format(s) adopted to encapsulate the SBAS data into VDES messages to be retransmitted then. As per the conclusions included into this ANNEX A, there are some constraints about the frequency of message retransmission as well as on the message size to ensure the compliance with the integrity requirement (see [1]). Moreover, it is also identified other limitations because of the lack of standardization to convert the SBAS data to the required format.

# SBAS L5 (DFMC) and the compliance with IMO requirements

Before presenting the potential alternatives for SBAS L5 augmentation data retransmission, firstly it is necessary to identify the requirements to be demanded to the transmission means (e.g. latency, transmission bit rate) and to the container of the corrections (for instance, message size) to enable the SBAS corrections and integrity information retransmission. To do so, the following bullets detail the main features of SBAS L1 and L5 messages needed to determine the requirements to the transmission means and container:

* In the worst-case scenario, it takes 1 second for a SBAS signal to reach the user (equipment) once is transmitted from the GEO satellite
* The general format of this SBAS L5 message is nearly identical to the SBAS L1 message format but their information (SBAS Message Types - MTs) and parameters, on the contrary, are fully independent of the ones defined for SBAS L1[[2]](#footnote-3).
* SBAS L5 message is the same 250 bits size as the message broadcast via SBAS L1 service. It could be reduced to 216 bits considering only the data field, in case the message type and CRC is encapsulated separately.
* SBAS L5 messages are broadcast once per second similarly to the SBAS L1 message transmission.
* SBAS L5 integrity information (for all augmented satellites and in accordance with the related SBAS L5 MTs) is broadcast once every six seconds (identically to the SBAS L1). All other messages (corrections, SBAS satellites ephemeris, etcetera) are broadcast in between not exceeding the maximum update interval.
  + The user time-out intervals are defined to limit the time interval of applicability of all corrections, integrity and SBAS broadcasting satellite navigation data
  + Every alert condition (when SBAS information is not adequate for safety application) is repeated three times after the initial notification of the alert condition (for a total of four times in four seconds)
  + The most restrictive update interval corresponds in SBAS L5 service to the integrity information (6 seconds)

On the other hand, the retransmission of SBAS L5 messages shall be done to ensure the compliance with the requirements defined in [1] and [2] such as:

* The data retransmitted shall ensure an update rate of the computed position data not lower than once every 2s.
* An integrity warning of system malfunction, non-availability or discontinuity should be provided to users within 10s[[3]](#footnote-4).

About the compliance with the integrity requirement, it has been performed a latency analysis considering:

* Right now, there is no value committed for SBAS DFMC service, it is assumed that at least the time-to-alert (TTA) commitment shall be equal (if not better) than the value already committed by SBAS L1 legacy service, this is a TTA ≤ 5.2 seconds[[4]](#footnote-5). This TTA value is defined between the onset of the alarm condition and the time that the last bit of the alert message reaches the antenna of the user receiver.
* Specifically for the retransmission, the previous TTA is committed till SBAS alert reaches the VDES system (instead of the antenna of the user receiver).
* It should be also accounted the time it takes to the VDES signal (containing the SBAS integrity alerts retransmitted) to reach the user receiver from the VDES system. This time should be dependent on the VDES channel selected. It is assumed 1 second for this time at most.
* Additionally, even though the IMO requirement is not clear on this, it should be accounted the time required by the user receiver to process the alert[[5]](#footnote-6). About this value, in Aviation it is assumed a 0.8 second for the receiver to process the warning alerts.

As a result of the analysis done in the bullets above, it is concluded that the maximum latency acceptable for the VDES system to retransmit the integrity alerts from SBAS is 3 (three) seconds to guarantee the compliance with the related IMO requirement.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Value | Comment | Conclusion |
| Message Size | 250 bits or 216[[6]](#footnote-7) bits (only message data field) | Standard SBAS L5 messages for DFMC SBAS GNSS positioning as defined in [10]  Similarly, SBAS L1 messages is 250 bits size, including preamble, message type identifier and CRC. | Container shall offer the capability to encapsulate a single standard SBAS L5 message of 250 bits or both the SBAS L1 and SBAS L5 standard messages |
| Transmission rate | ≥250 bits per second | One 250-bit message is sent every second (see [10]) | User equipment on board shall be capable to compute the user positioning augmented with SBAS L5 data in compliance with the 2 second requirement defined by IMO |
| Latency (from SBAS GEO to user) | ≤ 3s | In the worst-case scenario, it takes 1 second for a SBAS signal to reach the user once is transmitted from the GEO satellite  New SBAS L5 augmentation data must be delivered and processed by the user in compliance with the IMO requirement: 10-second time to alert (since the onset of the alert and the time the alert is completely processed by the user equipment).  It is assumed that the processing and communication delays in other parts of the augmentation system are such that the overall 10-second time-to-alert requirement is met.  It is assumed that at least the time-to-alert (TTA) commitment shall be equal at least (if not greater) than the value already committed by SBAS L1 legacy service, this is a TTA ≤ 5.2 seconds | During this 3 second time period VDES systems shall be capable to receive the SBAS DFMC messages (L1 plus L5) from GEO satellite(s), to process this information to be encapsulated (and formatted) in the corresponding VDES message/container (AIS, ASM or other VDE-TER/VDE-SAT) and finally to retransmit and reach the user by the proper channel. |

