Jernbaneverket

Risk Evaluation Criteria

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Definition of Goals, Systems, Operations

Hazard Identification

Scenario definition

Step 1
Hazard Identification

Step 2
Risk Analysis

Step 3
Risk Control Options

Step 4
Cost Benefit Assessment

Step 5
Recommendations for Decision Making

Preparatory Step

Step 1
Scenario definition

Step 2
Cause and Frequency Analysis

Step 3
Consequence Analysis

Step 4
Risk Summation

Step 5
Options to decrease Frequencies

Options to mitigate Consequences

Risk Controlled?

No

Yes

Cost Benefit Assessment

Reporting
PRIOTITISATION PRINCIPLES

- Resources prioritised according to
  - Consequence
    - War on terror (e.g. ISPS)?
  - Risk
    - Most risk mitigation strategies
  - Risk Reduction
    - Correct – not done
INDIVIDUAL RISK

\[
10^{-0}: \text{Probability of dying for some reason sometime} \\
10^{-1}: \text{Annual probability of dying as king of Norway AD 1000} \\
10^{-2}: \text{Annual probability is dying for any reason any time} \\
10^{-3}: \text{Annual probability of dying for any reason at the lowest [10-15]} \\
10^{-4}: \text{Mother’s probability of dying giving birth (OECD)} \\
10^{-5}: \text{Additional probability of cancer by eating extra peanut butter sandwich daily} \\
10^{-6}: \text{Probability of being killed by husband or lower (US)} \\
10^{-7}: \text{Annual probability of being killed by lightening (Norway)} \\
10^{-8}: \text{Annual probability of being killed by event killing also everyone else (Gamma burst, Asteroid Impact)}
\]

Define how Risks Should be Measured!
What get measured get Done!
Risk Acceptability - Individual Fatality Risk

- Intolerable
  - Crew: 0.001/year
  - Passengers: 0.0001/year
  - ALARP
  - Crew & Passengers: 0.000001/year

Negligible

Interpretation of HSE, and other standards adopted for ships.
Individual Risk

- Intolerable Risk
- ALARP
- Negligible Risk

Risk levels for various types of vessels:
- Oil Tanker
- Chemical Tanker
- Gas Tanker
- Bulk/Oil Carrier
- Bulk Carrier (incl. Ore)
- Container Vessel
- General Cargo Carrier
- Ro/Ro Cargo Carrier

Individual risk values range from $1.00E-07$ to $1.00E-02$.
Societal Risk - FN Diagrams

- Societal risks are risks for groups of people
- Society generally is more concerned with large accidents
- Society generally perceives N fatalities happening at the same time as worse than N fatalities happening individually (risk aversion)
- The societal risk aversion does not have a clear rationale
- The societal risk aversion is likely to result in non-optimal use of resources
- The societal risk aversion may be associated with one of the conversion factors between perceived and objective risk
Societal Risk - FN Diagrams

- FN diagrams should not be copied between industries and activities (since importance to society varies between activities)
- Suggest to use unique FN diagrams for activity
- Suggest to scale FN diagrams to importance of activity
- Scaling factors from aggregated information
- Ships are
  - Work Place (and place for leisure activities)
  - Transport
- Two scaling factors needed
  - Work related accidents: 1.5 fatalities per billion £ GDP (to count leisure time as work is conservative, as accidents at home and during leisure activities are more frequent than at work)
  - Transport related accidents: 8.6 fatalities per billion £ GDP
Note: Statistics only from US and Norway
Societal Risk - FN Diagrams

• Suggest to use economic information, because
  – Good statistics on ship (turnover) and societal level (GDP)
  – Collection of statistics should be improved
  – Wish to avoid debating “purpose of activity”
    • Passenger kilometres (air traffic look good, ships bad)
    • Passenger hours (ships look good, air traffic bad)

• For transport, suggest to compare to air traffic, because
  – High Standard
  – Good Statistics
Societal Risk - FN Diagrams

General Format:

Scaling needs two input parameters
- Number of crew/passengers
- Annual operating revenue
Societal Risk - FN Diagrams

Frequency of N or more fatalities (per ship year)

- Oil tankers
- Chem. tankers
- Oil/Chemical tankers
- Gas tanker

Intolerable
ALARP
Negligible
Cost Effectiveness

• The unit of cost effectiveness applied to loss of life will be “cost of fatality averted”
• This does not imply that all RCOs need to be analysed for their cost effectiveness
• Many of the RCOs discussed are associated with almost no costs, e.g.
  – Some ergonomic measures (Since you bought this expensive equipment, install it properly)
  – Water tights doors that should be kept closed: Keep them closed
Cost Effectiveness

- Cost effectiveness evaluation is a typical engineering approach, attempting to get “value for money”, also in safety
- The basic idea is to get more safety for the current “budget”
- The potential have been documented in a large number of studies
## Results from Tengs et al. (1995)

“Five Hundred Life-Saving Interventions and their Cost Effectiveness”

