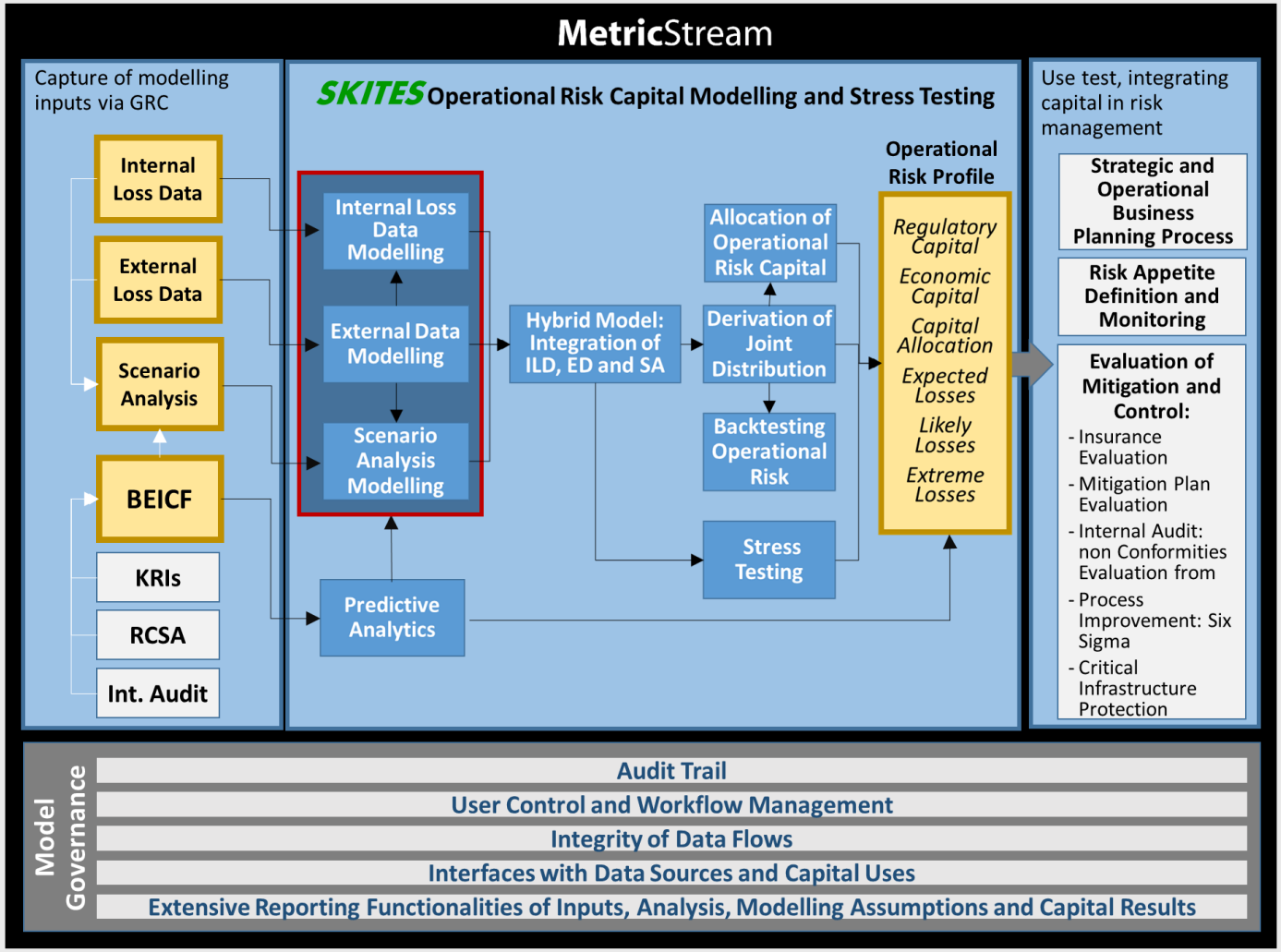
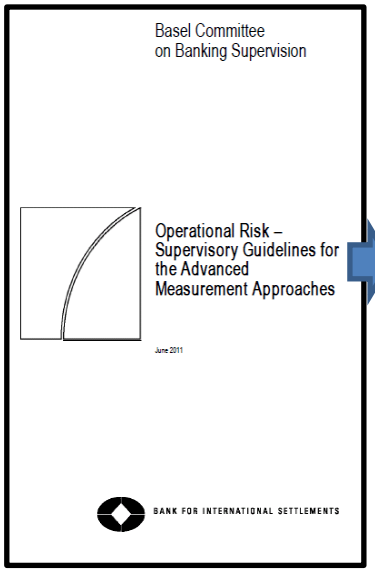


