“THE IAA’S VISION ON THE USE OF INTERNAL MODELS FOR INSURER RISK ASSESSMENT AND CAPITAL REQUIREMENT”

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The draft by the IAA Solvency SubCommittee on Internal Models

The IAA- Solvency SubCommittee (SSC) is composed by various representatives of the IAA member national actuarial associations, and it gives its conclusions to the IAA Insurance Regulation Committee (IRC). SSC exchanges by e-mail ideas, documents and comments, and meets twice a year.

At the meeting held in Rio de Janeiro (November 2005) the SSC started to regard as suitable a paper on the use of Internal Model as a IAA guidance;

At the beginning the idea was to regard Internal Model for Capital requirements only but successively the paper was extended to Insurer Risk Assessment also

in the SSC Meeting in Paris (May 2006) the first draft of the paper was presented

successively in the SSC Meeting in Edinburgh (November 2006) an updated version was presented

That updated version (yet under discussion) will be illustrated here (available on the IAA website: www.actuaries.org)

From the minutes of the SSC meeting in Rio de Janeiro (Nov 2005):

- The SSC discussed the contents of the draft paper on the agenda of the meeting and had several comments:
  - Paper should define what is an internal model, when is it appropriate to use them
  - Consistency in the quality of data being used in the model is vital
  - The proper use of models in relation to risk management is very important
  - It is likely that the SSC will eventually develop other special topic papers which will provide additional technical guidance in some areas (e.g. calibration, tail correlation etc)
  - Paper must aim to prevent abuses of the internal model process brought about by the “cherry-picking” of various aspects of internal model design
  - Change control procedures are very important. They need to not only identify the changes made but the rationale for making such changes. Assumption changes made primarily for changing the level of conservatism in the model should be identified as such.
  - Internal models must not be regarded by stakeholders as black boxes. Should this be the case, stakeholder confidence in the work of the profession will be diminished. The paper must address the importance of proper model documentation and disclosure"
The purpose of the IM paper

• The purpose of the IM paper is to provide guidance to risk professionals, such as actuaries, insurance regulators and supervisors regarding best practices for internal models developed for insurer risk assessment and capital requirements.

• The objective of having minimum standards for the use of internal capital models is to ensure the following:
  - **Realistic:** Ensure the models accurately reflect the risks of the insurer and the way they are managed.
  - **Comparability:** Ensure results are comparable between companies.
  - **Consistency:** Ensure results are consistent between valuation dates and risks.
  - **Transparency:** Ensure that models are documented and that their capabilities and limitations are well understood by all users and stakeholders.
  - **Reliability:** Ensure that the process of generating capital results is robust.
  - **Practicality:** Recognize cost and time constraints and appropriate trade-offs between theoretical accuracy and materiality.

The road-map of the paper

• Once recently approved by IAA Professionalism Committee to develop an IASP (International Actuarial Standard of Practice) on the Internal Model topic, the road-map for the IM paper is now as follows:
  - **January 2007:** first stage exposure draft to all Member Associations (in practice it will be the updated version reflecting the Edinburgh discussion)
  - **Mid-March 2007:** Draft ready for the SSC meeting in Mexico City (April 2007)
  - **Mid-April 2007:** SSC agrees on Preliminary Exposure Draft
  - **April 2007:** presidential approval for Preliminary Exposure
  - **May 4, 2007** (at the latest): Issue Preliminary Exposure Draft
  - **August 24, 2007** (60 days prior to IAA Dublin Council & Meetings in October 2007): deadline if IAA Council is to consider exposure draft
  - **October 2007** (IAA Dublin Council & Meetings): IAA Council approval?
Definition and Stakeholders

- The term “internal model” is increasingly being used to identify those models built by insurers for their own risk management, economic capital and capital requirement purposes. The adjective “internal” was added to the more general word “model” through common insurance industry usage to identify models built by the insurer. Internal models can vary from simple standardized calculations to extremely complex econometric models. Internal models can utilize component parts built either by the insurer itself or outside vendor software selected by the insurer outside vendors.

