Incorporating Expert Judgement in Operational Risk Quantification

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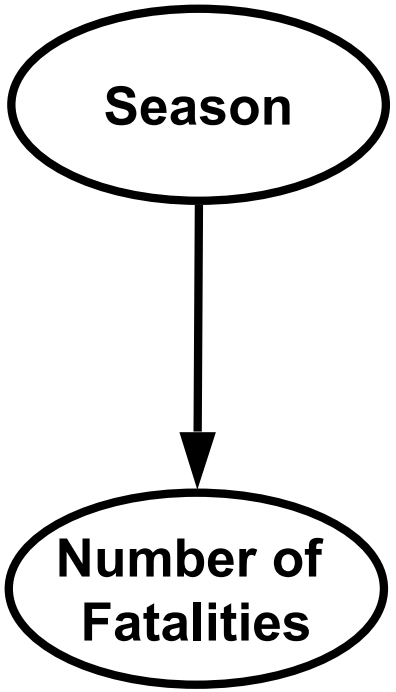
Outline

- A motivating example
- Some definitions of operational risk
- Identifying the causes
- Navigating the risk continuum
- “Risk accounting” using Bayesian networks
- Example Bayesian network
- Conclusions

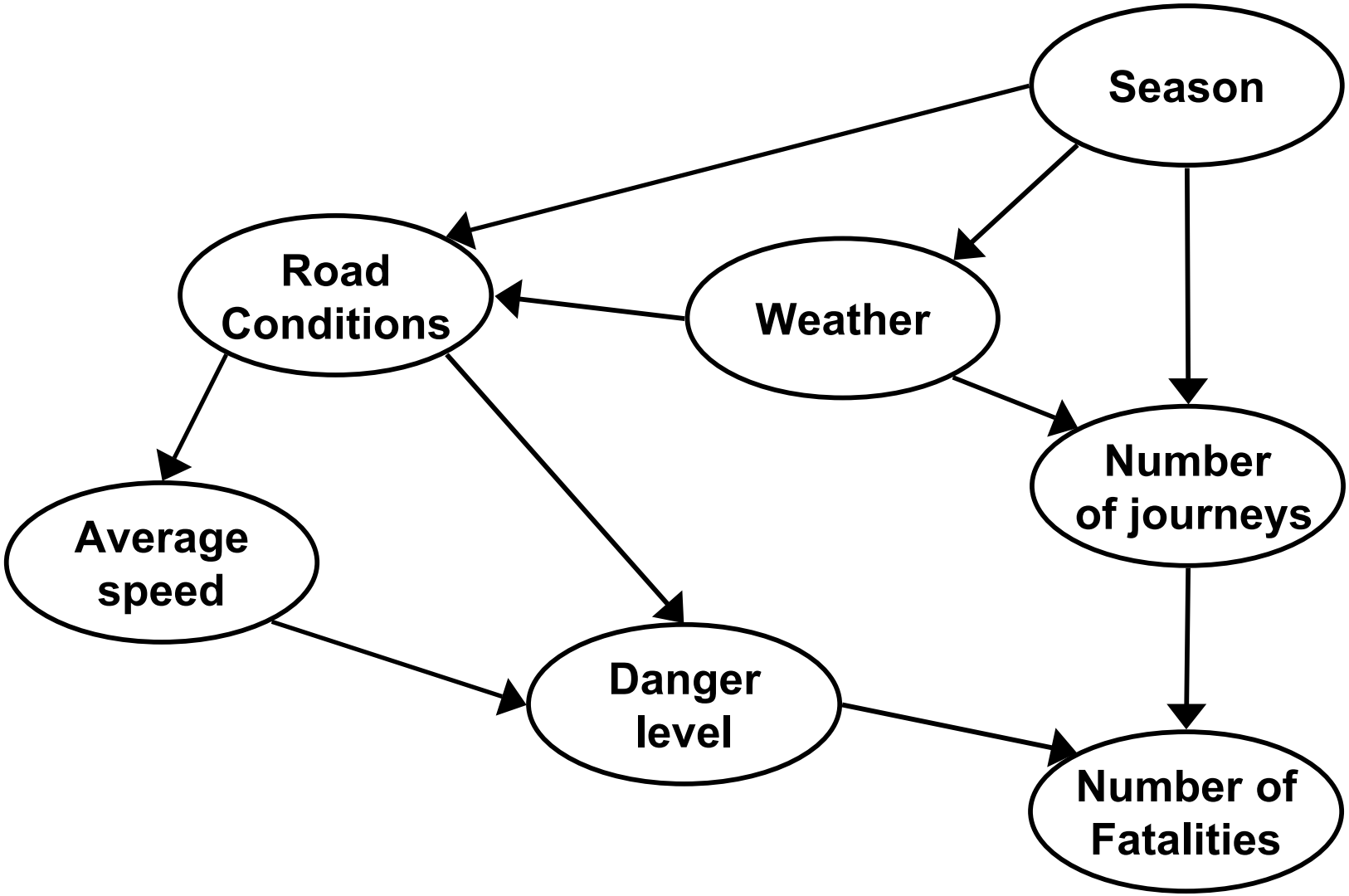
Assessing Risk of Road Fatalities: Naïve Approach