Table 2‑1 - SBAS DFMC compliance with IMO requirements analysis

# VDES Channels and Message types for SBAS data retransmission

VDES is seen as an application to make an effective and efficient use of the radio spectrum, building on the capabilities of AIS and addressing the increasing requirements for data through the system. New techniques providing 32 times the raw data rates than those used for AIS are a core element of VDES. Furthermore, the VDES network protocol is optimized for data communication so that each VDES message is transmitted with a high confidence of reception. VDES increases the capability for digital data exchange in a manner like AIS, which includes provision of data to vessels in a geographic area (broadcast), to a specific vessel or a group of vessels in a geographic area (addressed) or to a fleet of vessels (addressed).

In essence, the VDES provides a variety of means for the exchange of data between maritime stations, ship-to-ship, ship-to-shore, shore-to ship, ship-to-satellite and satellite-to-ship.

The VDES is a multi-component system comprising of VDE, ASM and the AIS in the VHF maritime mobile band (156.025-162.025 MHz). The VDES has a terrestrial component VDE-TER and a satellite component VDE-SAT.

VDES channels have been doubled and so the different channels have been allocated into two bands separated by 4.45 MHz, where both bands are used to facilitate VDES communications between ships, shore stations, and satellites.

The following figures included in [4] detail the VDES system, channels and frequencies.

Diagram

Description automatically generated

Table 3‑1 - VDES system (as per [4])

The following picture details the different channels and bandwidth allocated to each one either for the VDE-TER, VDE-SAT, AIS1 and AIS2 as well as ASM1 and ASM2 channels. ASM 1 and ASM 2 are ASM channels used in accordance with this recommendation for ASM and are also used for receiving ASM by satellite.

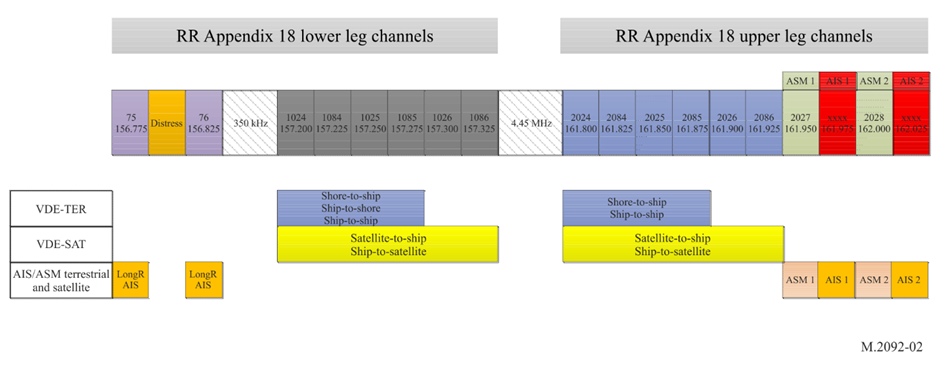


Table 3‑2 - VDES system frequency allocation to channels (as per [4])

These AIS, ASM and VDE-TER/VDE-SAT channels have been analysed for the retransmission of SBAS corrections considering the following options for SBAS data format:

* SBAS messages converted to local RTCM v2 DGNSS corrections in accordance with [7]
* SBAS messages sent as per RTCM v3 SSR corrections format defined in [9]
* SBAS messages sent following SBAS RTCA corrections format as per [10]

# VDES AIS channel. Potential use of current AIS Message 17 for SBAS data L5 retransmission

Currently, AIS technology already presents an optional functionality for the provision of DGNSS corrections. To this purpose, it is defined the AIS Message 17 “Global Navigation Satellite System broadcast binary message“ [5] which is still of application for the messages to be provided via VDES AIS channels 1 and 2. Indeed, in regard to SBAS, this AIS Message 17 is considered right now the assigned container of SBAS L1 corrections which is converted into local DGNSS corrections in the corresponding RTCM format (as per [7]) and in accordance with the AIS ground stations in case they are intended to be retransmitted via AIS (defined in [6]).

