# MEC-E2004 Ship Dynamics

## Manouvering – Case study of Crown Princess accident

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# Case study - Heeling Accident on M/V Crown Princess

- 18th of July, 2006 off Port Canaveral, Florida
- Based on NTSB report **Heeling Accident on M/V Crown Princess Atlantic Ocean Off Port Canaveral, Florida July 18, 2006 (ntsb.gov)**
- 14 persons seriously injured and 284 persons with minor injuries due to excessive heeling of the vessel

Picture Princess Cruises

# Summary of key accident events

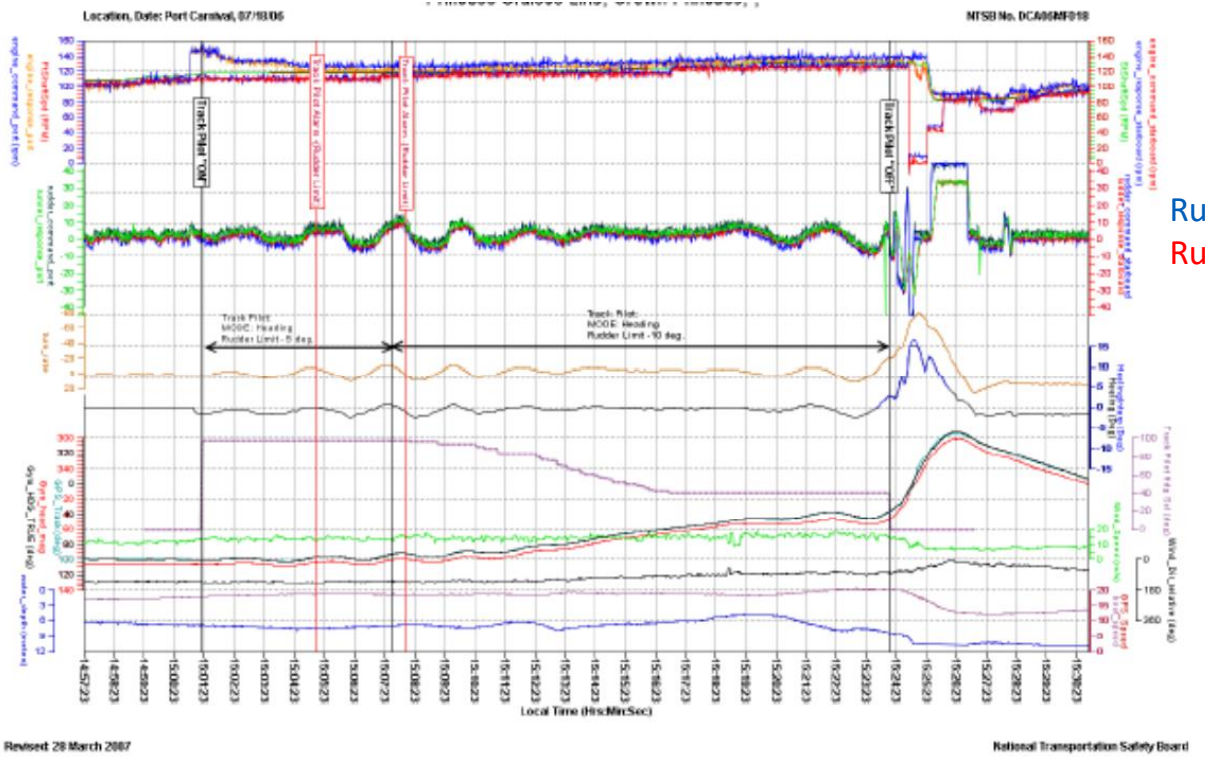
## Chain of events

- Vessel departed Port Canaveral, Florida 18th of July 2006 at 1406(EST) with 4545 persons onboard (3285 passenger and 1260 Crew)
- At 1456 vessel starts to accelerate (after pilot disembarked)
- At 1501 vessel Trackpilot engaged (Autopilot connected within INS) with course 100° (calm seas, gentle breeze from NE)
- At 1505:06 Trackpilot rudder alarm sounds
- At 1507:07 Rudder limit increased to 10°
- At 1508:00 Trackpilot rudder alarm sounds
- At 1513 New course input to trackpilot - heading of 040°
- At 1524 Office on Watch (OOC) disengaged the trackpilot and starts handsteering…
- About 1525 Vessel reached a maximum heeling angle of 24°
  - Rate of Turn (ROT) reached maximum of 80°/minute
  - Levers pulled back and speed reduced to 12 knots (1525 vessel upright)

