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Solvency Assessment Models Compared

Essential groundwork for the Solvency II Project

Produced by CEA and Mercer Oliver Wyman
in cooperation with all European insurance markets

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Foreword

As Chairman of the CEA Solvency II Steering Group, I am delighted to be presenting the study "Solvency Assessment Models Compared" produced jointly by CEA and Mercer Oliver Wyman in cooperation with all European insurance markets.

The European Commission has, through the Solvency II Project, initiated a fundamental and wide-ranging review of the current EU solvency regime in the light of current developments in insurance, risk management, finance techniques, financial reporting, etc. One of the key objectives of Solvency II is to establish a solvency system that is better matched to the true risks of an insurance company.

European insurers and reinsurers are very supportive of the Solvency II project and its aims, and are conscious that it will represent a major change for their businesses. There is recognition that a closer alignment between how well companies manage themselves and how they are regulated can only be beneficial to insurers, policyholders and shareholders alike. The industry is therefore extremely keen to play an important role in the development of the project.

As the representative of the European insurance and reinsurance industries, the Comité Européen des Assurances (CEA) together with the national insurance associations established a Solvency II Steering Group in order to coordinate our responses and input to the project.

This study represents a key part of the groundwork for the CEA Solvency II work and is aimed at building a better understanding of existing solvency regimes in order to develop the best possible one for Europe.

This relatively quick study does not pretend to explore every aspect of every model, but rather provides a factual overview and comparison of a number of prevailing solvency assessment frameworks in order to help understand areas of similarities and differences.

We hope that you will find this study useful and we are looking forward to tackling the remainder of this challenging project for the European insurance and reinsurance industries.

Olav Jones

1. Introduction

This report summarises the insights generated during a relatively quick study comparing prevalent solvency assessment models within the largest European and non-European insurance markets. It includes a model generated by Jukka Rantala as part of early CEA work into solvency measures, as well as Basel II[1] for banking. It aims to provide a factual comparison of these frameworks with a view to inform on common features, recent trends and emerging issues. Through this, it aims to provide a better understanding of existing solvency regimes in order to develop the best possible one for Europe under the Solvency II project.

Note that only capital requirements have been considered in any detail. Definitions of available capital also vary significantly across the solvency regimes but this has not been covered in any detail in this study. One should also note that this comparative study sometimes goes beyond the solvency assessment model and addresses the wider regime under which they have been stipulated. The non-supervisory or non-regulatory models are not defined within a unique regime of their own. As a result, the comparisons are not always comprehensive.

This document is structured as follows: the remainder of the introductory chapter provides summary insights into the study as well as background information on the broad approach taken in conducting the study. In the second chapter we then set out the results and insights of a structural comparison of the models. The third chapter focuses on the insights provided by a focus on the parameters and implementation of each model. In the final chapter we discuss the alignment of the models with some of the key principles put forward by the main stakeholders on the future prudence regime under Solvency II. References and supporting material can be found in the appendices.

1.1 Summary insights

The study shows that there are clear differences between the existing Solvency I framework and the new, more risk-based approaches.

We observe some key areas of convergence and a high level of consistency with the principles indicated so far by the European Commission, IAIS and the IAA. However we also see that while the key principles underpinning the newer regimes are converging there is still a variety of approaches chosen in applying those principles. In particular different regimes have chosen different trade-offs between sophistication and simplicity.

Emerging common areas include:

- Applying a total balance sheet approach (i.e. including both assets and liabilities)

- A trend towards 'economic' or market value based measurement of the balance sheet rather than relying on existing accounting measures

- A value-at-risk type approach to determining capital requirements

- Inclusion of a wide range of risks within Pillar 1

- Calibration of capital requirements to a specific confidence level over one year, generally above 99.5%

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1   This study considers the Basel II Capital Accord and not the European Capital Adequacy Directive, CAD3

1.2 Approach adopted

The following approach was adopted:

- Step 1: Selection of the solvency models to be compared;

- Step 2: Gathering of information on the models through questionnaires (see appendix 3) and additional research;

- Step 3: Based on the information gathered through the previous steps, compare the various aspects of each system including a comparison against the guiding principles related to Pillar I issues put forward by the EU Commission, the International Association of Insurance Supervisors (IAIS) and the International Actuarial Association (IAA).

Step 1

The model scope of the comparative analysis was the following[2]:

- **Solvency I**: EU Directives 2002/13/EC and 2002/83/EC (Solvency I), European Parliament and Council;

- **FTK Model**: The Financial Assessment Framework (FTK), DNB, The Netherlands[3];

- **SST Model**: The Swiss Solvency Test (SST), FOPI, Switzerland;

- **FSA Model**: FSA Integrated Prudential sourcebook for insurers, Financial Services Authority (UK-FSA), United Kingdom;

- **Jukka Rantala Model (JR)**: Model developed by Mr Jukka Rantala, formerly Chairman of the CEA Solvency II Working Group, in the context of CEA's work on a Standard Approach[4];

- **NAIC Model**: The National Association of Insurance Commissioners (NAIC) Risk-based capital Forecasting model, USA;

- **2002 GDV Model**[5]: The 2002 Supervisory Model for German Insurance Undertakings (GDV), Germany;

- **S&P Model**: Standard and Poor's European Insurance Group capital model (S&P);

Beyond these, we also reflected on the following solvency regimes for select topics:

- **Singapore Model**: Risk-based Capital Framework For Insurance Business (Singapore), (MAS, Singapore);

- **Australia Model** Insurance Reform Act (Australia), (APRA);

- **Canada Model**: The Office of the Superintendent of Financial Institutions Canada (OSFI) Minimum Continuing Capital and Surplus Requirements (MCCSR) for Life Insurance Companies and Minimum Capital Test (MCT) for Federally Regulated Property and Casualty Insurance Companies.

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2   Please refer to Appendix 1 for references to these solvency assessment models
3   We focus on the solvency assessment only as the continuity analysis and the short term stress test fall under pillar II
4   See the Appendix 4 for more details on the Jukka Rantala model
5   The GDV is currently reviewing the structure and parameters used in the model and will be updating this in the near future

For completeness Basel II was also included:

- **Basel II**: International Convergence of Capital Measurement and Capital Standards: a Revised Framework (Basel II), Bank of International Settlements;

Step 2

The basis for the comparative study was a reference table that allowed for consistent comparison of key framework elements of these solvency models. The reference table was completed after reviewing model documentation and checked by experts from national markets for correctness[6]. Below we briefly highlight the framework elements that were addressed in the qualitative review and which will be discussed in the remainder of this document:

- General information
  - Insurance segments covered by the model (i.e. life, P&C, health, reinsurance)
- Solvency assessment typology
  - Rules-based vs. principles-based assessment
  - Solvency model classification (e.g. simple factors, risk factors, closed form solutions, stochastic)
  - Applicability of company internal models
  - Comprehensiveness of solvency assessment (e.g. stress test, scenario analysis)
- Time perspective
  - Retrospective vs. prospective solvency assessment
  - What is the capitalisation horizon?
  - Going-concern vs. in-force
  - What calculation frequency is requested?
- Risk measure and calibration
  - What is the definition of the risk measure?
  - What risk calibration is chosen?
  - Is the risk calibration tied to the capitalisation horizon?
  - Is a minimum capital requirement specified?
- Valuation basis
  - What is the valuation basis of assets and liabilities?
  - Is a total balance sheet approach taken?
- Risk classification
  - What risk classes are included under Pillar I?
- Risk aggregation and dependencies
  - Are diversification benefits accounted for? How?

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6   Please refer to the appendix for a copy of the questionnaire leading to the reference table

- – Are concentrations accounted for? How?

- – Is risk mitigation accounted for? What risk mitigation? How?

- ■ Company treatment

  - – At what entity level does the solvency assessment hold?

Step 3

In a third step we include a review of how well these existing solvency models comply with the guiding principles related to pillar I-type issues that have so far been put forward by key organisations which are referred to by the EU Commission:

International Association of Insurance Supervisors
Principles on Capital Adequacy and Solvency (2002)[7]

1	Technical provisions of an insurer have to be adequate, reliable, objective and allow comparison across insurers
3	Assets have to be appropriate, sufficiently realisable and objectively valued
4	Capital adequacy and solvency regimes have to address the matching of assets with liabilities
6	Capital adequacy and solvency regimes have to be sensitive to risk
8	A minimum level of capital has to be specified
11	Any allowance for reinsurance in a capital adequacy and solvency regime should consider the effectiveness of the risk transfer and make allowance for the likely security of the reinsurance counterparty
14	Capital adequacy and solvency regimes have to address double gearing and other issues that arise as a result of membership in a group

International Actuarial Association
A Global Framework for Insurer Solvency Assessment (2004), p.9-14

Principles – versus rules-based approaches

2.11 ■ Solvency assessment should be based on sound principles. Implementation of solvency assessment will require rules developed from these principles. However, the Working Party (WP) considers that the rules used should include provisions to allow their adaptation to current or unforeseen circumstances with the prior agreement of the relevant supervisor.

■ Implementation will require rules developed on these principles.

■ Rules should include provisions to allow adaptation to unforeseen circum-stances.

Total balance sheet approach

2.13 ■ The WP believes that a proper assessment of an insurer's true financial strength for solvency purposes requires appraisal of its total balance sheet on an inte-grated basis under a system that depends upon realistic values, consistent treat-ment of both assets and liabilities and does not generate a hidden surplus or deficit.

■ Appraisal of the total balance sheet using realistic values and consistent treat-ment of assets and liabilities.

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7   Two further papers have been produced by the IAIS: 'Cornerstones for the formulation of regulatory financial requirements', February 2005 and 'A new framework for insurance supervision', October 2004

Degree of protection

2.15 ■ In forming its recommendation for an appropriate degree of protection for insurer solvency assessment purposes, the WP considered the role of rating agencies in assessing insurers and the substantial volume of credit rating and default data available from these agencies. The WP also noted the relation between the degree of protection and the time horizon considered. In addition, the specific manner of applying the capital requirement risk measure may also affect the degree of protection chosen. The WP's recommendation for degree of protection is therefore linked with its recommendation for an appropriate time horizon for solvency assessment as shown in the following paragraphs.

■ It should be linked with the capitalisation horizon.

Appropriate time horizon

2.16 ■ A reasonable period for the solvency assessment time horizon, for purposes of determining an insurer's current financial position (Pillar I capital requirements), is about one year. This assessment time horizon should not be confused with the need to consider, in such an assessment, the full term of all of the assets and obligations of the insurer.

■ It is reasonable to choose one year.

■ Full term of assets and liabilities should also be considered.

2.17 ■ The amount of required capital must be sufficient with a high level of confidence, such as 99%, to meet all obligations for the time horizon as well as the present value at the end of the time horizon of the remaining future obligations (e.g. best estimate value with a moderate level of confidence such as 75%).

■ Suggested confidence level of 99% over one year and 75% confidence of meeting future liabilities.

Types of risks included

2.19 ■ In principle, the WP recommends that all significant types of risk should be considered (implicitly or explicitly) in solvency assessment. However, there may be valid reasons why certain risks do not lend themselves to quantification and can only be supervised under Pillar II. The WP believes that the types of insurer risk to be addressed within a Pillar I set of capital requirements are underwriting, credit, market and operational risks.

■ Certain risks do not lend themselves to quantification and should hence be addressed under pillar II.

■ Pillar I should address U/W, credit, market and operational risk.

Appropriate risk measure

2.20 ■ A risk measure is a numeric indicator that can be used to determine the solvency capital requirement for an insurance company. The most appropriate risk measures for solvency assessment will exhibit a variety of desirable properties (e.g. consistency). Of course, it is difficult for one risk measure to adequately convey all the information needed for a particular risk. One risk measure that exhibits several desirable properties for various (but not all) risks is Tail Value at Risk (also called TVaR, TailVar, Conditional Tail Expectation, CTE or even Policyholders' Expected Shortfall). In many situations, this risk measure is better suited to insurance than Value at Risk (VaR), a risk measure commonly used in banking, since it is common in insurance for their risk event distributions to be skewed.

■ Recommends tail VaR

Risk dependencies

2.21 ■ The solvency assessment method should recognize the impact of risk dependencies, concentration and diversification. This has implications for the desirable properties of the appropriate risk measure.

   ■ Solvency assessment should recognise concentrations and diversifications.

Risk management

2.25 ■ The solvency assessment method should recognize appropriately the impact of various risk transfer or risk sharing mechanisms used by the insurer.

   ■ Should recognise the impact of various risk transfer or risk sharing mechanisms.

   ■ Need to recognise that some techniques introduce new risks.