The following table describes this Message 17 and the parameters and bits referred below.

|  |  |  |
| --- | --- | --- |
| Parameter | Number of bits | Description |
| Message ID | 6 | Identifier for Message 17; always 17 |
| Repeat indicator | 2 | Used by the repeater to indicate how many times a message has been repeated. See § 4.6.1, Annex 2; 0-3; 0 = default; 3 = do not repeat any more |
| Source ID | 30 | MMSI of the base station |
| Spare | 2 | Spare. Should be set to zero. Reserved for future use |
| Longitude | 18 | Surveyed longitude of DGNSS reference station in 1/10 min (180°, East = positive, West = negative). If interrogated and differential correction service not available, the longitude should be set to 181° |
| Latitude | 17 | Surveyed latitude of DGNSS reference station in 1/10 min (90°, North = positive, South = negative). If interrogated and differential correction service not available, the latitude should be set to 91° |
| Spare | 5 | Not used. Should be set to zero. Reserved for future use |
| Data | 0-736 | Differential correction data (see below). If interrogated and differential correction service not available, the data field should remain empty (zero bits). This should be interpreted by the recipient as DGNSS data words set to zero |
| Number of bits | 80-816 | 80 bits: assumes N = 0; 816 bits: assumes N = 29 (maximum value); see Table 69 |

Table 4‑1 - AIS Message 17 size and format ([5])

The field “Data”, as the container of DGNSS messages, it is formatted as it follows.

|  |  |  |
| --- | --- | --- |
| Parameter | Number of bits | Description |
| Message type | 6 | Recommendation ITU-R M.823 |
| Station ID | 10 | Recommendation ITU-R M.823 station identifier |
| Z count | 13 | Time value in 0.6 s (0-3 599.4) |
| Sequence number | 3 | Message sequence number (cyclic 0-7) |
| N | 5 | Number of DGNSS data words following the two word header, up to a maximum of 29 |
| Health | 3 | Reference station health (specified in Recommendation ITU-R M.823) |
| DGNSS data word | N = 24 | DGNSS message data words excluding parity |
| Number of bits | 736 | Assuming N = 29 (the maximum value) |

Table 4‑2 - AIS Message 17 DGNSS corrections size and format ([5])

Within the “DGNSS data word”, the DGNSS messages are provided as defined in [6]. These messages mainly correspond with a set of the messages defined in [7] for the transmission of DGNSS corrections by IALA beacons. Below, the message types are presented.

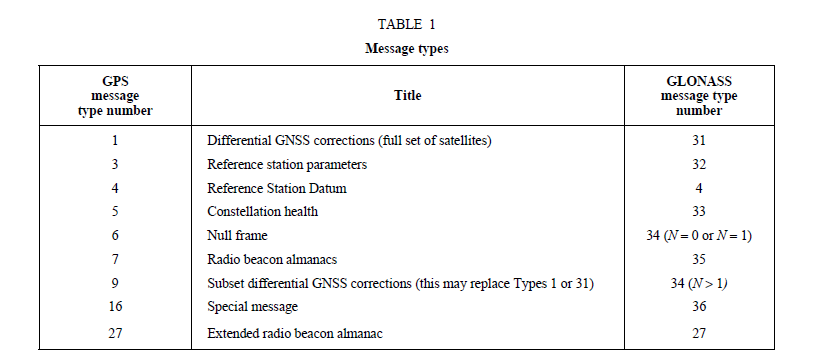


Table 4‑3 - Message types for DGNSS message data words [6]

When SBAS L1 corrections are used in AIS Message 17, a processing needs to be done in the AIS reference station to convert the RTCA SBAS messages to RTCM DGNSS corrections (see Annex E of [11]).  
The next subchapters extend the analysis on options to format the new SBAS L5 corrections and integrity to allow their retransmission via AIS Message 17.

## SBAS messages sent in RTCA ED-259/DO-401 format

For the retransmission of SBAS L5 messages in RTCA format (250 bits), there is no guarantee that AIS Message 17 is broadcast every second. This assumption should be verified considering the frequency defined in VDES for the provision of AIS messages based on the new capabilities defined for AIS channels. Thus, a priori this message would not be suitable for the retransmission of SBAS L5 (250 bits) message in the corresponding RTCA format. Indeed, this option was neither considered for the retransmission of legacy SBAS L1.

## SBAS converted to local DGNSS corrections in RTCM v2

The “DGNSS data word” is designed for transmission of DGNSS corrections for GPS and GLONASS L1 frequency. In accordance with the current versions of the standards, the actual “DGNSS data word” field could not be used for the retransmission of SBAS DFMC due to the following constraints:

* On one hand, in [6] there is no message type defined for the transition of legacy DGNSS corrections (based on GPS L1) in DFMC corrections (GPS + Galileo L1-E1 and L5-E5a), they are only defined for L1 frequency, covering GPS and GLONASS. Indeed, Galileo is not included either.
* On the other hand, there is no plan to update RTCM v2 standard to cover DGNSS for GPS and Galileo L1-L5 / E1-E5a.

