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PERFORMANCE STANDARDS FOR MULTI-SYSTEM SHIPBORNE NAVIGATION SYSTEMS

Development of associated guidelines for shipborne position, navigation, and timing (DATA PROCESSING) unit

Submitted by Germany

SUMMARY

Executive summary: This document provides draft guidelines for reliable PNT (Position, Navigation, and Time) data processing based on multi-system/multi-sensor-based techniques as envisaged by e.g. multi-system radio navigation receivers. Within the guidelines an onboard PNT Unit facilitates reliability, integrity, and resilience for the improved provision of PNT data to onboard applications.
The autonomous onboard inspection of all PNT relevant data sources performed by the PNT unit is an essential prerequisite to protect the onboard process of PNT data generation against intrusions by malicious actors (cybersecurity).

Strategic direction: 5.2

High-level action: 5.2.4

Planned output: 5.2.4.9

Action to be taken: Paragraph 16

Related documents: MSC 94/21; NCSR 1/28, NCSR 1/9, NCSR 1/9/2, NCSR 1/10; MSC-MEPC.1/Circ.4; SN.1/Circ.274; NAV58/6/1, NAV58/INF.5; resolutions A.1061(28), A.915(22), A.1046(27); MSC.252(83), MSC.112(73) to MSC.115(73), and MSC.233(82) and FAL 39/7

Introduction

1 MSC 94 approved the report of NCSR 1 (NCSR 1/28), where Member Governments and interested organizations are invited to continue their work on draft performance standard for shipborne multi-system radionavigation receiver equipment (NCSR 1/10, including

comments in NCSR 1/10/1 and 1/10/2) and on draft recommendations for PNT data processing (NCSR 1/9/2) to consider the matter in more detail and to provide joint comments and proposals to NCSR 2.

2 The modular and open concept of an integrated PNT system (NAV 58/6/1, NAV 58/INF.5 and NCSR 1/9/2) considers the need on functional requirements for PNT data processing in a defined and harmonized manner.

3 The performance standards for multi-system shipborne radionavigation receiver equipment, currently under development (NCSR 1/10), should provide the basis to enable the full use of data coming from current/future radionavigation systems/services (e.g. range measurements, system parameters and variables such as orbit, correction and augmentation data).

4 The specified PNT unit is defined as the shipborne data processing to facilitate the application of *multi-system-/multi-sensor-based techniques* for resilient provision of PNT data and reliable monitoring of data and system integrity (NAV 58/6/1, NAV 58/INF.5, NCSR 1/9/2).

5 The combined use of PVT relevant sensors (e.g. GNSS receiver DGNSS corrections) and other onboard sensors (e.g. radar, gyro, echosounder with bathymetric data) is the prerequisite to introduce data and system integrity and to improve the resilience of PNT data provision. This facilitates also to protect the onboard process of PNT data generation against intrusions by malicious actors (cybersecurity).

6 The aim of the proposed guidelines is the establishment of a consistent and harmonized framework to provide PVT as well as PNT data for maritime navigation. Within this framework dependencies between system architecture, functions, methods, and requirements are explained. Differences in requirements and equipment are addressed, avoiding any preferences to particular technologies.

7 The guidelines are considered as an indispensable, complementary step towards improved reliability, resilience and integrity of bridge equipment and navigation information.

8 Consequently, these guidelines are considered as a key element for the development of a multi-system radionavigation receiver.

Discussion

9 Reliability, integrity and resilience are fundamental requirements on nautical onboard equipment/systems identified as user needs and addressed as high-priority solution in the frame of e-navigation.

10 Fundamental requirements should be detailed as follows:

- .1 For the determination of equipment/system "Reliability" it is necessary to specify the tasks/functions performed by the equipment/system, the nominal operating conditions including dependencies on external systems/services and the required interruption free period of time.
- .2 For the evaluation of "Integrity" it is necessary to specify the methods of integrity monitoring in an unambiguous manner to achieve the standardization of results.

- .3 For the provision of "Resilience" it is necessary to specify tasks, functions and performance requirements to identify the demand on intrasystem error compensation.

11 The fulfilment of fundamental requirements (reliability, integrity and resilience) is evaluated with respect to specific sets of performance requirements.

12 These specific sets of performance requirements have to be derived from the diversity of ship types, the variety of nautical tasks and changing complexity of situations up to customized levels of support.

13 The guidelines are structured according to the modular concept (SN.1/Circ.274) and support the scalability of system operation to different performance requirements.

14 Modularity of systems is an appropriate approach to point out 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).

15 The application of a modular system structure in combination with scalability of systemic/functional system requirements:

- .1 promotes a task and application orientated specification of requirements;
- .2 supports the identification of appropriate system solutions;
- .3 facilitates differences in installed equipment;
- .4 establishes transparencies between system and requirements; and
- .5 enables the consecutive support of already defined and evolving user needs in the same guidelines.

Action requested of the Sub-Committee

16 The Sub-Committee is invited to consider and to decide on:

- .1 the draft guidelines as a complementary step towards resilient PNT data provision as envisaged by the multi-system radionavigation receiver (NCSR 1/10);
- .2 the draft guidelines for the consistent processing and validation of different navigation systems and sensor data to enhance and safeguard their use as outlined in paragraphs 6 and 7; and
- .3 the application of the concept of modularity and scalability on the guideline (paragraphs 13 to 15).