Standardised approaches

2.28 ■ Regardless of the risk management process used by the insurer for its risks, including retention of its risks, effective management of these risks is encouraged by appropriate of the extent of the risks and their management by the company. Appropriate audiences disclosure includes the stakeholders of the insurer including the supervisors.

   ■ Simple risk measures are appropriate when it is recognised that the risk in question is of minor importance or if there is no generally accepted way of how to assess it.

   ■ Sophisticated approaches are appropriate for material risks.

Advanced approaches

2.33 ■ Required capital can be thought of as a second line of defence protecting an insurance company's solvency and its policyholders. The first line of defence is solid risk management. If trouble develops that cannot be prevented through management of a risk, then capital should be available to cover the financial losses that emerge. It follows that in order for a supervisor to be content with a lower amount of required capital under a company-specific approach, there must be some assurance that the particular source of risk is under control, its effects are well mitigated and there is a reduced need for the required capital. Therefore, in approving a company's use of an advanced or company-specific approach, the supervisor should confirm that the company has in place appropriate risk management processes together with a satisfactory reporting structure.

   ■ Internal models should be accepted by regulators only if they can prove that appropriate RM processes and reporting is in place.

EU Commission Services
Framework for Consultation on Solvency II (July, 2004)

   ■ An increased level of harmonisation for technical provisions is a cornerstone of the new solvency system. To that effect it is recommended to set a quantitative benchmark for the prudence level in technical provisions. The relationship between technical provisions in the new solvency system and the future accounting regime and an appropriate level of prudence for technical provisions require analysis.

   ■ The SCR reflects a level of capital that enables an institution to absorb significant unforeseen losses and that gives reasonable assurance to policyholders. The SCR should be calculated in such a way that the quantifiable risks to which an institution is exposed are taken into account and based on the amount of economic capital corresponding to a specific ruin probability and time horizon. The appropriate ruin probability and time horizon to be used and the implications for the calculation of the SCR using a going-concern basis require analysis.

- The Minimum Capital Requirement (MCR) reflects a level of capital below which ultimate supervisory action would be triggered. It shall be calculated in a more simple and robust manner than the SCR as this kind of action may need authorisation by national courts. To facilitate and stabilise the transition to the new overall solvency system, the MCR should be constructed in a straightforward manner such as under the present 'Solvency I Directives', while maintaining existing levels of prudence.

- The risks addressed in the capital requirements should be based on the IAA risk classification and include: underwriting risk, credit risk, market risk, operational risk and liquidity risk. Additions and adjustments to the IAA risk classification could be made provided specific reasons for such exceptions are given. To the extent these risks are not quantifiable they will be taken into account in Pillar 2.

- Institutions' internal models may be used to replace the standard approach to the SCR if the internal model has been validated for this purpose. The validation criteria and the validation process should be developed and harmonised. The possibility to extend this option to group-wide internal models requires analysis.

2. Comparative study on solvency regimes

In this section we discuss a structural comparison of the various solvency assessment models outlined in the first section. The discussion broadly follows the structure of the solvency reference table presented in 'step 2' above.

The focus of the comparative study is on the regulation for capital requirements only. Considerations of any rules which define available capital, or in other words the rules that determine the balance sheet items that can be held to meet the requirements, were beyond the scope of the study. As a result, capital adequacy comparisons are equally beyond the scope of the study.

2.1 Model typology

Whilst all solvency assessment models are based on a detailed methodology to arrive at minimum capital requirements, these methodologies differ greatly across solvency assessment models. In order to structure the discussions on common and divergent features of models, the following classification is proposed[8/9]:

Table 1: Classification of surveyed solvency assessment models

Static/accounting-based models		Dynamic/cash flow-based models	
Simple factor-based	Risk factor-based	Scenario-based	Principles-based
■ Solvency I ■ Australian (1973)	■ S&P ■ 2002 GDV ■ NAIC ■ Jukka Rantala ■ [Basel II][I] ■ UK-FSA (non-life) ■ UK-FSA (non-profit life)[II] ■ FTK (underwriting risks) ■ Canada (life) ■ Canada (P&C) ■ Singapore (non-life) ■ Singapore (some life asset risks) ■ Australia (P&C prescribed method)	■ UK-FSA (with-profits life – MCR) ■ SST (Asset risk scenarios) ■ FTK (financial risks) ■ NAIC (ALM risks, if material) ■ Canada (Life segregated funds) ■ Singapore (life underwriting and interest rate risks) ■ Australia (Life) ■ Canada (P&C policy liabilities risk)	■ UK-FSA (with-profits life – SCR[III]) ■ SST (Additional scenarios/non-life)
Rules-based approaches		Rules-based for risk measurement and principles-based for valuation	Principles-based approaches

I   Solvency regime for credit institutions

II   In the FSA documentation the resilience capital requirement is based on a scenario, but is actually applied as a factor for non-life and non-profit businesses

III The FSA encourages covering all businesses in the SCR (or Individual Capital Assessment), however there is a lot of flexibility in the approach, while for life with-profits businesses some principles have been identified

8   Note that this is only one of many possible ways to classify the various solvency assessment models. Other ways of classification can be just as appropriate, however, this classification is probably aligned with the most common views of differentiating solvency assessment models. It should also be noted that the suggested classification does not aim to describe all the differences between the models that fall under the various classes. We observe significant differences even between models of a given class, e.g. the S&P's European insurance capital model is rather different from the Basel II model in Banking

9   Refer to the appendix for definitions of the terms used in this model classification

The table on the previous page makes a distinction between static, accounting-based models and dynamic, cash flow-based models. In the former, the capital requirements are arrived at by applying a certain calculation methodology on static, i.e. fixed at a given due date, accounting basis. The accounting basis stands for either certain balance sheet positions, P&L positions or underlying 'risk' positions, e.g. the total exposure to BBB-rated corporate bonds.

In the latter, models rely on cash flow projections, rather than fixed positions. Hence, we refer to them as dynamic. In order to arrive at the capital requirements, calculation methodologies are applied to the projected cash flows. These cash flow projections can be of varying granularity and differentiation.

Static, accounting-based models are further broken down into simple factor-based models and risk factor-based models. Simple factor-based models are referred to as simple because they apply only a small number of factors to the static accounting positions in order to arrive at the capital requirements. As a result, these models would be expected not to be risk-based since the level of factor differentiation is much too reduced to reflect the risks of the insurance undertaking. The magnitude of the factors is also not necessarily calibrated to a certain desired confidence level. The current Solvency I prudence regime is an example of a simple factor-based model as the life insurance capital requirements are arrived at by multiplying a factor of 4% to the mathematical reserves of participating business (for unit-linked business the factor is reduced to 1%) plus a factor of 0.3% to the sum-at-risk.

Risk factor-based models are the most prevalent in the industry. They apply fixed ratios to select accounting positions. The ratios are frequently calibrated to cover the underlying risk to a certain confidence level. The 2002 GDV model is a classic example of a risk factor-based model. It provides a series of risk factors that need to be applied to clearly defined underlying accounting positions in order to arrive at the various risk capital numbers, which later are aggregated assuming correlations[10].

Since both types of static, accounting-based solvency models apply well defined factors we refer to them as 'rules-based'. That is, there are clear rules on what positions the factors are to be applied to and the factors are typically clearly defined as well.

Similar to the static/accounting-based models, dynamic/cash-flow based assessment models are further broken down into scenario-based models and purely principles-based models. In the former, the solvency methodology is based on the insurance company measuring the impact of specified scenarios on its net asset value through a discounted cash flow projection. In most cases these scenarios are clearly defined in the model 'charter' and therefore we refer to this as a rules-based risk measurement. An example of this would be given by the SST, where e.g. the insurance companies are requested to calculate the impact of a fixed fall in property prices on the net asset position. Insurance companies have to measure how this fall in property prices affects both their market value of assets and realistic liabilities. The approach to arrive at the realistic liabilities (i.e. the valuation) is specified by general principles. Hence, we refer to these models as principles-based only for the valuation of the assets and liabilities.

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10   Please refer to chapter 3 for a more detailed discussion of the factors used in the 2002 GDV model

In the case of purely principles-based models, no rules have either been specified for the risk measure or for the valuation, but the insurance company is requested to arrive at its own view of the capital requirements on the basis of its internal modelling following certain calculation principles put forward. An example of this is the UK-FSA's requirement for insurance companies to arrive at the Individual Capital Assessment (ICA) using internal models that comply with the principles put forward in UK-FSA Policy Statement 04/16.

Note that the sub-classification within the static and dynamic models is not necessarily mutually exclusive. For instance, it is feasible for a model to be in theory scenario based but in practice is static, accounting-based where the scenarios are converted into fixed factors or multipliers. However, all the observed solvency assessment models can be classified in this way, even if some of these need to be sub-divided within this classification.

It should also be noted from the above table that the more recent solvency assessment models developed by regulatory and supervisory bodies, e.g. in Switzerland, The Netherlands, the United Kingdom, but also in Singapore, Canada and Australia, include dynamic modelling, at least for some of the risks covered. The motivation to do so may be related to the view that standard formulaic approaches to setting minimum solvency requirements are difficult to apply due to a lack of flexibility and tend to dis-incentivise improvements in companies' risk management[11]. On the other hand, the drawback of these approaches is that they require significantly higher implementation effort, as will be discussed later.

It should also be noted that, whilst these more recently developed solvency assessment models do include the more complex dynamic approaches, their overall prudence regime is flexible in terms of integrating elements of a variety of the classes presented. For instance, the current UK-FSA prudence regime uses a risk-factor based approach for the solvency assessment of non-life insurance activities, as well as non-profit life insurance lines. However, due to the materiality of the non-linear ALM risk in with-profits life operations, these lines' solvency is assessed using a dynamic, cash flow-based approach for the minimum capital requirements. Furthermore, the UK-FSA requests life insurers to develop their own internal models to assess the target capital requirements (the ICA) of their with-profits life insurance activities.

The Swiss and US regimes similarly argue that due to the non-linear nature of ALM risks, these risks were chosen to be captured by a more dynamic and implicitly more sophisticated risk measurement approach in that it better captures the nature of these risks than a risk factor-based approach could do.

A further point to note is that few prudence regimes currently make a distinction between Minimum Capital Requirements and Solvency or Target Capital Requirements[12]. The three more recent supervisory models developed in Switzerland, the Netherlands and in the United Kingdom stand out by making this distinction, at least partially, but by taking different approaches[13]:

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11   See 'White paper on the Swiss Solvency Test', section 1.1
12   We exclude the consideration of absolute minimum funding requirements in the current Solvency I regime
13   It should be noted that the 2002 GDV model is meant to be an example for the standard approach for the future Solvency Capital Requirements under Solvency II. The GDV generally advocates the development of company internal models

Table 2: MCR versus SCR treatment in select solvency assessment models

Prudence regime	MCR	SCR
■ Switzerland	■ Solvency I	■ SSST
■ The Netherlands	■ Solvency I	■ FTK
■ United Kingdom[I]	■ UK-FSA (scenario-based model)	■ Company internal models

I   For life insurance activities only

Finally, we note that only the UK, Swiss and Dutch solvency assessment regimes actively incentivise companies to enhance their internal risk capital modelling capabilities within their supervisory solvency regime by requesting the use of these internal modelling capabilities in their solvency assessment. In all three cases, this is due to the fact that the solvency assessment models are based on realistic balance sheets where realistic liability values can only be arrived at through internal modelling. In the SST, company actuaries are also requested to define company specific scenarios that need to be investigated. In the UK FSA approach, life insurance companies are requested to develop internal models to arrive at the Solvency Capital Requirements[14]

Some observations from the classification of the currently existing solvency assessment models are summarised below:

■ There is a variety of ways solvency assessment models can be classified. The proposed classification does not purport to be more appropriate than any other. No classification will be able to reveal all the differences of the existing solvency assessment models;

■ The more recently developed solvency assessment models by supervisory authorities tend to apply dynamic cash flow-based approaches, at least for capturing the financial risks of life insurance operations;

■ Whilst the use of internal models to assess risks and capital needs is generally supported, only the UK-FSA, SST and FTK request internal modelling capabilities and therefore actively incite insurers to enhance their risk measurement capabilities.

2.2 Model scope

Having established that the various solvency assessment models exhibit significant methodological differences we now turn to the question whether their scope differs. We differentiate the scope of insurance segments covered from the scope of risk classes explicitly covered by each model.

2.2.1 Insurance segments covered

The aim of this investigation is to identify at what maximum level of granularity the various solvency assessment models differentiate insurance activities along business segments. We apply the following segmentation: at a first level we distinguish between life insurance, P&C, health and reinsurance activities. At a second level we differentiate within life insurance activities, between non-profit products, with-profit products and unit-linked products.

