Fires on offshore platforms:
A risk analysis perspective on Piper Alpha

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Outline

- Risk analysis and extension to human and organizational factors
- Piper Alpha (use of the model *post-mortem*)
- A few things I have learned

Probabilistic risk analysis for offshore platforms

- A classical systems analysis:
  - Initiating events: hurricanes, wave loads, fires, blowouts, (ice, earthquakes, etc)
  - Response of the structure
  - Probability and consequences

- A difficult part to characterize: the risks of fires and blowouts

A few general observations

- Most accident sequences and technical failures involve human errors
- Most of these human errors are rooted in management decisions
- Most regulations (government or industry) follow accidents: lack of proactive risk management
- Precursors and near-misses are not systematically recorded and acted upon

A few horror stories

- The platform that embedded upside down (failure to learn from wrong design)
- The platform without foundation: piles had been hammered down in the mud (lowest bid)
- Wrong steel because the right one was not available (time pressures)
- Foundation failure: design before getting the test results; inhomogeneous soil and failure to account for uncertainties

Probabilistic risk analysis

- Has been (is being) done on and off but not systematically. Ex: jacket-type and tension-leg platforms with focus on structure and specific initiating events.
- Safety criteria, sometimes by initiating events.
- Nothing systematic or required (that I know of)

Probabilistic Risk Analysis: how do we do it?

- Functional analysis => failure modes
- External events and their probabilities
- Probability of failure including dependencies
- Probability distribution of the “source term” (amount of oil released)
- Probability distribution of the consequences

