Using FRAM to design a resilient traffic management system:
Which lessons can be learned from Air Traffic Control & Vessel Traffic Services?

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• Motivation for study
• What is Vessel Traffic Service (VTS)?
• Stena Danica accident
• Accident analysis with FRAM
• Comparison of VTS with Air Traffic Control (ATC)
• FRAM analysis with ATC functions
• Conclusions
Motivation for study

- Historically technological/organisational changes in maritime domain influenced by aviation.
- However few cross-domain studies exist comparing traffic management in maritime (VTS) & aviation (ATC).
- FRAM used to describe functions of VTS & ATC during approach phase to assess resilience of each traffic management domain.
- Stena Danica maritime accident used as case study.
- Wanted to understand how accident may have been prevented if VTS functions replaced by ATC-like functions.

Identify lessons to be learned from ATC domain.
What is Vessel Traffic Service (VTS)?

- Shore-side service to the maritime community implemented by the Competent Authority.
- Improve the safety and efficiency of vessel traffic and protection of the environment.
- Information service, traffic organisation and navigational advice and assistance.
- Shaped by international guidelines, but implemented locally.
VTS centres & VTS operators
VTS area

NOTE
BRIDGE TEAM TO CONSTANTLY FOLLOW UP THAT VESSEL IS PROCEEDING ACCORDING TO PLAN AND IMMEDIATELY INFORM THE PILOT IF ANY UNCERTAINTY APPEARS.
2nd Iteration of the accident analysis

[Diagram showing the steps of the accident analysis process with labels and connecting arrows.]

- Provide INS to TM
- Communicating ship to ship (Tor Magnolia to Dinideon)
- Reassuring intentions (TM to O)
- Monitor DSS on bridge (TM)
- Take appropriate navigation action (TM)
- Vessels meeting (TM & O)

Other steps include:
- Agree on meeting location (Stena Danica & Tor Magnolia)
- Monitor DSS on bridge (SD)
- Take appropriate navigation action (SD)
- Provide INS to SD
23 functions identified (10 background, 13 foreground).

- Main source of variability affecting the overall outcome in functions “Provide Information Service” & “Ensure Adequate Bridge Resources”.
- VTS is Control and Resource, but has a conflicting role when it comes to traffic organisation.
Comparison with Air Traffic Control

How might the Stena Danica accident scenario have evolved differently if existing VTS service was replaced by an ATC-type service (‘Vessel Traffic Control’)?
Air Traffic Control on Arrival/Approach

- ATCO starts to monitor aircraft ~200 Nautical Miles (NM) before it arrives at sector boundary.
- ATCO starts to plan early sequencing measures required.
- Flight ‘activated’ 8 mins or 40 NM before entering sector.
- More detailed sequencing plan formed to optimise aircraft spacing.
- ATCO can request changes to altitude, speed, heading & sector entry point.
- ATCO issues clearance to flight crew, which flight crew must acknowledge and follow.
Vessel Traffic Control (VTC) functions

- VTC would monitor compliance with pre-determined trajectories (speed, course).
- All changes in trajectory would need to be cleared by VTC.
- Any potential traffic conflicts would be immediately rectified by VTC.
- No monitoring of vessel-to-vessel communication required.
Vessel Traffic Control (VTC) functions

- Most optimum sequence meeting minimum separation requirements.
- Ensures no meetings in tight parts of fairway.
- Sequence plan constantly updated.
- Additional ‘sectors’ opened during busy traffic periods.

OR

Some traffic routed along alternative fairway.
Vessel Traffic Control (VTC) functions

- **ALL** trajectory changes issued via verbal clearances by VTC.
- All communication in English.
- Additional information to enhance situational awareness also provided.
- Vessel Master or pilot obliged to acknowledge and respond to instructions.
Vessel Traffic Control (VTC) functions

Execute Traffic Sequencing

- Vessels follow instructions provided by VTC to form requested traffic sequence.
- All speed & course clearances obeyed.

Monitor DSS & Weather Conditions on Bridge

- Monitor DSS & weather during navigation procedures.
- Report to VTC if change in trajectory required.
1. Some vessels may have been routed along northern fairway or additional ‘sectors’ opened up.
2. Dintelborg requests different bunkering location due to bad weather conditions.
1. Some vessels may have been routed along northern fairway or additional 'sectors' opened up.
2. Dintelborg requests different bunkering location due to bad weather conditions.
3. New sequence planned ensuring minimum separations achieved (weather conditions accounted for) & no meeting in tight part of fairway.
4. Tor Magnolia instructed to slow down in adequate time. Stena Danica also slowed down.
5. All vessels must acknowledge instructions (inc. Dintelborg).
Instantiation of incident with presumed Vessel Traffic Control (VTC) functions

6. Traffic responds to VTC instructions and forms planned traffic sequence.
Instantiation of incident with presumed Vessel Traffic Control (VTC) functions

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5. All vessels must acknowledge instructions (inc. Dintelborg).

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VTC functions

- Traffic Monitoring
- Traffic Sequence Planning
- Communicating VTC Clearances/Traffic Information to Vessels

Vessel functions

- Vessel Acknowledgement of Clearance to VTC
- Execute Traffic Sequencing

7. VTC continuously monitor trajectories of Dintelborg, Tor Magnolia & Stena Danica.
Instantiation of incident with presumed Vessel Traffic Control (VTC) functions

2. Dintelborg requests different bunkering location due to bad weather conditions.

5. All vessels must acknowledge instructions (inc. Dintelborg).

6. Traffic responds to VTC instructions and forms planned traffic sequence.

7. VTC continuously monitor trajectories of Dintelborg, Tor Magnolia & Stena Danica.

8. Tor Magnolia & Stena Danica pass safely – accident avoided.
Conclusions

• Accident avoided due to authority of VTC to fully control all vessel movements.

• VTC instantiation less complex as only one function required for communication, navigation, etc centralised control service reduces dependencies.

• Current VTS at Gothenburg similar to ATC in uncontrolled airspace, although VTS at other ports more similar to ATC (e.g. Port of Rotterdam).
Potential Issues

- Traditional split between ship and shore organisation
- Legal framework is stated on international level, but allows local implementation leading to a general need for standardisation in language and procedures before organisational change can become a focus
What is next?

• Validation of the first iteration of VTC model with VTS operators
  • Study visits at VTS centres coupled with observations and interviews
  • Focus groups with ATCos and VTSOs

• Define resilience cornerstones (Learning, Anticipating, Monitoring and Responding) for ATC and VTS domain
Discussion Questions

• How can we differentiate between “good” and “bad” variability when FRAM is used for the design of a system that does not yet exist?

• How do we know that we have reached a good level of detail in the model?
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