Introduction

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



Basel Commitee		
Supervisory Guidelines for AMA		**OpRisk Capital Software Needs**
Governance	*General*	User control: governance over modeling process and options Audit trail of data sources and their transformations Full control and understanding over statistical processes
	Verification	Reporting of modeling assumptions Automatic documentation of data sources and transformations
	Validation	Backtesting
	Use test	Insurance evaluation Investment on risk mitigation business case
Data	*Managed at the GRC platform*	Gross loss definition, thresholds, date, grouped losses, etc. Consistency with accounting
Modeling	*Granularity*	Flexible definition of business units and risk categories Capital allocation functionalities
	Distribution assumptions	Threshold determination Split of distribution body and tail Light and heavy tail distributions Methodology to reduce estimates variability
	Joint distribution	Monte Carlo Single loss approximation
	Correlation and dependence	Empirical data and expert judgment Copulas
	The use of the 4 elements	Modeling of ILD, ELS, SA Combination of the elements

Workflow management	
Integrity of data flows	
Reporting of capital results	
Replicability of results	
All verification functionalities	
Reporting of capital results	
Completeness of collection	
Realistic capital estimates	
Robust methods	
GoF graphical and numerical	
Capture tail events	
Stressing correlations	
BEICF	
Stressing the modeling	

Introduction

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…"