# Vessel main characteristics

- Main dimensions
  - LOA 289,3m
  - LWL 250,5m
  - B 36m
  - DWT 6750
  - GRT 113651
  - Lightship weight 43814 ton
- Propulsion
  - Diesel-Electric powerplant
    - 4xWärtsilä 16VZA40S
    - 2xWärtsilä 12VZA40S
    - Total 69205kW
  - Propulsion motors
    - 2xSiemens Electric motor 19MW/each
  - Propellers
    - 2xFPP 6 blades/each
    - 5.6m diameter
- Rudders
  - 2xSemibalanced 44m2
  - 2.6% of Lpp*Td

# VDR Data




Rudder command
Rudder response

# Detailed data analysis of NTSB

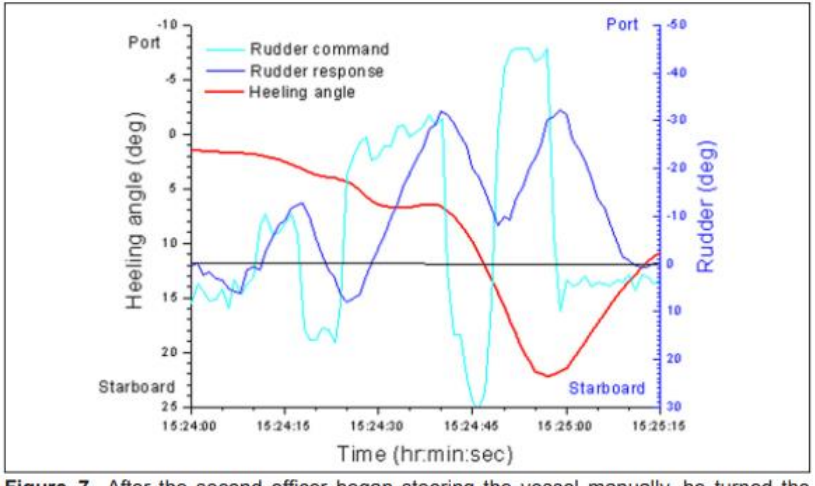



**Figure 7.** After the second officer began steering the vessel manually, he turned the wheel faster than the rudders could follow, as shown by the divergence between the rudder commands (light blue line) and the rudder responses (dark blue line). As the vessel attempted to respond to the commands, it heeled increasingly to starboard (red line).

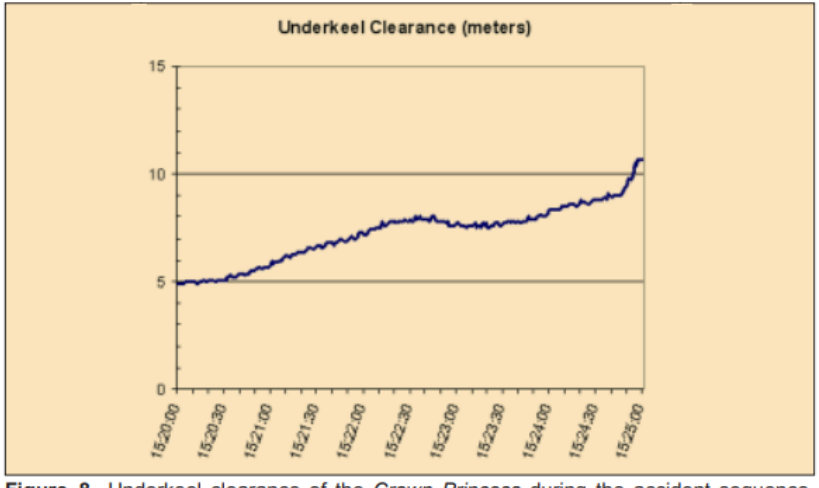



**Figure 8.** Underkeel clearance of the *Crown Princess* during the accident sequence, from data recorded by the vessel's VDR.

