FRC

Board for Actuarial Standards

Modelling: Consultation Paper

November 2008

FOREWORD BY THE CHAIRMAN

Modelling is at the heart of actuarial work. A standard for modelling, applying across the range of actuarial work, is therefore a vital component in the BAS's new book of technical actuarial standards. Together with standards on data and reporting, it will underpin the standards that are developed to address specific areas of actuarial work, such as insurance and pensions.

But modelling is not an activity that is limited to actuaries. On the contrary, it could be said that modelling is all-pervasive in today's financial world – and of course it is equally significant in engineering and scientific disciplines as well as in the social sciences. As we have developed this paper we have drawn on expertise from many different fields, but we are especially grateful to members of our Advisory Group, (listed in Appendix C) who have helped us to avoid taking a narrow actuarial perspective.

"Essentially, all models are wrong, but some are useful," as George Box said in 1979.[*] Recent events have only reinforced the truth of this saying. I cannot stress enough how important it is that users of actuarial information, especially those who make important decisions based on it, should not only understand how useful the underlying models are, but also understand their limitations. The proposals in this paper will, we hope, go a long way towards achieving this aim. In developing the proposals, we have tried to draw out principles of good modelling practice and make them explicit. They will also help to ensure that the models that are used in actuarial work are of high quality, addressing the needs of those users.

The Board has been greatly assisted in its work by the members of the Advisory Group, by the practitioners and others who were members of the Working Groups, and by other academics, practitioners and stakeholders. Our thanks are due to them all.

The proposals in this paper are likely to affect actuarial work and the resulting information over many years to come. Your views are important, and the Board looks forward to receiving them.

Paul Seymour
November 2008

[*] Box, G.E.P., Robustness in the strategy of scientific model building, in Robustness in Statistics, R.L. Launer and G.N. Wilkinson, Editors. 1979, Academic Press: New York.

CONTENTS

1 INTRODUCTION

BACKGROUND

1.1 The Board for Actuarial Standards (the BAS) is responsible for setting technical actuarial standards in the UK; it is an operating body of the Financial Reporting Council (the FRC).[1]

1.2 The BAS is developing a new set of Technical Actuarial Standards (TASs), as it proposed in its consultation paper on the *Structure of new BAS standards*.[2] There will be three generic TASs, applying across the range of actuarial work, on data, modelling and reporting. There will also be a number of specific TASs, applying to work in particular areas, such as long term insurance business, pensions, general insurance and business rearrangements. This document sets out proposals for the generic TAS on modelling.

1.3 The BAS has published its *Conceptual Framework for Technical Actuarial Standards* and *Scope & Authority of Technical Standards*. Its standards will be principles-based, and will be developed through a fully consultative process. This document, a consultation paper, will be followed by an exposure draft which will also be subject to public consultation.

1.4 A recent FRC discussion paper on *Promoting Actuarial Quality*[3] highlighted the importance of models in actuarial methods. The FRC will shortly be publishing an analysis of the responses it received. In developing this document the BAS has taken those responses into account. It believes that the proposals being presented will be a valuable contributory factor to the reliability and usefulness of actuarial methods, one of the drivers of quality identified in the discussion paper.

1.5 The remainder of this section sets out the intended audience and aims of this document. It then discusses a number of problems that models are often perceived to have, in order to explore some of the issues that should be addressed by a standard on actuarial modelling.

AUDIENCE AND AIMS OF THIS DOCUMENT

1.6 This document has been written for anyone who is likely to be affected by the standard that the BAS intends to publish on modelling. The intended audience includes actuaries, the entities that actuaries advise, the regulators of and shareholders in those entities, and those for whom those entities provide benefits or services (including, for example, pension benefits, life insurance policies, annuities and general insurance policies).

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[1] The Financial Reporting Council is the UK's independent regulator responsible for promoting confidence in corporate reporting and governance.

[2] All the BAS's publications are available from its website at http://www.frc.org.uk/bas/publications.

[3] Available from the FRC's website at http://www.frc.org.uk/publications/pubs.cfm?mode=list&year=2008.

1.7 Models are used throughout actuarial work, and they play a significant role in evaluating the solvency of insurance companies and determining the levels of contributions to be paid to pension schemes. They are also widely used as part of the risk management process and in making strategic decisions. Much of the actuarial information that is used by pension scheme trustees, insurance company directors and others consists of, or is derived from, the outputs of models.

1.8 This document will be far from the BAS's final word on modelling. Not only will there be further consultation on the modelling TAS in the form of an exposure draft, but the proposed specific standards on Long Term Insurance Business, General Insurance and Pensions are likely to address aspects of modelling. Modelling is a very broad field, and the BAS intends that the modelling TAS should cover only those aspects that are most significant to the users of actuarial information and that are widely applicable across a range of actuarial work.

1.9 This document proposes a number of definitions and principles for inclusion in the BAS's generic modelling TAS. However, it is by no means an exposure draft of the proposed TAS, and the proposals are intended to convey more the general sense of the requirements that may appear in the TAS than the precise words that are likely to be used, or the precise structure that the standard is likely to take.