Colder months

Fewer fatalities

Assessing Risk of Road Fatalities: Causal/explanatory model

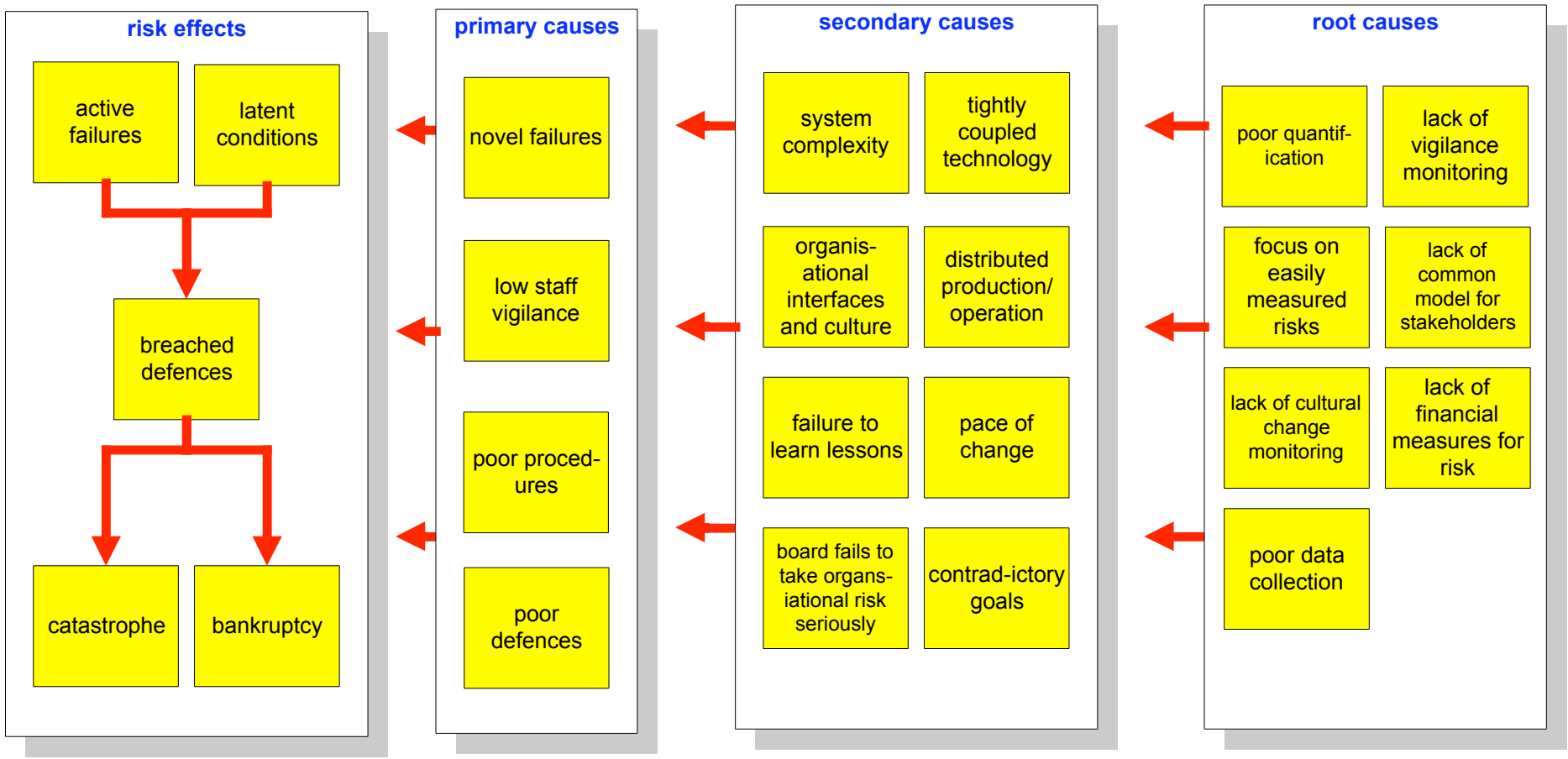


Operational Risk Definition

The risk of loss resulting from inadequate or failed internal processes, people and systems or from external events

Basle regulatory committee

Hierarchy of operational risks



Anatomy of a Vulnerable Organisation

- Risk analysis seen as one off exercise; no ongoing monitoring of performance
- Confusion over who is responsible for ensuring risks are monitored
- Audit spots problems which day to day monitoring fails to identify and remedy
- Data widely collected, but fragmented and not used
- Performance indicators not structured to monitor non-production issues
- Root causes of accidents tend to be ignored. Incident analysis superficial

Navigating the Risk Continuum

Difficult Questions

- Statistical modelling difficult because of lack of catastrophic loss data
- Loss data alone is imperfect guide to true risk unless you have experienced many losses
- Zero losses wrongly reported
- Historical loss data less relevant over time as organisation improves/degrades
- As industry improves there will be less data from which to draw credible statistical estimates

The operational risk assessment challenge

- **To produce a *unified* prediction of an organisation's operational vulnerability by:**
  - **Combining different types of OpRisk evidence**
  - **Exploiting expert knowledge in a reliable and repeatable manner**
  - **Making the model visible and auditable to the regulator**
- **To be able to claim lower levels of risk than is possible from loss data alone**

Solution: Bayesian Networks (BNs)

- Best method for reasoning under uncertainty
- Combines diverse data, including subjective beliefs and empirical data
- Allows incomplete evidence and still obtain prediction
- Performs powerful ‘what-if’ analysis to test sensitivity of conclusions
- Compelling visual reasoning tool and a major documentation aid

