

Log # M-4086



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: APR 10 1997

In reply refer to: M-97-27 and -28

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On June 10, 1995, the Panamanian passenger ship *Royal Majesty* grounded on Rose and Crown Shoal about 10 miles east of Nantucket Island, Massachusetts, and about 17 miles from where the watch officers thought the vessel was. The vessel, with 1,509 persons on board, was en route from St. George's, Bermuda, to Boston, Massachusetts. There were no deaths or injuries as a result of this accident. Damage to the vessel and lost revenue, however, were estimated at about \$7 million.¹

The National Transportation Safety Board determines that the probable cause of the grounding of the *Royal Majesty* was the watch officers' overreliance on the automated features of the integrated bridge system, Majesty Cruise Line's failure to ensure that its officers were adequately trained in the automated features of the integrated bridge system and in the implications of this automation for bridge resource management, the deficiencies in the design and implementation of the integrated bridge system and in the procedures for its operation, and the second officer's failure to take corrective action after several cues indicated the vessel was off course.

Contributing factors were the inadequacy of international training standards for watchstanders aboard vessels equipped with electronic navigation systems and integrated bridge systems and the inadequacy of international standards for the design, installation, and testing of integrated bridge systems aboard vessels.

The performance of the watch officers during the voyage and the circumstances leading to the grounding were linked to several error inducing deficiencies in the design of the equipment and to an inefficient layout of system displays on the bridge.

¹ For more information, read Marine Accident Report—*Grounding of the Panamanian Passenger Ship Royal Majesty on Rose and Crown Shoal near Nantucket, Massachusetts, June 10, 1995* (NTSB/MAR-97/01).

Although the *Royal Majesty* was equipped with multiple position receivers, the navigation and command system (NACOS) 25 autopilot was not configured to compare position data from multiple independent position receivers such as the 920 global positioning system (GPS) and the 780 Loran-C receivers. Given the *Royal Majesty's* frequent proximity to land and the expected reasonable accuracy of the Loran-C in that area, the NACOS 25 could have recognized the large discrepancy between the GPS and the Loran-C positions as the vessel approached Nantucket Shoals had it been able to compare them. The Safety Board concludes that had the autopilot been configured to compare position data from multiple independent position receivers and had a corresponding alarm been installed that activated when discrepancies were detected, the accident may have been avoided. The safety benefits associated with the redundancy of such critical systems as position receivers would help prevent such single-point catastrophic failures as occurred on the *Royal Majesty*.

The NACOS 25 central console provided efficient access and display of most information needed to conduct a passage when the GPS was fully operational. However, where various sources of position information were possible (i.e., GPS, Loran-C, or dead reckoning [DR]), as with the NACOS 25 autopilot, it was important to delineate clearly which mode was in use. On the *Royal Majesty*, because the NACOS 25 could not detect the GPS's change to DR mode, the central console display switched from GPS to DR-derived positions without changing its display in any perceivable way or notifying the crew. The integrated bridge system, as configured, did not indicate to the officers at the central console that the navigation system had defaulted to the DR navigation mode.

Of particular concern was the alarm system for the GPS. The internal aural alarm for the GPS lasted 1 second, despite its critical function. Neither the brief aural alarm nor the visual alarm, in the form of very small *DR* and *SOL* (solution) characters on the GPS receiver's screen, could be easily seen or heard at the command console. Rather, the GPS receiver was in the chart room behind the console on the bridge. The remoteness of the location probably precluded the *Royal Majesty's* watch officers' hearing the GPS receiver's brief aural alarm or initially noticing the *DR* and *SOL* indications when the GPS defaulted to the DR mode. Further, the integrated bridge system installer did not connect the GPS receiver's external alarm switch to a loud and continuous external alarm, even though one was available. Had the GPS external alarm been installed or had its internal aural alarm required user action to silence it, the officers would have been alerted to the GPS antenna problem shortly after leaving St. George's. Consequently, the Safety Board concludes that the Raytheon 920 GPS receiver's brief aural alarm, the remoteness of the receiver's location, and the failure of the installer to connect the GPS external alarm resulted in the inadequacy of the aural warning sent to the crew when the GPS defaulted to the DR mode. In view of the foregoing, the Safety Board believes that the International Chamber of Shipping should recommend to its members that they ensure that integrated bridge systems installed on their vessels provide critical aural alarms that are continuous and require the user to take action to silence them.

The failure of the GPS antenna connection and the subsequent failure of the NACOS 25 autopilot to recognize the GPS data as invalid and to sound an alarm resulted in a single-point, "silent" failure mode. Aeronautical and aerospace design safety practices typically require the analysis of potential failure modes via failure modes and effects analyses (FMEAs). FMEAs of

the *Royal Majesty's* integrated bridge system could have highlighted the need for multiple independent comparisons of positioning systems for discrepancies between systems, the need for removal of the DR input to the Raytheon 920 GPS receiver, and the need for interrogation of the National Marine Electronics Association 0183 *valid/invalid* position data bits by the NACOS 25. The Safety Board concludes that FMEAs of the *Royal Majesty's* integrated bridge system would probably have disclosed the shortcomings of the system's components. The Safety Board believes that the International Chamber of Shipping should recommend that each of its members ensure that their existing and new integrated bridge systems incorporate the following:

- multiple independent position receiver inputs;
- monitoring position receiver data for failures/invalid data and subsequent positive annunciation to the crew;
- comparing position receiver data for significant discrepancies between position receivers, and subsequent positive annunciation to the crew; and
- FMEAs on existing systems, during the design process for new systems, and whenever peripheral devices or equipment details change.

Therefore, the National Transportation Safety Board recommends that the International Chamber of Shipping:

Recommend to its members that they ensure that integrated bridge systems installed on their vessels provide critical aural alarms that are continuous and require the user to take action to silence them. (M-97-27)

Recommend that its members ensure that their existing and new integrated bridge systems incorporate the following:

- multiple independent position receiver inputs;
- monitoring position receiver data for failures/invalid data and subsequent positive annunciation to the crew;
- comparing position receiver data for significant discrepancies between position receivers, and subsequent positive annunciation to the crew; and
- failure modes and effects analyses on existing systems, during the design process for new systems, and whenever peripheral devices or equipment details change. (M-97-28)

The Safety Board also issued Safety Recommendations M-97-1 through -4 to Majesty Cruise Line; M-97-5 through -11 to the U.S. Coast Guard; M-97-12 and -13 to STN Atlas Elektronik GmbH; M-97-14 and -15 to Raytheon Marine; M-97-16 through -18 to the National Marine Electronics Association; M-97-19 and -20 to the International Electrotechnical Commission; M-97-21 through -26 to the International Council of Cruise Lines; and M-97-27 and -28 to the

International Association of Independent Tanker Owners. The Safety Board also reiterated Safety Recommendations M-93-18 and -19 to the U.S. Coast Guard.

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility "to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is interested in any action taken as a result of its safety recommendations. Therefore, it would appreciate a response from you regarding action taken or contemplated with respect to the recommendations in this letter. Please refer to Safety Recommendations M-97-27 and -28. If you need additional information, you may call (202) 314-6450.

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: Jim Hall
Chairman