Employing New Technologies in Marine Accident Investigations at the National Transportation Safety Board

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During its investigations, the U.S. National Transportation Safety Board[1] uses a range of computational tools to reconstruct accidents and incidents to determine probable cause and formulate recommendations for improvements to transportation safety. Increasingly, we access voyage data recorders (VDRs), engine-mounted sensors, video footage, and onboard and shore-based navigational equipment to collect an array of complex data. We then analyze these data using our collection of computational tools to explain how and why accidents occur.

One of the most significant advances in the NTSB's computer technologies for marine data analysis has been the Marine Accident Data Analysis System (MADAS), developed in conjunction with the United Kingdom's Marine Accident Investigation Board. MADAS is a set of computational tools comprising a series of modules that parse and decode VDR and radar data, decode Automatic Identification System data, view multiple independent data sets on nautical charts, and analyze bridge audio.[2]

Other tools include the NTSB's vehicle simulation capability, which was originally designed for airplane accident analysis. Fortunately, the laws of physics apply as much to ships as they do to airplanes, and we were able to modify this tool to precisely define the control inputs and reaction forces that determine a ship's motion. In addition, video analysis—photogrammetry techniques, specifically—are used to obtain critical quantitative information regarding speed and motion. Additionally, computer animations are generated to integrate the results of these analyses into a real-time display of a vessel's motion, allowing viewers to readily comprehend the dynamics of the accident sequence from various perspectives.

Allision of the Cosco Busan with the San Francisco Bay Bridge

During the investigation of the 2007 allision of the containership M/V *Cosco Busan* with the San Francisco–Oakland Bay Bridge,[3] the VDR provided a range of information invaluable in piecing together the events of the accident. Investigators used MADAS to create a real-time animation that coordinated a variety of VDR information, including radar screen displays, the pilot's exchanges with the master and crew, the ship's speed and heading, the vessel traffic service operator's exchanges with the pilot, and the pilot's commands for rudder inputs. MADAS was

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[1] The NTSB is an independent U.S. Federal agency that investigates transportation accidents, determines probable cause, and makes recommendations to prevent similar accidents from occurring.

[2] Although initial development is complete, the NTSB and MAIB are considering development of additional modules to further enhance MADAS capabilities.

[3] *Allision of Hong Kong-Registered Containership M/V Cosco Busan with the Delta Tower of the San Francisco–Oakland Bay Bridge, San Francisco, California, November 7, 2007,* Marine Accident Report NTSB/MAR-09/01 (Washington, DC: 2008).

also used to study other traffic in the Bay that morning to compare their operations to those of the *Cosco Busan*, in part to understand how the *Cosco Busan* pilot was handling the limited visibility. Use of these technologies enabled the NTSB to determine that the probable cause of the accident was the result of the pilot's degraded performance, the master's inadequate oversight, and the pilot and master's lack of effective communications.

***Crown Princess* Heeling Accident**

To understand the dynamic forces causing the 2006 *Crown Princess* heeling event,[4] NTSB investigators needed to measure the heel angle accurately, but found that the vessel's VDR neither captured nor was required to capture heeling angles.[5] Investigators turned to the ship's security video cameras positioned around the ship. Investigators used photogrammetry techniques to determine the maximum heeling angle by measuring angles formed by the apparent horizon with the vertical axis of the vessel and by measuring the difference between the angle of the shadow created by the vessel and the angle that would have been created by the ship's orientation to the sun at that time of day. Investigators found that the maximum angle of the heeling event was 24° starboard.

