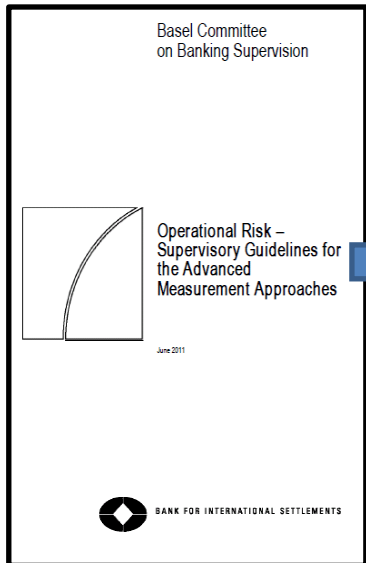


# Introduction

Our integrated platform permits to respond to all concerns expressed by Basel Committee on Banking Supervision on Advanced Modelling Approach.



Basel Committee		OpRisk Capital Software Needs	
Supervisory Guidelines for AMA			
<b>Governance</b>	<i>General</i>	User control: governance over modeling process and options Audit trail of data sources and their transformations Full control and understanding over statistical processes	Workflow management Integrity of data flows Reporting of capital results
	<i>Verification</i>	Reporting of modeling assumptions Automatic documentation of data sources and transformations	Replicability of results
	<i>Validation</i>	Backtesting	All verification functionalities
	<i>Use test</i>	Insurance evaluation Investment on risk mitigation business case	Reporting of capital results
<b>Data</b>	<i>Managed at the GRC platform</i>	Gross loss definition, thresholds, date, grouped losses, etc. Consistency with accounting	Completeness of collection
<b>Modeling</b>	<i>Granularity</i>	Flexible definition of business units and risk categories Capital allocation functionalities	
	<i>Distribution assumptions</i>	Threshold determination Split of distribution body and tail Light and heavy tail distributions Methodology to reduce estimates variability	Realistic capital estimates Robust methods GoF graphical and numerical Capture tail events
	<i>Joint distribution</i>	Monte Carlo Single loss approximation	
	<i>Correlation and dependence</i>	Empirical data and expert judgment Copulas	Stressing correlations
	<i>The use of the 4 elements</i>	Modeling of ILD, ELS, SA Combination of the elements	BEICF Stressing the modeling

## Stress testing is a major concern by banking supervisors:

**US Federal Reserve**  
CCAR (Comprehensive Capital  
Analysis and Review)

**Monetary Authority of  
Singapore**  
Annual Industry-Wide Stress Testing

**European Banking Authority**  
EU-wide Stress Testing

Our capital modelling solution supports all generally applied stress testing industry standards and best practices and their adaptation to regulatory requirements:

- Historical losses for baseline scenario
  - Similar as in Use Case 5. The caveat is a backward-looking character
- Regression models
  - Identify statistical relationship between macro-economic variables and operational risk
- Modified Loss Distribution Approach
  - Increased frequencies given correlation analysis
  - Use a lower than 99.9% percentiles for stress scenario (i.e., 70% for stress scenario and 98% for severely adverse scenario)
- Scenario analysis
  - Opinions from different managers
  - Performance Based Expert Judgment
- Sensitivity analysis of the model parameters
  - Shifting frequencies, tail parameters, weight of the fit on extreme losses and other

