

# DEFINIRE UN SISTEMA PER LA GESTIONE DEL RISCHIO DI MODELLO

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# Background

- The **financial world** is experiencing an **increasing use of complex quantitative models** to carry out core business activities. The **success of both banking and insurance sectors** clearly **relies on these tools**.
- **Model risk** has become a **major concern of financial institutions** as it may be considered an unavoidable consequence of their operating as a business.

ERM view requires insurance companies to **enhance their risk culture and awareness considering Model risk as a key risk factor.**



**MODEL RISK MANAGEMENT**

Develop a robust framework to deal with its **identification, measurement, management and control.**

Main **purpose** of the seminar is to

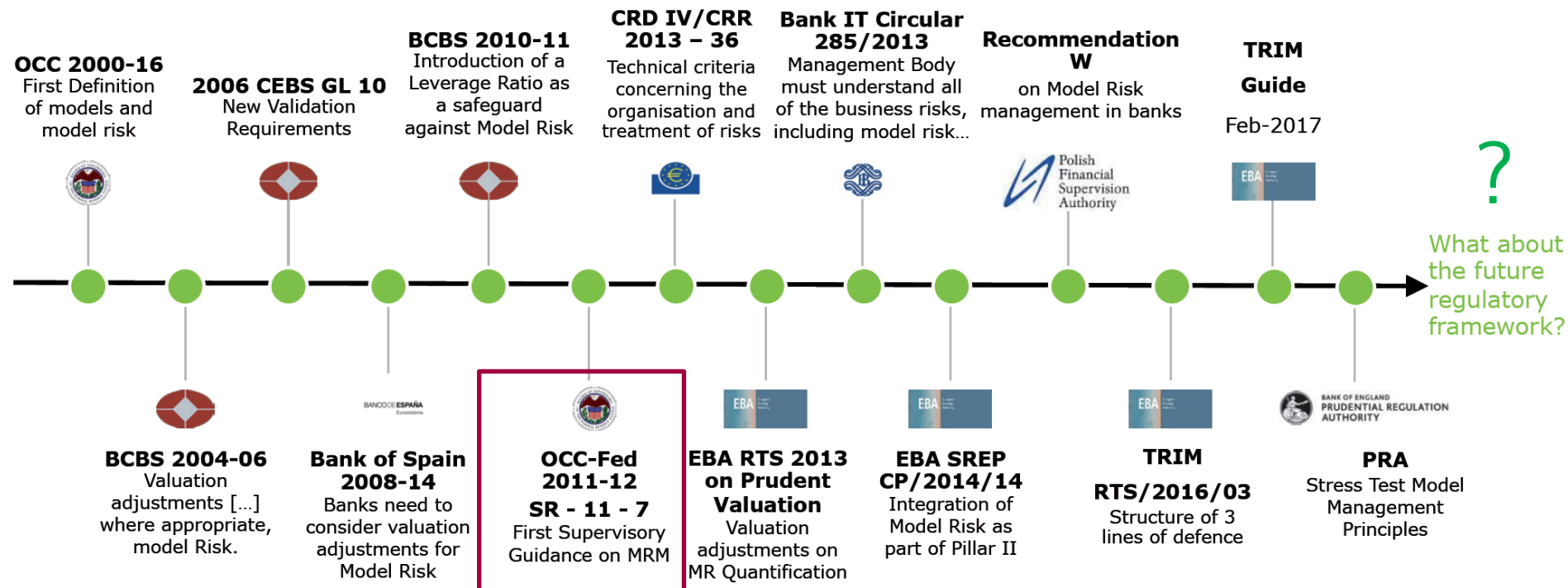
- provide an **overview** of this cutting edge topic,
- present what **best practices** are followed across the market including
- discuss **key aspects** that could be considered when approaching the development of a risk management framework for mitigating model risk.

# Outline

- ① Introduction
  - Regulatory landscape
  - MRM definitions and scope
- ② Model Risk Management
  - MRM framework overview
  - Risk identification, assessment, listing, mitigation
  - Model Lifecycle
  - Governance
  - Emerging Practice
- ③ Conclusions
  - MRM benefits
  - ...to recap

# A new type of Risk – Regulatory landscape

- **Model Risk Management (MRM)** is a new type of risk, currently involving significant organizational and process changes in risk management departments.
- In the **banking** industry, regulators have paid a particular attention to Model Risk since the **early 2000s** with the **first definition** of models and model risk.



# Regulatory references



The Federal Reserve and the Office of the Comptroller of the Currency (OCC) : **Supervisory Guidance on Model Risk Management (OCC 2011-12/SR11-7)** that is often seen as the target aspirational state for the management of model risk.

CRD IV / CRR



Defines **Model Risk** (Art. 3.1.11) and the **process** by which the Authorities should **assess how** the **institutions** manage and implement policies and processes to **evaluate the exposure** to Model Risk as part of the Operational Risk (Art. 85).

Guidelines on SREP



The '**Guidelines** on common procedures and methodologies for the supervisory review and evaluation process (SREP)' define the main activities that the Authorities should assess **in the institution's exposure to model risk** arising from **the use of internal models** in its main business areas and operations.



The BoE Prudential Regulation Authority (PRA) has recently defined a set of **four key principles** for **stress testing model management**. Banks should:

- 1) Establish definition of a *model* and maintain a *model inventory*.
- 2) implement an effective *governance framework, policies, procedures and controls* to manage their model risk.
- 3) implement a robust *model development and implementation* process and ensure appropriate use of models.
- 4) undertake appropriate *model validation and independent review* activities to ensure sound model performance and greater understanding of model uncertainties.

**PRA**  
Stress Test Model  
Management  
Principles

# What is a Model?

- “The term **model** refers to a **quantitative method**, system, or approach that **applies statistical, economic, financial, or mathematical theories, techniques, and assumptions to process input data into quantitative estimates**”



Inputs

- Data
- Inputs
- Assumptions
- Scenarios



Model

- Statistical
- Financial
- Mathematical
- Economic



Outputs

- Forecasts
- Estimates
- Management decision support

- Modelling viewed as a three stage process involving:
  - The **input** stage which delivers assumptions and the data to model
  - The **processing** stage which transforms the inputs into estimates
  - The **reporting** stage which produces useful business information from the estimates

# What is Model Risk?

- “The use of models invariably presents **model risk, which is the potential for adverse consequences from decisions based on incorrect or misused model outputs and reports.**

Model risk can lead to financial loss, poor business and strategic decision making or damage to reputation.”