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14   In theory static, factor-based models could also incentivise internal risk capital modelling capabilities if they apply conservative rules with a view to somewhat 'inflate' capital requirements vis-à-vis internal models or better the capital requirement that would reflect the true risk profile. This argument however only holds if the factor-based model is in fact an option to another approach which would yield more realistic and lower capital requirements

We summarise the results in the table below:

Table 3: Granularity of insurance segments that are uniquely treated in the surveyed solvency assessment models

	Insurance solvency models								Bank solvency model
	Solvency I	2002 GDV	NAIC	S&P	JR	FSA	FTK	SST	Basel II
Life insurance	✓	✓	✓	✓	✓	✓	✓	✓	
With profits		✓				✓			
Non profits						✓			
Unit linked		✓				✓	✓		
P&C insurance	✓	✓	✓	✓	✓	✓	✓	✓	
Health insurance			✓					✓	
Reinsurance			✓					✓	

✓ Treated
Blank: No treatment

Obviously, Basel II does not differentiate along insurance business segments as it defines only the prudence regime for banking activities.

Health insurance activities are only explicitly treated under the US and new Swiss prudence regimes. The 2002 GDV model explicitly excludes health insurance from its consideration, due to the unique nature of the German health insurance regime. In the other solvency assessment models investigated, health insurance products are treated either as life or non-life products, rather than applying a bespoke approach for health insurance.

Similarly, only the US and SST apply tailored prudence regulation for reinsurance activities. In all other cases there is no explicit solvency regulation of reinsurers.

The treatment of life insurance activities is rather diverse across the models investigated. The UK-FSA applies distinct methodologies to non-profit life and unit-linked activities vis-à-vis with-profits life activities. This aspect is unique to the UK insurance system where with-profits funds may be ring-fenced from the other life insurance assets and are certainly apportioned for the calculation. This could not easily, if at all, be replicated in most other jurisdictions since non-profits life and with-profits life assets are all booked in a single general account[15]. The 2002 GDV model explicitly applies a different treatment for unit-linked products with guarantees evaluating these on a contract by contract basis[16].

This is not to say that the other regimes do not treat these different product types. Rather they do not use a different approach designed specifically for each of these segments. While most factor-based models, for some risk types, will apply different risk factors for protection and savings products, this is not a separate approach rather a differentiation in the factors. Solvency I explicitly differentiates life and annuities linked to investment funds with guarantees from those without guarantees. Here different factors are applied to the mathematical provisions of these activities. For products with guarantees the factor is 4% and without guarantees it is 1%.

15　For completeness note that whilst segregated accounts are common in some jurisdictions they typically refer to ring fenced assets for segregated group contracts
16　Please refer to Annex 3 of GDV (2002) Supervisory Model for German Insurance Undertakings (Life), July 2002

Some observations can be drawn from this analysis:

- Currently, reinsurers' solvency is rarely regulated via the use of solvency assessment models

- Health insurance activities are in most cases covered by the approach for either life or non-life activities when applying solvency assessment methodologies

- There is a tendency to differentiate the risks within life insurance activities, depending whether they have been underwritten as non-profit life, unit-linked or with-profits life contracts

2.2.2 Risks covered

A comprehensive set of risk classes can in theory be defined and chosen in any model. We applied a risk classification which is broadly aligned with the IAA's risk classification[17/18]

Table 4: Risk classification of existing solvency assessment models

	Insurance solvency models								Bank solvency model
	Solvency I	2002 GDV	NAIC	S&P	JR	FSA	FTK	SST	Basel II
Underwriting risk		✓	✓	✓	✓	✓	✓	✓	
Catastrophe risk					(✓)			✓	
Pure market risk		✓	✓	✓	(✓)	✓	✓	✓	✓
ALM risk		✓	✓		✓	✓	✓	✓	
Credit risk		✓	✓	✓	(✓)	✓	✓	Basell II	✓
Operational/ Business risk		✓	✓	✓	(✓)	✓			✓

✓ Treated
(✓) Work in progress
Blank: No treatment

Under the Solvency I prudence regime the simple factors applied are intended to arrive at one overall capital requirement that covers all risks of the insurance company. Therefore, no further differentiation of risk classes is applied in the calculation methodology.

The 2002 GDV model has a highly differentiated risk classification. This includes the treatment of business risk within both the GDV Life and Non-life models under General Business Risk (C4) and Non-Insurance Risk (C6) respectively. The 2002 GDV model documentation explains that business risk can be subdivided into four groups: procedural, personnel, external and disaster risks. These four groups also capture operational risks. However, since these risk types are difficult to quantify with no available data, they are accounted for by an overall business or non-insurance risk factor of 1.5% of Earned Premiums. Some of the other models considered also cover business risks but not both for non-life and life, as is done by the GDV.

The Jukka Rantala approach is also highly differentiated across risk types. However it should be noted that in the current model implementation (which has been

17   Please refer to the IAA's A Global Framework for Insurer Solvency Assessment (2004)
18   Please refer to the appendix for a more detailed definition of the risk classes differentiated

developed as an example of the model structure and how the calculation would work), only the ALM and underwriting risks have been included. The referenced working document however discusses including other risk types if they are found to be measurable and significant (available on CEA's website at www.cea.assur.org). These are therefore included in brackets in the above table.

The new UK-FSA regulations contain guidance on how a firm should determine its policy for operational risk. Guidance is given on systems, controls and documentation. This is not used in the risk capital calculation but is instead covered by the supervisory controls process under pillar II.

Within the SST model, operating risks (i.e. operational risks and business risks) have been excluded from the risk capital calculations on the grounds that they are too difficult to quantify, given the lack of experience typically available. They should rather be covered, in the same manner as the UK-FSA, through the supervisory controls process under pillar II. It is noted that catastrophe risk is only explicitly covered in the SST regime.

Similarly the Dutch FTK does not currently include any quantification for operational risks. There is an intention to include these by 2008 although no approach has yet been specified.

Amongst the pure insurance solvency assessment models (i.e. excluding Basel II), the S&P's insurance capital model stands out by not covering ALM risks explicitly. This is a common and well documented criticism of this model[19].

Naturally, the Basel II prudence regime does not cover insurance risks since they are not prevalent in banking operations.

In wrapping up this section we draw the following observations:

- Most existing insurance solvency assessment models objectives are sufficiently well aligned with the proposed IAA risk classification

- Catastrophe risks are relatively more difficult to differentiate from 'normal' claims in a risk factor-based model and are hence more likely to be covered explicitly in a more dynamic model

- Operating risks are relatively more difficult to quantify and hence at times covered outside pillar I and within the supervisory controls process

- Some risk factor-based models implicitly cover ALM risk under what has been classified as pure market risks in the table above

2.3 Valuation basis

Most of the models considered require asset and liability values to be entered. For many of the factor-based models the required inputs are related to the accounting values for assets and liabilities. The more dynamic (scenario or principles) based models typically define a new valuation approach, in particular for liabilities, representing the market value.

In this section we first examine whether models take a total balance sheet approach and secondly how they consider the liabilities to be valued.

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19   Refer for example to the article in German by Th.Schubert and G.Grießmann from the GDV: Solvency II = Basel II + X, Versicherungswirtschaft, Heft 18/2004

2.3.1 Total balance sheet

The IAA principles state that a SCR should be based on the appraisal of the total balance sheet using a consistent treatment of both assets and liability representing realistic values for both. In addition the IAIS has stated that technical provisions should be calculated in a way that is objective and comparable across insurers. This suggests a likely change since currently technical provisions are inconsistently valued across European insurance markets.

Most of the models considered do include the total balance sheet in the calculation of the required solvency capital. The notable exception is Solvency I which includes only the liability side, but does not consider the composition of the assets held in the capital calculation. It is generally recognised that in order to be adequately 'risk-based' both assets and liabilities, as well as the interaction between these, must be captured in any solvency capital model.

Having said this, most of the static models currently require the technical provisions based on local accounting rules or IFRS to be used as the appropriate liability values. This ignores any prudence included in the valuation and, at a European level, may lead to inconsistencies across markets.

2.3.2 Liability valuation

The scenario and principles based models considered all define a 'realistic valuation' of liabilities and use this in order to calculate the required capital. Using the same definition of 'realistic value' across different geographies would lead to objective and comparable technical provisions (as expressed by the IAIS), however currently different regimes define 'realistic values' inconsistently.

2.3.2.1 FSA PS04/16 life with-profits model

As discussed above, for life with-profits products the new UK-FSA solvency regime uses a scenario approach to define the required capital.

Under this approach both the market value of assets and the realistic value of liabilities is required. The realistic value of liabilities[20] is defined as the present value of expected cash flows under best estimate assumptions, including the value of any options or guarantees. Expected cash flows include both conditional (and guaranteed) and unconditional (based on policyholders' reasonable expectations) cash flows.

This means that the market value of liabilities excludes any prudent margins or assumptions, capturing any uncertainty in the risk capital margin. However, in order to calculate the required solvency capital, the technical provisions (under current accounting rules) are subtracted from the sum of the market value of liabilities and the risk capital margin. In this way, the UK-FSA rules use a newly defined realistic market value for liabilities, but link the result with current technical provision calculations, including some prudent margins. This is shown in figure 1 on the next page.

2.3.2.2 FTK model

The FTK also uses the market value of liabilities, however this is defined as the realistic value of liabilities (which is in line with the UK-FSA liability value) plus a risk margin (referred to as a market value margin).

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20   In the documentation the realistic value is made up of three components: the 'realistic current liabilities', the 'with-profits benefit reserves' and the 'future policy related benefits'

This risk margin is included in order to account for unavoidable risks covering modelling uncertainty (model risk), parameter risk and structural uncertainty. It is currently calculated by stressing the underwriting parameters to a 75% probability outcome, increasing the value of liabilities. It is this value that is then used as the base liability value under each of the scenarios.

This is in contrast to the UK-FSA approach as the required capital is calculated including prudent margins in the liability value, rather than calculating a required risk margin excluding any prudent assumptions and subsequently reducing this amount to allow for prudent technical provision calculations.

2.3.2.3 SST model

The SST is based on a market value of liabilities including a risk margin (similar to the FTK), but uses only the realistic value in order to calculate the required capital (in the same way that the risk capital margin is calculated in the UK-FSA model).

However, the risk margin is based on the cost of holding the minimum required capital assuming that the book is being run-off and that the assets have been gradually switched in order to reduce the risk in the book as far as possible. This is intended to represent the cost a third party would incur when purchasing the book in case of insolvency. This is fundamentally different from the FTK definition, in both its intention and approach.

Note than the target capital is not just the capital required above the market value of liabilities, but also includes the risk margin, as shown in the figure below.

Figure 1: Comparison of realistic liability valuations[I]
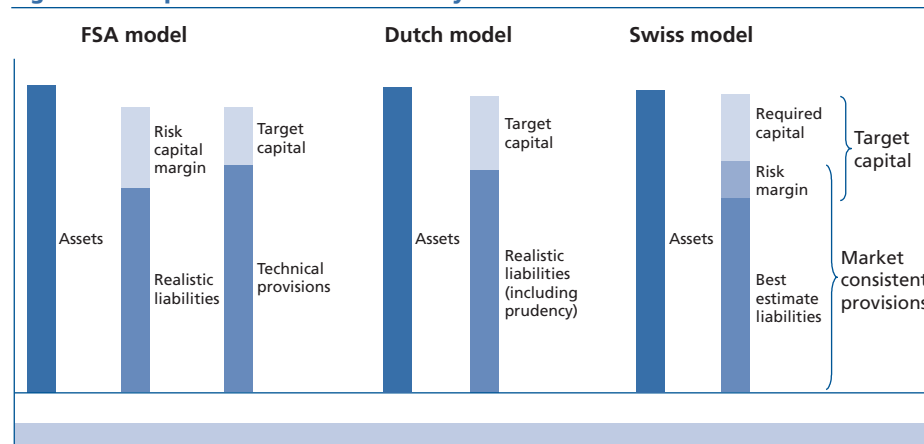
I   This chart is for illustrative purposes. The relative heights of the bars are not an indication of differences between models

In observation:

- All risk-based models under consideration apply a total balance sheet approach including both the asset and liability components

- Most of the static models are based on the current local rules for technical provisions. There is no reason why factor based models could not specify the calculation of the liability value or use market/realistic valuation if appropriate factors are used, however in the models considered this is currently not the case.

