Formal Safety Assessment

Overview

and

IACS Experience

Presentation at MSC 75 - 16 May 2002
Contents

• FSA - Overview
  What it is and how it can be used

• Some FSA Criticism

• IACS and FSA
  Experiences made and future use

• Importance of FSA Training
Historic Background for FSA

- Nuclear Industry in 60s: Probabilistic Safety Assessments
- Chemical Industry in 70s: QRA, Seveso Directive I and II
- Offshore Industry in 80s: QRA, Industrial Self Regulation Regime in Norway, Safety Case Regime in UK
- Shipping Industry in 90s: FSA
  - 1993, MSC 62: UK proposes FSA concept
  - 1997, MSC 68: FSA Interim Guidelines
  - 2001, MSC 74: FSA Guidelines
Purpose of FSA

• Supportive tool for rule-making at IMO with the intention
  – to make the decision process at IMO more rational, reduce ad-hoc proposals and implementations
  – to provide a proactive and holistic approach, comprising technical as well as human & operational aspects

• Generate and achieve information in a way which is:
  – systematic, objective, comprehensive, auditable, documented

• Demonstrate that
  – suitable up-to-date techniques have been applied
  – sufficient efforts have been made to identify hazards and manage the associated risk
FSA - a risk based approach

1. **Preparatory Step**
   - Definition of Goals, Systems, Operations

2. **Step 1**
   - Hazard Identification

3. **Step 2**
   - Scenario definition
   - Cause and Frequency Analysis
   - Consequence Analysis
   - Risk Summation

4. **Step 3**
   - Risk Controlled?
   - Options to decrease Frequencies
   - Options to mitigate Consequences

5. **Step 4**
   - Cost Benefit Assessment

6. **Step 5**
   - Reporting

**Step 5** Recommendations for Decision Making
### Difference between FSA and current regulatory safety assessment approach

<table>
<thead>
<tr>
<th>Step 1</th>
<th>What might go wrong?</th>
<th>Hazard identification</th>
<th>What did go wrong?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2</td>
<td>How often, how likely? How bad?</td>
<td>Risk analysis Frequencies, probabilities Consequences</td>
<td>Risk = probability x consequence</td>
</tr>
<tr>
<td>Step 3</td>
<td>How can matters be improved?</td>
<td>Risk control options identification</td>
<td>How can matters be improved?</td>
</tr>
<tr>
<td>Step 4</td>
<td>How much? How much better?</td>
<td>Cost benefit evaluation</td>
<td></td>
</tr>
<tr>
<td>Step 5</td>
<td>What actions are worthwhile to take?</td>
<td>Recommendation</td>
<td>What actions are worthwhile to take?</td>
</tr>
</tbody>
</table>
FSA - Approach

Preparatory Step

Hazard Identification

Scenario definition

Cause and Frequency Analysis

Consequence Analysis

Risk Summation

Options to decrease Frequencies

Risk Controlled?

Yes

Cost Benefit Assessment

No

Options to mitigate Consequences

Reporting
FSA - Preparatory Step

Definition of purpose and objective of FSA study

Study scope:
  - ship type, ship size,
  - accident categories,
  - operational conditions

System and operations specification

Type of risk: to persons, environment, property

Risk acceptance criteria

Data collection
FSA - Approach

Definition of Goals, Systems, Operations

FSA Step 1

Cause and Frequency Analysis

Consequence Analysis

Risk Summation

Options to decrease Frequencies

Risk Controlled? Yes

Cost Benefit Assessment

Reporting

Options to mitigate Consequences

No

Yes
Step 1 - Hazard Identification

- Identification of all conceivable and relevant hazards
- Multidisciplinary team:
  - selected experts providing the required expertise
- Structured approach for Hazard Identification
- Analysing also coarsely
  - possible scenarios developing from identified hazards
  - causes of the hazard
  - preventive or mitigating safeguards
  - probability and severity of hazard/scenario
- Ranking, prioritising hazards/scenarios by associated risk
FSA - Approach