ANNEX

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

Purpose

- 1 The purpose of these guidelines is to enhance the safety of ships' navigation by improved provision of position, navigation and time data (PNT) to bridge teams, pilots and ship-side applications (e.g. AIS, ECDIS, etc.).
- 2 The PNT unit specified within these guidelines is defined as a set of data processing functions (MSC 94/18/10, NCSR 1/9/2 and NAV 58/6/1) facilitating:
 - .1 the combined use of data provided by PVT relevant sensors (e.g. GNSS receiver, DGNS corrections) and other onboard sensors (e.g. radar, gyro, echo-sounder with bathymetric data) to procure redundancy in the PNT-relevant database; and
 - .2 the application of multi-system- and multi-sensor-based techniques for reliable provision of PNT data (reliability) or continuative for integrity monitoring (integrity) as well as error detection and compensation (resilience).
- 3 These guidelines aim to establish a modular framework for the further enhancement of onboard PNT data provision:
 - .1 to support the consolidation of requirements on PNT data provision considering the diversity of ship types, nautical tasks, applications and the changing complexity of situation up to customized levels of support;
 - .2 to point out 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 to harmonize and improve the modular concept for onboard PNT data processing as appropriate approach to facilitate changing performance requirements in relation to navigational tasks, carriage requirements, and under consideration of current and evolving user needs;
 - .4 to support the consequent and coordinated introduction of data and system integrity as smart mean to protect the PNT data generation against disturbances, errors, and malfunctions (safety) as well as intrusions by malicious actors (cybersecurity); and
 - .5 to achieve standardized PNT output data including integrity information to support the system awareness for bridge team and the pilot.

Scope

- 4 These guidelines define major principles and functions for onboard PNT data processing, taking into account differences in requirements and dependencies on supported PNT system architecture.

- 5 A structured approach for the stepwise introduction of data and system integrity is developed to achieve resilient PNT data provision in relation to supported performance levels and the system in use (SN.1/Circ.274).
- 6 These guidelines aim to achieve standardized PNT output data to enhance user awareness regarding achieved performance level.
- 7 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.

Application of guidelines

- 8 These guidelines are the indispensable prerequisite for consistent integrity monitoring and handling to achieve resilient PNT data provision.
- 9 These guidelines are recommended for manufacturers, installers, yards, suppliers and ship surveyors to onboard equipment and systems used for resilient PNT data provision.

Definitions (tbd)

- 10 Definitions used in the context of PNT, WWRNS and GNSS are pointed out in the annex to harmonize the common understanding of e.g. performance requirements, design principles and interface specifications within these guidelines.

Module A – Data sources: sensors, services and onboard systems (tbd)

Description of PNT relevant sensors and services, requirements on components, and input data:

- 11 (tbd)

In this section it should also be explained that the data processing could take place when the multi-system receiver is used, either the processing could take place in both the receiver and the PNT unit, or raw data is provided from the multi-system receiver (so it is effectively a sensor) and then processed in the PNT unit

Module B – Principles, functions, methods and requirements (tbd)

Description of principles of PNT data provision, specification of PNT output data and integrity information, requirements on PNT data provision, description of function and methods for PNT data provision....

- 12 [Principles (tbd)]
 - .1 Aim of a PNT unit is the provision of PNT data including integrity information.
 - .2 Provided PNT data should characterize ship's position, attitude and movement, as well as date and time of day in an unambiguous manner.
 - .3 Integrity information characterizes the current status of PNT-relevant data sources (e.g. sensors, services), data processing (e.g. realization of functions) and performance of PNT data provision (e.g. completeness).

- .4 Integrity information related to a PNT data type provided as flag indicating the passing of plausibility or consistency tests; or as attributes characterizing the achieved accuracy and integrity; or as alerts indicating any violation of safety-critical requirements; or a combination of them.
 - .5 ...]
- 13 [Functions (tbd)
- .1 The required performance level of provided PNT data is achieved:
 - .1 if relevant functions are performed regarding to their specification; and
 - .2 if availability of onboard equipment and the coverage of PNT-relevant services ensure the application of these functions.
 - .2 The reliability and resilience of PNT data provision depends on:
 - .1 available redundancy;
 - .2 the supported functions; and
 - .3 the overarching system concept and principles determining what functions are used alternatively and/or complementary.
 - .3 ...]
- 14 Methods (tbd)
- Description of specific algorithms to perform specific functions.
- 15 ...(tbd)

Module C – Functional architecture of PNT unit (tbd)

Aspects of functional architecture (optimization and/or fusion of functions, redundancy and/or backup approaches for improved error detection/management towards reliability/resilience, selection criteria for "best" PNT).

Module D – Interfaces (tbd)

Requirements regarding input and output data including status, integrity, alerts and contributions to maintenance reports.

Module E – System documentation (tbd)

Description of supported functions, supported performance levels regarding integrity monitoring and level of reliability and resilience.