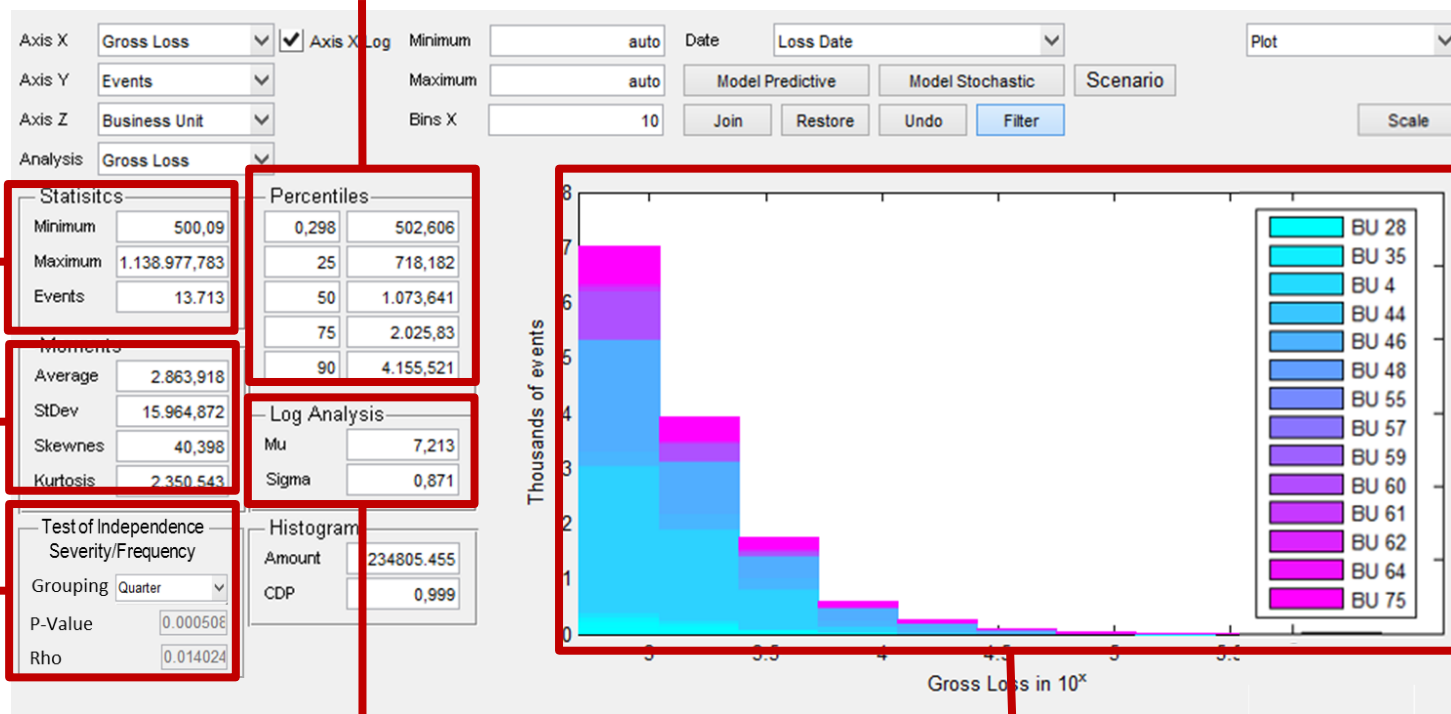
# Modelling

## The Use of the Four Data Elements: Internal Loss Data

“a bank should generally adhere to the following: Exploratory Data Analysis (EDA) for each ORC to better understand the statistical profile of the data and select the most appropriate distribution...”