1. Definition of Goals, Systems, Operations
2. Hazard Identification
3. Scenario definition

FSA Step 2

- Options to decrease Frequencies
- Options to mitigate Consequences

Yes

Cost Benefit Assessment

Reporting
Step 2 - Risk Assessment

Cause and Frequency Analysis

Water Ingress in Forepeak or Cargo Hold No.1

-or-

Side shell failure

-or-

Deck fittings failure

-or-

Hatch cover failure

-or-

Excessive load

-or-

Shortage of strength

-or-

Wastage due to lack of maintenance

-or-

Severe loads due to inappr. speed

-or-

Hatch cover opens due to rolling

-or-

Design failure
### Step 2 - Risk Assessment

#### Consequence Analysis

<table>
<thead>
<tr>
<th></th>
<th>Detection/Corrective Action</th>
<th>Water Ingress in Hatch No.1</th>
<th>Detection/Corrective Action</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Ingress in Forepeak</td>
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<td></td>
<td>None</td>
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<td>Forward trim</td>
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<td></td>
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<td></td>
<td>Ship Loss</td>
</tr>
</tbody>
</table>

None

Forward trim

Forward trim

Ship Loss
Step 2 - Risk Assessment

Risk Summation and Risk Acceptance

Consequence
Number of Fatalities

Frequency per vessel year

ALARP

High Risk

Low Risk

Risk = 0.004 fatalities per vessel year

Risk Assessment

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Number of Fatalities

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Step 2 - Risk Assessment

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FSA - Approach

- Definition of Goals, Systems, Operations
- Hazard Identification
- Scenario definition
- Cause and Frequency Analysis
- Consequence Analysis
- Risk Summation

- Risk Controlled?
- No

- Cost Benefit Assessment
- Reporting

FSA

Step 3
Step 3 - Risk Control Options

How can risk be controlled? Where in the risk model?

Causal Chain:

Human error, navigation → Collision → Flooding → Fire → Evacuation Failure

\[ \Delta \text{Risk} \approx? \quad \Delta \text{Risk} \approx? \quad \Delta \text{Risk} \approx? \quad \Delta \text{Risk} \approx? \]

Re-evaluation of the risk:

Implementation of Risk Control Options in the risk model
FSA - Approach

Definition of Goals, Systems, Operations

Hazard Identification

Scenario definition

Cause and Frequency Analysis

Consequence Analysis

Risk Summation

Options to decrease Frequencies

Risk Controlled?

No

Yes

Options to mitigate Consequences

FSA Step 4

Reporting
Step 4 - Cost Benefit Assessment

Types of costs, e.g.:
- investment costs
- costs related to operation
- costs related to training, inspection, maintenance

Types of benefits, e.g.:
- reduced fatalities/injuries
- reduced loss of properties
- damage to the environment

Ranking of risk control options according to their cost effectiveness:

\[
\frac{\Delta \text{Cost}}{\Delta \text{Risk}} \approx ?
\]

\[
\frac{\Delta \text{Cost}}{\Delta \text{Risk}} \approx ?
\]

\[
\frac{\Delta \text{Cost}}{\Delta \text{Risk}} \approx ?
\]

\[
\frac{\Delta \text{Cost}}{\Delta \text{Risk}} \approx ?
\]
FSA - Approach

1. Definition of Goals, Systems, Operations
2. Hazard Identification
3. Scenario definition
4. Cause and Frequency Analysis
5. Consequence Analysis
6. Risk Summation

- Options to decrease Frequencies
  - Risk Controlled? (Yes → Cost Benefit Assessment)
  - Risk Controlled? (No → Options to mitigate Consequences)

- Options to mitigate Consequences

FSA Step 5
Step 5 - Recommendations for decision making

Providing a selection of risk control options, which are:
- cost effective and
- reduce risk as low as is reasonably practicable

Preparation of a report,
- presenting the scope of the analysis,
- any limitations and assumptions made,
- the results achieved,
- providing a clear explanation of the reasoning behind the conclusions made.

Recommendation of risk control options to the decision maker for further consideration.
Ways of using FSA and Risk Analysis
Summary of discussion at IMO

1: FSA - for rule making

2: RA - for assessment of individual ship designs (Design Safety Case)

3: RA - for use within ISM-Scheme (Operational Safety Case)
FSA Criticism

• FSA takes too much time
  – (while public pressure calls for fast solutions)

• Experience:
  – A HAZID takes three days and produces an overview and prioritisation of weak points
  – IACS FSA BC study took about one year
  – Japanese FSA BC study largely completed in one year
  – Norwegian study took less than one year
  – All reported to MSC 74, which was the initial deadline
FSA Criticism

• FSA used to slow down decision processes
• Experience
  – Some FSAs may have
    • Too large scopes
    • Too high ambitions
• Need realistic Terms of Reference
• Need in depth understanding of FSA to break down the scope into manageable tasks
FSA Criticism