About this second bullet, the RTCM proposed a draft v2.4 standard [8] that defined a new message 41 for Multi Frequency Multi Constellation Differential GNSS corrections, supporting several frequencies and constellations. Thus, that draft standard [6] enabled the conversion of SBAS DFMC corrections (ED-259A/DO-401 format [10]) into differential corrections of L1-L5 / E1-E5a frequency for GPS/Galileo. This draft standard was presented to IALA for publication approval. However, IALA proposed a new approach to update the standard on April 2024 (see [10]) discarded mainly the initial proposed message 41 for DGNSS MFMC corrections and stated the following:

* “IALA DGNSS radio beacon stations have limited capacity and are only capable of supporting single frequency GPS and GLONASS only. They do not have capacity to support multiple systems and multiple frequencies”
* “Rather than updating the RTCM 10402.X standard with new generic multi-constellation, multi-frequency messages that we believe will not be used, RTCM proposes to keep the existing RTCM 10402.3 standard to support legacy users. This standard could be amended to add support for R-mode as proposed in the IALA Liaison note”

Thus, the actual RTCM 10402.X standard under development will support R-mode and, in the future, it may include Integrity Support Message (ISM) for other constellations.

Additionally, there is not a IEC 61108 part standard for the DGNSS DFMC shipborne receiver equipment. IEC 61108-4 only covers DGPS and DGLONASS maritime radio beacon receiver for L1 frequency.

In conclusion, considering the recommendations from IALA to not upgrade the IALA DNSS radio beacons or the shipborne receiver standard to support DGNSS based on GPS and Galileo L1-L5 / E1-E5a in the medium term, SBAS L5 conversion to DGNSS RTCM v2 would not be considered a suitable option for its retransmission through AIS Message 17[[7]](#footnote-8).

## SBAS converted to local DGNSS corrections in RTCM v3

On the other hand, it could be analysed the potential provision of SBAS L5 corrections through the SSR messages provided in [9] (see Appendix B for details) as a potential alternative to overcome the lack of support to evolve DGNSS standard to enable DFMC. If considered feasible, RTCM SC104 working group 3 should be approached to include Galileo SSR messages in the standard for clock and orbit corrections (currently only SBAS DFMC corrections to GPS could be provided through SSR messages defined in the RTCM v3 standard).

# VDES ASM channels

Taking into consideration the latest version of [4] and the different ASM messages already defined by ITU, it is considered that “Message 0 Broadcast AIS ASM Message” as well as “Message 1 Scheduled Broadcast Message “could be potential containers to retransmit SBAS corrections (L1 + L5 or just only L5).

The following table lists the different ASM messages defined by ITU in [4].

|  |  |  |
| --- | --- | --- |
| Message ID | Name | Description |
| 0 | Broadcast AIS ASM Message | Encapsulated AIS ASM messages. |
| 1 | Scheduled Broadcast Message | Broadcast data using communication state. |
| 2 | Broadcast Message | Broadcast data with no communication state. |
| 3 | Scheduled Individual Addressed Message | Individual addressed data with communication state. Requires acknowledgement. |
| 4 | Individual Addressed Message | Individual addressed data with no communication state. Requires acknowledgement. |
| 5 | Acknowledgment Message | This message is used to provide and acknowledgment for one or more addressed messages. |
| 6 | Geographical Multicast Message | Addressed to a group of stations defined by their geographical location with no communication state. No acknowledgment required. |

Table 5‑1 - ASM Messages summary [4]

In addition to the previous table, [4] also remarks the following about Message 0 “Broadcast AIS ASM Message”:

* ASM Message 0 may contain encapsulated AIS Messages 6, 8, 12, 14, 21, 25 or 26. This message type is for terrestrial use only.
* The encapsulated message may or may not be transmitted on AIS 1 or AIS2 channels.
* If the encapsulation repeats a message that was transmitted on AIS1 or AIS2 channel, the encapsulation and transmission of messages shall be performed as soon as possible, according to configuration, after receiving the relevant messages which are required to be retransmitted.

