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INTERNATIONAL MARITIME ORGANIZATION

SUB-COMMITTEE ON NAVIGATION, COMMUNICATIONS AND SEARCH AND RESCUE
3rd session
Agenda item 8

NCSR 3/8
26 November 2015
Original: ENGLISH

GUIDELINES ASSOCIATED WITH MULTI-SYSTEM SHIPBORNE RADIONAVIGATION RECEIVERS DEALING WITH THE HARMONIZED PROVISION OF PNT DATA AND INTEGRITY INFORMATION

Draft guidelines for shipborne Position, Navigation and Timing (data processing) unit

Submitted by Finland and Germany

SUMMARY

Executive summary:	This document provides draft guidelines for the harmonized provision of position, navigation and timing (PNT) data and integrity information (I) for shipborne applications. The PNT principles and functions specified in these guidelines also facilitate the application of *multi-system-/multi-sensor-based techniques* to enable reliable monitoring of data and system integrity as prerequisites for resilient PNT data provision. The autonomous onboard evaluation and consistent data processing of all PNT relevant data sources should enhance the reliability of information provided. Furthermore, these guidelines also ensure a robust approach to support wholesome user guidance by provision of standardized PNT/I data products.
Strategic direction:	5.2
High-level action:	5.2.4
Planned output:	5.2.4.5
Action to be taken:	Paragraph 8
Related documents:	MSC 95/22; NCSR 2/7/1; MSC 94/21; NCSR 1/28, NCSR 1/9, NCSR 1/9/2, NCSR 1/10; MSC-MEPC.1/Circ.4/Rev.4; SN.1/Circ.274; resolutions A.1061(28); MSC.401(95); MSC.379(93); A.915(22); A.1046(27); MSC.252(83); MSC.112(73) to MSC.115(73), and MSC.233(82)

Introduction

1 This document is submitted in accordance with the *Guidelines on the organization and method of work of the MSC and MEPC and their subsidiary bodies* (MSC-MEPC.1/Circ.4/Rev.4).

In the annex to this document *Draft guidelines for shipborne position navigation and timing (data processing) unit* are provided to the Sub-Committee for further consideration.

2 The Maritime Safety Committee, at its ninety-fifth session (MSC 95), via resolution MSC.401(95), adopted the *Performance standards for multi-system shipborne radionavigation receivers* which provide the basis to enable the full use of relevant data originating from current/future radionavigation systems/services (e.g. range measurements, system parameters and variables such as ephemeris/ephemerides, correction and augmentation data), with the provision that associated PNT Guidelines are to be developed.

3 At NCSR 2 the need to develop associated guidelines for the harmonized provision of both PNT data and integrity information was recognized, following which at MSC 95 the planned output 5.2.4.9 was amended accordingly, with 2017 as target completion year.

Discussion

4 These guidelines should support the connectivity and integration of sensor deliveries. The production of relevant test standards to the multi-system GNSS receiver performance standards as above, are also provided to support and exploit benefits of GNSS Compatibility and Interoperability.

5 Although these guidelines are directly associated with the performance standards for multi-system shipborne radionavigation receivers, the scope of application should cover all shipborne navigation equipment and systems applying or providing PNT/I data.

6 The attached draft guidelines specify principles and functions in a modular framework to support the consolidation and standardization of requirements on PNT data provision considering the diversity of applications and equipment installed on board ships.

7 Basic definitions are also introduced and reproduced, as appropriate, to clarify the meaning of terms frequently used in the context of PNT data provision to enable a common understanding and application of those terms.

Action requested on the Sub-Committee

8 The Sub-Committee is invited to note the above discussion and to take appropriate action in order to ensure that the draft guidelines, provided in the annex, are finalized at NCSR 4.

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ANNEX

DRAFT GUIDELINES FOR SHIPBORNE POSITION, NAVIGATION, AND TIMING (DATA PROCESSING) UNIT

Purpose

1 The purpose of these guidelines is to enhance the safety and efficiency of navigation by improved provision of position, navigation and timing (PNT) data to bridge teams, pilots and ship-side applications (e.g. AIS, ECDIS, etc.).

2 The shipborne provision of PNT data and integrity information is realized by the combined use of onboard hardware (HW) and software (SW) components. The shipborne PNT Unit (data processing) is the core repository for principles and functions used for the provision of PNT data.

3 The PNT Unit specified within these guidelines is defined as a set of data processing functions facilitating:

.1 the use of multiple, approved sources of data provided by PVT-relevant sensors and services (e.g. GNSS receiver, DGNSS corrections) and other onboard sensors and systems (e.g. radar, gyro, echo-sounder providing real-time data) to procure redundancy in the PNT-relevant input data; and

.2 the application of multi-system and multi-sensor-based techniques for enhanced provision of PNT data with respect to accuracy, integrity, continuity and availability.

4 These guidelines aim to establish a modular framework for further enhancement of shipborne PNT data provision, by supporting:

1. consolidation and standardization of requirements on shipborne PNT data provision considering the diversity of ship types, nautical tasks, maritime applications, and the changing complexity of situations up to customized levels of support;

.2 the identification of dependencies between PNT relevant data sources (sensors and services), applicable PNT data processing techniques (methods and thresholds) and achievable performance levels of provided PNT data (accuracy, integrity, continuity and availability);

.3 harmonization and improvement of the modular concept for onboard PNT data processing as appropriate approach to facilitate changing performance requirements in relation to nautical tasks, variety of ship types, maritime applications, and under consideration of current and evolving user needs (SN.1/Circ.274);

.4 the consequent and coordinated introduction of data and system integrity (NAV 54/2, Annex 12) as smart means to protect the PNT data generation against disturbances, errors, and malfunctions (safety) as well as intrusions by malicious actors (cybersecurity); and

.5 standardization of PNT output data including performance information to support the system awareness for bridge team and the pilot.

Scope

5 These guidelines define principles and functions for onboard PNT data processing taking into account the scalability of PNT Unit.

6 These guidelines provide rules to handle differences regarding installed equipment, current system in use, feasibility of tasks and related functions, performance of data sources as well as usability in specific regions and situations.

7 A structured approach for the stepwise introduction of data and system integrity is developed to achieve resilient PNT data provision in relation to the application class and supported performance levels.

8 These guidelines aim to achieve standardized PNT output data to enhance user awareness regarding achieved performance level.

Structure of guidelines

9 These guidelines have a modular structure, starting with the general part which introduces the purpose, scope and application of the guidelines. General part also explains the high-level architecture of PNT Unit and how the PNT Unit can be integrated into vessel's navigation system, e.g. INS, ECDIS and RADAR.