Extension to human and organizational factors: the SAM Model

1. Risk analysis of the physical <u>system</u>

2. People who operate that system, and decisions and <u>actions</u> that influence the risk (errors)

3. Effect of <u>management</u> decisions (incentives, information, constraints, etc.) on probability of error

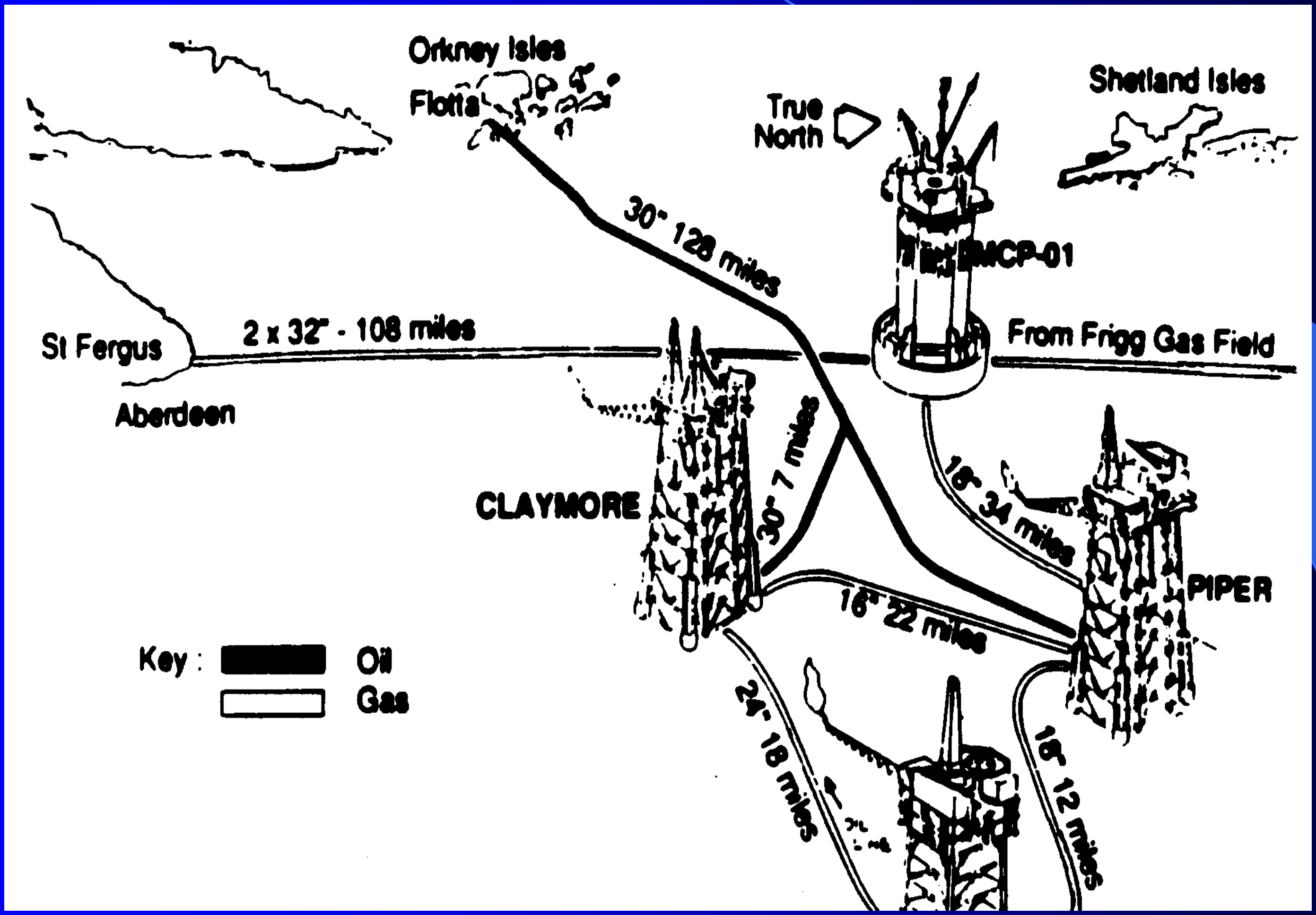
Piper Alpha

- Blew up in the North Sea in July 1988
- A turning point in the oil industry: industry-wide measures and new regulations thereafter