1.10 The BAS would welcome views on the matters addressed in this document, and in particular on the questions listed in section 8. The responses that are received will inform the BAS's thinking first as it develops an exposure draft leading to a TAS on generic modelling issues, and, later, as it develops further TASs covering specific fields of actuarial work.

PROBLEMS WITH MODELS

1.11 Models are widely used in many areas of finance and business and elsewhere. Although they are indispensible in actuarial work and in other areas, their use is by no means free of problems. During the last few months we have talked to a number of people, including those on our working and advisory groups, about modelling problems they know of and bad modelling practices that they have encountered. We did not limit these discussions to actuarial models. Modelling problems are rarely specific to the particular model or even field in which they occur, and the lessons that can be learned by those in other fields are often valuable.

1.12 The principal problems that were identified fall into three main categories, concerning what is modelled and how; understanding the power and limitations of models; and operational risks surrounding the use of models. All result in the model outputs differing from reality more than would otherwise be the case.

1.13 The BAS hopes that its modelling TAS will help to minimise the incidence of these problems in actuarial information (see Appendix A).

What is modelled and how

1.14 When we asked people for their views on the major problems with models, many of them said that models often omitted factors that, in the event, turned out to be vital. For example, when London's Millennium Bridge opened in June 2000 it was found to sway from side to side and had to be closed within two days (it has since been modified and reopened). It emerged that the sideways movement was because chance correlation of footsteps in a crowd generated slight sideways movements of the bridge. It then became more comfortable for people to walk in synchronization with the bridge movement, so the sideways forces matched the resonant frequency of the bridge and the effect was magnified. Although this phenomenon had been observed before, it was not widely known about and had not been included in the models that had been used in designing the bridge.

1.15 A related problem is that of using only recent data in the development of models and, especially, in deriving their parameters. Some financial models have had these weaknesses exposed by recent events, as they have not captured the effect of the longer term credit cycle or of sudden market changes. Some of these problems may have been exacerbated by the adoption across the industry of similar modelling methodologies for driving trading.

1.16 Indeed, many people thought that there was often an over-reliance on an established view – modellers were unwilling to go out on a limb, or to stand out from the crowd. Models often failed to make adequate allowance for extreme events, or to give satisfactory representation of extreme circumstances (correlations between phenomena may be very different in the tails of distributions from their levels under normal circumstances).

1.17 More specific problems included unrealistic assumptions regarding options on life insurance policies, especially financial options that would not be taken up in the current circumstances (ie that are currently out of the money), inconsistencies of assumptions across the range of models used for different purposes within the same organisation, and the anchoring of assumptions (ie the tendency for assumptions, once chosen, to remain the same over a long period or when the model is used for different purposes). The use of inappropriate data in models was also identified as a problem – for example, mortality data for populations that had little in common with the populations for whom mortality rates were being derived.

1.18 Several of these problems occurred in connection with mortality assumptions. Models used to investigate possible future mortality rates tended to conform to the established view, and little credence was placed on the possibility that future rates of improvement might be much higher than those in the past. Also, the mortality assumptions used in modelling life insurance and pensions liabilities did not change as rapidly as might have been warranted by the changing knowledge about current trends.

1.19 Several people identified a lack of reasonableness, either in assumptions or in overall results, as a problem.

Understanding

1.20 Another common theme that emerged was connected with how well models are understood, and a lack of understanding resulting in their being used inappropriately. For example, if you have a hammer, there is a tendency to view every problem in the light of a nail – in other words, a model might be used because it is convenient rather than because it is a good tool for the job.

1.21 A related problem is that of using a model outside its range of applicability. A notable example of this, though not with an actuarial or even financial model, was the Columbia space shuttle disaster. This occurred because of damage from debris that came loose during the launch, harming the heat shielding tiles, which incurred more damage than the model predicted. The shuttle burned up during re-entry to the earth's atmosphere. The model that was used had been developed from the results of controlled experiments. The piece of debris that caused the problems had a mass of around 1kg, far larger than any of the objects used in the experiments. The model simply was not applicable to the purpose at hand.

1.22 The use of poorly understood models bought in from outside was widely held to be a problem. A commonly cited example was the use of economic scenario generators when modelling the capital requirements of insurance companies.

1.23 Hidden assumptions were often thought to be a problem. Models often depend on assumptions that are not explicitly part of the model structure or parameters, but are implicit in the way the model has been developed.

1.24 The view was widely held that the power of models is often overestimated. Models are, by their nature, simplified representations of the real world. Although the information they provide is often very useful, they are not the whole answer.

Operational risk around models

1.25 Many people cited poor documentation as a major source of problems.

1.26 Lack of testing has been a notable cause of model failures. There have been several public instances of major earnings restatements caused by errors that could have caught by testing, including $1.2 billion by Fannie Mae in 2003.[4]

1.27 Another problem that is known to have occurred is the misuse of data because of misunderstandings. For example, amounts in dollars have been treated as if they were pounds sterling. In 1999 NASA lost a Mars orbiter because one team of engineers used imperial units while another used metric units – neither team was aware of the inconsistency. More recently, when developing the SAPS mortality tables, the CMI discovered a discrepancy in age definition between the data and the software used to analyse it, resulting in draft tables with mortality rates that were out by half a year.