- The IAA document will use the term “internal model” to refer specifically to those models built for the purposes of insurer risk assessment and capital requirements.

- In this context, internal models are subject to some form of minimum standards arising from regulatory and professional actuarial sources.

- The International Association of Insurance Supervisors (IAIS) and the International Actuarial Association (IAA) are in the process of developing standards relating to internal models for regulatory capital requirements.
Scenarios and Methods

- Models used for insurer risk assessment and capital requirements are usually designed to calculate the financial effects on an insurance company of various patterns of experience with respect to a particular source or set of sources of risk ("risk factors").

- A particular pattern of possible future experience is often called a scenario. Scenarios employed in a study of capital requirements can generally be chosen in two ways: a) scenarios may be derived from a stochastic process designed to replicate the uncertainty or randomness of the risks being modelled, or b) scenarios may be constructed based upon experience and judgement.

- In the first case, a), the set of financial results itself forms a probability distribution and the model is said to be a stochastic model. The accuracy of such a model will depend upon the number of scenarios that are used and the effectiveness of its capture of the key characteristics of the underlying business. A stochastic model not only captures the randomness of possible future outcomes (e.g. the rolls of a die) but also the uncertainties of the underlying assumptions or processes (e.g. model error, mortality trends etc.). Computing capacity and total run time become important limiting factors.
In the second case, b), the utility of the model depends upon whether the scenarios chosen to be tested (generally many fewer in number than those used in a stochastic model) are “critical” scenarios that lead to somewhat extreme financial results. For example, if it is desired to determine a level of capital that will enable an insurer to remain solvent with a probability of at least 0.995, the actuary or other modeller would want to employ scenarios that have a likelihood of less than one percent. However, the choice of scenarios is based upon judgement as is the likelihood estimate. Experience has often shown that modellers tend to attribute likelihoods to extreme scenarios that are lower than they actually are. Caution must therefore be used when employing deterministic models.

The models discussed above are based upon simulation. Although these are becoming more common with the growth of computing power, these are not the only types of models that can be used to fix capital requirements. For example, ruin theory, a subject well-known to actuaries, provides a number of analytic models and techniques for determining required capital directly without simulation. These “non-scenario” models are also within the scope of this paper.

Model methods and assumptions should be chosen that are appropriate to the expected use of the model. Inappropriate assumption selection can occur if the assumptions are based on experience not relevant to the insurer’s experience or are derived from a time period which is not relevant to their use in the model. Simplified models or models making use of simplified assumptions may fail to reveal the true magnitude of the risks faced by the insurer. While undue complexity is generally undesirable, there are situations where complexity cannot be avoided.
• For example, it is important to properly assess risks which demonstrate high "tail" risk (i.e. considerable adverse consequences from low probability events).
  – **Deterministic models** are often simpler to implement and maintain than corresponding stochastic models. It may also be easier to understand their results. However, deterministic models only test scenarios and extremes of experience that are chosen by the user. There is often no assurance beyond the individual's judgement as to whether sufficiently adverse scenarios have been investigated. If model results are required to satisfy a numerical risk measure (e.g. Var or TailVar), it may be difficult to justify the results of a deterministic model on this basis. It may also be the case that experience with respect to the variable being studied is normally more volatile than is depicted in deterministic scenarios (e.g. the behaviour of financial markets).
  – **If stochastic methods are employed, it is important to make use of the appropriate scenario generator**. There are often multiple scenario generators available. Many are designed to be used for specific purposes and might give erroneous results if used inappropriately. The modeller should understand the origins and calibration of any such generators that are used in internal models.

