Document Revisions (Title style)

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**IALA Guideline No. ####**

**On**

**The maritime use of SBAS**

**Edition 1**

**[Date issued]**

**[Previous Edition; Date issued]**

Revisions to the IALA Document are to be noted in the table prior to the issue of a revised document.

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The Maritime use of SBAS

# Introduction

DGNSS is an essential component of the e-Navigation system. It has the potential to meet most accuracy requirements within e-Navigation, and to provide the integrity information which is lacking to GNSS while being vital for safety applications.

DGNSS corrections currently are computed locally at a reference station (RS), with fully redundant equipment.

SBAS can provide an alternative source for such corrections that can be accessed either through the SBAS SIS or through the Internet (by 2015 Internet Data Access Service only available for EGNOS, the European SBAS). Furthermore SBAS corrections are immune to possible local (RS) disturbances. They consequently have the potential to become at least the secondary source of corrections for any DGNSS reference station and to be part of a more robust, and redundant design.

Note that at this moment (2015/ENAV17) for the options considered within this guideline SBAS augments only GPS constellation.

# [Background, as required]

Background would be a section of the introduction, if required. It could refer to previous editions or other IALA documents that have been used / are superseded by this document.

# SCOPE [Scope / Purpose (may be called Objectives)]

This document is a guideline for the use of SBAS in maritime domain. It describes SBAS applications and services envisaged and its contribution to achieve resilient PNT in the maritime domain.

Additionally the intention is to provide reference information as input for further recommendations and standards development.

# [Definitions / Acronyms, as required]

1. Acronyms

|  |  |
| --- | --- |
| EDAS | EGNOS Data Access Service |
| RSIM | Reference Station - Integrity Monitor |
| SiS | Signal in Space |
| SLA | Service Level Agreement |
|  |  |

# Description of SBAS System

Reference to NavGuide [section 4.10.2]

# SBAS benefits and limitations

Reference to NavGuide [section 4.10.2]

# Identification of the different existing SBAS systems, coverage and performances

Reference to NavGuide [section 4.10.2]

## PERFORMANCES

## COVERAGE

## INTEROPERABILITY (IWG)

## INTEGRITY CONCEPTS

### INTEGRITY AT SYSTEM LEVEL

### INTEGRITY AT USERS’ RECEIVER LEVEL (SBAS INTEGRITY CONCEPT)

# SBAS Services description and status, including current use of SBAS by the maritime community

Reference to NavGuide [section 4.10.2]

# SBAS future developments eg. Extension of SBAS coverages, new versions

Reference to NavGuide [section 4.10.2]

# Potential use of SBAS in maritime

SBAS data may be received by the mariner through various communication methods, with each method resulting in a different level of standardization, legislation and number of organizations involved. The following options are considered and shown in Figure 1:

* SBAS Data used form GEO Satellites (Signal in Space)
* SBAS Data used via Internet \*By 2015/by the time of ENAV17 this service is only available for EGNOS
* SBAS Data used via Maritime Service providers’ AtoNs