Bayes' Theorem

A: 'Person has cancer' p(*A*)=0.1 (*prior)*

B: 'Person is smoker' p(*B*)=0.5

What is p(*A*|*B*)? (*posterior)*

p(*B*|*A*)=0. 8 (*likelihood)*

Posterior probability

Likelihood

Prior probability

$$p(A|B) = \frac{p(B|A)\,p(A)}{p(B)}$$

So p(*A*|*B*)=0.16

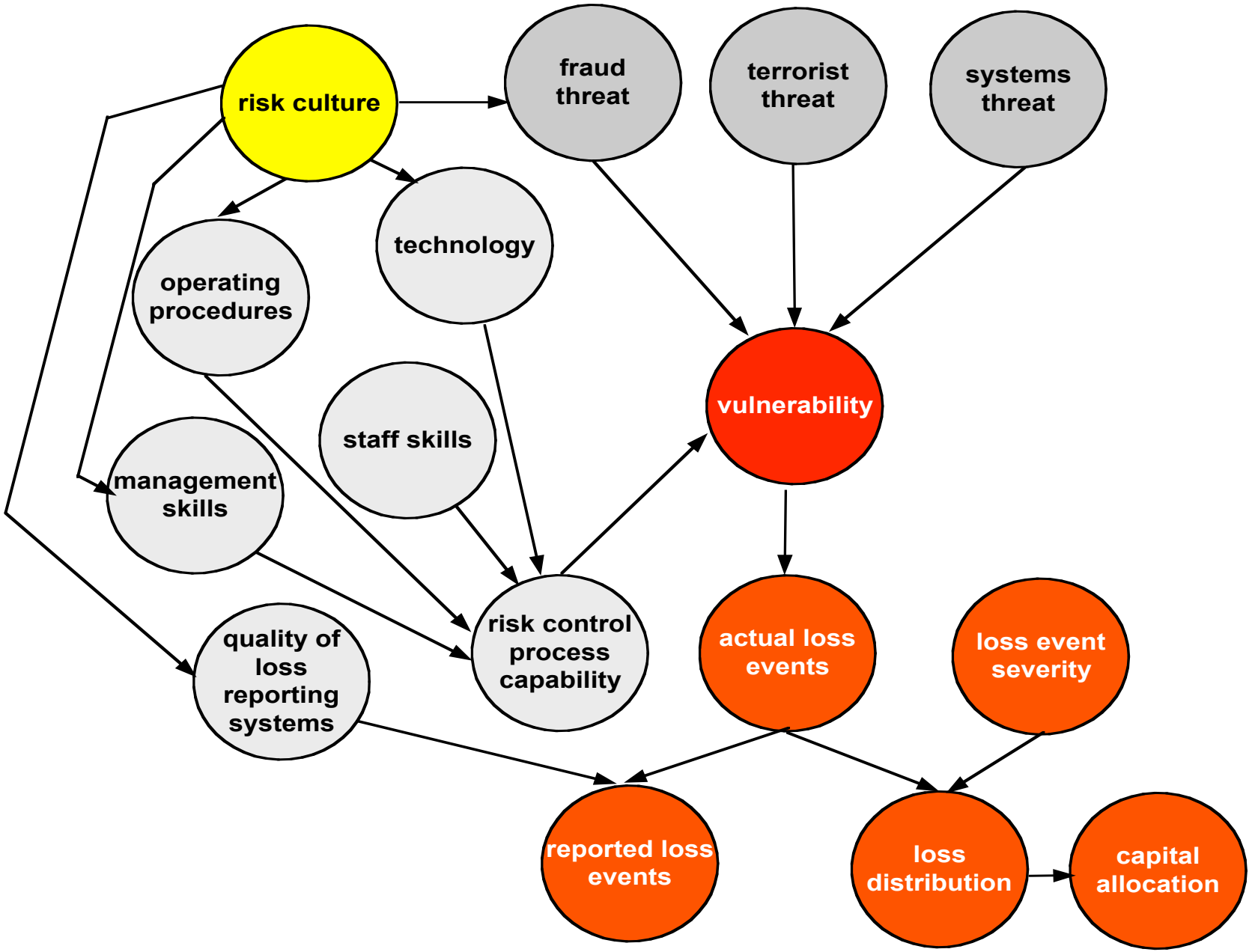
Agena's BN applications

- **TRACS (for QinetiQ) – Provide improved reliability predictions of prototype military vehicles**
- **NATS – Predict effects of changes to ATM (Air Traffic Management) architecture on mid air collision risk**
- **Railtrack – Assess safety of PES components in the railway industry**
- **Motorola – predicting field returns of electronic components**
- **Philips – Predict defect counts for software modules in consumer electronics products**
- **i*Risk* – Quantifying OpRisk in finance**
- **TV Supreme – TV programme personalisation and recommendation system for digital TV**

Risks Factors in OpRisk BN Model

- Risk Culture as root cause of poor controls and internal fraud threats
- Threats and Vulnerabilities (Proactive measures)
- Loss Data (Reactive outcome measures)
- Assess quality of data collection processes