• Appropriateness of assumptions also involves the experience data upon which they are based. The usual justification for making use of company-specific internal models is that the company’s experience, both past and expected in the future, differs from industry averages. It follows that the assumptions must be based upon specific adequate company data. If this is lacking, it could be difficult to justify a company-specific approach to modelling.
Assumptions and Data

- For each of the significant risks to which an insurer is exposed, a probability distribution will need to be assumed when modelling. The assumptions will need to cover not only current probabilities but also any trend that might occur over the full period covered by the modelling, particularly if this could increase the resulting required capital.

- The assumptions that need to be made in modelling can be divided into:
  - corporate assumptions – i.e. assumptions as to the decisions that the company will be likely to make in different circumstances in the future, covering areas such as investment strategy, the use of derivatives or hedging, the volume and type of new business, and future pricing, and
  - experience assumptions – i.e. assumptions as to what the company’s future experience will be in areas such as underwriting risks and investment returns. The experience assumptions used in modelling may be based on:
    - internal data (data from the insurance company’s own records)
    - industry data (data from a number of insurance companies)
    - external data (data from other sources)

Structure of Internal Model:

- deterministic vs stochastic
- single vs multi-period models
- time horizon, confidence level and management action
The structure of an internal model should be designed to enable the user to develop an understanding of all material risks, the interaction between those risks and the impact of management actions on those risks.

- **Completeness and consistency:**
  - **Completeness.** Models should be complete to the extent that all material risks should be considered. If not all material risks can be modelled quantitatively, thought should at least be given to what those risks could be, how likely they are to materialise, what their potential impact could be and how they could be mitigated.
    
    *EG: the impact of large operational risks can generally not be accurately quantified, but a rough estimate can still be made, and measures for mitigation can be put in place.*
  
  - **Consistency.** Risks within a model should be measured and modelled on a consistent basis. Wherever it is not possible to use a consistent approach across all risk types due to practical constraints, this should be clearly indicated.

**Complexity vs. practicality**

- Internal models can vary from extremely simple to extremely complex. In deciding on the level of complexity, the following considerations apply.
- Different parts of an internal capital model can have different levels of complexity depending on the availability of data and the nature of the modelled phenomena. The different parts can be aggregated to produce a single unified result. Consideration should be given to the main goals and targets of building a model before deciding on its structure and complexity. A simple model that can be built within limited time and resources may be more advantageous than a more complex model.
- **More complex models** are able to more accurately reflect the behaviour of real world phenomena. More complex models take longer to build, are more expensive to maintain and the results may be more difficult to explain.
- **Simpler models** tend to use more conservative assumptions. Hence there is often a direct trade-off between the cost of increased model complexity, and the cost [often in terms of needing more capital] of using more conservative assumptions.
**Deterministic vs Stochastic**

- For phenomena that have been thoroughly researched and have ample data (including ample historical data where appropriate) [Market-consistent valuations use assumptions deduced from current market prices rather than historical data], **stochastic approaches tend to be appropriate** (e.g. stock markets).
- If data and or expertise are limited (e.g. avian flu), **deterministic approaches are usually more appropriate**.

**Deterministic models**

- Traditional actuarial models contain a single best estimate scenario, e.g. a claims projection or a mortality rate. When using a deterministic model for solvency assessment, at least a single worst case scenario should be considered [for each risk?].
- Deterministic worst case scenarios can be established on the basis of expert judgement, or on historic scenarios such as a repetition of a particular historic even (e.g. Spanish flu).
- Deterministic scenarios have the advantage of being easier to explain, compare and calibrate.
Stochastic Models

- Stochastic models estimate the probability distribution of a risk or a combination of risks. The calibration of a stochastic model requires a sufficient amount of experience data in order to estimate parameters and verify underlying assumptions such as the fit of a distribution.

  There are generally two types of stochastic models: analytic models and simulation models:
  - **Analytic models** derive the parameters and distribution of a risk or a combination of risks directly from parameters of individual risks and assumptions regarding the aggregation of risks.
  - **Simulation models** perform a large number of realizations of individually parameterised risks in order to generate the same number of realizations of all risks in aggregation.

