Actuarial Aspects of ERM for Insurance Companies

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This Paper has been produced by the Enterprise and Financial Risk Committee of the IAA.

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1. Introduction

1.1 Purpose

The purpose of this paper is to provide assistance to actuaries or other practitioners in relation to Enterprise Risk Management ("ERM"). The objective is to assist practitioners, and to help to achieve greater consistency in relation to knowledge and awareness of various topics.

The paper is wide ranging and deals with the possible components of an ERM system. The purpose of the paper is not to describe any individual element of ERM in detail but to assist in understanding the various elements of ERM and the various areas for consideration. Therefore, it is considered that the paper is more likely to be of relevance to practitioners who are assisting in the development of an ERM system or where the ERM system is at a relatively early stage of maturity.

It is important to note that the approaches and methodologies discussed in the note will not definitively address the many various topics on ERM practice. Depending upon the specific circumstances and proportionality there may be other approaches that are more appropriate and other considerations to be taken into account.

This white paper is intended to be complementary to previous papers produced by the IAA and is not intended to replace or to update such previous papers.

Other previous IAA papers on related topics include:

- Enterprise Risk Management for Capital and Solvency Purposes in the Insurance Industry, 2009. This note was developed by the IAA for insurers to support the Standards and Guidance materials developed by the IAIS for supervisors.
- Note on the use of Internal Models for Risk and Capital Management Purposes by Insurers, 2010. This note provided educational material for those responsible for constructing, using and approving the use of models to assess and manage risk and capital within insurance enterprises.
- Comprehensive Actuarial Risk Evaluation, 2010. This paper provided a framework for the comprehensive evaluation of risk by actuaries.
- Stress Testing and Scenario Analysis, 2013. This paper provided an actuarial perspective on scenario analysis and stress testing.
- Deriving value from ORSA – Board Perspective, 2015. This paper outlined the value of the ORSA process the type of information that Boards should expect to receive.

Many of the concepts covered in this paper are considered in the papers listed above, with the above papers going into depth on specific items. This paper focuses

on ERM from an actuarial perspective and is intended to assist practitioners in considering whether they have addressed all of the various potential topics of relevance. It is likely that the IAA will produce additional papers on related ERM topics in the future.

The paper is primarily focused on risk management in the insurance industry but many of the concepts are also applicable outside of the insurance industry.

1.2 Enterprise Risk Management

There are numerous definitions of ERM. This paper has been developed with regard to the common themes and principles that emerge from the various definitions, notably:

- ERM is a continuous process
- ERM adopts a holistic view to risk and assesses risk from the perspective of the company's aggregate position as well as from a standalone perspective
- ERM is concerned with all risks, including those that are unquantifiable or difficult to quantify
- ERM considers uncertainty from both a positive and negative viewpoint
- ERM aims to achieve greater value for all stakeholders by assisting in achieving an appropriate risk-reward balance
- ERM considers both the short term and the long term aspects of risk.

1.3 Relevant knowledge

The items discussed in the paper all require that there is a foundation of knowledge regarding the specific circumstances of the company in question and of all relevant regulatory requirements.

2. Definitions and Language

2.1 General Terms

Alternative definitions of these terms are possible and that the definitions below are only intended to define the terms as referenced in this document.

Alternative Risk Transfer (ART) the use of techniques other than insurance or reinsurance to provide risk transfer.

Bank for International Settlements an international organisation of central banks which fosters international monetary and financial cooperation and serves as a bank for central banks.

Cash flow projection models project all financial cash flow items, such as receipt of premiums and investment income, payment of insurance claims and other policyholder benefits, expenses, taxes and shareholder dividends. The cash flows are projected on a periodic basis for several years based on an underlying future economic path or scenario. The scenario can be selected deterministically, or a set of scenarios can be produced stochastically based on probability distributions within economic scenario generators.

Capital at Risk (CaR) the capital that would be lost if a predefined event occurs.

Chief Risk Officer (CRO) the executive responsible for the risk management of a company.

Claims frequency models the models which are constructed using frequency–severity distributions. Distributions of claim frequency (probability of a claim) and claim severity (loss amount given a claim has occurred) are constructed. The two distributions are then combined to obtain the distribution of aggregate claims. Since the tail of the aggregate claims distribution is particularly important for purposes of capital requirements, it is important to consider whether the tail adequately captures extreme events.

Contagion arises when one risk event generates another. Financial contagion is the spread of a financial shock throughout a wider group, such as a financial group, an economy or the world.

Corporate governance the mechanisms, processes and relations by which corporations are controlled and directed.

COSO the Committee of Sponsoring Organisations of the Treadway Commission is a joint initiative between five private sector organisations dedicated to providing thought leadership on enterprise risk management, internal control and fraud deterrence.

Credit spread a measure of the difference in yields between a risky asset and a risk-free security.

Earnings at Risk (EaR) the reduction in earnings that would occur if a predefined event occurs.

Economic capital the amount of capital a company requires to cover its obligations with a given degree of confidence over a specific time horizon.

Economic Capital Models (ECM) a model used to calculate economic capital as defined above.

Economic Scenario Generator (ESG) a consistent model that generates all the financial, economic and macro-economic variables required for economic capital calculations.

Financial Stability Board (FSB) was established to coordinate at the international level the work of national financial authorities and international standard setting bodies and to develop and promote the implementation of effective regulatory, supervisory and other financial sector policies in the interest of financial stability.

Generally Accepted Accounting Principles (GAAP) the common set of accounting principles, standards and procedures that companies use to compile their financial statements.

Global Systemically Important Insurers (GSIIs) In 2013 the IAIS published a methodology for identifying global systemically important insurers and a set of policy measures that would apply to such companies.

Hedging a strategy used to minimise exposure to a certain risk or risks.

International Association of International Supervisors (IAIS) represents insurance regulators and supervisors of more than 200 jurisdictions in nearly 140 countries.

Insurance Core Principle (ICP) an international set of principles, standards and guidance applicable to insurance supervisors, seeking to foster convergence towards a globally consistent framework, developed by the IAIS.

International Financial Reporting Standards (IFRS) international accounting standards developed by the International Accounting Standards Board.

National Association of Insurance Commissioners (NAIC) the US standard-setting and regulatory support organisation.

Own Risk and Solvency Assessment (ORSA) a company's assessment of its risks and of the solvency needs associated with those risks.

PESTLE a framework used to analyse the impact of external factors on an organisation. It analyses the exposure of the organisation to Political, Economic, Social, Technological, Legal and Environmental factors.

Risk Adjusted Return On Capital (RAROC) Risk-adjusted return on capital is a measure of return on capital that adjusts the capital to reflect the level of risk associated with that investment.

Risk Based Capital (RBC) Capital Requirements that reflect the risk profile of the financial institutions.

Residual risk the risk remaining with an organisation following its risk management process and internal controls.

Risk Appetite the level and type of risk that an organisation is willing to accept in order to achieve its objectives.

Risk Capacity the extent of risk that an organisation is capable of undertaking.

Risk Limit the maximum amount of risk that can be underwritten. Risk limits will often be identified for key risk-taking activities such as insurance underwriting and investment.

Risk Management Control Cycle a cyclical process typically involving identification, analysis, measurement, management and monitoring of risks.

Risk Profile a description of the risk exposures of an organisation.

Risk Response the response of the company to a particular risk, typically summarised as avoid, accept, transfer or manage.

Risk Tolerance a quantitative description of the extent of risk that the company is willing to take in respect of a specific risk.

Solvency II the prudential regime for insurance and reinsurance undertakings in the EU introduced on 1 January 2016.

Tail Value at Risk (TVaR) quantifies the expected loss given that an event outside a given probability level has occurred.

Time horizon the time period associated with a given decision or measure.

Value at Risk the maximum loss that could occur with a specified probability over a given time horizon.

Volatility the variability of potential outcomes.

2.2 Risks referenced in this document

Please note that this is not intended to be a complete list of risks but is solely intended to define the terms as used in this document. Please also note that alternative definitions of these terms are possible.

Agency risk the risk of loss as a result of an agent's pursuance of his or her own interests rather than the interests of the principal.

Basis risk the risk of loss arising from a difference in movement between the price of the asset to be hedged and the price of the hedge.

Conduct risk the risk that firm behaviour will result in poor outcomes for customers.

Credit risk the risk that a counterparty will be unable or unwilling to make payments due under a specific agreement.

Currency risk the risk of loss arising from movement in foreign exchange rates.

Emerging risk a risk which may develop or which may already exist that is difficult to quantify or may have a high loss potential

Equity risk the risk of loss associated with exposure to an adverse movement in equity prices.

Group risk the risk of loss associated with exposure to other group companies.

Inflation risk the risk of loss associated with exposure to an adverse movement in inflation.

Insurance risk the risk of loss arising from movement in insurance variables including claim incidence, claim termination and persistency.

Interest rate risk the risk of loss associated with exposure to adverse movements in interest rates.

Legal risk the risk arising from the understanding and/or adherence to legislation.

Liquidity risk the risk associated with the ability to trade a particular asset quickly without incurring a loss.

Market risk the risk of loss arising from changes in market variables.

Operational risk the risk of loss from failed or inadequate internal processes, people and systems, or from external events.

Regulatory risk the risk arising from changes in regulation or legislation.

Reputational risk the risk that events could have an adverse impact on an organisation's reputation or brand value.

Strategic risk the risk in relation to the achievement of an organisation's strategic business plan and objectives.

3. Enterprise Risk Management System

This section of the paper outlines various issues and considerations that might form part of a company's ERM system. There are numerous components to ERM and this section outlines some of the key components and considerations in relation to the components rather than providing an in-depth description of any specific component.

Key components are risk governance, risk culture and the steps that make up the core risk management process consisting of risk identification, risk assessment, risk measurement, risk response, risk monitoring and risk reporting.

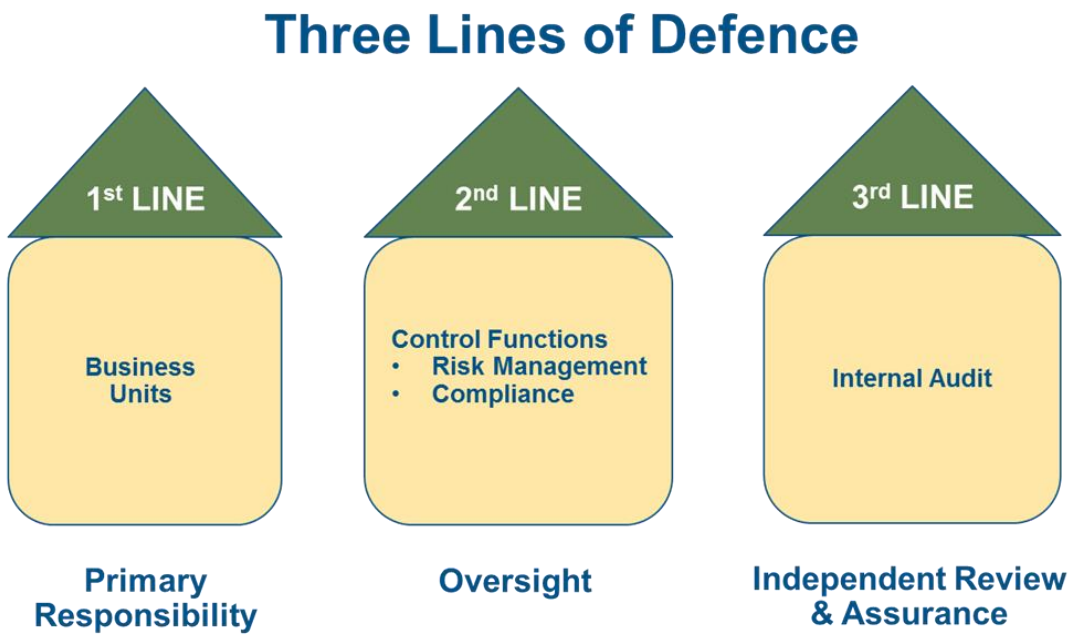
It is important to emphasise the dynamic nature of risk management as part of an ERM system. All of the sections in this document can be viewed as continuous processes that require ongoing review and updating so that they remain appropriate to the company's circumstances and external environment.

3.1 Risk Governance

Many companies start considerations of their ERM system by assessing the appropriateness of risk governance already in place. This encompasses the assignment of roles and responsibilities, policies and procedures and the internal control system.

3.1.1 Roles and Responsibilities

Many companies adopt a 'three lines of defence' model, as illustrated in the diagram below:



- The first line is responsible for the regular operations of the business and includes business management and staff.
- The second line is responsible for supporting and monitoring the business and oversight of the operations of the first line.
- The third line is responsible for independent review and assurance of the operations of the first and second lines.

It is important to note that various different interpretations of the 'three lines of defence' are possible and that the above diagram is just shown as an illustration. It is also important to note that companies might choose to use a structure other than the 'three lines of defence' model to achieve a similar outcome.

Actuarial duties and responsibilities can lie within any of the three lines of defence or across all three and different companies will structure themselves in different ways. Actuaries will also often commonly work within risk management or other units.

It is important that the second line provides an independent challenge to first line activities, but in order to do so effectively also has to maintain a trusting relationship. It can sometimes prove difficult to maintain this balance.

The Board, Board committees and senior management are often considered to be the primary stakeholders served by the three lines. They typically have responsibility for setting objectives, defining strategies and establishing governance structures.

Many companies assign roles and responsibilities of the various parties to ensure that the ERM system is robust. Key parties to be considered include:

- Board
- Risk committee
- Chief Financial Officer
- Chief Risk Officer
- Risk management function
- Chief Actuary
- Actuarial function
- Compliance
- Internal audit

The company would typically need to consider whether it has addressed potential conflicts of interest and any independence criteria in the final structure chosen. The company might also consider agency risk and the potential for management to have different interests to shareholders and/or policyholders.

3.1.2 Risk Policies and Procedures

Many companies document a risk strategy, outlining the high level attitude towards risk, as outlined in section 3.2. Many also establish risk policies for various individual risks, for example:

- Credit risk
- Insurance risk
- Liquidity risk
- Investment risk
- Operational risk

The exact risk policies required for any individual company will depend upon the individual circumstances of that company, its risks and exposures.

It might also be advisable to develop a policy in relation to risk mitigation techniques such as reinsurance and hedging.

Risk policies often outline:

- The company's objective in relation to the specific risk
- The link to the risk strategy
- The tasks to be performed including how the risk is to be measured
- Roles and responsibilities
- Process and reporting procedures to be applied
- Escalation processes in relation to policy breaches
- Frequency of review of the policy

Procedures are then required to outline how the company measures and reports risks in these areas on a regular basis.

3.1.3 Internal Control System

An internal control system addressing the key processes and controls within the company is an important consideration for most companies. Again there are various different definitions of internal control but a frequently used definition is that adopted by the COSO Internal Control-Integrated Framework:

"Internal control is a process, effected by an entity's board of directors, management and other personnel, designed to provide reasonable assurance regarding the achievement of objectives relating to operations, reporting, and compliance."

The COSO internal control framework outlines five components:

- Control environment

- Risk assessment
- Control activities
- Information and communication
- Monitoring activities

As part of the internal control system there would normally be clear documentation of all processes and controls. Internal audit would normally review the adherence to stated processes and controls on a regular basis.

The compliance function is often considered part of the internal control system, as are the risk policies and procedures detailed in section 3.1.2 above.

3.1.4 Risk Culture

Risk culture can be defined as "the norms and traditions of behaviour of individuals and of groups within an organisation that determine the way in which they identify, understand, discuss, and act on the risks the organisation confronts and the risks it takes."[1]

It is important to consider whether the company has an appropriate risk culture, including whether risk management is appropriately supported by senior management within the organisation. The Board and senior management, in particular the Chief Executive Officer (CEO), often determine how much weight is given to views on risk and how important a role the risk management function plays in relation to key business decisions such as new developments that involve taking on new types of risk.