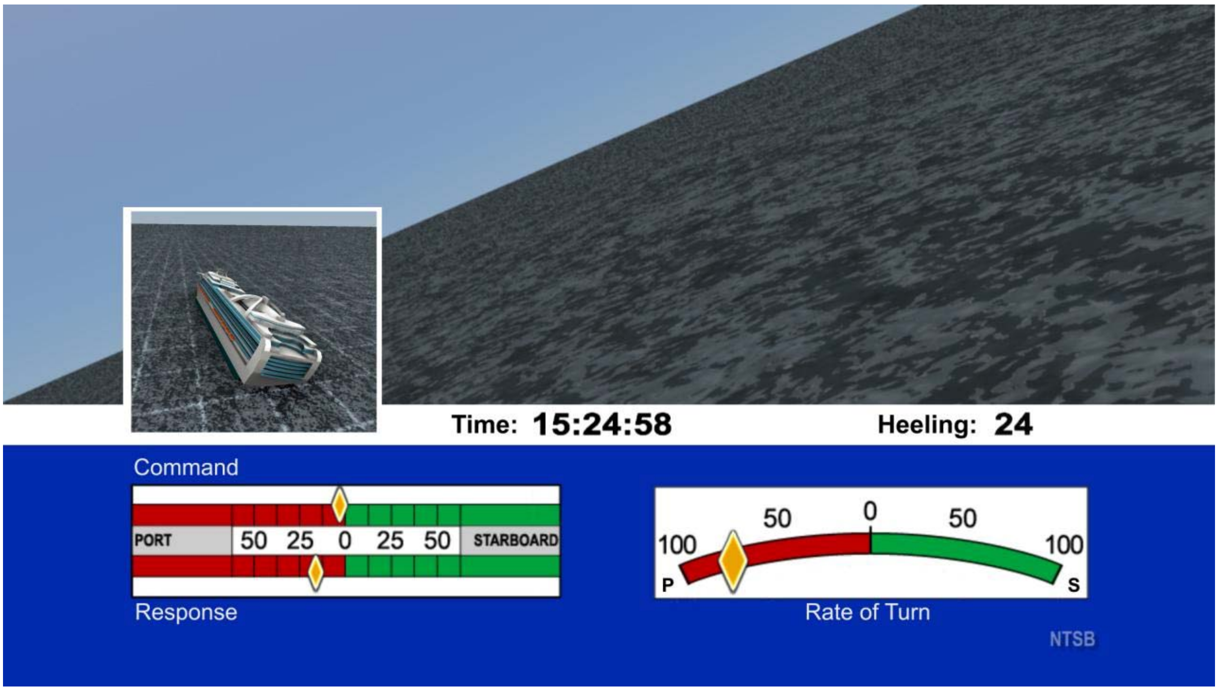
Using our newly developed ship simulation software, we then generated a computer simulation to re-create the motion of the ship. VDR data, including speed, turn rate, rudder deflection, pitch angle, and prop shaft RPM, were input into the simulation, along with the heeling angle determined from video analysis. The simulation was successful at determining an accurate time history of the details of the ship's significant response to the rudder commands as the heeling accident unfolded.

Simulation findings for the *Crown Princess* were convincingly illustrated by means of the NTSB's state-of-the-art animation software,[6] which was used to portray a real-time image of vessel motions and critical control inputs. All NTSB animations are limited to the presentation of actual evidence, and animators are scrupulous in providing only that level of detail necessary to tell the story, as shown in the screen shot below.

[4] *Heeling Accident on M/V Crown Princess, Atlantic Ocean Off Port Canaveral, Florida, July 18, 2006*, Marine Accident Report NTSB/MAR-08/01 (Washington, DC: National Transportation Safety Board, 2008).

[5] The vessel's onboard integrated monitoring, alarm, and control (IMAC) system sensor measured heeling angles, but only from starboard 15° to port 15°.

[6] The animation was created using Autodesk SoftImage and Flightscape Insight.



This screen shot from the *Crown Princess* animation shows the view from the bridge at the full heeling angle. The ship at full heel is shown in the inset. At the bottom of the screen are the rudder command indicator, the response indicator, and the rate of turn indicator.

Conclusion

To take advantage of the proliferation of data sources that may be available for transportation accident investigations, the NTSB has developed and adapted a number of computational tools and techniques. The NTSB is increasingly aware that this emerging segment in its investigative process holds great potential for others concerned with transportation safety. We believe that as these technologies evolve, our ability to understand transportation accidents will grow, further increasing our positive impact on transportation safety.

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