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Number of measures studied</td>
<td>587</td>
</tr>
<tr>
<td>Range of cost effectiveness</td>
<td>Negative to $10 billion/life year saved</td>
</tr>
<tr>
<td>Median Value</td>
<td>$42,000/life year</td>
</tr>
<tr>
<td>Median for Medical Interventions</td>
<td>$19,000/life year</td>
</tr>
<tr>
<td>Median for Injury Prevention</td>
<td>$48,000/life year</td>
</tr>
<tr>
<td>Median for toxic control</td>
<td>$2.8 million/life year</td>
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</tbody>
</table>

• By reallocation 40,000 lives could be saved annually in the US
• $42,000 • 35 = $1.5 million
Societal Indicators

• Societal Indicators used to rate “quality of life” in countries
• Published by e.g. UN (UNDP)
• Many different indicators exist
• Include such parameters as: GDP/Capita, Life Expectancy at Birth, literacy etc.
Societal Indicators

<table>
<thead>
<tr>
<th>HDI (1999)</th>
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<tbody>
<tr>
<td>1</td>
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<td>3</td>
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<td>10</td>
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<td>11</td>
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</table>
Societal Indicators

CAF for OECD Countries ( $ million )

Australia  Austria  Belgium  Canada  Czech Republic  Denmark  Finland  France  Germany  Greece  Hungary  Iceland  Ireland  Italy  Japan  Korea  Luxembourg  Mexico  Netherlands  New Zealand  Norway  Poland  Portugal  Spain  Sweden  Switzerland  Turkey  United Kingdom  United States  Average OECD
Individual Decisions

- Also individuals take decision that increase life expectancy and reduces accident frequencies
- For example:
  - Buy safer cars
  - Buy more healthy food
  - Go to the doctor more frequently
  - Etc.
- How much increase in purchasing power is necessary to increase the life expectancy in a population by “e”
- Effect demonstrated in the US (Keeney, Lutter, see references)
Individual Decisions
Societal Indicators

![Graph showing societal indicators for various countries and the average OECD]
## Cost Effectiveness, Published Criteria

### Table: Published ICAFs in use as acceptance criteria

<table>
<thead>
<tr>
<th>ORGANISATION</th>
<th>SUBJECT</th>
<th>ICAF</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Federal Highway Administration</td>
<td>Road Transport</td>
<td>$2.5m (£1.6m)</td>
<td>FHWA (1994)</td>
</tr>
<tr>
<td>UK Department of Transport</td>
<td>Road transport</td>
<td>£1.0 m (1998, uprated with GDP per capita)</td>
<td>DETR (1998)</td>
</tr>
<tr>
<td>UK Health &amp; Safety Executive</td>
<td>Industrial safety</td>
<td>As above or higher</td>
<td>HSE (1999)</td>
</tr>
<tr>
<td>Railtrack (UK rail infrastructure controller)</td>
<td>Overground railways</td>
<td>As above to £2.65m</td>
<td>Railtrack (1998)</td>
</tr>
<tr>
<td>London Underground Ltd</td>
<td>Underground railways</td>
<td>£2m</td>
<td>Rose (1994)</td>
</tr>
<tr>
<td>EU</td>
<td>Road Transport</td>
<td>ECU 1 million (£0.667m)</td>
<td>from Evans (1998)</td>
</tr>
<tr>
<td>Norway</td>
<td>All hazards</td>
<td>NOK 10m (£0.8m)</td>
<td>Norway (1996)</td>
</tr>
</tbody>
</table>
Societal Indicators

$US million

Cameroon  Pakistan  Mauritania  Ghana  Vietnam  India  Cote d'Ivoire  Azerbaijan  Turkmenistan  Senegal  Cuba  Average [100]
The new Format

High Risk

- Intolerable
  - Not acceptable

ALARP

- Life/Life
- Life for $
- $ value of Life

Low Risk

- Negligible
  - Acceptable

25/31
MANAGING RISK
Health and Injuries by QALY

Quality Adjusted Life Years gained by implementing the RCO

Expected Health index, when RCO not implemented

Expected Health index, when RCO implemented
Risk acceptance criteria divided over time
Risk acceptance criteria divided on subsystems
Risk acceptance criteria divided on departments

- Operational
  - Traffic-control
  - Schedule-planning
  - Power-provision

- Infrastructural
  - Development
  - Planning
  - Maintenance
Conclusion

• An upper limit on investing in safety exists, where self protective measures are more effective
• No regulator should implement less effective measures
• For public sector:
  – New meaning to “Born free, taxed to death”
• Different methods for defining criteria give similar results
• For an OECD member country (excluding the newest members) the criteria is somewhere in the range $1.5 -3.0 million
  – Some uncertainties relates to:
    • Fatalities as indicator or actual fatalities
    • NCAF or GCAF
    • Assumptions used in derivation
Conclusion

• Human Capital Approach ~ ge/2
• Life Quality Index/Human Capital Approach ~ 10/3
• Self Protective Measures/Life Quality Index ~ 10/3
• This is a narrow band!
• Published criteria are in the range between the Human Capital and Life Quality Index approaches
• A measure that should be implemented in a wealthy country, may be a “net killer” in a less developed country, as self protective measures give better effects