As an example, risk considerations often form an integral part of product development and pricing. Product development and pricing decisions could take into account economic value creation requirements for shareholders, a fair treatment of customers, the impact on statutory requirements, the speed of recouping investment of capital, impact on financials and tail event impact on risk tolerances. In particular, it is often desired that products not have a significant adverse impact on the risk positioning. Furthermore the pricing and product design of products is often designed to meet client needs, offer a reasonable return and provide clear information.

Many companies look to involve all staff in risk management and it is important to ensure that communication is working effectively in both directions. Assessing risk culture on a regular basis can provide insight into attitudes within the company and trends in risk culture over time.

[1] "Reform in the Financial Services Industry: Strengthening Practices for a More Stable System" Institute of International Finance December 2009

Risk culture can be measured through staff surveys testing awareness and views on risk issues such as the relative importance of potential adverse risk outcomes versus potential profits or sales targets.

Companies would often also be conscious of the importance of ensuring that employees escalate potential losses and risks on a timely basis. It is important to signal the gravity of being aware of a risk or potential loss and not reporting it. Companies might also consider the establishment of an independent channel to allow employees to report issues and inappropriate behaviour, potentially on an anonymous basis.

One item which contributes significantly to risk culture and the relative importance of risk management is that of remuneration. Companies sometimes link remuneration to risk-adjusted performance for certain departments rather than just considering performance. If this is not done then there can be an incentive for employees to take on more risk in order to increase the expected return, but with a corresponding increase in the risk of significant losses.

Similarly there can be a risk that greater focus is placed on short-term results if remuneration is overly influenced by short-term performance. Some companies and regulators are introducing longer term measures and other features such as the clawback of bonuses and the mandatory deferral of bonuses to help mitigate this risk.

3.2 Risk Strategy

There are a number of different components to risk strategy but typically companies would look to define and document the company's objectives, principles, Risk Appetite and responsibilities in relation to risk. The risk strategy would normally aim to be consistent with the company's business strategy.

There is often discussion regarding whether the company's business strategy is derived from the Risk Appetite or whether the company typically defines its business strategy first and then sets its Risk Appetite. In reality the two will typically be developed and evolve in tandem with the key point being that they remain internally consistent.

It should be noted that company practices will vary greatly depending upon the nature, scale and complexity of the underlying business and that some companies might choose not to use some of the elements discussed in this section (i.e. risk appetite, risk tolerances and risk limits).

3.2.1 Risk Appetite and Related Measures

3.2.1.1 Risk Appetite

There are many different definitions of Risk Appetite, a good example being that in the FSB Consultative Paper on "Principles for an Effective Risk Appetite Framework" (July 2013), which defines Risk Appetite as:

> *"The articulation in written form of the aggregate level and types of risk that a firm is willing to accept in order to achieve its business objectives. It includes qualitative statements as well as quantitative measures expressed relative to earnings, capital, risk measures, liquidity and other relevant measures as appropriate. It should also address more difficult to quantify risks such as reputation and money laundering and financing of terrorism risks, as well as business ethics and conduct."*

Companies' Risk Appetites will often have evolved informally over time and companies often start by analysing the risks that they are currently exposed to and the risks inherent in the company's current strategy. They may however also consider establishing the Board's appetite to risk directly by surveying Board members on their attitudes to specific risk events, such as the potential for the company to issue profit warnings or to breach minimum acceptable regulatory solvency levels.

As the analysis of risk exposures is developed, including how the risk exposures diversify/aggregate, how they may evolve over time and how they may interact in extreme conditions, it may well mean that the Risk Appetite needs to be reviewed and revised.

3.2.1.2 Risk Tolerances

As well as having qualitative elements in Risk Appetite statements, where possible, companies will often set risk tolerances for each risk type. These will be used to determine for each material risk the maximum level of risk within which the firm is willing to operate, based on its Risk Appetite, risk capacity, and risk profile.

Risk tolerances, are the typical measures of risk used to monitor exposure compared with the stated Risk Appetite. In practice, they enable the high-level Risk Appetite statements to be broken down into measures that are actionable and can be measured and monitored.

The aggregate maximum amount of risk the company is willing to take is expressed in terms of key measures, which often include:

- Capital adequacy (usually economic, or the higher of economic and regulatory) and/or a credit rating target.
- Earnings or earnings volatility (usually the published accounting basis but possibly other earning measures such as embedded value).

- Liquidity (for example expected or stressed cash requirement over, say, 4 to 13 weeks).
- Operational risk including conduct risk. As operational risk is often expressed as a mix of qualitative and quantitative statements, it is often difficult to develop risk tolerances for this risk.

Developing risk tolerances helps to ensure that appropriate reporting and monitoring processes can be put in place for the effective management of these risks. As such, these tolerances would benefit from being clearly articulated and readily measurable.

3.2.1.3 Risk Limits

Whilst risk tolerances are set for a company or Group as a whole, it is important that risk limits are set at the most granular level for business operations. These translate enterprise risk tolerances and Risk Appetite for each risk category into risk-monitoring measures for business units.

The consistency between risk limits and the enterprise risk tolerance helps the company to realise its risk objectives and maximise risk-adjusted returns. This tends to be a challenge for various reasons, including:

- The technical challenges of projecting future scenarios and capital requirements.
- The availability of data and its relevance to forecasting future experience, for example in respect of risk dependencies.
- The conflict that can arise between different risks and measures, for example between capital and earnings volatility.
- The interaction of risks and capital, in particular where assumptions have been made about the diversification benefits of certain strategies.
- Maintaining consistency between Business Unit and Group objectives.

Business units are sometimes expected to operate within Capital at Risk, Earnings at Risk and other limits set as part of the Group's risk limits framework. So the metrics for them to do this need be readily available – this may mean that actuaries need to develop proxies to the exact calculations (and validate them and communicate the circumstances under which they may be unreliable).

In circumstances where a limit is at risk of being, or has been, breached, the business units would normally notify the CRO team as soon as they become aware of the matter.

3.2.1.4 Important Considerations

Important considerations to some of the key aspects of developing and managing the business in accordance with Risk Appetite include:

- The development of the link between the business strategy and the risk strategy enabled through the modelling of cash flows and the calculation of risk exposures as well as regulatory and/or economic capital in a variety of scenarios and stressed conditions.
- Risk Appetite would ideally be sufficiently clearly articulated to provide assurance and guidance to stakeholders – the actuarial input to this includes a clear quantitative analysis of risk exposures against the stated appetite and how these are likely to evolve given the current business strategy.
- The allocation of resources (capital, people, risk versus reward) can be enabled through the tolerances and underlying limits framework. The actuaries in the first line would often work with the risk function to assist with the development of a framework which works at a business level and is consistent with the company's overall Risk Appetite.
- The Risk Appetite would ideally be sufficiently clear to support the monitoring of risk profile and might also be supported by forward looking analysis (see section 3.5.5), and subject to stress and scenario testing (see section 3.5.6), to ensure that the firm understands what events might push the company outside its Risk Appetite and/or risk limits.
- A clear set of risk metrics supporting the Risk Appetite statement is often considered to help to shape the risk culture of the Group. It is important that the risk metrics achieve a balance between being relatively easy to produce on a regular basis and being sufficiently reflective of the underlying risk exposures to be relevant.

The Risk Appetite has a direct impact on many operations, including but not limited to:

- New Business Mix/Budgeting – the analysis of risks would often include both new business mix (looking at risk concentrations as well as opportunities to improve diversification) and volumes, taking into account both available capital and risk concentrations.
- Capital Allocation – an analysis of the risks in different parts of the business will not only identify the capital required but also the uncertainty or volatility associated with the risk profile. This will be an important factor in allocating capital to different parts of the business. An additional consideration will be how, and to what extent, the benefit of diversification of risk at the company level is allocated to lower levels within the business in the determination of capital requirements and Risk Appetite.
- Asset Allocation – asset allocation would often take into account the respective Risk Appetite (and how risks diversify/interrelate) in optimising asset returns against both liabilities and capital requirements.

- ORSA – this could include, inter alia, an assessment of how well the risk profile of the business is aligned with the agreed Risk Appetite and how this is expected to develop in the future over the business planning period.
- Liquidity Management – actuarial analysis of circumstances to determine the extent of the need for (short-term) liquidity is an important consideration, particularly when conventional actuarial models are not sufficiently granular for this purpose.
- Performance Measurement and Management – typically companies set targets for earnings and/or earnings volatility. Actuarial teams would often play some role in defining and communicating such targets, and whether performance has been achieved by operating within Risk Appetite.

3.2.2 Stakeholder Perspective

Due to their different interests, stakeholders may have different opinions on risk related strategies. Some stakeholders will be more risk averse than others. Stakeholders may include:

- *Regulators* - Generally look to protect the public interest and maintain the stability of the financial system.
- *Investors* - In order to profit from their investment, they tend to be less risk averse and more focused on return maximisation.
- *Board of directors* - The Board represents the interests of investors but also have to consider all other views and constraints to maximise the company's long term value relative to its Risk Appetite.
- *Senior management* - They are expected to work to achieve the objectives of the Board but there can sometimes be a risk that they focus on short-term performance to the detriment of longer term performance.
- *Bond holders* - Their interest is in relation to the capacity of the company to repay the bonds and make interest payments as required.
- *Credit rating agencies* - Strategies which result in volatility and risk may result in a downgrade, which would increase the cost of borrowing for the company. It should also be noted that a potential conflict of interest can arise for rating agencies because they are paid by the issuer of bonds rather than by the investors purchasing the bonds.
- *Customers* - Their interest is in relation to the capacity of the company to pay out on their insurance policies as required.

A company's Risk Appetite statement would often cover its desired position regarding major stakeholders. Together with risk tolerances, this may include the

desired level of capital adequacy and earnings volatility, target bond ratings and financial strength ratings.

3.3 Risk Identification

This section discusses the risk identification process, with specific reference to emerging and group risks.

Industry best practice would consider emerging risks separately but not all companies would treat it as a separate category.

3.3.1 Identification Process

The core risk management process is typically structured around a risk management control cycle involving the systematic identification, assessment, measurement, response, monitoring and reporting of risk. The precise steps in the cycle will vary from company to company depending upon circumstances but it is important to have a fully thought through documented process that can be demonstrated as required.

The first stage in the process is typically in relation to risk identification. Most companies have a process for identifying, categorising and tracking potential risks, ensuring that risk is not limited to financial or insurance risks but also considers strategic, reputational and other risks. Conduct risk (the risk that firm behaviour will result in poor outcomes for customers) is another category that many companies now define as a separate risk category, whilst others still consider it to be part of operational risk.

The risk identification process can be bottom up or top down or some combination of the two. In a bottom up risk identification process, many people within the company are asked to identify risks. Those risks are categorised into major groupings and eventually fit into a hierarchy of risks that can be used by senior management in their strategic decision making. In a top down process, senior management identifies the major risk categories that they feel are best suited for management and board attention. Those major risk categories are then often subdivided as risk management responsibilities are delegated to different levels within the company.

The company needs to consider how to ensure that all staff have a common understanding of the various categories so that risk can be reported consistently. Many companies establish a risk taxonomy clearly defining what risks are considered to fall within various categories such as:

- Market risk
- Credit risk
- Liquidity risk

- Insurance risk
- Operational risk
- Legal risk
- Regulatory risk
- Strategic risk
- Reputational risk

Within these categories risk can be further subdivided. For example, subsections of market risk could contain:

- Equity risk
- Interest rate risk
- Inflation risk
- Currency risk

It is also possible to establish categorisation systems using various different methodologies. For example, some companies categorise risks using a PESTLE methodology, where the acronym stands for Political, Economic, Social, Technological, Legal and Environmental.

Important terminology in categorising risks are the cause, the event and the adverse impact of a risk and it often helps in the identification process to give meaning to these terms.

There are numerous elements that might be included in the risk identification process, including:

- Regular information flows from all departments highlighting key risks within the departments.
- Workshops with senior management covering most material risks.
- Specific workshops with specialists focused on an individual area.
- Analysis of error logs detailing all risks or near misses that have occurred can help to identify risks.
- Industry benchmarking can serve to highlight risks.
- Scenario analysis can identify particular exposures of the company.

Once risks are identified they are typically recorded on a risk register. The risk register might also contain information on the assessment of the risk such as probability, impact, control effectiveness and residual risk. Sometimes it will also contain information on potential risk responses and any planned actions.

3.3.2 Emerging Risk

Emerging risks are sometimes defined as risks which are developing or changing, which are difficult to quantify and which could have a major impact on the company. They are often associated with a high degree of uncertainty, a lack of data and are often beyond the company's control. Examples would include items such as climate change, cyber risk and the possibility of the euro currency breaking up.

Identification of emerging risks possibly require specific attention given that there can be limited data and they might not be captured by a process that might be otherwise focused on more routine risks. Environmental scanning can be one method of gathering information on external risks, as can the use of external experts facilitating the identification of emerging risks in internal workshops.

3.3.3 Group Risk

Group risk is another category for companies that are members of groups to consider. Companies that are members of a group might be adversely affected by an event that happens within a different group entity and group risk can arise in a number of different forms including contagion, leveraging, multiple gearing concentrations and large exposures. Examples of these issues are outlined below:

- Contagion can occur where financial difficulties in one entity in the group results in other group members also experiencing financial difficulties.
- Leveraging can arise where a parent issues debt or other instruments which are ineligible as regulatory capital and down-streams the proceeds as regulatory capital to a subsidiary.
- Multiple gearing occurs when an insurer invests in a capital instrument that counts as regulatory capital of its subsidiary, its parent or another group entity. In effect, the same capital is used twice to cover regulatory requirements.
- A concentration of risk can occur when relatively small exposures to an entity in separate group companies accumulates to a large exposure when aggregated to a group and parent level. This can also contribute to some of the other issues mentioned above.

3.3.3.1 Considerations for Entities Within a Group

Groups typically consider Enterprise Risk Management across the entire group. In fact the sound management of a group often comprises Intra Group transactions that allow, amongst other purposes, the diversification of risks within its component entities. Certain integral functions of the group, such as funding or liquidity management, are often carried out by designated entities that have the requisite licenses or ratings.

However, when carrying out ERM effectively throughout the group, insofar as business decisions are made locally or where the local business environment has specific features warranting additional consideration, circumstances of local entities can be separately analysed. The local business' contribution towards the wider group's overall risk profile can be articulated as well.

This could allow the local management team to better understand the risks inherent within their businesses, and how they fit into the wider group's risk profile. Considerations such as when the local entity would start to monitor local capital or liquidity requirements more closely, and when they may start to request additional capital or transactional support from the group, can be articulated within the local risk management framework.

There may be differences in approach where the local entity is a legal entity (subsidiary of a group or holding entity), or where the local entity is a branch. A legal entity would probably have its own Board, which could be staffed with either internal senior management, or potentially also independent Board members. In these circumstances, the local Board will potentially want to require or request a separate ORSA and other ERM frameworks or reports.

A branch however, is unlikely to have a separate Board, but will generally have a management team. In order to aid them in a proper risk based decision making process, a proportionally appropriate element of ERM can be brought to a branch level. Liquidity and other considerations could be more important in the context of a branch.

3.4 Risk Assessment

Once risks have been identified many companies will undertake some form of assessment or profiling. This is often done via an assessment of the likelihood of the risk occurring and the impact on the company if the risk were to occur. This assessment is often performed in addition to the risk measurement, which is more focused on statistical and actuarial methods, detailed in section 3.5. The results of the risk assessment and risk measurement are often combined into one integrated analysis.