1. Generic view of the three considered options for SBAS transmission/reception in the maritime sector

## SBAS Signal In Space (SiS)

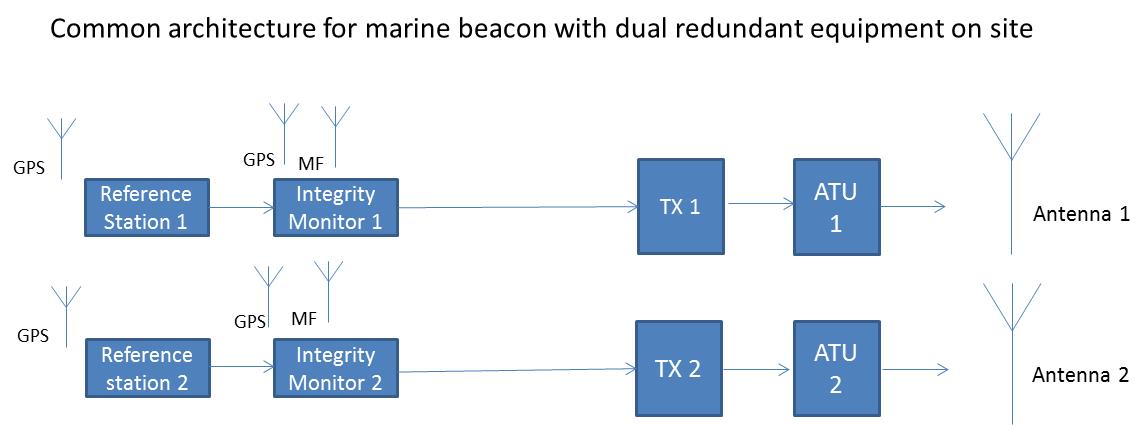
## SBAS Data used via Internet

## SBAS Data used via Maritime Service providers’ AtoNs

### SBAS over DGNSS messages (IALA Beacon)

Generally, marine beacon infrastructure can be considered to fall into two different architectures with either equipment all sited at the broadcast locations, or some of the infrastructure is centralized with only the transmitting equipment at the broadcast site. While this generalization can be made, there will be subtle differences within each installation, depending on the degree of risk associated with communication failure, hardware failure and the cost/time associated with attending the site for repair.

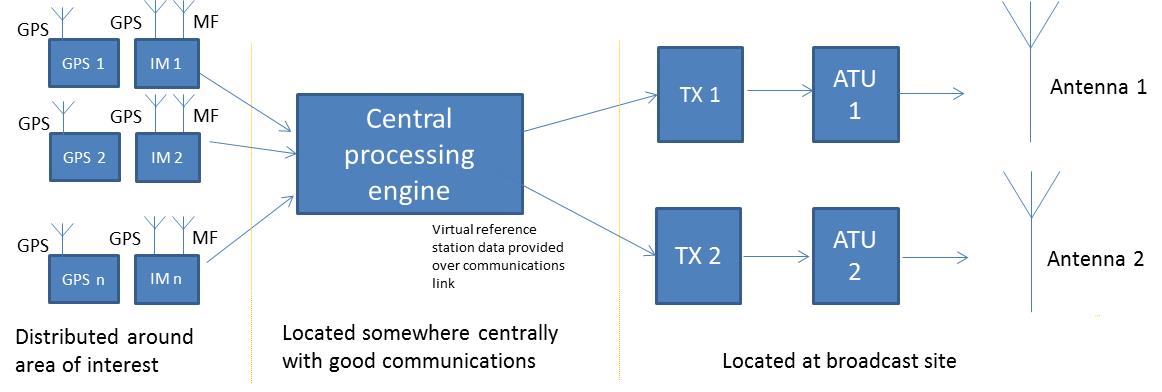
Figure 2 provides a generic schematic for the infrastructure used when locating all equipment at the broadcast site. In this figure it can be seen that there are two processing channels to provide full redundancy. GPS data is used in the reference station which compares the GPS calculated position to the known antenna location to generate differential corrections. This information is then used in the integrity monitor where the correction information is applied to the received GPS data to ensure it meets the required accuracy levels (assuming pre-broadcast integrity is available). Correction information is then provided to the transmitter for modulation on the carrier signal and then via the ATU[[1]](#footnote-1) to the antenna for broadcast. The broadcast data is received by the integrity monitor which then assesses the radio signal characteristics and the correction data to ensure they meet the required level. If at any point the system detects a problem, the station will automatically switch from one processing channel to the other.



1. Generic architecture for all marine beacon components located at the broadcast site.

It is worth noting that some National Maritime Service providers operate systems with are subtly different to this approach; examples are that some providers use a single integrity monitor, others have the system configured so that each component can be swapped with a redundant unit without switching the entire processing path, etc.

Figure 3 shows the architecture used in the distributed virtual reference station approach.