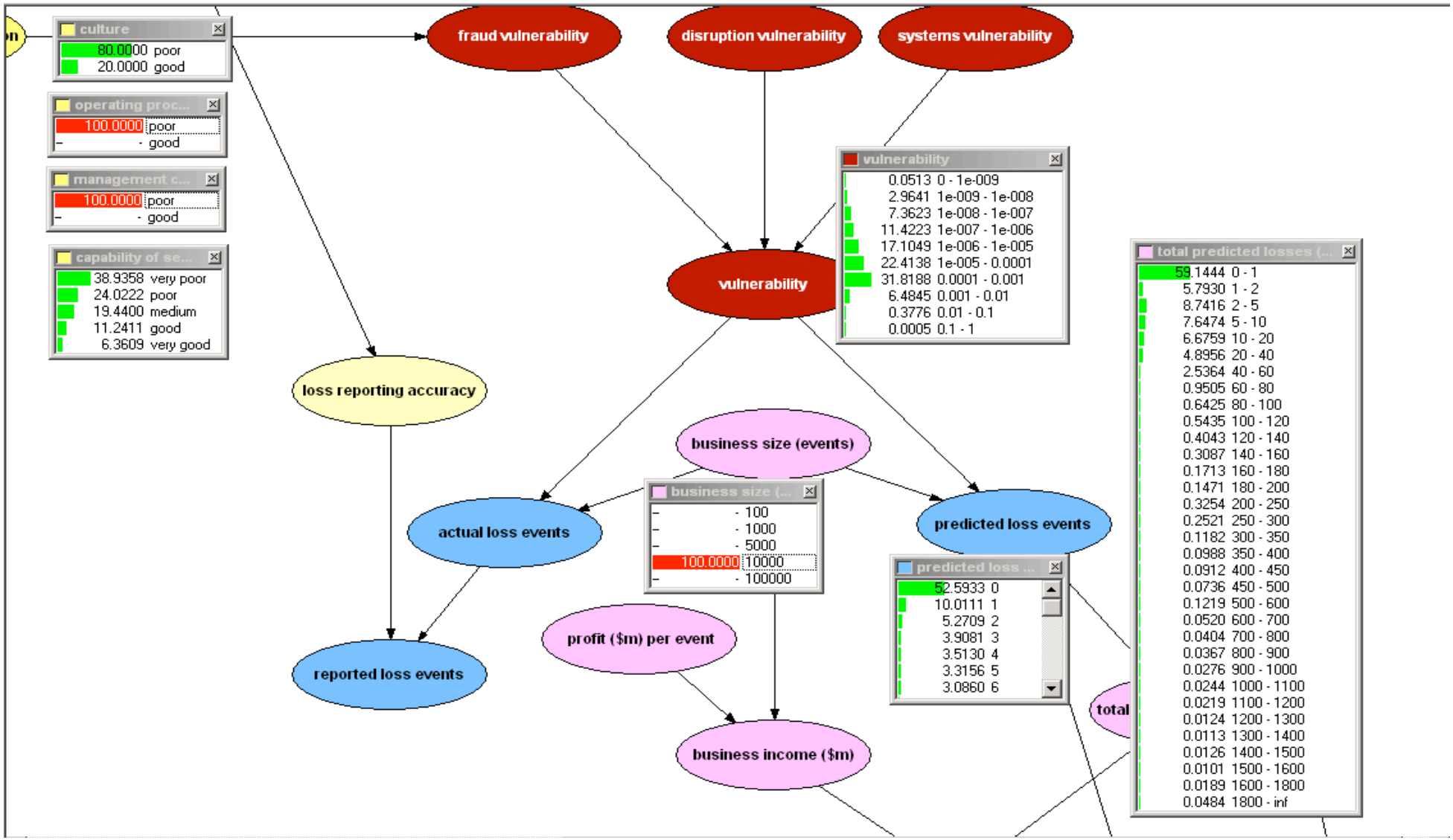
Example OpRisk BN



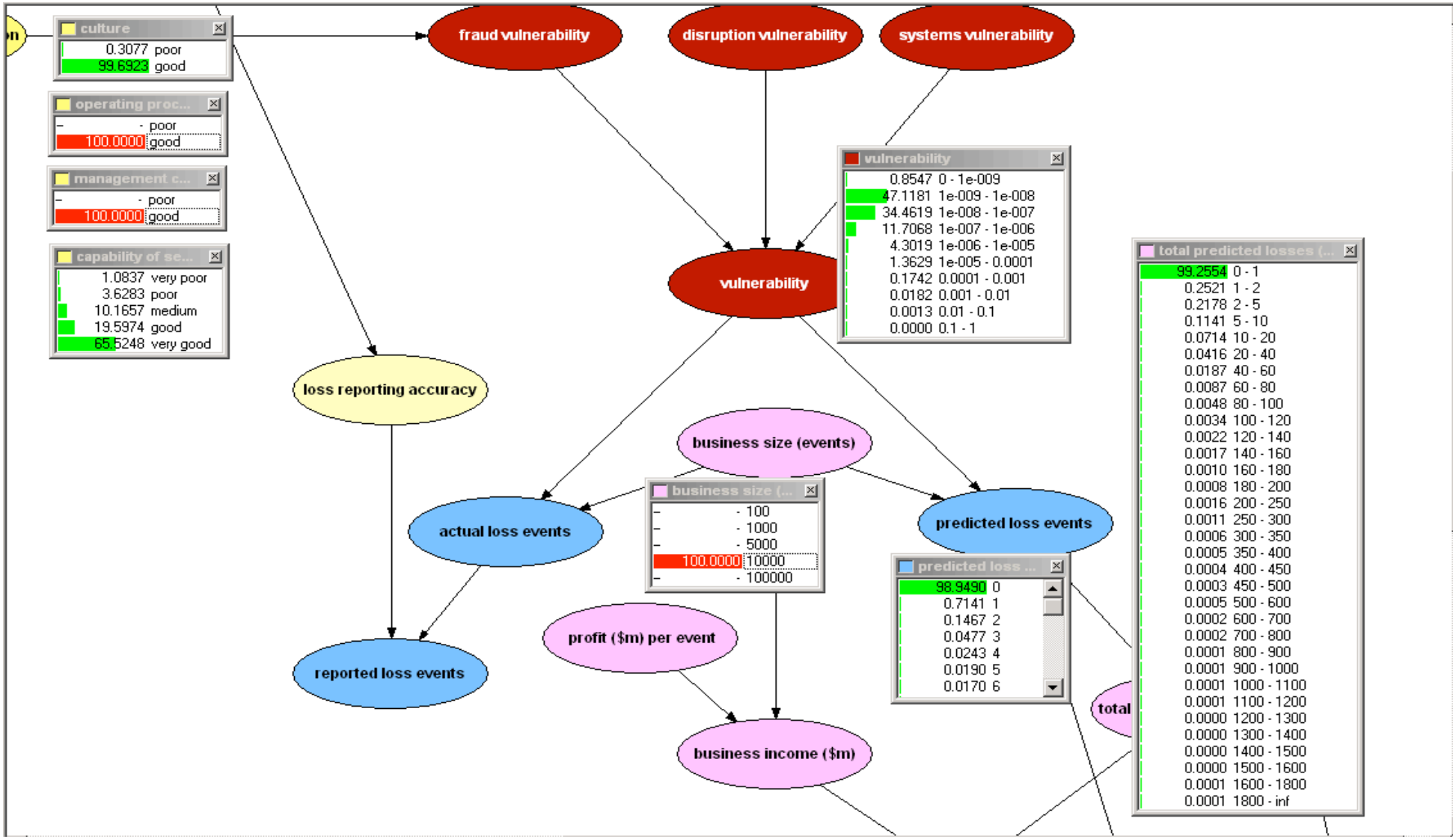
Scenarios

- Bank A
  - Loss frequency unknown
  - Poor values for process capability indicators
- Bank B
  - Loss frequency unknown
  - Good values for process capability indicators
- Bank C
  - One loss reported but very poor reporting system
  - Poor risk culture evident from process capability indicators
- Bank D
  - 10 historical loss events