- Use of the SAM model to connect the accident sequence to human errors and management factors after the fact

How did it work?

- Riser (brings product to the platform)
- Separation, Compression, Storage
- Transportation to land
- Oil was sent to Piper Alpha from different platforms
- The accident of July 1988: Catastrophic fire
  167 deaths, 3.4 billion dollars (1988) damage

The platform network



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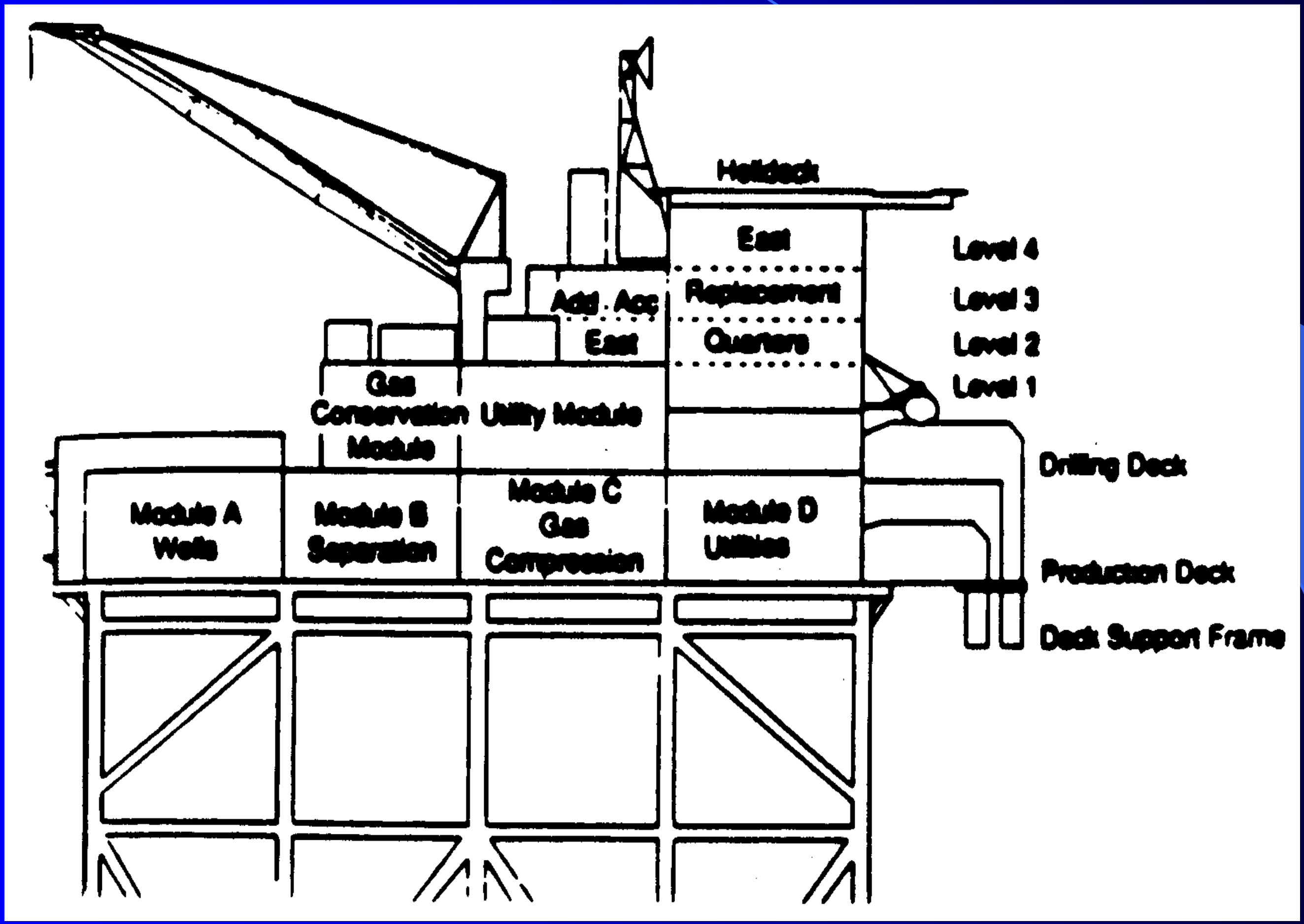
The layout of Piper Alpha



