



North American CRO Council

Capital Modeling Principles and Practices in the Insurance Industry

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October 2013

Acknowledgement

The CRO Council would like to thank Towers Watson for their support, guidance, and coordination throughout the development of this work product.

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Section 1: Executive Summary

The effects of a tough economic environment in recent years have led insurance companies to focus on enhancing risk and capital management capabilities to support business objectives and long-term sustainability by providing management with key insights into their company's risk profile. At the same time, a sharper focus on risk management by regulators and rating agencies has highlighted the importance of internal capital models to support decision making by informing management about the risks that influence a company's success.

The North American CRO Council is a professional association of Chief Risk Officers (CROs) of leading insurers that seeks to promote key risk management principles, including principles related to capital modeling. Through the perspective gained from surveying current practices and longer term plans of current member companies of the North American CRO Council, this paper strives to promote sound practices related to internal risk capital modeling. These models are a core component of an enterprise risk management (ERM) framework and provide key support for enabling CROs and others to perform their duties and strengthen the organization's risk and capital management capabilities. The principles presented in this paper have the distinction of being grounded in the actual practices of CROs and their organizations, and are intended to be a useful guide in developing internal risk capital models and in embedding capital models within a business-as-usual process. They also may be useful to internal or external parties tasked with reviewing a company's internal capital model.

It is common for insurance companies to use several capital models – for example, insurers are required to calculate required capital according to prescribed regulatory models and many will also perform capital calculations using prescribed rating agency models. While these types of capital models are important, they are not the focus of this paper. Instead the focus here is on internal risk capital models, where the design, methodology, assumptions etc. have been developed internally (as opposed to prescribed externally) with the aim that they are appropriate to the nature and management of the business and reflect internal management views of the risk inherent in the business (and how that risk is managed). Additionally, most of the principles concern internal risk capital models from an enterprise perspective (or some other aggregate organizational level), i.e., they look holistically across a range of businesses, legal entities, and risks.

Since internal risk capital models should be developed consistently with the management framework, the CRO Council believes in a broad definition and application of risk models. The Council does not subscribe to any single given approach. For example, the use of economic capital and a 1-year market consistent balance sheet may be appropriate if a company chooses to manage its business according to such principles. Equally, a company may elect to think about capital from purely a statutory perspective or using a runoff profile over the longer term. Provided the approach supports the management framework and its objectives, then it is a valid approach and suitable for the application of the principles described in the subsequent pages.

The principles described in this paper are as follows:

1. Internally developed capital models should be a demonstrable component of an insurance company's risk management process
2. The development of a "fit for purpose" capital modeling framework requires defining upfront its function and purpose within a company
3. An enterprise capital modeling framework should have a centralized process with business unit engagement
4. Capital model reporting should be aligned with the risk management structure
5. Enterprise capital models should be designed to support strategic decision-making
6. Enterprise-level and lower-level processes should connect
7. Development of a capital model should be an iterative process involving continual business use and feedback
8. Stress testing should be integral to capital modeling frameworks
9. A structured process should exist for identifying and addressing capital modeling limitations
10. Capital modeling should be subject to the same model validation principles as other company models
11. Capital modeling requires striking the right balance between theoretical purity (e.g., mathematical precision and complexity) and practical reality
12. Conclusions drawn from capital models need to be challenged and understood using business judgment before taking action

In summary, the primary focus of this paper is the development and use of internal risk capital models. The core principles span a range of topics, including approaches to capital modeling, features and limitations of capital models, and the use of capital models.

While the principles address a range of topics, one of the most critical themes highlighted is the importance of context in developing an internal risk capital model. That is to say, factors such as the type of business and risks the insurer writes and how these are managed in practice should be kept in mind when designing, developing and applying a model. Similarly, it is important that the ultimate intended use(s) of the model be accounted for when developing, validating, and applying the model. In practice, this means that by applying the principles laid out in this paper, it should be expected that different companies will end up with different internal risk capital modeling approaches, given their specific characteristics, views and objectives. By implication, the principles do not support a "one-size-fits-all" approach to internal risk capital modeling.

Although the discussion supporting each principle may be read independently in any order, the reader is encouraged to consider how all principles in combination jointly support a sound capital modeling framework.

Section 2: Introduction

Internally developed risk capital models can serve many useful purposes and are increasingly becoming a core part of many insurers' risk and capital management processes. They also are subject to increasing interest and scrutiny from external parties such as regulators and rating agencies.