There would often be an assessment of both the inherent and the residual risk, following the application of controls or risk mitigation. This allows companies to form some view on the effectiveness of the controls that are applied to risks and also on the extent of reliance on controls. A risk assessment or profile might include:

- A description of the risk in sufficient detail.
- The consequence of the risk, considering both financial and non-financial impacts.
- An appropriate categorisation of the risk.

- An inherent risk assessment that considers the likelihood and impact of the risk, often expressed in qualitative terms as high/medium/low.
- An assessment of the effectiveness of the controls or risk mitigation strategies.
- A residual risk assessment after the application of controls or risk mitigation.
- A description of any actions required to reduce unacceptable residual risk below an appropriate limit.

Section 3.8 on risk reporting outlines how the risk profile report can often provide a useful snapshot of the company's risk positions and can be effective in communicating those risks.

Due to their nature assessing emerging risks often require specific consideration with scenario analyses often playing an important role.

3.5 Risk Measurement

Risk measurement is used to support company decision making and processes (including capital management and performance measurement) by providing important quantitative information related to the risks a company faces. The nature, scale and complexity of the risks in question would normally dictate the techniques used to measure risk with materiality and proportionality (i.e. whether the extent of effort is proportional to the size of the risk or potential losses) also being important considerations. This section covers a range of practices but it should be acknowledged that some of the detailed modelling considerations will not be applicable to smaller and less complex organisations.

This section focuses on risk measures which are the output of risk models. It is divided into a number of subsections with the main subsections consisting of:

1. Risk Measures
2. Models
3. Data
4. Aggregation
5. Forward Looking Assessment
6. Stress and Scenario Testing
7. Risk Measurement documentation and reporting

3.5.1 Features of Risk Measures

This section focuses on the desired outcome and generic features of risk measures. This will drive many of the other choices that are made when performing other elements of the risk measurement process (including calibration, modelling and stress testing).

More specifically, this section outlines the following three areas:

- Risk measurement selection criteria
- Risk measure properties
- Common risk measures

These three criteria are not meant to be an exhaustive list of considerations to weigh up during the selection of a risk measure; however, they do provide a good starting point for determining the appropriate risk measure to use.

3.5.1.1 Risk Measurement Selection Criteria

There are several criteria that contribute to the selection of which risk measure to use, including the objective of the analysis being undertaken, the stakeholders involved (internal/external), limitations in available data to perform calculations and available modelling approaches given resource and time constraints. These criteria are important because they inform the desired level of sophistication for risk measures as well as limitations actuaries may face in selecting a risk measure.

Objective of analysis

The objectives for performing an economic capital calculation are quite different to the objectives for determining the annual volatility of incentive compensation (for example). The risk measures utilised for each of these may be different, and when combined with the other selection criteria, may warrant different levels of sophistication in the risk measure chosen.

Stakeholders

Taking account of the various stakeholders that use or contribute to the analysis is another important consideration when selecting the risk measure to be modelled and subsequently reported. While some level of education and disclosure is always recommended, if a highly sophisticated measure is chosen, actuaries can expect to dedicate significant time for education related to the risk measurement methodology and definition of the risk measure provided. Considering the audience that will view and use the risk measure results will assist in mitigating the risk of misunderstanding and misuse of the risk measure.

Data and modelling limitations

Data and modelling limitations are key pieces of information that contribute to the understanding of the sophistication of the risk measure that might be used to satisfy a specific objective. Prior to deciding on a risk measure, the capabilities for both data and modelling might be assessed against the requirements for data and modelling of the risk measure chosen. Addressing this at the outset will help to mitigate the risk of costly implementation projects that do not justify value add and will limit the amount of unnecessary investment on systems / data requirements.

3.5.1.2 Risk Measure Properties

Alternative risk measures have different inherent mathematical properties and it is important to understand which of these properties the chosen risk measure includes (and perhaps more importantly the properties that the risk measure does not have). The four key properties of coherent risk measures as first proposed by Artzner et al (1999) are sub-additivity, monotonicity, positive homogeneity and translation invariance. However, there may be additional properties that an actuary can consider as well as other classifications of risk measures to choose from[2].

Kaye (2005) describes the coherence axioms by saying that they "*represent a basic set of common sense rules, the failure to comply with which must put into question a method's suitability for measuring or allocating risk*." However, it should be noted that depending upon the specific purpose not all of the coherence axioms are necessarily required for sensible allocation of risk, as long as the allocation has separate risk and return elements (e.g. as used in Markowitz mean-variance portfolio optimisation). These properties are explained in Appendix A.

3.5.1.3 Common Risk Measures

There are several risk measures that are commonly used within the insurance industry and for risk measurement purposes in general. It is important to understand their limitations as well as their usefulness. An understanding of risk measure limitations provides additional information that helps to inform the selection of an appropriate risk measure. Common risk measures include standard deviation, value at risk (or "VaR") and Conditional Tail Expectation (or Tail Value at Risk). These risk measures are outlined in Appendix B in terms of their definition, advantages and limitations.

3.5.1.4 Risk Metrics for Business Planning

In order to ensure effectiveness risk management would ideally be integrated with business planning. Business planning covers many areas such as new business targets, asset allocation, and capital allocation. Actuaries are often required to predict the future financial outcomes of different strategies. The predictions usually cover not only the best estimate but also the volatility of the outcomes. These predictions are valuable inputs and have significant influences on the decision-making.

Many risk metrics can be used to measure the risk and its impact in business planning. To gain a comprehensive view of the risk and return of different strategies, the following risk and risk adjusted measures could be used.

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[2] Insurance risk measures are described in *Axiomatic characterisation of insurance prices* by Wang et al. (1997). Additionally, a different set of risk measure axioms is proposed to describe *natural risk statistics* in *What Is a Good External Risk Measure: Bridging the Gaps between Robustness, Subadditivity, and Insurance Risk Measures* by Heyde et al.

Pure risk measures:

- *Capital at Risk (CaR)* - the capital loss at a specified confidence level. It can be described as the loss of capital/equity that is projected to occur with a probability of Y% over a specific time period. For example, there would be a loss of €100 million in a 99.5% scenario over a one year time period. Some companies focus on the potential capital ratio change due to the loss, as the risk might not only lead to a reduction in available capital but also to an increase in required capital.
- *Earnings at Risk (EaR)* - the loss of earnings at a specified confidence level. It can be described as the probability of an X% loss of expected/target earning in one year is less than Y%. Alternatively, with a probability of Y%, the earnings will be non-negative.

Risk adjusted measures:

- *Risk adjusted return* - the measure of expected return that is adjusted according to the level of risk. The adjustment could be a reduction of the cash flows or an increase in the discount rate. For example, risk adjusted return on capital (RAROC). The capital used is the required capital that reflects the corresponding level of risk.
- *Risk adjusted value* - the measure of expected value that is adjusted according to the level of risk. The adjustment could be a reduction of the cash flows or an increase in the discount rate. For example, embedded value calculation techniques that explicitly take account of the riskiness of modelled cashflows.

Different valuation bases and accounting bases are used for different purposes. IFRS, US GAAP, other local GAAPs, and economic basis may be used for measuring the EaR and risk adjusted return and value. Solvency II, NAIC RBC, other local solvency frameworks, economic capital framework, and rating agency capital framework may be used to measure the CaR. The appropriateness of the basis being used for these measures might be a factor to consider. The basis would often be consistent with those used in the company's Risk Appetite framework and how performance is measured in practice.

It is worth noting that 99.5% VaR over a one year time period is a minimum level of regulatory capital in many territories and by convention approximates to a BBB credit rating. Many firms target a higher credit rating and accordingly target a higher level of confidence such as 99.95% VaR if targeting an AA rating.

The selection of appropriate risk metrics is a factor for actuaries to consider. For CaR and EaR, when the loss distribution is heavily skewed, conditional tail expectation (CTE) may be used instead of the value at risk (VaR). For risk adjusted

return and value, the risk adjustment can be made to the discount rates for future cash flows or to the cash flows directly using the cost of capital approach. Judgment is often needed to decide the most appropriate approach under each specific circumstance.

When selecting between two alternative capital projects or strategies, pure risk measures act like constraints, for example ensuring that a given risk exposure falls within agreed limits, and risk adjusted measures act like a combined measure of return and risk, or a way of assessing value on a risk adjusted basis. When two strategies work within the constraints, risk adjusted measures might be used to compare them.

3.5.2 Models

This section focuses on models in the context of risk measurement. This includes guidance to actuaries when contemplating the design, development, selection, review and/or the maintenance of a model to measure risk. The section includes a description of models which measure specific risk factors and models that simultaneously cover all risks. Risk is commonly measured in terms of impact on capital, and therefore this section also covers economic capital models.

3.5.2.1 Types of Models

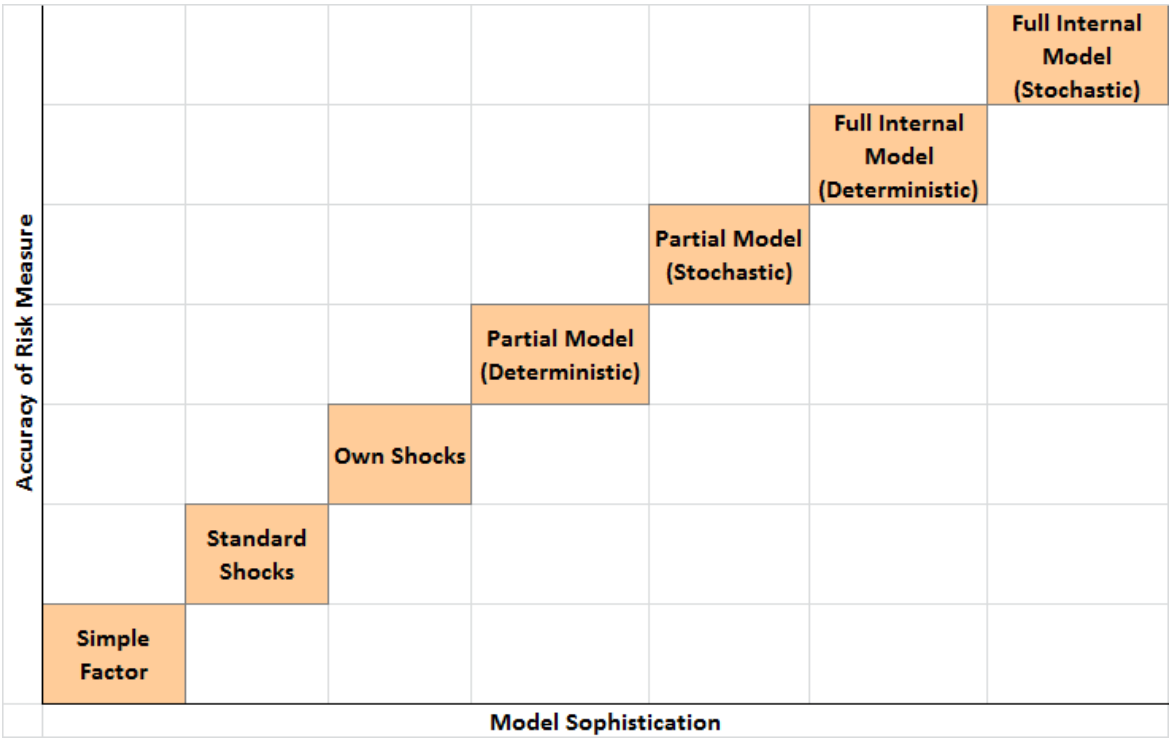
Models vary in sophistication and complexity depending on factors such as the materiality of the risk measurement result and the risk type being modelled. The following paragraphs outline various model types that an actuary can consider using when measuring risk. Models are described as those that vary by the level of sophistication employed and those that vary according to the individual risks being modelled.

It is also important to bear in mind that depending upon the specific purpose a model can encompass a lot more than just the calculation kernel or the software used. For example, a model could be considered to encompass (noting that this list is an example and not definitive):

- Data
- Methodology
- Assumptions
- Expert judgement
- Documentation
- Calculation kernel
- Software
- Model governance

Models that vary by sophistication

In selecting a model, the actuary might examine the materiality and complexity of the underlying risks being modelled. For small companies and less material risks, a less sophisticated model, such as a simple factor model or deterministic stress tests, may be appropriate for measuring risk. As complexity and/or the materiality of the risk increases, the actuary might consider the use of a more sophisticated model, such as a full stochastic internal model. The development of a full internal model takes significant time, effort and expense. If the development of a full model is not feasible, the use of a partial model (i.e. a combination of standard regulatory stress tests for certain risks and more detailed company specific calibrations for others) can be a prudent alternative and can be used as a transitional step while the full model is being developed.



- *Simple Factor Models* – This is the simplest form of model that can be used to measure risk. A prescribed factor is multiplied by a known base amount to estimate the amount of risk. As examples, factor-based models are used in rating agency risk-based capital models, US statutory risk-based capital models, and simplified calculations for the EU Solvency II Standard formula. A common use is in measurement of asset default risk, where ratings-specific credit default charges are applied to the value of assets held.
- *Standard Shocks (Stress Tests)* – A risk can be measured by assessing the financial impact of a prescribed risk factor stress or set of stresses. Examples of this type of model are the standard stress tests applied in the EU Solvency II Standard Formula and Swiss Solvency Test. In this model, for example,

mortality risk is assessed by calculating the financial impact of a 15% increase to best-estimate mortality rates, while longevity risk is measured based on a 20% decrease in mortality rates.

- *Own Shocks (Stress Tests)* – Instead of applying prescribed stress tests, the actuary can measure the risk using stress tests calibrated to the specifics of their particular risks instead of the standard prudent industry stresses determined by regulators. For example, an actuary may measure longevity risk with a 10% stress test instead of the prescribed 20% stress test, if the actuary demonstrates that a 10% stress test appropriately reflects the desired confidence level (such as 99.5% VaR over a one year time period) based on the company's own experience or experience for specific the product line being measured.
- *Partial Models* – If the actuary determines that a simple model cannot produce an accurate measure, a more complex model might be developed for those particular risks. The model can be based on a probability distribution or distribution of scenarios, determined either stochastically or deterministically. The partial model can be used in conjunction with simpler models for other risks to create an aggregate measure of company risk. An example of this in practice is the C-3 phase II portion of the US NAIC risk-based capital model, where a stochastic model is used to measure the risks of variable annuity contracts.
- *Full Internal Models* – The most comprehensive (and most complex) way to measure an insurer's risk is with a full internal model. To develop this model, one method is to use a multivariate probability distribution function as a basis to measure all risks simultaneously. Another method is to model each risk separately and aggregate the results using copulas as an aggregation approach. For underwriting risks with thin tails, where little data is available, it may not add value to develop a full simultaneous probability distribution function. However, a holistic model is more appropriate for risks with great risk dependencies, especially in the tail, which is our main area of focus. Once the model is developed, the risks can be assessed based on a set of underlying stochastic or deterministic scenarios. Results of stochastic scenarios will produce a distribution of financial results, and the risk can be assessed by analysing the tail scenarios. Results of deterministic scenarios are useful for understanding the impact of extreme scenarios under stress and scenario testing.

<u>Models that vary by risk type</u>

Models will vary based on the type of risk they are measuring. Different types of models may be appropriate for different categories of risk, such as market, credit, life underwriting, non-life underwriting and operational risk.

- *Market Risks* – These risks, including interest rate risk, spread risk, foreign exchange risk and equity risk, are largely dependent on external economic factors. These risks are often measured using stochastic models, which may

make use of sub-models such as economic scenario generators. Asset/ liability mismatch risks are less important in shorter-term business, although they might still be considered.