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How did the accident actually start?

- Repair of a pump at end of a July afternoon by a young unsupervised worker
- Work was not finished (one valve did not work)
- The guy put a blind flange on a pipe and tightened it by hand and did not tag the pump
- Redundant pump failed => attempt to start half-fixed pump => 45 pounds of condensate released => sequence of explosions

The accident sequence

1. Explosion in compression module
2. Fire propagates to utilities/equipment module
3. Loss of power/control/radio telecom/production manager (living quarters and control room above production modules)
4. Fire spreads to separation module and deck (fuel storage on deck)
5. Interface of Tartan riser and deck fails
6. Platform engulfed in fire. Structure fails. 167 people killed. $3.4 billion dollar cost.

Question: How did it happen and why?

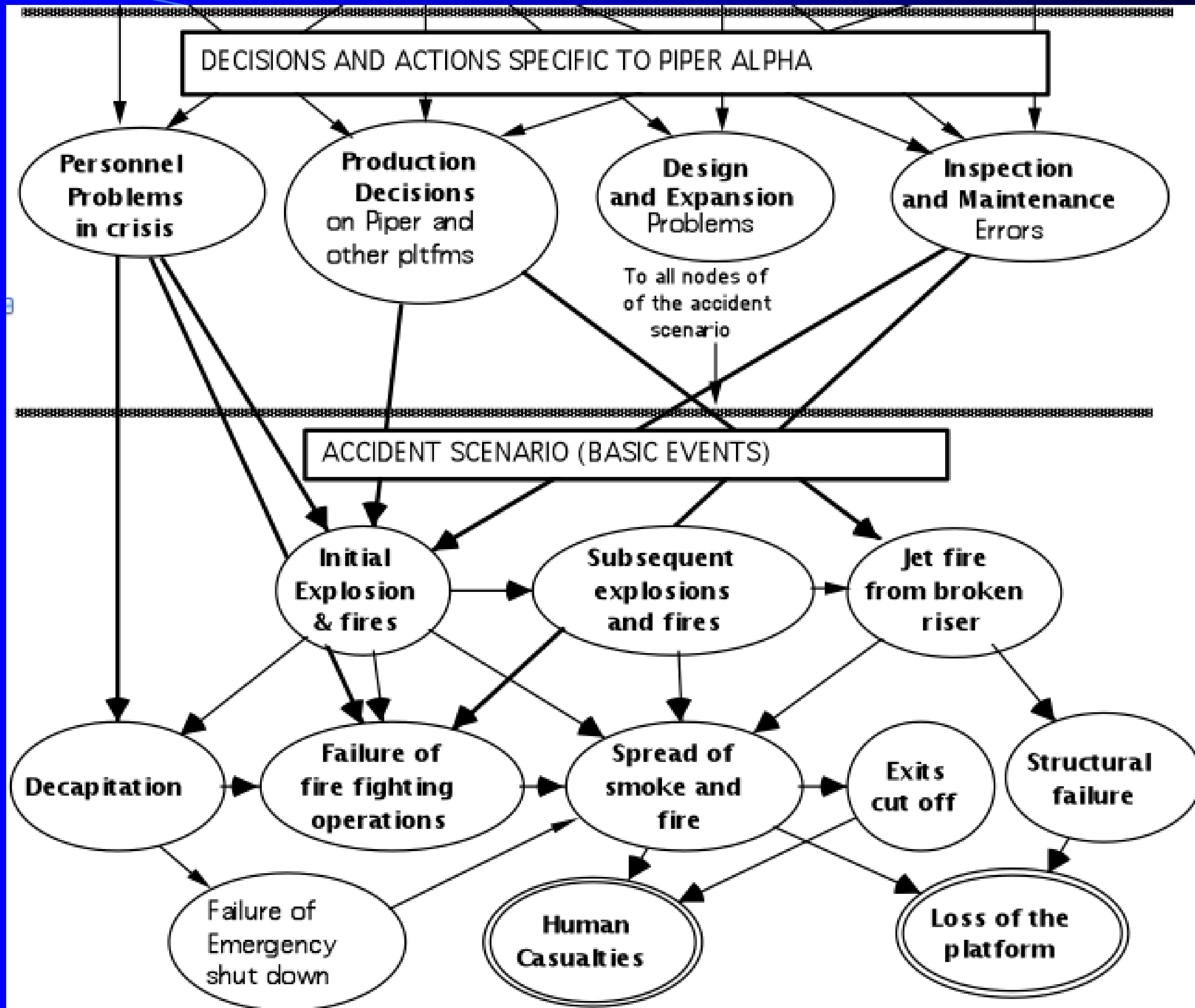
Linking technical and management problems
SAM in the *post-mortem* mode

- Accident sequence

  Initiating and subsequent events
- Human decisions and actions specific to Piper Alpha (some at the time of the accident)
- Management factors that lead to these decisions