STRUCTURE OF THIS DOCUMENT

1.28 In section 2 we consider the purpose and scope of the proposed generic modelling TAS. Section 3 discusses a number of general concepts and principles including such matters as the application of judgement and documentation of models. The objective for the TAS that is proposed in section 2 has four components: sections 4 to 7 consider each component in turn and include proposals for requirements that would, in the BAS's view,

[4] See http://www.louisepryor.com/showTheme.do?theme=14 for more details, and descriptions of other similar incidents.

further the objective. Finally, section 8 summarises the matters on which the BAS would appreciate the views of respondents.

1.29 Appendix A describes how the proposed principles would address the problems identified in paragraphs 1.11 to 1.27. Appendix B lists the proposed definitions and requirements for the convenience of the reader and Appendix C lists the members of the Board and working groups.

RESPONSES TO THIS CONSULTATION PAPER

1.30 Details of how to respond to this paper are set out in Section 8. Comments should reach the BAS by **23 February 2009**.

2 PURPOSE AND SCOPE

INTRODUCTION

2.1 The BAS's conceptual framework states that each TAS will set out its purpose, its scope of application and any underlying legal or regulatory authority. In this section we propose a purpose for the modelling TAS, discuss the scope of its application, the definition of *model* that it will use and describe some matters that will not be covered. We also discuss what it might mean for a model to comply with the TAS, and summarise the departures that will be permitted by virtue of the BAS's *Scope & Authority of Technical Standards*.

PURPOSE OF THE MODELLING TAS

2.2 The overall purpose of all BAS standards is to ensure that the users for whom a piece of actuarial information was created should be able to place a high degree of reliance on the information's relevance, transparency of assumptions, completeness and comprehensibility, including the communication of any uncertainty inherent in the information. This is the BAS's Reliability Objective, and is set out in the *Scope & Authority of Technical Standards*. It is derived from one of the FRC's strategic outcomes.

2.3 Actuarial information is often based on the outputs of one or more models. Models transform data into actuarial information through the use of assumptions (such as the statistical distribution which is assumed to underlie the data). For example, models can be used to convert data on death rates into a mortality table, or convert data on numbers of claims into claim probabilities by rating factors. The mortality tables or claim probabilities are then used as assumptions in other models.

2.4 Models are invariably simplifications of the real world, with a variety of limitations, including those that derive from the appropriateness of the assumptions that are used to construct them, the reliability of the data and so on. There are several conditions that would ideally be true for the effective use of their outputs in making decisions.

2.5 First, in a perfect world the models that generate the outputs would reflect those aspects of the real world that affect the decisions that are to be made. If actuarial information is to be relevant and complete, the phenomena that are modelled should be relevant to the decision and, in addition, no highly relevant phenomena should be omitted.

2.6 Second, if actuarial information is to be comprehensible to decision makers, they need to know what aspects of reality the model outputs are intended to represent – monthly outgoings, for example, or end quarter technical provisions. Users of actuarial information also need to know the significance of the assumptions on which the model outputs are based – monthly outgoings assuming that a certain volume of new business is written, for instance.

2.7 Third, the model should do what it purports to do. If a result is presented as the mean of the potential asset levels at a year end, for example, the calculations used to generate the result should have been performed correctly, using appropriate formulae. In this case the output should reflect the mean, and not some other measure such as the median, and the calculation should include all potential asset levels, weighting each by the correct probability.

2.8 And fourth, decision makers should be aware of the limitations of the models whose outputs they use. These limitations arise from the very fact that models are necessarily a simplification of the real world, depending on a number of assumptions which may or may not turn out to be correct. Information that omits explanations of significant limitations is not complete.

2.9 The BAS therefore believes the purpose of the modelling TAS should be that actuarial information based on models should:

a) be based on models that sufficiently represent those aspects of the real world that are relevant to the decisions for which the actuarial information will be used;

b) include explanations of how the inputs to models are derived and what the outputs from models are intended to represent;

c) be based on models that are fit for purpose both in theory and in practice; and

d) include explanations of the significant limitations of the models.

2.10 Sections 4 to 7 respectively describe how the BAS proposes to address each part of this purpose in the standard.

2.11 All explanations included in the actuarial information should comply with the BAS's proposed generic reporting standard (see also paragraph 2.26). In particular, they should be presented in a clear and comprehensible manner, and material information should not be obscured by the inclusion of information that is not material or not relevant. To achieve this, the preparer (or preparers) of the information should understand the matters in question in enough detail to enable them to determine the appropriate level of explanation for the audience.

2.12 As a generic standard, the modelling TAS will apply across a broad range of actuarial work. It will contain general principles that support its purpose, but will not cover all eventualities in detail. It is important that the principles are identified and set out clearly. They may appear to be obvious, but they are still sufficiently important to be worth stating explicitly. Section 1 gives some examples of modelling practices that would not comply with the proposed principles.

SCOPE OF APPLICATION

2.13 The BAS proposes to use the following definition of the term *model*:

> A model is an abstract and simplified representation of some aspect of the real world consisting of a set of mathematical formulae and algorithms, together with inputs in the form of data and estimated parameters.