- *Credit Risks* – These risks, including default risk and counterparty credit risk, are commonly measured using a factor model, where ratings-specific credit default charges are applied to the corresponding asset values or exposures. More sophisticated stochastic models can also be used to measure these risks, using a statistical distribution that defines the probabilities of default and loss given default for each underlying instrument or counterparty. Financial contagion might be another factor to consider in relation to credit risk, where the default or financial difficulties of one entity could result in financial difficulties for other linked entities.

- *Life Underwriting Risks* – These risks, including mortality, disability, longevity, lapses, annuitisation and expenses, can be modelled using factors, stress tests or more sophisticated stochastic models. Since these risks are long-term in nature, the stress tests and models tend to be structured as cash-flow projection models, which could include stochastic elements.

- *Non-life Insurance Risks* – These risks, including claim frequency and claim severity components, are generally modelled using 'claims frequency' models (described below). Catastrophe models in particular assess risk in the tail of claims distributions. Geographical concentration is an important aspect of general insurance modelling.

- *Operational Risks* – These risks include fraud, and risks related to information systems, compliance, business processing, human resources, business continuity, outsourcing, distribution channels, changes in the legal, regulatory and taxation environments, and changes to the insurer's reputation. Due to the difficulty in quantifying these risks, a highly subjective scenario based approach is often adopted, relying on the opinion of subject matter experts. Regulatory regimes and rating agencies vary on their assessment of this risk with many ignoring it or using a simple factor model. Particular diligence might be required in the understanding and mitigation of these risks wherever possible. If the measurement of operational risks is undertaken, the actuary might consider documenting any assumptions made, and seeking assistance from subject matter experts in the business, due to the high level of judgement and subjectivity involved. Some literature has suggested that, although the results may not be particularly robust, the quantification exercise may provide stakeholders with a better understanding of the true nature of operational risks.

Economic Capital Models

Economic Capital models (ECMs) are a key component of risk modelling for some companies. A common definition of economic capital is the value-at-risk assessed on

the market value of assets over liabilities. However, this is not necessarily the only definition of economic capital. More generally, an economic capital model allows a company to quantify, assess and communicate its complete risk exposure using internally defined methods and assumptions.

The primary purpose of an ECM is to assess capital adequacy by comparing the ECM's calculation of required capital to the company's actual available capital. The results can be used by the company to make decisions regarding business strategy and capital allocation. ECMs can also be used to compare this internal risk assessment to rating agency and regulatory model assessments, which can assist in the communication of a company's risk profile to external stakeholders. Most large insurance organisations have developed some form of ECM, but the range of structure, complexity, and use of these models varies widely.

ECMs can only provide useful results if they adequately reflect all the underlying risks of the company and the range of scenarios that it may encounter. The model would normally be proportionate to the nature, scale and complexity of the company's risks. The ECM can be constructed using any combination of the model types listed above (factor, stress tests, partial), or it can be a fully integrated internal model either with stochastic scenarios and/or deterministic scenarios and stress tests.

3.5.2.2 Model Design

This section provides guidance on the factors to consider when designing a model.

Purpose and proportionality

The purpose of the model is one of the primary considerations and proportionality (not making the model more complex than it needs to be) is an important factor to bear in mind. Model design can only be judged in the context of the purpose of the model.

Industry best practice and professional guidance

Model designers might first examine accepted industry modelling practice based on the nature of the risk(s) to be modelled. It is important to consider whether the accepted practice is only applied to the circumstances specified. For example, accepted practice for motor vehicle claim variability is not applicable to asbestos liability claims. Guidance may also have been issued by local actuarial societies or professional risk associations to assist in the modelling of specific risks in the local product context.

Select model type appropriate to the risks being measured

The model type selected would normally be appropriate to the risk being measured. The actuary might also consider the size, breadth and diversity, and inherent volatility of the risks:

- *Size of risk* – Risks of greater materiality would often be modelled with a more sophisticated model, bearing in mind the costs vs. benefits of more complex model designs.
- *Number of risks (breadth and diversity)* – Insurers with greater diversity of risks might consider using an integrated internal model to capture risk interactions and ensure that the aggregate risk and capital of the company is appropriately modelled and managed. For a smaller number of risks (e.g., a mono-line insurer operating in a single jurisdiction), simpler models might be appropriate.
- *Uncertainty of risk (inherent volatility)* – Greater uncertainty around a risk increases the value of risk analysis, and increases the value of additional consideration of the model choice. Risks with lower volatility can potentially be modelled using simpler model designs depending upon materiality and circumstances.

Considerations for Complex Models

Complex models can be used to estimate a range of potential future outcomes given a set of input scenarios. These inputs can either be deterministic scenarios or stochastic scenarios. The results of the model will be estimates of changes in available capital under each of these scenarios. The focus will be on the scenarios in which the insurer's financial condition is adversely impacted, where the insurer will seek to understand and possibly control or mitigate the risks underlying the adverse scenarios. These complex models include ECMs and internal models, built for regulatory purposes or for an insurer's own internal risk measurement. The following factors might be considered in the development of these complex models:

- *Valuation framework* – In general, the selected accounting framework would normally be consistent throughout the model and appropriate for the model's intended use. ECMs tend to make use of observable market data to value assets and liabilities. However, a discounted cash flow approach can be utilised, especially if the model is focused on measuring risk over a longer time horizon.
- *Time horizon* – The time horizon is set by regulatory guidelines or accepted reporting practice, generally reflecting the time frame during which management and/ or supervisory action is expected. The most common regulatory requirement for ECMs is a one-year horizon. Other models may use longer periods or even the entire lifetime of the risks (run-off approach), which is appropriate for assessing risks which take several years to fully emerge. The time horizon would often be linked to the valuation framework. A one-year time horizon is generally used with a market-consistent valuation framework, while other frameworks might use a run-off approach, e.g. a U.S. statutory framework.
- *Risk metric* – The risk measure will likely be specified by an insurance company's regulators or guided by rating agencies and accepted reporting practice. However, the company may establish its own measures to fit its risk

management objectives, with ECMs potentially being accepted by the regulator as a capital requirement for regulatory solvency calculations.

- *Confidence level* - The selection of an appropriate confidence level for an insurer to use in an internal model will depend on the specific use of the model, its time horizon and choice of risk measure. For ECM's, the confidence level may be guided by the work of rating agencies, for example, incorporating the large volume of credit rating and default data accumulated by rating agencies. With internal models used for regulatory capital requirements, a minimum confidence level will generally be specified. With internal models, the company has more flexibility to choose their own confidence level. The degree of protection provided by a certain confidence interval will vary with the time horizon used. In general, the confidence level required will decrease as the time horizon lengthens to maintain a similar level of prudence in the overall capital assessment. For example, a 99% confidence level over one-year may be equivalent to a 90% confidence level measured over the entire lifetime of the risks.
- *Terminal provision* – If the selected time horizon is shorter than the full lifetime of the insurer's obligations, then a terminal provision might be included in the model to account for the remaining risk at the end of the measurement period. The terminal provision can sometimes represent a large portion of the financial risk measurement. The actuary might consider the appropriate level of conservatism and allowing for events that could develop after the modelled time horizon. Also, the correlation of adverse outcomes within the time horizon to adverse outcomes beyond the terminal provision time horizon might be considered. This occurs, for example, in claim liability estimates within property/casualty business.
- *Management buy-in* – A model is only useful if management agrees to use the results in its decision making. When developing a complex model, consideration would normally be given to building the understanding and obtaining buy-in of senior management during the development process. The value of the model could be demonstrated by use within a business, and there may be situations where some simplifications may be justified to facilitate use and understanding of a risk measure. Alternatively, use of a given risk measure could be facilitated by incorporating exposure against agreed limits within management performance scorecards.

Deterministic stress tests and stochastic scenarios

The selection of deterministic stress tests is a difficult task, especially in areas where limited data exists in the distribution tails. Deterministic stress tests would often be calibrated to the desired confidence level. For example, if a model defines capital at the 99^{th} percentile VAR over a one-year period, then the deterministic stress tests would correspond with a 1-in-100 event over a one-year period.

The set of stochastic scenarios may be mandated by a regulatory body. If not, the scenarios can be provided by an external party, produced by an economic scenario generator (ESG) provided by an external party but calibrated in-house, or using an in-house calibration and model. An ESG generates scenarios of periodic financial market parameters over time (e.g., yield curves, spreads, share prices etc.). There are two types of economic scenarios, real world and risk neutral. The choice will depend on the modelling purpose. Risk neutral scenarios are used for market consistent valuation, whereas real-world scenarios can be useful in exploring and communicating exposures and in valuation that is not based on market consistency.

Run times

Internal models may involve long run times, especially if stochastic scenarios are used. Several techniques are available to help reduce run times and the actuary might consider and assess any potential negative impact on accuracy. Examples of time-reducing techniques include grouping of data into model points, use of deterministic scenarios instead of stochastic scenarios for portfolios without options, equivalent closed-form solutions, a decrease in the number of stochastic scenarios, and a reduction time granularity. In addition, run times could be improved by employing variance reduction techniques when generating stochastic scenarios, such as antithetic variates.

Limitations

Models will always have statistical and theoretical limitations. The results can never be expected to fully replicate the real world. It is important to bear these limitations in mind when designing the model and when communicating the results of the model. Documentation of any material limitations in order to ensure that model users are aware of them is an important consideration.

Other Considerations

When developing a model, the actuary might bear in mind the general practical considerations of model design, such as usability, reproducibility, adaptability, timeliness, process effectiveness, technological capabilities, and cost efficiency.

3.5.2.3 Assumptions / Parameterisation

The selection of model assumptions requires careful consideration and judgement and depends critically upon the purpose of the model. This section provides guidance to be used for the selection and development of assumptions and model parameters.

Assumption categorisation

Assumptions can be classified into various categories: (1) observable from market data, (2) based on historical experience, (3) management actions, and (4) assumptions outside of management control.

1. *Observable from market data* – Assumptions might be based on observable market data, if available. Assets and liability products with deep and liquid markets will have reliable market prices readily available. For less liquid markets, market values can be derived using a set of stochastic scenarios that are calibrated to market prices (i.e. risk-neutral scenarios). The scenarios can be validated by demonstrating that observable market prices can be derived. It should be noted that insurance liabilities rarely have an observable market price and that it is often necessary to use other techniques when determining liability assumptions.
2. *Based on historical experience* – Demographic assumptions are often required in the valuation of insurance liabilities to estimate future experience and policyholder behaviour. The calculation of demographic assumptions would often incorporate company experience, industry experience, changes in the environment and observed trends. It may be appropriate to include a risk margin or PAD (provision for adverse deviation) to reflect the uncertainty in the determination of the best estimate, where a higher margin reflects a higher degree of uncertainty. Any assumptions which significantly impact model results warrant more attention and documentation regarding the development of the central best estimate and any additional margin or PAD.

   Some assumptions will depend totally or partially on external variables, such as policyholder lapse rates or claims rates. Instead of a central best estimate plus margin, these assumptions might take a tabular or formulaic form, where experience data and regression analysis are used to link the assumption to the appropriate external variable(s), for example life product surrender rates and the level of interest rates or yields.

   Historical experience might also be relevant to the calibration of market assumptions depending upon the purpose of the model. For example, historical equity returns could be used to calibrate a real world projection of equity returns.
3. *Management action* – In some cases, a model may include assumptions for expected future management actions. Management actions can impact compensation, expenses, and reinsurance, investment and hedging strategies. In setting these assumptions, the actuary might consider any contractual requirements, policy language, approval process, timing, and past experience.
4. *Assumptions outside of management control* – Examples of other assumptions outside management control include tax rates, regulatory requirements and reserving requirements. These assumptions would normally reflect the actual situation as of the valuation date, as well as any known future changes.

Considerations by risk type

Model parameters can vary significantly by risk type, either due to the nature of the risk or due to industry normal practices, or both. This section provides some insight into the parameterisation of a few key insurance risk types.

- *Asset risks* – If the model includes a projection of asset cash flows, the actuary may consider mapping the company's assets to proxy asset classes or benchmark indices in order to assist with parameterisation. The mapping would often be reviewed regularly and clearly documented. For hedging, the basis risk might be analysed if there are any mismatches between the hedge instruments and the underlying asset. The parameterisation will also vary with the type of valuation, which includes a number of different aspects such as stochastic or deterministic, market consistent or not etc.
- *Insurance risk, mortality* - Life insurance variables tend to be modelled using expected rates rather than stochastic modelling, mainly due to lack of statistical data credibility. The focus is generally on variations in mortality year-over-year and on longer-term mortality improvements by age. Probability distribution around mortality, morbidity and mortality improvements increase in popularity as more credible experience accumulates.
- *Insurance risk, lapse/surrender* – The lapse rate assumption is generally a key life insurance risk. However, the probability distributions of lapses are generally not known or modelled. Lapse risk can be very complex, varying widely by product type and marketing method. Lapse behaviour is driven by policyholder decisions, which are influenced by external factors, often economic ones. Research studies have shown that lapse behaviour is not necessarily fully rational. In principle, a stochastic approach including dynamic dependencies between economic variables and policyholder behaviour is the best approach to capture this assumption. However, current experience may not capture behaviour under all plausible scenarios, such as a rising interest rate environment, which therefore means that significant judgement might be needed.
- *Insurance risk, Property & Casualty (P&C) claims* – In contrast to the life models, most P&C insurance variables are represented by probability distributions using stochastic techniques.

<u>Use of professional judgement</u>

Selection of some assumptions based on professional judgment will often be required as risk measurement tends to focus on unlikely as opposed to regularly occurring events. The development of assumptions and their interrelationships in tail events can be challenging.

There are several factors that the actuary may consider when exercising professional judgment in the selection of assumptions. These include historical data, market prices, opinions of other experts, fit of the assumed distribution to available data, the ability of the assumed distribution to reflect possible extreme values, sensitivity of results to changes in assumptions, internal consistency of the assumptions, and consistency in the application of assumptions.

Validation of expert judgement is an important factor to consider. This validation might include benchmarking, back-testing, sensitivity analysis or independent review.

General considerations

Assumptions would normally be realistic, applicable and relevant for the situation, objective, used consistently through the models, accounting for future developments, and consistent with the assumptions used for other purposes.

Experience studies would normally be updated regularly to verify whether assumptions are still appropriate. Periodic back-testing might be performed, where the assumptions are compared with actual experience. There would normally be clear links between the conclusions of the back test and consequent steps in the assumption setting process. When substantial differences are identified remedial actions would normally be taken.

Calibration of Assumptions and Parameters

Calibration refers to the process of validating the model's underlying assumptions and parameters such that the resulting model output aligns with observable or known values. The calibration of the model involves adjusting inputs and examining the impact on resulting output. The actuary could then consider whether the resulting changes in outputs are explainable.

Any industry or regulatory guidance, where available, would normally be observed with respect to calibration. For regulatory capital purposes, it may be necessary to demonstrate that the parameters reflect industry or market experience. Also, it may be necessary to demonstrate that the model produces results consistent with the confidence level required by the regulator. The assumptions might be periodically re-calibrated to allow for recent, relevant and credible experience as part of a regularly repeated process.

For models which make use of economic stochastic scenarios, calibration has a special significance. The economic scenarios would generally be calibrated such that the resulting output is consistent with either historical experience adjusted as necessary for known expected future variances (real world scenarios) or current market data (risk neutral/market consistent scenarios).

Methodical testing of changes greatly facilitates the calibration process. Model designers would normally bear the calibration process in mind when structuring the model. Careful documentation of the calibration process and results is normally considered appropriate.

3.5.2.4 Model Governance

The governance of the model is something to consider both when developing the model and subsequently in respect of maintenance of the model. This includes the initial validation of the model, as well as the ongoing model governance.

