Experiences Using FRAM in Engineering and the Maritime Domain

FRAMily 2016

Doug Smith
PhD Candidate
Faculty of Engineering and Applied Science
Memorial University of Newfoundland

About Me

Who Am I?

- Doug Smith
- PhD candidate at Memorial University of Newfoundland
- B. Eng. in Naval Architecture and M. Eng. In Marine Hydrodynamics

About my research

- Working as part of a international research team of 5 universities, sponsored by Lloyd's Register Foundation
- Scenario based risk management for Arctic shipping and operations
- Initially undertook a thesis topic of probabilistic accident modelling for Arctic shipping
- Currently researching the use of FRAM to understand and inform safe navigation of ships in ice covered waters

MEMORIAL UNIVERSITY

NTNU Norwegian University of Science and Technology

UNIVERSITY OF HELSINKI

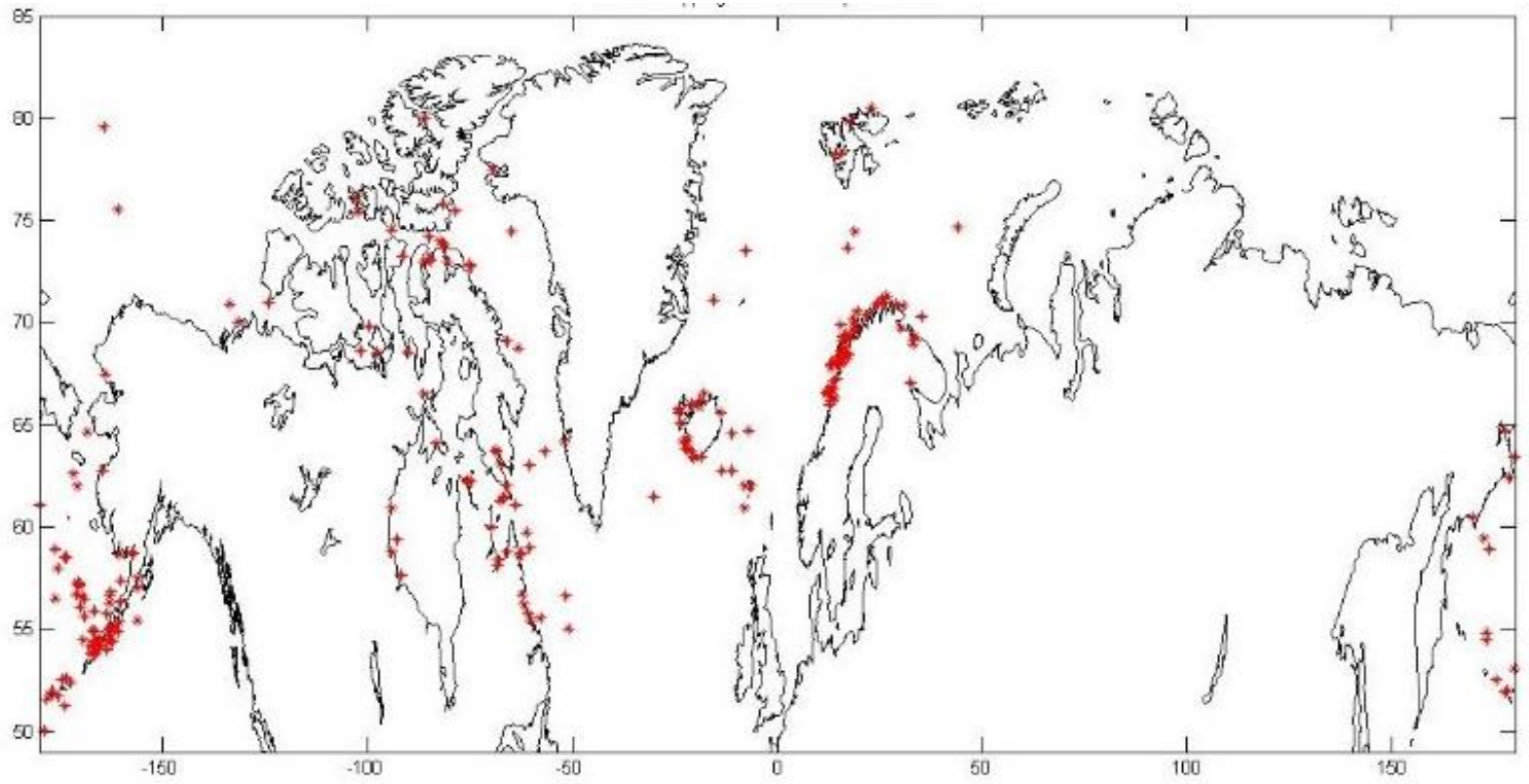
TUHH Technische Universität Hamburg-Harburg