Then, this Message 0 presents the following parameters detailed in Table 5‑2

| **Parameter** | **Number of bits** | **Description** |
| --- | --- | --- |
| Message ID | 4 | 0 – Selected AIS messages that are output at receiving mobile station PI by using VDM sentence with no communication state |
| Retransmit flag | 1 | 0 (reserved for future use) |
| Repeat indicator | 2 | If the encapsulation repeats a message that was transmitted on AIS1 or AIS2 channel, this is used to indicate how many times a message has been repeated. Encapsulation represents one repeat.  Possible values: 0 – 3:  0 = default, shall be used in case where the message is sent only on ASM channel(s);  1: also transmitted on AIS channel(s);  2, 3 = also transmitted on AIS channel(s) and repeated as counted by the repeat indicator on ASM channel. |
| Session ID | 6 | The Session ID associates the VDL transmission with a specific PI transaction |
| Source ID | 32 | The Unique Identifier of the transmitting station as described in § 2.4, Annex 1. |
| Data count | 11 | Size of actual data in Binary Data and ASM Identifier field in bits, excluding padding bits range: from 1 to maximum data count |
| Application data  (no FEC / FEC) | 1 slot: 296 / 200 2 slot: 808 / 584 3 slot: 1320 / 968 | Content is encapsulated AIS Messages that are channeled through ASM Channels. Receiver is expected to be ASM-capable mobile station where the ASM-box would relay the encapsulated AIS messages to local presentation interface. The encapsulated AIS Messages would then be output at the PI using VDM sentence. The arrangement would thus be compliant with existing nav presentations.  Application data as specified by the ASM Identifier.  The available length of the binary data is specified by the Link Id. |

Table 5‑2 - ASM Message 0 “Broadcast AIS ASM Message” parameters [4]

With respect to Message 1 “Scheduled Broadcast Message”, [4] defines the following:

* This ASM message is used to broadcast data to all stations and utilizes MITDMA communication state. Multiple messages, or periodically broadcasted messages may be chained together using the MITDMA communication state. The first transmission in the chain will use RATDMA to access the link, and all additional transmission will use slots allocated by the MITDMA communication state. Scheduled broadcast message is defined in Table 26 in [4].

| **Parameter** | **Number of bits** | **Description** |
| --- | --- | --- |
| Message ID | 4 | 1 – Broadcast message with MITDMA communication state |
| Retransmit flag | 1 | 0 (reserved for future use) |
| Repeat indicator | 2 | Used by the repeater to indicate how many times a message has been repeated.  0 – 3; 0 = default; 3 = do not repeat any more |
| Session ID | 6 | The Session ID associates the VDL transmission with a specific PI transaction |
| Source ID | 32 | The Unique Identifier of the transmitting station as described in § 2.4, Annex 1. |
| Data count | 11 | 1 – Max data count |
| ASM identifier | 16 | Application identifier and described in § 6.2 |
| Binary data (no FEC / FEC) | 1 slot: 240 / 144  2 slot: 752 / 528  3 slot: 1264 / 912  SAT: N/A / 808 | Application data as specified by the ASM Identifier.  The available length of the binary data is specified by the Link Id.  Unused payload data is zero-filled |
| Communication state | 38 | MITDMA communication state as described in § 6.4 |
| Spare bits | 2 | Spare bits – reserved for the future |

Table 5‑4 - ASM Message 1 “Scheduled broadcast message” application data parameters [4]

Similarly to what is done previously for AIS Message 17, it is analysed in the following subchapters the options to provide the SBAS messages in RTCA or RTCM formats and the constraints identified to do so.

## SBAS messages sent in RTCA ED-259/DO-401 format

About the option “Message 0” as the container, as stated in [4], the access scheme identified for this message is Random Access Time Division Multiple access algorithm (RATDMA). This RATDMA access scheme should use a probability persistent (p-persistent) algorithm. When a candidate slot is selected, the station randomly selects a probability value (LME.RTP1) between 0 and 100. This value should be compared with the current probability for transmission (LME.RTP2). If LME.RTP1 is equal to, or less than LME.RTP2, transmission should occur in the candidate slot. If not, LME.RTP2 should be incremented with a probability increment (LME.RTPI) and the station should wait for the next candidate slot in the frame.

The Selection Interval for RATDMA should be 235 time slots, which is equivalent to 6.3 s. The candidate slot set should be chosen within the Selection Interval, so that the transmission occurs within 6.3 s. Then, there would be no guarantee to broadcast at least one Message 0 per second to meet the required SBAS update rate (1 message per second). As stated in section 4.5.7.8 of [4], when the ASM station needs to transmit ASM message periodically, it should use Multiple Incremental Time Division Multiple Access scheme (MITDMA). Thus, this RATDMA access defined for ASM message 0 “Broadcast AIS ASM Message” would not be suitable for messages sent periodically, as it is the case of SBAS corrections.

Another option would be to use the “Message 1 Scheduled Broadcast Message” which is provided through multiple access channel access (MITDMA). The MITDMA access schemes allows a station to pre-announce transmission slots that the station will use in the future. For the case of SBAS message, 2 slots would be occupied (see Table 5‑4). A single MITDMA transmission may be used to schedule up to three future transmissions with each transmission occupying up to three slots. However, further analysis would be needed to assure the feasibility of using this message in a continuous way (1 message per second).

Further assessments should be conducted within IALA and ITU committee to identify the most suitable message type for encapsulating the SBAS message or to define a new one. This would ensure efficient use of bandwidth, especially given that the SBAS message in this format should be transmitted periodically every second.