- Two main and high level causes of model risk:
  1. Model has **fundamental errors / inaccuracies** and produces incorrect/inaccurate outputs
  2. Model may be **used / interpreted incorrectly or inappropriately**

# Role of Models



Simplify Real World Phenomena Often Complex in Nature



Simulation Tool to Understand Potential Impact of Different Scenarios



Help to Explain Previous Experience and Forecast Future Observations



Automated Decision Making Improve Efficiency & Reduced Costs



# Drivers for Model Risk Management (MRM)



## Increasing use of complex quantitative models

Financial institutions are increasingly using models for decision making



## Success increasingly reliant on model output

Success of banking and insurance sectors heavily rely on model outputs



## Always an incomplete representation of reality

There is model risk in every model. Clarity on assumptions & limitations is key to making decisions based on model output



## Material model failure examples expose risks

There have been numerous high profile model failures leading to increasing regulation

# Examples of Model Failure

## Mouchel Pension Fund accounting miscalculation (2011)

External independent actuaries made an error in a spreadsheet for the scheme valuation. Pension fund deficit wrongly valued.

- Profits downgrade of £8.6m + CEO resigned + Share price fell by a third
- <https://www.accountingweb.co.uk/practice/general-practice/spreadsheet-error-leads-to-mouchel-meltdown>

## M&S results hit by spreadsheet mishap (2016)

A spreadsheet double counting error forced the retailer to issue a correction to its quarterly trading statement for the first quarter of 2016/17:

- Original statement (7am) : group sales had *grown 1.3%*.
- 1:31pm correction: group sales had in fact *fallen 0.4%*.
- Reputational damage



Minor error but led to some reputational damage

## London Olympics (2012)

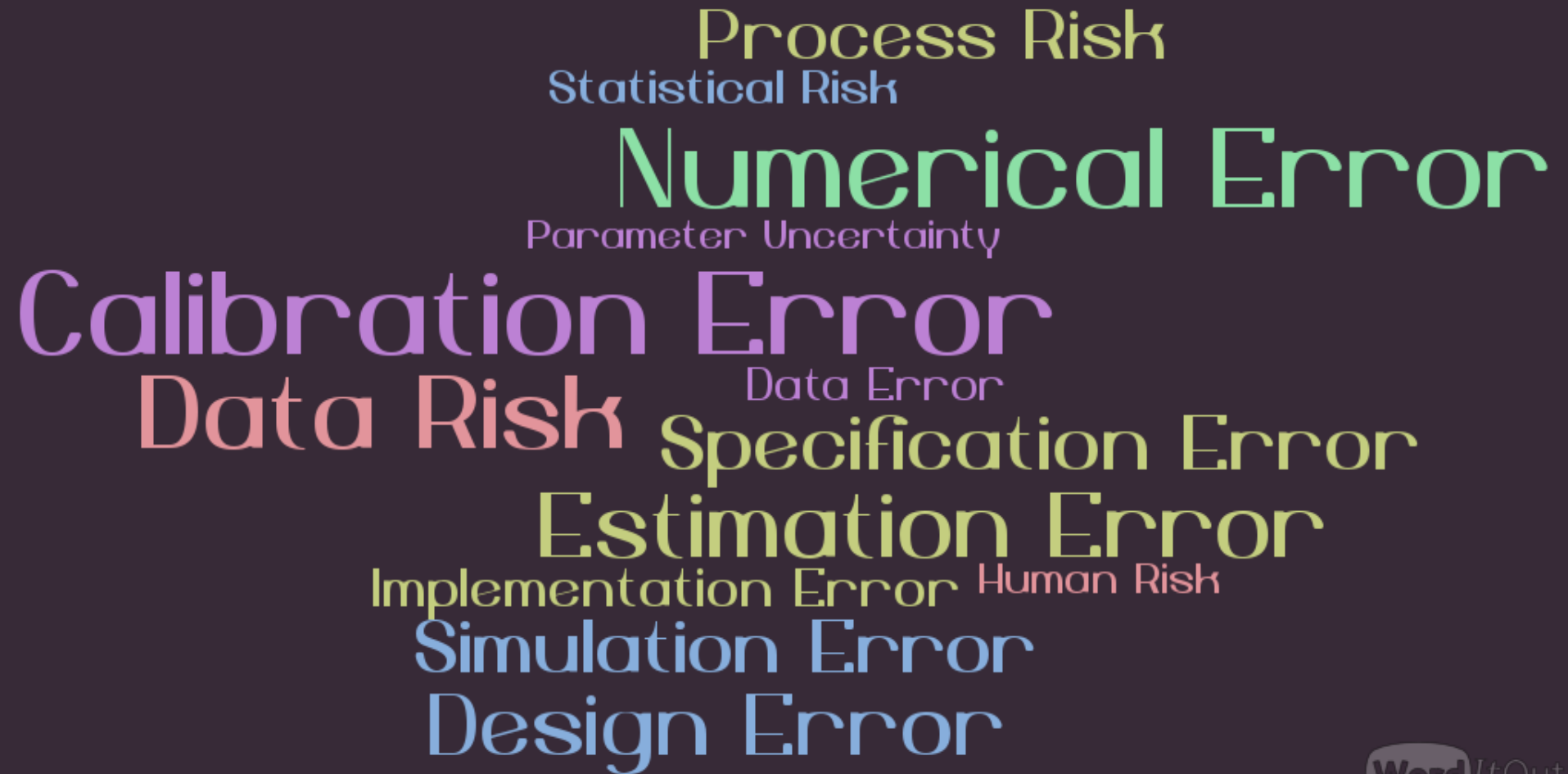
The London 2012 Olympics organisers oversold the synchronised swimming sessions by double!

- One staff member incorrectly typed a 2 instead of a '1' – and 10,000 unhappy spectators were left without a poolside seat because '20,000' seats were sold instead of '10,000'. You could say it was somewhat unsynchronised...