Basel Committee on Banking Supervision

### Percentiles



General statistics

Moments analysis

Independence severity frequency

Log Analysis

Histogram of composition by BU

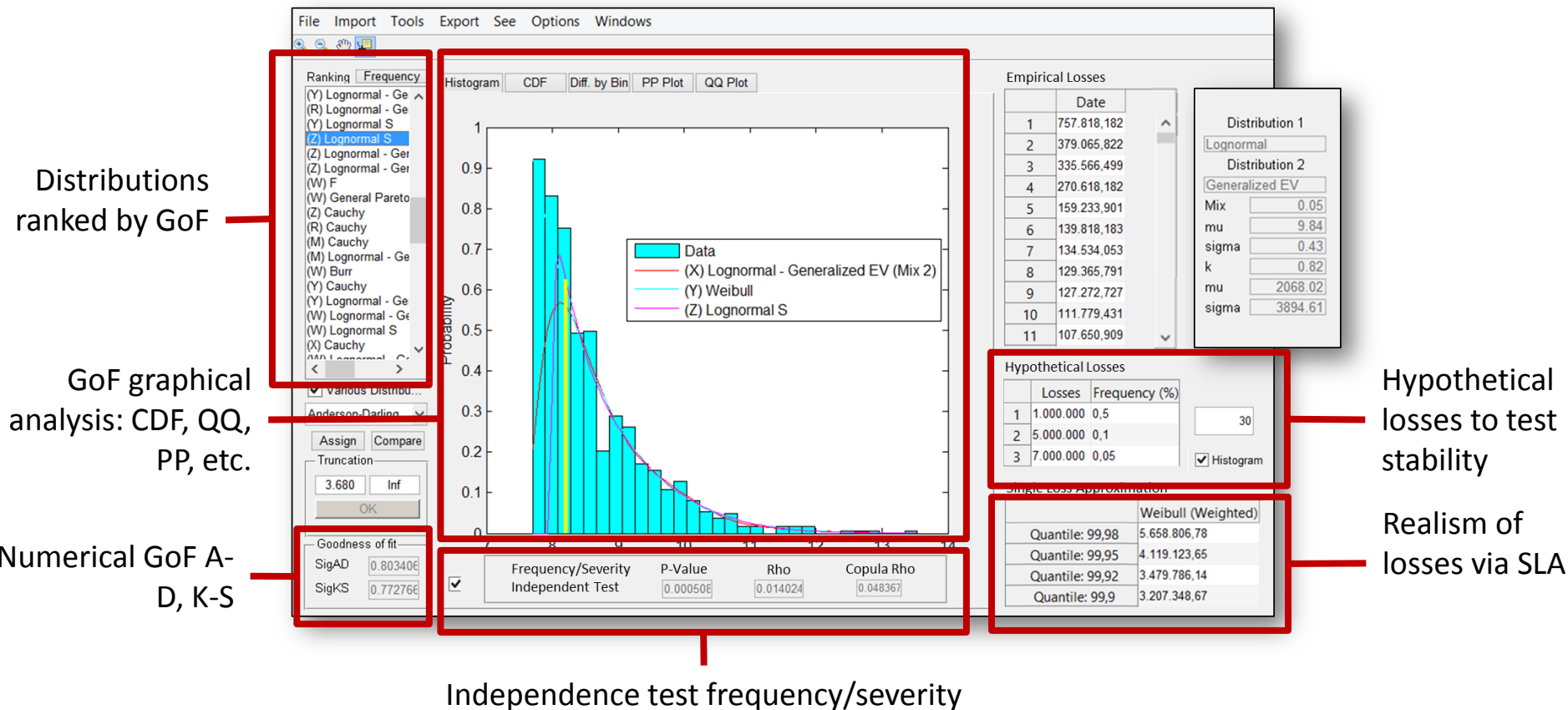
# Modelling

## The Use of the Four Data Elements: Internal Loss Data and Distribution Assumptions



“Supervisors expect ILD to be used in the operational risk measurement system (ORThe) to assist in the estimation of loss frequencies; to inform the severity distribution(s) to the extent possible”.

Basel Committee on Banking Supervision



# Modelling

## The Use of the Four Data Elements: Scenario Analysis Modelling

“A robust scenario analysis framework is an important element of the ORMF. This scenario process will necessarily be informed by relevant ILD, ED and suitable measures of BEICFs”.

### Scenario Information

- Detailed scenario description
- Causal pathway
- Risk control situation,
- Opportunities for mitigation
- Available data such as internal and external losses,
- KRIs,
- Evolution of RCSA
- Results from internal audits.



### Biases Mitigation

- Anchoring
- Herding
- Self-Herding
- Recency
- Denial
- Insensitivity to the size of the sample
- Design of the questionnaire
- Design of the scenario analysis process and workshop



### Scenario Analysis Elicitation Methods

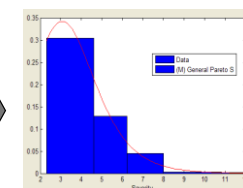
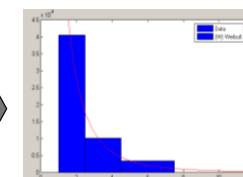
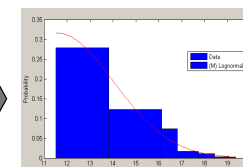
What is the annual frequency for events costing between 0\$ and 10.000\$?

What would be the worst loss within 100 years?

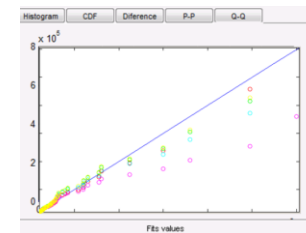
What is your worst loss per 100 events materialised?



### Modelling



### Validation



mu	-5,296
sigma	7,23
Frequency	1
Percentil (%)	99,9
Maximum loss	25.301.634,94
Mode	65.412,29
Mean	209.812,98
Variance	92.944.746.284.919,3
Skewness	63,61
Kurtosis	4.254,32

# Modelling

## The Use of the Four Data Elements: Scenario Analysis Modelling

“A bank should thus ensure that the loss distribution(s) chosen to model scenario analysis estimates adequately represent(s) its risk profile”

Basel Committee on Banking Supervision

### Scenario Analysis Modelling

Derived from the analysis of external data

Answers from the scenario analysis rating



What is your worst loss in 1 year, 10 years, 25 years and 50 years?