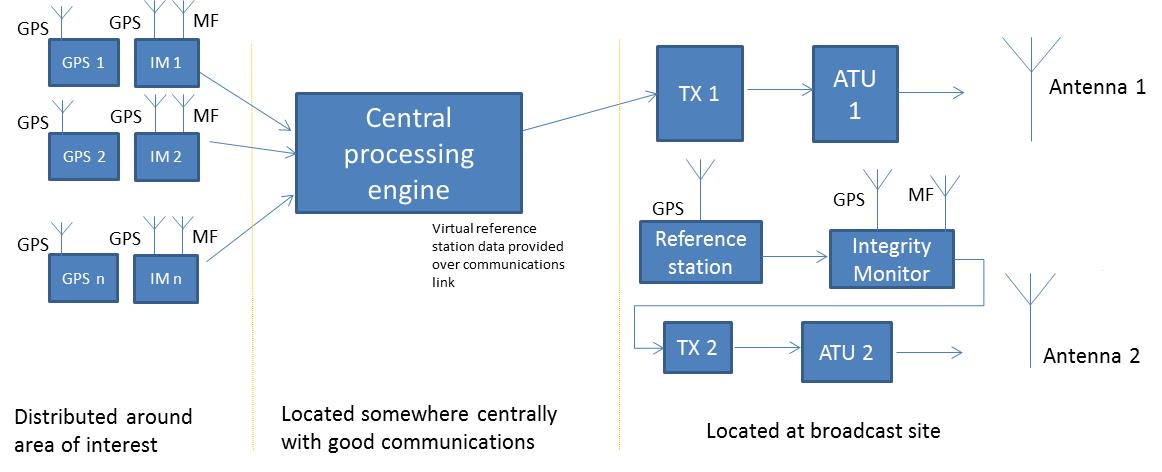


1. Generic architecture of the distributed virtual reference station approach

The position of the IM should be further discussed.

Again there may be some subtle differences to this architecture employed; however the concept is the same. In this approach a number of GPS receivers are placed around the area of interest. These receivers provide raw observable data to a central processor located generally within the network. The processor creates a virtual reference station solution based on the location of the transmitting station, undertakes integrity checks on that data and then passes it to the transmitter site via a communications link. The equipment on site is then limited to the transmitter infrastructure and antennas. The broadcast is still monitored by an integrity monitor located within the range of the station which then provides a feedback of data to the central processing engine.

The two approaches have different advantages and disadvantages when it comes to reliance on communications, control and monitoring and ease of upgrade etc. The virtual reference station solution clearly places a greater reliability on the communications infrastructure and will cease transmission if communications are lost. As such, a hybrid approach is also possible, as outlined in Figure 4, which provides an element of redundancy should communications become unavailable.



1. Generic hybrid approach between the local and distributed approaches.

The position of the IM should be further discussed.

It would be possible to integrate SBAS data into these architectures, although there are technical questions and issues to resolve in order to do so.

SBAS can be integrated in a number of ways, which are subject for discussion:

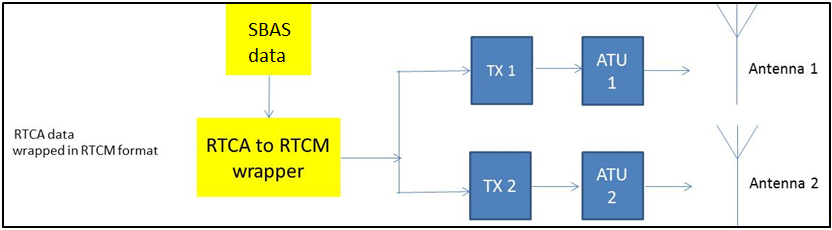
1. SBAS data repeated over the MF link (presented as is in RTCA format)
2. SBAS data extracted and converted to the form of maritime beacon correction information (RTCM format data)
3. SBAS Internet (EGNOS EDAS) virtual reference station data used in place of “central processing engine” in distributed approach.
4. SBAS information (from space) used to provide a local backup at the transmitting site when using the VRS approach to bridge network interruptions (similar to C but exchanging the roles of SBAS)
5. SBAS information used as an additional integrity check on the existing beacon infrastructure (SBAS data not part of the transmitted information)

Please note that the management of RSIM messages should be further studied (as it has not been considered in the analysis below).

#### Approach A: SBAS data repeated over the MF link (presented as is in RTCA format)

Figure 5 provides a generic schematic for the re-broadcast of SBAS SiS data (or Internet Data if available), provided in a RTCA format. Existing marine beacon receivers are designed to receive data in an RTCM format and there is no RTCM format capable of transmitting SBAS data, or RTCA formatted data.