- The scenario or principles based models typically use some sort of realistic or

market value of liabilities specifying the basic principles or rules to calculating these

- The market/realistic values used are currently inconsistent across regimes as is their use in defining the required capital.

2.4 Capital measurement methodologies

In this section we discuss the methodologies underlying the required capital measurement approaches of the solvency assessment models in more detail. We observed significant differences in the underlying methodologies across models. In order to better reflect these variations we break the discussion into key elements of risk capital measurement methodologies, namely:

- What is the definition of risk for capital measurement purposes?

- What confidence level is chosen to link risk to capital requirements?

- What underlying time perspective is applied?

- What are the more detailed measurement approaches per risk class?

- How are risk interdependencies considered in the risk aggregation process?

### 2.4.1 Risk definition for capital measurement purposes

First, we summarise the differences in the definition of risk for the required capital measurement purposes. In general, risk can simply be defined as the potential of a deviation away from expectations. In financial services, these expectations typically refer to either earnings or value. Hence, risk is typically being measured using either an earnings-at-risk or value-at-risk approach. As we will see below, there are some variations within these two broader risk measurement approaches.

The Solvency I regime stands out in that, since it is not risk-based, it does not refer to any underlying definition of risk that should be covered by required capital needs. The overall capital requirement measurement does not include an appreciation of the risks being taken.

The most prevalent risk measurement approach in insurance solvency regulation is value-at-risk. Besides the standard value-at-risk measurement approach, we also observed the use of tail value-at-risk (also referred to as conditional tail expectation or expected shortfall). The value-at-risk is the threshold value that losses to a certain confidence level, e.g. in 99% of cases, would not exceed. The tail value-at-risk expresses the expected (i.e. average) size of the loss if it exceeds the value-at-risk threshold. We outline the difference between these two approaches in the next graph[21]:

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21 Please refer to http://www.gloriamundi.org/introduction.asp and
    http://www.riskglossary.com/link/value_at_risk.htm for a more detailed discussion of value-at-risk and tail
    value-at-risk

Figure 2: Value-at-risk versus tail value-at-risk
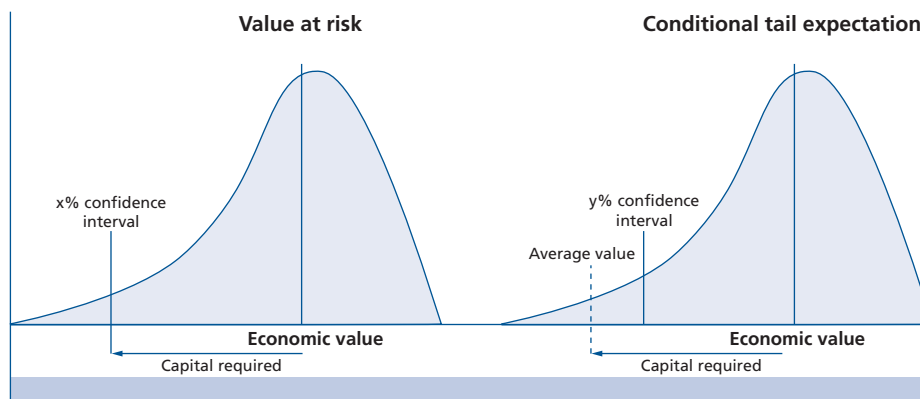
Below we summarise the general risk measurement approach underlying the various solvency assessment models:

Table 5: Underlying risk measurement approach in the surveyed solvency assessment models

	Insurance solvency models								Bank solvency model
	Solvency I	2002 GDV	NAIC	S&P	JR	FSA	FTK	SST	Basel II
None specified	✓								
Earnings-at-risk									
Value-at-risk									
■ Standard VaR approach		✓	✓	✓	✓	✓	✓		✓
■ Tail value-at-risk								✓	

2.4.2 Confidence level

Another element of the capital measurement is the desired confidence level, against which an insurer should be capitalised. The confidence level expresses the probability of losses which the required capital is intended to cover. We list the observed target confidence levels in the table below:

Table 6: Target confidence levels

Solvency assessment model	Target confidence level
Solvency I	None specified
2002 GDV	99,78% (assumed equivalence with BBB rating)
NAIC	None specified; although confidence levels are inherent in the calculation of factors.
S&P	None specified; the capital requirements are a function of the desired debt rating. A Capital Adequacy Ratio of 100% to 125% is required to attain BBB rating
Jukka Rantala	99,5%
FSA	99,5% (assumed equivalence with BBB rating)
FTK	99,5% for life insurance; 97,5% for pension funds
SST	Average loss of the largest 1% outcomes
Australia	None specified
Canada	None specified
Basel II	Insurance not explicitly specified in Accord, but considered equivalent to 99.9% for Operational risk advanced approach, 99% for Market risk VaR and 99.5% for Credit risk

2.4.3 Time perspective

The time perspective comes into play for the following considerations in the capital measurement methodology:

- Over what time horizon should the required capital protect against losses, i.e. what is the capitalisation horizon?

- Over what time horizon should assets and liabilities be valued, i.e. what is the valuation horizon?

- What capitalisation perspective is chosen: retrospective or prospective?

- What calculation frequency is recommended in the solvency assessment models?

With respect to the capitalisation horizon, all solvency assessment models apply a 1-year capitalisation horizon with the exception of the Solvency I regime, Canadian and Australian models. The Solvency I regime does not specify any capitalisation horizon while the Canadian model considers multiple periods for certain products and risk types. In the Australian Life model part of the capital required is based on new business reserves which should be an amount that ensures the Solvency Requirement of the statutory fund will continue to be met over the next three years.

The definition of a valuation horizon is only applicable when using a dynamic cash flow-based solvency model. In all observed cases of dynamic cash flow-based solvency models, the valuation horizon is the run-off of liabilities.

The definition of a valuation horizon is not applicable in static models since the values used are typically the book values according to either the local financial accounting rules, statutory accounting rules or IFRS rules. Where the accounting rules specify that the market value is required (typically on the asset side) these same rules are also applied in the models. For most static models, the liabilities are not input at market value. One notable exception is the Jukka Rantala model which

allows for any surplus in the reserves by comparing these with the market value of liabilities. Although the 2002 GDV model currently requires accounting reserves to be input, this is due to the complexity of calculating the market value which would be the preferred approach.

The capitalisation perspective refers to basing the required capital measurement either on past volume experience (i.e. retrospective) or expected future volume experience (i.e. prospective). Most observed solvency models apply a retrospective capitalisation method. For example they base the calculations on recent premiums or claims volume, reserves for the in-force book or invested assets from the in-force book. Few solvency assessment models are prospective in nature, assuming a true going concern, by including new business expectations over a given time period. Having said this, some of the models taking a retrospective view also allow expected asset returns or earnings over the capitalisation horizon to reduce the required capital. In particular the 2002 GDV model and the Jukka Rantala proposed approach, both take this effect into account.

Below we allocate the surveyed models to either class, except the FTK framework which has both retrospective and prospective requirements:

Table 7: Time perspective

Solvency assessment model	Retrospective view	Prospective view
Solvency I	✓	
2002 GDV	✓	
NAIC	✓	
S&P	✓	
Jukka Rantala	✓	
FSA	✓	
FTK	✓	✓
SST		✓
Canada		✓
Basel II	✓	

The requested calculation frequency of the solvency assessment models is generally once a year. Few request a more frequent calculation of solvency. Only the UK-FSA has stipulated that it will request more frequent calculations of solvency using its solvency assessment model depending on the overall solvency level achieved.

The requested calculation frequencies are summarised in the next table. It should be noted though that the information in this table bears relatively limited insight on the models themselves as we summarise the requested calculation frequency. These models could be recalculated more frequently. It was outside of the scope to make statements as to how easily these processes can be repeated for each model.

Table 8: Requested calculation frequency

Solvency assessment model	Yearly	Intra-year
Solvency I	✓	
2002 GDV	✓	
NAIC	✓	
S&P	✓	
Jukka Rantala	✓	
FSA		Depending on acheived solvency
FTK	✓	
SST	✓	
Canada		Quarterly
Basel II		Twice a year

Chapter 3 includes more detailed insights on the measurement approaches per risk type for the various solvency assessment models.

2.4.4 Risk interdependencies

Risk interdependencies refer to the recognition of risk diversification during the aggregation process. One can differentiate three levels of aggregations and hence three types of diversification[22]:

■ Level I: The first level aggregates the stand-alone risks within a single risk class in an individual business line. Examples include aggregating the credit risks in a corporate bond portfolio, the equity risk in a life insurer, or the underwriting risk in the motor portfolio of a P&C insurer. The first type of diversification therefore refers to the risk diversification to be expected within a risk class within a product or business line. Analogous to the above, the first type of diversification would be the intra-credit risk diversification across the corporate bond portfolio, the intra-market risk diversification within the life insurer's equity holdings, or the intra-motor underwriting risk of a P&C insurer.

■ Level II: The second level aggregates risks within and across different risk classes within a legal entity. Examples include aggregating credit risks, ALM risks and underwriting risks within a P&C insurer. The second type of diversification therefore refers to the risk diversification to be expected (a) within a risk class across the business lines of a legal entity and (b) across risk classes but within the legal entity. Analogous to the above example, the second type of diversification could be further broken down into (2a) the diversification across motor underwriting, fire underwriting, household contents underwriting etc. of a P&C insurer and (2b) the diversification across credit risks, ALM risks and underwriting risks within a P&C insurer.

■ Level III: The third level aggregates risks across different businesses (as in legal entities), such as the life and P&C lines of a composite insurer. This leads to the composite view at the top level of an insurance group or holding. The third type of diversification therefore refers to the risk diversification to be expected when aggregated across all risk classes and business lines of an insurance group. That is, e.g. aggregating the ALM risk, underwriting risk, etc. across life insurance and P&C insurance.

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22 Please also refer to the Study on the Risk Profile and Capital Adequacy of Financial Conglomerates (Oliver Wyman & Company, 2001) commissioned by the Dutch Council of Financial Services Supervisors

Regulatory solvency assessment models do not capture the third type of diversification as regulation applies at the legal entity level. We will discuss the Group treatment of solvency assessment models under point 2.6 below.

The next table summarises the surveyed solvency assessment models' capture of the other types of diversification.

Table 9: Types of diversifications explicitly considered

	Insurance solvency								Bank sovency model
	Solvency I	2002 GDV	NAIC	S&P	JR	FSA	FTK	SST	Basel II
Type 1, intra-risk class diversifications within a business line		✓	✓	✓	✓	✓	✓	✓	✓
Type 2a, intra-risk classes across business lines, within a legal entity		✓	✓					✓	
Type 2b, across-risk class, within a legal entity		✓	✓			✓	✓	✓	

Because the Solvency I regime is not risk-based we assume that the simple factors have not been calibrated with a risk dependencies in mind.

All other solvency assessment models calibrate the factors or scenarios for the measurement with any risk class to their desired confidence level bearing in mind the diversification benefits within this risk class (the type 1 diversification).

The type 2a diversification, intra-risk class and across business diversification, is not universally recognised, at least not explicitly. The 2002 GDV, NAIC and SST models recognise the less than perfect correlation between the underwriting risks across different P&C lines and apply a correlation matrix to capture these.

The type 2b diversification, across-risk class diversification, is also not universally recognised, neither explicitly nor implicitly. The 2002 GDV and Jukka Rantala models apply less than full correlation across risk classes in life insurance activities (note, that it assumes full correlation across risk classes in non-life insurance activities). The NAIC model assumes less than full correlation across risk classes in both life and non-life insurance activities, as is the case for the PVK and SST approaches. The UK-FSA approach for with profits-life insurance activities makes implicit correlation assumptions by specifying joint scenarios.

In general it should be noted that diversification can be accounted for in any of the four broader solvency assessment model classes considered. We observed that type 2a and 2b diversifications have been accounted for by applying Variance-Covariance measurement approaches in static, accounting based models[23]. Dynamic, scenario based approaches would do so by either specifying joint scenarios, e.g. equity crashes and yield curve shifts simultaneously, or by applying Variance-Covariance measurement approaches. The SST also applies the aggregation by convolution technique for non-life products.