# Causes of Model Failure - Examples

Human related	Model design, methodology and use	Inputs and control framework
Broken links	Model used differently from its original purpose	Heavy reliance on Expert Judgement
Wrong formulae	Model limitations can make it invalid	Poor Data Quality
Over reliance on manual processes	Approach is reasonable at the time, but experience proves that it wasn't the best choice	Invalid Assumptions
Accidental cell substitution	Dependencies not understood	Simplification not reviewed
Misinterpretation of outputs	Change in environment invalidating model	Limited controls Control warnings not clear enough

# Model Risk sources - statistical perspective



# Type of models in scope – insurance company(example)

Comprehensive Model Coverage: A large global insurance company has a wide range of model types that should be subject to governance and model risk management.

## Models that often come to mind first

Pricing	Valuation	Risk & Capital	ALM	Forecasting
Performance measurement Reinsurance Profit testing Value of new business	Best estimate Regulatory Accounting Embedded Value	Economic Regulatory Rating Agency Capital Allocation Stress testing	Hedging Asset Allocation Derivatives	Business Planning

## Others include...

Experience Monitoring & Assumptions Setting

Biometric  
Investment

Other

Fraud Management  
Dividend models  
Administration

Customer Profiling & Marketing  
Human Resourcing

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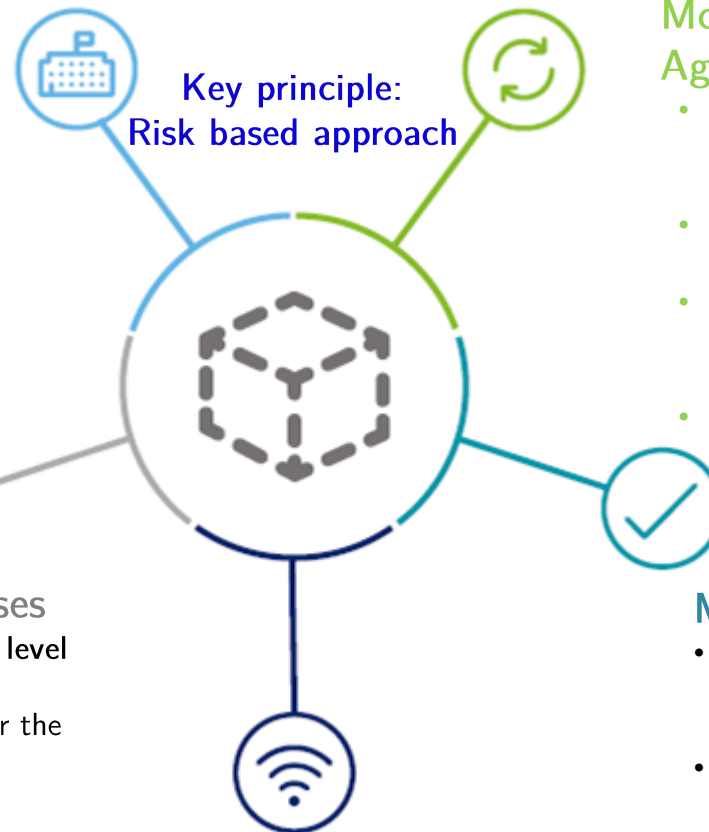
# An End-2-End MRM framework

## Structure Organisation and Governance

- Existence of a **Model Risk Management** approved by the **Board**, who receive periodic reports regarding compliance.
- Existence of a **Model Risk function** that reports to the **CRO** and is responsible for the MRM framework, the governance and oversight over the implementation.
- Existence of a model validation **function** responsible for the **independent validation of models**.

## Policies, Guidelines and Processes

- **Model Risk Policy** which defines the **high level principles** of the MRM framework, MRM mandate **and roles and responsibilities** for the relevant stakeholders in MRM (3 Lines of Defence LoD).
- **Model Risk standards/guidelines and procedures** that support the MRM implementation: Model Risk Identification, MR measurement procedures and reporting, management of model development/model changes and general principles for internal validation.



## Model Risk Appetite

- Develop the Statement: **Model Risk Appetite** based specific metrics which quantify the limits of model risk the board is willing to take.

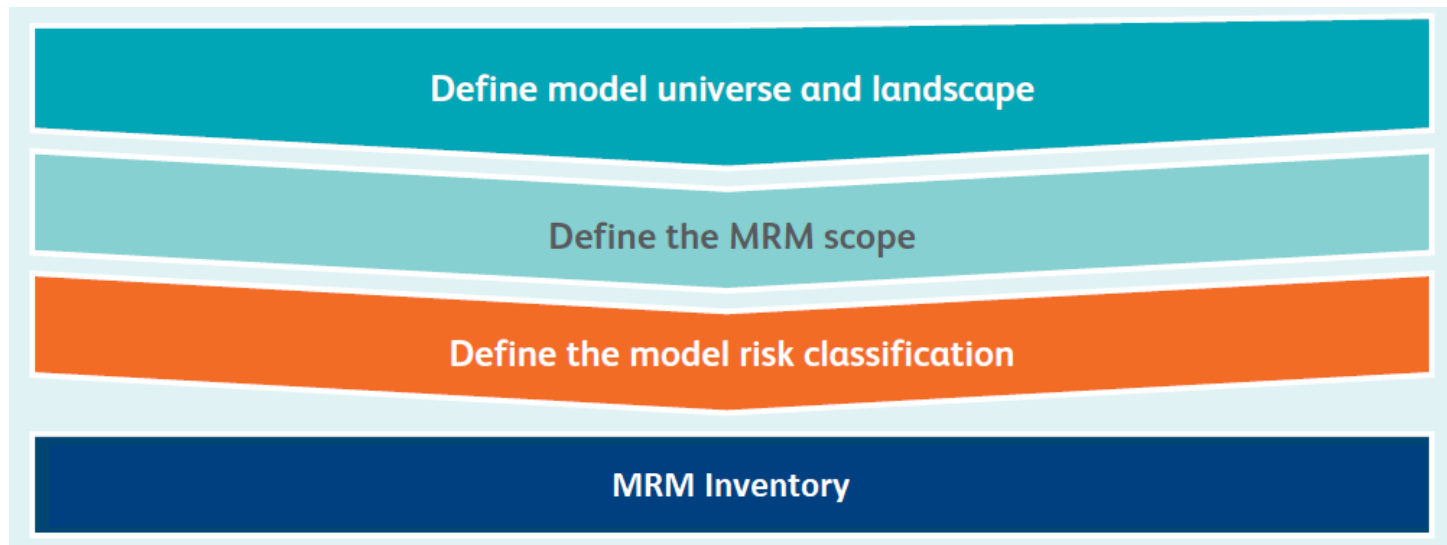
## Model Risk Identification, Aggregation and Evaluation

- **Comprehensive inventory** covering all existing models and framework scope.
- **Models are classified** according to the level of risk.
- **Model Lifecycle** should ensure that each model adheres to the MRM policy at every point time.
- **Reporting, Monitoring of exposure.**

## Model Risk mitigation

- Models are subject to **documentation, controls and validation requirements** based on the level of risk.
- The documentation should include description, key variables, assumptions and algorithms.
- Testing and validation should consider inputs, outputs and methodology.