The screenshot shows the 'Scenario parameters' table and the 'Distributions' table. The 'Scenario parameters' table has columns for 'Loss' and 'in years' with four rows of data. The 'Distributions' table has columns for 'Burr' and 'Cauchy' with parameters like 'Par1', 'Lower1', 'Upper1', etc. Below these tables is a 'Moments and mode' section with input fields for 'Skewness' (9.6) and 'Kurtosis' (115). At the bottom, there is a table for selecting a distribution model (Generalized EV, Lognormal, Gamma, Weibull) with columns for various statistical moments.

Loss	in years	Weight
1 256	1	1
2 1.200	10	2
3 3.200	25	2
4 10.800	50	1

Model	Skewness	Kurtosis
Generalized EV	0,753	0,768
Lognormal	8,222	118,013
Gamma	1,22	1,225
Weibull	1,421	1,421

#### Input to the fitting process

Skewness

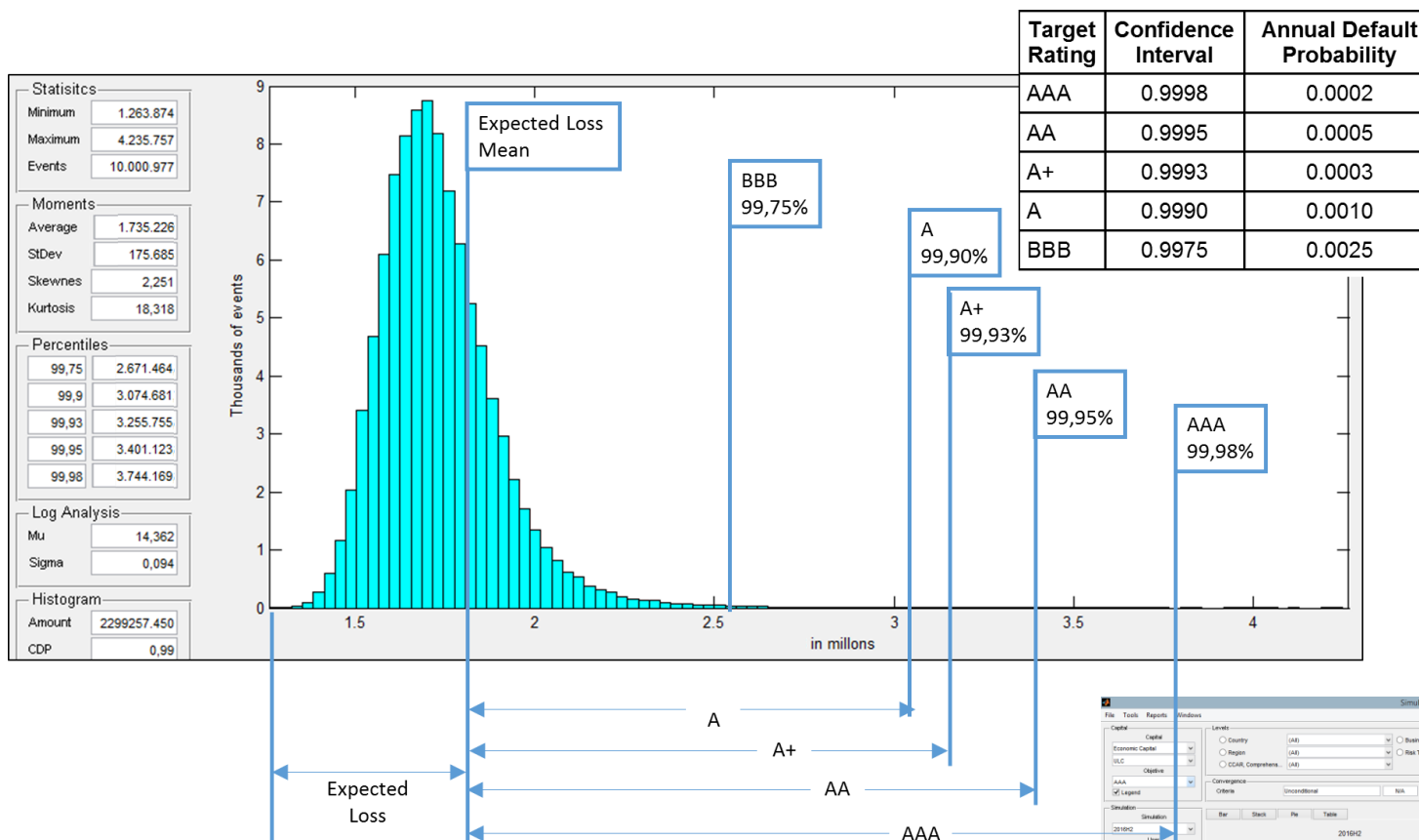
Kurtosis

#### Fitted Distribution

Skewness	8,222	8,268
Kurtosis	127,134	118,013

# VaR and Capital Calculation

## Capital and Stress Testing



“Whatever approach is used, a bank must demonstrate that its operational risk measure meets a soundness standard comparable to that of the internal ratings-based approach for credit risk (ie comparable to a one year holding period and a 99.9<sup>th</sup> percentile confidence interval).”