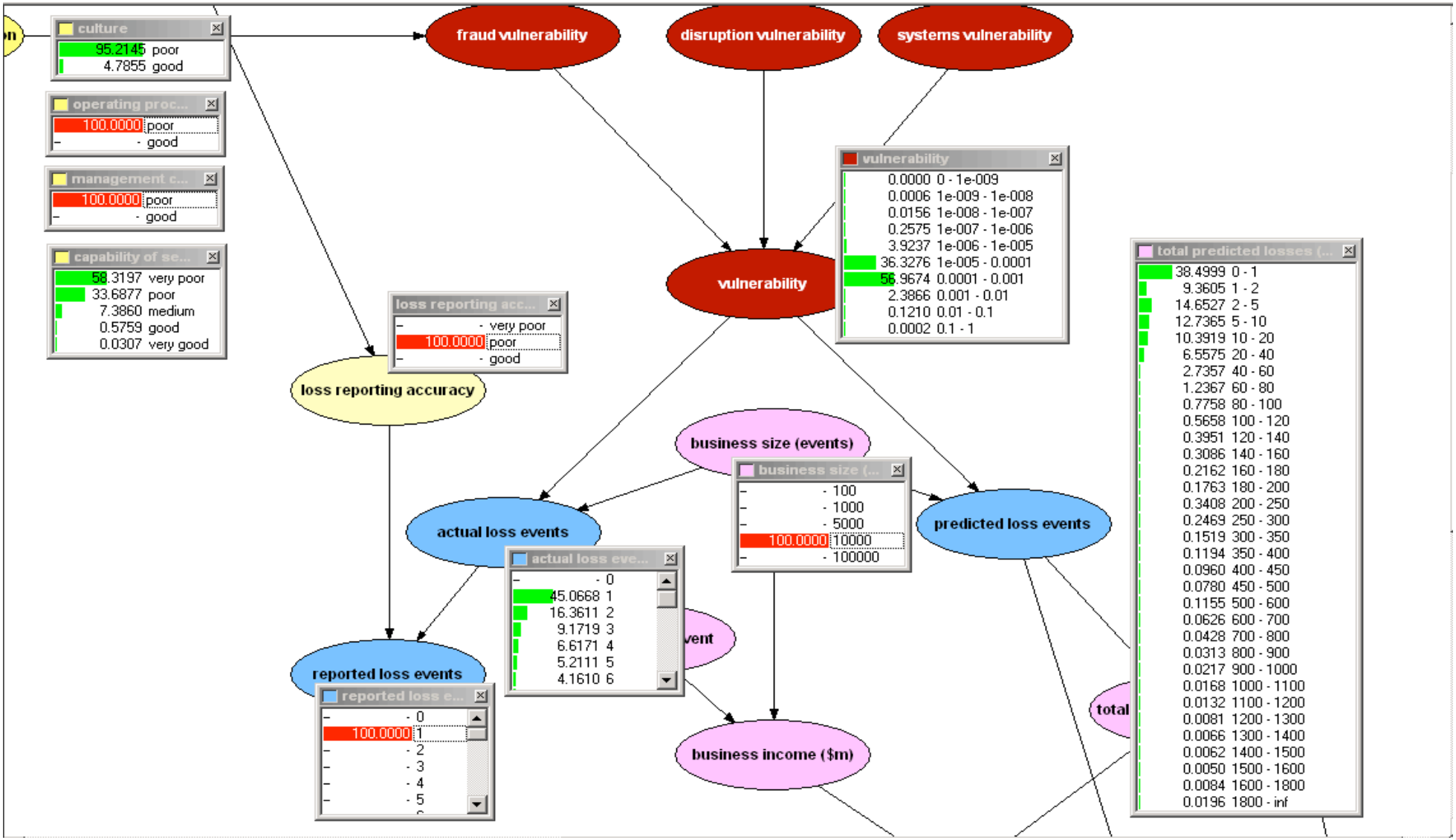
Bank A


culture
80.0000 poor
20.0000 good
operating proc...
100.0000 poor
- good
management c...
100.0000 poor
- good
capability of se...
38.9358 very poor
24.0222 poor
19.4400 medium
11.2411 good
6.3609 very good
fraud vulnerability
disruption vulnerability
systems vulnerability
vulnerability
vulnerability
0.0513 0 - 1e-009
2.9641 1e-009 - 1e-008
7.3623 1e-008 - 1e-007
11.4223 1e-007 - 1e-006
17.1049 1e-006 - 1e-005
22.4138 1e-005 - 0.0001
31.8188 0.0001 - 0.001
6.4845 0.001 - 0.01
0.3776 0.01 - 0.1
0.0005 0.1 - 1
loss reporting accuracy
business size (events)
business size (...
- 100
- 1000
- 5000
100.0000 10000
- 100000
actual loss events
predicted loss events
predicted loss ...
52.5933 0
10.0111 1
5.2709 2
3.9081 3
3.5130 4
3.3156 5
3.0860 6
profit ($m) per event
reported loss events
business income ($m)
total
total predicted losses (...
59.1444 0 - 1
5.7930 1 - 2
8.7416 2 - 5
7.6474 5 - 10
6.6759 10 - 20
4.8956 20 - 40
2.5364 40 - 60
0.9505 60 - 80
0.6425 80 - 100
0.5435 100 - 120
0.4043 120 - 140
0.3087 140 - 160
0.1713 160 - 180
0.1471 180 - 200
0.3254 200 - 250
0.2521 250 - 300
0.1182 300 - 350
0.0988 350 - 400
0.0912 400 - 450
0.0736 450 - 500
0.1219 500 - 600
0.0520 600 - 700
0.0404 700 - 800
0.0367 800 - 900
0.0276 900 - 1000
0.0244 1000 - 1100
0.0219 1100 - 1200
0.0124 1200 - 1300
0.0113 1300 - 1400
0.0126 1400 - 1500
0.0101 1500 - 1600
0.0189 1600 - 1800
0.0484 1800 - inf