Some companies classify the various financial models used to different risk levels, with the classification based on the impact and likelihood of the risk associated with the model. In general, models with higher risk levels would then have a higher level of control associated.

Model validation and integrity checks

Model validation is a key activity to help make sure that models function as intended, both upon initial implementation and on an ongoing basis, and to confirm the model's appropriateness. The validation could take place through regular independent review, using either internal or external parties depending on materiality. The sufficiency and relevance of the experience of model reviewers is a factor to consider.

Models are generally calibrated to normal situations, but the validity of the model in tail situations is crucial when measuring risk. Below are two potential methods to assess the model's behaviour in the tail.

- One validation method is to use deterministic scenarios to assess the reasonableness of the outcomes of the model. Specifically, extreme scenarios correspond with losses at the far tail of the distribution. By examining the positions of the extreme scenarios' results in the distribution, the model's integrity can be validated.
- Another validation method involves the use of reverse scenarios to assess the model reasonableness. Here, the required capital for certain percentiles of the distribution are calculated, e.g., the 80^{th}, 95^{th}, 99.5^{th} and 99.9^{th} percentiles. Then for each selected percentile, a reverse scenario consisting of a combination of individual risk factor stress tests is formulated that that would lead to a similar loss amount. By subjectively assessing the likelihood of these reverse scenarios relative to the percentile amount, the actuary can draw conclusions on validity of the model.

Other procedures that are applicable when validating a model include:

- Review of the logical and conceptual soundness
- Comparison against other models
- Comparison of model predictions against subsequent real-world events

The model would normally be tested to be sure that any changes in assumptions produce reasonable and reproducible results.

Model Governance Framework

Model governance dictates the orderly development and usage of models, with a goal of minimising model risk to the company. Actuaries might first examine their jurisdiction's regulatory requirements, if any, regarding model validation and model governance. For example, Solvency II mandates six tests for internal models to meet prior to approval and upon any material change to the model, including model validation, use test and documentation. These tests do not focus solely on the calculation engine but also include wider processes and governance.

When developing a model governance framework, the following items might be considered:

- Roles and responsibilities for the model governance
- Model approval process and application for approval of major model changes or extensions. Some companies have adopted policies governing model changes which outline the types of changes that might be required and the governance associated with those changes.
- Strategic direction of the model
- Sufficient resources to develop, monitor and maintain the model
- Monitoring on-going compliance with the supervisory requirements
- Adequate independent review procedures

3.5.3 Data

This section discusses data that an actuary uses in risk measurement activities and provides information related to data selection, data quality review / validation and data transformation and adjustment. Data quality is a crucial component in risk measurement because the inputs are the ingredients for the results of risk modelling activities. Ensuring the appropriate diligence is paid to data helps in avoiding the old adage of "garbage in, garbage out."

3.5.3.1 Data Selection

An actuary has two main sources from which to obtain data: internally and externally:

- *Internal data sources* – Produced within a company and is likely to be the most relevant and reliable data for the actuary to use if performing risk measurement activities specific for a company or area within a company.
- *External data sources* – Any data that is not internally produced and can be obtained from other sources including industry groups and other computerised databases or provided by a data vendor. External data is often relevant for performing broader analysis that expands beyond the borders of a company and can also be used for internal risk measurement purposes,

where internal data does not exist, after accounting for the potential drawbacks of using external data for this purpose.

Determining which type of data to use often includes consideration of the scope of the exercise, the availability of data, the cost of data and any limitations of the available data (credibility and volume). These considerations are not exhaustive but provide good starting criteria for analysing potential data options. These elements would be considered through the lens of the impact that each may have on the risk modelling results and in turn any consequences of decisions made based using risk measurement results.

The scope of the exercise determines the granularity and fields of data required. Understanding the overall scope will assist actuaries in only selecting data that is directly related to the modelling activity and limiting superfluous data fields. Certain extraneous data fields can have significant potential operational risks due to potential breach of protected or proprietary information.

All data comes with various costs including cost of acquiring, maintenance and storage. Clearly outlining the scope can provide an estimate for the costs associated with the data and potential alternatives can be determined. A cost/benefit analysis is a good approach to determine whether the costs associated with a certain type of data, a specific data field, etc. are worth the additional accuracy provided to the results of the risk measurement exercise.

Most data has some set of limitations associated with it and understanding these will provide insights into the appropriate data to select. Knowing the limitations during the selection process will also assist downstream processes such as data quality review and data transformation. The costs associated with accommodating these limitations can also be captured during this stage.

Obtaining data from reputable sources will add to the reliability of not only the data but the entire risk measurement process and results. Additionally, if multiple sources of data are available, a good review and verification exercise is to reconcile between those sources to test the alignment of the data. In addition to contributing to reliability, selecting data from a reputable source will assist actuaries in defending their selection of data to other actuaries, auditors and regulators.

One last consideration that is important to include in the data selection process (and the data sections that follow) is compliance with all applicable regulations, actuarial guidelines / standards of practice and codes of conduct related to data.

3.5.3.2 Data Quality Review / Validation

Prior to using data for risk measurement, it is often a requirement for the data to be reviewed for consistency, accuracy and overall quality. There are several standard "data checks" that can be applied to nearly any data set and can provide comfort around the quality of the data. These data checks include:

- *Missing data* – Review data fields to determine if required data elements are missing.
- *Reconciliation* - Where possible reconcile the data with known values from other data, expected totals and other summary information. Reconciliation includes the reconciliation of data to administrative systems.
- *Data values* – Perform common sense checks on fields such as date of birth, gender, policy dates, benefit levels, etc. to identify questionable data values.
- *Data definitions* – Review data definitions to ensure the data fields used are appropriate and the data provided aligns with expectations and requirements for the analysis.
- *Benchmarking* – Benchmarking can take many forms and includes comparing against prior year data, industry benchmark data or other available data. Reviewing prior data for comparison purposes to identify any large discrepancies and changes from year to year. This check is useful for attribution of results to changes in the data.
- *Suitability* - Review data to consider whether it is suitable for the model and is consistent with the underlying theories and methodologies of the model.

Automation of these (and other) data checks can be instituted to ensure efficient and consistent data review. However many data checks are performed, disclosure of the extent of the data review typically accompanies any reporting of the analysis. This disclosure can also include the level of reliance on a 3rd party review of the data.

It is important also to distinguish between data review and data validation. The key difference between these two concepts is the level of rigor applied to the various data checks performed. When performing a data validation exercise, performing all data checks at a detailed level is often required and is often included in a model validation exercise.

3.5.3.3 Data Transformation and Adjustment

When data limitations or deficiencies are identified, adjustments might be applied to the data set in order for it to be used. Common adjustments to data include:

- Exclusion of certain data records i.e. outliers or records with insufficient data.
- Deletion of duplicate records.
- Creation of data values based on reasonable assumptions for missing but required data elements.

Clear documentation of these adjustments will assist reviewers in understanding how source data has been used and the underlying assumptions applied to it.

Additionally, an analysis that quantifies the impact of these and other changes is often a helpful analysis to determine if these changes are material.

Actuaries often transform data for purposes other than to correct limitations or deficiencies in data. This includes the method of grouping data which is commonly performed when there is a restriction on computer run-times. When grouping data (and performing other transformations) an analysis justifying the level of grouping (or other changes) can be performed by comparing results on representative portfolios through statistical analysis and setting clear guidelines for accepted deviations between samples.

The decision related to the appropriate level of grouping involves a trade-off between speed and accuracy of the results. This is a factor to consider depending on the task at hand. Additionally, when deciding to group data, it is worthwhile to consider the features of the data including product types, risk types and other attributes to ensure that the uniqueness of each group is maintained on materially the same level as if the data was ungrouped.

3.5.4 Aggregation

The objective of many risk measurement activities is to develop a comprehensive view of the risks taken across an organisation. As opposed to individual risk measurement, when performing risk measurement across multiple risk types, there is an added element of risk measure aggregation to consider.

There are several approaches to aggregating risk measures ranging from simple to complex. The appropriate approach to use in a given situation might be determined by the actuary and other key stakeholders involved in the process. The factors often considered are the extent of computing power, end-user sophistication and the balance between complexity and additional accuracy. Appendix C outlines some common methods of aggregation and their limitations. Sometimes a mixture of methods may be used depending upon the purpose, the data available, the specific risk in question, materiality and other factors.

The approach towards aggregation can be a very significant factor in determining the overall capital requirement. Therefore, validation of the parameterisation and expert judgement involved is very important and could include analyses such as:

- Comparison of output correlations with input correlations, and explanation of material differences
- Tables or charts of joint exceedance probabilities between different pairs of risk factors and consideration of these probabilities.

3.5.4.2 Fungibility and Transferability

When performing risk measurement activities for an insurance group, which often encompasses many entities, any allowance for diversification might incorporate the balance of risks across these various entities. There are two key concepts that are

important to consider when performing risk measurement aggregation for an insurance group with multiple entities.

- *Fungibility* - the ability to move funds freely from entity to entity within an insurance group in order to absorb losses wherever they arise. The focus of fungibility is on the ownership of assets or liabilities. When performing internal risk measurement activities, risk modellers often assume full fungibility of assets.
- *Transferability* - the actual ability to transfer funds from one entity to another within a certain time frame. This concept is meant to incorporate the various limitations met in practice including timing and legal constraints and is imperative to account for in liquidity management exercises.

The two concepts above are important to distinguish between and are often times not accounted for in practice. Depending on the purpose (e.g. solvency testing, liquidity risk management) these concepts could be incorporated as appropriate.

For more information related to fungibility and transferability, see the CRO Forum's October 2013 paper: *Diversification Consideration on Modelling aspects & Related Fungibility and Transferability*, which outlines the distinction between these two concepts.

3.5.5 Forward Looking Assessment

The Own Risk and Solvency Assessment (ORSA) is discussed in section 3.9. One of the objectives of the ORSA is to understand how risk and capital metrics are expected to develop in future, linked to an insurer's business planning process, and is seen as an important tool in the development of risk and capital management strategies.

3.5.5.1 Forward Looking Assessments in Context

In order for the projection process to be most useful to an insurance company, and increasingly required in international ORSA principles, the forward assessment of risk and capital information could be an integrated part of the business planning process. Projection of risk and capital information within the business plan helps to ensure that strategic decisions made by senior management have regard to the implications on risk and capital on a forward looking basis.

Risk measures projected would include those that are used within the organisation to determine risk exposure against agreed Risk Appetite limits, internal capital measures such as economic capital, as well as regulatory and rating agency capital measures. The time horizon used for the forward looking assessment would normally be consistent with the projection of other business plan metrics, usually a 3 to 5 year projection. The projection is also likely to take the form of a base case projection, potentially together with additional scenarios to test a range of different business and/or external market scenarios.

Instead of being a once-off exercise as part of the business plan, the forward assessment of risk and capital is typically iterative as part of the Risk Appetite and limit setting process. Initial forward looking assessments, perhaps performed using approximate methods, are used to assist management in determining Risk Appetite, translated into limits on key risk measures that strategic business planning can adhere to. In addition, an initial assessment will help inform the insurer's risk strategy, or decisions on which risks are to be avoided, reduced, maintained or increased as part of the risk strategy to ensure that risk and capital metrics are optimised in the strategic planning process.

3.5.5.2 Practical Considerations in Building a Projection Model

Risk measurement calculations performed at a point in time during a given reporting period are complex. The projection or forecasting of risk measures according to a given future scenario is significantly more complex from a theoretical and computational perspective, involving nested stochastic calculations of assets and liabilities where an insurer has provided financial guarantees. For practical purposes, simplified estimation methods are often used to produce point in time risk measurement calculations, which can then be used to practically estimate risk measures on a forward looking basis.

Proxy modelling techniques

Common methods used to speed up risk measurement calculations include the following forms of proxy modelling techniques:

- *Closed form solutions*: Approach used where the calculation of assets and liabilities can be closely represented using a closed-form solution of a stochastic process, which may be the case for fixed liabilities and simple financial guarantees.
- *Replicating portfolios*: An approach that tries to replicate the cash flow outcomes of insurance liabilities using a portfolio of financial derivatives (either real or theoretical), which then become a proxy for the value of the liabilities.
- *Other parametric approaches*: Other estimation approaches are also possible, including the use of regression analysis of asset and liability outcomes to determine the best fit parametric function as a proxy model. This could be a relatively simple polynomial function or more complex functions that could include closed form solutions as part of the chosen parametric form.

More simple estimation techniques

A different approach to proxy modelling involves approximating the result of a risk measure outcome using a scenario derived from a small number of individual risk factor stress tests. The chosen scenario is likely to be made up of the most material underlying risks that contribute to the risk measure result. The chosen scenario can be checked for stability over time to ensure that it remains representative of the risk measure result in a forward looking projection scenario.

For example, a 90th percentile value-at-risk calculation for the economic value of a single-premium investment product could be approximated using a 25% fall in equity markets and a 30% increase in assumed surrender rates, with these being the most material risk factors.

A simpler approach would be to use a known relationship between a given risk measure and underlying risk drivers to approximate the risk measure result. Even where this approach is not used, it is important to ensure that underlying risk drivers modelled elsewhere in the business plan projections are consistent with the progression of risk and capital results.

For example, where a major component of operational risk scenarios includes risk of transactional errors on an in-force book of policies, the number of in-force policies may be a good proxy for operational risk calculations. Operational risk calculations could then be projected using an anticipated pattern for the projection of in-force policies on books.

Additional considerations of the chosen approach

Where risk measurement projections are simplified to the extent that broad risk drivers are used to estimate forward-looking aggregated calculations, it is necessary to make an assumption about the future proportions of underlying risks and the impact of the dependency structure. Assuming a stable distribution of risks over time may be a reasonable assumption, but might be assessed against the impact of potentially changing risk proportions over time.

The simplification approach chosen can consider the most material risk variables that are likely to drive risk measurement results over time and consider whether these variables are modelled in a robust way.

The estimation process might be regularly validated against actual reporting period results to consider whether it remains a reasonable representation of the risk measure on a forward looking projection basis.

3.5.5.3 Consistency With Other Forward Looking Projections

It is important to consider whether the risk measurement projections produced are consistent with the other business planning metrics produced.

In addition, risk metrics by their nature describe the effect of changes in markets or other risk variables on specific business outcomes. The maintenance of consistency between risk measurement outcomes and business plan projection outcomes where both describe similar changes in the business or external market environment is a factor to consider.

For example, a risk measure describing the impact of a fall in equity markets on capital resources could be compared to the direct projection of a downside equity

scenario as part of the business planning process to consider whether both movements in capital resources are consistent.

The level of sophistication used for the risk measurement projection process could recognise the importance of the projection for strategic decision making purposes, i.e. whether the specific risk measure in question is a peripheral consideration or part of a key risk / capital constraint in the given projection. The modelling approach chosen could also consider the accuracy and sophistication of projection models used for other projected metrics that act as inputs to the projection of risk measures, such as earnings and new business value. A complex modelling approach that uses simplified projection inputs as a calculation basis will risk producing results that are spuriously accurate.