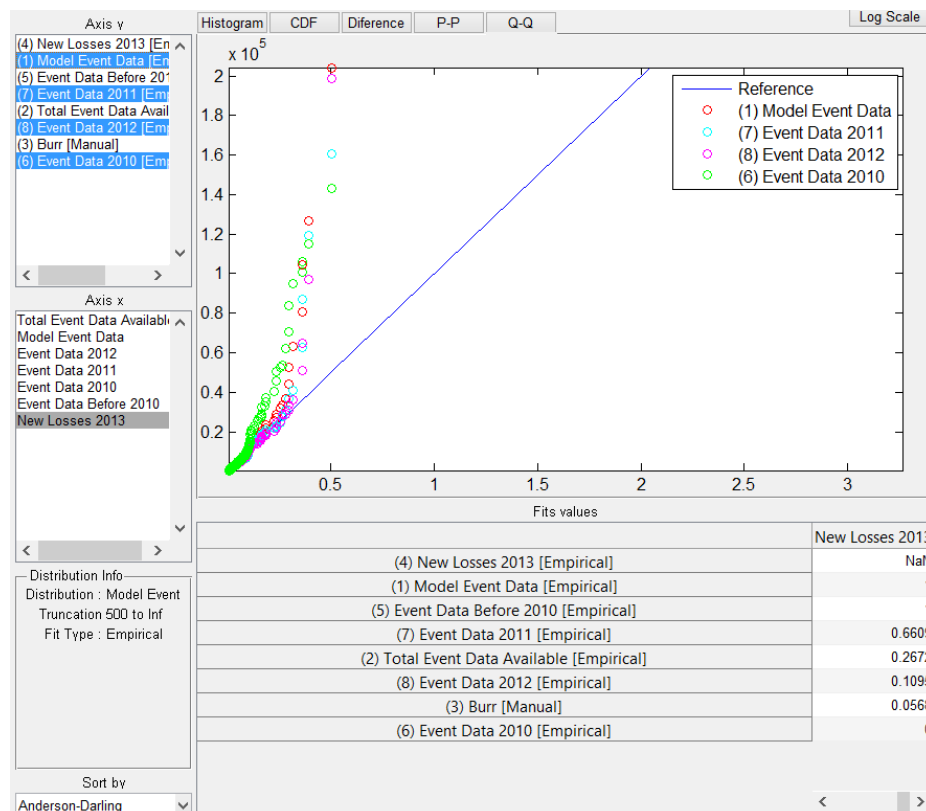


# Governance

## Verification and Validation

*“Validation ensures that the ORThe used by the bank is sufficiently robust and provides assurance of the integrity of inputs, assumptions, processes and outputs”.*

Basel Committee on Banking Supervision



*“Verification of the ORMF includes testing whether all material aspects of the ORMF have been implemented effectively ...:  
...a comparison of scenario results with internal loss data and external data”.*

Basel Committee on Banking Supervision

### Backtesting of severity:

- Distribution used to calculate capital compared to new losses.
- New losses compared to the losses used to construct the capital model.

### Backtesting of frequencies:

- Violation ratio using UoMs observations

### Backtesting of total losses:

- Violation ratio using UoMs observations

# Governance

## Verification and Validation

*“Verification activities test the effectiveness of the overall ORMF, consistent with policies approved by the board of directors, and also test ORThe validation processes to ensure they are independent and implemented in a manner consistent with established bank policies. “*