10 More detailed guidelines on the different aspects of the PNT Unit are given in the following Modules A to E, as follows:

Module A - Data Sources and Sensors;
Module B – Principles, Functions, Requirements and Methods;
Module C - Operational aspects and fall-back procedures of PNT Unit;
Module D – Interfaces; and
Module E – Documentation.

11 In addition, these guidelines have three appendices listing definitions, abbreviations and expected operational requirements for different PNT parameters.

Application of guidelines

12 These guidelines provide prerequisites for harmonized provision of PNT data and integrity information**.**

13 These guidelines are recommended to manufacturers, yards, and shipowners for onboard equipment and systems used for resilient PNT data provision.

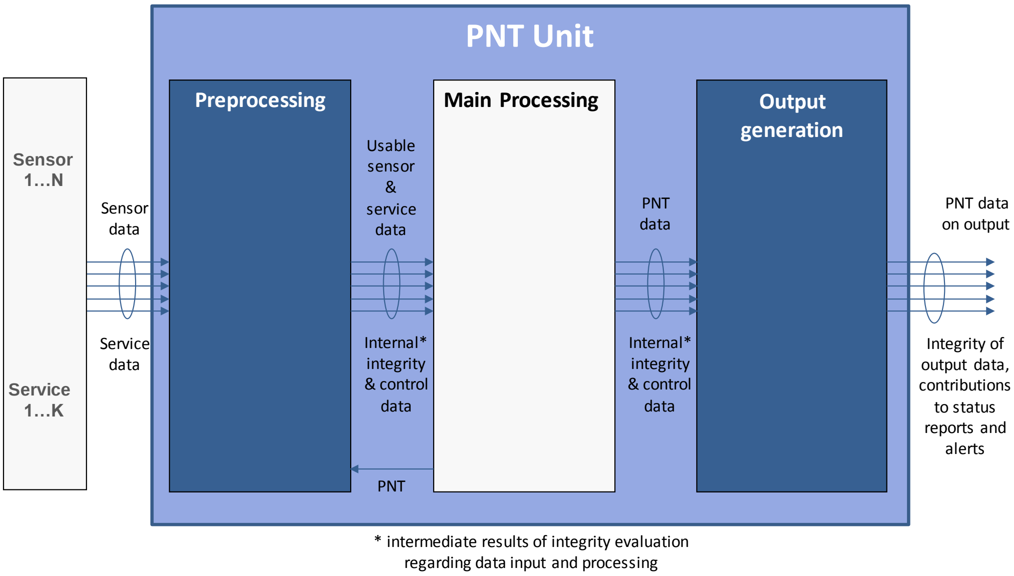
Definitions

14 Definitions used in the context of PNT, WWRNS and GNSS are detailed in appendix A to harmonize the common understanding of, inter alia, performance requirements, design principles and interface specifications within these guidelines.

Architecture of PNT Unit

15 The generalized architecture of the PNT Unit is shown in Figure 1.

Figure 1 - Generalized architecture of PNT Unit



16 Generally, a shipborne PNT Unit is built up of three functional blocks realizing:

.1 preprocessing;

.2 main processing; and

.3 output generation.

17 The preprocessing function is responsible for the extraction, evaluation, selection and synchronization of input (sensor and service) data (including the associated integrity data) to preselect the applicable techniques for the determination of PNT output data and integrity output information.

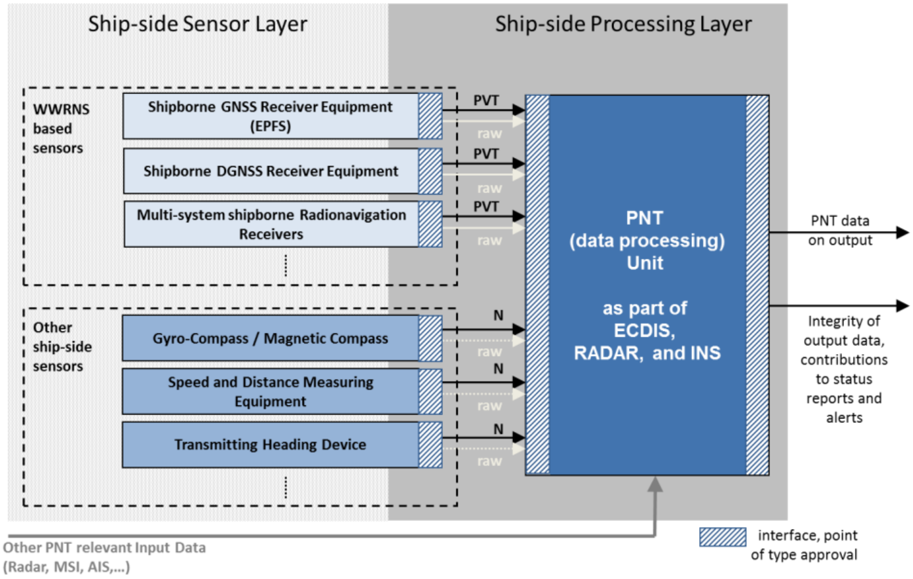
18 The main processing function generates the PNT output data and associated integrity, status and alert information.

19 The output generation function generates the output messages by coding the PNT/I (PNT and integrity) output data into specified data protocols.

Integration

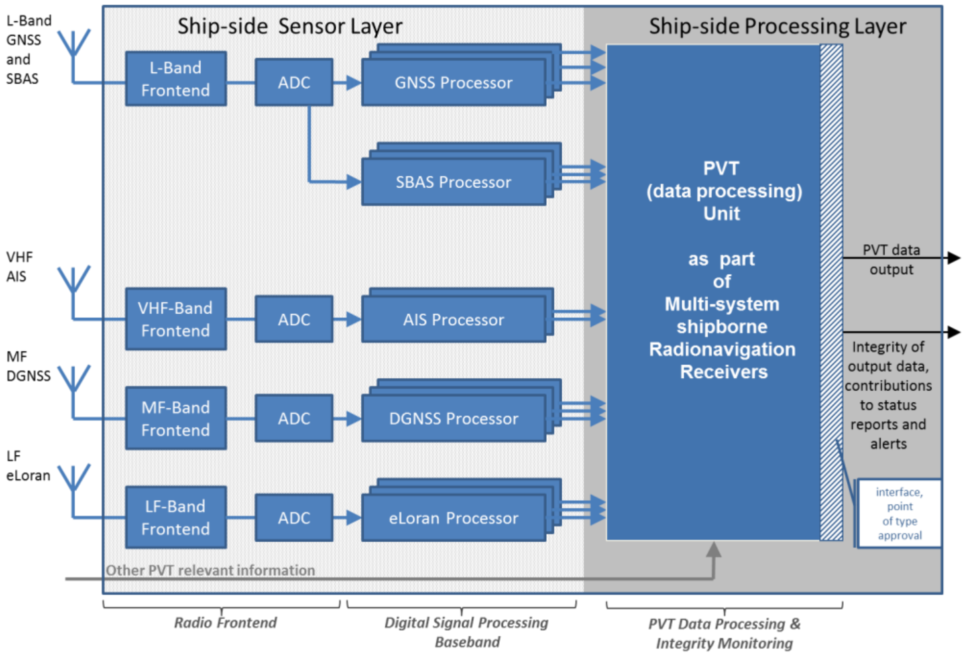
20 The PNT Unit can be integrated into ship's navigation systems such as INS, ECDIS or RADAR as pictured in Figure 2.