This publication describes a number of principles relevant to the development, maintenance, and application of internal risk capital modeling frameworks with the intent that they can serve as useful guidelines to interested stakeholders who may be developing, reviewing or using internal risk capital models. They are intended to be applicable to insurance company models and could help guide a company's internal procedures, policies and processes. Additionally, they may be useful to external stakeholders, such as rating agencies and regulators, as they consider how an insurer's internal models have been developed and are being applied.

The CRO Council's perspective is that a strong ERM program has many interrelated components:



To illustrate the interconnectedness within the ERM program, the capital models discussed in this paper form a key part of the risk measurement process, which itself provides a critical link between aspects such as risk appetite and risk monitoring and reporting. All of these are key inputs to capital management and further strategic decisions. Thus, internal risk capital models can be seen as fitting within a broader ERM framework, which is the foundation for Principle #1.

In practice, internal risk capital models can vary considerably in their structure, calibration and application and one of the important conclusions to be drawn from a number of the principles described is that there is no "one-size-fits-all" approach to developing an internal risk capital model. Differences in company structure, business written, as well as in management's philosophy and

practice in managing risk and capital associated with that business can lead to different approaches being more applicable for some insurers than others.

It should be noted that the principles described in this paper were developed from a survey of the North American CRO Council membership. This survey involved interviews with CROs and/or capital modeling teams of CRO Council member companies. The principles were derived based on the responses regarding member companies' current and planned practice across a range of areas such as model design, processes, features, use, validation, and limitations. As such, it is important to note that these principles are grounded in practice. It should also be noted, that while they reflect practice of CRO Council companies, they are intended to be broadly applicable to the insurance industry, regardless of company size, location or business written.

The principles are summarized at the beginning of the Core Modeling Principles section, followed by a more detailed discussion of each. Although the reader is encouraged to review the discussion associated with each principle, there is not a strict sequential order, so it is possible to focus directly on areas of particular interest.

Section 3: Core Capital Modeling Principles

A high level summary and reference chart of the core capital modeling principles is below, followed by a more detailed description of each principle.

No.	Principle	Brief Description
1	Internally developed capital models should be a demonstrable component of an insurance industry's risk management process	<ul style="list-style-type: none"> • Prescriptive standardized models do not provide sufficient information to support risk management decisions • Internal models promote alignment between the measurement of risk exposures and management's risk appetite and risk tolerance statements • ORSA regulations around the world have influenced companies away from "one-size-fits-all" calculations
2	The development of a "fit for purpose" capital modeling framework requires defining upfront its function and purpose within a company	<ul style="list-style-type: none"> • How the model will be used should drive how the model is designed • Several design decisions exist related to calculation methodology and parameterization • Sufficient flexibility allows different stakeholders to use the model as a primary or supplementary decision-making tool
3	An enterprise capital modeling framework should have a centralized process with business unit engagement	<ul style="list-style-type: none"> • A centralized process promotes consistency in aggregation and parameterization approaches across business units • Business unit engagement is needed for subject matter expertise and to promote broader use and buy-in of approach
4	Capital model reporting should be aligned with the risk management structure	<ul style="list-style-type: none"> • Multiple perspectives provide additional insight • Standalone results by risk type remove impact of correlation assumptions or joint distribution models, which can be challenging to parameterize
5	Enterprise capital models should be designed to support strategic decision-making	<ul style="list-style-type: none"> • Internal risk capital models empower senior management with timely and relevant information at an enterprise level • While robust quantitative metrics are important, more critical will be the design of the model and ability to communicate results.
6	Enterprise-level and lower-level processes should connect	<ul style="list-style-type: none"> • Aggregate views should reconcile with more detailed underlying models • e.g., Limits allocated to individual risk exposures should reconcile with macro level risk tolerance
7	Development of a capital model should be an iterative process involving continual business use and feedback	<ul style="list-style-type: none"> • The process enriches the framework and better enables the model to meet requirements • Internal buy-in and validation are under continual development as the role of capital models within an organization continues to evolve • How the model will be used informs decisions to leverage existing systems