- The advantages of analytic methods are that they take less run-time and the working of the model itself is easier to understand. The advantages of simulation models are that they can be used where analytic approaches are not available, and that each realization can be regarded as a real world scenario. The latter can help to understand the dynamics of risks and interactions between them.

- Stochastic simulation models have the added advantage that management actions can be built in by way of decision rules that trigger certain actions only in specifically defined circumstances. For example risky assets can be sold only if the solvency margin falls below a predefined threshold.

- Where a company has issued policies that contain options of guarantees that can change in value considerably in certain economic or demographic circumstances, then a stochastic approach would normally be appropriate.

- Because of the law of large numbers it is often not necessary to value stochastically the variation from year to year that can be expected in the number of claims such as death claims. However, where there are portfolios of large risks (net of reinsurance) and the extreme outcomes of such variation may be significant to the result of the overall valuation, it may be appropriate to do so.
- Single vs multi-period models

- The question whether to use a single or a multi period model is closely related to the choice of time horizon and the modelling approach used.

- If the time horizon used is short, a single period model has the advantage of simplicity allowing the use of analytic stochastic approaches. On the other hand, single period models do not reflect the impact of management actions during the run-off of a risk. Also the impact of differences in timing of cash flows within the run-off period is ignored.

- Thus the use of a single period model will generally force the user to apply more conservative assumptions such as that there will be no management actions and all cash flows will occur either at the beginning or end of the single period used.

- Time horizon, confidence level and management action

- In forming its requirements for an appropriate degree of protection for insurer solvency assessment purposes, a regulator will often specify a time horizon together with a required degree of protection.

- In such circumstances the amount of required capital will be sufficient with a high level of confidence, such as 99%, to meet all obligations for the specified time horizon as well as a required “terminal value” - the present value at the end of the time horizon of the remaining future obligations (e.g. best estimate value with a margin specified by the regulator).

- This time horizon should not be confused with the need to consider, in the assessment of required capital, the full term of all of the assets and obligations of the insurer. This may extend for many years or decades beyond the end of the assessment period time horizon. Modelling should take account of the whole of that full term.

- The form taken by the modelling may be different as between that for the specified time horizon and that for the terminal values. For instance, the modelling for the former may be based on fairly limited number of chosen scenarios while that for the latter may be stochastic, or vice versa. One reason for this is that if both parts are modelled stochastically this would involve “nested stochastic” modelling, likely to be very onerous in terms of computing capacity and run times.
• Due to the long term and complex nature of some insurer risks, an insurer should also consider modelling its risks for their lifetime using a series of consecutive one year tests with a very high level of confidence (say 99%).

• Alternatively, this test can be conducted with a single equivalent, but lower (say 90% or 95%), level of confidence for the entire assessment time horizon. This lower level of confidence over a longer time horizon is consistent with the application of a series of consecutive higher level one-year measures.

• Some supervisors require that a multi-period future financial condition report be prepared annually for presentation to the insurer’s Board of Directors and a copy provided to the supervisor. Typically these reports are not publicly available because of the confidential nature of the information they contain.

• The longer the time horizon over which any particular modelling assumption is to apply, the more uncertain that assumption will become. In particular, changes to the business such as management actions have a greater impact over a longer time horizon. The need to consider the impact of management actions and other potential changes to the business therefore increases with the time horizon used.

• Modelling techniques:
  - Economic Scenario Generator
  - Collective Risk Model for general insurance
Modelling Techniques: Economic Scenario Generator (ESG)

- A suitable [Need to make clear for what suitable] economic model is stochastic in nature and is used to produce probability distributions of possible future outcomes of macro-economic variables such as inflation rates, interest rates and equity returns. The macro-economic variables that are incorporated are typically interrelated. For example, interest rates usually rise as inflation rates increase. Such known interrelationships must be recognized and incorporated into the economic model.