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23   More specifically assuming either 100% or 0% correlations thereby allowing the use of more straight forward approaches such as the square root of the sum of squares

Some observations can be drawn from the analysis of the capital measurement methodologies:

- Whilst we see a great number of variations in the more detailed underlying measurement methodologies, there is also a significant number of common elements in the methodologies

- The most common risk measurement approach is the value-at-risk technique. However, more complex solvency assessment models use the tail value-at-risk definition

- Typically, risk based solvency approaches have converged on relatively high levels of confidence, typically at or beyond 99%

- The one-year capitalisation horizon is basically the standard

- The requested solvency calculation frequency is also typically once a year

- Dynamic cash flow-based solvency assessment models use the run-off of liabilities for the valuation horizon

- Whilst static, accounting-based solvency assessment models typically take a retrospective view, the dynamic cash flow-based models typically take a prospective view

- Risk correlations are increasingly accounted for in the aggregation processes, mostly through the application of Variance-Covariance techniques

2.5 Risk mitigation

Insurance companies are making increasing use of risk mitigation techniques to manage their true solvency position. Any solvency assessment model should hence ideally recognise the companies' risk mitigation arrangements. The IAA and IAIS have put this forward as a key principle for any prudence regime for insurance.

Risk mitigation affects either the risks on the asset side, liability side or the interaction of both, i.e. the asset/liability mismatch risk. For the purposes of solvency assessment, risk control mechanisms reducing operational risks, such as Business Continuity Process, are typically not reflected in the capital requirements quantifications.

Risk mitigation on the liability side is achieved via reinsurance arrangements (for primary insurers) or retrocession (for reinsurers), the issue of CAT bonds or some Alternative Risk Transfer (ART) arrangements[24]. There is a diverse set of feasible reinsurance arrangements, e.g. proportional versus non-proportional, facultative versus obligatory. Risk mitigation on the asset side and in ALM is achieved via either the use of stop-loss arrangements, the purchase of derivatives (e.g. Swaps, put-option) or more complex risk transfer mechanisms e.g. Collateralised Loan Obligations (CLO). A discussion of these is beyond the scope of this study.

It should be noted that when entering reinsurance arrangements or purchasing derivatives to hedge asset risks, credit risk is acquired through the exposure to a third party.

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24   At least in the short term

2.5.1 Liability risk mitigation

All insurance solvency models give some credit for reinsurance by reducing the required capital charge[25]. In static, risk factor-based solvency assessment models, this is typically achieved by applying risk factors to e.g. net (of reinsurance) premiums (rather than gross premiums) or technical provisions net of reinsurance.

Dynamic cash flow-based solvency assessment models lend themselves more easily to reflect the non-proportional reinsurance arrangements. They would also do this more accurately, provided the methods applied are correct.

Most insurance solvency assessment models also recognise that the ceding company has a credit exposure to the reinsurer and therefore charge for that risk. The Solvency I regime is a notable exception.

2.5.2 Asset and ALM risk mitigation

Stop loss limits are difficult to capture in static accounting based models. The 2002 GDV model is the only one of those investigated that allows for this type of risk mitigation. This is taken into account by reducing the risk factor for equity volatility risk. The amount the risk factor can be reduced by is limited by a minimum floor and depends on whether the limit is applied through informal management action or contractually via the use of derivatives.

Hedging via the use of derivatives cannot be accurately reflected via the use of static risk factor-based models. It requires the use of dynamic analysis and valuation. Both management actions (such as stop-loss limits) and the use of derivatives can be more accurately and relatively more easily captured in dynamic cash flow-based models. In most cases they are, although there may be additional rules concerning available assets backing required capital. Often the amount of risk mitigation provided by these assets or management systems need to be justified either analytically or descriptively (in which case this may be part of reporting or Pillar II requirements).

2.6 Group treatment

Insurance solvency regulation applies at a legal entity level. Therefore, the primary focus of all insurance solvency assessment models investigated was at insurance entity levels. It was outside of the scope of this study to consider the Insurance Group Directive or Financial Conglomerate Directive.

Some of the insurance solvency assessment models explicitly refer to the application of their approach at insurance Groups levels. The FTK makes an allowance for the use of internal models at the Group level, however any risks that have a substantial effect at legal entity level must be reflected in the Group calculations, and there is an additional requirement that legal entities can be reviewed if there is any doubt that they are adequately capitalised independently of the group[26].

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25 Note that we exclude the Basel II model in this part of the discussion as it does not cover insurance liability risks and pertains to banks only

26 FTK documentation page 13: "From the viewpoint of the administrative burden, a test at group or conglomerate level is preferable to testing at the level of the licensed entity. The principal statutory solvency requirements in the insurance environment are, however, directed towards the entities. In order to combine these two aspects efficiently, the idea is to link the starting point of the FTK to the starting point for risk management selected by the insurance group or financial conglomerate. If the group's internal risk model is located at group level, the FTK is in line with this. There is, however, an additional explicit requirement that risks which could lead to major fluctuations in the financial position at entity level are identified in the group model, and that licensed entities can be reviewed if, although a group is well capitalised, there is reason to assume that the licensed entity is not."

Whilst not really an element of the SST, the new insurance supervisory law (VAG) in Switzerland mandates that insurance groups build internal models. A set of roughly 13 insurance groups can be identified and fall under this jurisdiction.

In banking, minimum capital requirements apply at a group level. The Basel II Accord applies on a consolidated basis as this is regarded as the best means by them to preserve the integrity of capital in banks with subsidiaries by eliminating double gearing. The scope of application of the Accord will include, on a fully consolidated basis, any holding company that is the parent entity within a banking group to ensure that it captures the risk of the whole banking group[27]. However, in practice, since Basel II does not consider any diversification at the group level, the result is equivalent to calculating capital at the legal entity level and adding the requirements together.

2.7 Minimum absolute capital requirements

This refers to the need to hold an absolute minimum capital amount rather than reflecting on the existence of Minimum Capital Requirement rather than Standard or Target Capital Requirements. That is, the existence of minimum absolute capital requirements is independent of the differentiation of MCR versus SCR.

Solvency I mandates an inflation-linked minimum guarantee fund at €3 MM (€2 MM for some classes of non-life insurance). The other European insurance solvency assessment models do not mandate a minimum absolute capital requirement. The Solvency I rule is binding. The NAIC model does not specify an absolute minimum capital requirement; instead the minimum is a percentage of the risk-based capital calculated using the NAIC model. Basel II does not specify an absolute minimum capital requirement.

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27   For further information on Basel II: http://www.bis.org/publ/bcbs107.pdf

3. Differences in implementation

As described in the introduction, this section focuses on the factors, scenarios and other detailed technical differences between the models. This provides a better understanding of the differences and complexities of implementing the models as well as further informing the comparative analysis.

Of the models considered in the study, the following have been included in this section:

- Solvency I
- S&P model
- 2002 GDV model
- NAIC model
- Jukka Rantala model
- FSA PS 04/16[28]
- FTK
- SST

3.1 Comparison of static – accounting based models

In this section we consider both the simple and the risk factor based models discussed above. These are[29]:

- Solvency I
- S&P Model
- GDV 2002 model
- NAIC model
- Jukka Rantala model

The other models under consideration may have some risk types or product types which are calculated using a factor based approach. For the UK-FSA (non-life and annuities), these have been included as appropriate, for comparison purposes. Underwriting risk in the FTK is also factor based, but the factors are as yet undefined for non-life and an approximation is applied for the life products. As a result it is not included in this section.

At a high level, several key differences between the various factor based models are identified in attempting to implement these. These are highlighted in table 13 below.

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28   For the life with-profits analysis only the 'realistic' peak was calculated. This is expected to be larger than the
      'regulatory peak', making the latter redundant in this analysis
29   Please refer to section 2.1. for a breakdown of the model typology

Table 13: Differences between static – accounting based models

	Solvency I	S&P	2002 GDV	NAIC	Jukka Rantala	FSA (Non-life & non-profits)
Risk classes (as described in model documentation)	No differentiation between risk classes. Asset side of balance sheet is not considered	Four classes of risk are identified for life (asset, insurance, interest rate and business) and non-life (asset, underwriting premium and underwriting reserve)	Several classes of risk are identified for life (investment, pricing, interest rate and business) and non-life (investment, re-insurance credit, premium, loss reserve, life assurance reserve and business)	Four classes of risk are identified for life (asset, insurance, interest rate and business) and non-life (asset, underwriting premium and underwriting reserve)	Only considers ALM risk for life and ALM and underwriting risk for non-life	Non-life is split into asset related and insurance related capital requirements. Annuities are divided into death, health, expense and market risk
ALM treatment	No specific treatment for ALM	No specific treatment for ALM	Duration mismatch is captured and reserves are split between short medium and long	If interest rate risk is above 40% of total capital requirements, scenario analysis is required to calculate ALM risk capital	Duration mismatch is captured	No special treatment for ALM for non-life. For life products, includes resilience reserve reflecting capital (based on ALM stress scenarios)
Aggregation		Assumes perfect correlation (no diversification) between all products and risk types	Aggregation assumes some diversification between risk types for life, but not non-life. For non-life, some diversification across lines of business is captured	Aggregation assumes some diversification between risk types for life and non-life. For non-life, some diversification across lines of business is captured	Correlation matrix is used to capture diversification within ALM risks. For non-life, some diversification across lines of business is captured	
Other			Expected earnings over the time horizon are taken into account and used in the required capital requirements	More detailed breakdown of factors by product line. Heavy reliance on US GAAP accounts	Expected earnings over the time horizon are taken into account. Method based on calculating combined volatility	

It is worth considering in more detail the factors that have been used in each of the models. The following tables do not reflect all of the factors used, but are instead a summary of the key factors which are comparable. The Jukka Rantala model has not been included in this section as it is structurally very different. This will therefore be described in the appendix.

Table 14: Summary of asset/investment risk factors

Asset class	S&P (factors)	2002 GDV (factors)	NAIC[I] (factors)	FSA[II] (factors)
Bonds				
AAA	0.0042	0	0	0.035
AA	0.0042	0.0042	0.003	0.035
A	0.0042	0.0042	0.01	0.035
BBB	0.0326	0.0326	0.02	0.035
BB	0.0752	0.0752	0.045	0.035
B	0.1372	0.1372	0.1	0.035
CCC	0.2018	0.2018	0.3	0.035
Default	0.3	0.3	0.3	0.035
Unrated	NA	0.03	NA	NA
Bond value volatility	NA	0.042	NA	NA
Common stock[III]	0.15	0.266	0.15	0.16/0.25
Real Estate[IV]	0.18	0.103	0.10	0.075/0.20

I   NAIC factors are for non-life. For life these are typically higher but are offset by the effect of tax reductions

II   UK-FSA factors are applied for non-life products only except common stock and real estate where factors refer to non-life/non-profits respectively

III Common stock relates to non-affiliated common stock

IV   Real estate relates to real estate for investment purposes

For bonds, the S&P, 2002 GDV and NAIC models all have factors that increase in line with the credit rating of the bond. Although these are of roughly similar magnitudes, the S&P makes no differentiation between bonds rated AAA to A (but has a separate class for exempt or risk free bonds) and the UK-FSA (non-life) makes no differentiation between any credit ratings. Although the analysis of the Jukka Rantala model has been based on the spreadsheets that have been developed, it is understood that the intention of the Jukka Rantala approach would be to include credit risk using the current Basel II rules. This is not at this stage included in the model or the analysis. The 2002 GDV model also includes a factor capturing the market value volatility of the bond portfolio; this is not included in the other models.

For equities (common stock) the factor applied by the 2002 GDV model is significantly higher than the factor used by the S&P and NAIC models. The UK-FSA uses different factors for different product types. For non-life products this is similar to the S&P and NAIC models and for annuities this is closer to the 2002 GDV model. The reasons for this are not defined.

For real estate (for investment purposes) the factor applied by the S&P model is significantly higher than the factor used by the 2002 GDV and NAIC models. Similar to the treatment for equities, the UK-FSA uses different factors for different product types. For non-life products this is lower than the 2002 GDV and NAIC models and for annuities this is slightly higher than the 2002 GDV model. The reasons for this are not defined.

It is worth noting (although this is not captured in the above table) that the 2002 GDV, S&P and NAIC models all capture concentration risks, although they do not use the same approach:

- The S&P and NAIC use a concentration factor to determine these effects
- 2002 GDV considers large holdings explicitly

Re-insurance is also captured in different ways in the various models. Most give credit for re-insurance by allowing the use of net premiums and/or reserves, but require additional capital to be held[30]:

- The S&P and 2002 GDV require capital to be held to cover the credit risk of the re-insurer. This is based on factors that vary by credit rating, similar to the approach used for bonds
- The NAIC only gives a partial benefit for re-insurance, but does not explicitly calculated a capital requirement for the credit risk

3.1.2 Interst rate/ALM risk

Table 15: Interest rate risk factors

Risk type	S&P	2002 GDV	NAIC	FSA[I]
Interest rate risk	2%	0.3 to 1% depending on formula	1.15%	3%

I   UK-FSA factors are applied for the non-profits product (interest rate risk is referred to as the insurance market risk capital component)

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30   Although concentration risk and re-insurance risk are not currently captured explicitly in the example considered, the effect of these differences on total capital requirements should be examined in detail in any future analysis as it may have a significant impact on the results

For interest rate risks the different models apply slightly different approaches:

■ The S&P and UK-FSA models simply apply the factors to the total reserves

■ The 2002 GDV splits the reserves between short, medium and long duration, as well as applying different factors depending on the rate at which the products were written.