8	Stress testing should be integral to capital modeling frameworks	<ul style="list-style-type: none"> Stress tests may be core inputs to the capital model or used to validate and supplement stochastic analysis
9	A structured process should exist for identifying and addressing capital modeling limitations	<ul style="list-style-type: none"> Limitations should be documented with materiality estimated Gaps in data are often filled with expert judgment or benchmarking along with suitable documentation Understanding the model and its limitations helps management take ownership
10	Capital modeling should be subject to the same model validation principles as other company models	<ul style="list-style-type: none"> Inputs, calculations, and outputs need to be vetted Intensity of review should align with complexity of model and potential use of results
11	Capital modeling requires striking the right balance between theoretical purity (e.g., mathematical precision and complexity) and practical reality	<ul style="list-style-type: none"> Near real time decision support demands timely production of results This highlights the need for model validation and clear communication Structuring internal risk capital models around their potential uses allows stakeholders to focus directly on the relevant components
12	Conclusions drawn from capital models need to be challenged and understood using business judgment before taking action	<ul style="list-style-type: none"> Models can provide useful input to inform decisions but cannot replace sound business sense Results should not be viewed in isolation, but rather should be interpreted in their business context

1. Internally developed capital models should be a demonstrable component of an insurance company's risk management process

To be able to manage business with an informed view of the risks they face, more companies see internal risk capital models as an important management tool and an improvement over externally prescribed models. Internal models enable insurance companies to support decision-making by measuring risk exposure and capital requirements in a way that is consistent with their own view of risk and how it is managed. These models provide an alternative lens to existing reporting practices and grant flexibility for companies to address perceived shortcomings in prescribed approaches such as those associated with statutory or regulatory reporting. These prescribed requirements typically involve relatively simple techniques with standardized factors, which can be advantageous from a regulatory perspective to simplify oversight and ensure consistency and ease of application. While these requirements form important constraints for insurers, the underlying models are usually too simple, too rigid and too standardized to be of much value to management in supporting risk and capital management decisions. Additionally, the valuation basis underlying a prescribed calculation may differ from the basis on which senior leaders believe the business should be managed.

By developing an internal risk capital model, insurers can more robustly reflect company-specific characteristics or exposures that could be obscured by simpler methods, as well as management's views on these risks and the dynamic way in which these are managed. By supplementing or challenging existing required capital standards, internal models provide additional insight to senior management. Because they present a truer picture of the risk profile of the organization, reflective of

management's views, internal risk capital models should more easily align with internal processes used to evaluate and execute risk management and broader strategic decisions. Consequently, internal risk capital models can be used in a variety of areas (examples are listed in Principle #2) to influence strategic decisions and form an important part of an insurer's risk management process.

External stakeholders also recognize the importance of an insurer using internally developed risk capital models to drive risk and capital management decisions. Emerging regulations and other external trends can be seen as reinforcing the development of these internal models. For example, Own Risk and Solvency Assessment (ORSA) regulations around the world place an emphasis on insurers' internal qualitative and quantitative processes and models for managing risk and capital. These are influencing companies away from a one-size-fits-all calculation in recognition of the increasing complexity throughout the industry and the importance of management taking ownership of its own views of risk inherent in the business and capital required to support it. Insurers will be expected to demonstrate the use of their internal risk capital models (in addition to regulatory capital models) in risk management and decision-making as part of their ORSA. Rating agencies have similarly been pushing for insurers to advance the development and use of internal risk capital models. They recognize that the specific insight they can gain from a company's own model of their risk (and how these models are used) may supplement or even exceed what can be obtained solely from rating agencies' proprietary models.

2. The development of a “fit for purpose” capital modeling framework requires defining upfront its function and purpose within a company

A capital modeling framework can address multiple purposes while including multiple calculation approaches, and upfront recognition of this potential diversity encourages the placement of appropriate design elements and controls. Internal risk capital models have important potential applications in a number of areas, including:

- Solvency assessment
- Strategic planning
- Risk-adjusted performance measures
- Risk mitigation, including reinsurance and hedging decisions
- Product development and pricing
- Risk appetite and tolerances monitoring
- Investment strategy and asset allocation

For each area of use, there are several design decisions associated with a capital model, including distinct calculation approaches or parameterization methods that may be used. An important point is

that the intended use of the model should drive the methodology and design of the model. The insurer's overall view of risk and capital and how they are managed will also be key influences here. For example, given its risk and capital management options, a mutual insurer may choose to assess required capital using a runoff approach (i.e., where capital needs are assessed by analyzing surplus positions over the life of the product under risk drivers that move throughout the projection), whereas a stock company may prefer the use of a one-year value-at-risk approach (i.e., where capital needs are assessed based on the change in net assets over one year). Although a detailed analysis and comparison of these approaches is beyond the scope of this paper, both have their strengths and weaknesses, and both are used in the insurance industry. Influencing factors such as the ability to communicate results and the capabilities of underlying valuation systems should be considered when designing the capital model.