In this scenario, SBAS data broadcast in the RTCA format is maintained but is sufficiently encased in the RTCM plain text message, which would enable it to be transmitted using existing infrastructure and enable existing receivers to decode the data. Legacy receivers would not know how to deal with the data in that format, therefore receiver updates would be required in order to then apply the SBAS RTCA data.



1. Generic schematic for SBAS data re-broadcast over marine beacon infrastructure at the local broadcast site.

Approach A has a number of issues:

* Data throughput may not be sufficiently high enough (latency of data and frequency of updates). Further investigation is needed.
* Legacy receivers will ignore the RTCA data. Receivers will need a firmware upgrade to make use of the data.
* The integrity monitoring of this approach should also be discussed.

While not shown, an integrity monitor may be required at the local site to ensure the integrity of the medium frequency transmission and the quality of the data (e.g Bit Error Rate, but will not check the correction data, unless updated to do so).

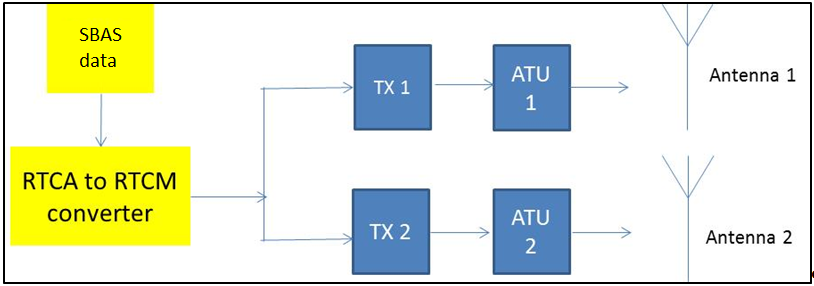
SBAS information displaces the marine beacon information and therefore does not act as a complementary or back up system to marine beacon and vice versa. Without the in-depth study into the two systems this may be a significant risk.

Approach A is unlikely to be considered with the distributed beacon architecture (and as such the hybrid architecture) as other approaches may be more appropriate. However, encapsulated RTCA data could be provided if deemed appropriate.

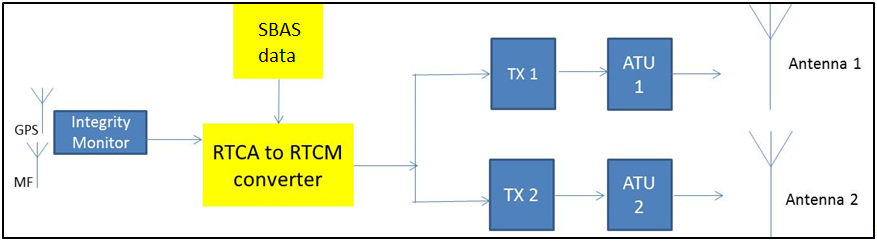
#### Approach B: SBAS data extracted and converted to the form of maritime beacon correction information (RTCM format data)

Approach B considers the conversion of SBAS data (either from SiS or via Internet) for transmission on the marine beacon infrastructure, using the RTCM format and data content. A RTCA to RTCM converter is considered and would need to be able to provide the correct format and control the station health flags.

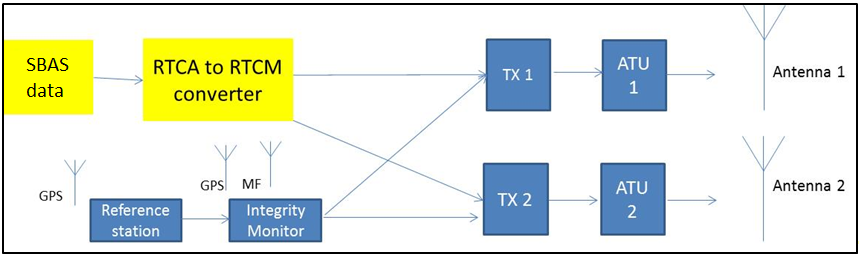
Figure 6, Figure 7 and Figure 8 below outline three possible architectures which could be considered under Approach B.



