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A Method of Reliability Improvement based on IEC 61924 for the Integrated Navigation System

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Abstract: The purpose of an integrated navigation system (INS) is to provide a "high level safety system" for the functions and information needed by the officer in charge of the vessel. The INS supports the safety of navigation by evaluating inputs from several independent sensors, combining them to provide warnings of potential dangers and their integrity condition. This paper presents a method of reliability improvement for integrity monitoring and validity check of INS based on IEC61924.

1. INTRODUCTION

IEC61924 specifies the requirements for the design, manufacture, integration, methods of testing and required test results for the integrated navigation system (INS) to comply with the International Maritime Organization (IMO) requirements. The integrated navigation system consists of navigational sensors (GPS, Gyro, Speed Log, Echo Sounder and so on) and navigational systems (Radar, ECDIS, Conning and so on). This system receives the navigation data from various sensors and has to process, evaluate them and provide appropriate alarms and warnings for potential dangers and degradation of the integrity of these data. This paper describes the process of integrity monitoring and validity check for the purpose of improving the reliability of INS based on IEC61924.

2. DATA FOR INFORMATION FLOW

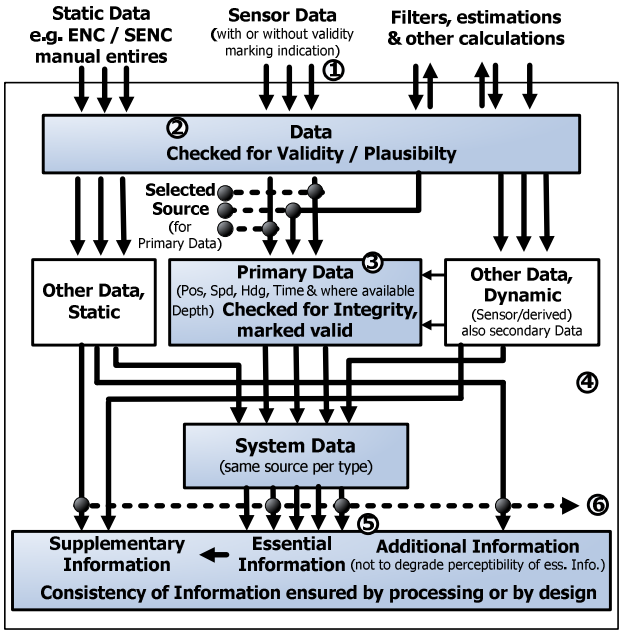

Fig. 1. Data for Information Flow

Fig.1 shows the minimum requirements for data flow within the INS, and how these data are processed as primary data, distributed as system data and finally become information for display or data output. (IEC61924Ed. 2003)

Data is defined as following:

① The INS receives sensor data from various sources. The raw data from a sensor can or can not be marked with validity.

② The information derived from sensor data or from calculations, is called data. The validity checks of all data received or derived from sensors are made by plausibility check.

③ Data from the selected sources for position, speed, heading and depth, are primary data.

④ The Common Consistent Reference System (CCRS) processes input data and primary data to determine validity and integrity respectively, provides system data for essential information to ensure that the same type of data is from the same source, and ensures consistency of any distributed or displayed information, either by processing (e.g. verifying, centralizing or synchronizing data sources) or by the system design.

⑤ Information is all measured, acquired, computed or manually entered as data available for presentation (display) to an operator, and is appropriately complemented with type, source and properties. A subset of information is denoted as essential information.

⑥ Data used for processing, display or output of essential information are to be distributed as system data (SD). As a minimum, system data includes position, speed, heading, time and, where available, depth. All system data of the same type shall be from the same source. Interfacing with INS complies with the International Standards, IEC 61162 series.

3. VALIDITY AND PLAUSIBILITY

The validity of the data received from sensors and used or distributed by the INS shall be checked as a minimum for plausible magnitudes of values. Data that fail the checks or are flagged invalid by the sensor or as a result of integrity monitoring shall be indicated as invalid in all output interfaces.

In all NMEA (National Marine Electronics Association) sentences, the checksum field is the last field and follows the checksum delimiter character "*". The valid character set consists of all printable ASCII characters except for those defined as reserved characters. The plausibility is considered to be the quality of trustworthy in NMEA sentence.

NMEA sentence : $aaccc, c---c*hh<CR><LF>

hh : Checksum field, <CR><LF> : end of sentence

If the main data do not recover their functions within the time set after an alarm generation, then fallback warning is activated, and the system switches over to the backup source. The timeout is set to 5 s. There is no switchover to the backup source without their passing the necessary checks.

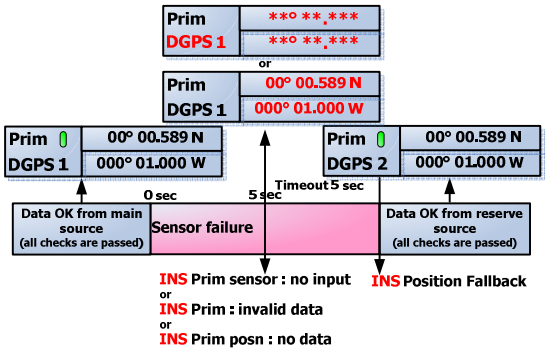

Fig. 2. Sensor Failure

4. COMMON REQUIREMENT

Conning station position of the vessel system is used as reference position. The time of INS is set up according to GPS. Using each time message by GPS, check for the time difference between GPS and systems is carried out. If the difference exceeds time limit, e.g. 2sec, the time of INS is equalized with that of GPS. Data latency of INS should be consistent with the data requirements for the individual part and their relevant international standards. The maximum data delay of INS should not exceed 1 s.

5. INTEGRTIY MONITORING

After check for data checksum, validity and plausibility, it is necessary to ensure accuracy of received data by using the integrity check. The integrity check compares same type data from different independent sources. All the same data from sources automatically participate in the integrity check. If the comparison shows that the difference in position between the data is smaller than the threshold, the check is considered to be passed. The integrity check for vessel position is shown in Fig. 3.

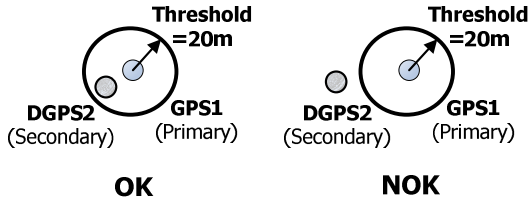

Fig. 3. Integrity Check Diagram

If the main data do not recover their integrity within the time duration after an alarm generation, then fallback warning is activated, and the system switches over to the backup source. The timeout is 5s. There is no switchover to the backup source without their passing the integrity checks.

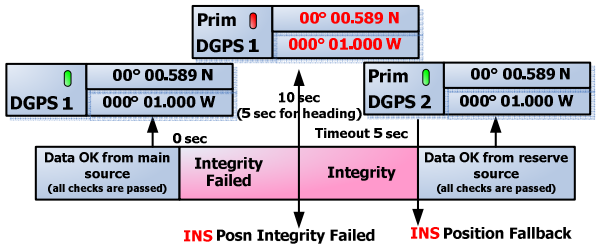

Fig. 4. Integrity Check Failure

6. CONCLUSIONS

This paper described the processes to evaluate the primary data (position, depth, time and speed) from sensors of the integrated navigation system and to check validity, plausibility and integrity. And the method suggested in this paper will be used to provide a "high level safety system" for the functions and information needed by the officer in charge of the navigational watch to plan, monitor or control the progress of the vessel.

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