In practice, internal risk capital models are often intended to serve multiple purposes, and as such frequently need to contain a sufficient degree of flexibility. For example, results may need to be available across multiple dimensions; risk owners will need to see aggregation of a particular risk category across all businesses, while product managers will be more focused on results within a given product line across all risks. Similarly, the intended use may require the model to be able to produce different metrics in order to measure capital requirements at a range of confidence levels. As another example, the ability to include a range of sensitivities produces a rich set of information that can be relevant for multiple stakeholders. By incorporating this type of flexibility, an internal risk capital model can provide additional insights which make it a more valuable tool and encourage buy-in across the organization.

An internal risk capital model may be the primary decision-making tool or may be used to supplement information from other existing tools. For example, the internal risk capital model may be the primary tool used to monitor solvency, while playing a supplementary role in product development decisions. Establishing how the capital model will interact with other metrics to inform decision-making should be considered in the model development. Clarifying the model's intended use provides important context for the appropriate audience when interpreting and using results.

Establishing a clear connection between measurement approaches, reporting structures, and threats to overall company objectives is an important part of model development, and dedicating resources to these areas allows companies to significantly enhance the value extracted from their capital models as part of broader ERM programs.

3. An enterprise capital modeling framework should have a centralized process with business unit engagement

ERM programs strive to capture a holistic view of risk management within the enterprise. At their core, many internal risk capital models aim to derive an aggregate view of risk across the organization and so it stands to reason that some centralized process is needed to perform or facilitate this. Moreover, structuring capital models around a centralized process promotes consistency and control within the capital modeling framework, leading to several advantages. With a centralized process, the

calibration and application of risk calculations can be standardized to promote consistency across the organization and to enhance clarity around the interpretation of results. For example, the central team might define the key risks and how they are calibrated (e.g., specifying appropriate stresses to run for each), while the business units use their product knowledge and models to measure the impact of the stresses. Furthermore, this places the central team in a position to perform aggregation at the enterprise level while minimizing the need for adjustments resulting from potential disconnects between business units. Continuing our example, the central team can define correlations between risks rather than allowing business units to develop their own (potentially conflicting) correlation assumptions. Finally, the central team accounts for constraints on capital fungibility and ensures that holistic reporting occurs, with the appropriate stakeholders receiving the necessary information at relevant levels of granularity.

At the same time, a centralized process depends heavily on business unit engagement. As with most successful initiatives, collaboration is a key requirement, as diverse perspectives can offer unique and valuable insight. For example, business units can provide subject matter expertise in the form of qualitative and quantitative input regarding calibrations and procedures as well as quantitative output from underlying models. On a standalone basis, bottom-up results from these models serve as a key source of information to supplement aggregate and diversified metrics. Finally, business unit buy-in can be a significant factor in increasing the broader support and application of the internal risk capital framework across the organization.

As with all elements of the internal risk capital model, design of the process should reflect how the company intends to use the model. For example, business units should be able to access the portion of the model related to their business to ensure that they can provide the necessary expertise regarding local data and assumptions, subject to consistent guidelines issued by the central team. At the same time, central users will generally need access to the aggregation function and will want to review results across the total enterprise. From a reporting perspective, tailoring information to the unique demands of each user ensures that a clear message can be delivered to support actions at all levels of the company.

4. Capital model reporting should be aligned with the risk management structure

In addition to an aggregate view of available and required capital, which plays a key role in monitoring overall company solvency, assessment by risk type, business unit, or other levels within the company allow for further analysis and plays an important role in the management of those risks, and so needs to be captured by the capital modeling framework. Within an insurance company, individuals or teams are often assigned ownership of specific risk exposures, so assessing capital by risk allows for a natural alignment with this method of organization and creates a clear link to each risk target. There should be awareness if the enterprise-wide capital assessment for any single risk exceeds a stated tolerance so that corrective actions or increased monitoring can be initiated. For example, risk exposures that are comparable in isolation may have very different impacts after diversification with other risks. In this case, the approach for managing each risk would be distinct, based on an

awareness of the relationship between them, and would be supported in part by modeling performed at the risk level.