Lloyd's Register Foundation

Getting Started

Understanding accidents

- Look for databases of Arctic shipping accidents
- Found 2 databases publicly available
- 150 accidents in one about 300 accidents in the other (some overlap)
- Level of detail was low
  - Was ice present? – yes or no
  - The type of vessel? – Fishing vessel/cargo ship/tanker/etc
- Potential Biases (even at low detail)
  - Information collected by different accident investigators
  - Information seems to be given voluntary



MEMORIAL UNIVERSITY

NTNU
Norwegian University of Science and Technology

UNIVERSITY OF HELSINKI

TUHH
Technische Universität Hamburg-Harburg

Lloyd's Register Foundation

Getting Started

Still trying to understanding accidents

- Accidents do not happen because the ship is a fishing vessel, but accidents do happen to fishing vessels from time to time
- Identification of causes would require much more detail
- 4 classes of accident factors – External, Human, Organizational and Technical
- What sub classes are important to Arctic shipping accidents?
- It seems almost everything could contribute
- So, let's include many factors and use data to determine significance (Causes as imagined)

“Evaluating” probabilistic model

“Prediction is hard, especially of the future” – Yogi Berra

- Data is limited, in some cases non-existant
- Impossible to verify, even difficult to evaluate
- Even if you believe the probabilities, what can you do with them?
- Place a bet – make odds favorable
- Have you determined causal chains or chain of probable causes?
- I was not comfortable betting on safety

Learning about FRAM

- Learning from successes as well
- Equivalence of success and failure
- Work as imagined vs. Work as done
- Adaptive age of Safety
- Resilience and robustness
- Organizing information in a socio-technical system
- Emergent Accident theory

Using FRAM

Decided FRAM was appropriate method to study Arctic shipping safety

- Shipping is very much a socio-technical system
- Available information for Arctic shipping is scarce
- It would be appropriate to learn about shipping safety from successful shipping operations – FRAM provided structure to do this

When building models.

“All models are wrong but some are useful” – George Box

MEMORIAL UNIVERSITY

NTNU Norwegian University of Science and Technology

UNIVERSITY OF HELSINKI

TUHH Technische Universität Hamburg-Harburg

Lloyd’s Register Foundation

Justifying switch to FRAM

Questions that were asked to me

- How can FRAM improve safety? Examples?
  - Offers a different perspective – a more balanced view of the operation
  - Had trouble with examples
- What can we learn from successes? Why not consider the accidents?
  - We first learn why we should (or shouldn't) expect the operation to succeed
  - Then a new perceptive on why an accident occurred can be examined
- How do we know it is safe if we can't quantify?
  - How do you make a decision to get in your car and drive to work in the morning?
  - You have an understanding of the system and dynamic strategies for success

Writing a review paper

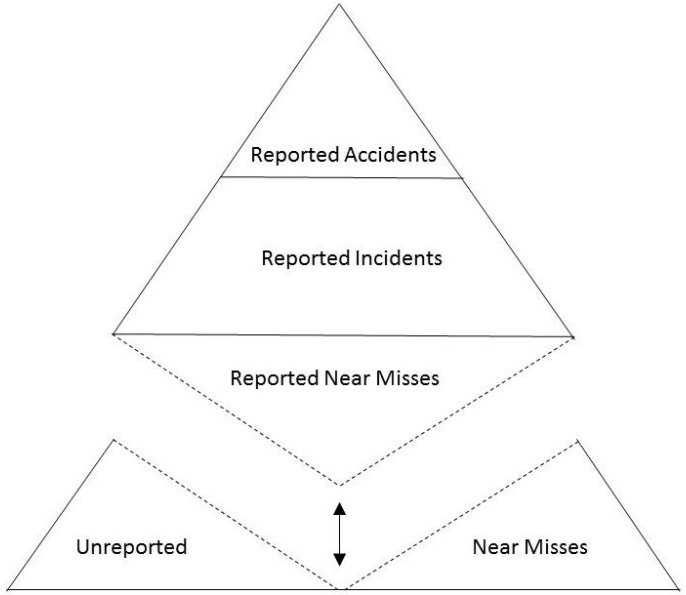
Understanding Industrial Safety: Comparing FT, BN and FRAM

- Evolving industries that must be matched by evolving safety assessments – continual learning
  - Ages of safety – change being connected to quite severe accidents
- Case study of a Propane feed heater system
  - FT and BN representation from another source
  - FRAM representation by me
- Discuss how information is used and understood in each method
  - P_hum_error = 0.2696
  - Does this mean that the operator will make an error 26.96% of the time or we are 26.96% sure that the operator will make an error? What error?
  - How can we prevent the operator from making the error?