Basel Committee on Banking Supervision

### Results Modelling

#### Audit Trail of Modelling Assumptions

User: Rafael Cavestany

Operation: Add

Initial date: 01/05/2011

Final date: 16/05/2011

Launch

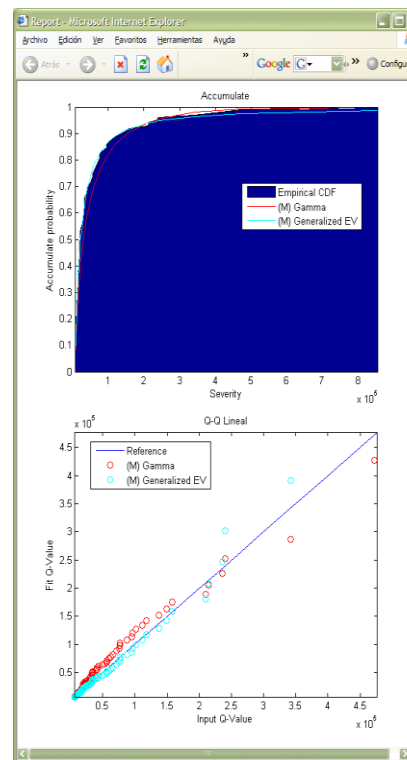
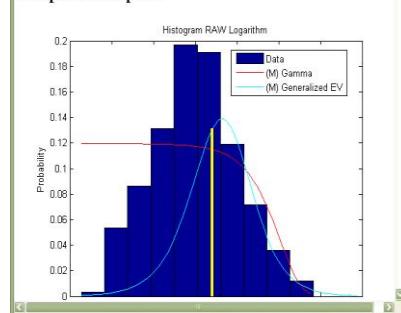
everis	Risk Type	Business
9	Spain Internal Fraud	(All)
10	Spain External Fraud	(All)
11	Spain Employment Practices	(All)
13	America Internal Fraud	(All)
16	America External Fraud	(All)
18	America Employment Practices	(All)
24	Europe Internal Fraud	(All)
25	Europe External Fraud	(All)
26	Europe Employment Practices	(All)
27	Africa Internal Fraud	(All)
28	Africa External Fraud	(All)

Apply Cancel

Table 1.2. Distributions

Distribution	(M)
Gamma	
Name	Gamma
mu	2.0959e-009
B	1.76336 6581
SigAD	0.031658
SigKS	0.055252
Distribution	Generalized EV
Name	Generalized EV
k	0.87325
mu	0.018756
sigma	-12446 8455
SigAD	0.66426
SigKS	0.94502

#### Chapter 2. Graphics



*“Results from verification and validation work should be documented and distributed to appropriate business line management, internal audit, the corporate operational risk management function and appropriate risk committees. Bank staff ultimately responsible for the validated units should have access to, and an understanding of, these results”.*

Basel Committee on Banking Supervision

# Governance

## Use Test: Mitigation Plan Evaluation



Description and support data
Scenario rating
Loss Analysis
Mitigation Plan
Mitigation Insurance

Pre-Mitigation

Worst Loss In  Year

Worst Loss In  Year

Worst Loss In  Year

Worst Loss In  Year

Annual Expected MANUAL

Post-Mitigation

**Risk mitigation justification**

The effective enforcement of the trading limits established for each of the management layers allows other control mechanisms to work adequately, reducing the number of limit breaches and their severity

**Related mitigation plans**

Trading room fingerprint scan

Fitted curve

Lognormal

mu

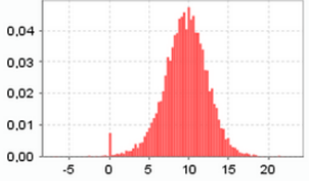
sigma

Number of simulations

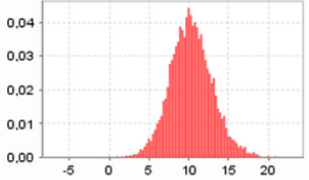
Time horizon (Months)

Number of bins

Analysis of aggregate post-mitigation losses implicit in the risk assessment

Expected Loss	€ 3,303,014.01			
Worst aggregate loss in 5 years	€ 129,752.5	<input type="text" value="80.0"/>	%	
Worst aggregate loss in 10 years	€ 412,492.87	<input type="text" value="90.0"/>	%	
Worst aggregate loss in 50 years	€ 3,308,460.93	<input type="text" value="98.0"/>	%	
Worst aggregate loss in 500 years	€ 65,558,394.33	<input type="text" value="99.8"/>	%	
Worst aggregate loss in 1,000 years	€ 102,738,099.28	<input type="text" value="99.9"/>	%	
Worst aggregate loss in 5,000 years	€ 717,686,237.93	<input type="text" value="99.95"/>	%	