Figure 2 - PNT Unit integrated into INS, ECDIS, or RADAR



21 The Multisystem Radionavigation Receiver is appropriate to facilitate the combined use of WWRNS to improve the provision of PVT data and related integrity information. The application of enhanced processing techniques can be realized by the Multisystem Radionavigation Receiver (Figure 3) itself or by PNT Unit as part of INS (Figure 2).

Figure 3 - PNT Unit integration into EPFS (PVT)



Module A – Data sources: sensors and services

22 Different PNT data processing functions need different quantity and quality of input data to keep it sufficiently running. This guideline defines how the shipborne PNT Unit should provide output data out of input data (sensors, services), which availability and quality underlie timely and spatial changes.

23 The aimed level of PNT data output depends on currently available inputs that may independently and uncorrelated vary over a short or long period of time. The guideline should specify the demand on needed types of services and sensors for predefined performance levels of PNT/I data (module B).

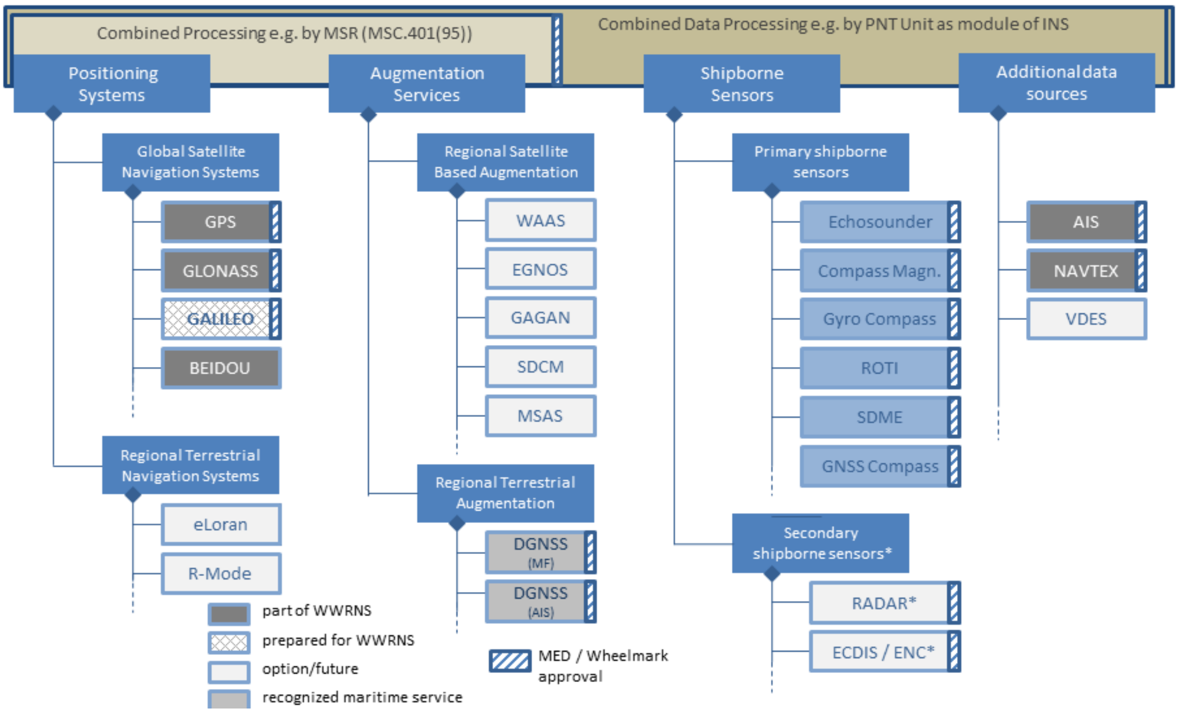
24 This guideline specifies PNT Unit's real-time adjustments of the used data processing functions (module B and C) to applicable methods taking into account the available input data.

25 The PNT Unit shall process data from type approved sensors and services.

26 The minimum sensor configuration is determined by carriage requirements for the ship-type and area of operation (SOLAS V/19).

27 The necessary sensor and service layout is determined by the necessary performance of PNT data provision and integrity evaluation for the subsequent navigational functions and tasks.

Figure 4 – Ship-side sensors



A. 1 Type of sensors

28 The type approved sensors and data sources are distinguished into the following categories:

.1 **Autarkic sensors** use a physical principle, e.g. earth rotation or water characteristics and are independent of any human applied service provision (shown in figure 4, mainly used to provide information of ships attitude and movement).

.2 **Service dependent sensors** rely on any service from outside the ship provided by human effort. They cannot be used onboard without at least a satellite-based or terrestrial communication link to the service provider (shown in figure 3, mainly used to provide information of ships position, velocity and time).

29 Both above described sensors/sources are considered to be available world-wide and free of any rebilling user charge.

A.2 Type of services

30 Services are classified regarding its geographical coverage:

.1 **Global services** are characterized by its world-wide coverage. They may have restrictions regarding usability for different phases of navigation due to signal disturbances reducing the availability or quality of transmitted signals and/or provided information.

.2 **Regional services** (and may be local services) are only available in dedicated service areas. They may be used to improve the quality of ships' navigational data in terms of accuracy, integrity, continuity and availability.

31 Services are furthermore classified regarding its grade/type of service:

.1 **Radionavigation services** provide navigation signals and data which enable the determination of ships position, velocity and time.

.2 **Augmentation services** provide additional correction and/or integrity data to enable that the radionavigation based determination of ships position, velocity and time may be improved.

A.3 Additional PNT relevant input data

32 In addition to sensors and services listed in A.1 and A.2 further data sources may be used for shipborne PNT data provision to increase redundancy or to evaluate plausibility and consistency of data input. This additional data may be derived from any kind of marine information, e.g. deviation tables, water depth at known position from ENC's or other official bathymetric data, or provided by other onboard systems such as RADAR to verify directions, heading and speed or location.