=> Representation by an influence diagram

Link between technical failures and operators' decisions and actions



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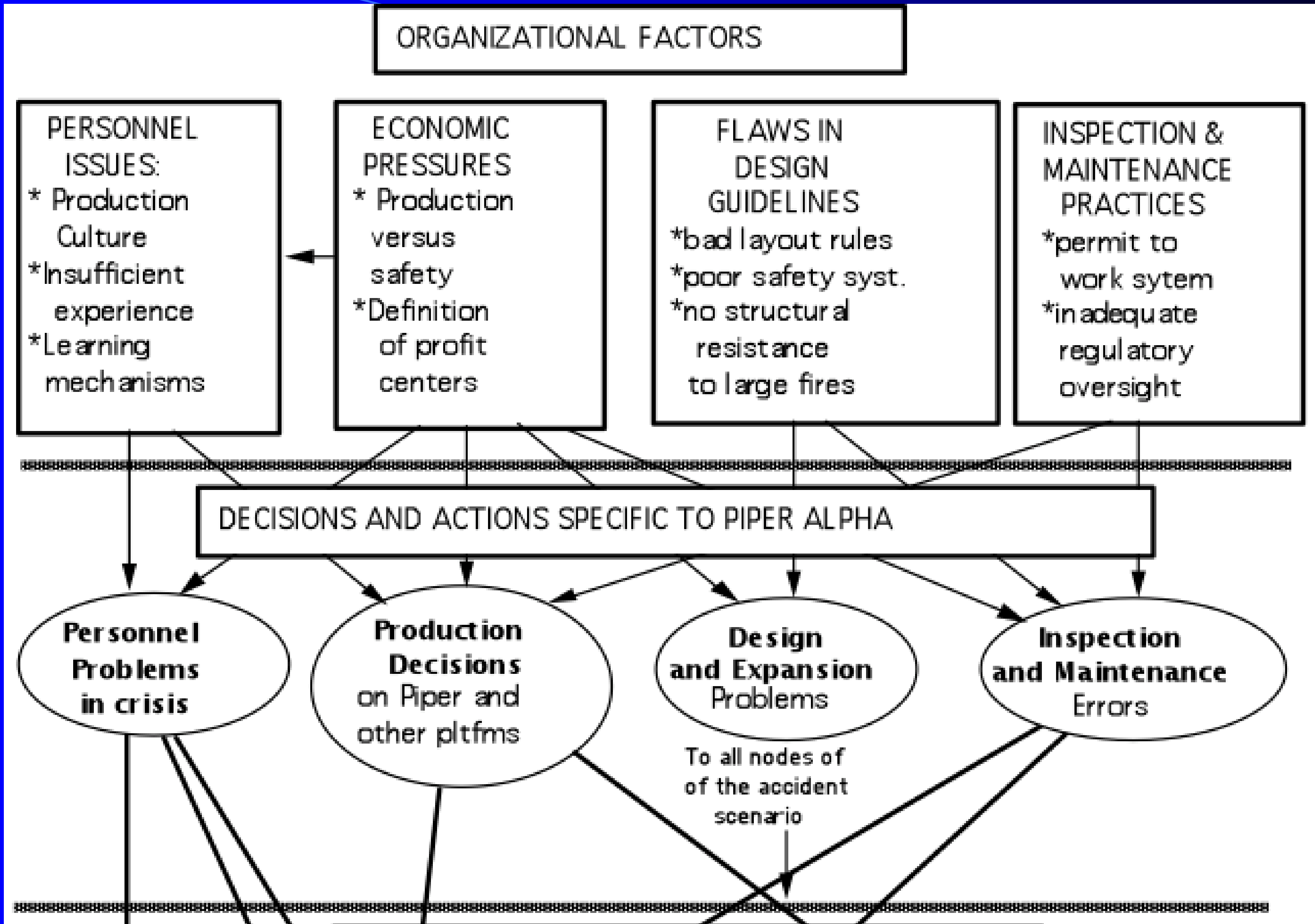
Organizational problems

- Lack of government safety guidelines and/or failure in enforcement
- Problems of managing safety vs. productivity
- Flaws in the design philosophy
- Problems of personnel management
- Insufficient attention to maintenance and inspection