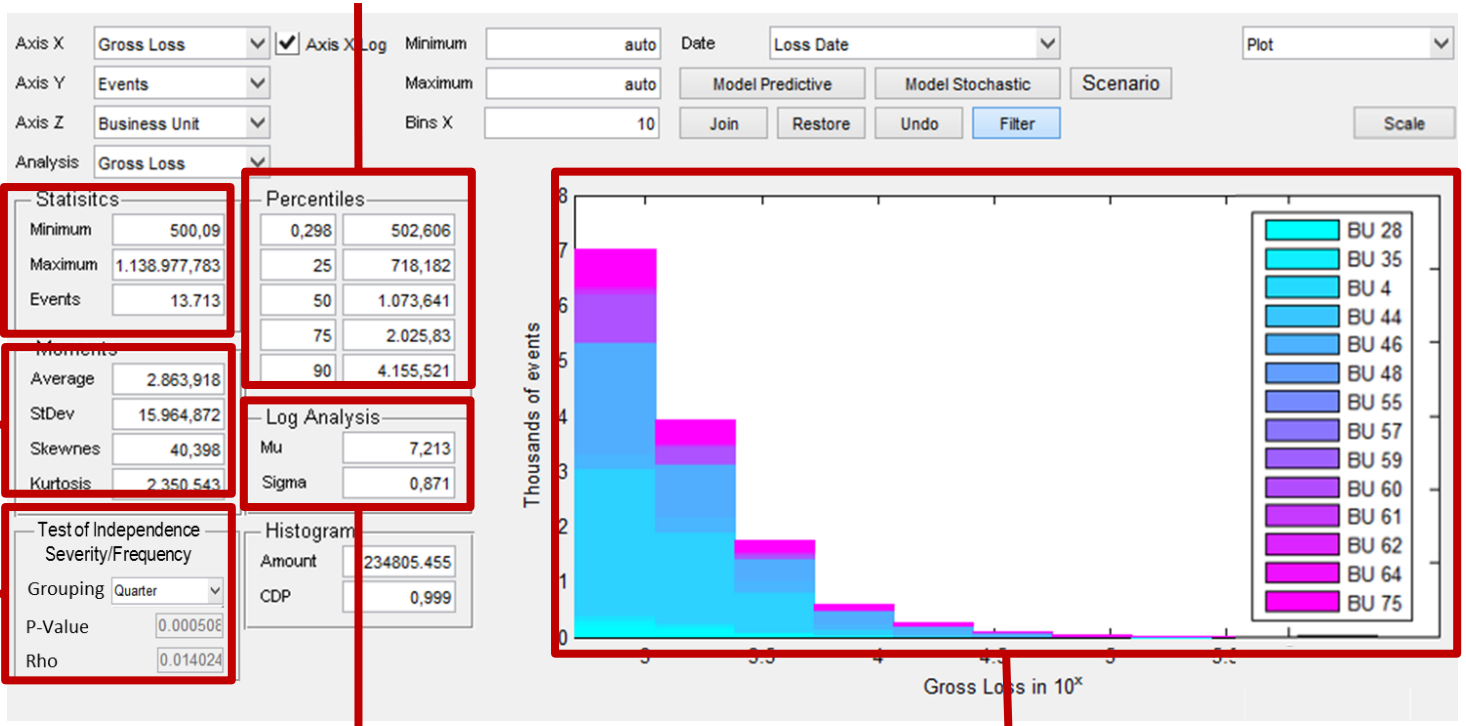
Basel Committee on Banking Supervision

Percentiles

Gereral stadistics

Moments analysis

Independence severity frequency



Log Analysis

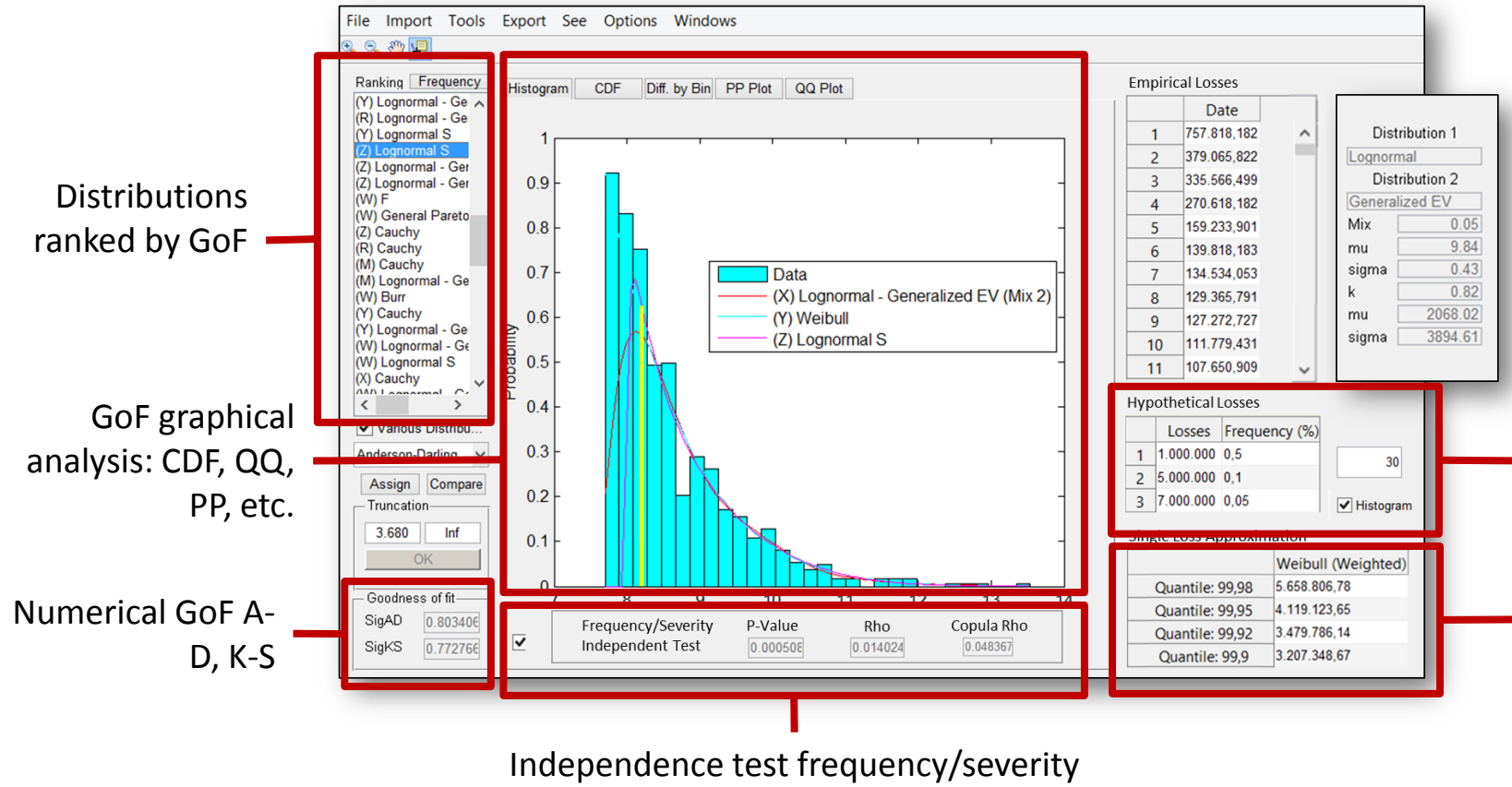
Histogram of composition by BU

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 path way
- 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

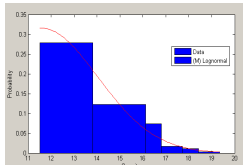
Scenario Analysis Elicitation Methods

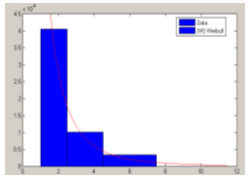
What is the annual frequency for events costing between 0$ and 10.000$?

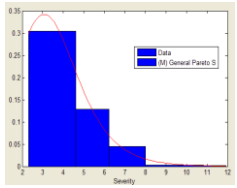
What would be the worst loss within 100 years?

What is your worst loss per 100 events materialised?