A.4 Requirements on input data

33 The fundamental requirement for navigational equipment onboard is the type approval to ensure a minimum standard of performance for sensor and service data fed into the shipborne PNT Unit for the provision of any PNT data product.

34 The minimum requirement for the usage of sensor or service data as data input for the shipborne PNT Unit has been specified by at least the compliance with IMO Performance Standards.

35 All sensors and services comply with international standards for data exchange.

36 Onboard multi-sensor systems should comply with the rules of this guideline or should provide raw data of included sensors to shipborne PNT data processing Unit.

Module B – Principles, Functions, Requirements and Methods

B.1 Principles

37 The overarching task of the shipborne PNT Unit (data processing) is the reliable provision of PNT data including integrity, status and alert information or a subset of them. PNT data output shall provide:

.1 data for ship's position, attitude and movement, as well as date and time of day in a consistent and unambiguous manner;

.2 integrity information in relation to performance of PNT output data (e.g. checked plausibility and consistency, estimated accuracy) in a standardized format; and

.3 integrity information regarding usability of applied data sources (sensors, services) and current capability of the PNT Unit.

38 The performance of the standardized PNT data output depends on the available quantity and quality of input data. The available and usable input database determines whether functions and methods supported by the shipborne PNT Unit can be applied for the provision of PNT data and integrity information.

39 Principal functions (see figure 1 and 5) cover:

.1 the pre-processing of input data by:

.1 analysing their current availability and quality in relation to their usability for ongoing PNT data processing;

.2 timely and spatial synchronisation of input data within the common consistent reference system (CCRS); and

.3 determining the feasibility of functions in relation to supported methods taking into account the current performance of data input;

.2 the main processing with resulting determination of:

.1 PNT data in the supported quality (e.g. accuracy, real-time availability); and

.2 associated integrity, status and alert information in relation to integrity of sensors and services, functional capability of onboard data processing, and estimated integrity of PNT output data;

.3 provision of PNT output data including integrity, status and alert information.

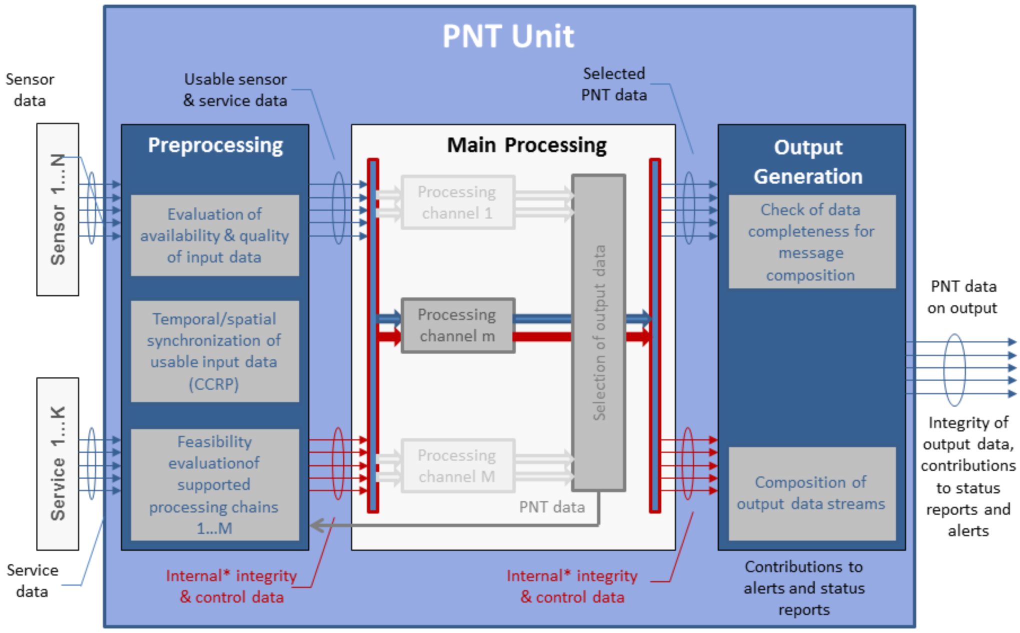
.3 the output generation providing:

.1 check of completeness of PNT output data in relation to supported composition of messages; and

.2 generation of output data streams in the designated message-coding.

40 In minimum the determination of PNT output data and associated integrity, status and alert information should be performed by a single processing chain sequentially using the principal functions as explained in previous paragraph and shown in Figure 5.

Figure 5 - Functional Architecture of PNT Unit



41 Each of the processing function is based on parallel and/or serial operated sub-functions performing specific data processing tasks with appropriate methods to ensure that a certain performance level of PNT output data and associated integrity information will be met under nominal operation conditions.

42 The functional architecture of the shipborne PNT Unit is based on a modular structure to support the adaption of shipborne data processing on:

.1 different performance requirements on PNT output data in relation to navigation scenarios and nautical tasks in their spatial and temporal context;

.2 differences in data input of PNT Unit in dependence on carriage requirements, equipment level, or both; and

.3 current available/usable sensors, services, and data sources.

43 The modular structure is the necessary prerequisite to point out the multidirectional scalability of the shipborne PNT data processing (functions and methods) in relation to:

.1 requirements on data input, provided by sensors and services;

.2 requirements on PNT data output, including associated integrity, status and alert information; and

.3 alternatively and complementary use of several processing chains to meet the application class of PNT and integrity data provision in relation to required performance level.

B.2 Functions

B.2.1 Preprocessing

44 The preprocessing starts with the extraction, verification, and selection of the defined or configured input sensor and service setup against the one in use. Taking respective actions in order to enable the subsequent data processing scheme to deal with degraded input sensor and service availability.

45 Incoming data provided by sensors, sources and services should be evaluated with respect to:

.1 completeness and correctness of transmission (e.g. checksum verification, message length verification);

.2 plausibility of the data content (e. g. range checks, input sensor and service status verification); and

.3 quality of the data content (e.g. input sensor and service self-diagnosis evaluation, input sensor and service operating mode analysis).

46 Incoming data of sensors and services should be excluded from the further consideration within the PNT data determination process:

.1 if the data sources (e.g. sensors and services) have indicated that they are invalid; or

.2 if the evaluation verifies that necessary requirements on data quality are not met.

47 Subsequently, the passed input sensor and service measurement should be corrected for spatial distribution and asynchronous timing effects.

48 The feasibility of main processing is assessed in relation to individual processing chains and their needed usable data input.

B.2.2 Main Processing: Generation of PNT data output and associated integrity information

49 Within the main processing the pre-evaluated input data (sensors, services) are used to feed at least one data processing channel.

50 A single data processing channel may be built out of a set of functions generating the PNT data. Additionally, if defined, functions for the evaluation of integrity are to be applied within this processing channel.

