Internal models – key challenges

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April 2010

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Internal models – what does an internal model mean?

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What is an internal model?

Not explicitly defined in the Directive

But broader than the calculation engine used to calculate technical provisions and capital requirement

Framework for assessing company risk, capital requirements including the controls around inputs and outputs from the framework.

Encompasses data, development of probability distributions, calibration and so on as well as assessment of outputs, feed back loops etc.

Groupe Consultatif/CEA Definition

Groupe Consultatif/CEA Solvency II Glossary, March 2007

"Risk management system of an insurer for the analysis of the *overall* risk situation of the insurance undertaking, to quantify risks and/or to determine the capital requirement on the basis of the company specific risk profile.

Within the Solvency II framework an internal model is intended to fully or partially replace the standard formula for the calculation of the Solvency Capital Requirement. Both quantitative and qualitative requirements will be set by the regulator and explicit approval has to be granted by the supervisor"

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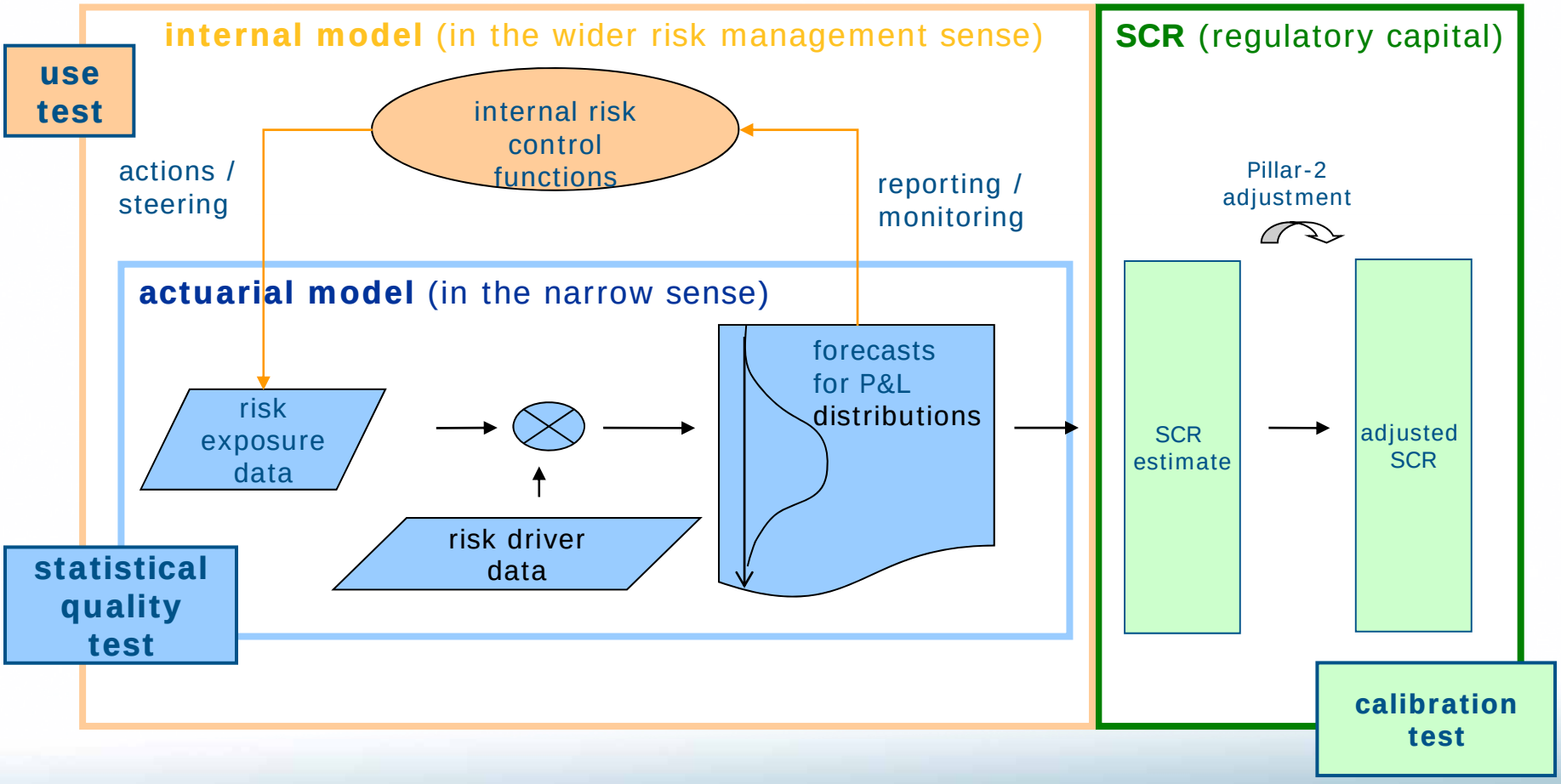
Internal Models Framework – FSA Interpretation



[5] Source – Paolo Cadoni, Financial Services Authority presentation in October 2008

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Internal models – statistical and calibration challenges

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Satistical Quality & Calibration Issues

Statistical Quality	• **Concerned with the quality of data used to calculate the SCR including data used to develop the *probability distribution forecast* (PDF) and quality of methodology and assumptions.**
Calibration	• **Concerned with ensuring that internal model produces results equivalent to VaR 99.5% over one year.**

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Statistical Quality Issues

CEIOPS –DOC-48/09

"5.1 an internal model is not just a black box or an expert with good predictive power for the probability distribution forecast. Instead, the various elements making up the internal model and the inputs used have to pass quality standards"

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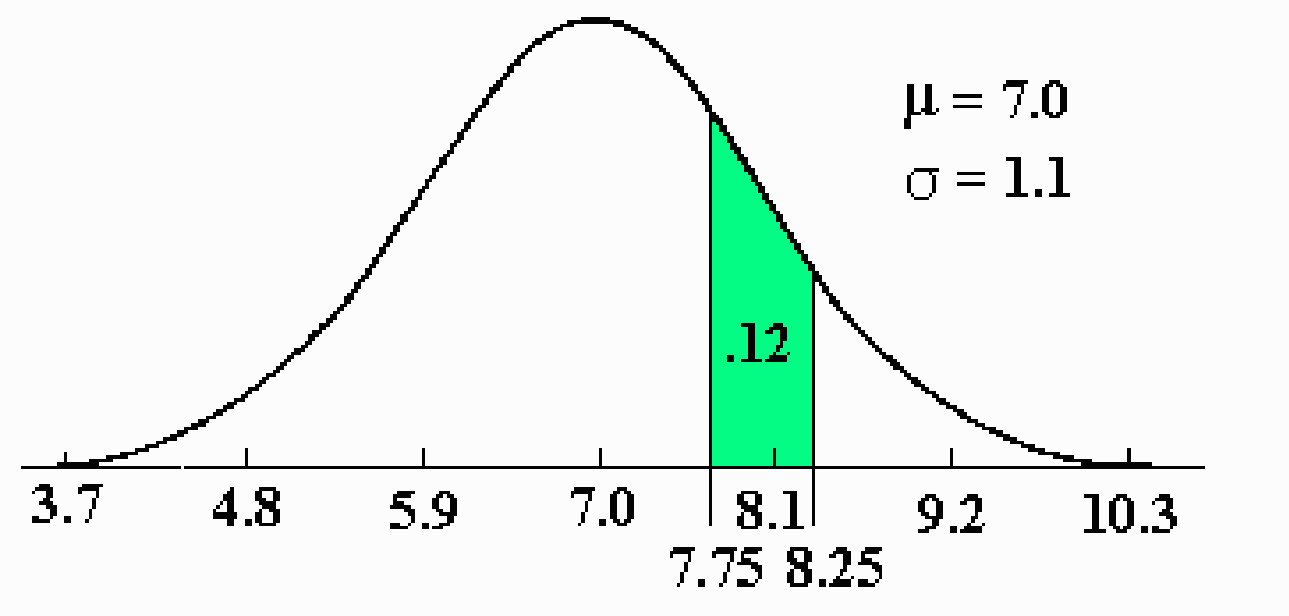
Probability Distribution Forecasts

- Defines the likelihood of different outcomes along a scale



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Probability Distribution Forecasts continued

At the heart of the internal model

- “garbage in, garbage out” principle applies

CEIOPS –DOC-48/09

“5.47 The probability distribution forecast shall refer, among other things, to a quantity of monetary value such as profits and losses. Accordingly, any **methodology** ***that valuates the financial impact of future events is also subject to statistical quality requirements.”***

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PDFs – Data

The Level 1 Text defines a PDF as *"a mathematical function that assigns to an exhaustive set of mutually exclusive future events a probability of realisation"*.