- The complexity of the economic model used by an insurer will depend upon the nature of the insurer’s business. For example an insurer operating in several countries will need to have a model that incorporates several economies including exchange rates between countries. Because an economic model is not specific to the insurer, it should be useable by multiple insurers. As a result, numerous vendors produce economic models for the insurance sector. This gives rise to the possibility of insurance regulators approving the use of specific commercially available models.

- The economic model is typically implemented in a Monte Carlo simulation environment by producing future “scenarios” that simultaneously project all macro-economic variables. The computer implementation of the model is often called an economic scenario generator (ESG).

An economic scenario generator (ESG) is a computer-based financial model that is used to produce a range of future economic possible outcomes. An ESG is exogenous to an insurer-specific model. The economic scenario generator typically provides projections covering the following interrelated macroeconomic processes, among others:

- general price inflation
- GDP growth rates
- Wage growth rates
- fixed income yields
- equity yields
- real estate yields
- currency exchange rates
- credit spreads on credit-risky assets
- currency exchange rates
• The projections provided by the ESG are stochastically generated using a pseudo-random number generator. Typically many projections are done. This process is called (Monte Carlo) simulation. Each projection serves as input to a company-specific model of cash flows generated by both assets and liabilities. These simulated future cash flows may have varying degrees of sensitivities to the results of the ESG. The simulated asset cash flows of an insurer clearly depend directly the ESG directly. In both life and non-life insurance, simulated liability cash flows may also be affected by the ESG results. For example, insurance claim loss amounts may depend on inflation rates in the economy.

Modern financial models have varying levels of complexity. The level of complexity of an ESG that is used by an individual insurer should reflect the size and nature of insurer. For example, insurers operating in several countries will need to incorporate a model for currency exchange rates and for multiple economies in an internally consistent manner.

Modelling Techniques: Collective Risk Model for general insurance

The Basic Model:

• An increasingly popular stochastic model of losses in general insurance is the collective risk model. At its most basic level, one can view it as a simulation algorithm. Here is an example for a single line of insurance:

  Collective Risk Model Simulation Algorithm:
  1. Select a random number of claims, \( N \), at random from a claim count distribution.
  2. For \( j = 1 \) to \( N \), select a random claim size, \( Z_j \) from a claim severity distribution.
  3. Set the aggregate loss \( X \) equal to the sum of the \( Z_j \)'s.
• General insurers often impose, either directly with those they insure or through reinsurance, contractual limits on their liability. These limits can usually be addressed by adjusting the $Z_j$'s or the $X_i$'s as they appear in the simulation.

• Multiline insurers can invoke this algorithm for each line, denoted by $i$, independently by simulating an aggregate loss $X_i$. Their total loss $X$ is then equal to the sum of the $X_i$'s.

• General insurers will also have liabilities for unsettled claims from prior years. These liabilities should be treated as separate lines by accident year as the smaller claims tend to be settled earlier.

• There are a variety of distributions that have been used to describe claim severity, $Z_j$. One could describe claim severity by a table developed from a compilation of historical claims. Quite often, the real risk to an insurer comes from a relatively small number of large claims. For this reason, insurers tend to favour parametric distributions such as the Lognormal and the Pareto distributions. Natural catastrophes pose a significant risk and insurers often use a specially designed model for these claims.

• The Poisson and the Negative Binomial models are often used to describe the distribution of claim counts. The Poisson distribution was used in early work on the collective risk model because of its nice theoretical properties such as homogeneity. However, most real-world case involve heterogeneous lines of business where the negative binomial distribution is more appropriate.
Data Sources:

- The primary source of data for building a model should be an insurer’s own data. However, it is often the case that an insurer’s own data are insufficient for the task and must rely on industry sources.
- In the United States, regulators require insurers to file information in two ways.
  1. **Insurer financial information** is reported to the state of domicile in the NAIC (National Association of Insurance Commissioners) Annual Statement. The primary purpose of this statement is to monitor insurer solvency. These statements include a fairly detailed listing of assets and liabilities. They also include premium and losses by aggregated by line of business spanning a period of ten years. These statements are publicly available. The NAIC and the AM Best Company both sell compilations of these data for a reasonable price.
  2. **Insurer premium and loss information** is reported to the state of domicile in accordance with a detailed statistical plan that is promulgated by each state. While individual state requirements may vary, there is a large degree of uniformity in these plans because of the influence of the NAIC. The purpose of this statistical plan is to monitor insurer’s compliance with the law that insurance premiums cannot be “inadequate, excessive or unfairly discriminatory.” The data is very detailed. Individual claims are reported. Premium, exposure and classification are reported at the individual policy level. Insurers typically report this information through a designated statistical agent (main statistical agents ISO, NCCI, NAII).

Correlation:

loosely defined, correlation is the tendency for losses to “move together.”

This section discusses three kinds of correlation in the collective risk model.

1. **“common shock” correlation**: a simple form of common shock correlation is produced by the following simulation algorithm.

   **Common Shock Simulation**
   - Select \( X_1 \) and \( X_2 \) from collective risk models #1 and #2.
   - Select a random number \( b \) from a distribution with mean 1 and variance \( b \).
   - Multiply \( X_1 \) and \( X_2 \) by \( b \).
   - The coefficient of correlation between \( bX_1 \) and \( bX_2 \) will depend upon the variability of \( X_1 \) and \( X_2 \). Figures 1-4 below illustrate how this algorithm generates correlation. The volatility of \( X_1 \) and \( X_2 \) depend, in part, on the total insurance exposure in \( X_1 \) and \( X_2 \). Thus the common shock model implies that coefficients of correlation should change in response to changes in insurance volume.
2. A second kind of correlation is that caused by natural catastrophes. When a hurricane occurs, it could blow down a large number of insured buildings at once. Insurers commonly use specialized models to deal with catastrophes. One can think of a catastrophe model as a collection of events, each with an assigned probability, that cause damage to a particular kind of structure at a specific location. An insurer enters a list of its buildings, along with codes that define each building’s structure and location, and the catastrophe model then calculates the insurer’s loss associated with each event.

- Even though catastrophes are covered in standard lines of business such as Homeowners or Commercial Property, insurers should separate catastrophes for modelling purposes. One can treat each modelled catastrophe as a line of insurance with its claim count distribution as a binomial (or Poisson) with its assigned probability. The claim severity distribution will assign a probability of one to the loss generated by the catastrophe model.

3. A third kind of correlation is modelled with a copula. To illustrate how to use a copula, suppose one has two lines of insurance for which one already has univariate distributions of their random losses. Copulas provide a way to simulate the distribution of the sum of losses from the two lines when one thinks the losses from each line are correlated.

- A two dimensional copula is a joint distribution of random variables on the unit square, subject to condition that the marginal distributions are uniform on the unit interval. Suppose $X_1$ and $X_2$ are random losses from two lines of business. One simulates correlated losses $Y_1$ and $Y_2$ by the following simulation algorithm:
  - Simulation Algorithm for Correlated Losses with a Copula
  - Select a point $(P_1,P_2)$ from a copula
  - Calculate $Y_i$ as the $P_i$th percentile of $X_i$ for $i = 1$ and 2

- Copulas are often used when high losses in one line of business are associated with high losses in a second line of business. There are copulas with the property that if $P_1$ is high, it is likely that $P_2$ is also high.
Computational Considerations:

The collective risk model has been described as a series of computer simulations. It is generally the case that computer simulations are relatively easy to explain. With the increasing speed of modern computers, it is possible to actually do the simulations. But for a larger insurer, this could take days. The purpose of this section is to describe some mathematical techniques that can speed up the process by many orders of magnitude.