51 The main processing should combine several data processing channels, if the combination increases the performance, e.g. accuracy, integrity, continuity, availability, and resilience of PNT data provision, or manages changes in data input e.g. with/without external service data.

52 If the main processing uses several data processing channels, the data output selection process (see B.2.3) is based on predefined quality assessment rules using the results (intermediate PNT data and internal integrity information) provided by each data processing channel.

53 Each processing channel should be capable to automatically react on a degradation of input data, such as temporary sensor failures or permanent sensor malfunction.

54 The PNT data provided by individual processing channels should be a set of best estimates of the PNT data, such as (but not limited to):

.1 geographic latitude and longitude with respect to the WGS84 datum;

.2 date and UTC time;

.3 speed and course over ground; and

.4 roll and pitch angles.

55 Result of integrity evaluation (by individual processing channel or combination of their outputs) is provided either as a flag indicating the passing of e.g. plausibility and consistency tests or as attributes characterizing the current estimate of accuracy.

B.2.3 Main Processing: Selection of PNT output data and integrity information

56 The selection process as part of main processing identifies the intermediate data results of active processing channels used for the provision of PNT/I output data.

57 The selection process comprises:

.1 evaluation of results per individual processing channel regarding its intended performance level of PNT/I data provision;

.2 consistency checks between results of individual processing channels on the basis of a common PNT data model; and

.3 the selection of "best" PNT/I data based on pre-defined assessment rules (redundancy & degradation).

B.2.4 Output generation

58 The output generation composes messages by coding the PNT output data and associated integrity information into specified data protocols. This may comprise check of validity and completeness of data output provided by main processing.

59 Output messages include the PNT data together with its standardized integrity data. These standardized integrity indicators enable the subsequent connected equipment to identify whether the provided data is usable for its dedicated nautical task (e.g. automated track-control).

60 Alert messages reflecting the top-level health status of the entire PNT data processing unit are generated, if necessary, and complete the PNT output data-package.

B.3 Requirements

61 The safe execution of nautical tasks (to be performed on the bridge) and the feasibility of specialist navigational applications (e.g. track control) depend on the availability and usability of needed PNT data. During ship's voyage the requirements on provision of PNT/I data may vary with the area, the weather and traffic situation. The design requirements on a certain PNT Unit are determined by accumulation of requirements coming from supported nautical tasks and navigational applications.

62 The requirements on PNT/I data provision are specified by:

.1 the application class of PNT Unit defining the amount and types of PNT/I output data; and

.2 the supported performance level of provided PNT data regarding accuracy and integrity.

63 Application classes and performance levels are introduced as means to enable the need-orientated specification of requirements on functionality of PNT Unit and performance of PNT data output. This serves the shipborne harmonization between PNT/data provision and utilization.

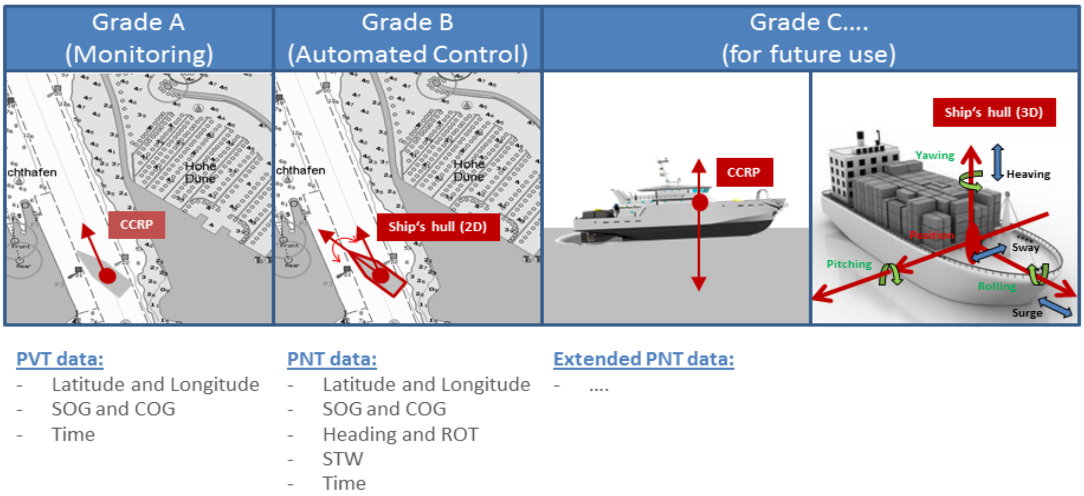
64 The following application classes of a PNT Unit (see Figure 2) are defined to address different requirements on amount and types of PNT data output:

.1 Grade A (monitoring) supports the description of position and movement of a single onboard point (e.g. by a single GNSS receiver);

.2 Grade B (automated control) ensures that attitude and movement of ship's hull are unambiguously described in the horizontal plane; and

.3 Grade C or higher is prepared for the extended need on PNT data e.g. to monitor or control ship's position and movement in three-dimensional space.

Figure 2 Application Classes of PNT Uni



65 Generally, in dependence on supported application class of onboard PNT Unit, the following PNT data is provided:

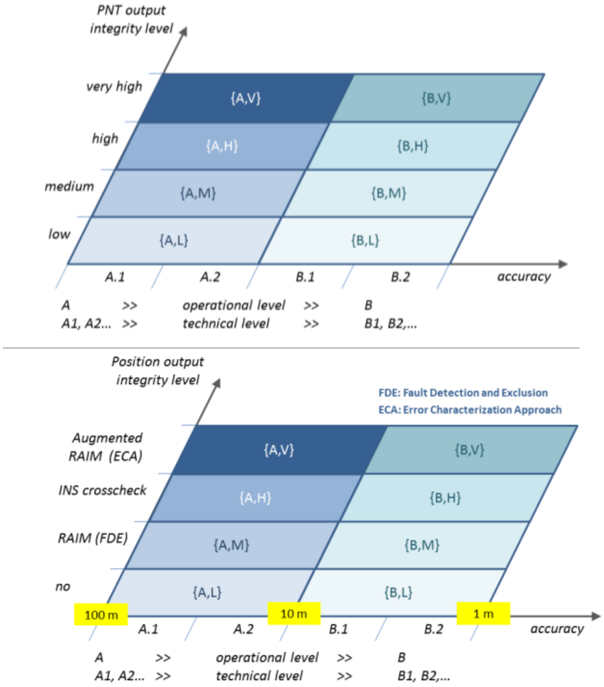
.1 Grade A: horizontal position (latitude, longitude), SOG, COG, and time;

.2 Grade B: heading, rate of turn, and STW in addition to Grade A; and

.3 Grade C: tbd e.g. altitude, UKC …. in addition to Grade B.