In theory, the term "exhaustive" could imply a continuous probability distribution or close to continuous.

PDFs – Data continued

In practice, there will not exist sufficient data to generate a truly continuous distribution and the level of data available will depend on the type of risk and the size of the company.

- **There is a considerable amount of date in relation to market risks and ESGs have developed significantly over the last decade**
- **Less data in respect of underwriting risks, to varying degrees depending on the risk e.g. more data available on mortality than say lapse risk or non-life catastrophe risk**
- **In a lot of cases, more limited data on operational risk**
- **Small companies will naturally have less data than larger companies, but could combine internal data with market data or other data where available**

Expert judgement will be critical.

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PDFs – Data continued

CEIOPS final advice stipulates that undertakings should use all relevant information available in order to maximise the "richness" of the PDF.

Naturally, a PDF with more data points is richer but CEIOPS cautions against "unfounded richness".

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PDFs – Data continued

A PDF with limited distribution points can still meet the standards provided:

- It takes into account current knowledge and developments in internal modelling or the undertaking can justify not taking into account some aspects on proportionality grounds
- Alternative methods that generate more data points are not available or would be disproportionate
- Model meets or exceeds generally accepted market practice where this has been established
- Any shortcomings are compensated for by additional measures (it is not clear what these may be)

Expert Judgement

Expert judgement will inevitably play a role in constructing a PDF

- To greater or lesser extents for individual risk factors, depending on the level of data available

Role of expert judgement is acknowledged by CEIOPS provided its use is well-founded and follows a scientific method where it has a material impact:

- It must be **falsifiable** … must be able to define circumstance where expert judgement would be considered false
- The expert must be **transparent** as to level of uncertainty (scope, basis, limitations)
- **Standards** concerning methodology used must exist and be maintained
- Expert judgement must be **documented** and a **track record** of expert judgement be available

Expert Judgement continued

Follows a scientific method ...

- It must be **validated** e.g.
  - Assess the track record of the expert judgements to assess reliability
  - Challenge using other experts
  - Compare expert judgement with existing and emerging data

Potentially challenging requirements

- although it should be noted that they apply where the impact of expert judgement **is material**
- In addition, CEIOPS dropped the requirement that expert judgement have a known or potential error rate in its final advice

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PDFs – Other points of note

Proportionality	• It is interesting and welcome to note that CEIOPS makes a number of references to proportionality in its final advice (nature, scale, complexity etc.)
Systemic risk	• Arises where heavy reliance on industry developed methodologies and practices.
Groups and solo entities	• CEIOPS views overall aim is to develop PDF at overall Group level, but may need individual entitty and Group PDFs e.g. for lapses.

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Aggregation – Diversification Effects

- Potentially more challenging than developing a PDF for individual risks.
- Most companies likely to use correlation matrices
  - Some companies may use more complex approaches to develop multivariate distributions with dependencies e.g. copulas
- Likely to rely more heavily on expert judgement.
- May need higher validation standards, references to scientific or other sources
  - Supervisory authorities will require a detailed description of the methodologies used.

Diversification Effects continued

Undertakings will need to be able to demonstrate that the system for measuring and recognising diversification effects (DE):

- **Identifies the key variables driving dependencies**
- **Provides support for existence of DE**
- **Justifies assumptions underlying modelling of dependencies**
- **Particular consideration taken of extreme scenarios and tail dependence**
- **Tests robustness of system on a regular basis**
- **Takes DE actively into account in business decisions**

Diversification Effects continued

SIAS paper, October 2009 Practical Implementation Challenges of Internal Models under Solvency II

"It could arguably be one of the significant potential flaws in the Solvency II regime that while individual risks may with some confidence be fitted to appropriate Probability Distribution Forecasts, that these will then be aggregated using correlations that firms (and CEIOPS) find almost impossible to give a full and comprehensive justification to."

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Calibration Issues

Calibration of SCR should correspond to VaR 99.5% over a one year time horizon

- **Value at Risk of Basic Own Funds**

Directive allows use of a different risk measure or time horizon

- **e.g. TailVar or Conditional Tail Expectation (CTE) over the life of the portfolio**
- **provided this results in an equivalent level of protection.**

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Calibration Issues continued

Equivalence should be demonstrated at least annually

- Not a reconciliation between 2 different models (i.e. regulatory and economic capital purposes)
- Process that explains the differences in how same model is used and the rationale

CEIOPS advice requires, where the time period is different to 1 year, that the undertaking

- Demonstrates that the model takes into account the time effect of the risks to which it is exposed
- Demonstrates that all significant risks over a 1 year period are managed
- Pays special attention to the choice of data used
- Justifies time horizon in view of average duration of liabilities and the uncertainty related to long time horizons

Calibration Issues continued

Benchmark portfolios

- Supervisors can require companies to run internal model using a benchmark portfolio
- Level 3 measures will be developed regarding construction of the benchmark
- Will be some flexibility for supervisors as single benchmark not appropriate for all companies
- Supervisory request could be at model application stage or if the supervisor subsequently has concerns

Most UK companies likely to model on a VaR 99.5% one year basis

Internal models – Developing the calculation components

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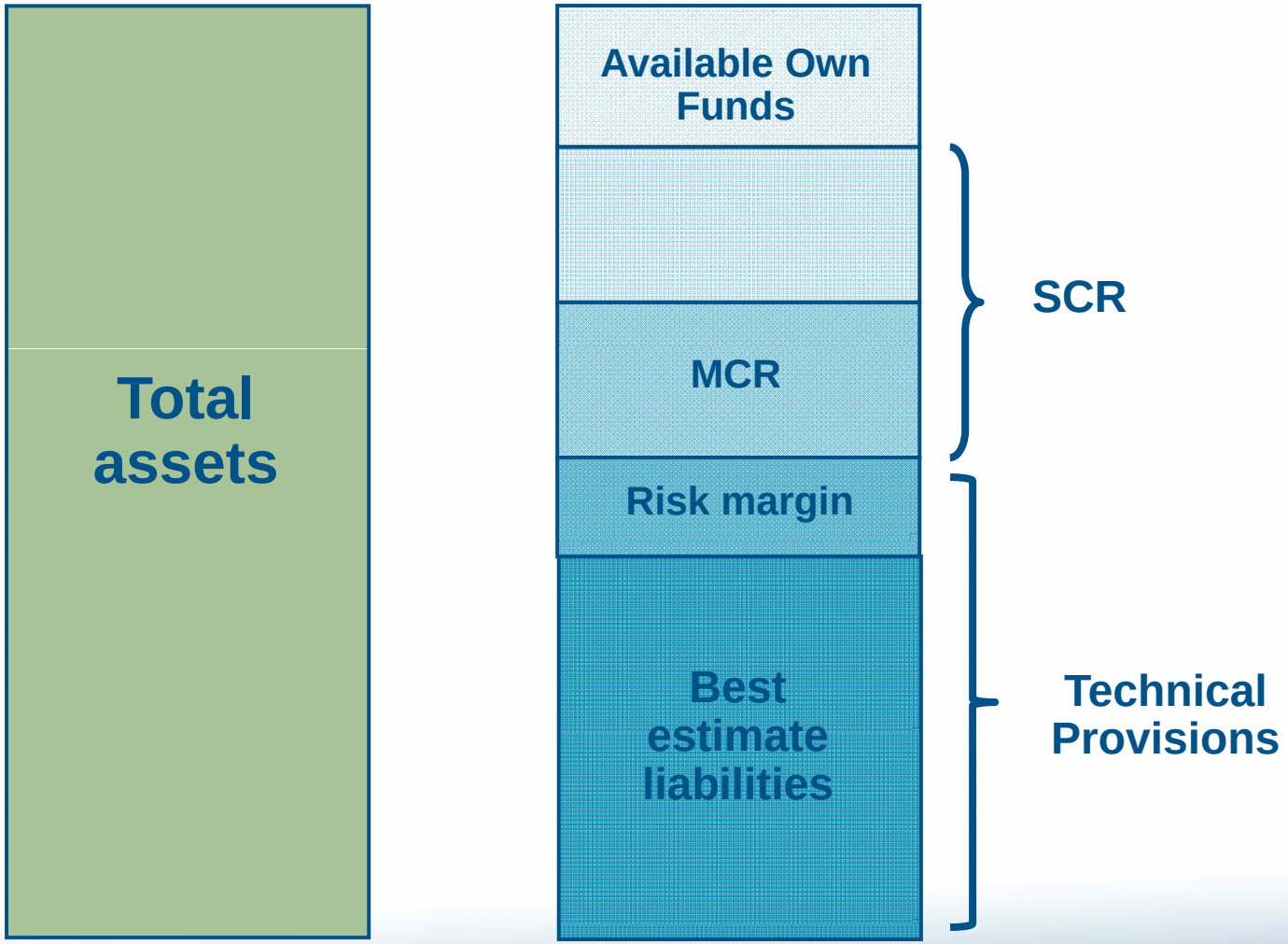
Solvency II Balance Sheet