## SBAS converted to local DGNSS corrections in RTCM v2

Similarly, as it was proposed in AIS Message 17, SBAS corrections could be converted to local DGNSS corrections in RTCM v2 and broadcast through ASM channel. For example, the message 0 “Broadcast AIS ASM Message” could be used. Considering that in this format DGNSS DFMC corrections do not require to be sent every 1 second, the Random Access Time Division Multiple Access algorithm (RATDMA) presented in this message could be suitable for the SBAS retransmission. Unfortunately, as it was advanced in previous section 4.1 of this ANNEX A, currently there is no plan to evolve the legacy DGNSS based on GPS to DFMC (including Galileo) so this option would be (a priori) vanished.

## 3.2.1 SBAS converted to local DGNSS corrections in RTCM v3

On the other hand, it could be analysed the potential provision of SBAS L5 corrections through the SSR messages provided in [13] (see Appendix B for details) as a potential alternative to overcome the lack of support to evolve DGNSS standard to enable DFMC. If considered feasible, RTCM SC104 working group 3 should be approached to include Galileo SSR messages in the standard for clock and orbit corrections (currently only SBAS DFMC corrections to GPS could be provided through SSR messages defined in the RTCM v3 standard).

# VDES VDE-TER Channel

In accordance with the latest version of [4] and the complete list of VDE-TER messages defined (see table below) it is considered “Message 93 Short data message (no ACK)” as a potential container to retransmit SBAS corrections (L1 + L5 or just only L5).

|  |  |  |
| --- | --- | --- |
| Type | Name | Description |
| 0 | Media access control | Changes random access selection interval |
| 4 | Resource allocation | Allocated LC resource to data session |
| 13 | ACK/NACK | Acknowledgement or negative-acknowledgement |
| 20 | Bulletin board message start fragment | Start fragment of bulletin board message used for control station service area configuration |
| 21 | Bulletin board message continuation fragment | Middle fragment of bulletin board message used for control station service area configuration |
| 22 | Bulletin board message end fragment | Last fragment of bulletin board message used for control station service area configuration |
| 74 | Start fragment | Start data fragment of the TDMA frame |
| 75 | Continuation fragment | Middle data fragment of the TDMA frame |
| 76 | End fragment | Last data fragment of the TDMA frame |
| 81 | Padding byte | Byte used for padding |
| 90 | Resource request / Transmission announcement | Request resource from station or announce transmission to follow |
| 92 | Short data message (with ACK) | Short data message. ACK is required |
| 93 | Short data message (no ACK) | Short data message that does not require an ACK. May be used for broadcasting |

Table 6‑1 - VDE-TER messages summary [4]

Thus, Message 93 is defined as detailed in Table 6‑2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Field no.** | **Value  (dec)** | **Size  (bytes)** | **Function** | **Content** |
| 1 | 93 | 1 | Type |  |
| 2 | 0 to 216-1 | 2 | Length | Total size in bytes, variable. |
| 3 | 0 to 232-1 | 4 | Source ID | The unique identifier of the transmitting station, as described in § 2.4, Annex 1. |
| 4(1) | 0 | 1 | Session ID | Session ID. |
| 5 | 0 to 232-1 | 4 | Destination ID | The unique identifier of the receiving station, as described in § 2.4, Annex 1.  Set to 0 for broadcast. |
| 6 |  | Variable | Payload |  |

Table 6‑2 - VDE-TER Message 93 “Short data message (no ACK)” parameters [4]

## SBAS messages sent in RTCA ED-259/DO-401 format

In regards the “Payload” field, the size is variable and not yet standardised (with an expected maximum size of 2^16-1). Thus, there is no “a priori” limitation in terms of the size of this field which means both SBAS L1 and L5 corrections could be retransmitted into this field. Next versions of the document will take into consideration the update of reference documentation to confirm the previous assumption.

SBAS messages could be broadcast “shore to ship” using the Announcement Signalling Channel (ASC), where slots are reserved for data transmissions by the control station. It should be analysed within the committee if a periodic transmission of a “Short data message (no ACK)” in ASC channel containing SBAS L1/L5 corrections and integrity information would be suitable. Definition of the packet messages to encapsulate SBAS L1 and L5 messages could be included in an updated version of [4] or within an additional recommendation (as done with DGNSS messages in [6]).

## SBAS converted to local DGNSS corrections in RTCM v2

The analysis done in section 4.1 of this ANNEX A is also applicable for this case. At this stage there is no plan to evolve the legacy DGNSS based on GPS to DFMC (including Galileo) so this option DFMC has been currently withdrawn.