1. Approach B with minimal infrastructure (referred as B.1)



1. Approach B with local integrity monitor (referred to as B.2)



1. Approach B with SBAS and marine beacon DGPS providing complementary services and back-up to each other (referred to B.3)

Approach B can be considered with three levels of complexity, each with its own set of pros and cons.

* Approach B.1 has the least amount of infrastructure but offers no local integrity monitoring or fall back should communications fail. Therefore it is most likely that the liability would need to reside with the SBAS Service provider and could lead to a more stringent Service Level Agreement (SLA). The ability to enforce such a SLA would also need to be considered reflecting the overall governance arrangements. There is likely to be a significant SLA in place with the communications provider as well.

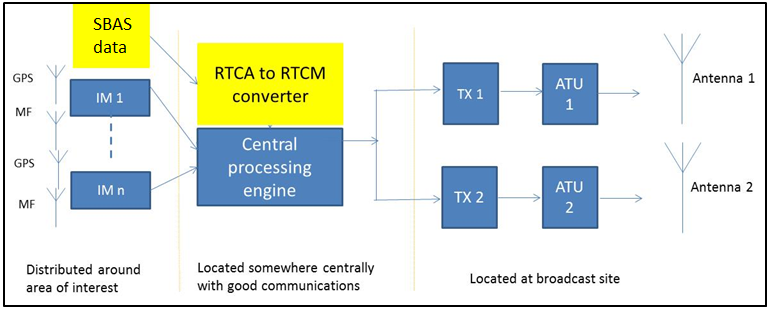
It should be noted that in this case the signal broadcast will be labelled as unmonitored – not used by onboard receivers.

* Approach B.2 would include a local integrity monitor which would then inform the mariner if a fault condition was detected with either the broadcast signal or SBAS-derived correction data. As the service will be used to help navigate vessels, this is a vital addition for such a safety of life service.
* Approach B.3 includes a local reference station at the broadcast site in addition to the integrity monitor. The inclusion of the local reference station would allow for a complementary use of both systems, allow both sources to back each other up – therefore should either generation method fail the mariner will continue to receive the service. In addition, having two dissimilar means of generating corrections would allow the correction data to be compared as an additional integrity check. The technical implementation of this needs to be further analysed.

Either system identified in this approach can be the primary source of correction information; their order in the image does not imply priority. The B.3 Approach removes the reliance on communications, which should lead to greater availability for the service.

Note that alternative architectures for approach B.3 could be analysed: for instance, the architecture in Figure 8 could be simplified in one chain, where the Rx at the Reference Station is also EGNOS-enabled and can do parallel processing.

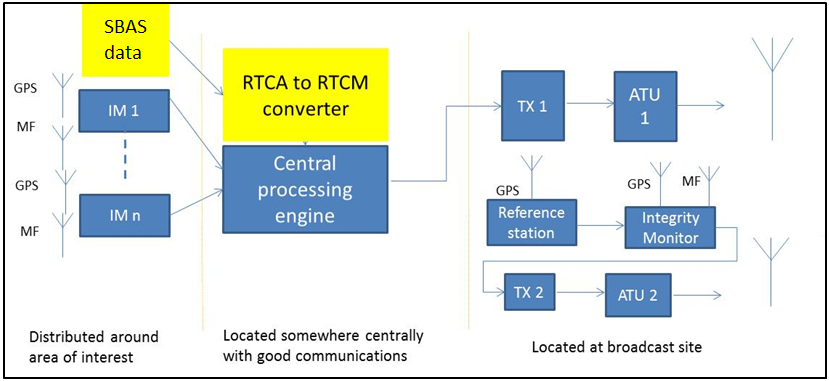
Approach B would take the format as outlined in Figure 9 and Figure 10 below, for the distributed and hybrid architectures.