The 2002 GDV and NAIC both have elements in the model that specifically take into account asset and liability matching, but apply this in different ways:

■ The 2002 GDV model considers what proportion of the bond portfolio is explicitly used to match liability cash flows and excludes these from the bond value volatility calculation (but includes the credit risk capital for these bonds). The reasoning behind this is that if these bonds match liabilities the market value loss from the bond portfolio will be offset by the reduction in value for the liabilities. This assumes that the value change is proportional. This does not affect the interest rate risk capital which applies only to the liabilities.

■ The NAIC required additional scenarios to be calculated if interest rate risk is larger than 40% of the total required capital.

Although the Jukka Rantala model is also a risk-factor based model that treats ALM risk, it is structurally very different to the other models. Asset and liability data is multiplied by factors representing the sensitivity of each of these in order to calculate the joint volatility for the entire product. This is then used to calculate the change in value at a 99.5% confidence interval. The current implementation of the model focuses on ALM risks (as well as underwriting risk for non-life products). For a more detailed description of the approach please refer to Appendix 4.

3.1.3 Underwriting risk

Table 16: Underwriting risk factors

Risk type	S&P	2002 GDV	NAIC	FSA[I]
Preumium and underwriting				
Non-life – motor	7%	26%	See notes	10%
Reserve risk				
Non-life – motor	11%	3.80%	See notes	9%
Life pricing/				
underwriting risk	0.16%	Not comparable	0.23%	0.3%

I   UK-FSA factors are applied for the non-life product (premium and reserve) and the non-profit product (business – this is referred to as the insurance expense risk capital component)

In comparison to the asset risks discussed above, there is a much larger divergence between the factors used for premium and reserve risks. For the S&P, NAIC and UK-FSA non-life models, the factors are all multiplied by the non-life premiums, resulting in a large difference in the required capital results. Conversely, the factors for reserve risk are not applied consistently across models. For the 2002 GDV the factor (which is significantly smaller than the UK-FSA and S&P factors) is applied to the provisions for claims outstanding, rather than the total reserves and is split between loss and life assurance reserves. This means that the result for reserve risk using the 2002 GDV model will be even smaller in comparison to the other models. The factors used in the NAIC model for both premium and reserve risks depend on the position of the company relative to the industry average.

For the life pricing/underwriting risks the factors are roughly comparable. The NAIC factor, although higher than the S&P is offset by including a tax factor that reduces the overall capital requirements. The S&P, NAIC and UK-FSA models consider the sum at risk separately for protection and savings products. The 2002 GDV uses a very different approach considering the risk of misestimation of costs, cancellations (lapses), and biometric risks separately.

Although the Jukka Rantala model is also a risk-factor based model which treats underwriting risks, it is structurally very different to the other models. Product and liability data are used to calculate the joint volatility for the entire product. This is then used to calculate the change in value at a 99.5% confidence interval. The current implementation of the model focuses on underwriting risk for non-life products (as well as ALM risk). For a more detailed description of the approach please refer to Appendix 4.

3.1.4 Business risks

Table 17: Business risk factors

Risk type	S&P	2002 GDV	NAIC	FSA[I]
Operational/business risk	1 to 2%	1.50%	3%	1%

I   UK-FSA factors are applied for the non-profit product

For business risk the factors are much more in-line across all models. However, similar to the premium risk factors these are applied differently across the different models:

- For the 2002 GDV, this factor is used for both life and non-life, for the other models it is only used for the life products. Furthermore, for the UK-FSA, this applies only to non-profits life products

- For the UK-FSA the factor is multiplied by reserves rather than premiums which may potentially result in a higher requirement than the other models even though the factor is generally lower

3.1.5 Observations

Comparing the factors used in the various models highlight the following observations:

- Apart from the Jukka Rantala model, the factor based models apply similar approaches and broadly cover the same risk types

- In particular market and credit risks are treated very similarly in the different models (although some of the factors differ substantially)

- Re-insurance is typically included although the models do require additional capital to be held either to cover the credit risk associated with a re-insurance agreement or through other mechanisms

- For interest rate or ALM risks, as well as underwriting risks, the models vary both in the approach and in the factors used

- In particular the 2002 GDV model has included the effects of matching bonds to liability cash flows by reducing the capital related to the value volatility of the bond portfolio

- Similarly the NAIC model requires some scenario analysis to capture the effects of ALM if interest rate risk is above a certain threshold

- The 2002 GDV model has also taken different approaches to life underwriting risk (taking the effect of lapses and cancellations into effect), concentration (by explicitly considering large holdings) and interest rate risk (where liabilities are split into categories reflecting maturity and technical rates).

3.2 Comparison of scenario based models

In this section we consider scenario based models discussed above. These are:

- UK-FSA for life with-profits products ('realistic' basis)

- FTK

- SST

Table 18 below gives a high-level description of the differences between the models.

Table 18: Differences between scenario based models

	FSA PS04/16	FTK	SST
Risk classes and product coverage	Scenario analysis required only for life with-profits funds Includes asset and ALM risks as well as lapse risk Excludes default risk and operational risks	Scenario analysis applied for all product types Scenarios consider asset and ALM risks, including risk due to misestimating volatility parameters affecting option prices. Excludes default risk and operational risks Underwriting risk treated using factor based approach (some factors are as yet undefined)	Scenario analysis used for life, non-life and health products. Includes asset, ALM and liability risks Excludes operational risks Default risk captured using Basel II approach
Aggregation	Model considers one stressed scenario affecting all risk types simultaneously No aggregation required	Model considers 6 scenarios separately and then aggregates the results assuming some diversification between the different risk types	Using several sensitivity scenarios combined with additional tail scenarios using a correlation matrix. Aggregation by convolution required for non-life products
Valuation	Uses realistic value of liabilities excluding any safety margins as basis for calculation (see section 2.3 above)	Uses market value of liabilities made up of realistic value plus a risk margin covering 'unavoidable' risks (e.g. parameter, process and model risks - see section 2.3 above)	Uses realistic value of liabilities as basis for calculation but calculates a risk margin for liabilities covering the cost of capital (see section 2.3 above)
Other		Includes FX and commodities risks	Includes FX risks

It is worth considering in more detail the scenarios that have been used in each of the models. The following sections do not provide a complete explanation of the scenarios used, but instead summarise scenarios and approaches which are comparable. The appendix contains references to the full documentation.

3.2.1 Scenario comparison

Table 19: Brief description of scenario/sensitivity shocks used in the models

Description	FSA	FTK	SST[l]
Equity shock	-20%	-40%	-10%
Equity volatility shock	-	+15%	+10%
Real Estate shock	-12%	-20%	-10%
IR shock	+/- 15% of long term yield	Varies along, and is dependent on, the yield curve	+/-100bp for 9 term buckets individually
IR volatility shock	-	+25%	+10%
Credit spread shock	Dependent on average portfolio	60% of current spread	10% of current spread
Underwriting/ lapse shock	35% change in lapses	Factor based approach	10% change in lapses Separate mortality scenarios

l   These are sensitivity shocks, not scenarios. The results of these are subsequently used to calculate the effects of various scenarios as explained in the text

Although there are similarities in the types of scenarios used by each of the models under consideration, there are substantial differences in the magnitude and application of these scenarios.

The FTK consistently has larger shocks than the other two models. However differences in the way that the scenarios are applied to calculate the economic capital largely offset this.

The FTK and UK-FSA models work using similar approaches: the net asset value is calculated under best estimate and stressed assumptions. The required capital is effectively the value lost under the stressed assumptions. However the UK-FSA applies one stress scenario using all of the shocks described in the table above. The FTK model applies each of the shocks independently and calculates a capital requirement for each of these separately. These individual risk capital requirements are then aggregated assuming correlations between them. A full description of the aggregation process can be found in appendix 4.

The SST model similarly calculates the net asset value under a best estimate scenario and then for each of the sensitivity shocks identified in the table above. These sensitivities are then used to calculate the effect of various historical and assumed extreme scenarios. This is done by assuming that the resulting change in asset and liability values is linear. This approach also allows the joint volatility for all risks to be calculated using a covariance matrix. This volatility can be used to calculate the value loss at a 99.5% confidence interval to calculate the required capital. The effect of additional historical and/or tail scenarios are included if it is deemed that the required capital does not cover these. This is done by weighting the effect of the various scenarios by the probability of them occurring. These scenarios include:

- An equity value shock of -50%

- Stock market crash (1987, equity/real estate drop -30%, rise in interest rates +300bp, policy lapses=25%, volume of new business=-75%)

- Nikkei crash (1990)

- Global equity market crash (2000/2001)

- European FX crisis (1992)

- US interest rate crisis (1994)

- Russia crisis/Long Term Capital Management (1998)

These differences between the models will have a significant impact on the final results. Although the FTK shocks are larger than the UK-FSA shocks this will be offset by the diversification effects of considering correlations between the various risks (which is implicitly done in the UK-FSA model). Similarly, the SST shocks are much smaller and also consider diversification between the risk factors. However, these are used to calculate the 1 standard deviation movement which is then used to calculate the 99.5 percentile loss. In addition to the historical/tail scenarios, this will result in an increase in the total required capital.

Please refer to Appendix 4 for a more detailed description of these approaches.

3.2.2 Observations

Comparing the scenarios used in the various models leads to some initial observations:

- Both the scenarios used and the methodology applied vary greatly between models.

- Similar to the factor based models, the magnitude of the shocks is not the only driver of risk capital:

  – The approach used to consider effects of diversification can offset extreme factors or scenarios (FTK)

  – Small shocks may be used to calculate the sensitivity which is at a second stage used to calculate the risk capital in the tail (SST)

4. Alignment of the solvency regimes with key Solvency II-related principles

As presented in the first chapter, the major pillar I-related principles put forward by the IAA, the IAIS and the EU Commission Services were analysed. We investigated each model's alignment with these principles and provide a summary in the table below:

Table 20: Summary of the solvency models' alignment with key principles
Note: Table is only an indicative guide of difference between the models

	SI	'02	GdV	NAIC	S&P	Basel II	JR	FSA	PVK	SST
IAIS principles										
Capital adequacy and solvency regimes have to be sensitive to risk	○	●		●	●	●	●	●	●	●
IAA principles										
Principles versus rules-based approaches										
Solvency assessment should be based on sound principles	○	●		●	●	●	●	●	●	●
Implementation will require rules developed on these principles		●		●	●		●	●	●	●
Rules should include provisions to allow adaptation to unforeseen circumstances							●	●	●	●
Standardised approaches										
Simple risk measures are appropriate when it is recognised that the risk in question is of minor importance or if there is no generally accepted way of how to assess it	○	●		●	●	●	●	●	●	●
Sophisticated approaches are appropriate for material risks	○	●	●	●	●	●	●	●	●	●
Advanced approaches										
Internal models should be accepted by regulators only if they can prove that appropriate RM processes and reporting is in place										
EU framework 'directive'										
General issues										
Assess the overall solvency of an institution on risk-based approach	○	●		●	●	●	●	●	●	●
In Pillar I the new solvency system should contain two capital requirements: the SCR and MCR	○	○		○	●	○	●	●	●	●
It should incentivise the insurer to measure and properly manage the risks										
The aim is to attain maximum harmonisation	●	●			●		●	●	●	●
The solvency system should set a uniform level of prudence, both for technical provisions and the SCR										
The solvency system should to the extent necessary and possible be combatible with the approach and rules in banking	○	○	○	○			○	○	●	
Pillar I features										
The SCR can be based on a modular approach, including insurer's internal models	○	○	○	○	●	○	●	●	●	
The MCR sets the threshold for supervisory action and should be based on simpler and more robust manner than the SCR							●	○	●	

● Model complies

○ Model does not comply

Blank Not applicable/information not available

We have provided some comments and observations on some of these principles below:

4.1 IAIS principle – Capital adequacy and solvency regimes have to be sensitive to risk

In Section 2 of the document, the analysis of the solvency assessment models highlighted that all but the Solvency I approach are risk-based, or sensitive to risk.

A significant range of approaches, from simple to highly sophisticated, have been applied in order to achieve this. The accuracy of this risk sensitivity is more a function of choosing a sound approach within any specific model rather than being precluded by the choice of the solvency model class itself.