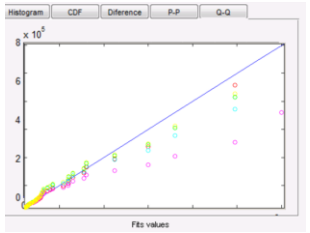
Modelling







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"

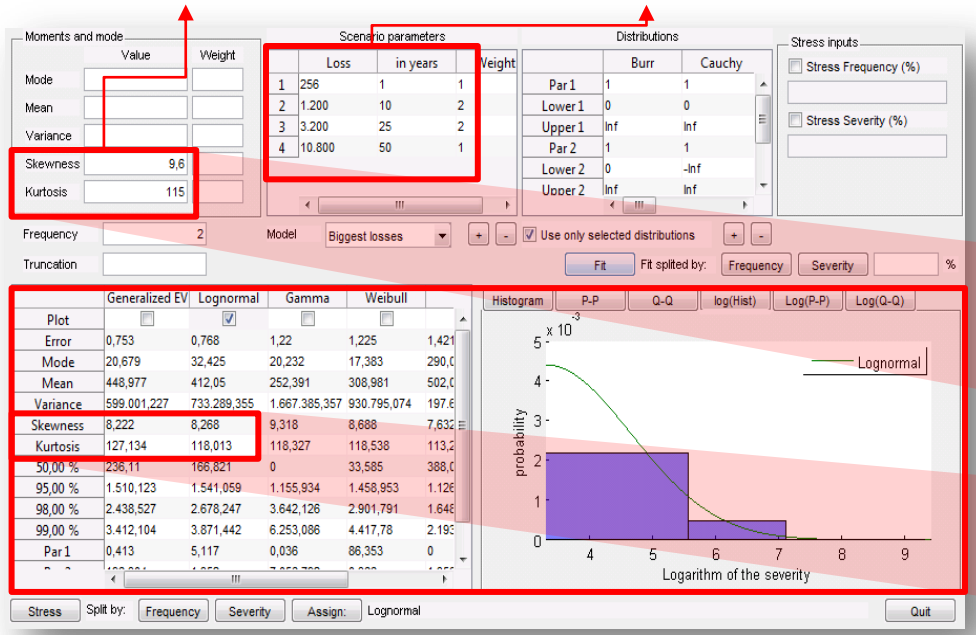
Basel Committee on Banking Supervision

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?