1. Approach B with SBAS data fed into the distributed approach (referred to as B.4)

* Approach B.4 would require SBAS data to be provided either via SiS or via an Internet to a central processing unit. This unit would then decode the data, generate the model of the atmospheric delays and other errors associated encapsulated in the marine beacon information. The central processing engine would then need to generate the virtual reference station correction information, based on the location of the transmitter site (in RTCM format). These corrections are then sent over a communications medium to the broadcast site for transmission to the mariner. It is expected that an integrity monitor local to the broadcast site would be used to monitor the performance of the correction information and transmission link.

This approach would have the same reliance on communications as outlined previously, therefore the hybrid approach may be considered, as shown in Figure 10. This approach may be modified further by the inclusion of SBAS data sourced locally at the broadcast site for use in the on-site solution.

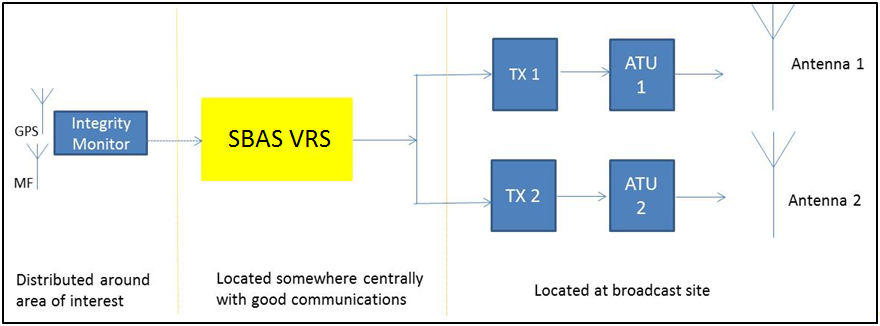


1. Approach B with EGNOS data fed into the distributed approach with back up option (referred to as B.5)

#### Approach C: SBAS Internet (EGNOS EDAS) virtual reference station data used in place of “central processing engine” in distributed approach.

Approach C considers the use of a virtual reference station (VRS) solution provided, presumably, as part of the SBAS Data Access Service (EGNOS EDAS for the moment – 2015/ENAV17). Little public reference is available for this approach. Therefore much of this section is based on a generic understanding of the concept and may need revision when more information is widely available.

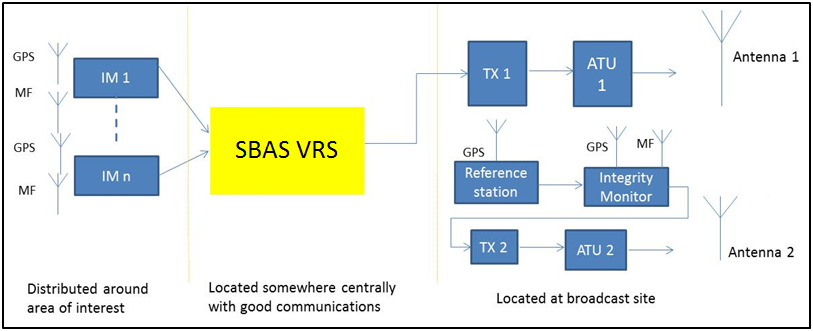
Given the virtual reference station nature of this EDAS service, it does not fit the local architecture approach and therefore this is not considered. The virtual reference station approach is most suited for use within the distributed and hybrid architectures; these are considered in Figure 11 and Figure 12 respectively.



1. Approach C considered with the distributed architecture.

As shown in Figure 12, the SBAS VRS data replaces the previous central processing engine and generates correction data in the correct maritime data format, based on the transmitter location, which is then sent for broadcast via a 3rd party data link.

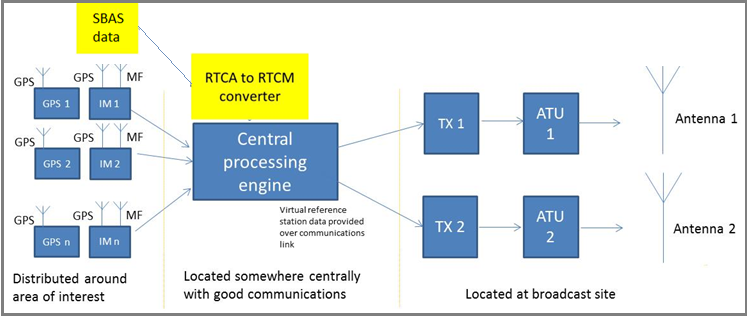
As with the other examples of this infrastructure, there remains a significant reliance on the communications link to the broadcast site. However, in this case there is also a reliance on the provision of data from SBAS Internet Service (EGNOS EDAS). While there are a number of possible methods of mitigating any outage, it is likely that a detailed SLA will be required.