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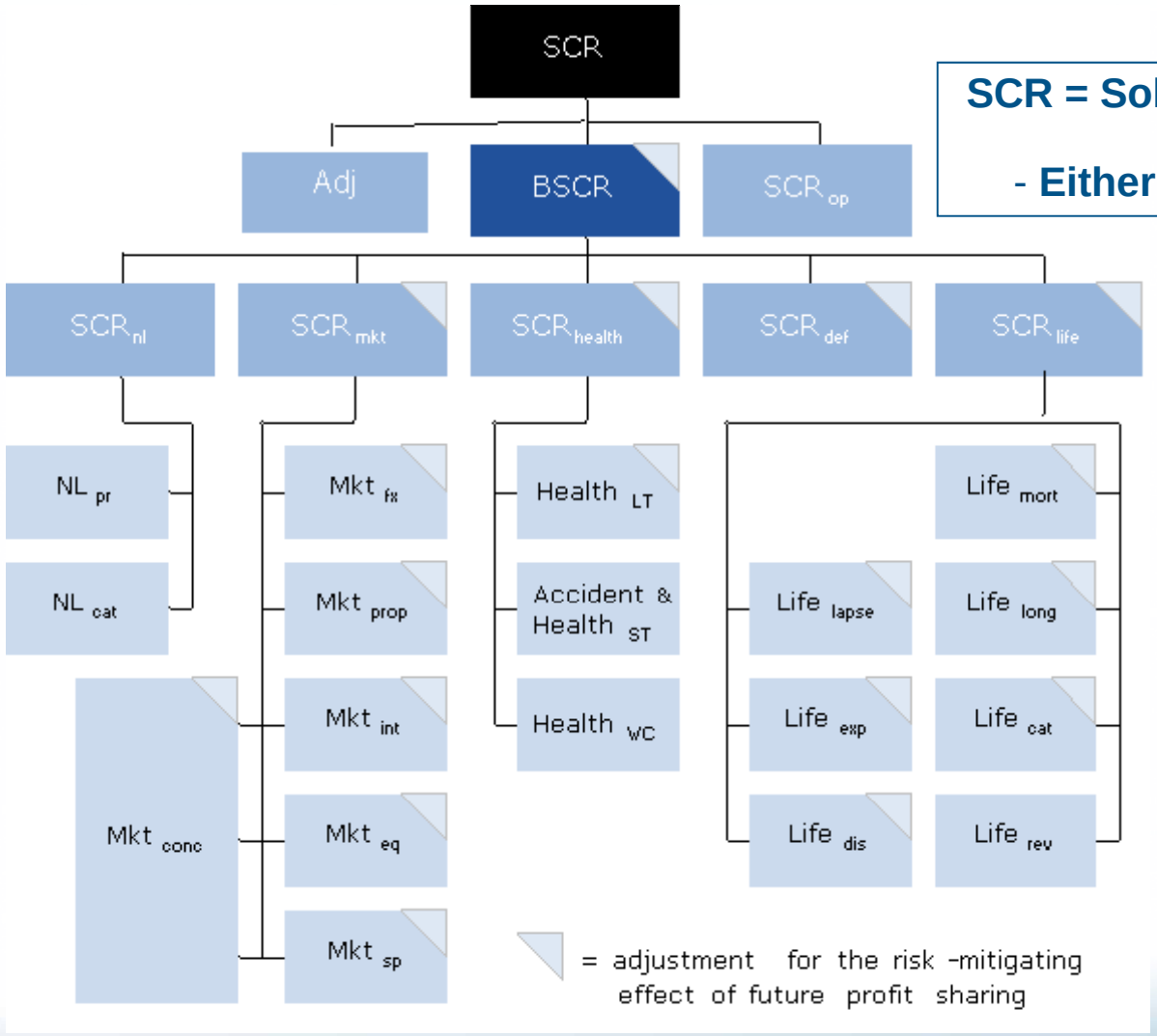
SCR Standard Formula



SCR = Solvency Capital Requirement
- Modular design
- Either formula or shock impact

Modules

Sub - Modules

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SCR Standard Formula Correlation Matrix

- Market Risk draft QIS5 specification

CorrMktDown	interest rate	equity	property	spread	currency	concentration
interest rate	**1**					
Equity	**0.5**	**1**				
Property	**0.5**	**0.75**	**1**			
Spread	**0.5**	**0.75**	**0.5**	**1**		
currency	**0.25**	**0.25**	**0.25**	**0.25**	**1**	
concentration	**0**	**0**	**0**	**0**	**0**	**1**

Solvency II Economic Balance Sheet

Will often require monte carlo stochastic calculations	Internal models may involve nested stochastic modeling	Issues can arise with meeting reporting deadlines and delivery of timely MI
• Significant computing power and time may be required	• Stochastic within stochastic • Even greater processing and run time challenges	• particularly in the context of the Use Test

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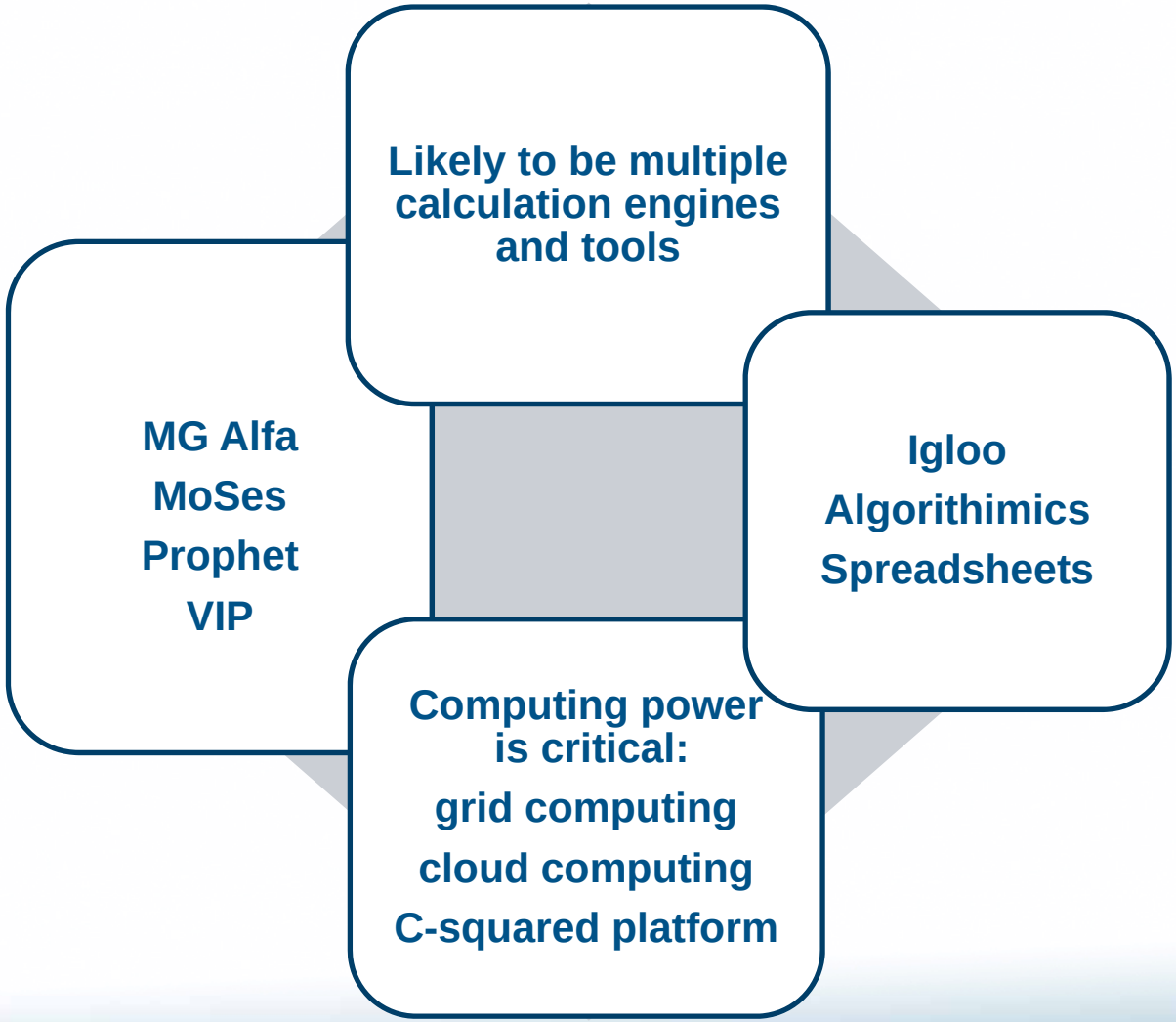
Modelling systems