2.14 This definition is not intended to replace the definition of an *internal model* provided by the Groupe Consultatif and Comité European des Assurances as "a risk management system developed by an insurer to analyse the overall risk position, to quantify risks and to determine the economic capital required to meet those risks." The FSA believes that insurance firms that follow this definition are "unlikely to find their work incompatible with the Solvency II Directive" (which does not provide a definition).

2.15 The BAS definition does not apply only to models used by insurers, or even to models used only in actuarial work. A *model*, in the BAS sense, is both rather narrower than an *internal model*, as it does not cover a whole risk management system, and also rather broader as it covers models with purposes that may have nothing to do with risk. A system that meets the definition of an *internal model* would typically contain one or more *models* meeting the BAS definition.

2.16 Models have three aspects. The first aspect, the theoretical construct, consists of the set of mathematical formulae and algorithms.

2.17 The second aspect, the practical implementation, embodies those formulae and algorithms in a form that will accept inputs and will generate outputs. In many cases the implementation is a computer program, but other types of implementation are possible – for instance, pen and paper are often used for simple models. The TAS will cover implementations of all types.

2.18 The third aspect, a specific realisation, consists of an implementation together with a set of inputs. In other words, for a model implemented using a computer program, a realisation is a run of the program. Different runs, with different data or parameters, are different realisations even if the program itself has not changed. It is only a specific realisation that can actually generate model outputs, and different realisations may generate different outputs.

2.19 The word *model* may be used to describe any of these three aspects. To avoid confusion, this document and the TAS will identify which of the three is meant.

2.20 The modelling TAS will apply to all models used in preparing actuarial information within the defined scope of the TAS. As currently specified in the Schedule to the BAS's *Scope & Authority of Technical Standards*, the modelling TAS, as a generic standard, would apply to all work that is covered by any specific TAS. To avoid repetition, this is not stated explicitly in the proposed principles. Nevertheless it should be understood when reading this paper.

2.21 The assumptions used in models are themselves often derived from other models. For example, models that are used to investigate the capital requirements of insurance companies often take their economic assumptions from other models, such as economic scenario generators. The mortality assumptions used in models of pension scheme funding, and in models of many aspects of long term insurance business, may also be generated by dedicated models.

2.22 In some circumstances the outputs of several models may be combined to comprise the final outputs that form the basis of actuarial information. For instance, as discussed in paragraph 2.15, an internal model used by an insurance firm under the provisions of Solvency II is likely to be composed of many smaller models whose outputs are combined to give estimates of quantities relating to the firm as a whole. In other contexts, several independent models, of different types and using different assumptions, may be used to estimate economic variables. In both these cases the combination or aggregation of results is itself performed by a model.

2.23 All models used in the production of actuarial information, whether their outputs are used directly or mediated through other models, will be included in the scope of the modelling TAS (see paragraphs 6.36 to 6.38). The information depends on the models, so it is important that the users of the information can rely on them.

EXCLUSIONS

2.24 The BAS intends to publish generic TASs on data and reporting as well as on modelling. The data and reporting TASs will apply to the same work as the modelling TAS, so their principles will not be repeated in the modelling TAS.

2.25 The data TAS is expected to include principles concerning the following topics, which will therefore not be addressed in the modelling TAS:

- selection of data,
- testing the adequacy and accuracy of data used, and
- steps taken to address the insufficiency of the data.

2.26 The reporting TAS will cover some aspects of what should be included in actuarial information, and how it should be presented. The modelling TAS will supplement the reporting TAS by providing more details of what will be required in respect of models, their data and assumptions and their outputs. The principles in the reporting TAS that govern how information should be presented will apply equally to information that is required by the modelling TAS. In particular, the reporting TAS will require that material information should not be obscured by the inappropriate inclusion of items that are not material or not relevant.

2.27 In some cases the methods to be used for a particular task are specified by the relevant regulator. For instance, the Pension Protection Fund requires the value of liabilities to be the present value of accrued benefits using certain specified assumptions. Other constraints may be imposed by, for example, the Pensions Regulator or the FSA, or in accounting standards.

2.28 The BAS notes that other regulators may have different objectives to those of the BAS. It cannot rule out the possibility that its standards will be inconsistent with the immediate requirements of other regulators, but in such circumstances it would work with them to resolve any differences. Part of any impact assessment performed before the introduction of BAS standards will be an examination of whether they are consistent with current requirements of other regulators in the relevant field.

2.29 The modelling TAS will not address the choice of models for particular tasks. The BAS intends to publish specific TASs in a number of areas, including Pensions, Long Term Insurance, and General Insurance. These specific TASs may address issues such as the forms that models should take.

THE COMPLIANCE OF MODELS

2.30 The overall purpose of the modelling TAS is to serve the users of actuarial information (see paragraph 2.2). Compliance with the TAS will not only involve providing explanations to the users, but also affect the development of all aspects of the models that are used, and their documentation.

2.31 Compliance with many of the principles will depend crucially on the context in which the model in question is being used – the purpose to which the model outputs will be put, the decisions to be made by the users of the actuarial information, and their areas of expertise. It will not be possible to say of any model that it complies with the modelling TAS in all circumstances. A model (together with surrounding documentation and explanations) that meets the standard in one context may well not do so in another. In particular, a model that is designed to answer a particular narrowly defined question may well not meet the standard if it is used for another purpose.