Analysis of aggregate losses implicit in the risk assessment

Expected Loss	€ 3,807,810.06			
Worst aggregate loss in 5 years	€ 251,467.45	<input type="text" value="80.0"/>	%	
Worst aggregate loss in 10 years	€ 860,534.27	<input type="text" value="90.0"/>	%	
Worst aggregate loss in 50 years	€ 11,638,587.73	<input type="text" value="98.0"/>	%	
Worst aggregate loss in 500 years	€ 151,775,822.81	<input type="text" value="99.8"/>	%	
Worst aggregate loss in 1,000 years	€ 570,958,438.11	<input type="text" value="99.9"/>	%	
Worst aggregate loss in 5,000 years	€ 1,186,290,692.42	<input type="text" value="99.95"/>	%	

←

Loss distribution after mitigation

←

Loss distribution post mitigation

# Governance

## Use Test: Mitigation Plan Evaluation



**Insurance program**

Max. # events insured:   
 Deductible:   
 Maximum coverage:

Loss:     Total loss:   
 Fitted curve:   
 mu:     sigma:

Number of simulations:   
 Time horizon (Months):   
 Number of bins:

---

**Analysis of aggregate post-insurance losses implicit in the risk assessment**

Worst aggregate loss in 5 years	€ 11.88	<input type="text" value="80.0"/>	%
Worst aggregate loss in 10 years	€ 17.15	<input type="text" value="90.0"/>	%
Worst aggregate loss in 50 years	€ 20	<input type="text" value="98.0"/>	%
Worst aggregate loss in 500 years	€ 21.58	<input type="text" value="99.8"/>	%
Worst aggregate loss in 1,000 years	€ 25.76	<input type="text" value="99.9"/>	%
Worst aggregate loss in 5,000 years	€ 32.68	<input type="text" value="99.98"/>	%

---

**Analysis of aggregate post-mitigation losses implicit in the risk assessment**

Worst aggregate loss in 5 years	€ 11.88	<input type="text" value="80.0"/>	%
Worst aggregate loss in 10 years	€ 17.15	<input type="text" value="90.0"/>	%
Worst aggregate loss in 50 years	€ 33.73	<input type="text" value="98.0"/>	%
Worst aggregate loss in 500 years	€ 72.93	<input type="text" value="99.8"/>	%
Worst aggregate loss in 1,000 years	€ 89.08	<input type="text" value="99.9"/>	%
Worst aggregate loss in 5,000 years	€ 123.88	<input type="text" value="99.98"/>	%

---

**Analysis of aggregate losses implicit in the risk assessment**

Worst aggregate loss in 5 years	€ 6.8	<input type="text" value="80.0"/>	%
Worst aggregate loss in 10 years	€ 15.68	<input type="text" value="90.0"/>	%
Worst aggregate loss in 50 years	€ 85.1	<input type="text" value="98.0"/>	%
Worst aggregate loss in 500 years	€ 452.75	<input type="text" value="99.8"/>	%
Worst aggregate loss in 1,000 years	€ 658.82	<input type="text" value="99.9"/>	%
Worst aggregate loss in 5,000 years	€ 3,489.83	<input type="text" value="99.98"/>	%