1. Approach C considered with the hybrid architecture.

As before, the hybrid approach may be considered with the provision of a local back up at the broadcast site. EGNOS data, using off-air information, may be integrated into the local correction chain, although this is not shown in the diagram.

#### Approach D: SBAS information (from SiS) used to provide a local backup at the transmitting site when using the VRS approach to bridge network interruptions (similar to C but exchanging the roles of SBAS)



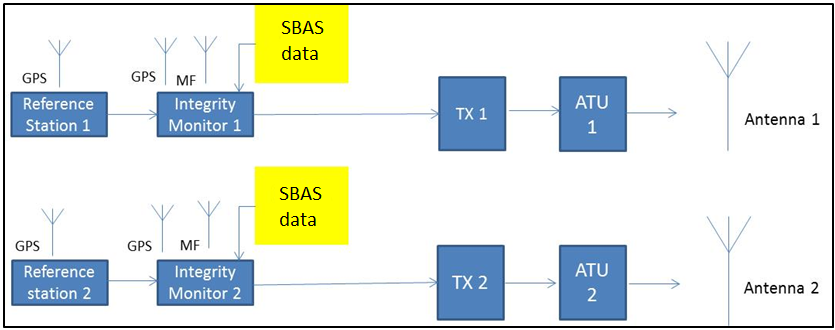
1. Approach D: SBAS information (from SiS) used to provide a local backup at the transmitting site when using the VRS approach.

#### Approach E: SBAS information used as an additional integrity check on the existing beacon infrastructure (SBAS data not part of the transmitted information)

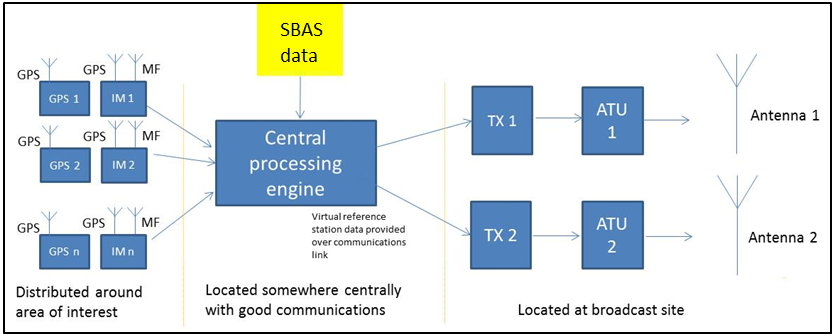
Approach E is a different approach where SBAS data is used as an additional integrity check and does not propagate through to the mariner. In this case the transmission remains the same as that currently applied.

As SBAS can provide an alternative position source, with integrity information, it can be used to corroborate the pseudorange corrections calculated on site by the local reference station and used within the integrity monitor. By comparing the marine beacon pseudorange correction information with that provided by SBAS, it should be possible to identify any significant differences, should the station be affected by external influences such as spoofing.

This data can be used within both the local and distributed architectures, as shown in Figure 14 and Figure 15 below.



1. SBAS data employed in the local architecture as an additional integrity check (Approach E, SBAS data either from SiS or Internet).



1. SBAS data employed in the distributed architecture as an additional integrity check (Approach E, SBAS data either from SiS or Internet).

### SBAS over Automatic Identification System (AIS)

### SBAS over other data channels under development such as VDES (VHF Data Exchange System) and LDC (Loran Data Channel)

# Consideration on how SBAS can be used in a resilient PNT system.

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# Pre-requisite for the adoption of SBAS

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# conclusions

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1. Annex

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# ANNEX HEAD1

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1. Antenna Tuning Unit: used to match the antenna impedance and resistance to the transmitter to ensure efficient transmission. [↑](#footnote-ref-1)