Risk management is often performed not only at the total company level but also at the risk level, with individual risk owners responsible for particular sources of risk across the organization. When designed with this perspective in mind, internal risk capital models need to be able to produce the necessary metrics to align with risk management practices. More generally, risk limits may be set at multiple levels or across multiple regional partitions within the organization (e.g., global life insurance business, total Canadian business, European annuity business), and viewing results at these levels is as important as viewing total aggregate results. Designing an internal risk capital model that accommodates aggregate perspectives and risk perspectives allows each of these management objectives to be achieved while retaining flexibility for future inclusion of additional reporting metrics.

Finally, from a practical perspective, assessing capital by risk type helps to minimize an overreliance on aggregation parameters within the model, particularly when viewed at more granular levels within the company structure. Correlation assumptions or joint distribution models may rely heavily on expert judgment or limited calibration data, and supplementing aggregate results with standalone risk reports promotes a more diverse risk view, which can be further enhanced by communicating model sensitivity to correlations and other key assumptions.

5. Enterprise capital models should be designed to support strategic decision-making

Enterprise capital models are primarily used to inform strategic decisions, and they may be used in a supporting role in conjunction with other models to drive detailed risk transactions. For example, an internal risk capital model could demonstrate the aggregate risk impact of hedging a block of business, at which point a supplementary asset model would be used for selecting specific assets to be held within the hedge portfolio. Such an interaction between models reinforces the idea that models may serve multiple purposes, and establishing relationships between distinct systems is key to ensuring that the appropriate information can be produced. The use of internal risk capital models to inform strategic decisions supports the objective of embedding the model within business processes. In addition to empowering senior management with timely and relevant information, an internal risk capital model designed around strategic applications helps to satisfy external requirements surrounding the use of capital models—in particular, a link between annual planning and capital modeling is part of the developing ORSA requirements.

The deployment of internal risk capital models within an organization recognizes the value in a common understanding of risk exposures and a common framework for measurement. The primary mechanism by which this type of enterprise modeling setup adds value is through its ability to deliver a broad understanding of risk characteristics within the business, which can then be used to inform and influence a variety of strategic decisions. When used in this way, it is important to recognize that high degrees of precision may not always be required, but that the timeliness of the results and their ability to capture information across different dimensions of the company is important. In this way, identifying

how an internal risk capital model will be used helps to ensure that it will be developed to produce the appropriate metrics while facilitating integration with other metrics and decision-making processes. Furthermore, the model and its conclusions should not be overly complex and should allow strategic decision makers to reach a common level of understanding. As with other models, processes involving internal risk capital models should follow a continuous cycle of review and improvement to ensure that the models are being used appropriately and are capable of producing timely and relevant information.

6. Enterprise-level and lower-level processes should connect

The ability to embed capital models effectively into business processes requires a connection between enterprise-wide results and lower-level results. Although significant insight can be gained from an enterprise-level capital model that aggregates results across distinct areas of the business, the value of this insight depends on a clear connection to other models developed and used in those parts of the business. Connecting bottom-up and top-down processes allows managers to communicate efficiently across areas of the business and coordinate risk management actions. For example, a company that issues a broad range of business across several regions might conclude that diversification benefits allow the total capital requirement to be less than the sum of each business unit's standalone requirement. In this situation, a clear process for allocating a portion of the diversification benefit back to each business unit would connect the management of the enterprise with the management of the business unit.

Establishing links between aggregate and lower-level models can also help to address certain risk management challenges. For example, the ability to cascade enterprise-level risk capital measures into daily risk operating metrics crucially depends on a connection across different levels within the organization, and managers at each level should take steps to promote these connections. Similarly, risk owners within different business units can leverage their shared connection to the enterprise model to promote communication and collaboration and to help establish sound modeling practices that are consistent with enterprise targets.

Connection to risk appetite and risk tolerances should also be considered. Limits allocated to individual risk exposures should reconcile with macro level risk tolerance, as this helps to reinforce a common platform for understanding and managing risk throughout the enterprise. In this regard, one of the initial steps to reconciling top-down and bottom-up processes is promoting a common definition of risk and a common basis for measuring risk exposure. For example, risk owners can communicate much more effectively when they classify risks into internally established categories with a widely understood modeling structure. By promoting a common language for discussing risk and ensuring that lower-level results can be reconciled to aggregate results, risk managers will be better positioned to understand their exposures at all levels of the enterprise.