• FSA can be a manipulative tool
• Experience:
  – We have seen independent studies with same results
  – IACS FSA BC study confirms DNV Cost benefit assessment from 1997 (Strengthening bulkhead between Nos. 1 and 2 holds)
  – Norwegian and Italian study on Helicopter Landing Area
  – IACS and Norwegian Study on Water Level Alarms
FSA Criticism

• Cost data are too fluctuating in time and variable geographically
• Analyses have been able to resolve this by
  – Presenting high and low estimates
  – Presenting reasonable assumptions
  – Using averages over long time spans
• Some standardisation on how to do this may be required
FSA and Challenges

• Where data lacks, qualitative assessments through expert judgement is unavoidable

• Confidence in achieved results highly depends on:
  – the confidence in the experts, i.e. their qualification and competence, and
  – the effectiveness of assessment procedures

• However, uncertainties will be revealed and documented, rather than suppressed

• With proper training and understanding an FSA is very transparent
FSA and Challenges

• Costs and efforts relatively high compared to today's way of assessing safety, but:

What does current approach cost?

Instead of continuously amending fragmented requirements, FSA utilisation aims at replacing them by results of comprehensive assessment.
FSA IACS Experience

- IACS established WG on FSA back in 1996
- WG FSA initiatives
  - Internal case studies
  - FSA terminology
  - Establish project teams on:
    - Human Reliability Analysis in FSA (in the new IMO FSA Guidelines)
    - HAZID on Ballast Water Exchange
    - FSA Training - Management Module
    - FSA Training Course
    - HAZID on Fore End Watertight Integrity (BC), MSC 71/INF.7 and MSC 74/INF.4
    - FSA on Fore End Watertight Integrity (BC), MSC 74/5/4
Experience with FSA/BC

- Core project team established headed by FSA Experts (DNV, NK, RINA)
- Internal project teams with other experts established in each society
- Three RCO brainstorming meetings
- Regular co-ordination meetings
- Internal review
- IACS Review meeting
# Experience from FSA/BC

## DNV Team:
- FSA
- Structural Reliability
- Environmental Loads
- Hydrodynamics (2)
- Automation

**Brainstorming:**
- BC Captain/QA
- Structures (2)
- Surveyor
- SOLAS & LL
- Environmental Loads
- ISM/Former Captain
- FSA

## NK Team:
- FSA
- Hull Dam. Invest.
- Hull Structural Rules
- Hull/Design (2)

**Brainstorming:**
- Design
- Captain
- Hull Structural Rules
- Hull/Plan approval
- Machinery
- ISM & Chief
- Materials & IMO Reg.

## RINA Team:
- FSA
- Structures
- Hydrodynamics

**Brainstorming:**
- Hydrodynamics (2)
- Hull Structures Surveyor
- Machinery Surveyor
- Construction
- Automation

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MSC 75-30/47
Experience from FSA/BC

- IACS was able to carry out the project in 1 year (March 1, 2000 - February 15, 2001)
- No diverging views on FSA approach
- Previous HAZIDs were reviewed
- Time used on data collection and modelling
- Used Structural Reliability Theory to model reliability of Hatch Covers (Probabilistic modelling)
Result presented as suggested in MSC 72/16 (Norway)

Summary of CEA for risk control options related to water ingress scenarios in general

<table>
<thead>
<tr>
<th>RCO description</th>
<th>ΔC (US$)</th>
<th>ΔR (fatalities averted per ship)</th>
<th>Gross CAF (US$ million)</th>
<th>Net CAF (US$ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water ingress alarm in all cargo holds and forepeak</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New-building</td>
<td>7,500 - 27,000</td>
<td>2.15E-02</td>
<td>0.4 - 1.3</td>
<td>0.4 - 1.3</td>
</tr>
<tr>
<td>10 year old ships</td>
<td>25,000 - 90,000</td>
<td>2.85E-02</td>
<td>0.9 - 3.2</td>
<td>0.9 - 3.2</td>
</tr>
<tr>
<td>15 year old ships</td>
<td>25,000 - 90,000</td>
<td>1.90E-02</td>
<td>1.3 - 4.7</td>
<td>1.3 - 4.7</td>
</tr>
<tr>
<td>20 year old ships</td>
<td>25,000 - 90,000</td>
<td>9.50E-03</td>
<td>2.6 - 9.5</td>
<td>2.6 - 9.5</td>
</tr>
</tbody>
</table>
Recommendations from the FSA/BC