4.2 IAA principle – standardised approaches

Commenting on the IAA's principle with regards to standard approaches does require a certain degree of judgment. First, one would first need to agree on what constitutes a minor and what constitutes a major risk. Second, one would need to agree on what constitutes a simple and what constitutes a more sophisticated approach. The 2002 GDV model for instance is one of the risk-factor based models that have a specific treatment for ALM risks (rather than treating them as pure asset or market risks). The method adopted is pragmatic and relatively straight forward to execute.

The NAIC, whilst also a risk-factor based approach, however recognises that risk-factor approaches have limitations to capture non-linear risks. Thus, if the ALM risks are material in terms of their weight within the overall risk position, than the NAIC requires a more elaborate dynamic scenario analysis to establish the ALM risk capital requirements of the insurance enterprise.

Similarly, whilst currently the UK-FSA's approach for non-life and non-profit life insurance lines applies more readily applicable risk factors, due to the complexity of financial risks within with-profits life operations, their solvency assessment is captured using a dynamic scenario approach.

4.3 IAA principle – internal models should be accepted by regulators only if they can prove that appropriate risk management processes and reporting is in place

Our observations on the solvency assessment models' alignment with the IAA's principle around advanced approaches also merits further comment. The European solvency assessment regimes all accept the use of internal models.

Having said this, the Swiss, British and Dutch regimes explicitly state that their internal models will only be accepted if the insurance companies can provide sufficient evidence that these models are actively and appropriately used in the internal risk management processes and reporting. There is as yet little guidance as to what the exact requirements will be or how the internal models will be used. This is in contrast to the banking requirements which clearly specify how these are applied.

Even though the other investigated solvency assessment models do not actively refer to or incorporate companies' internal modelling capabilities in the solvency calculations, some of their 'authors', e.g. for the 2002 GDV model and Jukka Rantala model, explicitly welcome and recommend that companies develop their internal modelling capabilities. Furthermore, in developing the 2002 model, the GDV has explicitly referred to this as an example for a standard approach of the SCR under Solvency II.

4.4 EU framework 'directive' – Pillar I features

Generally, the newer regimes consider a dual capital level. In particular, the Swiss, Dutch and British regimes make a distinction between a MCR and a SCR. This has been discussed under Chapter 2.1.

4.5 EU framework 'directive' – The solvency system should set a uniform level of prudence, both for technical provisions and the SCR

We propose splitting the discussion in the two elements: setting uniform levels of prudence for technical provisions vs. for the SCR. As discussed under 2.4.2., the majority of the investigated solvency assessment models specify a target confidence level for the risk capital measure and hence set a uniform level of prudence in solvency. The notable exceptions are Solvency I, NAIC and S&P. The Basle II framework also does not explicitly specify a target confidence level or set a uniform level of prudence.

Most of these regimes currently apply to a single country which means that they do not aim to unify the level of prudency in reserves across borders. However, explicit uniform levels of prudence for technical provisions within the solvency assessment are defined by the new British, Swiss and Dutch regimes. Other models rely on local, international or statutory accounting approaches, which are currently inconsistent across geographies.

4.6 EU framework 'directive' – The solvency system should to the extent necessary and possible be compatible with the approach and rules for banking

Finally, none of the observed insurance solvency assessment models are fully consistent with the banking framework of Basel II. However, the EU Commission so far suggested that the insurance solvency system should, to the extent *necessary* and *possible*, be *compatible* with the approach and rules in banking. Defining the level *necessary* implies a certain judgement which would go beyond the factual nature of this study. However, it is worth briefly pointing out some of the differences between risks in insurance and banking, as well as some of the limitations of the Basel II regime when viewed from an insurance perspective. Some of these are summarised below[31]:

■ Basel II does not specify a common target confidence level for all risks in the capital requirement calculation. This is contrary to the set objectives under Solvency II.

31   Refer also to e.g. the article in German by Th.Schubert and G.Grießmann from the GDV: Solvency II = Basel II + X, Versicherungswirtschaft, Heft 18/2004, which contains their opinions on some of the differences between Basel II and the forthcoming Solvency II regime

- The risk scope of Basel II (Pillar I) is narrower than that required to take a full balance-sheet or comprehensive approach in insurance. Basel II does not explicitly cover structural asset-liability risks (in Pillar I). Furthermore, Basel II does not cover insurance liability or underwriting risks.

- Basel II does not explicitly capture inter-risk dependencies (within Pillar I). It is not clear whether Solvency II will be in line with this.

- Basel II requires all material subsidiaries or sub-groups ultimately to be using the same approach (e.g. for credit risk: standard, foundation or advanced). This might be contrary to the set objectives under Solvency II, depending on model modularity.

- It also worth noting when discussing advanced or internal models that for credit risk, the IRB Advanced approach (within Pillar I) allows internal models to be used only to calculate the inputs into the credit risk calculation, but does not allow changes in the calculation itself, even if internal processes better reflect the risk that the company is exposed to. For market and operational risks however, full internal models are used to calculate the capital for these risk types.

Appendix 1 – Solvency model references

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e&c=sp_article&cid=1086102101036&s=&ig=&b=2&dct=24

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Appendix 2 – Terminology

Risk glossary

Asset-liability mismatch (ALM) risk	Risk associated with the cash flow mismatches between liabilities and associated assets, which results in required reinvestment, disinvestments, or borrowing required by the insurer to satisfy liquidity needs.
Business risk	Business risk results from a company's uncertainty about future revenues and costs. It represents the volatility of operating results which fundamentally stems from changes in volume, price and costs. Business Risk is driven to a great extent by the competitive environment and the market place, but can be mitigated by effective management practices.
Catastrophe risk	The risk that a catastrophe occurs that causes a one-time spike in mortality experience, with a corresponding impact on claims and/or liabilities.
Credit risk	The risk of default and change in the credit quality of issuers of securities, counter-parties and intermediaries, to whom the company has an exposure.
Diversifiable risk	A risk is diversifiable when the volatility of the average claim amount declines as the block of combined insurer risks increases.
Liquidity risk	The exposure to loss in the event that insufficient liquid assets will be available, from among the assets supporting the policy obligations, to meet the cash flow requirements of the policyholder obligations when they are due or assets may be available, but only at excessive cost.
Market risk	Market risk arises from the level of volatility of market prices of assets. Market risk involves the following: ■ Exposure to movements in the level of financial variables ■ Exposure of options to movements in the underlying asset price ■ Exposure to other unanticipated movements in financial variables ■ Exposure to movements in the actual or implied volatility of asset prices and options
Non-diversifiable risk (Systematic risk)	Risk that can not be (relatively) reduced by increasing portfolio size.
Operational risk	The risk of loss resulting from inadequate or failed internal processes, people, systems or from external events; and is intended to include legal risks but exclude strategic, reputation and systemic risk.
Underwriting risk	Underwriting is the specific insurance risk arising from underwriting of insurance contracts. The risks within the underwriting risk category are associated with both the perils covered by the specific line of insurance and with the specific processes associated with the conduct of the insurance business.
Volatility risk	Volatility is the risk of random fluctuations in either the frequency or severity of a contingent event.

Capital glossary

Actual capital	Amount of equity capital actually held to protect the company against economic and statutory insolvency, designed to communicate accounting solvency and profitability to outside constituents.
Rating agency driven capital	Amount of capital the rating agencies expect the company to hold for a given rating. It is designed to test and communicate capital adequacy warranting the target debt rating based on the rating agency metrics and models.
Local statutory capital	Amount of capital required to protect against statutory insolvency (i.e. the minimum capital), and is designed to protect the policy holders and creditors, as well as acting as a floor, which triggers takeover by the regulator.
Internal economic capital	Amount of capital required to protect the company against economic insolvency for a given probability. It is fully comprehensive, covering all risk types, and is designed as an internal corporate decision making tool.

Definition of terms in assessment model typologies

Please note again that the classification used in this report is not meant to be superior to other alternative classifications. The model classifications are not mutually exclusive.

Model typologies

Static model	A model is referred to as static if the underlying risk capital calculation uses static, i.e. fixed in time size drivers or accounting positions. That is, no cash flow projections are made and hence a static model is the opposite of a dynamic model.
Dynamic model	Dynamic models use cash flow projections in the risk capital calculation.
Factor-based model	A model is factor-based if the risk capital calculation uses a formula which applies fixed factors or ratios to pre-defined size drivers which act as a proxy to risk exposure. The size drivers are frequently taken from the insurer's financial accounting basis, i.e. the balance sheet or P&L.
Simplefactor-based model	A model is referred to as a simple factor-based model if the number of factors used in the risk capital calculation is rather limited
Risk factor-based model	A model is referred to as a risk factor-based model if an extended number of factors is used in the risk capital calculation in order to reflect differentiated exposures to risk.
Scenario-based model	A model is referred to as scenario-based if the risk capital calculation implies measuring the impact of specified or company-specific scenarios to the net asset value of the insurer. The models can apply one or more scenarios.
Rules-based model	A solvency assessment model is referred to as rules-based if the computation of the risk capital follows clear guidelines and rules.
Principles-based model	A solvency assessment model is referred to as principles-based if the computation of the risk capital follows principles. The more detailed methodology is however left to the description of the insurer as long as it is consistent with the principles set out.

As shown in the table above, the model type classifications used in this report are not mutually exclusive. For instance, it is in theory perfectly possible for a solvency assessment model to be scenario-based and static. However, the aim of the classification chosen for the purposes of this report was to find a clear and informative differentiation of the solvency assessment models investigated (a discussion of general feasible solvency assessment models was beyond the scope of the comparative study).

Appendix 3 – Solvency assesment model questionnaire

0. General information

Solvency model investigated:

Type of companies/businesses covered:

- [ ] Life insurance
- [ ] P&C insurance
- [ ] Health insurance
- [ ] Reinsurance
- [ ] Other

Reference sources _____

Author _____

Date _____

I. Solvency assessment typology

I.1. Rules-based vs. principles-based solvency assessment

- [ ] Rules-based
- [ ] Principles-based
- [ ] Mixture

Commernts _____

_____

I.2. Solvency model classification

- [ ] Simple factor base
- [ ] Risk-factor/scenario base
- [ ] Principles base with stochastic modelling
- [ ] Principles base with closed form solutions
- [ ] Other

Comments _____

_____

I.3. Use of company internal models

Does the solvency assessment allow for the use of company internal models (yes/no)? _____

If yes, does it accept a modular application if internal models (i.e. only for some risks)? _____

If yes, do regulatory guidelines/rules apply to the internal model with respect to

- [ ] The parameters used
- [ ] The model points chosen
- [ ] The scenarios calculated
- [ ] The method(s) used
- [ ] Other

Comments _____

_____

I.4. Comprehensiveness – what elements does the solvency assessment include

- [ ] Short-term stress test
- [ ] Capital requirements calculation (over a pre-defined period)
- [ ] Multi-period scenario analysis
- [ ] Other

Comments _____

_____

II. Time perspective

II.1. What capitalisation perspective is taken?

☐ Retrospective view
☐ Prospective view

Comments _____
_____

II.2. What capitalisation horizon is recommended?

☐ One year
☐ Multi-year (indicate how many years)
☐ Run-off of assets or liabilities

Comments _____
_____

II.3. What calculation frequency is recommended?

☐ Monthly
☐ Quarterly
☐ Bi-annually
☐ Annually

Comments _____
_____

III. Risk measure and calibration

III.1. What risk measure is chosen?

☐ Earnings-at-risk
☐ Value-at-risk
☐ Fair Value-at-risk
☐ Tail Value-at-risk/expected shortfall
☐ Other

Comments _____
_____

III.2. What is the risk calibration of the solvency assessment?
Comments _____

III.3. Is the risk calibration tied to the capitalisation horizon?
Comments _____

III.4. Is a minimum capital requirement specified?
Comments _____

IV. Valuation basis

IV.1. What is the valuation basis for the solvency assessment?

☐ Local financial accounting principles
☐ Local statutory accounting principles
☐ International accounting principles
☐ Market-consistent valuation of assets
and liabilities
☐ Other

Comments _____

_____

IV.2. Balance sheet approach

Is the entire balance sheet considered? _____

If not, what elements are left out? _____

Are assets and liability value treated consistently? _____

Comments _____

_____

V. Risk classification

V.1. Which of the following risks are explicitly included in the solvency assessment?