# Model Risk Identification, Aggregation and Evaluation



- **Define Model universe:** A commonly used definition (e.g. the Federal Reserve's SR11-07)

**Bottom-up approach**, which looks at each of a firm's quantitative tools being used in all its processes, and then decides whether they are models.

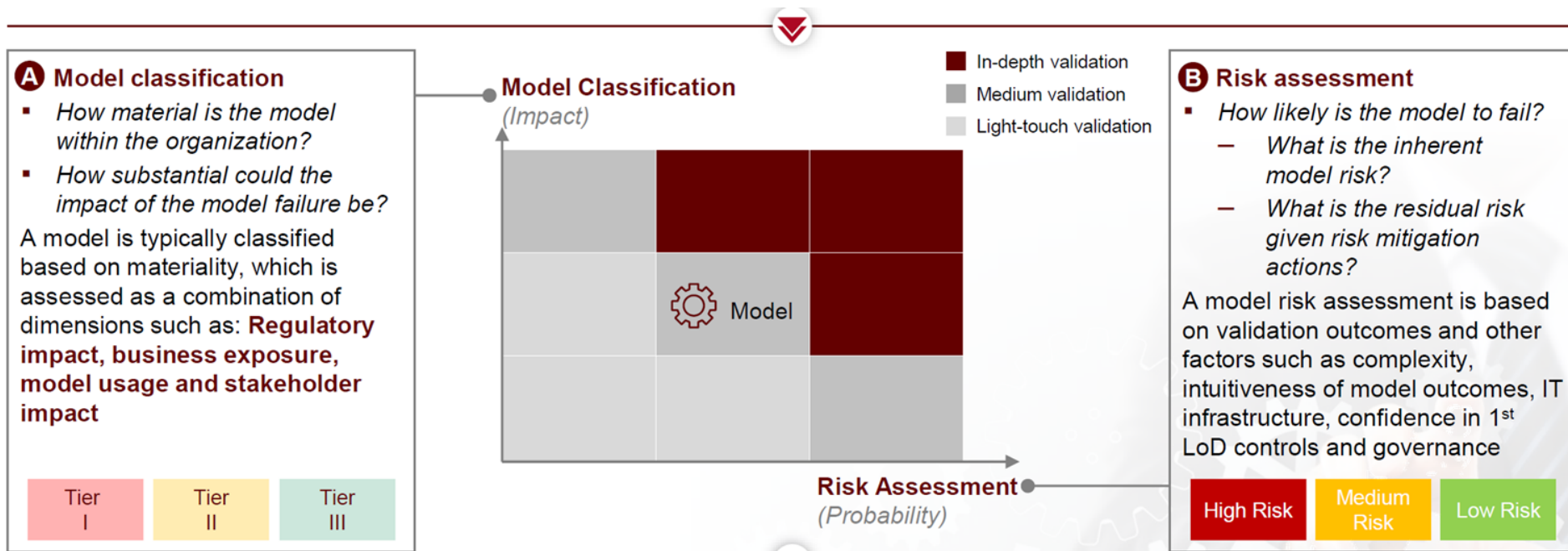
**Top-down approach**, which starts from the measures being used by management in their key decision making and identifies all the models used to produce these measures.

- **MRM Scope:** ideally all of a firm's models should be **within the scope** of MRM. Alternatively possible to define a filtering mechanism.



# Model Risk classification

- The classification of models enables models to be subject to a level of control appropriate to the level of model risk arising from them.



- Regular reviews of the classification, taking into account changes in the business environment and use of models, as well as any coding or data changes so that the classification remains relevant,

# Model Risk inventory

- Develop a **Model Inventory** which provides a key summary of the main characteristics of each model

Dimension	Item	Description
Model characteristics	Item description	ID, name, version, category, champion/challenger, in-house/vendor, data source(s), methodology, output, platform/system
	Model use	Use category, detailed use, use frequency, underlying
	Model dependency	Upstream models, downstream models, associated challenger/champion models
Governance	Key stakeholders	Vendor (if applicable), legal entity, geography, business unit/LoB, owners, developers, validators, users, implementer, business sponsor
	Key dates	Submission date, approval date, deployment date, last validation date, next scheduled validation date
Classification	Key dimensions	Materiality, model usage, external impact, classification result
Risk & Control	Validation	Validation status, last validation type, model risk assessment results, validation frequency
	Risk	Issues from validation (notices), regulatory/audit issues, limitations, ongoing monitoring status
	Mitigation	Compensating controls, remediation action plans, use restrictions

# Model Risk mitigation

- To reduce exposure to model risk and to ensure the institution operates within the boundaries of its risk appetite, model risk mitigants are to be prescribed:
- **Documentation:** All models that are used for business decisions should be properly documented. Without adequate documentation, model risk assessment and management will be ineffective. Documentation should be comprehensive, providing evidence of the diligence used to create the model, capturing the findings of the validation, and clarifying the intended use and limitations of the model; including:
  - Data sources
  - Model Methodology
  - Testing and plan test
  - User's manual
  - Technological Environment
- **Controls.** Implementation of risk-based controls to ensure tools used are accurate, appropriately used and the risk of errors is minimised;
- **Validation** Model validation is the set of processes and activities intended to verify that models are performing as expected, in line with their design objectives and business uses. Validation involves a degree of independence from model development and use

# Model Controls

**Holistic approach** to Model Validation. Not only the mathematics/methodology, but also: Documentation, Quality of the data used, Quantitative aspects, Governance, Technological, Environment, Process.