66 Performance requirements on each set of PNT output data is described in terms of accuracy and integrity, whereby several levels are specified to address the diversity of operational as well as technical requirements.

Figure 3 Generic performance level for each PNT output data (left) and application example for horizontal positioning (right)



67 Like shown in Figure 3, number and thresholds of operational performance level per PNT data type should be compliant with existing performance standards and resolutions, e.g. A.1046(27) for horizontal positioning results into 2 operational accuracy level: A (better than 100 m) and B (better than 10 m) to 95% confidence.

68 In addition, the introduction of technical performance levels (A.1, A.2, B.1, B.2…) enables on the one hand that a finer specification of task- and application-related requirements on PNT data is supported. And on the other hand, it prepares a need-driven indication and evaluation of achieved accuracy.

69 Integrity information per individual PNT output data is provided to indicate the further usability of data. The value of integrity information (low, medium, high, very high) depends on applied principles of integrity evaluation (none, sensor autarkic plausibility and consistency test, multi-sensor based consistency test, evaluated accuracy) in relation to certain accuracy level.

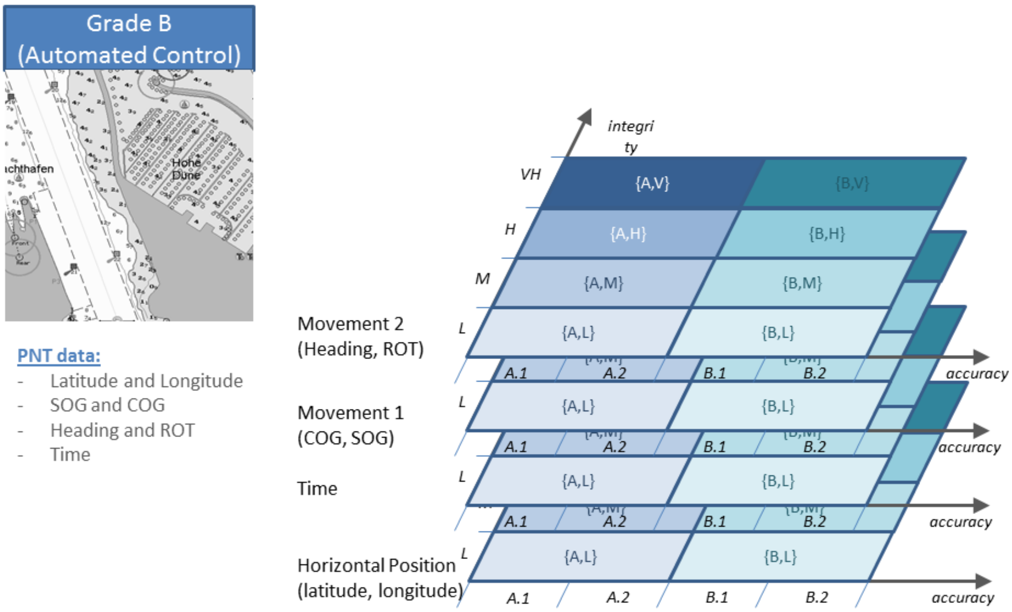
70 As a result of paragraphs 62 to 65 the performance of an individual PNT output data (requirement as well as result of evaluation) is defined by a certain accuracy and integrity levels.

71 Therefore the requirement on data output of PNT Unit is comprehensively specified, if accuracy and integrity levels are defined for all PNT data of supported application class or a combination of them (see).

72 The PNT Unit should provide resilient PNT data including integrity, status and alert information. Resilience can be generated by two complementary means, as below:

.1 Resilience in data acquisition and processing up to a certain level to ensure immunity against relevant failures and malfunctions to meet the specified

Figure 4 Composition of requirements on PNT/I output data (application class B as example)



requirements for accuracy and integrity with respect to a certain continuity, and availability under nominal conditions.

.2 Redundancy of input data and processing offers the possibility to detect, mitigate and compensate malfunctions and failures to avoid the loss or degradation in functionality.

73 A redundant system layout supports the detection and compensation of failures and malfunctions and will lead to a higher resilience being measurable by an increase of integrity, continuity, and/or availability in PNT system operation and data provision.

B.4 Methods

(after consolidation of requirements in 2016, methods will be identified, which are appropriate to meet certain performance level of PNT/I data; different methods could provide the same performance level)

74 Text…

Module C – Operational aspects and fall-back procedures of PNT Unit

C.1 Configuration and mode of operation

75 The configuration of a shipborne PNT Unit is realised by the system integrator before commissioning to ensure compliance between supported performance class of shipborne PNT Unit and operational environment.

76 The configuration determines the supported performance class of PNT Unit specified by requirements on its output data.

77 The current status of operational environment (e.g. quantity and quality of needed sensor and service data) determines, if the supported performance class of shipborne PNT Units will be achieved.

78 The default operation mode realises preprocessing, main processing, and composition of output data automatically taking into account results of internal evaluation and monitoring processes corresponding supported performance class of shipborne PNT Units.

79 External and internal integrity information with standardized meaning acts as indicator for the usability of data and functions. They are used to control and optimize the operation mode of PNT Unit to ensure its functionality.

C.2 Manual selection of operation mode

80 A manual selection of PNT Unit's operation mode by users should be supported to enable that the automated mode can be overridden by users based on explicit additional knowledge regarding usability and integrity of sensors and services.

81 By manual selection of operation mode a proper functionality of a shipborne PNT Unit could be ensured by deactivating processing channels and functions or excluding input data in cases of assumed failures and abnormal behaviour in automated processing.

82 Basically there shall be no processing difference between a user switched off data input, or a failed data input, although status information for users shall distinguish between failures of connected sensors or services and switched off inputs.

83 De-selected inputs shall be marked as manually switched off and corresponding processing limitations are to be communicated to the user via an appropriate interface.

84 Furthermore there shall be no processing difference between a user switched off processing channel or function, or a failed processing, although status information for users shall distinguish between failures in processing and switched off processing.

85 De-selected functions shall be marked as manually switched off and corresponding processing limitations are to be communicated to the user via an appropriate interface.

86 Both manual configuration and real-time user intervention, influence the capability of shipborne PNT Units and result normally in performance degradation or loss of functionality.

C.3 Redundancy, fall-back and fail-safe procedures

87 Failed data input as well as failed processing function are reasons that at the PNT Unit a degradation or loss of functionality occurs. The self-monitoring of a shipborne PNT Unit should detect and indicate critical states.

88 A certain redundancy in input data is a prerequisite to enable the application of shipborne PNT Units of a higher performance class. Generally, the redundancy is exploited for the detection and compensation of typical errors to increase the quantity and quality of PNT data provision and associated information.