7. Development of a capital model should be an iterative process involving continual business use and feedback

As the role of internal risk capital models within an organization continues to be refined, development of these models will remain an iterative process, incorporating detailed feedback and high level guidance from a number of key stakeholders. In developing an internal risk capital model, it is important to have buy-in from key stakeholders within the organization as this supports adoption of the model within existing and developing business processes. To ensure that stakeholders are supportive of capital modeling efforts, feedback should be obtained at regular intervals and incorporated into the development of the model. As internal buy-in continues to evolve, often in conjunction with training and increased understanding of the actual and potential uses of the model, the unique perspectives from different functions within the organization can provide valuable insight for continued model development. Additionally, the model validation exercise will often lead to recommendations for how the model can be enhanced or how results can be communicated more effectively, and iterative testing of model outputs should be incorporated into the validation aspect of model development. Furthermore, the process by which the model is validated may itself benefit from review and iterative improvement.

External factors play an important role as well. Evolving industry best practices in the measurement and projection of assets and liabilities demand regular review of underlying valuation systems and their interaction with capital models. Similarly, emerging ORSA requirements are motivating companies to review and refine their internal risk capital models to ensure that they accurately measure key risks and incorporate this measurement into business management.

A common approach when developing an internal risk capital model is to leverage existing systems and processes and layer on incremental modifications over time. How the model will be used is a key factor in identifying how to integrate optimally with other systems, so establishing this upfront promotes efficiency in the allocation of resources. For example, a company that wishes to measure its required capital might begin with regulatory cash flow testing models as a first step for quantifying the impact of key stress scenarios (Stress test frameworks are explored further in Principle #8). The information obtained from these models will often highlight areas where further investigation is desired, at which point resources can be allocated accordingly to further build out the capital modeling framework. A culture that promotes an ongoing process of feedback and subsequent refinement enriches the framework and better enables the model to meet the requirements of each key stakeholder.

8. Stress testing should be integral to capital modeling frameworks

Stress testing can support broader capital modeling frameworks. The results of stress tests—in which the analysis may focus on either a single adverse event or a combination of adverse events—can be incorporated in a number of ways:

- Stress test results may be used as part of the validation exercise. Conclusions drawn from a capital model may be compared to existing stress test results to ensure that material risk drivers have been captured adequately.
- Stress tests provide detailed analysis of the risk profile and risk drivers that may not be available from stochastic projections.
- Stress test results can be referenced to assist with the communication of capital requirements.
- Scenario analysis can demonstrate how the business would react now if specific historical events were repeated (e.g., 1918 pandemic scenario, 2008 credit scenario). The use of actual events can make the analysis more “real” for communicating to senior management.

In addition to stresses performed on capital model results (e.g., for ORSA and planning purposes), stress testing approaches may be used to produce core inputs to the capital model itself. In particular, a relatively common approach to calculating capital requirements (particular among life insurers) takes a set of stressed balance sheet impacts and aggregates through multiplication with a correlation matrix. Alternatively, a more complex framework may use a range of stress test results to calibrate a full loss distribution for the business.

Due to the prevalence of stress testing in conjunction with statutory reporting and internal analysis, adapting existing results can be a quick and effective way to support the ongoing development of an internal risk capital modeling framework.

Reverse stress testing can provide further insight to support internal risk capital modeling efforts. Reverse stress testing analyzes an adverse outcome such as insolvency to identify the circumstances that might cause this to occur. Understanding sources of risk supports the development of an action plan for managing these risks.

Because stress testing has applications in multiple areas throughout an insurance company, the nature and intent of the tests themselves must be clearly communicated and understood. In particular, there should be a clear indication of which metric(s) are being examined, which assumptions are being stressed, how the stresses are being applied, and what the intended purpose is. For example, in some applications, stress tests are designed to identify how sensitive an underlying valuation model is to a particular variable. In other applications, the stress itself is chosen for the particular objective of calibrating a dependent model. Design of the internal risk capital model should take this into account to ensure that available information is leveraged appropriately.

9. A structured process should exist for identifying and addressing capital modeling limitations

Many companies see several common challenges and limitations in their capital modeling framework:

- Incomplete data for calibrations. Capital models that largely rely on assessing impacts in tail scenarios lack sufficient data that provide robust credibility of modeled results. For example, correlation assumptions may depend heavily on expert judgment.
- Limited ability to run stochastic scenarios. Developing a full distribution of possible outcomes is a sound practice of capital modeling, but the robustness of these distributions is hampered by the inability to run a sufficient number of scenarios.
- Limited resources available to support the capital model development. Often the resources responsible for providing inputs into the internal risk capital modeling framework are the same resources required by senior management to complete higher priority statutory or GAAP reporting.
- Slow or unstable process for performing aggregation. The processes and technology leveraged to support those processes do not, for the most part, create results that are fast enough to be actionable.
- Inability to perform contribution analysis. The use of a correlation matrix to aggregate individual risk exposures does not lend itself to a clear drill-down to the specific scenario or scenarios driving enterprise impacts, or to the individual products that are contributing to tail outcomes.
- Difficulty validating the model. Complexity within the model may restrict the ability to detect possible errors, which might emerge only during periods of instability in the business environment.