## INITIAL MODEL VALIDATION AND REVIEW

Validation KPIs and activities :

- Actual vs. Estimation analysis
- Stability Tests
- Discriminatory Power
- Concentration analysis
- Source Code Tests
- Sensitivity tests
- Benchmark tests
- Stress tests
- Convergence Tests
- Counter-checking with expert judgment

## MODEL APPROVAL

Internal Model Approval Process:

- Model Approval requires the model validation to be completed
- Further approval from the senior risk and/or board risk committees

## ONGOING REVIEW AND VALIDATION

Ongoing model validation and review are essential to assessing whether models are continuing to perform as expected new model limitations. Typically, model review and revalidation include :

- Material model changes
- Significant market changes
- Significant product or portfolio changes
- Change in the model risk ranking
- Backtesting
- Model performance deterioration detected by ongoing performance monitoring
- Regulatory and audit concerns

# The Ongoing MRM cycle

**7 Performance monitoring;**  
Propose (re)development of new and existing models;

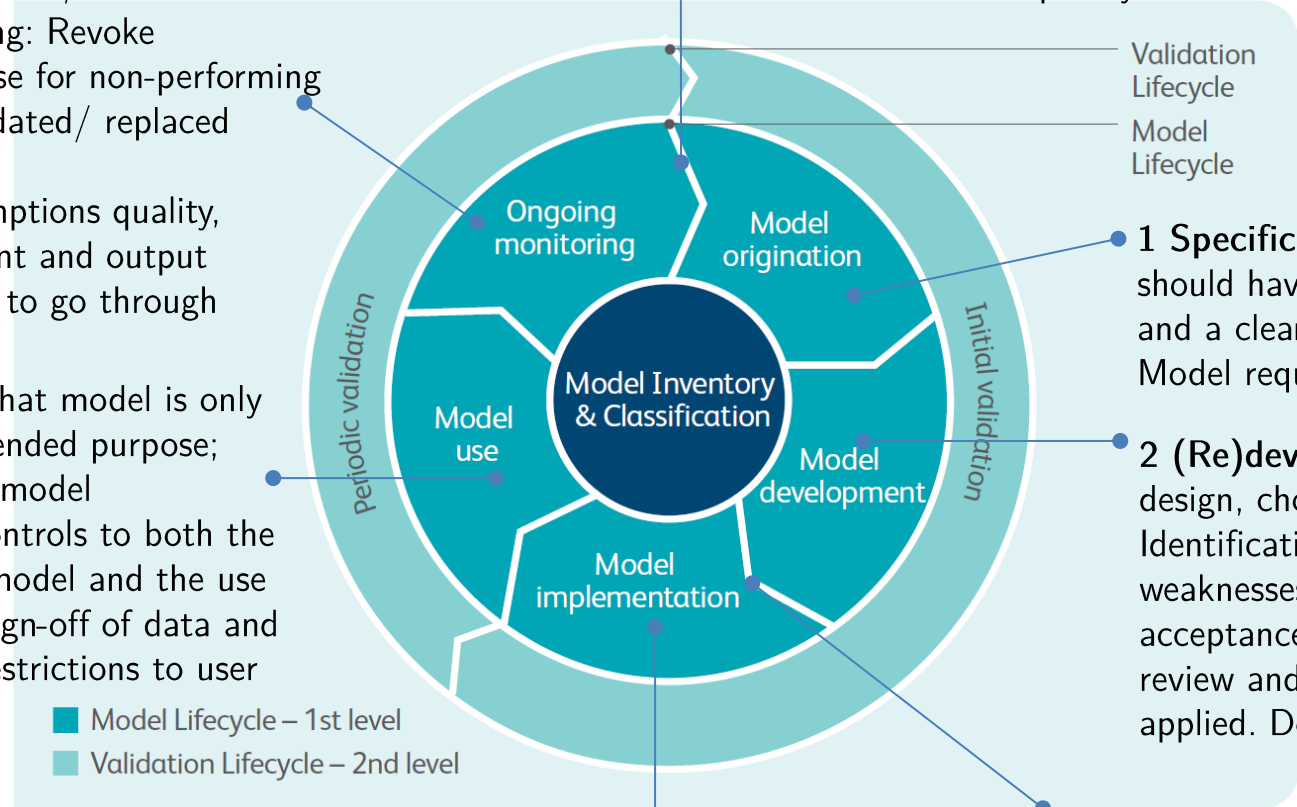
Decommissioning: Revoke permission of use for non-performing or unused/ outdated/ replaced models

Data and assumptions quality, expert judgement and output appropriateness to go through monitoring

**6 Use:** Ensure that model is only used for the intended purpose; Control of post model adjustments; Controls to both the running of the model and the use of the results; sign-off of data and assumptions; Restrictions to user access

**5 Implementation:** secure, “production” environment, Implementation on delivery platform; Functional and user acceptance testing; Defined change control process; back-up and protection tested and validated (generally by an IT control function)