Input to the fitting process

Skewness	9,6	
Kurtosis	115	

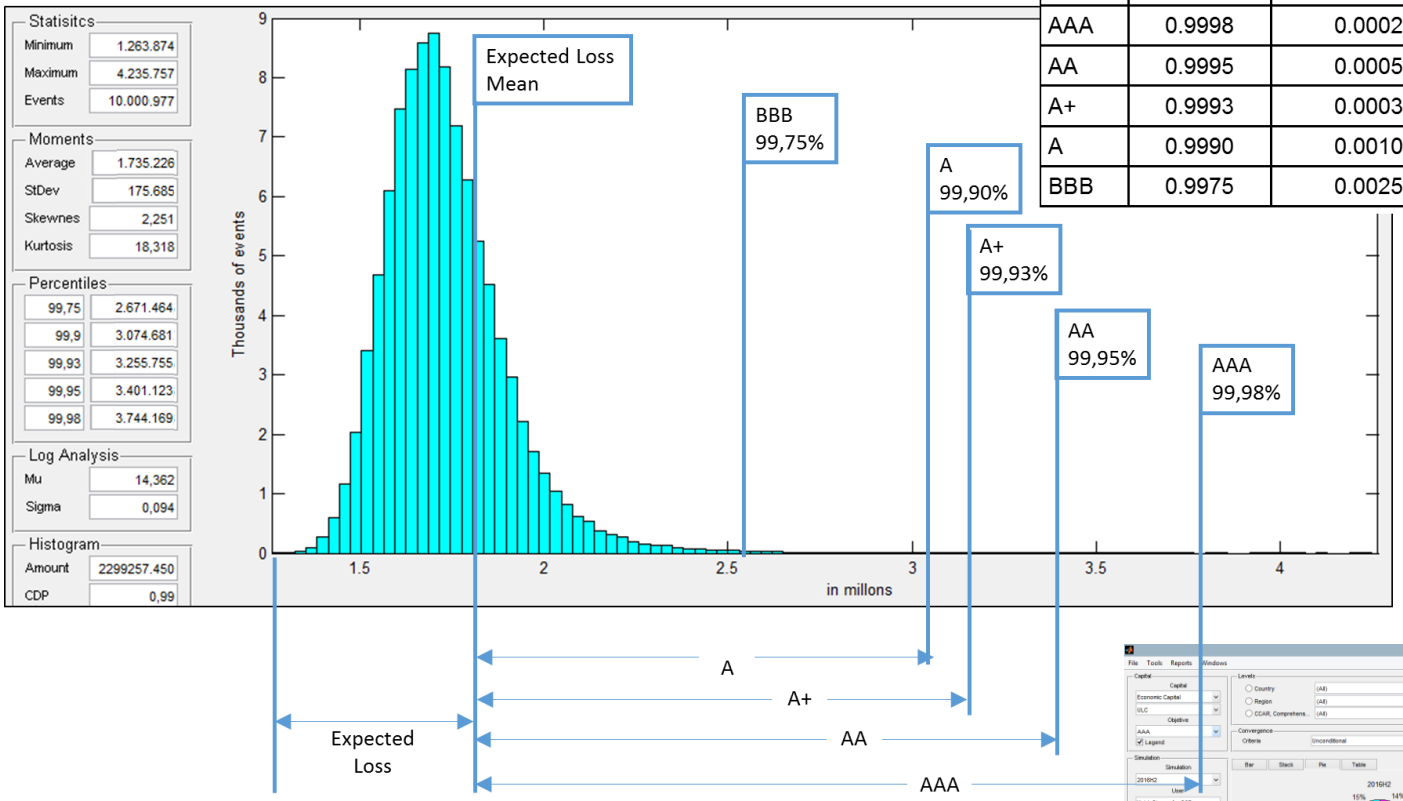
Fitted Distribution

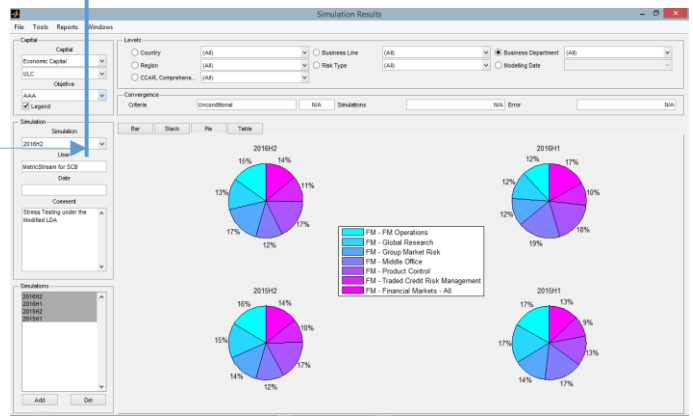
Skewness	8,222	8,268
Kurtosis	127,134	118,013

VaR and Capital Calculation

Capital and Stress Testing

Target Rating	Confidence Interval	Annual Default Probability
AAA	0.9998	0.0002
AA	0.9995	0.0005
A+	0.9993	0.0003
A	0.9990	0.0010
BBB	0.9975	0.0025





"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 99.9th 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".*

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*"**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".

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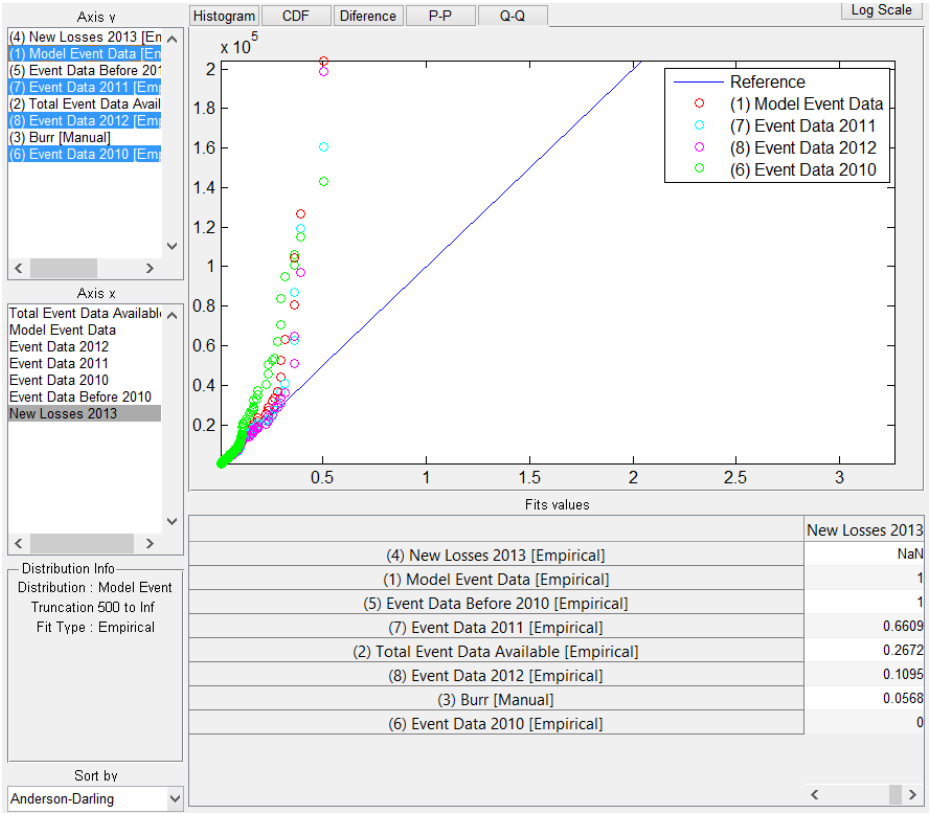

Backtesting of severity:

- 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. "