2.32 Models are often developed and used over long periods of time. The requirements in the modelling TAS will apply to all models used in the preparation of actuarial information, regardless of when they were first developed.

DEPARTURES

2.33 The permitted or required departures from compliance with TASs are set out in full in paragraphs 20 to 24 of the BAS's *Scope & Authority of Technical Standards*.

2.34 Paragraphs 22 and 23 of the *Scope & Authority* explain that departures that have an immaterial effect on the work being performed are permitted. A departure should be considered material if, at the time the work is performed, the effect of the departure (or the combined effect if there is more than one departure) could influence the decisions to be taken by the intended recipients of the work product (but see paragraphs 3.2 to 3.8).

2.35 Paragraph 24 of the *Scope & Authority* explains other possible departures, of which the most important is that departure is required in the extremely rare circumstances that compliance would conflict with the Reliability Objective (see paragraph 2.2).

2.36 The *Scope & Authority* sets out the disclosures that are required in the event of any departure.

2.37 The BAS believes that the proposed principles contained in this document will support the achievement of the purpose of the modelling TAS that is set out in paragraph 2.9**.** However, it recognises that principles are inevitably subject to interpretation. It therefore proposes that the TAS should contain a statement that it would be wrong to interpret any principle in a way that would conflict with the achievement of the purpose.

For the reasons set out in paragraphs 2.2 to 2.12 the purpose of the modelling TAS will be that actuarial information based on models should:

a) be based on models that sufficiently represent those aspects of the real world that are relevant to the decisions for which the actuarial information will be used;

b) include explanations of how the inputs to models are derived and what the outputs from models are intended to represent;

c) be based on models that are fit for purpose both in theory and practice; and

d) include explanations of the significant limitations of the models that have been used.

The definition that the BAS proposes to use for the term *model* is given in paragraph 2.13.

The BAS would welcome responses to the following questions:

1. Will the proposed purpose of the modelling TAS as set out in paragraph 2.9 help to ensure that users of actuarial information can place a high degree of reliance on its relevance, transparency of assumptions, completeness and comprehensibility?

2. Will the definition of a model given in paragraph 2.13 encompass the full range of models that contribute to actuarial information?

3 GENERAL CONCEPTS AND PRINCIPLES

INTRODUCTION

3.1 This section discusses several issues that are fundamental to the modelling TAS. It starts with user needs and materiality, which are both vital concepts in the context of the BAS's standards. Next comes documentation, which, while not aimed directly at the user of actuarial information, is an important component of high quality models. A proposed principle on proportionality follows, and the section ends with a discussion of the application of judgement in the context of modelling.

USER NEEDS AND MATERIALITY

3.2 The BAS believes that the needs of the users of actuarial information are paramount, as set out in its Reliability Objective (see paragraph 2.2). The purpose of the modelling TAS set out in paragraph 2.9 also reflects this priority. All the proposed principles in this paper are intended to support the purpose and, through it, the Reliability Objective. Paragraphs 2.33 to 2.37 explain how the Reliability Objective and purpose of the TAS will affect its operation.

3.3 Materiality is also a vital concept in the context of the BAS's standards. As described in paragraph 2.34, materiality is both central to the notion of compliance and directly driven by user needs.

3.4 The BAS's *Scope & Authority of Technical Standards* states that, unless defined otherwise, a departure from a TAS should be considered material if, at the time the work is performed, the effect of the departure (or the combined effect if there is more than one departure) could influence the decisions to be taken by the intended recipients of the work product.[6]

3.5 The BAS is proposing a number of principles for its modelling TAS concerning the documentation of models. It recognises that the omission of information from documentation may not of itself directly influence the decisions to be taken by users. However, this does not mean that departures from the documentation requirements of the modelling TAS would be immaterial. We therefore propose that the modelling TAS should, as provided in the *Scope & Authority*, extend the definition of a material departure as follows:

> A departure from the modelling TAS should be considered material if, at the time the work is performed, the effect of the departure (or the combined effect if there is more than one departure) could influence the decisions to be taken by the intended recipients of the work product. If the departure concerns documentation, it should be considered material if it concerns an assumption, data item, or other piece of information contributing to the development or use of a model whose effect on the model outputs is such that it could influence the decisions to be taken by the intended recipients of the work product.

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[6] Paragraph 23 of the *Scope & Authority of Technical Standards*.

3.6 The modelling TAS will be subject to the provisions in the BAS's *Scope & Authority of Technical Standards*. To avoid repetition and potential confusion, materiality is not explicitly mentioned in many of the proposed principles. The lack of an explicit mention does not mean that it can be ignored.

3.7 Whether a matter is material depends on the size and nature of the item in question as judged in the particular circumstances of the case. It is usually a combination of factors, rather than any one in particular, that will determine materiality. For example, the omission of a single policy from the data when constructing a model of a life insurance company would usually be immaterial, and therefore would not need to be documented, but the test should be applied to the whole policy class. In general, a single aspect of a model may be immaterial if taken on its own, but material when taken in conjunction with one or more other aspects. It is the latter materiality that is important.

3.8 Materiality is not necessary directly related to the size and complexity of a model, or the number of times that it is expected to be used. The outputs of a simple model, used only once, may contribute vital information on which an important decision will be based. A simple model, or one that is intended to be used only once, will not therefore automatically be exempt from compliance with the modelling TAS.