Link between operators' decisions and management factors



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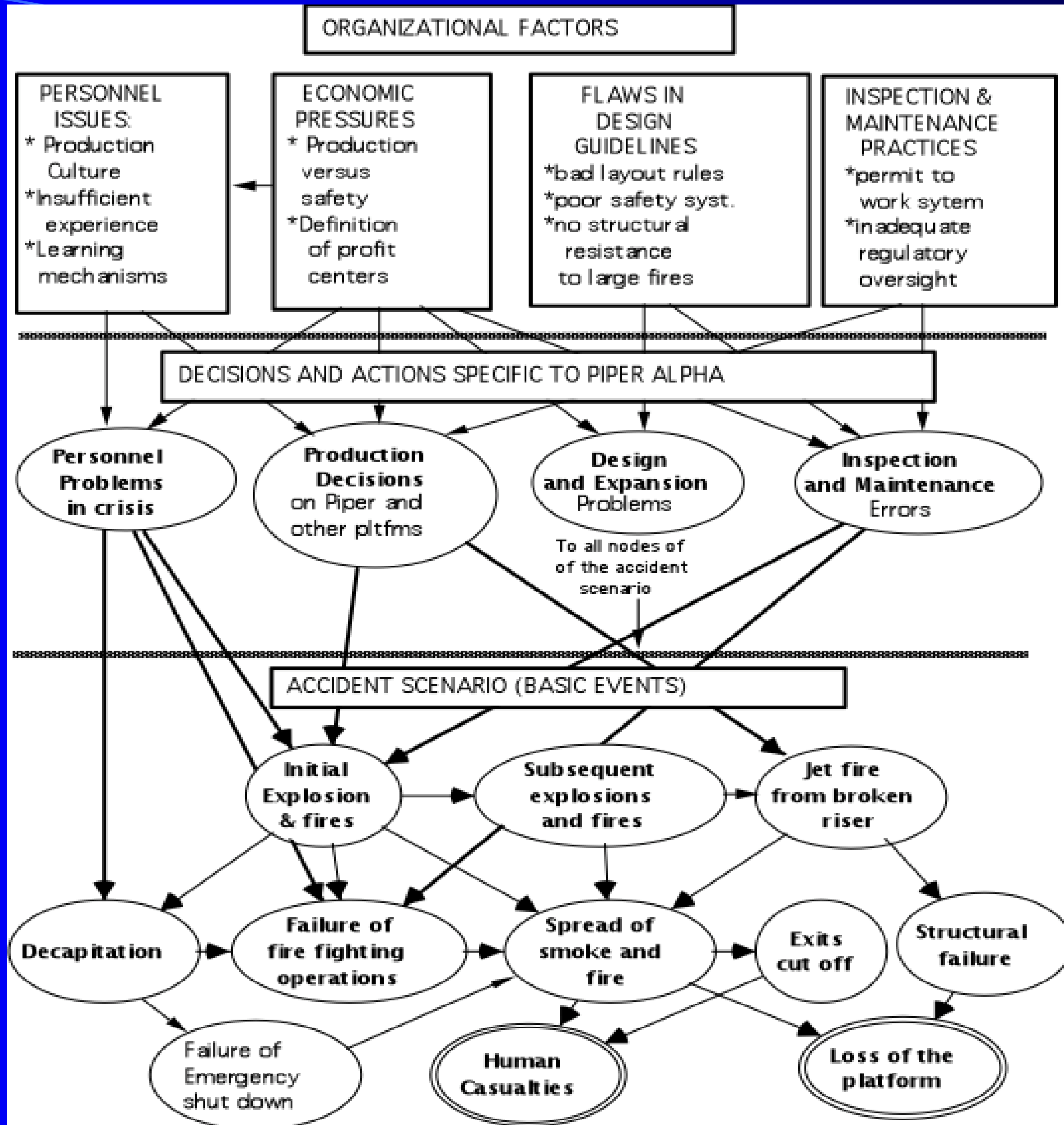
The whole picture



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Forward-looking risk analysis including management factors

Ref. Paté-Cornell, 1990; Paté-Cornell and Bea, 1992

Question:

Costs and benefits of external review of platform design (an organizational decision)

Compare risk reduction benefits to structural improvements ("adding steel to the structure")

Key results
Contribution of design errors

- About 40% of the failure probability

  25% from high severity. 15% from low severity

- 15% gross errors; 25% errors of judgment

- Synergies among errors: computation of the probability of failure with scenarios of error combination, based on expert opinions

Effect of Error Accumulation

- 95% of the risk involves at least one error - 5% "bad luck" (extreme values of load)
- 80% of the failure probability: scenarios that contain at least one high-severity error
- Low-severity errors: about 40% of the failure probability; computed by eliminating HS errors => problems of cumulative effects of LS errors

Benefits of improving design review

- Could reduce the risk by 20% (1/2 of the 40% contribution of design errors)
- Cost of $100,000.
- Cost of the same benefits by adding steel to the structure: ≈ $9 million.
- BUT: uncertainty of organizational measure benefits (seems safer to reinforce the structure because it visibly increases the capacity)

Some general organizational problems

- Inadequacy of the design review
- Time pressures on the critical path
  $\rightarrow$ corner cutting, parallel processing, etc.
- Poor communication of uncertainties
- Incentive problem: reward for productivity only
- Problems of learning: tendency to cover up incidents.
- Loss of expertise
- Contract with lowest bidder

Conclusion on management issues

- Management and organizational factors are key contributors to failure probabilities
- Need for systematic risk analysis to set priorities and support decisions
- Importance of monitoring, and systematic reporting of accident precursors and near-misses
- Organizational measures can be very cost-effective risk mitigation options: people do what they are rewarded for, given what they know about the system

Backups

What has improved since then

- More sharing of info within companies and throughout the industry
- Tighter operation standards (in the US: Coast Guard, MMS)
- Improvement of safety culture