Acknowledging limitations upfront and establishing a structured process for addressing them ensures that results are understood in the appropriate context and plans for future development can be prioritized accordingly. Documenting the limitations is crucial, particularly in areas where expert judgment has been relied upon, and the materiality of these limitations should be estimated. Communication of limitations to each stakeholder is also crucial to ensure that users of the model are fully informed. This communication should reflect that different stakeholders will have different uses for the model, and consequently, certain limitations may be more or less material depending on the context. After identifying and defining material assumptions that drive results, companies will be better positioned to establish an ongoing review and sensitivity testing of those assumptions to ensure that risks continue to be adequately monitored.

10. Capital modeling should be subject to the same model validation principles as other company models

Capital models are increasingly important to an insurer's risk management process, and as with any model used by the business, require validation and review. Independent teams should assess the robustness of capital models, and the intensity of the review should align with the complexity of the model and potential use of results. Throughout the review, attention should be placed on each of the core components, including inputs, calculations, and outputs. As with other models, following these

sound practices helps to ensure that any potential material misstatements are avoided and aids in the communication of results.

As risk management departments establish capital models within their organization, attention should broaden to model validation to provide confidence in the use of the model. Recognizing the importance of applying validation principles to the capital modeling process is a critical first step so that companies can more fully develop their capabilities in this area. Increasing use of modeled results to drive business decisions underscores the importance of validation efforts. Additionally, validation standards and documentation will be critical to meet external risk-based requirements, such as ORSA and other regulatory and rating agency requirements.

Companies should take steps to overcome validation challenges. Due to limited resources, independence with respect to model validation is often lacking, meaning that the team that is building the model and related processes performs a significant portion of the validation as well. Credibility from both internal and external perspectives will be improved if an independent party reviews the work developed by the capital model designers. From a balance sheet perspective, dedicated functions for processing asset-related analysis have traditionally existed within many insurers and have benefited from relatively widespread access to historical data. In contrast, liability validations are often less developed and may require additional effort to get comfortable with results. Additionally, validation efforts at the corporate level largely rely on validation provided by business units. Although this approach helps to leverage existing processes while incorporating detailed subject matter expertise, it may overlook any misalignments between business unit targets and group objectives. Companies should recognize these challenges and develop or implement action plans to enhance model validation, which can ultimately be expected to enhance credibility and support for capital modeling processes.

For a fuller discussion of model validation of risk capital models, the reader is referred to the CRO Council's paper on model validation principles (http://crocouncil.org/images/CRO_Council_-_Model_Validation_Principles.pdf).

11. Capital modeling requires striking the right balance between theoretical purity (e.g., mathematical precision and complexity) and practical reality

As with all models, a natural tradeoff exists between the theoretical pursuit of mathematical precision and the practical goal of using the model to achieve objectives. For internal risk capital models, this tradeoff can be particularly apparent due to the emphasis on events in the tail, for which historical calibration data is often limited. Given the uncertainty around tail scenarios, capital models may lack high degrees of precision, which highlights the need for extensive model validation and clear communication of results (discussed further in Principle #10).

This is not to say that capital models cannot be useful or that results cannot be trusted. Indeed, for many of the intended uses of internal risk capital models, there does not need to be the same high degree of precision as may be required for other models (e.g., policy level statutory reserving models).

Capital models can support many areas of the business (discussed further in Principle #2), and near real time decision making demands timely production of results. To maximize the potential for embedding capital models into business management, a balance must be struck between the pursuit of mathematical precision and the practical ability to calculate materially correct results when needed.