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Replicating portfolios

- Modelling of liabilities by reference to closest equivalent assets
- Can be a powerful closed form solution as an alternative to stochastic modelling, particularly where non-financial risk is not significant

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Replicating portfolios continued

- The market consistent value of the replicating assets represents a proxy for the value of Solvency II technical provisions
  - Can be used to approximate SCR (and MCR) calculations during the year, particularly where non-financial risks are not material
  - In practice, non-financial risks probably won't be immaterial for an insurer and so replicating portfolio approach will be more approximate particularly:
    - When dynamic policyholder behaviour is taken into account
    - If discernible market movements since replicating portfolio was constructed
  - Replicating portfolio will need to be rebalanced from time to time

Model compression

- An alternative practical solution is to compress the input data
  - Essentially a model point approach
- Model point approaches have been used for many years
- Modern approaches make use of clustering techniques
  - Development of vectors using policy data and seriatim calibration runs
  - Recursive process that combines groups of policies into clusters or model points
- Stochastic projections then run using model points rather than policy by policy
  - Run times and processing power can be dramatically reduced

Model compression continued

Model compression can be more powerful than replicating portfolios

- **Allows modelling of non-financial risks**
- **Dynamic policyholder behaviour can be modelled**
- **Requires a small number of calibration scenarios compared with many economic scenario runs for replicating portfolios**

Model compression can be used in conjunction with replicating portfolios

Further reading: "Cluster Analysis: A spatial approach to actuarial modelling (Freedman, Reynolds)"

Internal models – The challenges of project management

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Internal models – project management challenges

IAIS - 2008

"An internal model is a risk measurement system developed by an insurer to analyse its overall risk position, to quantify risks and to determine the economic capital required to meet those risks. Internal models may also include partial internal models which capture a subset of …"

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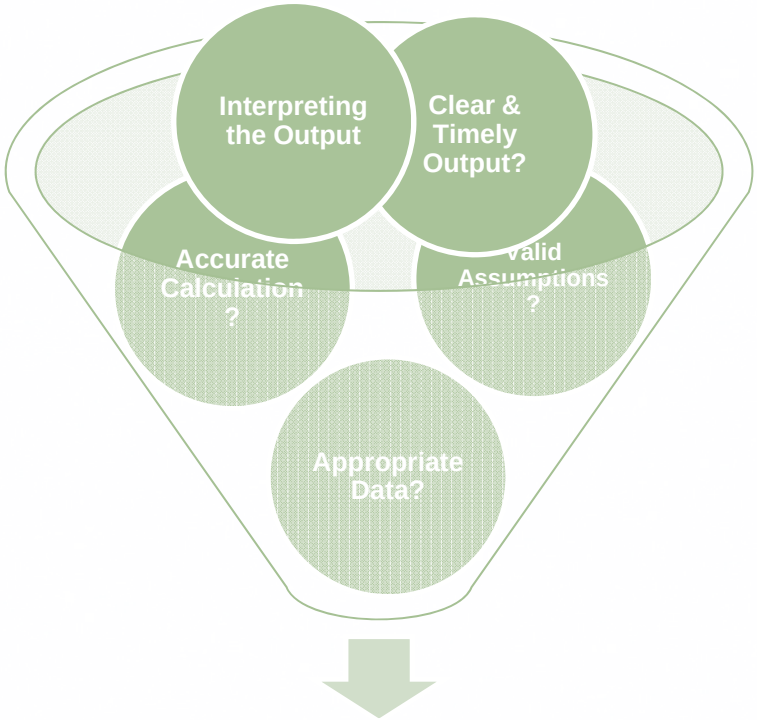
Internal models – project management challenges



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Internal models – project management challenges

- Early engagement of the business
- Education of the Board and senior management
- Data quality management
- Systems development
- Resources with the required skill levels
- Tie in to other business projects
- Ensure a long term viable and useful internal model
- Internal model approval by the supervisor
- Meet the use test

Early engagement of business

- Early engagement with the business unit managers and business leaders will be key.
- This is not just a technical exercise for the IT or actuarial departments on capital allocation.
- More than just a compliance exercise?
- It must not seem remote – the importance needs to be appreciated across different areas:

Marketing	Sales	Underwriting
Risk Management	Strategy	Finance

- The output needs to be presented in an understandable and relevant way.

Early engagement of business

- Early buy-in from the leaders across the business will make subsequent project stages much easier:

- Early assessment of the impact of Solvency II requirements and the internal model on current processes for data management, systems development and financial reporting.

- Potential problems and issues in our experience:
  - Underestimation of the resource commitment and time required.
  - Silos and internal competition allowed to develop.
  - Key resources lost.
  - Buy-in not set up to be ‘persistent’.

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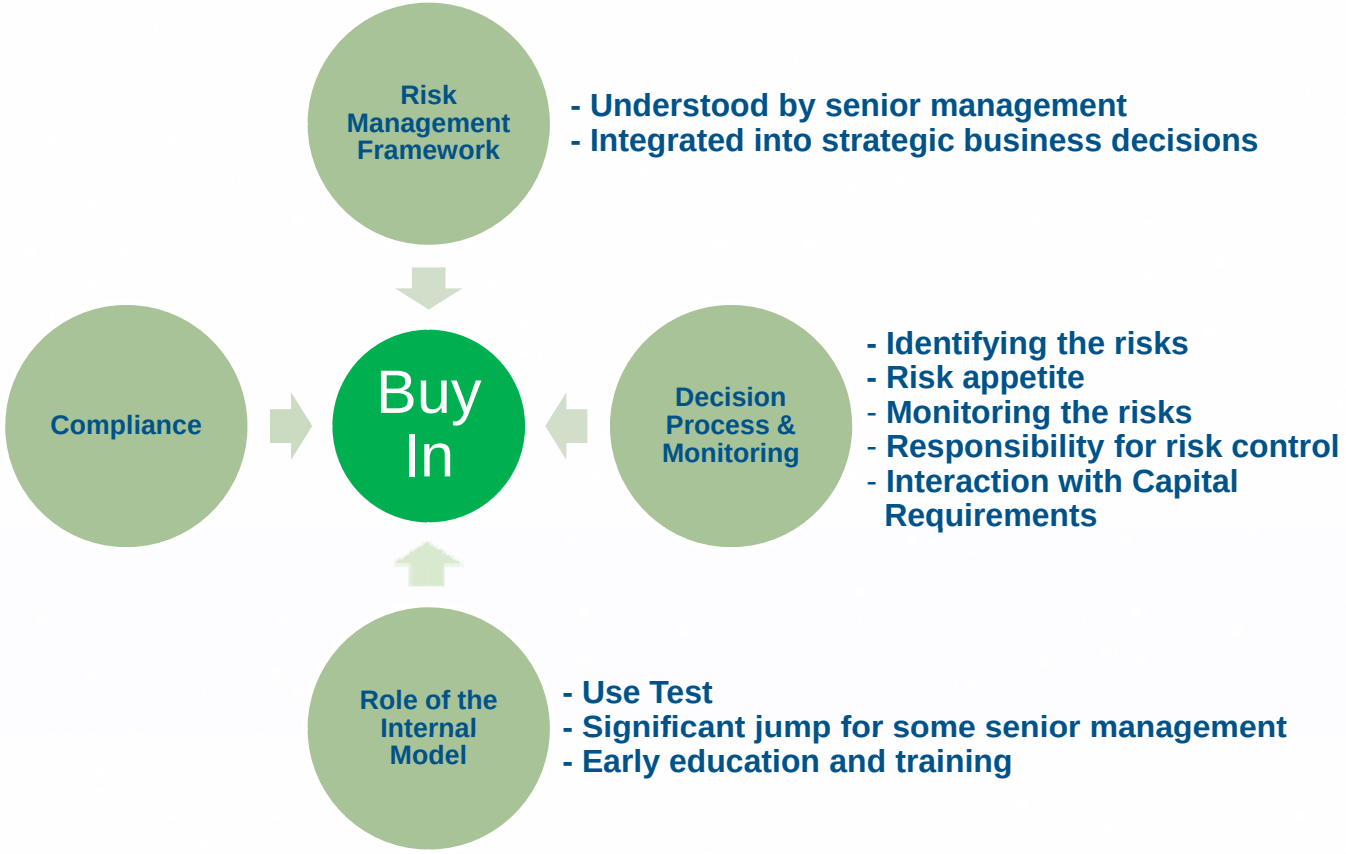
Educating the Board and senior management