89 An increased redundancy in the input data allows for more than a processing channel to be used for the generation of PNT and integrity data. The use of alternative processing channels increases the fail-safety of a shipborne PNT Unit's functionality (increased continuity, availability and resilience), if error sources assigned to the channels are mostly uncorrelated.

90 As a technical system the shipborne PNT Unit has a residual risk regarding total loss of all functionalities. For this purpose the operational environment of a shipborne PNT Unit should ensure by a bypass that available sensor and service data are available for applications.

C.4 TBD

91 ????

Module D – Interfaces

92 Interfaces with connected sources, sensors and services providing PNT-relevant data (processed or raw) and connected systems receiving PNT data should follow a standardized communication concept.

93 Text…..

D.1 Input interfaces

94 The communication protocol for input interfaces should allow the implementation of the functions described in these guidelines. In particular, this includes:

95 Transmission of all relevant raw or processed PNT data, states and associated integrity information. The integrity information should be determined by application of standardized methods and could be provided as flags or qualitative or quantitative values.

96 Transmission of data source identity so that originator component and/or function can be determined.

97 Text…..

D.2 Output interfaces

98 The communication protocol for output interfaces should allow for transmitting the information derived by the functions described in these guidelines. In particular, this includes:

99 Transmission of processed PNT data, states and associated integrity information.

100 Text…..

D.3 Contributions to alert management

101 The alert-related communication should follow a standardized concept to provide the functions and operations as described in the associated Performance Standards.

102 Text…..

D.4 Contributions to reporting

103 Text…..

Module E – Documentation

104 Description of supported functions, supported performance levels regarding integrity evaluation and level of resilience.

105 (see MSC.252(83) and MSC.302(87)) – Adaption an Guideline-Topics A-D

106 …..

E.1 [tbd…

Appendix A

DEFINITIONS

Term	Definition	Source
Accuracy	Degree of conformance between estimated parameter at a given time and its true parameter at that time.	*Resolution A.915(22)*
Accuracy of position	Radionavigation system accuracy is usually presented as a statistical measure of system error and is specified as: – Predictable: the accuracy of a radionavigation system's position solution with respect to the charted solution. Both the position solution and the chart must be based upon the same geodetic datum. – Repeatable: the accuracy with which a user can return to a position whose coordinates have been measured at a previous time with the same navigation system. – Relative: the accuracy with which a user can measure position relative to that of another user of the same navigation system at the same time.	*Education Curriculum on Global Navigation Satellite Systems - Glossary; by UNOOSA (United Nations Office for Outer Space Affairs)*
Amount of data types	The amount of data types is a certain set of unique data types at output of PNT Unit.	-
Application Class	Specifies the need on amount and type of PNT (PVT) data in relation to nautical use cases.	-
Attitude	The orientation of a vehicle or other object in a plane or space.	-
Attitude of AHRS	Roll, pitch and rate of turn about all three axes; accounting for the six-degrees of freedom of vessel in a seaway.	*Adopted from generally accepted scholarly definitions for Attitude and Heading Reference Systems (AHRS)*
Availability	The percentage of time that a system is performing a required function or set of functions under stated conditions in a specified period of time.	*Modification from Resolution A.915(22)*
Compatibility	Refers to the ability of global and regional navigation satellite systems and augmentations to be used separately or together without causing unacceptable interference and/or other harm to an individual system and/or service: – The International Telecommunication Union (ITU) provides a framework for discussions on radiofrequency compatibility. Radiofrequency compatibility should involve thorough consideration of detailed technical factors, including effects on receiver noise floor and cross-correlation between interfering and desired signals; – Compatibility should also respect spectral separation between each system's authorized service signals and other systems' signals. Recognizing that some signal overlap may be unavoidable, discussions among	*GNSS - Glossary; by UNOOSA*

	providers concerned will establish the framework for determining a mutually acceptable solution; – Any additional solutions to improve compatibility should be encouraged.	
Configuration parameter	Input value of a system used to manage and/or control the system operation regarding used input data, realized tasks, used techniques, applied functions and/or aimed output data.	-
Consistency of data	Quality characteristic of a data set to be compliant with a common model (space, time, sensors) specifying the relationship among each other.	-
Consistent Common Reference Point (CCRP)	Location on own ship, to which all horizontal measurements such as target range, bearing, relative course, relative speed, closest point of approach (CPA) or time to closest point of approach (TCPA) are referenced, typically the conning position of the bridge.	*MSC.252(83)*
Consistent Common Reference System (CCRS)	A sub-system or functions for acquisition, processing, storage, surveillance and distribution of data and information providing identical and obligatory reference to sub-systems and subsequent functions to other connected equipment or units as available.	*Modification from MSC.252(83)*
Control variable	Dynamic value extracted from intra-system status information and used for intra-system process controlling (data, tasks, techniques, functions).	-
Continuity	Continuity is the ability of a system to perform uninterruptedly its functions for a specified period of time. More specifically, continuity is the probability that the specified system performance will be maintained for the duration of a phase of operation, presuming that the system was available at the beginning of that phase of operation.	-
Data	Carrier of information.	
Data integrity	Quality characteristic of data derived from successfully passed tests of integrity monitoring for the respective type of data to indicate the validity and correctness of the data content.	-
Data type	Data type are specific PNT data such as position, speed, heading, …	
Degraded condition	Reduction in system functionality and/or performance as a result of deviations from standard conditions induced by e.g. disturbances, malfunctions and failures.	*Modification from MSC.252(83)*
Ephemeris	Parameters, such as Keplerian coefficients, that can be used to compute a satellite's position at a specified time. Ephemerides is the plural of ephemeris.	*GNSS - Glossary; by UNOOSA*
Essential data	Indispensable data to be available as required.	-
Function	Sub-process within a system to perform a certain sub-task by transformation of input variables into output variables taking into account system configuration parameters and intra-system control variables.	*Modification from Wikipedia*
Functionality	Ability of a system to successfully realize its functions with the desired performance	-