Writing a review paper (continued)

Understanding Industrial Safety: Comparing FT, BN and FRAM

- Well by using a method like FRAM we are “forced” to consider more about the process
  - The failure process will not emerge until appropriate details are understood
- “…About 75-96% of marine casualties are caused, at least in part, by some form of human error…” (Rothblum, 2000)
  - Human error needs to be better understood – this could be the biggest improvement to safety
- Learning from success and failures
  - Speed up the rate at which we learn
  - Use previously uninteresting information



Some responses to paper

One reviewer

- The paper provides a new and relevant contribution to the issue of learning from industrial and occupational accidents
- FRAM provides an alternative to improve the understanding which is the basis of any safety assessment.
- The comparison is very honest, as strength and weakness of FRAM are discussed.
- The case used as benchmark is adequate for the purpose
- I imagine your paper will stimulate new research as it is interesting both for accident investigation and safety management system
- Proposed to the editor to publish the paper as is

Some responses to paper

Another reviewer

- The main issue in the paper which is the case study using FRAM. Unfortunately that section does exactly what the FRAMily (http://www.functionalresonance.com/) says it does not: looking at the failures
  - The main issue in the paper is how we have learned and can learn from accidents
  - “Understanding success is a prerequisite for understanding failure”
- FRAM is supposed to look at the successes and describe the variations of normal behavior in order to find emergent "mishaps" that are not in the regular causal chains of known failure modes.
  - FRAM can look at success and find emergent mishaps, but is not limited to this
  - Known causal chains may be based on incomplete information - Believed causal chains
- The Heinrich triangle in this context can be missed. That the "fixed“ ratio is an urban myth has been described elsewhere abundantly
  - Regardless of the ratio, the point was that near misses can be difficult to identify and may be grouped with successes

Some responses to paper

Another reviewer continued…

- A possible conclusion: That FRAM cannot be used for quantification and that BBNs are the technique to use when quantification of complex interactions in a socio-technical system
  - It is not as simple as wanting quantification- what level of understanding is behind the method
- It should be demonstrated that FRAM resulted (1) in a description of the system behavior under normal situations with the variability due to circumstances etc (see that FRAM site)
  - FRAM is not only for so called emergent mishaps
- and (2) how a better estimate of the probability of correct functioning (or the probability of failure, which is its complement) than the well known FT/BBN methods and regular engineering reasoning
  - Quantification does not mean objective – Probabilities are full of subjectivity, but disguised

Some responses to paper

Sent back to same reviewer with rebuttal and some revisions

- The answers to the comments given at the first version confirm that at least in this case the actual FRAM is not used. The only "variation" is a pre-stated failure. Unless the authors want to say that FRAM is nothing new and that having FRAM in their paper provides more hits in a literature search. Even as a review paper it is a meagre contribution
  - Not Actual FRAM – I suppose means work as imagined. The BBN is also imagined,
  - I believe to this reviewer quantification comes first and understanding second in safety (risk) assessment

A sample of an acceptable review paper

"Expert elicitations and Bayesian Network modeling for shipping accidents: A literature review"