**8 Model Risk reporting to the board** periodically and tailored to meet the board’s interest in model complexity.



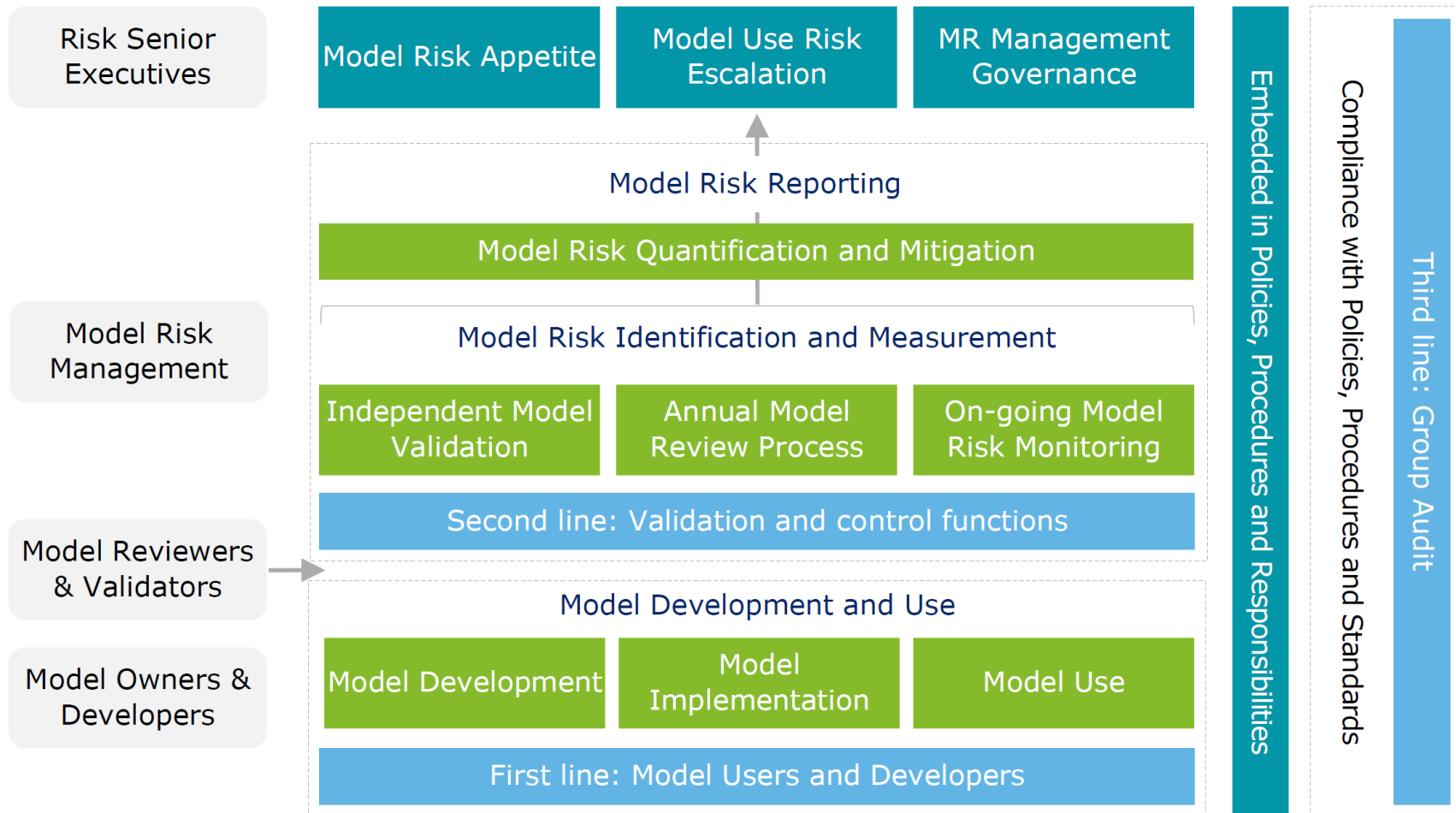
**1 Specification.** Each model should have a (business) owner and a clearly defined purpose. Model requirements definition.

**2 (Re)development:** Model design, choice of methods; Identification of model weaknesses and limitations; acceptance criteria, rigorous review and testing should be applied. Documentation

**3 Classification** and risk assessment

**4 Approval** Permission to use the model for the intended purpose

# Structure Organisation and Governance



# Structure Organisation and Governance

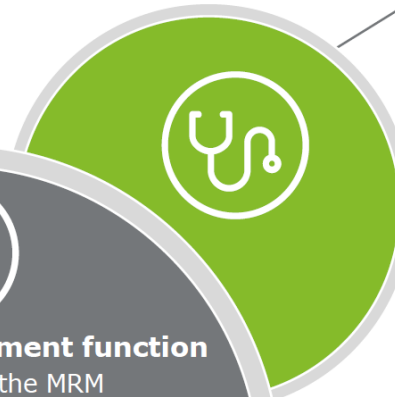
## Model builders / model users

- Distinction to be made between model builders and users
- Clearly establish their respective duties and responsibilities in MRM
- Clear model ownership framework to be established (especially for models used in a number of entities / BLs)
- Both model builders and users are subject to model construction and MRM policies (incl. model risk assessment)



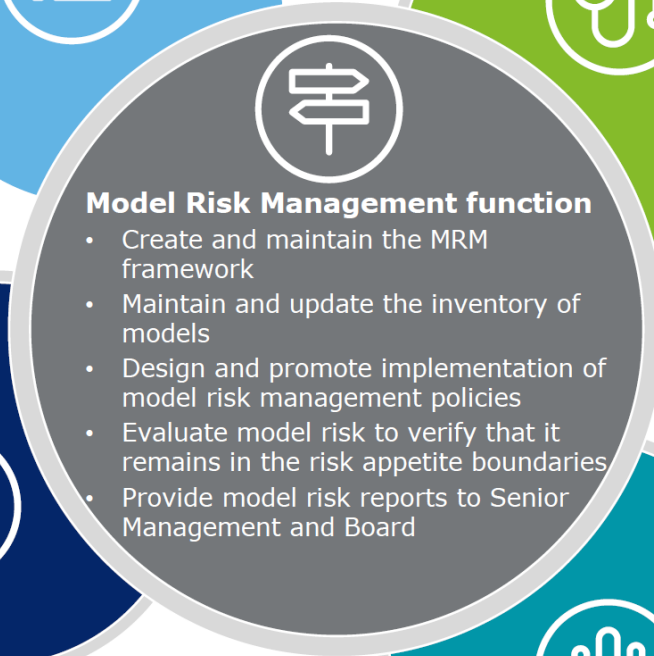
## Model validation

- Perform model validation tests and performance review for models whose model risk is deemed significant or high
- If model health is 'poor' or 'fair', is empowered to propose model risk mitigants and quantification of model risk, in liaison with model owners and with the MRM function
- As an outcome of model validations and performance reviews, confirm or amend model risk ratings
- Strong integration of model validation into a firm's risk culture



## Model Risk Management function

- Create and maintain the MRM framework
- Maintain and update the inventory of models
- Design and promote implementation of model risk management policies
- Evaluate model risk to verify that it remains in the risk appetite boundaries
- Provide model risk reports to Senior Management and Board



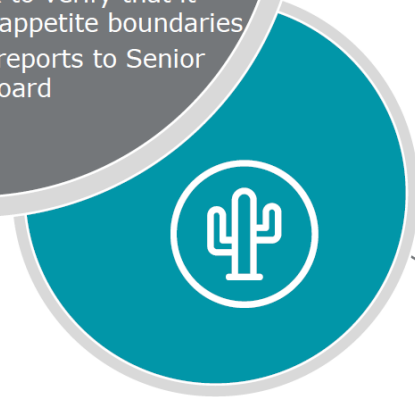
## Three lines of defence

- Implement a model risk control framework
- Report to the MRM function on the related control KPIs feeding the key MR metrics (model materiality, model health, etc.)
- Verification that model risk mitigation requirements are in place