DOCUMENTATION

3.9 Many of the principles that are proposed for inclusion in the modelling TAS require either an explanation to be included in the actuarial information, or the documentation of assumptions, judgements or other factors. These two types of requirement are linked but are by no means identical, not least because documentation is generally not directed at the users of actuarial information.

3.10 The BAS believes that documentation is important because, if actuarial information is to contain relevant explanations that are comprehensible to the user, the preparer of the information should understand the matters being explained. That understanding often needs to be in more depth than the explanation that is presented, as the preparer must be able to make judgements about the appropriate level and type of explanation.

3.11 In many cases, the preparer of the actuarial information may not be the person who made the judgements or assumptions, or there may be a delay between making the judgement and preparing the actuarial information. Documenting the assumptions and judgements both ensures that they are available when the information is prepared, and provides evidence that the relevant factors were in fact taken into account.

3.12 Documentation may take many forms, including (but not limited to) separate physical or electronic documents, comments in the code of an implementation, or annotations to the output of a realisation. Each form of documentation has advantages and drawbacks. Factors that affect the suitability of the documentation include ease of access for those who need to read it, and ease of updating. Documentation that is not consistent with the current state of the model (any or all of theoretical construct, practical implementation or specific realisation) may be either useless or positively misleading.

3.13 Documentation may, in some cases, form part of actuarial information, but is often for purely internal use. Any one piece of documentation may have one or more purposes – for example, it may be intended to help model developers, the users of model outputs, those testing or reviewing models, or those running models. Documentation, like any other form of communication, should be written with the potential reader in mind.

3.14 In the past, guidance to actuaries in some areas[7] has included the principle that an actuarial report should normally contain detail sufficient for another suitably experienced actuary to form an opinion on the original actuary's key judgements and assess the reasonableness of the outputs. Although the BAS does not believe that this principle should be applied to all actuarial information (the required detail may not be relevant to the intended users of the information) it does believe that it is useful in the context of documentation. Documentation should certainly contain enough detail for judgements to be examined and outputs assessed for reasonableness. Moreover, documentation should be written in such a way that it is comprehensible to someone who has the relevant technical expertise, but who has not hitherto had any involvement with the business background of the model being documented – this is sometimes known as the "technically competent new hire" test.

3.15 The BAS therefore proposes the following principle for inclusion in its modelling TAS:

> Documentation of a model should state both its purpose and its intended readership, and be complete for that purpose and clear and unambiguous for that readership. It should contain enough detail for a technically competent person with no previous involvement to understand the matters to which the documentation is relevant and assess the judgements that have been made.

3.16 In some cases the requirement to be able to assess the judgements that have been made may imply a requirement to be able to reproduce the model outputs.

3.17 The modelling TAS's requirements for the matters that should be documented are intended to be a minimum. Other regulators, or good business practice, may well require other matters to be documented in addition.

3.18 The BAS believes that the principle in paragraph 3.15 should apply to all model documentation, whether or not the documentation in question is required by its modelling TAS.

PROPORTIONALITY

3.19 The issue of proportionality was raised by many respondents in our consultation on the Conceptual Framework, and was discussed in the *Analysis of Responses to the Consultation Paper* that was published in April 2008. The BAS is committed to proportionate regulation, and has borne in mind the cost of applying standards in drafting the proposals in this paper.

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[7] For example, in GN12: *General insurance business – actuarial reports*.

3.20 The BAS also recognises its standards should not encourage those seeking to comply with them to perform work that does not provide benefit to the users of the resulting actuarial information.

3.21 Decisions on the scope of actuarial information often arise out of discussions between the providers of the information and its users. For instance, the Pensions Regulator's guidance for pension scheme trustees states that "Trustees will need to discuss with the actuary the scope of the advice needed. This should enable trustees to identify the features or circumstances which are particular to their scheme and in relation to which actuarial advice would be desirable."[8] Such discussions fall within the scope of BAS standards.

3.22 The BAS therefore proposes the following principle for inclusion in its modelling TAS:

> The development and use of models should be proportionate to the scope of the actuarial information that has been commissioned and the benefit the user would be expected to obtain from the models, striking a balance (where necessary and appropriate) between the interests of those who pay for the information and those who use it.

APPLICATION OF JUDGEMENT

3.23 The way in which the principles set out in a TAS are applied is a matter of judgement by those responsible for the preparation of actuarial information. In particular, it can be difficult to assess whether a change in an assumption, data item or other piece of information contributing to the development or use of a model will have a material effect on the outputs without actually carrying out the calculation using the alternative information. This would not normally be proportionate. It is therefore often necessary to make judgements about what is, or is not, material or proportionate.

3.24 Judgements of many kinds are frequently necessary when developing or using models. Judgements may concern, for example, such matters as the applicability of the model in question, the data that should be used, the relevance of information, the structure of the model, the assumptions that should be used, the outputs that are relevant, and so on.