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Educating the Board and senior management

- Some of the areas on the previous slide are more complex than others
- The outputs from the Internal model need to be understandable by the appropriate audience – preferably as wide an audience as possible:
  - Risk exposures
  - Economic capital output
  - Related to actions
- For some this will be a major behavioural change:

Securing buy-in and understanding	Reorganising the business	Suitable, fit and proper persons

- Arguably, most difficult of all is deciding the appetite for the different risk types and for risk as a whole.

Different stakeholder expectations	Business objectives	Ability to raise capital

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Data quality management

- Key that the project management plan addresses this from the start
- Data used in the operation of internal models – CPs 43 and 56
- Also need to consider all data that is key to the running of the business – for input into the ORSA
- Ongoing process and feedback loops:

- Key tests:
  - Accuracy ✓ Completeness ✓ Appropriateness ✓
- Need to understand the limitations of the current data quality.

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Data quality management

- Big issues from our experience with clients:

Building a data policy with measurable, actionable quality standards.

Providing a consistent assessment of data quality.

Documentation of responsibilities and controls with respect to data quality.

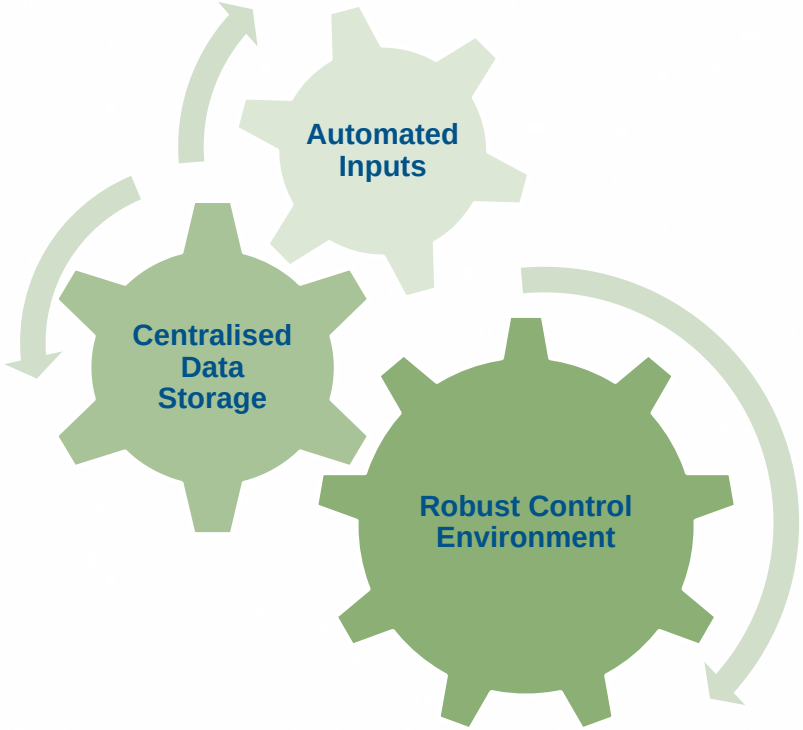
Managing data received from third parties.

Using external information.

Need to consider the business needs and the timing of these needs – collection of data should not be overlooked.

Systems development

- Solvency II is likely to require a more structured, larger scale approach to systems.



- Need to allow enough time for testing.
  - Back testing
  - Calibration loop

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Designing the output

Decide who the users will be and what they require

Design education programme

Prove robustness to gain buy in from external users

Consider the implications of the Pillar III disclosure and reporting frameworks

- Use this to define the outputs
- Need to consider strategic implications

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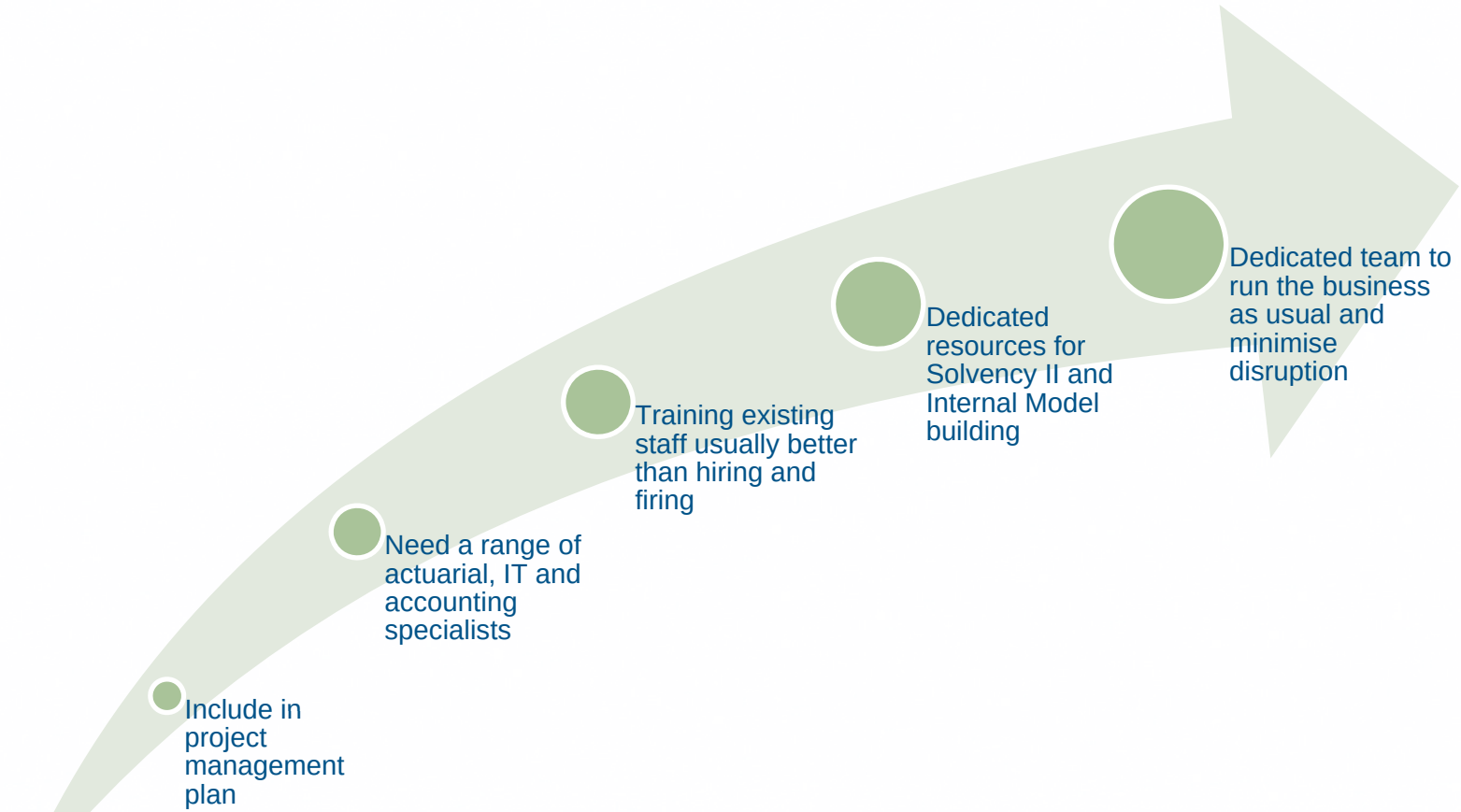
Fit for purpose resources



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Ensure a long term viable and useful Internal Model

"A model is for life, not just for..."

For some companies Solvency II is their first excursion into a full economic capital.

Costly to implement and to maintain

The updating of the model must be included in the project plan.