- **Moment Approximations** – It is possible to derive formulas that give the first and second moments (and beyond if desired) of the insurer’s distribution of its total loss in terms of moments of the underlying claim count, claim severity and common shock distributions. Then one can take an assumed distribution, such as a lognormal, and match moments to approximate the insurer’s distribution of its total loss.

- **Stratified Simulations** – It is often the case that the most of the risk is due to large, relatively infrequent claims. But most of the computing time in a brute-force simulation is spent simulating small claims. Stratified simulations provide a remedy to this by first simulating sums of “small claims” for a predetermined number of times (say 1,000). Then for each random sum of small claims, simulate a number (say 10) of sums of “large claims” to add to each sum of small claims.

- **Fourier Methods** – The process of simulating random sums is very time consuming. Fourier methods replace this simulation process by multiplication, which is very fast. Suppose one has a claim severity random variable $Z$. Calculate its Fourier transform $Z(t)$. Then the Fourier transform of the sum of $n$ random $Z$’s is given by the inverse Fourier transform of $Z(t)^n$. If $N$ is a random number of claims, there are formulas that calculate the Fourier transform of the aggregate loss that are analogous to formulas that sum power series.
**Internal vs Regulatory requirements**

- What uses does the model have for the company’s management vs what does a regulator require?
- What are the burning issues that have come up so far?

- Management uses models for refining plans for future management actions of the sort that are modelled. Also for estimating profitability and capital-hunger (ideally in the context of the company as a whole) of possible volumes and types of new business.
- Management is (or should be) interested in long-term run-off as well as in any shorter-term (say one year) risk horizon of the regulator.
- If regulator requires risk-neutral measures, management may also want to run the model on real-world assumptions (i.e. using a different ESG).

**Governance**

- The purpose of governance is to ensure internal models are developed in a disciplined and coordinated fashion. The governance best practices should encourage consistency, robust testing, validation and control of the internal models.

- **Roles and Responsibilities:**
  - The Board, Senior Management, Appointed Actuary and Chief Risk Officer play significant roles in the governance of models.
  - The Board should make sure that the relevant organizational structures, policies and adequate resources are in place.
  - The CEO and Senior management should be responsible for ensuring the establishment of a risk management process that operates in accordance with the authorities delegated by the Board, specifically that a risk management culture exists within the organization and the risk management function is comprehensive and global in scope, with underlying risks and models being incorporated into the overall risk management systems of the organization.
  - The development of models may be the responsibilities of both the CRO and the AA.
  - It is expected that the Appointed Actuary is responsible for the sign-off of the opinion on the application and results of models. The AA would typically have the responsibilities of the application of the models to insurance risks and for the aggregation of risks. The application of the models to asset risks and other business risks may be shared between the AA and the CRO or CFO. The work of the AA and CRO or CFO should be coordinated for the models application in general.
Review Process:

• An important part of controls is the review process. The review process for models and their implementation will rest on 3 components:
  – Internal review;
  – External review;
  – Mixed review

• These reviews are complemented by public disclosure of the methodology. This ensures transparency and comparability of internal models across the industry.

• The mix of the different types of review can – within limits – be company specific. For example, for a company with a strong internal audit function, external review might be de-emphasized whereas if a company undergoes a thorough external review of the model, internal audit requirements could be reduced. In all cases there should however be a certain minimum level of transparency of the three different types of review.

• The total review process using the above components should encompass all aspects of the model: methodology, assumptions, IT implementation, data and processes. Assumptions review covers parameters as well as assumptions. Data review includes data process and data integrity.
Main topics to be further analysed:

- The use of **Internal Model for Solvency** Requirement
- **Partial Internal Model**: how to be allowed by regulators (e.g. Solvency II)?
- Standard Formula / Partial Internal Model /Full Internal Model: the cherry picking risk
- **The bridge from Standard Formula to Internal Model**: management and regulator targets
- **Independent Review** of methodologies and assumptions used in Internal Model
- **Extreme Scenarios**: how to join results with simulation models output?