3.25 A single model implementation is often used, with some changes, for several different purposes, or for a single purpose over a period of time. Indeed, it is very unusual for a model to be used only once, whatever the intention at the outset. In many circumstances, a control cycle is in operation around the model, which is enhanced and improved as a result of experience, including the comparison of its outputs to actual outcomes. In this case, the general purpose of the model may change little. In other cases, however, an existing model may be adapted for use in new circumstances or to address a new problem. Models are very rarely static.

3.26 The relevance of factors may well vary with the purpose of the model, or change over time as new information emerges. In addition, the purpose for

[8] Code of practice 03, Funding defined benefits, paragraph 40. http://www.tpr.gov.uk/codesOfPractice/definedBenefit/defBen-11.aspx.

which a model is used may itself gradually evolve. Judgements made under different circumstances may no longer be applicable.

3.27 It follows that a BAS standard on modelling will only be effective in ensuring the high quality of actuarial information if high quality judgement is used in its application. The quality of actuarial information depends on its consistency, among other things, and so it is important that such judgements are applied consistently, even when different people are involved in the work or similar information is provided at a later date. The BAS therefore proposes the following principle for inclusion in its modelling TAS:

> Judgements about matters concerning models should be exercised in a reasoned and justifiable manner, taking into account the purpose of the model or models in question. The reasoning behind such judgements should be documented. Judgements should be reconsidered when the models are used for purposes other than those originally intended, after a period of time has passed, or after a previously unexpected event.

3.28 The materiality of a difference in the purpose of a model, a period of time, or an unexpected event depends on the type of the model and the use to which it is being put, and will itself require the application of judgement.

Section 3 discusses several concepts and principles that are fundamental to the modelling TAS.

User needs and materiality are covered in paragraphs 3.2 to 3.8. A definition of materiality extending that in the BAS's *Scope & Authority of Technical Standards* is proposed in paragraph 3.5.

For the reasons set out in paragraphs 3.9 to 3.18 the BAS is proposing that the modelling TAS should include principles covering the need for documentation, along with a principle covering all model documentation.

For the reasons set out in paragraphs 3.19 to 3.22 the BAS is proposing that the development and use of models should be proportionate to the scope of the actuarial information that has been commissioned and the benefit the user would be expected to obtain from the models.

For the reasons set out in paragraphs 3.23 to 3.28 the BAS believes that judgements concerning models should be exercised in a reasoned and justifiable manner, that the reasoning behind such judgements should be documented and that judgements should be revisited.

The BAS would welcome responses to the following questions:

3. Do respondents have any comments on the proposals in section 3, especially those in paragraphs 3.15, 3.22 and 3.27?

4. Do respondents have any views on the definition of materiality that is proposed in paragraph 3.5?

5. Should the modelling TAS include principles concerning the need for documentation as discussed in paragraphs 3.9 to 3.18?

4 REPRESENTING THE REAL WORLD

INTRODUCTION

4.1 The first part of the proposed purpose of the modelling TAS, as set out in paragraph 2.9a, is that actuarial information should be based on models that sufficiently represent those aspects of the real world that are relevant to the decisions for which the actuarial information will be used. This is, deliberately, a fairly general statement. In this section we consider principles that contribute to the achievement of that part of the purpose. The modelling TAS will not indicate any particular phenomena that should be modelled, although the specific TASs focussing on particular areas of actuarial work that the BAS intends to develop may do so.

4.2 This section starts by discussing the relevance of aspects of the real world in the context of modelling, and goes on to consider the concept of parsimony – that unnecessary complexity should be eschewed.

RELEVANCE

4.3 Both the decisions to be made based on the actuarial information to which the model in question contributes and the model's structure contribute to the materiality and relevance of a phenomenon that is under consideration for including in the model. For instance, mortality as a result of different diseases is clearly relevant when developing a causal model of future mortality, but is not materially relevant when developing a model using a purely extrapolative technique, such as P-Spline. The structure of such a model would not normally allow for the modelling of likely future improvements due to better cancer treatments, for example. Similarly, it might be difficult for a purely causal model of mortality to take direct account of perceived trends that have no causal explanations.

4.4 The choice of a structure for a model therefore implicitly involves decisions about the factors that should be modelled. The suitability of a model structure for a given purpose depends on the data and other information that are available, as well as on the use to which the outputs will be put (and therefore on what outputs should be produced). The latter point is often particularly important – for instance, extrapolation is often more useful for forecasting purposes than a causal model, although causal models may be more useful for exploring the effects of possible scenarios.

4.5 Some models are intended to serve very specific and narrow purposes. For example, models are often used to investigate the effects of investment returns and inflation on pension contributions. In these models factors such as mortality risk, changes in scheme membership, or investment manager risk are not modelled, because they are not deemed relevant to the purpose at hand. Such models, while useful, have significant limitations if they are used for other purposes, such as measuring the overall uncertainty in future contribution levels (see paragraphs 7.8 to 7.13).

4.6 One of the common causes of model failure is the omission of factors that turn out to be vital. For example, many risk models used by banks in the recent past failed to allow for the possibility of dramatically reduced liquidity. Sometimes factors are omitted because the model developers simply are not aware of the factor in question, and sometimes because, although they are aware of it, they judge it to be irrelevant or immaterial.