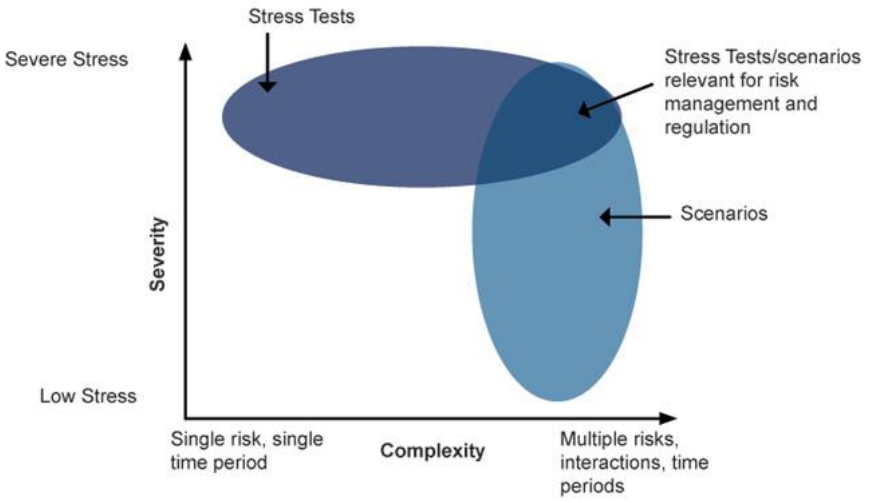
Whatever modelling approach is chosen and level of sophistication employed, the understanding and communication of the limitations of the method chosen is something to consider.

3.5.6 Stress and Scenario Testing (SST)

Models assume that the external economic and internal business environment is stationary on a forward looking basis, and in most cases that it can be predicted using average historic experience and/or relationships between risk variables. From a theoretical perspective, Stress and Scenario Testing (SST) is used to understand what happens if the environment is non-stationary. SST is a complementary process to risk measurement that assists in the understanding of key business outcomes.

- *Scenario* - A scenario is a possible future environment, either at a point in time or over a period of time. The effect of these events or changes in circumstances in a scenario can be generated from a shock to the system resulting from a sudden change in a single variable or risk factor. Scenarios can also be complex, involving changes to and interactions among many factors over time, perhaps generated by a set of cascading events.
- *Stress Test* - A stress test is a projection of the financial condition of a firm or economy under a specific set of severely adverse conditions that may be the result of several risk factors over several time periods with severe consequences that can extend over months or years. Alternatively, the severe conditions might be just one risk factor, acting over a short in duration. The likelihood of the scenario underlying a stress test is referred to as extreme but plausible.

Figure 1



Source: IAA (2013), Stress Testing and Scenario Analysis

A robust SST framework will aim to test:

- The adequacy of resources held within a business
- The validity of current strategic business plans and Risk Appetite
- The appropriateness of some aspects of resolution and recovery plans

It will also aim to assist in the process of identifying new risks that might have been overlooked via the usual base case business plan projections.

As such, SST is both a management tool and a supervisory tool, with regulators increasingly using this approach to test both robustness of individual company resources and plans, as well as the vulnerability and systemic risks associated with the entire national insurance industries.

The July 2013 IAA paper on Stress Testing and Scenario Analysis provides further detailed insight into this topic.

3.5.6.1 SST as Part of the ERM Process

Key aspects of the ERM process that involve SST include:

Identification of emerging risks

SST can firstly be used by management to quantify the types and extent of risks to which an insurer, or particular business model, is potentially exposed. By analysing the effects of multiple risk factors over multiple time periods, this process usually extends the remit of risks assessed through the usual suite of risk and capital measures.

Apart from the assessment of emerging risks and business vulnerabilities, another important use of SST is the identification of mitigating actions or contingency plans and their effectiveness.

Assist in determining Risk Appetite

SST could help management understand the reasonability of Risk Appetite limits through understanding what conditions would result in risk exposure measures exceeding risk appetite limits. Alternatively, if a Risk Appetite of an insurer is defined in terms of a specific adverse business outcome, such as a ratings downgrade, SST can help management understand the factors that contribute to that outcome and risk tolerances, or Risk Appetite limits, that might be defined as a result.

For example, a firm might identify that a loss of USD200m will lead to a reduction in resources and capital cover that would lead rating agencies to consider reducing an insurance company's credit rating. Senior management could then use USD200m as a Risk Appetite limit related to an earnings risk measure.

Strategic decision making

Analogous to the usefulness of senior management being involved in the forward looking assessment of risk and capital metrics, it is also useful to involve senior management through the entire SST process. The SST process is a useful risk communication tool and can help senior management to understand the implications of strategic decisions, together with the trade-offs of taking different courses of action.

Model validation

SST, or more specifically reverse stress testing, is a key aspect to model validation because it can focus on the tail events which are rarely observed.

Interactions with regulators

Regulators also find SST analysis useful, including the wider application to potential systemic risks, where a regulator may ask a number of firms to test the impact of the same scenario. Reverse stress testing is a useful way for regulators to assess the robustness of the firm's financial position and/or business model.

3.5.6.2 Types of Stress and Scenario Tests Used in Practice

SST can be prescribed by regulation or as part of a risk management framework in order to populate a risk dashboard. SST can also be used as a communication tool as part of risk workshops for senior management or as part of the risk measurement process. The following types of scenarios are often used in practice:

- Reverse scenarios (or "reverse stress testing"), with the purpose of back-solving a specific financial outcome.
- Historical scenarios, where one typically has a lot of detail of the sequence of events and risk factor outcomes over multiple time periods.
- Synthetic scenarios, derived as what-if prospective scenarios by extrapolating an extreme version of a recent trend or movement in risk factors.
- Company-specific scenarios that test specific outcomes unique to given company, or industry wide scenarios.
- Single and multi-event scenarios, where either a single or multiple events contribute to a specific future scenario outcome.
- Global scenarios that test the impact of an event that happens on a global scale.

3.5.6.3 Reverse Stress Testing

As described above, reverse stress testing is the process used to back-solve the required stress and/or scenario events that will give rise to a specific adverse business outcome. This is an iterative process that may involve an initial assessment of a plausible stress test based on estimates and desktop analyses, followed by a more rigorous bottom-up process once the appropriate stress test has been identified and chosen.

The adverse business outcome could be the point at which the company becomes insolvent under local regulatory guidelines or could be a less adverse scenario that is defined according to "business model failure", e.g. a scenario that would cause a credit ratings downgrade.

As there are many different possible combinations of risk factor outcomes that could give rise to a targeted adverse business outcome it is important to derive the stress test in a way that gives rise to the most likely combination of risk factor events.

Reverse stress testing in this manner allows companies the opportunity to learn from consideration of the stress test and to modify their business strategies to reduce the likelihood or consequence of failure.

Reverse stress testing is also a particularly useful way of describing the result of a risk measure calculation in a simplified way, for example describing a capital requirement result as the outcome of a few key risk factors instead of reproducing the mathematics behind the risk factor and aggregation calculations. In addition to testing the likelihood of a chosen scenario, derived reverse stress test scenarios can also be tested for stability over time, which will greatly assist in communicating modelled results.

The analogous use for SST is for model validation purposes to consider whether the outcome of a risk measurement model makes intuitive sense. A change in reverse stress test scenarios over time could be checked for consistency against changes in business conditions or modelled approach adopted.

Global Systemically Important Insurers (G-SIIs) are required to complete Recovery Plans addressing such failure scenarios, which focus on the options available to support the business in recovering and the prioritisation of those actions to form the plan.

3.5.6.4 Constructing Scenarios for Stress Testing

A comprehensive understanding of a scenario begins with a narrative and a trigger event. It is important to understand the purpose of the scenario to consider whether it is applicable to the business outcome that management wants to explore. To be most useful, scenarios could be constructed with input from the management committee or Board that is responsible for approving the business strategy and can sign-off actions to mitigate risk. It is often worthwhile to get a wide range of opinions on plausible scenarios from external industry experts or economists as well as internal experts from business subject matter experts. Scenarios might also need regular updating over time to maintain relevance when internal or external market conditions change.

A scenario chosen by senior management will often be a combination of quantitative outcomes for specific risk factors and a qualitative assessment of other variables or business impacts. It is important that the scenario definition is translated into a comprehensive and consistent set of risk variables that can be used to model specific business outcomes. This may involve either considering the impact on a fuller suite of risk variables where models are more complex or the impact on fewer variables if the modelling is more simplistic.

For example, a chosen scenario might describe a stagflation scenario where interest rates are low, equity markets are flat and inflation is high. Risk variables used in chosen models might need more defined information on the evolution of the entire term structure of interest rates and different types of inflation that might affect general economic forecasts vs. insurance company policyholders.

A key dimension to describing a given scenario is whether the entire insurance industry is affected in a similar way or whether a scenario is isolated to impacts on a given company in isolation. If scenarios are isolated, there are likely to be substantial effects on the company from stakeholder reaction, including customers and debt-holders, where stakeholders are likely to select against the company, reducing ability to attract business, retain clients and maintain a given credit rating.

For example, potential new policyholders might avoid a company or existing policyholders might surrender policies if they are made aware of a substantial drop in an insurer’s credit rating. This will differ from the situation where all insurance

companies are affected similarly and policyholders don't have the ability to move to an alternative provider for the same insurance product.

Scenarios can consider inter-dependencies between risk variables to consider whether a coherent set of impacts are explored. Two variables may have an immediate dependency (direct immediate causal linkage), time-lagged dependency, feedback dependency (where risk variables interact with each other over time) or phase-shift dependency (where a variable affects another only after a change has reached a certain threshold).

It is important to consider whether the chosen scenario would have a knock-on effect on underlying risk distributions being modelled. The decision of whether or not to rebase underlying distributions would depend on the risk factor calibration process itself and whether rebasing forms an automatic part of the approach chosen.

For example, if equity risk calibration within a capital model incorporates some form of mean reversion and would be rebased after a sudden change in market levels, this change could be incorporated into the scenario modelling.

3.5.6.5 Practical Considerations in Producing Stress and Scenario Test Results

Risk measure calculations

Approaches to simplify risk measurement calculations for forward-looking projections are discussed in section 3.5.5.2 above. The production of estimated risk measures calculated on a forward looking basis within adverse or extreme scenarios is likely to test the limitations of the simplified approach chosen. For these purposes it is useful to produce results at a granular level of detail, using individual assessments of chosen risk variables building up to the combined scenario impact (taking non-separability into account).

It is important to also consider 'limiting' figures for risk measures under extreme values of chosen risk factors to consider whether results are modelled sensibly.

For example, one could consider whether the impact of equity market falls is modelled correctly in extreme scenario by understanding the limiting values of risk measures as asset values fall towards zero.

Knock-on business effects

It is important to outline the scenario narrative clearly to consider whether risk variables can be appropriately modelled to describe the scenario. One could also consider whether any knock-on effects on business operations are carefully understood and modelled.

For example, if derivative transactions require the posting of additional collateral where credit ratings fall, this could be incorporated into the modelling results.

As another example, if an epidemic is being modelled that affects the insured population and hence claims pay-outs; one could also consider the impact of the scenario on illness rates among staff and costs to find temporary replacements.

Management actions

Allowance for the impact of management actions taken could be based on approved and plausible actions that will be taken in the given scenario. Interpretations of 'plausible' actions could differ widely among key stakeholders in the modelling process and it is therefore important to specifically agree on actions that are being modelled. It is also useful to produce information before and after the impacts of management actions to assist in the understanding and disclosure of the impact.

Qualitative assessments

Results of detailed scenario calculations might be supplemented with qualitative assessments of specific scenario outcomes by subject matter experts that may have an intuitive sense of scenario impacts from experience in a particular field. Qualitative assessments are particularly useful as they are likely to highlight potential limitations of the chosen modelling approach.

3.5.7 Risk Measurement Documentation and Reporting

This section describes best practice principles for documenting risk measurement models and results. Documentation is a key way of reducing model risk by ensuring that key stakeholders understand the modelled results and key judgement areas, and also helps to ensure continuity in the modelling process where there is staff turnover.

3.5.7.1 General Best Practice Principles

Reports would typically conform to internal corporate guidelines, applicable local actuarial guidelines and external regulatory guidelines if required. Information contained within reports would ideally be sufficiently accurate, with the level of independent verification and checking appropriate for the intended purpose of the report.

The information included within reports would ideally be unbiased and complete to minimise the risk of document users interpreting information incorrectly or making incorrect decisions as a result of information contained within the report. The sources of data and other information contained within reports would normally be clearly stated. Information contained within reports might also be reconciled to information quoted previously, with restatements of prior information clearly noted with impacts of restatements provided.

Actuaries would typically consider writing reports in such a way that they can be understood by the intended audience, with access to further detailed technical / risk practitioner information available on request.

3.5.7.2 Business Requirements

In order to provide context to reported information, and to ensure that the model is developed in line with its intended use, the business rationale and objectives for the risk measurement calculation would normally be clearly specified in the documentation, including the role of the documentation in the overall ERM and/or governance framework. This is likely to include some form of cost benefit analysis covering the research undertaken to develop the model and the costs of producing calculated information on a regular basis.

In addition, reports might specify upfront the level of robustness employed in the modelling of risk measures and the implications of any practical compromises have been made given scarce time and resources.

3.5.7.3 Model Technical Specification

The technical specification could include the theoretical justification for the chosen approach with information on alternative approaches and the justification for the chosen approach. The consideration of alternatives could be set out in an unbiased way instead of being focused on the ultimate method chosen.

The technical specification could include a list of all the data inputs (information sources) and assumptions required to perform the calculations and the process that is used to arrive at the assumptions, either through qualitative assessment by subject matter experts, or through direct statistical analysis. In addition, the specification could include an accurate mathematical/statistical representation of the model, including the transformation of data, relationships between assumptions and statistical processes assumed.

This could extend to the specification of modelling hardware and software required to produce the calculation results.

3.5.7.4 Modelling Procedures and Governance

Documentation on model procedures can help to minimise key-person risk by accurately specifying each step in the modelling process, including:

- Data collection, sanitising and transformation.
- Using the model software, validation and results output.
- Reconciling results from subsequent model runs.
- Results analysis and verification.

The documentation might also include specified governance procedures, including requirements for evidencing model reviews and sign-off and any independent verification procedures required for each step in the modelling process.

Documentation might extend to the steps in the model development lifecycle, including research and development, implementation of model changes, and post-implementation modelling. Model weaknesses and limitations could be clearly addressed in documentation, including the specific model risk that the weakness gives rise to and ways of mitigating this risk.

Another key aspect of model governance that could be documented is the materiality criteria to be adopted when making model changes or reviewing model results. Model users could then understand what procedures are to be followed when errors or omissions are uncovered that either fall below or above the materiality threshold, with the latter also involving escalation criteria.

Documented model procedures and governance would also cover hardware and software updates, including the timing of updates and testing procedures.

3.5.7.5 Communicating Modelled Results

Communication of results could include information on the external business environment and internal business context to ensure that the reader is informed of key issues that have either affected results for the current reporting period, or which may affect results in future reporting periods. All material considerations could be provided in the report to help in ensuring that the report users are fully informed and can make appropriate decisions as a result of the information presented.

The granularity of the presentation of results per risk factor, or broader risk category, is something to consider so that information is presented in enough detail to explain the impact of key risk drivers, but not so much detail that key messages can be lost when trying to interpret the results. Features of the aggregation process, such as the impact of the chosen dependency structure and allowance for fungibility and transferability and non-separability can be separately disclosed to ensure that these impacts are clearly understood. Other results features that can be separately disclosed are the effects of changes in assumed tax assets and liabilities, as well as any out-of-model add-ons/estimations that have not gone through the usual defined bottom-up model process.

Noting of material judgements made in preparing the results is something to consider, with the rationale for using the chosen approach and commentary on the impact of different possible judgements that could have been made. This disclosure might extend to a discussion of any material estimates or use of approximate methods to derive results.

Information included in reports could be validated (or reconciled) against previous reported results, preferably using an ‘analysis of movement’ type of approach, with

the restatement of prior period results clearly noted. It is also useful to reconcile information at a high level with other related information that may be been produced for the current period in order to prove the consistency of different measures.