But a lot remains to be done

And when risk management is well done,

no one hears about it…

SAM: equations

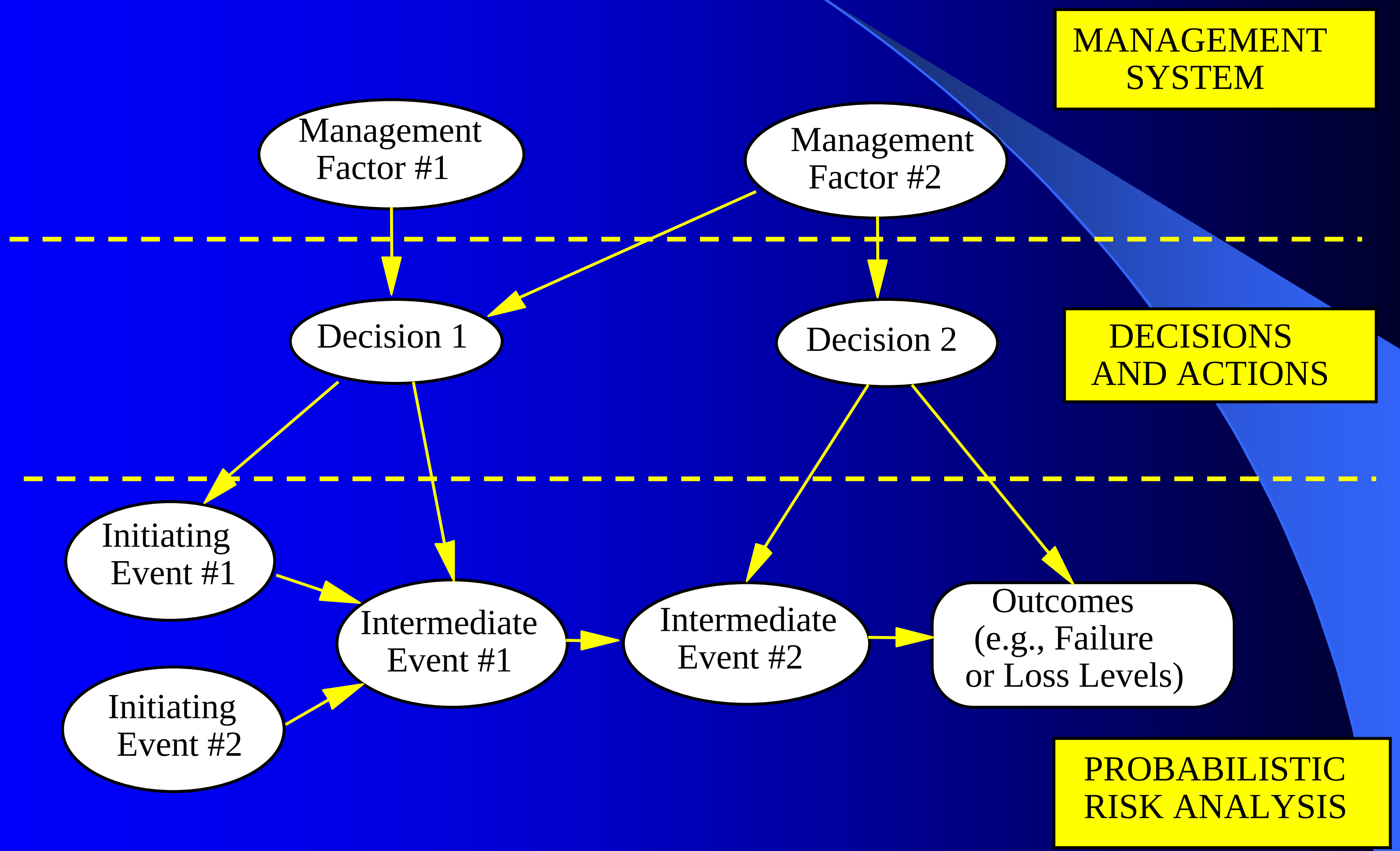
- Step 1: probability of system failure

- Step 2: effects of human decisions and actions on p(F)