Some RCOs had negative NCAFs

- This implies that the cost saving is larger than the cost in addition to the life saving effects

- Monitoring system for detecting water ingress in forepeak for Panamax and Handymax new-building
- Bulwark on Panamax and Handymax new-building
- Forecastle on Handymax new-building
Recommendations from the FSA/BC

Gross CAF below $1 million

- Double side skin in all cargo holds for all bulk carriers
  (New building as alternative to SOLAS XII)
- Water Level Alarm for all bulk carriers (new-building)
- Bulwark for Panamax and smaller bulk carriers (new-building)
- Fore-castle for Handymax and smaller bulk carriers (new-building)
- Monitoring system for detecting water ingress in forepeak for Panamax and smaller bulk carriers (new-building)

Gross CAF between $1 and $3 million

- Etc
Post FSA study experience

• Immediate work on scantling requirements of deck openings
• For a while the FSA was “just another document”
• Internal review changed the attitude
  – Clear recommendations
  – Solid foundation
  – Clear reasoning
  – Urgency
FSA - Possible use within IACS

FSA utilisation for

- Development of new rules
- Modification of existing rules
- Adjustment/Balancing of safety requirements in current rules
- Prioritisation of survey and inspections
IACS and Training

• WG FSA recommended extensive training in 1998, because
  – IACS structured in Working Groups by discipline (Strength, Machinery, Materials and welding, Electricity, Fire Protection and Safety, etc)
  – No WG could carry out an FSA
  – WG FSA could not carry out an FSA
  – FSA requires a **multidisciplinary** team of experts

We think this is similar to IMO and Flag State Administrations’ organisation?
IACS and Training

• Recommended
  – Train IACS WG members on FSA methodology
  – Distribute to all IACS WGs the relevant IACS works on FSA
  – Systematically involve selected members from each WG in FSA studies
  – Make members from the WG FSA available to act as facilitators of FSA applications to be performed by a multidisciplinary team
IACS Training Development

- Project Team “Management Training” - Spring 1999
- First Management Training Course to GPG - October 1999
- Milestone: Decide on more extensive training - October 1999
- Project Team “FSA Training” to prepare the full training course - Completed Spring 2001
- IACS “Train the Trainers” - September 2001
- Courses given in IACS and to a few administrations
IACS Training Goals

• Chairmen of WGs are **required** to be trained personnel
  – WG Strength
  – WG Stability and Load Lines
  – WG Fire Protection
  – WG Machinery
  – Etc.
• Other members of WG should **preferably** be trained
• General Goal: A sufficient number of trained persons available to carry out FSA projects.
Can we make FSA work at IMO?

- Competence is required to:
  - Make decisions based on FSA
  - Carry out an FSA
  - Defining the Terms of Reference
  - Understand the methodology
  - Distinguish the important issues from the unimportant
  - Distinguish between assumptions, data, models and expert judgement

- This is basics, and has nothing to do with favouring certain issues above others
Current Status

• FSA approach has been agreed amongst those involved, may be diverging understanding amongst others

• FSA studies are **not** diverging in general approach

• There is a need to harmonise the view on FSA:
  – Supportive tool
  – Not dictating decisions
  – No manipulation

• Many administrations & NGOs have demonstrated capabilities in carrying out FSAs
Challenges

• IMO is not the place to suggest new scientific methods
  – Use the guidelines or suggest amendments
  – Do not use methods that have been proposed and not accepted
• New scientific methods may be included in Guidelines if accepted in the scientific community
• Competence on reviewing FSAs needs to be improved
• Review process must not be used to delay decisions
• Everything dependent. Need to learn how to split up FSA studies into manageable part projects
  • How do you eat an elephant?
  • Bite by bite
  • May be more complicated in an FSA (by function, by operation, etc.)
In conclusion

- Decision makers need training
- Practitioners need training
- Formulating Terms of Reference requires training
- Managing and co-ordinating studies requires training
- Understanding results needs training
- Reviewing needs training
- Communication needs training
IACS FSA Training Course

Risk

- Measure of the frequency times the resulting consequences

Three key questions:
- What can go wrong?
- How frequently?
- With what outcome?

IACS
In Summary

• We hope to have given a brief overview and motivation
• We see much of the criticisms as a result of limited experience
• IACS has mostly positive experience, but new methods and work process take time to adapt to
• This presentation was made for MSC 75, and used some few slides from the training course
• Information about the course may be found at

www.iacs.org
Thank You For Listening