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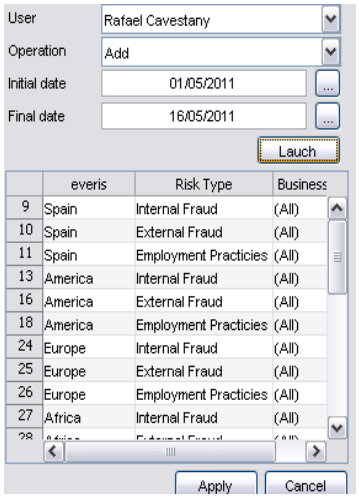
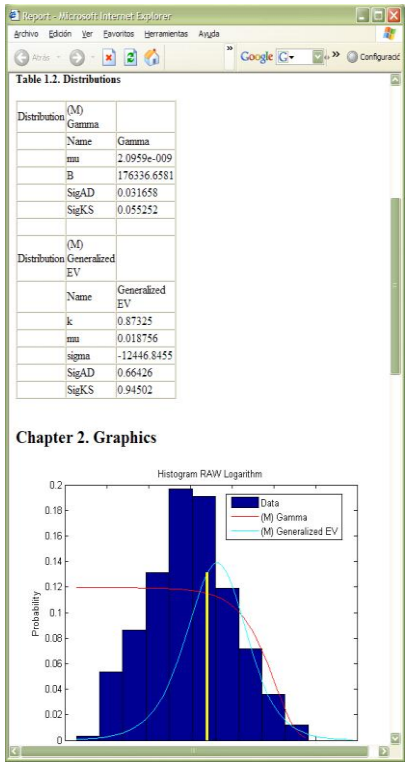
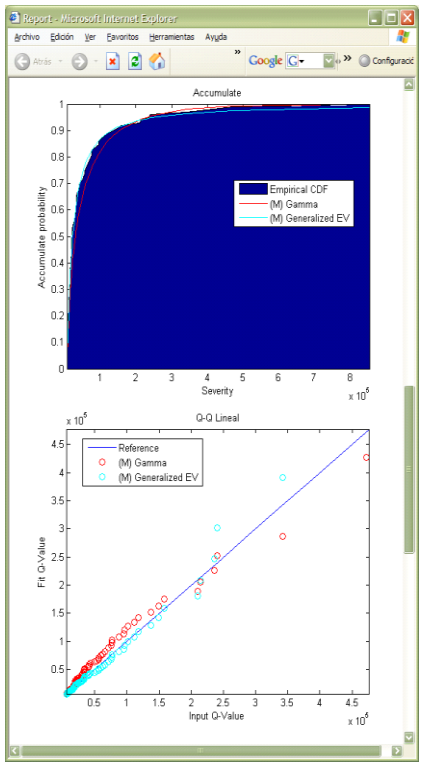
Audit Trail of Modelling Assumptions



Results Modelling





"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".

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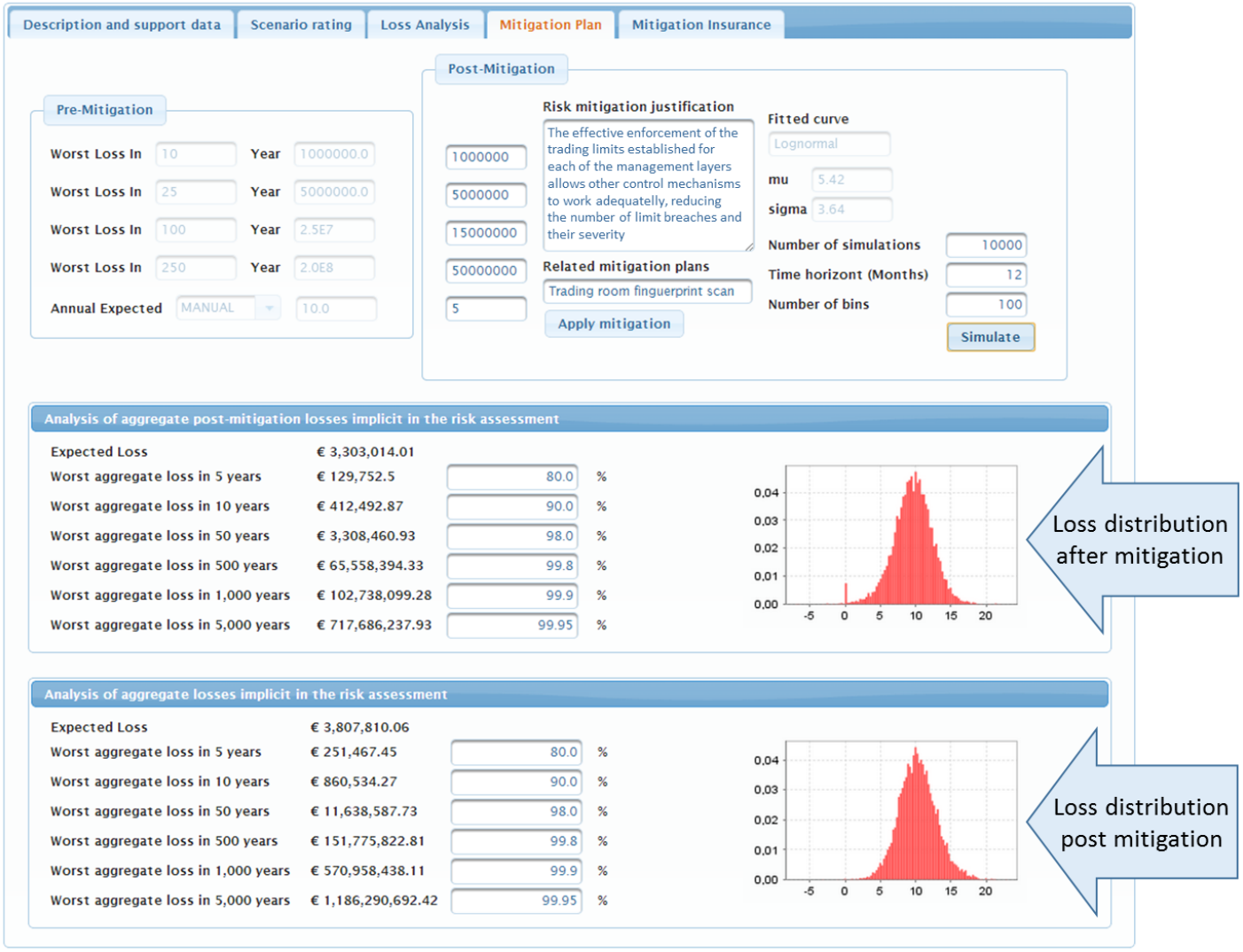
Governance