Any material events that have occurred after the date of the risk measure calculations could be noted and discussed. Although quantitative impacts might not be available, a qualitative discussion on the impact of such events will help ensure that the user of the results report is fully informed.

As may be required in ERM frameworks in some organisations, documentation could include detail of the independent review and challenge process that was conducted, with examples given of investigations into components of modelled results and any changes made as a result of the challenge process.

3.6 Risk Response

Once risk has been identified, analysed and measured then the Board and management are faced with responding to the risks. This section outlines some of the potential responses to risks.

3.6.1 Potential Risk Responses

Responses are often characterised into the following four categories (or indeed a combination of the four):

- Avoid
- Accept
- Mitigate
- Share

The Board's response to risks can be reflected in its Risk Appetite, risk tolerances and risk limits. One factor to consider is that the options to mitigate or share risk often create new forms of risk that might in turn require monitoring.

When making the decision regarding whether to accept/avoid/mitigate/share a risk the company might consider the risk-return profile of that risk and its impact on the company's overall risk-return profile. The impact of the risk on the company's capital position is an important consideration and the methodologies previously discussed in respect of aggregation in section 3.5.4 are relevant.

From the perspective of customer fairness principles the decision tree to take or accept a risk could start with the question of whether a customer need is served by accepting this risk. In many cases, customers are served by offering products that transfer risk from them to an insurance company e.g. mortality risk, longevity risk and equity risk through minimum return guarantees. Customer needs can also be served by taking on a risk so that customers have access to attractive returns that

can be used in the design of savings products e.g. credit or equity risk through the offering of savings products that invest in investment funds.

Pricing in respect of new business and reserving for the specific risks in question are other aspects of risk response. If the company decides that it wants to avoid the risk in question then pricing for new business would normally be consistent with that decision. The analysis of the risk might provide information that would be useful when reserving for the specific risk.

Once it is decided to mitigate or share a risk then the company can proceed to:

- Identifying the options to mitigate or share the risks.
- Assess the options through cost-benefit analyses.
- Prepare a plan to implement the response.

3.6.1.1 Avoid

The Board can decide that it wants to avoid the risk. Therefore, actions are taken to reduce the company's exposure to the risk or not to enter into a new development or area, noting that it is often difficult to totally avoid risks. Actuaries might be careful of statements regarding zero appetite for risks as often the actions necessary to totally eliminate the risk don't follow that statement.

3.6.1.2 Accept

The Board can decide that it is happy to accept the risk in its current form. Therefore, no additional action is taken to change the nature of the risk other than to monitor the risk and ensure that the appropriate technical provisions and capital are held in respect of it.

3.6.1.3 Mitigate

The Board can decide that it wants to mitigate the risk in some way. It can be useful to consider mitigating either or both of the likelihood of the risk occurring and the impact of the risk.

The actions that are taken to mitigate the risk will depend upon the type of risk in consideration. For example, certain operational risks might be mitigated by some of the following actions:

- Installing new control processes.
- Training and supervision.
- Specific audit, compliance and quality assurance programmes.
- Contract and policy conditions.

Actions that can be taken to reduce the impact of certain risks might include:

- Contingency planning.
- Emergency procedures.
- Disaster recovery and business continuity plans.

Other risks might require:

- Diversification of the risk (geographically or across other risks). This can be achieved by changing business mix, distribution or products.
- Hedging can be used for certain financial risks and in relation to credit risk through the use of credit default swaps.
- Additional financing might be necessary to mitigate liquidity risk.
- Collateral can be used to mitigate certain credit risks.

It is important to be aware of risk transformation in that some of the actions taken to mitigate risks could result in the creation of risk of a different nature, so that risk has been transformed rather than eliminated. For example, using collateral might reduce counterparty risk but could result in additional operational risk.

3.6.1.4 Share

The Board can decide to share the risk with some third party, through insurance or reinsurance for certain demographic risks. Reinsurance can be used to mitigate the frequency or the severity of certain risks.

Capital markets and alternative risk transfer can also be used to share certain risks. Sometimes risks can be shared with policyholders through features such as policy excesses and profit sharing, where permitted under product rules and policyholder fairness principles.

Outsourcing of activities or functions can be used to share certain operational and financial risks, although residual risks and risks created through the outsourcing processes need to be carefully considered.

Joint ventures or partnerships can be used to share risks associated with new developments where the company might lack expertise or simply where the company wants to reduce the financial risk associated with an exposure.

Sharing a risk often results in some reliance upon a third party, such as a reinsurer. Therefore, it often results in counterparty risk and the company might need to consider whether this new risk is taken into consideration when deciding whether or not to proceed.

3.7 Risk Monitoring

This section outlines some of the considerations in relation to the monitoring of risks and monitoring of the risk management system more generally.

3.7.1 Risk Monitoring Activities

Monitoring is linked to risk measurement and reporting in that the quality of measurement and reporting often determines the extent of monitoring possible at various levels. Therefore, risk monitoring will include monitoring of all the various risk measures used by the company.

Monitoring would normally be done with a frequency that is appropriate to the risk in question. For some risks it might be sufficient to monitor on a monthly basis whereas other risks might be monitored as close to real-time as possible. Monitoring could be sufficiently frequent to allow decisions to be made and for action to be taken on an informed basis.

Companies might need to monitor a range of risk related items. These might include:

- Output of risk evaluations.
- Risk Control self-assessments.
- Observation of defined risk limits, tolerances and appetite.
- External environment.
- Key risk indicators.
- Risk management action plans.

These items are discussed in greater detail below.

3.7.1.1 Output of Risk Evaluations

Risks might be monitored on an ongoing basis using the output from the risk evaluation. The company could monitor the extent of individual risks as well as the relationships between risks in order to monitor the total exposure of the company. It is useful to monitor total risk positions as well as effectiveness of internal controls and residual risk positions.

3.7.1.2 Risk Control Self-Assessments

Self-assessment reporting from various internal units can be very useful to provide insight from the operational units regarding risk positions and effectiveness of internal controls. Trends in these self-assessments are often indicative of some change which might impact upon the company's risk position.

3.7.1.3 Observation of Defined Risk Limits, Tolerances and Appetite

The company also might monitor the observation of its defined risk limits, tolerances and overall Risk Appetite. The actions taken in respect of any breaches would normally be assessed relative to the defined escalation plan.

3.7.1.4 External Environment

It is also necessary to monitor the external environment in order to contribute to risk evaluation. This includes monitoring of tax and regulatory developments in order to understand their impact on risk positions as well as the regulations themselves.

3.7.1.5 Key Risk Indicators

Many companies use key risk indicators to provide insight into risk positions, as part of their risk appetite framework for setting risk tolerances and risk limits or as additional information as they often provide insight into changes in risk exposures, likelihood and the external environment. They can serve to complement the core risk evaluations and to evaluate certain risks which are hard to measure precisely.

For example, operational risk is difficult to quantify. However, risk indicators can provide useful insight into changes that might increase operational risk (e.g. staff turnover could act as an indicator for operational risk). Therefore, the indicators can indicate when a risk exposure is increasing or when the likelihood of a risk occurring is increasing. The Company might decide to use this information in different ways depending upon the circumstances and the reliability and importance of the indicator. It could:

- Use the information to gain insight into the applicable risk
- Set risk tolerances and limits based on this information
- Incorporate the information into the Company's economic capital model.

3.7.1.6 Risk Management Action Plans

Many companies also monitor the progress of any risk management action plans that have been agreed and are in the process of being implemented.

3.8 Risk Reporting

This section outlines some of the considerations in relation to reporting of risks and outlines some common methods for communicating risk. Section 3.5.7 outlined considerations in relation to risk measurement reporting and documentation and many of those considerations are also relevant to more general risk reporting, in particular section 3.5.7.1 which outlined general best practice principles.

3.8.1 Risk Management Information

Effective ERM requires quality risk management information that contains certain attributes. Those attributes include:

- *Timely* - Information on risks would ideally be provided with sufficient speed to allow companies to make decisions to manage those risks appropriately whilst also meeting the other data requirements outlined. The frequency of reporting might vary depending upon the risks, the company's situation and the external environment.
- *Comprehensive* - The information provided would ideally be comprehensive, covering all risks in an appropriate level of detail. It is important to note that too much information can be as inappropriate as too little information depending upon the circumstances. Reporting can be tailored to the audience with recognition of the different needs of the Board, senior management and other levels and would ideally be clear and concise.
- *Consistent* - The information provided would ideally be consistent, in terms of both production and reporting to allow consistent evaluation.
- *Accurate* - All risk information would ideally be accurate and reflect the underlying risks appropriately. Risk data could be reconciled and validated.
- *Auditable* - All risk information would ideally be auditable and the entire process could be transparent and adequately documented.
- *Forward-looking* - Risk management information provided could incorporate a forward-looking element rather than rely solely on current and past data.

There are many different ways of achieving these objectives and risk management information might vary so that it is appropriate to the specific company and situation.

3.8.2 Assurance Regarding Information

There are a number of considerations that could help to provide assurance regarding risk management information and which might be appropriate, depending upon the circumstances:

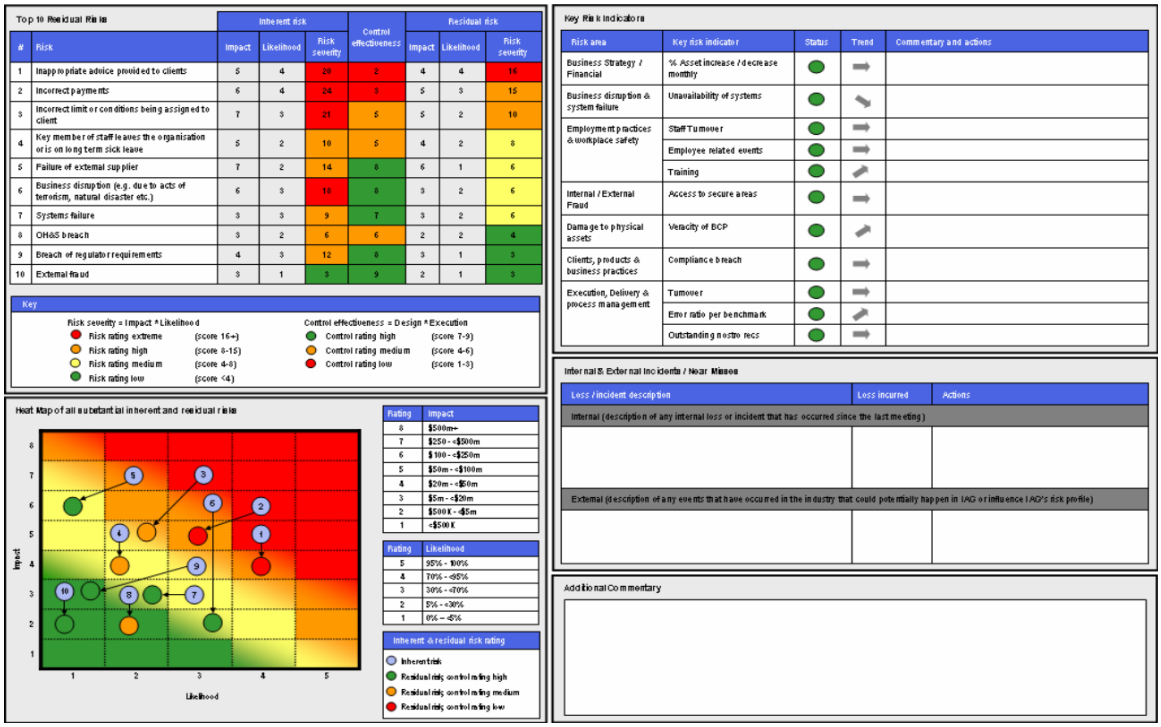
- Independent verification in relation to certain processes/information.
- Reconciliation of information between previous and current reports.
- Appropriate documentation of all processes and procedures.

3.8.3 Reporting Methodologies

There are a number of methodologies commonly used in industry to communicate risk management information including:

- Top 10 residual risks

- Heat Maps
- Key Risk Indicators
- Event logs



Source: Note on Enterprise Risk Management for Capital and Solvency purposes in the Insurance Industry

3.8.3.1 Top 10 Residual Risks

Many companies use an assessment of likelihood and impact to assess risks. This can be assessed both gross and net of controls, or alternatively gross risk and control effectiveness can be assessed with residual risk emerging from those assessments. It is important to define the scale that is used to categorise risks and this scale could include a number of measures such as solvency loss, regulatory fine, reputational impact.

3.8.3.2 Heat Maps

Heat maps are an effective method of communicating risk in a simple, straight-forward manner. Movements in assessments can also be incorporate as illustrated.

3.8.3.3 Key Risk Indicators

Key Risk Indicators are a useful means of incorporating factors that might indicate increased risk, but which might not be apparent otherwise. For example, staff turnover might indicate increased risk of operational losses but would not be apparent unless specifically reported.

3.8.3.4 Event Logs

Event logs are important in monitoring actual events that either led to losses or were "near misses". Reporting of event logs is important to allow insight into the events that are creating risk and losses for the company, recognising that low probability events might not feature in event logs for long periods.

3.8.4 Internal and External Reporting

The type and depth of information provided will vary depending upon whether it is to be provided internally or externally. Nevertheless, similar considerations apply to both.

Different information is required for different levels within the company and the company might consider separately the needs of the Board, of business units and of individuals. Relevant reports could be distributed to all relevant parties and contain information appropriately tailored to the audience.

The company might consider how to achieve consistent usage of risk management terminology by defining exactly what is meant by certain terms and ensuring that these are understood internally. The company might also consider the establishment of reporting standards and risk management information systems to assist in the production of consistent, coherent risk reporting.

3.8.5 Disclosures

Appropriate disclosures are something to consider in relation to any actuarial report on ERM. The following are areas that might be appropriate for disclosure:

- *Purpose* - The purpose of the report and scope would normally be disclosed.
- *Data* - Any limitations of risk management information could be disclosed, including an assessment of the potential impact of those limitations.
- *Assumptions* - Key judgements, assumptions and reliance upon expert opinion. It might also be appropriate to discuss sensitivities and uncertainties.
- *Methodologies* - Appropriateness of methodologies chosen, any shortcomings and reasons for using
- *Changes* - Any material changes to systems or processes, and the impact of those changes, could be disclosed
- *Validation* - Any validation of results or models could be disclosed.

3.9 Own Risk and Solvency Assessment

The Own Risk and Solvency Assessment (ORSA) is becoming an increasingly international requirement, with regulators in many countries incorporating the requirement into supervisory plans and some leading insurers performing internal ORSA processes in advance of these being required for regulatory purposes. The International Association of Insurance Supervisors adopted Insurance Core Principle 16 ("ICP16") in October 2010 and the requirement for an ORSA was one of the key elements of ICP16.

3.9.1 Key Requirements of an ORSA

ORSA is a wide-ranging topic but the following are among the key requirements outlined in ICP16 are:

- Regular assessment of the adequacy of risk management.
- Regular assessment of the adequacy of current, and likely future, solvency position.
- Board and senior management to be responsible for the ORSA.
- All material risks to be encompassed, including underwriting, credit, market, operational, liquidity and group membership.
- Determination of the financial resources needed to manage its business.
- Risk management actions to be based on consideration of capital and financial resources.
- Assessment of the quality of capital resources.
- Analysis of the ability to continue in business including projections of future financial position and ability to meet capital requirements.

Section 3.5.5 of this document addressed some of the issues related to the forward looking perspective of the ORSA.

It is important to note that the precise ORSA requirements will vary from territory to territory in line with local regulation and that the above requirements are only indicative of what an ORSA generally attempts to achieve.

3.10 Evaluation of an ERM System

In some situations, actuaries may be called upon to give an opinion regarding the quality of an ERM system. The following discussion provides an example of a process for forming such an opinion.