Fundamental to achieving the optimal balance is a common understanding of how the internal risk capital model will be used. The following aspects should be considered:

- **Scope of the model.** The model supports certain areas of the business, and it must appropriately capture material risks to which the business is exposed. However, it is neither possible nor desirable to capture every possible event that could potentially impact the company, so practical development guidelines should be established.
- **Interaction with other decision-making tools.** To the extent that the model is the primary tool used to support business decisions, resources should be allocated to develop the model for these purposes. To the extent that the model is a supporting tool for other business processes, the ability to produce high level metrics or general directional impacts may be sufficient.
- **Output requirements.** The level of detail, frequency of results, and audience associated with model output should be identified, and output reports should be developed to meet these requirements. Overinvestment in producing excessively detailed reports does not necessarily add value or clarity and may even restrict the ability of stakeholders to take action.

By structuring the internal risk capital model around its uses, stakeholders can focus their attention on the relevant pieces of information without being distracted by extraneous details. For example, establishing flexible links between central capital models and lower-level business unit models is valuable in enabling internal risk capital metrics to be calculated with a focus on practical applications. With this structure, after the capital model is calibrated from business unit models, it can then function independently to produce sensitivity analyses and output reports without relying on repeated input or reruns from the underlying valuation systems. This enables risk managers to efficiently leverage information produced by more detailed models to develop a risk profile of the company.

12. Conclusions drawn from capital models need to be challenged and understood using business judgment before taking action

Models can provide useful output to inform and influence decisions but cannot replace sound business judgment. This is not to say that modeled results should be ignored or that expert opinion always trumps detailed analysis, but rather that models must be understood in their context, including any limitations (Addressing limitations is discussed in Principle #9).

Distinguishing between complexity and accuracy is an important part of the model development culture. It is tempting—and often easier—to put faith in a result “because the model said so,” and this temptation increases when calculations appear to be detailed, robust and produced by complex

models. In these situations, it is crucial for model owners to have a good understanding of how calculations are performed, including what key assumptions underlie the model and how much reliance has been placed on external sources. Crucially, this information must be communicated to decision-makers along with results.

As with most models, it is usually preferable that capital models are not used in isolation. Supplementing capital models with additional information obtained from other established processes creates a richer set of information to inform strategic decisions. To the extent that differing conclusions could be drawn from different decision-making tools within the organization, results must be reviewed to explain any conflicts before taking action.

In addition to the absolute numerical result produced by a model, the relative movement in results over time can provide equally useful insight. When making decisions based on modeled results, including those from internal risk capital models, management should reference other tools to gain additional insight. If actual decisions made differ from conclusions implied by the result of a capital model, the decisions may still be appropriate, but management should be prepared to provide justification. Independent points of view should also be considered, as unique perspectives from distinct areas of the company might influence action taken at the enterprise level. By maintaining an awareness of the intended purposes for which internal risk capital models have been developed, senior managers can incorporate strategic considerations and the results of other internal models to ensure that they have a complete perspective for making business decisions.

Section 4: Conclusion

As insurers continue to look for ways to improve their risk and capital management capabilities, there is a heightened focus on internal risk capital models as part of companies' risk management and decision-making processes. In this paper the North American CRO Council has presented its perspectives on these types of models.

The principles described in this paper relate to the design, implementation and application of internal risk capital models. The principles are intended to promote sound practices with respect to internal risk capital models and be a useful reference for their various stakeholders. This would include those tasked with designing and developing the models, as well as management and the Board looking to use the models to make better informed decisions. By following the principles presented in this paper, insurers will be able to design and apply their internal risk capital models so that they can readily inform and influence a broad array of strategic business decisions and in so doing enhance the overall utility and value of the models to the insurer.

The principles address a range of topics and one of the most critical themes highlighted in a number of them is the importance of context in developing an internal risk capital model. Factors such as the type of business and risks the insurer writes and how these are managed in practice should be kept in

mind when designing, developing and applying a model. Similarly, it is important that the ultimate intended use(s) of the model be accounted for when developing, validating, and applying the model.

In addition to providing direct benefits to insurers internally, it is expected that these principles will be of value to external stakeholders such as regulators and rating agencies as they assess the strength and soundness of insurers' internal risk capital models, particularly to the extent that these assessments will impact the regulator or rating agency's view of the insurers' risk and capital management practices.

Note that though the paper lays out a number of principles that can be applied to the development and use of these models, this should not be interpreted as the CRO Council attempting to prescribe a particular methodology or approach that all insurers should adopt. Indeed, by applying the principles laid out in this paper, it should be expected that different companies will end up with different internal risk capital modeling approaches, given their specific characteristics, views and objectives. By implication, the principles do not support a "one-size-fits-all" approach to internal risk capital modeling and it is the CRO Council's view that there are dangers in applying such a view to capital models.