- Model could quickly become out of date
- Fail the use test
- Or worse: base strategic decisions on inappropriate output

Supervisors, Boards, analysts and other users of the results need to have confidence that the model is an accurate reflection of the risk profile and strategies of the company.

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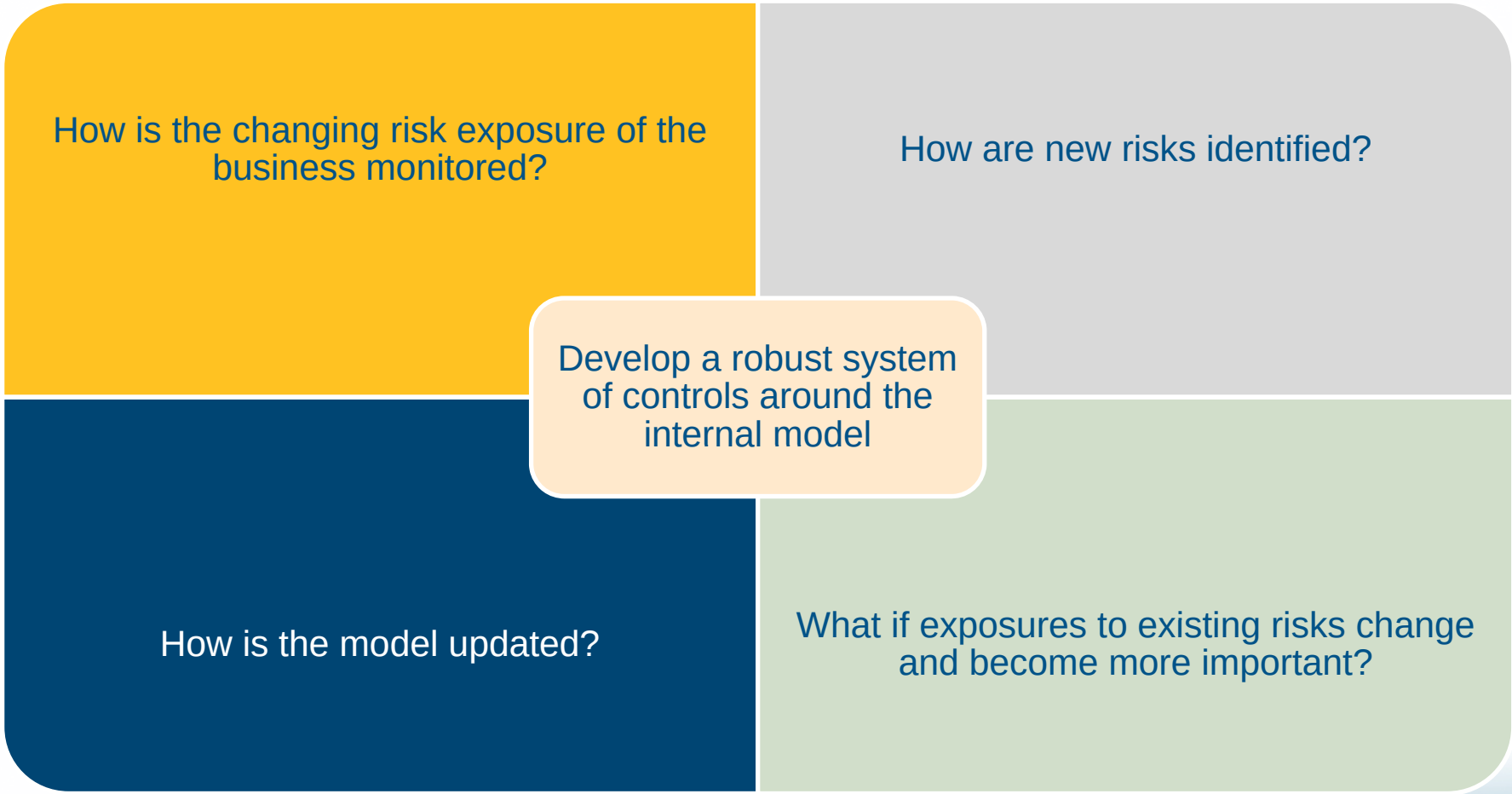
Ensure a long term viable and useful Internal Model



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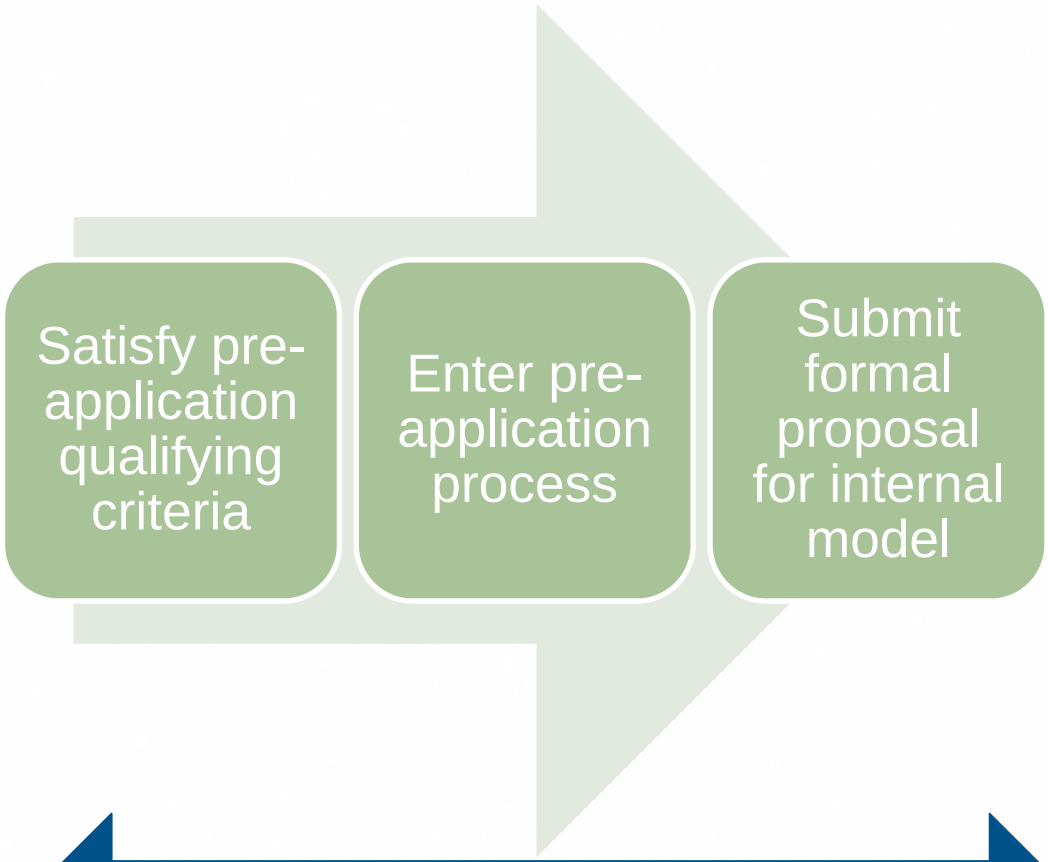
The pre-application process

Evolving Process



Comments from the FSA

- No firms yet accepted
- Generally okay
- Main issues are with project plan details

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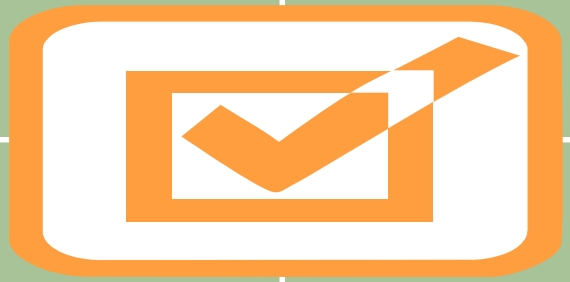
Internal model approval

Is the model used in the running of the business as a whole?

- Trusted output
- Not just valuation or capital management

What is the level of understanding amongst senior management and the Board of the model and what it does?

- Early engagement with the Board



What are the control and validation procedures around the internal model?

Partial or full internal models?

- Which risks should be dealt with first?
- How will the partial internal model be integrated?
- What is the process for bringing remaining risks into the internal model framework?