The actuary might first come to agreement with their audience on the elements of the ERM system that are to be included in the review. The topics in this report could be used to help define such a list of elements.

Subsequently, the actuary could receive or propose a scale which defines the possible opinions both in range of detail and levels of classification required. The following is an example of a possible scale. Practices would be reviewed to determine whether they are:

- *Ad Hoc* - Incomplete and undeveloped. No enterprise risk management goals underlying or considered in developing current oversight.
- *Basic* - Minimal tools and systems. Low sophistication. Objective of ERM is to meet external minimal expectations.
- *Standard* - Complete framework with adequate tools. Average sophistication in all areas. Competent execution in all risk areas.
- *Advanced* - Proprietary value-added components to ERM tools and systems. Leading edge sophistication in some major risk areas.

An even number of categories is suggested above to encourage differentiation of the scores. Scoring systems with an odd number of categories might attract a disproportionate number of results in the middle category.

For each area of practice that is evaluated, a separate score would be determined. Appendix D provides an example of scoring for one risk management practice area, Risk Identification. The examples of practice are provided to help guide the reviewer rather than to restrict the reviewer to those particular practices. ERM practices are continuously evolving and including a static set of practices into an evaluation process could result in the process becoming outdated because it would not include new practices that emerge after the development of the document.

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Appendix A – Properties of Coherence

To demonstrate the properties we introduce some simplistic notation:

- Let X and Y represent the outcomes of two separate portfolios or set of risks
- Let Risk() be the risk measurement function selected

Sub-additivity

Sub-additivity describes the notion of diversification and the expectation that when risks are combined, the total risk that results is not increased and it may in fact decrease due to diversification benefits. The sub-additivity property is defined as:

- Sub-additivity: $Risk(X+Y) \leq Risk(X) + Risk(Y)$

Monotonicity

Monotonicity is an axiom that stipulates if a portfolio's value is always less than (in all states) the value of another portfolio, than the risk of that portfolio is always less than the risk of the other portfolio. Monotonicity is defined as:

- Monotonicity: If the Probability that $X \leq Y = 1 \rightarrow Risk(X) \leq Risk(Y)$

Positive homogeneity

Positive homogeneity is a property that indicates that if you scale a portfolio's outcome by a certain amount, the resulting risk is equal to the original risk adjusted by the same scaling factor. Positive Homogeneity is defined as:

- Positive Homogeneity: $Risk(aX) = aRisk(X)$, for a constant a

Translation invariance

Translation invariance describes the situation when a risk free portfolio is added to a "risky" portfolio, which does not increase the overall risk and instead serves to diminish the overall risk. Translation invariance is defined as:

- Translational invariance: $Risk(X + B) = Risk(X) - B$, for a certain amount B

These axioms are especially useful for comparing properties of risk measures and understanding the characteristics of any risk measures selected.

Appendix B – Common Risk Measures

This appendix outlines three common risk measures in terms of their definition, advantages and limitations.

Standard Deviation

- *Definition* – Standard deviation is the square root of the variance of a distribution and measures the dispersion around the mean of a distribution. The variance is known as the second central moment of a distribution.
- *Advantages* – Standard deviation is easy to calculate and is commonly understood by most informed audiences. This decreases the amount of time needed to educate and describe the risk measure itself.
- *Limitations* – Standard deviation is not a coherent risk measure as it fails the monotonicity criteria and variance fails the sub-additivity criteria. Another drawback is that it does not explain the entire distribution of a given modelled risk factor. Distributions chosen to model risk factors can have the same standard deviation and dramatic differences in other aspects of the distribution, which could lead to a significantly different view of the risk profile. Information on the skewness or kurtosis (the third and fourth central moments) might be needed to understand the shape of the "tails" of the distribution. When measuring risk, this is often the area actuaries are most concerned with.

Value at Risk

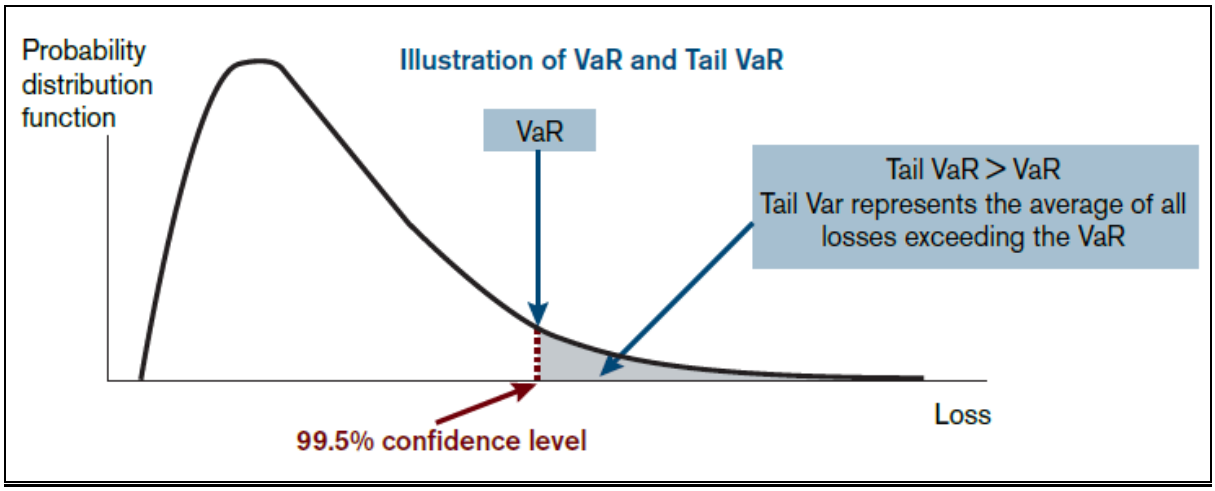
- *Definition* – Value at Risk or "VaR" measure is often defined as the smallest loss that is greater than a predetermined percentile of the loss distribution or in other words, the quantile at a pre-defined probability level. The predetermined percentile used in calculating VaR is often expressed as a confidence level, α, commonly 95% or 99% for risk analysis and a time interval over which the loss is expected to occur.
- *Advantages* – VaR is a well-known risk measure and is commonly used in the financial sector leading to greater comprehension from stakeholders. It is intuitive and can be explained in layman's terms as "with a probability of α, we will suffer a loss no greater than \$Y over a n-week period." There are also various options to calculate VaR including both parametric, non-parametric methods, Monte Carlo simulation, and approximations such as the delta-normal method, which uses first order sensitivities to approximate simulation results.
- *Limitations* – VaR is not a coherent risk measure because it fails the sub-additivity coherence axiom. Additionally, it provides information at one point of the distribution and does not provide information in the area of the

distribution above the specified confidence level. This area or "tail" is commonly of most interest when performing risk analysis. Lastly, while VaR is a popular measure that is in use today, it is often misinterpreted by users.

Conditional Tail Expectation (or Tail Value at Risk)

- *Definition* – Conditional Tail Expectation or "CTE" or Tail Value at Risk ("TVaR") is the mean of the distribution above a certain percentile or confidence level (α) or in other words, the expected value of a loss given that the loss is above a specified threshold, which is defined according to a specified percentile value α. This risk measure has many other names including Tail Value at Risk, Tail Conditional Expectation and Expected Shortfall.
- *Advantages* – The CTE is a coherent risk measure as it satisfies all of the coherence requirements. The risk measure does not focus only a single point of the distribution and provides information about the values above the threshold or in the tail. Additionally, CTE is used across the financial services industry and by regulators for determining reserve and capital requirements.
- *Limitations* – The CTE is more difficult to calculate compared to the standard deviation and the VaR measures as information related to the entire tail of the distribution is needed as opposed to a point measure. CTE is more complex than VaR and backtesting CTE can be significantly more challenging than backtesting VaR.

The graphic below displays the difference between the VaR and Tail VaR risk measures for a 99.5% confidence interval:



Source: CEA working paper on the risk measures VaR and Tail VaR, November 2006

The risk measures described above are also commonly used within regulatory frameworks in addition to being employed within insurance companies for management purposes.

The following table summarises the measures and their advantages and disadvantages:

Table: High-level summary of risk measures and their limitations

Risk Measure	Description	Advantages	Disadvantages
Standard Deviation	• Measures dispersion around the mean	• Easy to calculate • Commonly understood	• Not a coherent risk measure • Doesn't explain the entire distribution with limited focus on the tail distribution
Value at Risk	• The quantile at a pre-defined probability level	• Well known and commonly used • Allows different calculation methodologies	• Not a coherent risk measure • Only provides information about one point in the distribution • Sometimes misinterpreted
Conditional Tail Expectation (Tail Value at Risk)	• The mean of the distribution above a certain percentile	• Coherent risk measure • Doesn't only focus on one point in the distribution	• Somewhat more difficult to calculate • Somewhat more complex

Appendix C – Common Methods for Aggregation and Limitations

This appendix outlines some common methods of aggregation and their limitations.

Simple summation

Starting with perhaps the simplest approach, summation can be used to aggregate results across risk types. This is equivalent to assuming that all risks are 100% correlated and there is no allowance for potential diversification benefits. The approach does not require additional calibration due to the simplicity of summation and can be easily explained to end-users. The limitations of this method are that it does not provide information regarding how risk types interact and ignores potential diversification benefits, which could be substantial.

Fixed diversification percentage

A similar approach to a summation approach is the fixed diversification percentage method which consists of adding a diversification factor or adjustment to the overall risk measure. In addition to being easily communicated, this method does account for some level of diversification however the results are highly dependent on the value chosen for the diversification factor. Additionally, diversification factors may appear arbitrary and are viewed as a "top-side adjustment" for diversification benefits. This results in a significant amount of subjectivity contained within the results.

Variance-covariance

Moving to more technical approaches, a very common method for aggregating risk measures is to use a variance-covariance matrix. The variance-covariance method specifies the correlation between each risk type and this pair-wise correlation between risks drives the diversification benefit calculated. In terms of implementation, this method is fairly easy and many end-users have a general understanding of the concept of correlation which makes results communication easier.

The variance-covariance method has two main drawbacks. The first being that the specified pair-wise correlations are linear and do not vary over time or during stress events. This presents a problem when aggregating risks because history has shown that correlation often changes through time and can act differently during times of stress (which is commonly the situation we want to measure). The second drawback is that variance-covariance methods assumes all of the underlying risk distributions are elliptical which is often not the case as there is a tendency for correlations to be higher for very extreme events than for more regular events.

In order to utilise a variance-covariance framework, the correlation matrices typically employed would normally satisfy several criteria. In addition to the common criteria that correlation matrices normally exhibit (such as symmetry, values between 1 and -1 and having a 1 on the diagonal for all elements) another property to consider is positive semi-definiteness. Utilising terminology presented by the Bank for International Settlements, positive semi-definiteness is explained as follows:

An $n \times n$ matrix **A** is said to be positive semi-definite if, for all vectors $n \times 1$ vectors $\boldsymbol{v}$:

$$\boldsymbol{v}^T \boldsymbol{A} \boldsymbol{v} \geq 0$$

Where **A** is the linear correlation matrix and $\boldsymbol{v}$ is the vector of component risk measures and $\boldsymbol{v}^T$ is the transpose of $\boldsymbol{v}$.

The most common reason for non positive semi-definite matrices is that expert judgements on different pairs of correlated factors are probably internally inconsistent. Whilst there are mathematical techniques to move such a matrix to a positive semi-definite state, it might be better to reconsider the original decisions regarding the choice of pair-wise correlation coefficients.

Another topic to consider is the potential use of nested correlation matrices. Parameterising a correlation matrix with a large number of individual elements (e.g. a 50 times 50 matrix) and ensuring that the result is positive semi-definite can be a very time consuming and challenging task. Instead of using one matrix to reflect all elements it can be easier to use a set of nested matrices that reflect the structure of the underlying risk profile and such an approach makes parameterisation much easier to achieve.

Copulas

An aggregation approach which corrects for many of the shortcomings of the variance-covariance approach including allowing for non-elliptical distributions and non-linearity of dependence is to use copulas. Copulas are functions that allow risk modellers to separately model risks using their marginal probability distributions. The joint probability distribution can then be developed by applying a copula function which specifies how the originally modelled marginal probability distributions come together (or aggregate). Copulas come in many functional forms and are very flexible in determining the dependence structure of the modelled risks. One key limitation is that copulas can be confusing and difficult to communicate when presenting results to stakeholders within the risk measurement process. Additionally, the use of copulas require that each underlying risk's probability distribution function and the copula function be estimated and calibrated which can often lead to additional model and operational risk (and strains on computing resources) as these individual models themselves are mathematically complex.

Structural modelling

Modelling of the direct linkages between risks is another approach that can be used to aggregate risks. In this type of approach risk drivers are identified and simulated and relationships reflected directly, rather than modelling each risk separately and then aggregating. It is often used in combination with some of the other methods.

Table: High-level summary of common aggregation approaches and their limitations

Aggregation Approach Name	Description	Limitations
Simple Summation	• Assumes that the correlation between all risks is 100% • Simple to use • Easily explained to end-users	• Does not provide information regarding how risk types interact • Ignores potential diversification benefits
Fixed Diversification Percentage	• Accounts for diversification across risk types • Simple to use • Easily explained to end-users	• Results are highly dependent on the value chosen for the diversification factor • Diversification factor often chosen arbitrarily
Variance-Covariance	• Specifies the correlation between each risk type • Accounts for diversification across risk types • Simple to use • Easily explained to end-users	• Pair-wise correlations are linear and do not vary over time. • Assumes all of the underlying risk distributions are elliptical
Copulas	• Accounts for diversification across risk types • Flexible and can account for different types of dependence structures • Provides flexibility in modelling each individual risk type	• More complex to administer and calibrate • Computing power requirements • Difficult to explain to non-technical audiences • Need to specify the marginal distribution for each risk type • Need to specify the copula functional form

Structural modelling	• Intuitively appealing • Potential to reflect relationships more accurately	• Modelling can be complex • Significant judgement can be required • Can be difficult to parameterise

Appendix D - Example Evaluation of a Practice Area

This appendix deals with risk identification from the senior management perspective, whether the risk identification process started or ended at that level. The following table outlines some potential examples of practices that might be used when categorising the risk identification process. It should be noted that the examples are subjective and intended to illustrate possibilities rather than representing a definitive categorisation.

Ad Hoc	Basic	Standard	Advanced
1. Management will assert that "everyone knows" the top risks of the firm. But if polled, each member of management will list different risks. 2. No risk identification process. 3. Management risk focus is primarily on the most recent problem topic.	1. Management has a list of identified risks. 2. List is taken from an outside source and does not use terminology that matches with company language. 3. List of risks does not match up with senior management responsibilities. Several risks fall under multiple senior management areas or none. 4. List of risks that is used in reports to senior management and the board contains more than 20 top risks. 5. Most of senior management cannot recall the risks on the list. 6. List of risks is missing one or several of the top insurance related risks that generally impact insurance companies but there are many operational risks on the list.	1. Management has a list of top risks that they have reviewed carefully and/or that they have created. 2. Most of senior management can recall the entire list. 3. The list of risks is less than 20 elements. 4. Management has identified a short list that they discuss with the board. 5. List of risks will include all of the major categories that are found in many sources that affect insurance companies and often the very largest risks for the company are sub divided into parts that are managed separately.	1. All of the Standard elements. 2. Management has processes for regularly reassessing and renewing the identified risks. 3. Management is open to ad hoc changes to the risk list as situations change in between scheduled updates. 4. Companies that have used bottom up process are able to incorporate top down modifications without disrupting that process. 5. Companies that have used top down processes also have a process to allow input from around the organisation.