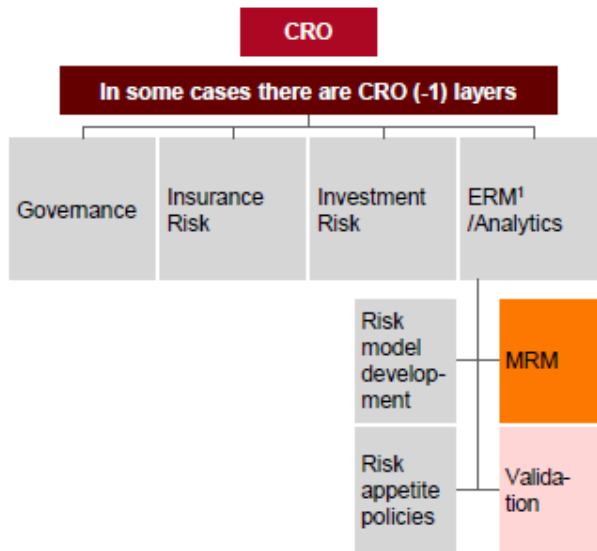
## Operational risk managers

- Capture model risk events in the OR database events
- Report model risk events to the MRM function



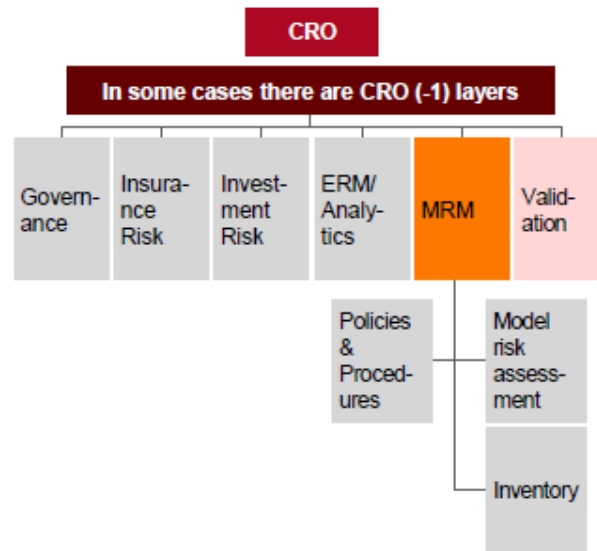
# MRM function set up evolves over time

Archetype 1 – Integrated MRM within the ERM function



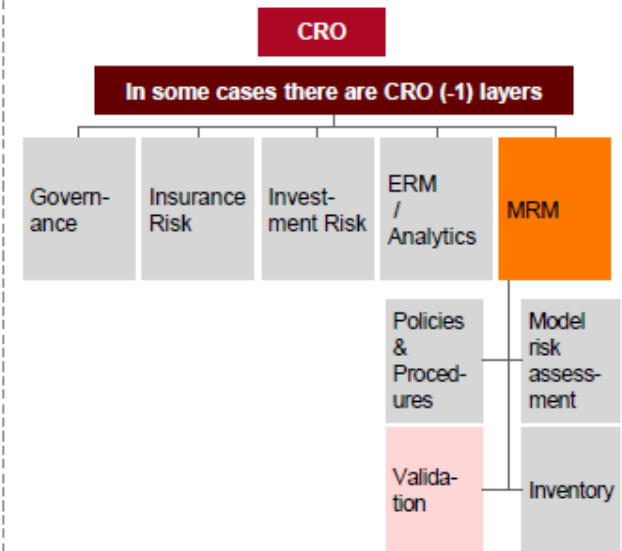
- ⊕ Appropriate for organisations aiming to centralise MRM activities
- ⊕ All risk management functions report to the CRO
- ⊕ Centralisation of MRM activities under the ERM function as an enabler for standardisation, and alignment with development standards
- ⊖ Can lead to issues of independence between MRM and validation functions
- ⊖ Centralisation might lead to excessive focus on other model activities (e.g. model development) and low priority for MRM

Archetype 2 – Fragmented MRM function



- ⊕ Suitable for organisations aiming to keep MRM and model validation as separate functions and at same level of risk management reporting hierarchy
- ⊕ Both functions independently report to the CRO
- ⊕ Specific MRM functions at the same level of risk management to ensure specific focus on model risk
- ⊖ Potential lack of consistency and leverage between MRM and validation functions in terms of methodologies, processes, and standards
- ⊖ Possibility of lower prioritisation of MRM compared to traditional regulatory model validation

Archetype 3 – Integrated model risk management



- ⊕ Suitable for organisations aiming to keep MRM and model validation independent, but placing MRM function higher in the risk management reporting hierarchy
- ⊕ Both functions independently report to the CRO
- ⊕ Specific MRM functions at the same level of risk management to ensure specific focus on model risk
- ⊕ In addition, this structure ensures appropriate level of prioritisation of MRM activities compared to development and validation-only activities
- ⊕ Centralisation of MRM activities under the MRM function as an enabler for standardisation, and alignment with development standards

<sup>1</sup> In archetype 1, MRM does not always sit within ERM (it could be risk analytics, or another function). No standard reporting structure for MRM is observed across EU banks. Source: Risk Dynamics MRM Survey