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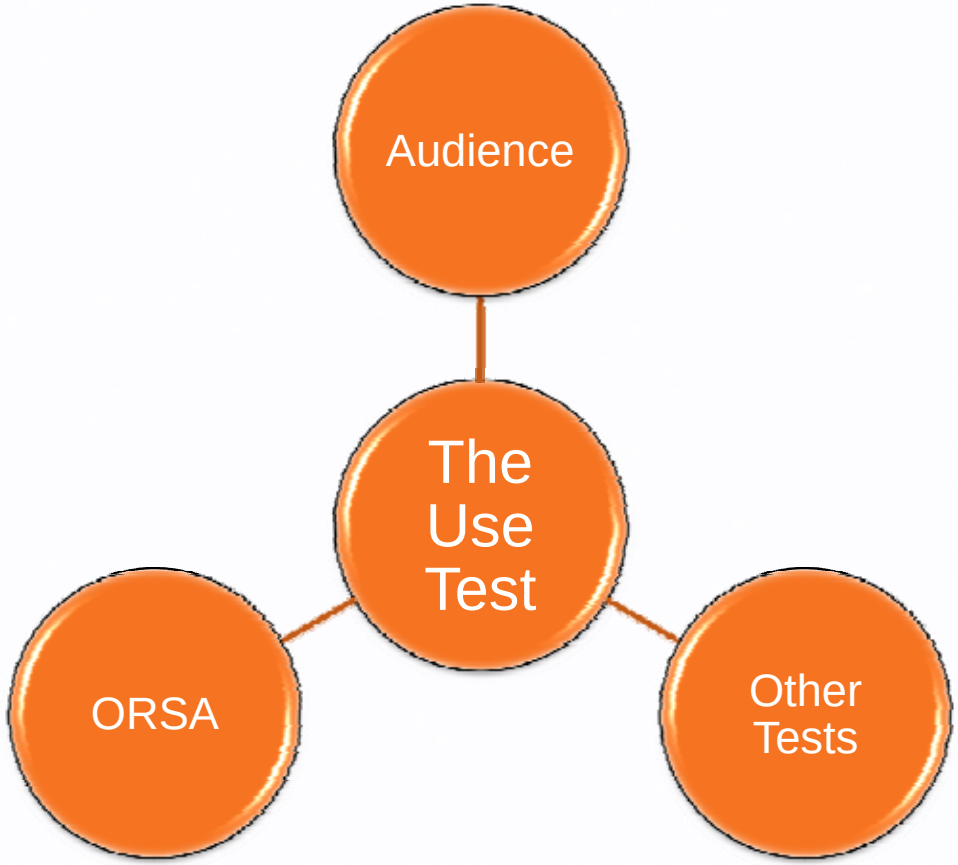
The use test



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Other Tests

- Statistical Quality
- Validation
- Calibration
- P&L Attribution
- Documentation

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Summary

In summary, the key steps to take are:

Early engagement of the stakeholders – including the education of the Board and senior management.

Assessment up front of your data and systems current capabilities and of what is required.

Be clear about the users and therefore required output from the model.

Skilled resources should be trained and retained.

Long term project management.

Integration of the wider requirements of the business.

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Internal models – the ORSA

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The Own Risk and Solvency Assessment (ORSA)

i.e. Running the company using a risk based view

•Not all risks.
•Confidence levels and timelines set by the regulator.

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Key Issues

- Current lack of guidance
- Companies may have a legacy of multiple models and multiple risk metrics
- Formulating a clear risk strategy
- Modelling the interaction between risks
- Embedding the ORSA into strategy, such as business plans and decisions
- Identifying risks and “unknown unknowns”

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Delivering the ORSA

- Think about the phrase in two parts:
  - : Need to assess “your” risks
  - : Need to assess the capital consequences of “your” risks
- Two important clarifications:
  - ORSA is NOT just a bigger SCR calculation
  - The result of an ORSA is NOT just a number
- Need to avoid just “seeing what you are looking for”
- Scenario approaches to consider what might happen
- Good use of sensitivities to challenge models
- Reverse stresses to consider how likely destruction might be
- Financial companies focus on financial risk
- ...but financial risks often start off operational
- Well-understood risk dynamics means catching emerging risks early before they become financial

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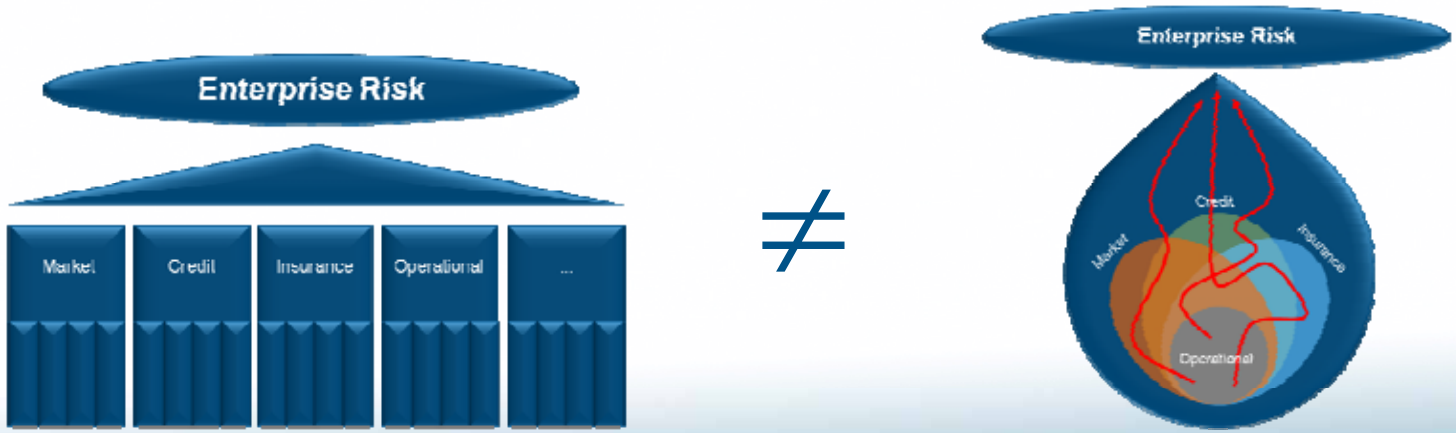
Seeing the Whole Picture

- The ORSA is about

  "...enhancing awareness of the interrelationships **between the risks** an undertaking is currently exposed to, or may face in the long term, and the internal capital needs that follow from this risk exposure..." *CEIOPS-IGSRR-09/08*
- A typical framework is actually looking at aggregations of ***risk characteristics*** not ***risks***



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Emerging Risk

- Would best-practice processes have considered this?
- Probably not
- But they would have known that a disruption in air travel mattered, so plans would be in place for that
- Knowing what matters to your risk profile helps you to know when something new is important

Summing up

- The ORSA essentially requires you to have ERM
- It specifies some minimum requirements for that ERM
- Not just a number and not just a bit more than Pillar I

- Modelling challenges: multi-year; new business; all risks; ...
- Relationship between the Internal model and the ORSA:
  - The internal model should be used in the ORSA but
  - The ORSA is not only about the internal model.
  -
- More profound:
  - What is your risk profile and how does/might it change?
  - What is the link between risk profile and own funds?
  - The organisation has to want to take and manage risk
  - Formal consideration of risk interactions
- Best practices are coming from outside financial services in many areas

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Internal models – partial internal models

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Partial Internal Models

Background

- Necessary consideration for all but the smallest UK insurers, including firms:
  - intending to initially adopt the standard formula
  - targeting approval of a full internal model

- PIM can be used for:
  - one or more risk modules, or sub modules, of the BSCR;
  - the capital requirements in respect of operational risk; and
  - the adjustment for the loss-absorbing capacity of technical provisions

- Can apply to whole business or one or more “major” business units

- Potential for wide range of implementation

Partial Internal Models

Why develop a partial internal model?