## SBAS converted to local DGNSS corrections in RTCM v3

Complementing the previous analysis, it could be relevant to analyse the potential provision of SBAS L1 and L5 corrections through the SSR messages provided in RTCM v3.4 [13] (see Appendix B for details). If feasible, RTCM SC104 working group 3 should be approached to include Galileo SSR messages in the standard for clock and orbit corrections (currently only SBAS DFMC corrections to GPS could be provided through SSR messages defined in the RTCM v3 standard).

# VDES VDE-SAT Channel

In accordance with the latest version of [4] and the complete list of VDE-SAT messages defined (see table below) it is considered “Message type 16 Downlink short data message (without ACK)” as a potential container to retransmit SBAS corrections (L1 + L5 or just only L5).

| Type | Name | Description |
| --- | --- | --- |
| 1 | Satellite Bulletin Board 1 | Satellite bulletin board fragment 1 |
| 2 | Satellite Bulletin Board 2 | Satellite bulletin board fragment 2 |
| 3 | Satellite Bulletin Board 3 | Satellite bulletin board fragment 3 |
| 4 | Satellite Bulletin Board 4 | Satellite bulletin board fragment 4 |
| 5 | Satellite Bulletin Board 5 | Satellite bulletin board fragment 5 |
| 6 | Satellite Bulletin Board 6 | Satellite bulletin board fragment 6 |
| 10 | Media access control | Changes random access selection interval, max ARQ retries. |
| 11 | Paging | Pages a ship. |
| 12 | Resource allocation | Allocated LC resource to data session. |
| 13 | Uplink addressed message acknowledgement | Acknowledgement or negative-acknowledgement of uplink data fragments for addressed messages. |
| 14 | Downlink short data message (with ACK) | Short data message to ship that requires acknowledgement |
| 16 | Downlink short data message (without ACK) | Short data message to ship with no acknowledgement. |
| 18 | End delivery notification to ship | Message from the application layer to acknowledge that the data was delivered to the end destination on the application layer. |
| 20 | Resource request | Request resource from ship. |
| 21 | Paging response | Paging response. |
| 22 | End Delivery Notification from ship | Message from the application layer to acknowledge that the data was delivered to the end destination on the application layer. |
| 33 | Uplink short data message (with ACK) | Short data message from ship with acknowledgement. |
| 23 | Uplink short data message (without ACK) | Short data message from ship with no acknowledgement. |
| 24, 25, 26, 27, 28 | Uplink short data message (without ACK) | 5 bytes of data to satellite pre-configured destinations. |
| 29 | Downlink addressed message acknowledgement | Selective acknowledgement of downlink data fragments. |
| 30 | Start fragment | Start data fragment of data session. |
| 31 | Continuation fragment | Middle data fragment of data session. |
| 32 | End fragment | Last data fragment of data session. |
| 34 | Uplink short data message Acknowledgement | Acknowledgement of uplink short data messages. |
| 35 | Padding byte | Byte used for padding. |
| 36 | Downlink short data message Acknowledgement | Acknowledgement of downlink short data messages. |

Table 7‑1 - VDE-SAT messages summary [4]

Thus, message 16 is defined as it is detailed in the following Table 7‑2.

|  |  |  |  |
| --- | --- | --- | --- |
| **Field  no.** | **Size  (bytes)** | **Function** | **Content** |
| 1 | 1 | Type | Type = 16 |
| 2 | 2 | Payload size | Size of fields 3 to 6. |
| 3 | 1 | Satellite ID | 0-255 |
| 4 | 4 | Source ID |  |
| 5 | 4 | Ship Station ID | The Unique Identifier of the destination station, as described in § 2.4, Annex 1.  [[8]](#footnote-9) |
| 6 | Variable | Payload | Binary data. |

Table 7‑2 - VDE-SAT Message 16 “Downlink short data message (without ACK)” parameters [4]

Considering that VDE-SAT Message 16 is similar to VDE-TER Message 93, it is concluded that the analysis of the conversion of SBAS corrections in the RTCA and RTCM formats done in the later one is of application in the former one.

# Conclusions

After assessing the different options for the retransmission of SBAS corrections in VDES, it is concluded that the a priori most suitable option is the encapsulation of SBAS L1 and L5 messages in RTCA format (as per [8]) within ASM channel or VDE-TER/VDE-SAT channels:

* ASM channel: An option is to use the “Message 1 Scheduled Broadcast Message” which is provided through multiple access channel access (MITDMA). However, further analysis needs to be performed to assure the feasibility of using this message in a continuous way (1 message per second).
* VDE-TER/VDE-SAT channels: SBAS messages could be broadcast “shore to ship” / ”satellite to ship” using the Announcement signalling channel (ASC), where slots are reserved for data transmissions by the control station. It should be analysed within the committee if a periodic (1 message per second indeed) transmission of a VDE TER “Message 93 - Short data message (no ACK)” and “Message 16 - Downlink short data message (without ACK)” in ASC channel containing SBAS L1 /L5 corrections would be suitable.