# What caused accident? - As per NTSB

1. Factors were not: Vessel mechanical condition, weather, sea state, and behavioral or physiological impairment of the crew
2. Officers didn't recognize high speed and shallow water impact on course stability
3. Inappropriate adjustment of trackpilot settings (ruddel limit instead of rudder economy)
4. Change of conn when vessel in non-static condition
5. Heeling caused by OOW disengaging trackilot and moving to manual steering and turning wheel manually (up to 45°)
6. No defiences in training
7. Errors in operating INS due to inadequate training

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# Autopilot

- $\delta_T = C_1(\psi - \psi_0) + C_2\dot{\psi}$
- Adaptive autopilot seeks minimum combained hull and rudder drag by
  - RMS values of heading error to memory
  - If current heading exceeds reference heading error (in memory), then gain is increased
  - Typical memory is ~30 minutes

Heading Mode

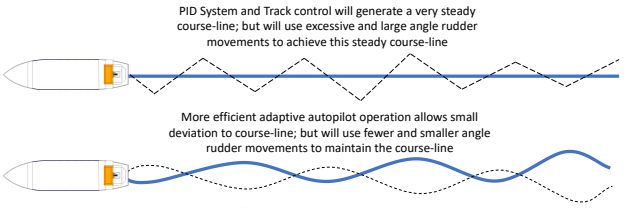
In this mode, the TRACKPILOT steers with a pre-set heading. Wind and current influences are not corrected.

Course Mode

In this mode, the TRACKPILOT steers with a pre-set course. Wind and current are considered and a drift correction angle will be calculated.

Track Mode

In this mode, the TRACKPILOT steers with a sequence of waypoints. Wind and current are considered and a drift correction angle will be calculated.




U.S. Patent Sep. 8, 1987 Sheet 1 of 2 4,692,868

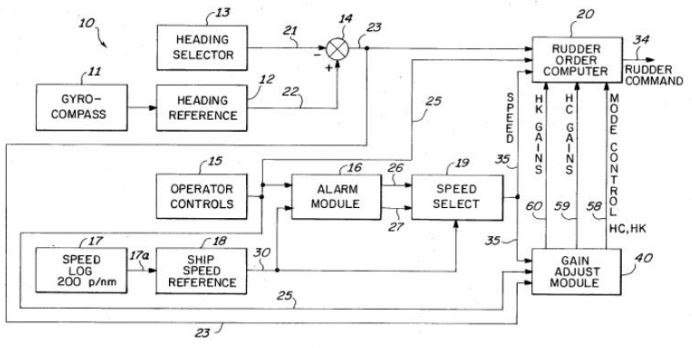



FIG. 1.

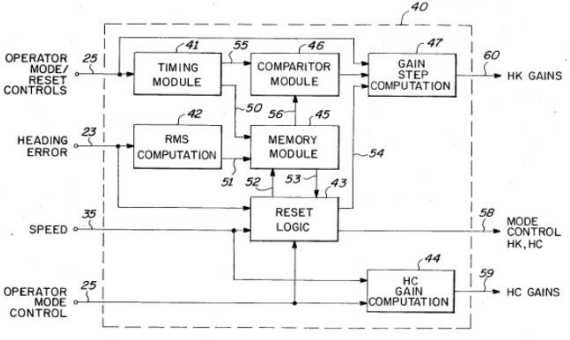
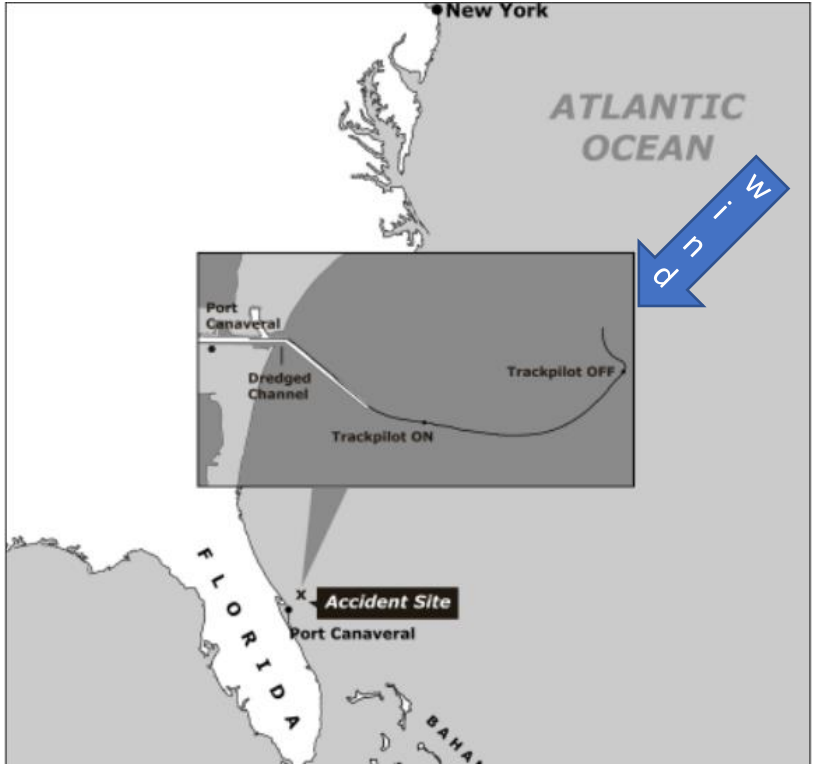