- Comparison with standard formula:
  - risk profile is not well reflected by standard formula
  - model risks not covered by the standard formula
  - acts as a transitory step to implementation of a full internal model

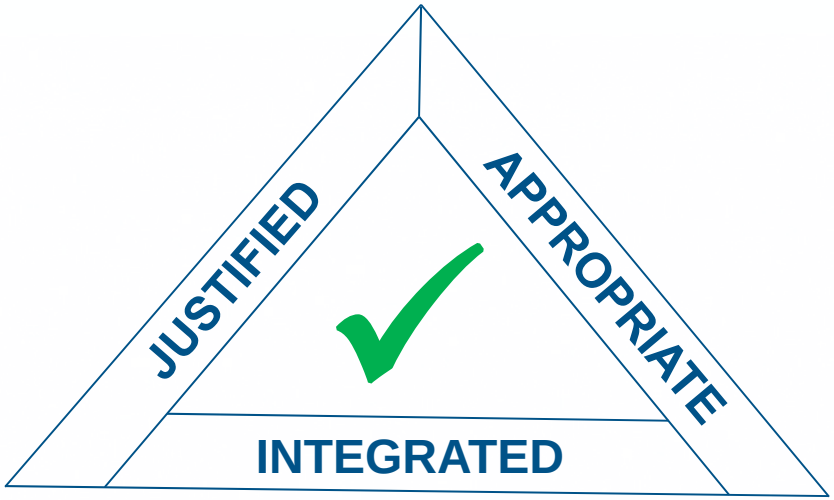
- Comparison with full model:
  - full model may be considered disproportionate given scale or complexity of business
  - lack of reliable data or modelling expertise to model some risks / lines of business
  - limited resources

- Wider considerations:
  - potential to stimulate innovation / specialization
  - more practical for M&A work

Partial Internal Models

Supervisory approval

- Conditions for supervisory approval:



- Burden of proof will lie with the insurer
- Tests no less strict than approval process for a full internal model
- May need to submit a transitional plan to extend the scope of the model

Partial Internal Models

Challenge 1 – Convince the supervisor of your rationale

- Engage early

- Supervisory assessment of the rationale for limiting the scope of the internal model will take into account:
  - consistency with the way the business is run
  - compliance with validation standards
  - nature, scale and complexity of the business
  - link with the ORSA process

Partial Internal Models

Challenge 2 - Justifying the scope

- Defining the scope of the model will be a balancing act between:
  - satisfying the use test, and
  - defining the boundaries of the model

- Supervisory assessment of the rationale for limiting the scope of the internal model will take into account:
  - consistency with the way the business is run
  - compliance with validation standards
  - nature, scale and complexity of the business
  - link with the ORSA process

Partial Internal Models

Challenge 3 - Integration with the Standard Formula

Options:

- Use the assumptions etc from the standard formula
- Use the methodology underlying the standard formula but different calibration
- Use a calibration and methodology derived by the undertaking
- CP65 favours a decision tree approach.
- Level 3 guidance should contain some ‘preferred methodologies’.
- If possible and appropriate to use the standard formula correlation matrix then firms should do so.

Internal models – the pricing process

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The Pricing Process

What's Important?

SPEED TO MARKET

ACCURACY and RELIABILITY

REGULATORY COMPLIANCE and USEFULNESS OF OUTPUT FOR DECISION MAKING

FLEXIBILITY FOR MARKET FEATURES (e.g. headline rates)

The Pricing Process

Speed to Market

Model extensions must be fully documented…

- … and audited…
- … and potentially require regulatory sign-off

This will lead to more competition for resources familiar with the internal model

Internal model needs to satisfy the use test

Therefore an opportunity to ensure the process for new business and pricing is as efficient as possible.

The Pricing Process

Good practice to model the proposed new business or repriced business alongside the existing business plans

- This is different to demonstrating the use of the ICA where it is really an add-on to the processes really driving the business decisions.

A review of proposed new business/pricing may naturally fit into a "business as usual" planning cycle under the internal model adoption.

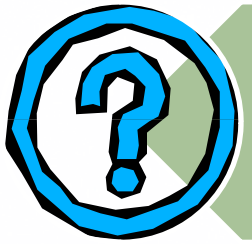
The Use Test / Regulatory Compliance

Does the company "record" case study examples?

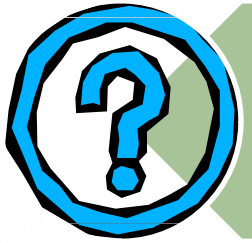
Could help secure credit rating with respect to new business risks?

The Pricing Process

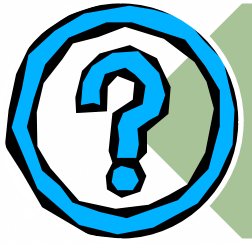
Internal Model Change Control for Pricing – Key Issues



Which is better from the pricing actuary's perspective?

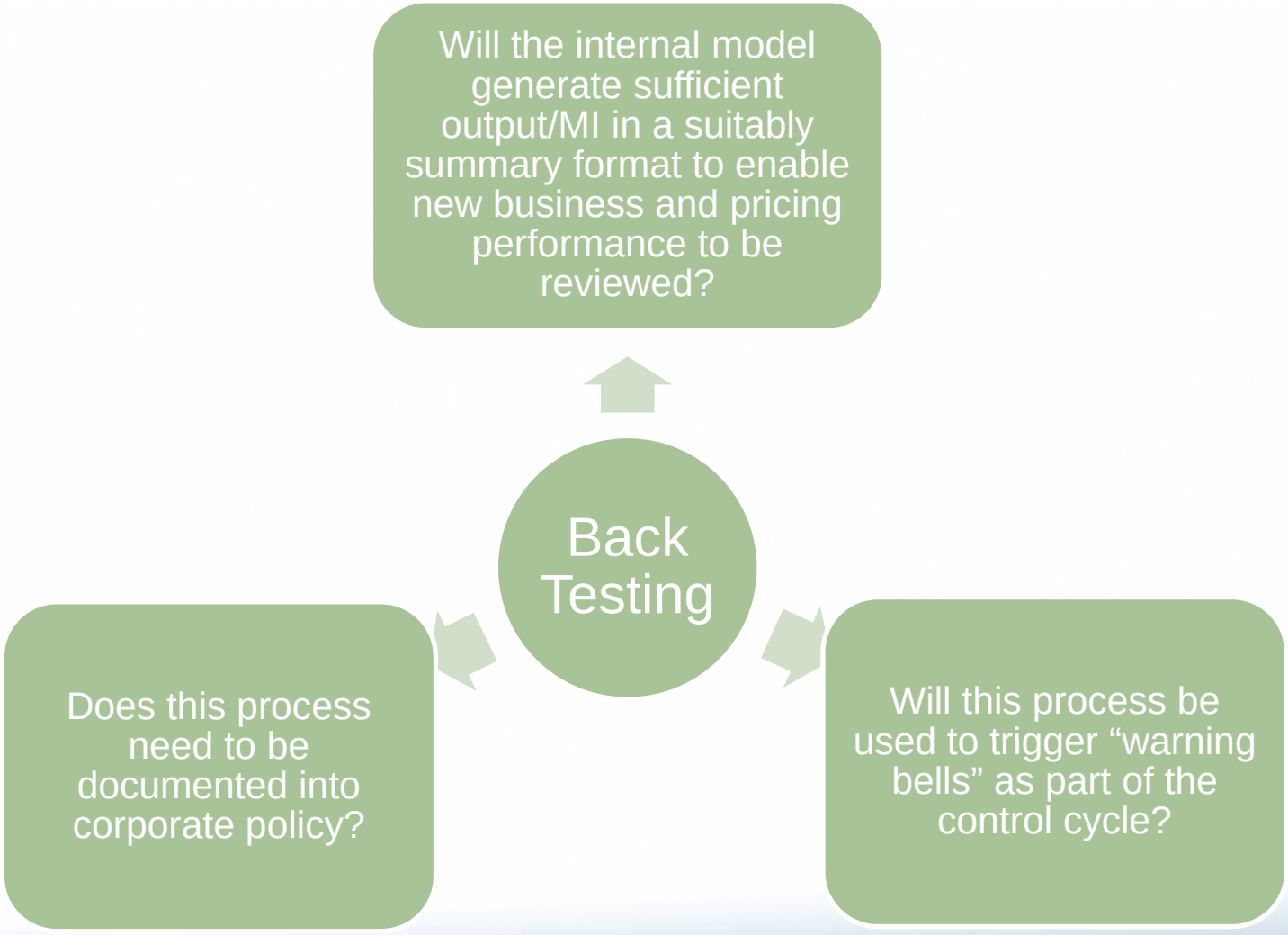


Which is better from a risk and controls perspective?



At what stage does the pricing team move from their draft calculations/rates and validate them with the master internal model?

The Pricing Process



The Pricing Process

Balance between how much to do within the model, and how much to do outside of the model

- E.g. scientific rates vs market-led rates

Previously for a new line of business, irrespective of size, standalone models could be developed to administer the business, with a proportionate scale of audit and controls

Flexibility for Market Features

Under internal models, the internal model will need to be adapted, and this must be fully controlled.

Does this hinder the new business design process? Or does it encourage best practice?

Internal models – key challenges

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April 2010

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