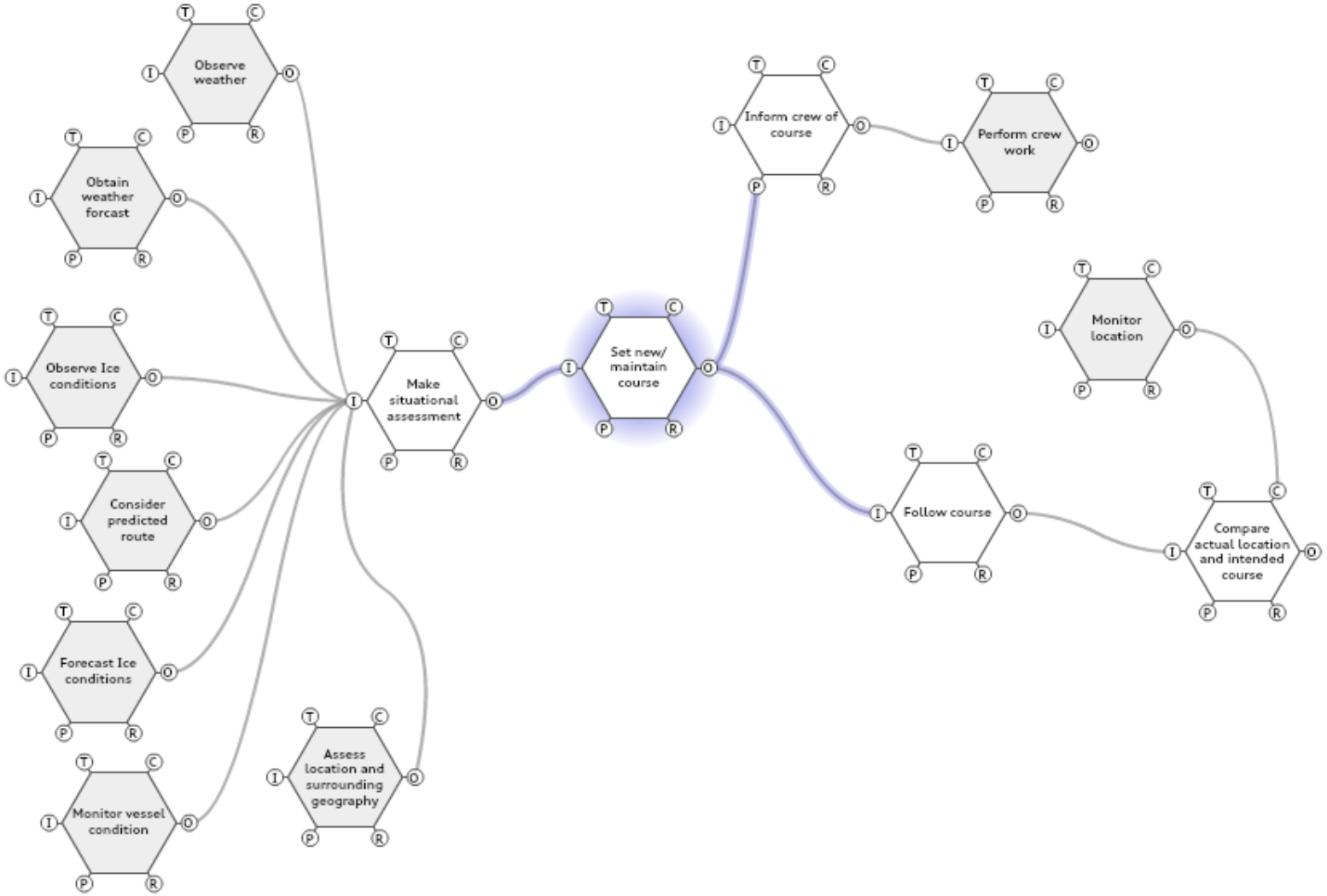
- BBN is a good approach
  - Explicit presentation of causal relationships – (as long as relationships are "known")
  - Making both forward and backward inferences
  - Combination of expert's knowledge and empirical data (combining subjective and objective information – must be careful)
  - Power to deal with uncertainty - (aleatory or epistemic?)
  - Making updates with new information/observation – (Often accidents)

- More focus on methods then understanding the processes (safety culture issue)

Current and future work

Arctic Navigation Model

- As Imagined >
- Recently spoken with an Icebreaker captain
- Was helpful in determining where some regulatory functions plug in
- Additional technical functions
- Identified a resilient strategy



MEMORIAL UNIVERSITY

NTNU Norwegian University of Science and Technology

UNIVERSITY OF HELSINKI

TUHH Technische Universität Hamburg-Harburg

Lloyd's Register Foundation

Current and future work

Planning more discussions with captains (build a FRAM knowledge database)

- Most are former captains
  - Some have experience in Ice
- In discussions with a North American shipping company
  - They like the ideas and are interested
  - Preforming their due diligence before agreeing for an outside party to assess safety
  - Operators seem to really understand the variability model

Acknowledgements

- Lloyd's Register Foundation for funding the research project
- Supervisory Committee for being supportive in the pursuit of this work

Discussion Questions

- Is there a safety culture issue, not just in organizations, but among the research community as well?
- Can we take preventative measures against misconceptions that FRAM can only be used for success analysis and traditional methods must be used for failure?
- Is there an effective way to have a free and open dialogue with organizations regarding safety?
- Are there more examples we can use to justify FRAM to others?
- Is variability the same as variance?

MEMORIAL UNIVERSITY

A?

NTNU
Norwegian University of Science and Technology

UNIVERSITY OF HELSINKI

TUHH
Technische Universität Hamburg-Harburg

Lloyd's Register Foundation