Use Test: Mitigation Plan Evaluation



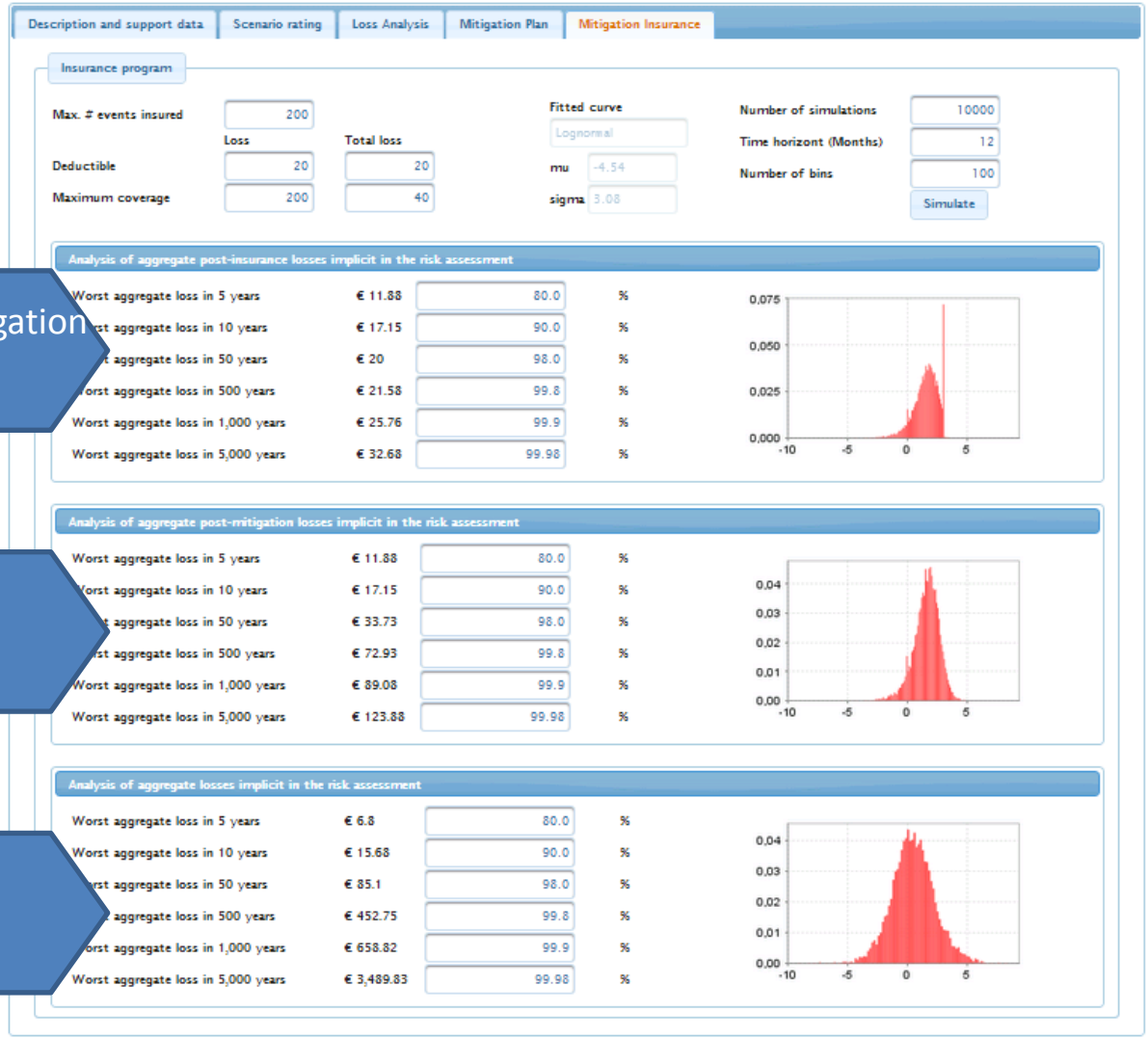
Governance

Use Test: Mitigation Plan Evaluation

Final residual risk after mitigation and insurance

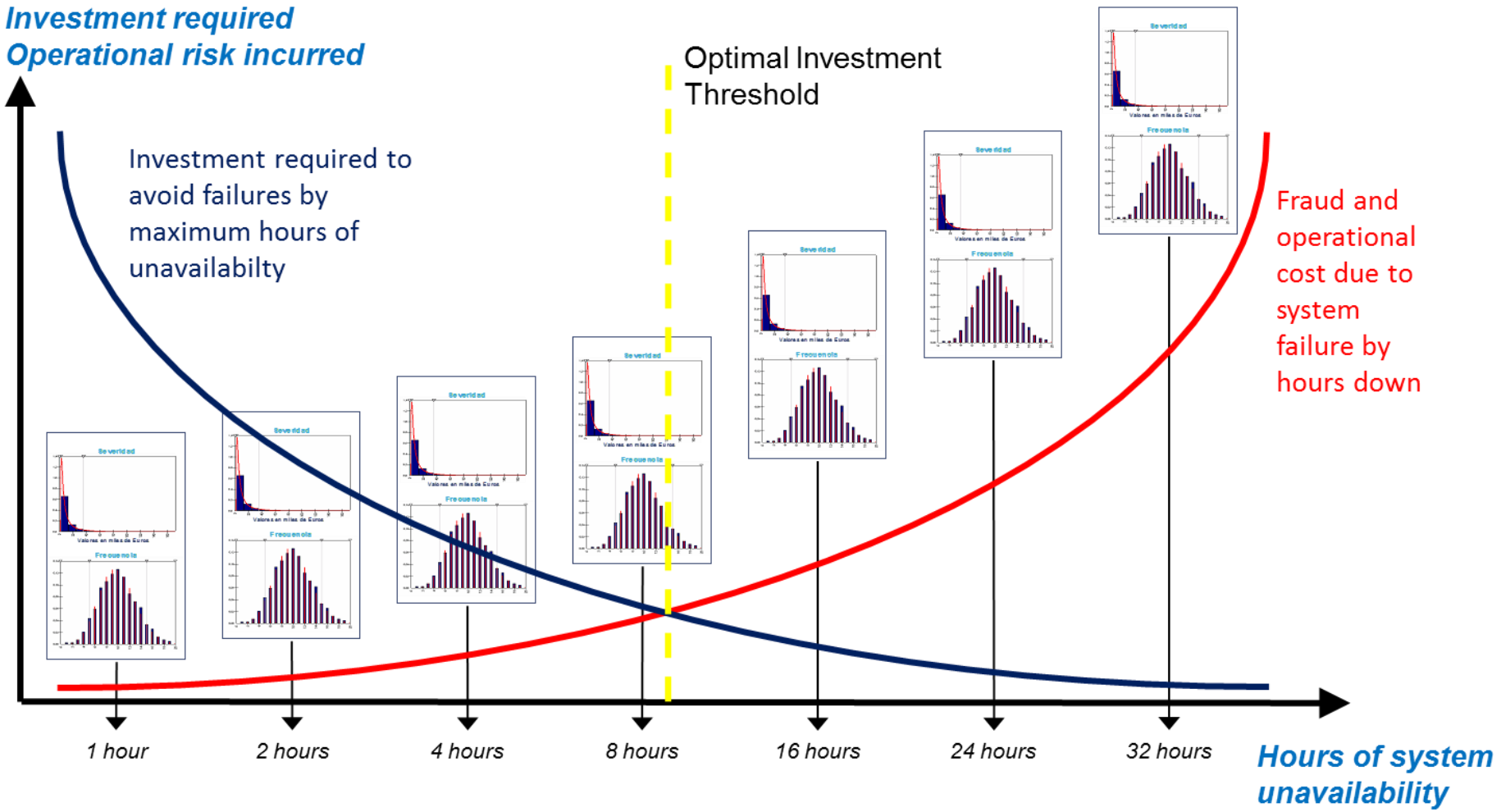
Residual risk after mitigation plan

Inherent risk after mitigation plan



Governance

Use Test: Mitigation Plan Evaluation



Introduction

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 incorporates 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