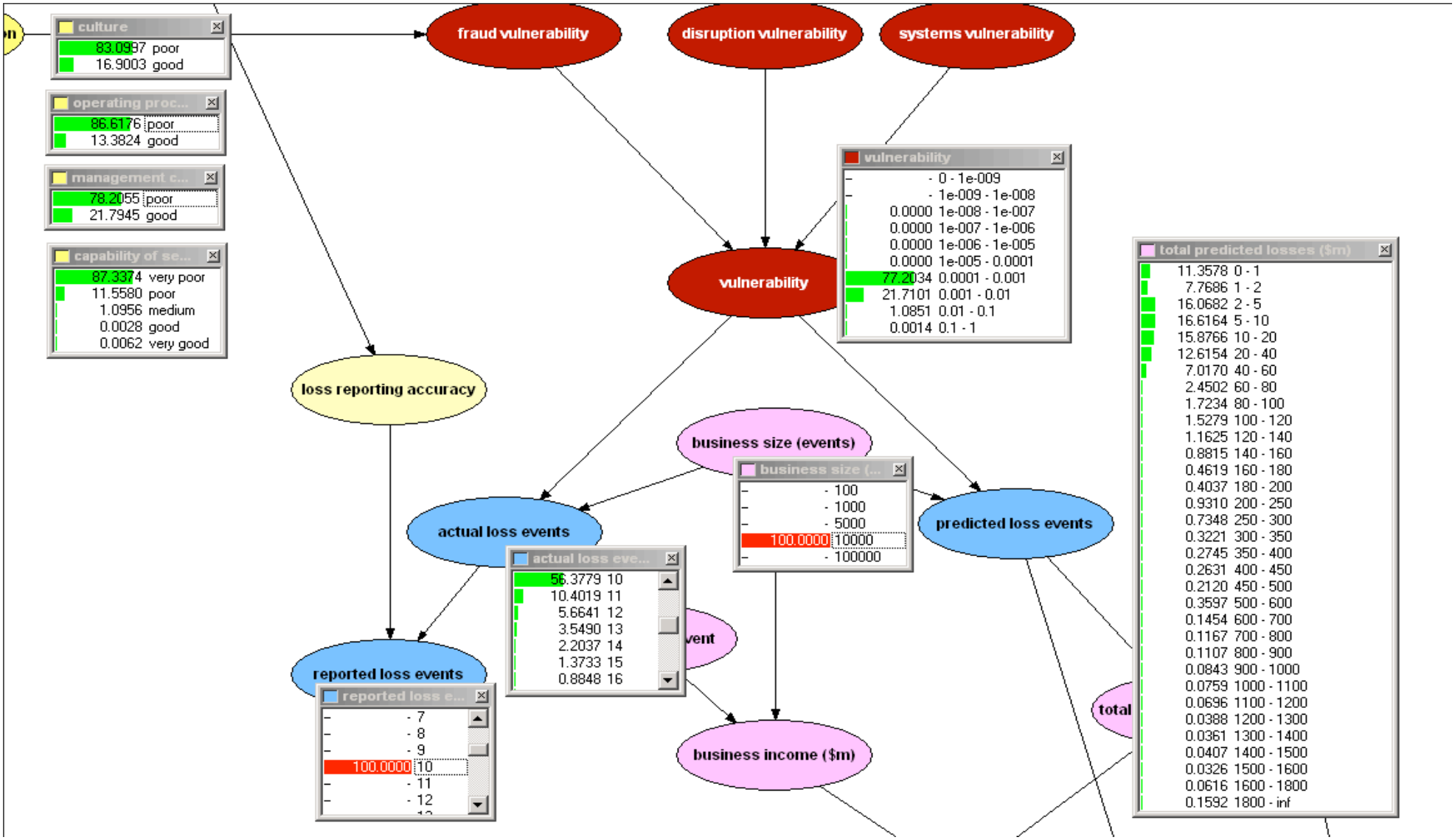
Bank B


culture
0.3077 poor
99.6923 good
operating proc...
- poor
100.0000 good
management c...
- poor
100.0000 good
capability of se...
1.0837 very poor
3.6283 poor
10.1657 medium
19.5974 good
65.5248 very good
fraud vulnerability
disruption vulnerability
systems vulnerability
vulnerability
0.8547 0 - 1e-009
47.1181 1e-009 - 1e-008
34.4619 1e-008 - 1e-007
11.7068 1e-007 - 1e-006
4.3019 1e-006 - 1e-005
1.3629 1e-005 - 0.0001
0.1742 0.0001 - 0.001
0.0182 0.001 - 0.01
0.0013 0.01 - 0.1
0.0000 0.1 - 1
vulnerability
loss reporting accuracy
business size (events)
business size (...
- 100
- 1000
- 5000
100.0000 10000
- 100000
actual loss events
predicted loss events
predicted loss ...
98.9490 0
0.7141 1
0.1467 2
0.0477 3
0.0243 4
0.0190 5
0.0170 6
profit ($m) per event
reported loss events
business income ($m)
total
total predicted losses (...
99.2554 0 - 1
0.2521 1 - 2
0.2178 2 - 5
0.1141 5 - 10
0.0714 10 - 20
0.0416 20 - 40
0.0187 40 - 60
0.0087 60 - 80
0.0048 80 - 100
0.0034 100 - 120
0.0022 120 - 140
0.0017 140 - 160
0.0010 160 - 180
0.0008 180 - 200
0.0016 200 - 250
0.0011 250 - 300
0.0006 300 - 350
0.0005 350 - 400
0.0004 400 - 450
0.0003 450 - 500
0.0005 500 - 600
0.0002 600 - 700
0.0002 700 - 800
0.0001 800 - 900
0.0001 900 - 1000
0.0001 1000 - 1100
0.0001 1100 - 1200
0.0000 1200 - 1300
0.0000 1300 - 1400
0.0000 1400 - 1500
0.0000 1500 - 1600
0.0001 1600 - 1800
0.0001 1800 - inf