Further assessments should be conducted within IALA and ITU committee to conclude the suited message type for encapsulating the SBAS L5 message, based on the options proposed in the analysis, or to define a new specific one. This should ensure efficient use of bandwidth, especially given that the SBAS message should be transmitted periodically every second.

Another option would be the transmission of SBAS L5 augmentation information through the SSR messages defined in RTCM v3 (see Appendix B) for GPS clock and orbit corrections. If feasible, RTCM SC104 working group 3 should be approached to include Galileo SSR messages in the standard for both clock and orbit corrections.

On the other hand, the analysis has concluded that other options initially considered for the retransmission of SBAS L5 messages have been finally discarded:

* As IALA does not recommend upgrading the IALA DGNSS radio beacons or the shipborne receiver standard (IEC 61108) to support DGNSS based on GPS and Galileo L1-L5 / E1-E5a in the medium term, the option to convert SBAS L5 into DGNSS RTCM v2 is not considered suitable. IALA stated that DGNSS radio beacon stations have limited capacity and are only capable of supporting single frequency GPS and GLONASS only, not having capacity to support multiple systems and multiple frequencies.
* There is no guarantee that AIS Message 17 is broadcast periodically every second and thus, a priori this message would not be suitable for the retransmission of SBAS L1 (250 bits) or SBAS L5 (250 bits) message directly in the corresponding RTCA format. This assumption should be verified considering the frequency defined in VDES for the provision of AIS messages based on the new capabilities defined for AIS channels.

1. Annex B - ANALYSIS OF SBAS CONVERTED TO RTCM V3

RTCM has maintained the RTCM 10402.X standard to support the IALA DGNSS radio beacons and the limited bandwidth available from these devices. All other users were recommended to move to the RTCM 10403.X standard. During the last years, several new GNSS have become available with multiple frequencies from each GNSS. RTCM v3 has the capability for providing Multi Frequency and Multi Constellation observations and corrections.

The most recent RTCM version is v3.4 standard [7]. Within this standard, there is no message defined to transmit the SBAS correction data. The main message groups are:

- Legacy GPS/GLONASS Observable Messages

- MSM (Multiple Signal Messages):

- Station Coordinates

- Antenna Description

- Receiver and Antenna Description

- Network RTK Corrections

- Auxiliary Operation Information

- Coordinate Information and Transformation Parameters

Mainly there are two types of messages provided in RTCM v3:

* GNSS observations: Provision of multi constellation observation measurements for a base receiver, pseudoranges and phases, to be used for RTK positioning technique by a GNSS rover receiver. For SBAS L5 the corrections are applied to the iono-free combination so the GPS and Galileo observations could not be virtually generated based on SBAS L5 messages for both frequencies L1/L5 & E1/E5a separately.
* SSR messages: Dissemination of state space information, which is combined with individual tracked GNSS data of a rover receiver to improve its positioning. These messages support GNSS Precise Point Positioning (PPP) . It could be analysed if SSR GPS Orbit and Clock corrections could be transferred from SBAS L5 messages. Unfortunately, there is not SSR Galileo message in the current version of this standard.

In conclusion, currently it is not possible to provide SBAS L5 messages in RTCM v3 version. For the transmission of the SBAS L5 corrections using the SSR messages of RTCM v3, the standard should be updated to include Galileo corrections. Additionally, another option would be to support a new message in RTCM v3 for the provision of SBAS L1 and L5 messages.

1. Leave open if uncertain [↑](#footnote-ref-2)
2. It is referred to the [10] document to get a complete view on the difference among SBAS L1 and L5 messages [↑](#footnote-ref-3)
3. For navigation in harbour entrances, harbour approaches and coastal waters [↑](#footnote-ref-4)
4. This value already considers the time taken by a SBAS signal to reach the user (≤1s) as well as the worst case scenario where user receives the latest 4th alert from the four alerts sent when an alert condition occurs [↑](#footnote-ref-5)
5. It is understood that the requirement from IMO about the 10 seconds for the TTA implicitly means the user receives the integrity warning once it is processed by the user receiver equipment. [↑](#footnote-ref-6)
6. SBAS L5 Data block consists of 250 bits: 4 bits of preamble, 6 bits of message type identifier, 216 bits of data filed and 24 bits of parity CRC. Depending on how the SBAS L5 message is encapsulated within the VDES message format, it could be used the complete 250 bits or only the 216 bits of message data. [↑](#footnote-ref-7)
7. This rationale is also applicable to other VDES message types as it is analysed in following sections of the document. [↑](#footnote-ref-8)
8. It is understood that, similarly to VDE-TER, here it should be remarked the option to “Set to 0 for broadcast”. In this way, this short data message could be transmitted even though there will not be any ID assigned as recipient. [↑](#footnote-ref-9)