Functional scalability	Enhancement of a system by adding new functions with minimal effort.	*Wikipedia*
Generation scalability	Ability of a system to scale up by using new generations of components.	*Wikipedia*
Integrated Navigation System (INS)	An INS is a composite navigation system, which performs at least [two of] the following tasks: collision avoidance, route monitoring [and track control], thus providing "added value" for the operator to plan, monitor and safely navigate the progress of the vessel. The INS allows meeting the respective parts of SOLAS Chapter V regulation 19 and supports the proper application of SOLAS Chapter V regulation 15.	*MSC.252(83)*
Integrity	Ability to provide users with information (integrity data) within a specified time.	*Modification from Resolution A.915(22)*
Integrity evaluation	Process of evaluation of the current performance of the system (or individual data products) to enable their assessment regarding usability or unusability by subsequent applications as well as navigation purposes.	-
Integrity data	Result of integrity evaluation characterizing the current performance of the system (e.g. flags) or individual data products (e.g. performance quantities) in form of provided attributes.	-
Integrity scalability	The meaning of provided integrity data taking into account the applied techniques of integrity evaluation.	-
Interoperability	Refers to the ability of global and regional navigation satellite systems and augmentations and the services they provide to be used together to provide better capabilities at the user level than would be achieved by relying solely on the open signals of one system: – Interoperability allows navigation with signals from different systems with minimal additional receiver cost or complexity; – Multiple constellations broadcasting interoperable open signals will result in improved observed geometry, increasing end-user accuracy everywhere and improving, service availability in environments where satellite visibility is often obscured; – Geodetic reference frames realization and system time steerage standards should adhere to existing international standards to the maximum extent practical; – Any additional solutions to improve interoperability should be encouraged.	*GNSS - Glossary; by UNOOSA*
L-band	The radio frequency band extending from 1000-2000 MHz. GNSS satellites transmit within this L-band.	*GNSS - Glossary; by UNOOSA*
Method	Used for the realization of a function employing dedicated algorithms.	-
Movement	Change of position and/or attitude over time.	-
Operational	Coarser scale of performance level used for specification of requirements on accuracy and integrity of PNT(PVT) data	-

level	or the indication of current achieved performance level - Suitable for presentation on HMI (simple PNT/PVT data awareness due to reduced information provision)	
Performance	The performance characterizes the functional capability of PNT Unit and is described by a set of specific performance parameters in relation to data output.	-
Performance class	The performance class is defined by the set of supported maximum possible performance levels by an individual PNT Unit.	-
Performance level	The performance level specifies the degree of merit achieved by each single performance parameter.	-
Performance parameter	Performance parameters used in relation to data output of PNT Unit are accuracy, integrity, continuity, and availability per data type as well as amount of data types. It is proposed to start with 4 performance level per performance parameter: low, medium, high, and very high.	-
Plausibility of data	Quality characteristic of data to be within the normal range for the respective type of data.	*Modification from MSC.252(83)*
Resilience	Resilience is the ability of a system to detect and compensate external and internal disturbances, malfunction and breakdowns in parts of the system. This should be achieved without loss of functionalities and preferably without degradation of their performance.	*NCSR 1/9 (Annex 1); NAV58/6/1*
Scalability	Scalability is the ability of a system to adapt its operation to different demands and application conditions.	-
Source	A device (sensor, receiver, transmitter) or a location of generated, stored or recorded data used as source for required input data.	*Generalization of INS related definition in MSC.252(83)*
Standard conditions	Nominal general conditions for system operation under which the fulfilment of all system requirements can be expected.	-
Status variable	Dynamic value used for the description of intra-system status.	-
System awareness	The perception of mariners regarding the system in use and achieved performance in system operation and data provision.	-
System integrity	Quality characteristics of a system derived from successfully passed tests of integrity monitoring covering system functions and quality of output data.	-
Technical level	Finer or continuous scale of performance level used for application-driven specification of requirements on accuracy and integrity of PNT(PVT) data or the indication of current achieved performance level - Suitable for connected technical systems e.g. ECDIS, RADAR, Track-Control with integrated automated PNT/PVT data usability evaluation.	-

Appendix B

ABBREVIATIONS

ADC	-	Analog-Digital-Converter
AIS	-	Automatic Identification System
BDS	-	BEIDOU Satellite Navigation System - Chinese GNSS
CCRP	-	Consistent Common Reference Point
CCRS	-	Consistent Common Reference System
CMDS	-	Common Maritime Data Structure
COG	-	Course over Ground
DGNSS	-	Differential GNSS
DOP		A statistical measure of the receiver-satellite(s) geometry
ECDIS	-	Electronic Chart Display and Information System
EDAS	-	EGNOS Data Access Service
EGNOS	-	European Geostationary Navigation Overlay Service
eLoran	-	Enhanced Loran
ENC	-	Electronic Navigational Chart
EPFS	-	Electronic Position Fixing System
GAGAN	-	GPS-aided Geo-augmented Navigation system - Indian SBAS
GAL	-	Galileo – European GNSS
GBAS	-	Ground-Based Augmentation System
GLO	-	GLONASS – лобáльная навигациóнная спýтниковая систéма (*transliteration* GLObalnaya NAvigatsionnaya Sputnikovaya Sistema, *or* "GLObal NAvigation Satellite System") - Russian GNSS
GNSS	-	Global Navigation Satellite System
GPS	-	Global Positioning System – U.S. GNSS
HDG	-	Heading
HDOP	-	Horizontal Dilution of Precision
HNSE	-	Horizontal Navigation System Error
HPE	-	Horizontal Position Error
HSC	-	High-Speed Craft
HW	-	Hardware
IRNSS	-	Indian Regional Navigation Satellite System
INS	-	Integrated Navigation System
LF	-	Low Frequency
Loran	-	Long Range Navigation
MF	-	Medium Frequency
MSAS	-	MTSAT(Multi-functional Transport SATellite) Satellite Augmentation System – Japanese SBAS
MSC	-	IMO Maritime Safety Committee

NAV	-	Safety of Navigation Sub-Committee
NCSR	-	Navigation, Communication and Search and Rescue Sub-Committee
NMEA	-	National Marine Electronics Assoziation
PDOP	-	Position Dilution of Precision
PNT	-	Position, Navigation, and Timing
PVT	-	Position, Velocity, and Timing
Racon	-	Radar Beacon
RADAR	-	Radio Detection and Ranging
RAIM	-	Receiver Autonomous Integrity Monitoring
ROTI	-	Rate of Turn Indicator
RTCM	-	Radio Technical Commission for Maritime Services
SBAS	-	Satellite Based Augmentation System
SDCM	-	System for Differential Corrections and Monitoring – Russian SBAS
SDME	-	Speed and Distance Measuring Equipment
SOG	-	Speed over Ground
Sonar	-	Sound Navigation and Ranging
STW	-	Speed through Water
SW	-	Software
UTC	-	Coordinated Universal Time
VHF	-	Very High Frequency
VPE	-	Vertical Position Error
WAAS	-	Wide Area Augmentation System
WGS84	-	World Geodetic System 1984
WWRNS	-	World-wide Radionavigation Systems
QZSS	-	Quasi-Zenith Satellite System – Japanese regional system

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Appendix C

OPERATIONAL AND TECHNICAL REQUIREMENTS ON PNT/I OUTPUT DATA
[TBD…