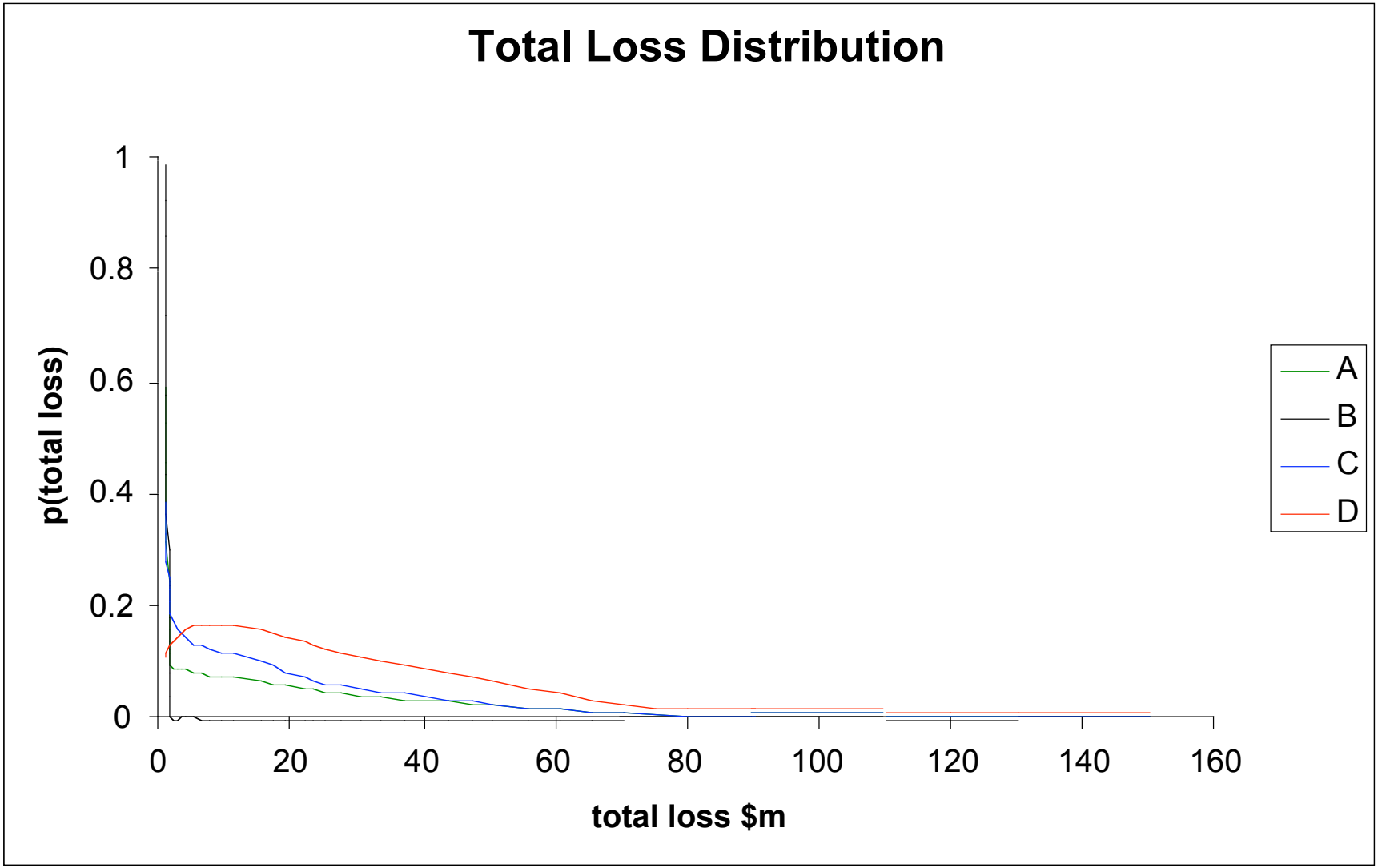
Bank C


culture
95.2145 poor
4.7855 good
operating proc...
100.0000 poor
- good
management c...
100.0000 poor
- good
capability of se...
58.3197 very poor
33.6877 poor
7.3860 medium
0.5759 good
0.0307 very good
fraud vulnerability
disruption vulnerability
systems vulnerability
vulnerability
vulnerability
0.0000 0 - 1e-009
0.0006 1e-009 - 1e-008
0.0156 1e-008 - 1e-007
0.2575 1e-007 - 1e-006
3.9237 1e-006 - 1e-005
36.3276 1e-005 - 0.0001
56.9674 0.0001 - 0.001
2.3866 0.001 - 0.01
0.1210 0.01 - 0.1
0.0002 0.1 - 1
loss reporting acc...
- very poor
100.0000 poor
- good
loss reporting accuracy
business size (events)
business size (...
- 100
- 1000
- 5000
100.0000 10000
- 100000
actual loss events
actual loss eve...
- 0
45.0668 1
16.3611 2
9.1719 3
6.6171 4
5.2111 5
4.1610 6
predicted loss events
reported loss events
reported loss e...
- 0
100.0000 1
- 2
- 3
- 4
- 5
business income ($m)
total predicted losses (...
38.4999 0 - 1
9.3605 1 - 2
14.6527 2 - 5
12.7365 5 - 10
10.3919 10 - 20
6.5575 20 - 40
2.7357 40 - 60
1.2367 60 - 80
0.7758 80 - 100
0.5658 100 - 120
0.3951 120 - 140
0.3086 140 - 160
0.2162 160 - 180
0.1763 180 - 200
0.3408 200 - 250
0.2469 250 - 300
0.1519 300 - 350
0.1194 350 - 400
0.0960 400 - 450
0.0780 450 - 500
0.1155 500 - 600
0.0626 600 - 700
0.0428 700 - 800
0.0313 800 - 900
0.0217 900 - 1000
0.0168 1000 - 1100
0.0132 1100 - 1200
0.0081 1200 - 1300
0.0066 1300 - 1400
0.0062 1400 - 1500
0.0050 1500 - 1600
0.0084 1600 - 1800
0.0196 1800 - inf

Bank D


culture
83.0997 poor
16.9003 good
operating proc...
86.6176 poor
13.3824 good
management c...
78.2055 poor
21.7945 good
capability of se...
87.3374 very poor
11.5580 poor
1.0956 medium
0.0028 good
0.0062 very good
fraud vulnerability
disruption vulnerability
systems vulnerability
vulnerability
vulnerability
- 0 - 1e-009
- 1e-009 - 1e-008
0.0000 1e-008 - 1e-007
0.0000 1e-007 - 1e-006
0.0000 1e-006 - 1e-005
0.0000 1e-005 - 0.0001
77.2034 0.0001 - 0.001
21.7101 0.001 - 0.01
1.0851 0.01 - 0.1
0.0014 0.1 - 1
loss reporting accuracy
business size (events)
business size (...
- 100
- 1000
- 5000
100.0000 10000
- 100000
actual loss events
predicted loss events
actual loss eve...
56.3779 10
10.4019 11
5.6641 12
3.5490 13
2.2037 14
1.3733 15
0.8848 16
reported loss events
reported loss e...
- 7
- 8
- 9
100.0000 10
- 11
- 12
business income ($m)
total predicted losses ($m)
11.3578 0 - 1
7.7686 1 - 2