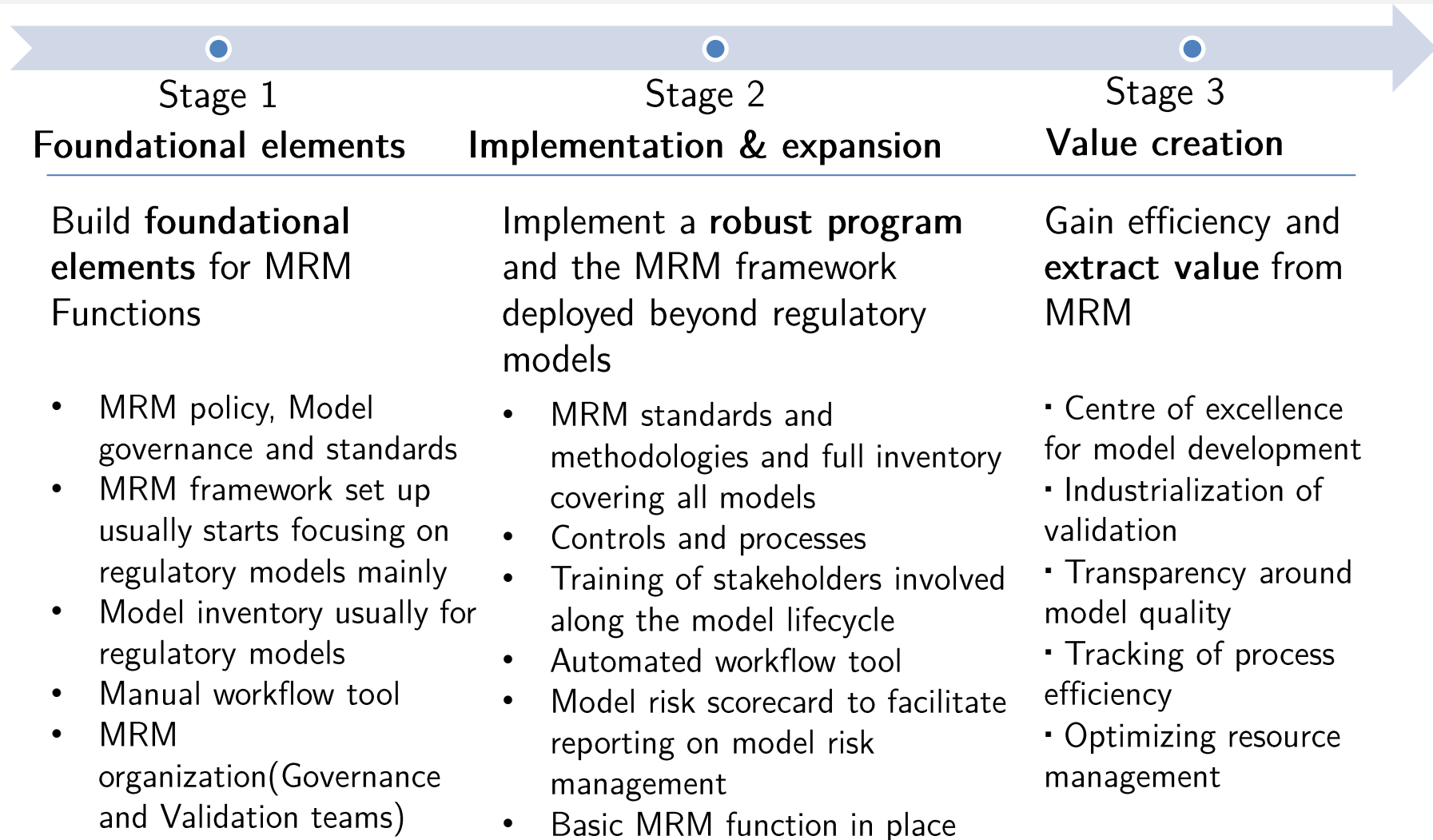
# Model Risk Policy



# High level view of the market

- Model Risk Management (**MRM**) is still an **emerging field**.
- Some **academic and leading industry partners** have developed some **key concepts** to implement in the framework. Quantification of model risk is an emerging academic field and currently no robust framework exists.
- Companies across the market are at various different stages of MRM implementation:
  - Ranges from initial discussions to more or less advanced stages of implantation
  - Larger organisations tend to be ahead and have a more formalised approach
  - There is a distinction
    - between the Life and Non-Life Insurance market with Life Insurers typically being more advanced
    - across geographies with the US being more advanced than Europe and
    - the banking sector being one step ahead of the insurance industry

# MRM has three evolutionary stages





# Business Benefits of Robust MRM

## Prevent issues occurring, before they arise

Natural human tendency to prioritise models which have recently caused problems.

Strong MRM should improve the ability of an organisation to spot potential problems at an earlier stage, allowing remediation activities to take place, minimising the future impact on the bottom line.

## Holistic view of model risk -> consistency

not solely confined to regulatory model. Widens the scope of consideration to models that are not subject to regulatory requirements but may still materially impact the business i.e. helps broaden the view of model risk beyond the capital model.

## Maximise cost/benefit allocation of resources

can identify areas where the most benefit will be obtained through model improvements or where the addition of a new model or control may be beneficial to an organisation which in turn will ensure resources are allocated to the areas yielding the greatest overall impact on the business.

## Reduced likelihood of poor decisions

Decisions based on the outcome of a model where the model is not fully understood may result in a misinformed decision being taken.

## Cultural understanding models are inherently risky

will lead to better communication with stakeholders

## Improved control efficiency

improved understanding of the model control framework will allow identification of potential duplications or inefficiencies.

## Better understanding of assumptions, limitations & output

## Increased confidence in business planning process

through reduced volatility in the capital calculations and greater confidence through better informed planning assumptions.

## Capital benefits

better informed view of capital buffers, reduced capital requirement through lower likelihood of uncertainty loadings

## ...to recap

1

**New topic.** MRM is a new topic in the insurance industry that is **emerging on the CRO agenda**. Most large insurers have set up or are looking into setting up MRM functions.

2

**Best practice.** Insurers acknowledge that it is in the industry best interest to **develop MRM from an industry perspective rather than to be led by regulation** (as it happened in the banking industry or for Solvency II internal model validation)

3

**Risk bases.** Most insurers see substantial benefit in a **proportionate approach focussed on the most material models from a business use perspective**. The list of most material models needs to be determined by the institution and will be insurer specific.

4

**ID approach.** All insurers prefer a **top down approach** starting from their model landscape and then identifying their most material models. Such an approach will be **more efficient and effective** in demonstrating the benefits of MRM.

5

**Wide scope.** Most insurers remain focused on regulatory models. Large insurers have expanded their scope into mainly **valuation and pricing models**. Insurers agree that MRM should focus on **providing assurance that all material models (not just regulatory ones) are properly controlled**.

6

**Artificial Intelligence & Machine Learning** is a focus point for some insurers setting up MRM. These models also require **changes to validation frameworks** focussed on **bias detection and interpretability**.

# Main references

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# Grazie per l'attenzione!

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