Final residual risk after mitigation and insurance

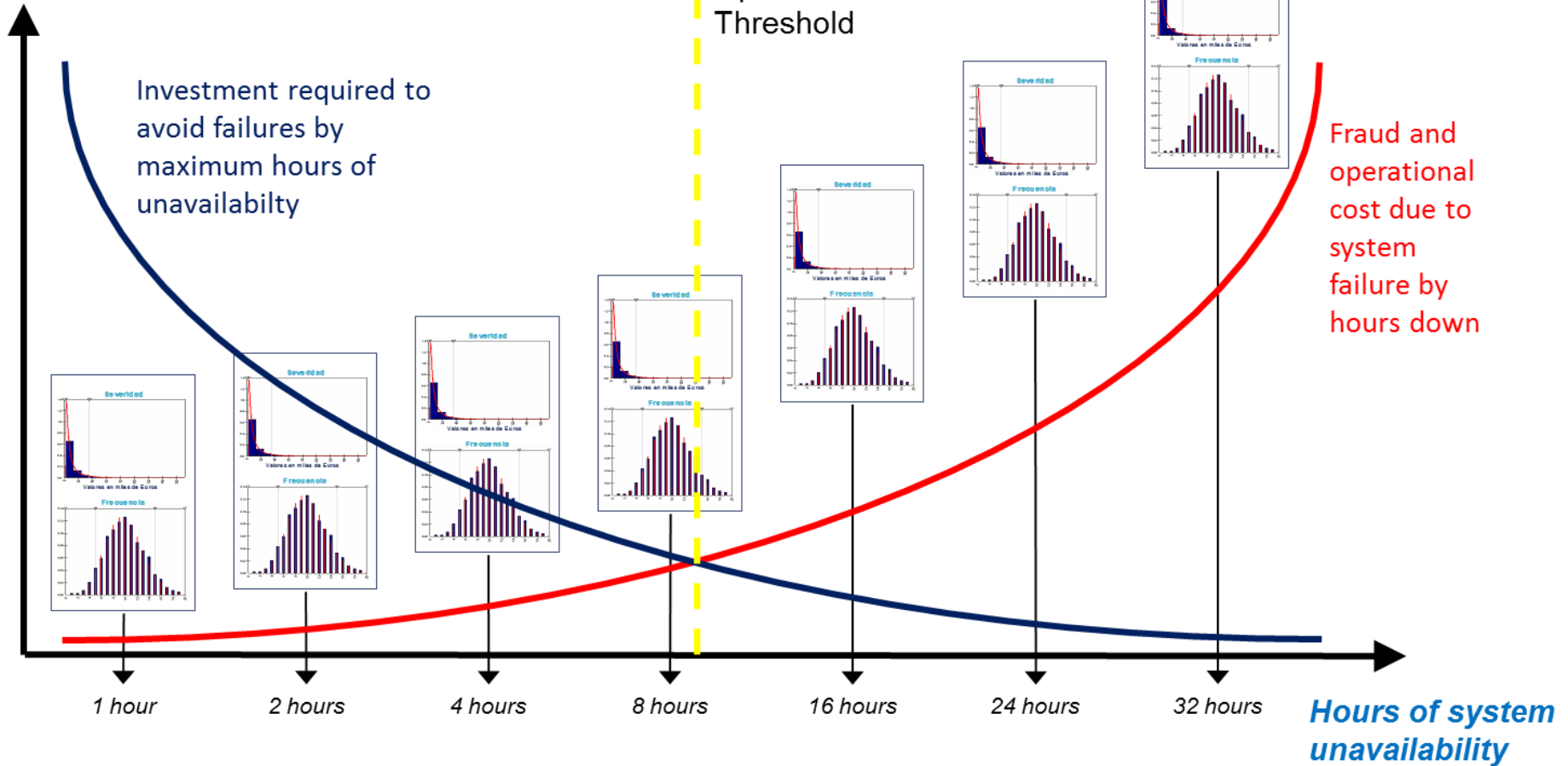
Residual risk after mitigation plan

Inherent risk after mitigation plan

# Governance

## Use Test: Mitigation Plan Evaluation

*Investment required*  
*Operational risk incurred*



Our solution provides clear benefits both to the operational risk modelling team and to the institution as a whole

Industry standards fully automated and integrated

- Capital modelling: LDA, SBA, Hybrid models.
- Stress testing: mean historical losses, regression analysis, modified LDA, SA, parameters sensitivity.
- Regulatory: Basel II/III, CCAR, Annual Industry-Wide Stress Testing, EU-wide Stress Testing

Errors minimised and model quality maximised

- Minimised manual errors thanks to automated analytical processes and data flows
- Decreased work load leads to improved process execution quality

Lower dependence from and relieve of skilled resources

- Analytical codes are formalised and integrated
- Standard reports are generated automatically and consecutively for multiple factor and models
- Audit trail facilitates the documentation of transformations and assumptions
- Additionally resources with no analytical coding skills can assume tasks in the modelling team

Full governance over the model

- Audit trail repository helps to explain results and permit their replication
- User control identifies who executed which tasks and controls staff permissions
- User friendliness enables the institution - rather than coding gurus - to be the owner of the model
- Extensive user manuals facilitate a smooth knowledge transfer to new team members

State of the Art capital modelling for supervisor concerns

- With only a few clicks, you can incorporate most advanced analytics and regulators concerns: hybrid model, credibility theory, severity-frequency dependence, time weighted fit, correlations, EVT, etc.
- Integrating capital into management requires a more realistic and forward looking capital calculations
- Thought leadership: reflected in our publications, clients and partners

Model inputs and results used in first line of defence

- Scenario analysis, BEICFs and correlations workshops with a focus into mitigation strategies
- ILD and ED analysis and models used to identify particularly vulnerable areas and processes
- Use test: evaluation of controls and mitigation, strategic planning process, Operational Risk Appetite