FIG. 2.

# Location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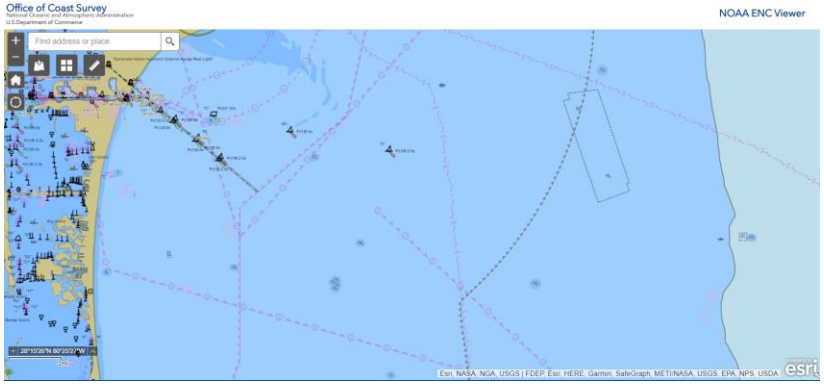
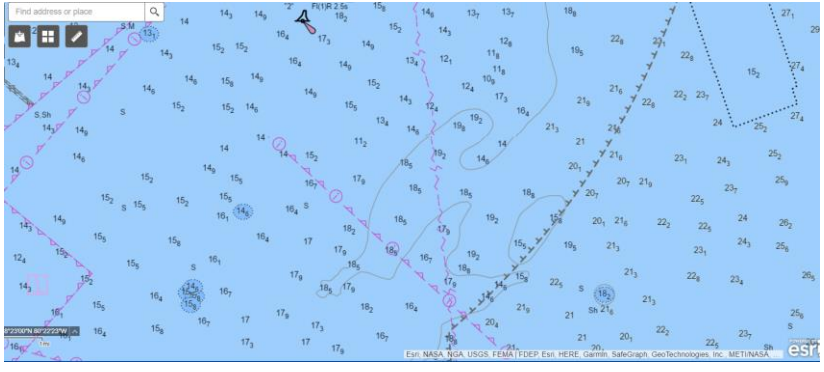
ATLANTIC OCEAN
Port Canaveral
Dredged Channel
Trackpilot OFF
Trackpilot ON
Accident Site
Port Canaveral
FLORIDA


Office of Coast Survey
NOAA ENC Viewer
Find address or place


Find address or place

# Could there be other explanations related to vessel dynamics?

- Course stability (IMO MSC.137 (76))?
- Rudder location?
- Hull form?
- Crew understanding of vessel dynamics?

# Accident investigation reports

- Typical structure
  - Events as occurred
  - Description of vessel
  - Findings
  - Analysis
    - Often includes analysis of accident response by authorities
  - Conclusions
  - Recommendations

- Where to find accident investigation reports:
  - NTSB (Home (ntsb.gov))
  - MAIB (Marine Accident Investigation Branch - GOV.UK (www.gov.uk))
  - EMSA EMCIP (Home - EMSA - European Maritime Safety Agency (europa.eu))
    - National bodies in EU: Example OtKes (Etusivu - Onnettomuustutkintakeskus (turvallisuustutkinta.fi))
  - Most nations have their own accident investigation authorities