  Key performance factors: alertness and competence of the operators => mistakes as well as life saving decisions (Ex: landing of a US Airways plane on the Hudson river; cosmonauts coming back to their crew cabin when the hatch was stuck)

- Step 3: effects of management factors on p(F)

From Management to Technical Failures: Structure of the SAM Model



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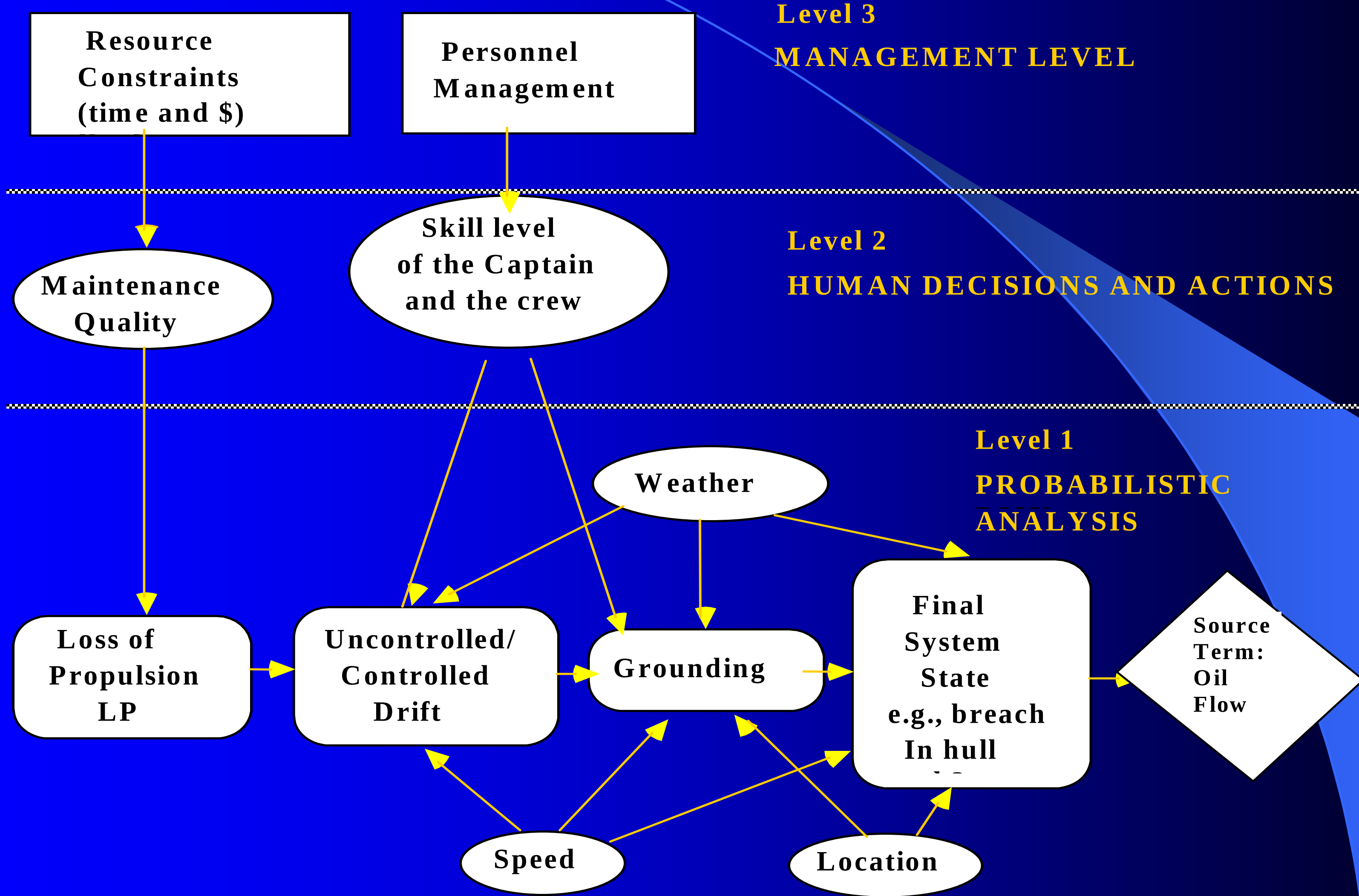
Application to Ship Grounding



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