☐ P&C premium risk
☐ P&C reserve risk
☐ Mortality risk
☐ Catastrophe risk
☐ Market risk (pure asset risk)
☐ ALM risk (mismatch risk)
☐ Credit risk
☐ Operational risk
☐ Business risk
☐ Other

Comments _____

_____

VI. Risk aggregation and dependencies

VI.1. Does the solvency assessment account for intra-risk diversifications?

Yes or No?   _____

If yes, how?   _____

Comments   _____

VI.2. Does the solvency assessment account for concentrations?

Yes or No?   _____

If yes, for what risks?   _____

If yes, how (for each risk)?   _____

Comments   _____

VI.3. Does the solvency assessment account for risk mitigation?

Yes or No?   _____

Reinsurance (indicate criteria)   _____

Market risk hedges (indicate criteria)   _____

Other   _____

Comments   _____

VII. Company treatment

VII.1. At what entity level does the solvency assessment hold?

☐ Legal entity

☐ Group (if so, define consolidation criteria for 'Group')   _____

☐ Other   _____

Comments   _____

VIII. Conclusions

Does the solvency assessment investigated foster the use of IFRS as a valuation basis?

_____

Does the solvency assessment account for diversification? How has the case been made?

_____

What risks are included under the Pillar I-equivalent calculation?

_____

Does the solvency assessment foster maximum harmonization or flexibility?

_____

Appendix 4 – Additional methodology details

Jukka Rantala Model

This model was developed by Mr Jukka Rantala, formerly Chairman of the CEA Solvency II Working Group, in the context of CEA's work on a Standard Approach

The spreadsheet developed with regards to the Jukka Rantala model currently covers two risk types (the working document itself discusses a wider set of risks as indicated in section 2 of the report):

- ALM risks for both life and non-life products
- Underwriting risks for non-life products

These are briefly described below.

ALM risk model

The model is based on generating a combined value loss distribution of assets and liabilities in one year's time in order to calculate the 99.5% worst case loss in value. The calculation can be broken down into 4 steps, as described below:

- **Step 1: Identify asset and liability values and project asset value over a time horizon.** This step uses the market value of assets split into six classes (cash/short term, bonds, direct loans, listed equities, property and other). Each asset class has an expected return parameter defined by the model and an estimated standard deviation also defined by the model. The total asset value in one year is calculated using the expected returns

- **Step 2: Calculate value loss for one standard deviation for each exposure separately.** The value of each asset class is multiplied by the standard deviation to give the 1-year standard deviation loss. An additional duration exposure is calculated using as inputs assumptions for the duration mismatch between the bonds and the liabilities. This exposure is also multiplied by a standard deviation factor (prescribed by the model)

- **Step 3: Calculate the combined standard deviation loss.** Using a correlation matrix and the individual standard deviation losses for each exposure the combined 1-year standard deviation loss can be calculated using a variance-covariance approach

- **Step 4: Calculate the required solvency capital for ALM risk**. Assuming a normal distribution, the 99.5% worst case loss is calculated as a multiple of the standard deviation loss. The required capital is then calculated by subtracting the expected return on assets and any prudency embedded in the technical provisions (by comparing these with the realistic value of liabilities) from this worst case loss

This is illustrated in figure 3 below.

Figure 3: Life underwriting and interest rate risk factors

Assets	Liabilities	Assets	Correlation	Cash	Bonds	Loans	Equities	Properties	Other	Duration
Equities	Reserve	Eq vol	Cash	1	0	0.6	0	0	0	0.2
Real estate		RE vol	Bonds	0	1	0.35	0.2	0	0	0.4
Bonds		FI vol	Loans	0.6	0.35	1	0	0	0	0.4
. . .		. . .	Equities	0	0.2	0	1	0.3	0	0
			Properties	0	0	0	0.3	1	0	0
			Other	0	0	0	0	0	1	0
			Duration	0.2	0.4	0.4	0	0	0	1

Expected return of assets ▶ Required capital = 99.5% value change – expected returns and prudent margin in liability valuation ◀ Confidence interval k at 99.5% ◀ Total volatility across exposures calculated

Underwriting risk model

The underwriting risk model is also based on generating a combined value loss distribution in order to calculate the 99.5% worst case loss in value. However generating the combined standard deviation follows a different theoretical approach.

Using the premium reserves, the claims, the long term combined and loss ratios a fixed formula calculates the volatility of each line of business independently. Currently the model simply then sums each line of business to give the total volatility across the non-life book.

Assuming a normal distribution, the 99.5% worst case loss is calculated as a multiple of the standard deviation loss as in the life model.

Far a detailed description and derivation of the formula and theory behind this calculation please refer to 'A STANDARD APPROACH FOR THE UNDERWRITING RISK IN NON-LIFE' by Jukka Rantala dated 23/4/2003

FTK Diversification

The FTK capital calculation is calculated by combining 6 risk factors indicated below:

- S1 – Interest rate risk
- S2 – Equity and Real Estate risk
- S3 – FX risk
- S4 – Commodities risk
- S5 – Credit risk
- S6 – Underwriting risk

The interest rate risk is calculated as the net value loss (of assets and liabilities) due to either an upward or downward movement in the yield curve (which ever give the largest loss) plus the value loss due to an increase of the interest rate volatility.

Equity and real estate risk is calculated as the sum of net value losses due to a reduction in equity prices, a reduction in real estate prices and an increase of the equity volatility parameter. FX risk is based on the net value loss due to a movement in various foreign exchange positions, similarly commodities risk is calculated as the net value loss to price reductions in a number of commodities. Credit risk capital requirements are based on the net value loss due to an increase in corporate bond spreads, but excludes (or does not implicitly include) any losses due to credit defaults or downgrades. Conversely to the above, the underwriting risk capital is not based on a scenario, but rather is based on factors divided by business segment.

These 6 risk factors are then combined along the following formula:

Required Capital = SQRT(S1^2+S2^2+2*0.8*S1*S2+S3^2+S4^2+S5^2+S6^2)

This effective assumes that equity and real estate risks are completely correlated with each other but only 80% correlated with interest rate risk. Other risk types are assumed to be fully independent.

SST Diversification

The SST capital calculation is calculated by considering 18 market risk sensitivity scenarios which are used to populate some of the 23 additional tail scenarios.

The 18 market risk sensitivity scenarios relate to movements on 8 year buckets on the yield curve, the volatility of interest rates, four key F/X rates, the volatility of F/X rates, the global equity index, the volatility of equity, a real estate index and corporate bond spread movements.

The sensitivity of the net value of assets minus liabilities is calculated for each of these scenarios. These results are multiplied through a variance-covariance matrix to calculate the combined value volatility for all market risks combined. This result is then used, in addition to the results of the additional tail scenarios, to calculate the required capital for all risks at the appropriate confidence interval.

Appendix 5 – Short discussion on available capital

The purpose of this study is to discuss common elements and differences in the assessment of capital requirements across a number of prevailing solvency assessment models in insurance as well as under Basel II for banking. This paper highlights the variety of approaches identified. As a result, one would assume that the overall numeric result of capital requirements for one and the same insurance undertaking can be very different, depending on which solvency assessment model was applied. However, this in itself provides little if any insight on the impact on the perceived overall financial health of the insurance undertaking under the variety of models.

In order to establish the overall financial health of an insurance undertaking one needs to consider its solvency, that is comparing capital requirements with available financial resources that can be held against these requirements (often referred to as 'available capital'). It is theoretically possible that when moving from one solvency assessment model to another, total capital requirements would increase in absolute Euro terms. However, if the rules under the second solvency assessment model allow to account different balance sheet positions against these requirements, or the same positions are valued higher, then it is perfectly feasible that the overall solvency could still appear stronger under the second assessment model despite the capital requirements themselves already being higher.

In general, the underlying rules for establishing available capital are typically consistent with the approach for arriving at capital requirements under one solvency assessment model. However, these rules can be very complex and would merit as much elaboration as the discussions around capital requirements. A few short examples are provided below to illustrate the great variety in establishing available financial resources across the solvency assessment models investigated in this study:

- Under the FSA approach, the Net Asset Value (which is the equivalent of Available Capital) is arrived at by applying realistic values for assets and liabilities, where as under Solvency I local statutory rules apply

- In the NAIC model, Goodwill is an admissible asset for Available Capital with the restrictions that it cannot exceed 10% of capital surplus (admissible assets minus liabilities) and is amortised over ten years.

Appendix 6

CEA Members

AT - Austria	Verband der Versicherungsunternehmen Österreichs (VVO)
BE - Belgium	Union Professionnelle des Entreprises d'Assurances (ASSURALIA)
BG - Bulgaria*	Association of Bulgarian Insurers (ABZ)
CH - Switzerland	Association Suisse d'Assurances (ASA/SVV)
CY - Cyprus	Insurance Association of Cyprus
CZ - Czech Republic	Česká asociace pojišt'oven (ČAP)
DE - Germany	Gesamtverband der Deutschen Versicherungswirtschaft (GDV)
DK - Denmark	Forsikring & Pension (F&P)
EE - Estonia	Eesti Kindlustusseltside Liit
ES - Spain	Unión Española de Entidades Aseguradoras y Reaseguradoras (UNESPA)
FI - Finland	Suomen Vakuutusyhtiöiden Keskusliitto
FR - France	Fédération Française des Sociétés d'Assurances (FFSA)
GR - Greece	Association of Insurance Companies-Greece
HR - Croatia*	Hrvatski ured za osiguranje
HU - Hungary	Magyar Biztositók Szövetsége (MABISZ)
IE - Ireland	The Irish Insurance Federation (IIF)
IS - Iceland	Samband Íslenskra Tryggingafélaga
IT - Italy	Associazione Nazionale fra le Imprese Assicuratrici (ANIA)
LI - Liechtenstein	Liechtensteinischer Versicherungsverband e.V
LT - Lithuania	Lietuvos draudiku asociacija
LU - Luxembourg	Association des Compagnies d'Assurances du Grand-Duché de Luxembourg (ACA)
LV - Latvia	Latvijas Apdrošinataju Asociacija
MT - Malta	Malta Insurance Association
NL - Netherlands	Verbond van Verzekeraars in Nederland (VVN)
NO - Norway	Finansnæringens Hovedorganisasjon (FNH)
PL - Poland	Polska Izba Ubezpieczen (PIU)
PT - Portugal	Associaçao Portuguesa de Seguradores
SE - Sweden	Sveriges Försäkringsförbund
SI - Slovenia	Slovensko Zavarovalno Zdruzenje (SZZ)
SK - Slovakia	Slovenská asociácia poistovni
TR - Turkey	Türkiye Sigorta ve Reasürans Sirketleri Birligi
UK - United Kingdom	The British Insurers' European Committee (BIEC): *Association of British Insurers (ABI); International Underwriters Association of London (IUA); Lloyd's of London*

*   Associate member

Addendum – Solvency assessment models compared

In light of changes to source documents[1] made after the report went to press, it has come to our attention that the first column, regarding the FSA scenario shocks, in Table 19 (Section 3.2.1, p.33) should be amended for completeness. The changes are highlighted below.

Current table 19

Description	FSA	FTK	SST[1]
Equity shock	-20%	-40%	-10%
Equity volatility shock	-	+15%	+10%
Real Estate shock	-12%	-20%	-10%
IR shock	+/- **15%** of long term yield	Varies along, and is dependent on, the yield curve	+/-100bp for 9 term buckets individually
IR volatility shock	-	+25%	+10%
Credit spread shock	Dependent on average portfolio	60% of current spread	10% of current spread
Underwriting/ lapse shock	**35%** change in lapses	Factor based approach	10% change in lapses Separate mortality scenarios

New table 19

Description	FSA	FTK	SST[1]
Equity shock	-20%	-40%	-10%
Equity volatility shock	-	+15%	+10%
Real Estate shock	**-12%**	-20%	-10%
IR shock	+/- 17.5% of long term yield	Varies along, and is dependent on, the yield curve	+/-100bp for 9 term buckets individually
IR volatility shock	-	+25%	+10%
Credit spread shock	Dependent on average portfolio composition	60% of current spread	10% of current spread
Underwriting/ lapse shock	**32.5%** change in lapses	Factor based approach	10% change in lapses Separate mortality scenarios

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1   For final text please refer to: http://fsahandbook.info/FSA/handbook.jsp?doc=/handbook/PRU

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CEA is the European insurance federation. Its 32 national member associations cover on average over 93% of their domestic insurance market. More than 5000 European insurance and reinsurance companies are represented by CEA. They generate domestic premium income of 855 bn Euros, employ more than 1 million people and invest over 5000 bn Euros in the economy.
CEA represents the European insurance industry's views to the EU institutions and international regulators and supervisors to ensure an appropriate regulatory framework.

For a full list of CEA's members, please refer to Appendix 6.

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