16.0682 2 - 5
16.6164 5 - 10
15.8766 10 - 20
12.6154 20 - 40
7.0170 40 - 60
2.4502 60 - 80
1.7234 80 - 100
1.5279 100 - 120
1.1625 120 - 140
0.8815 140 - 160
0.4619 160 - 180
0.4037 180 - 200
0.9310 200 - 250
0.7348 250 - 300
0.3221 300 - 350
0.2745 350 - 400
0.2631 400 - 450
0.2120 450 - 500
0.3597 500 - 600
0.1454 600 - 700
0.1167 700 - 800
0.1107 800 - 900
0.0843 900 - 1000
0.0759 1000 - 1100
0.0696 1100 - 1200
0.0388 1200 - 1300
0.0361 1300 - 1400
0.0407 1400 - 1500
0.0326 1500 - 1600
0.0616 1600 - 1800
0.1592 1800 - inf

Predicted Loss Distributions for Banks A, B, C, and D



Creating a BN OpRisk Model

- The challenge of “scaling-up”:
  - Building an operational risk model that fits all organisations in all business sectors is clearly an impossible task
  - Creating bespoke models for specific businesses or sectors is equally daunting
- Answer:
  - Create general risk modules (Bayesian Networks) for specific business areas
  - Reuse and tailor risk modules for each operating division
  - Use expertise and knowledge available within your organisation to a) identify the threat levels and b) assess the effectiveness of risk controls currently and in the future
  - Methodology and tool support is critical

iRisk System Features

- Risk prediction by business lines and loss event types
- Web-based publishing and execution of operational risk models and questionnaires for use by many users
- Loss reporting system, risk questionnaire and Bayesian Models integrated
- Editor to design and maintain questionnaires for assessing threats, process capability and residual vulnerabilities for all business areas
- Editor for creating and maintaining operational risk models

Concluding Remarks

- Operational risk is about avoiding catastrophic losses
- Organisations need to know where in the risk continuum they are and, more importantly, where they are headed
- Statistical modelling using loss data is *not* enough to predict and reduce OpRisk
- OpRisk prediction requires application of subjective (Bayesian) measures of threats, controls and vulnerabilities coupled with objective assessments of process capability
- OpRisk models can be built using Bayesian Network technology, statistical assumptions and expert judgements
- Recent innovations (iRisk system) mean that risk models can be developed, tailored and deployed throughout an organisation

Further Details

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