4.7 It is, of course, extremely difficult to determine in advance what the really significant factors are going to be – hindsight makes it much easier. However, extremely unlikely events certainly figure among the relevant phenomena. There may be many events that are, individually, extremely unlikely to occur – but the probability of at least one such event occurring is much higher. There are a number of psychological biases that increase the difficulty of determining relevance. People tend to underestimate the probability of rare events (ie overestimate their rarity) and often find it difficult to imagine circumstances different from those that currently pertain. It is often easy to give reasons why a particular occurrence from the past could not happen again, but more difficult to think of events that have never happened but could.

4.8 Materiality is particularly difficult to judge for events or situations that are rarely encountered. If a factor is material, it should be modelled – but it is that initial judgement that is difficult, and often based on little or no hard information. The principle that judgements should be reasoned and that the reasoning should be documented is especially important in this context (see paragraph 3.27).

4.9 The omission of a factor from a model is as much an assumption as the inclusion of a factor, although there is of course an infinite number of assumptions of the former type. However, both types of assumption may be material, as either the omission or inclusion of a factor may affect the model outputs in a way that would influence the decisions of the users of actuarial information derived from those outputs.

4.10 In some cases information based on a model may be insufficient for the user's needs because of unavoidable limitations of the model in question. For example, the information provided by most stochastic models[9] about extremely unlikely events is of poor quality, as discussed throughout this paper. However, even though they cannot be modelled in any satisfactory way, information about their effects may be material.

4.11 In such circumstances it may be possible to provide useful information to the user that is based on other models or other techniques. For instance, the use of a deterministic model of specific scenarios is one way of investigating the effects of extremely unlikely events (see also paragraphs 5.74 to 5.75).

4.12 The BAS proposes the following principle for inclusion in its modelling TAS:

> Models should cover all materially relevant phenomena, taking into account the purpose and structure of the model or models in question.

[9] By a stochastic model, we mean one that produces information about the probability distribution of possible outcomes, whether it does so analytically or through Monte Carlo simulations.

PARSIMONY

4.13 The idea that models should be as simple as possible, but no simpler, is an old one, dating back at least to the 14th century.[10] The difficulty lies in determining the level of simplicity that is possible, while still generating useful outputs.

4.14 The advantages of simplicity are well known. A simple model is easier than a complex model to understand and to check. It is also more likely to avoid over-fitting – such as conforming to the details of data rather than identifying trends. A more complex model might give better insights into the underlying drivers, while an over-simplified model may omit vital characteristics of the phenomena under investigation.

4.15 A more complex model will usually require more, or more detailed, assumptions to be made. This may be difficult if there is limited information available. In addition, the outputs may not be reliable if assumptions are based on insufficient data. For example, in theory a stochastic model may provide useful information about the possible range and variability of the outputs it generates. In practice, though, that information may be misleading if assumptions about the distributions of the underlying variables have been based on guesswork.

4.16 Models used in actuarial work are often built using data from the past in order to give information about what might happen in the future. The predictive power of these models is often reduced as they become more complex, as the inclusion of extra factors drowns the overall trends.

4.17 The BAS proposes the following principle for inclusion in its modelling TAS:

> Increasing degrees of complexity should be introduced into models if and only if they make a material difference to the outputs or materially reduce the limitations of the model in question.

4.18 The principle covering proportionality (see paragraph 3.22) is especially important in the context of decisions about whether to introduce complexity into models.

Section 4 discusses ways of meeting the objective that actuarial information should be based on models that sufficiently represent those aspects of the real world that are relevant to the decisions for which the actuarial information will be used.

Paragraphs 4.3 to 4.12 discuss the notion of relevance, and how it depends on the purpose and structure of the model. Paragraphs 4.13 to 4.18 discuss the notion of parsimony.

The BAS would welcome responses to the following question:

6. Do respondents have any comments on the proposals concerning relevance and parsimony that are presented in section 4, especially those in paragraphs 4.12 and 4.17?

[10] William of Ockham expressed it as "entia non sunt multiplicanda praeter necessitatem" – entities must not be multiplied beyond necessity.

5 MODEL INPUTS AND OUTPUTS

INTRODUCTION

5.1 The second part of the proposed purpose of the modelling TAS, as set out in paragraph 2.9b, is that actuarial information should include explanations of how the inputs to models are derived and what the model outputs are intended to represent. It is model outputs that usually form the primary contribution of models to actuarial information, and they depend crucially on the inputs.

5.2 Models are often used to provide estimates of quantities – for example, a best estimate of the amount of outstanding claims, or a prudent estimate of the technical provisions required for a pension fund. In the same way, they may be based on assumptions that are intended to be best estimates, to be prudent, or to have some other characteristic. *Estimates* may thus be either model inputs or model outputs, and in this section we use the term to cover both.

5.3 This section starts with a general discussion of the inputs to models, noting that inputs may take the form of either data or assumptions, and the likely provisions in the data and reporting TASs that will apply to them. It goes on to discuss two important aspects of data that will not be covered by the data TAS: how shortcomings in data affect models, and data grouping. A discussion of the need for consistent assumptions follows.

5.4 The use (in both assumptions and outputs) of point estimates of values that depend on underlying probability distributions is discussed, and some of the issues surrounding the use of best estimates described. A contrast is drawn with biased estimates, such as those involving prudence. Finally, methods of measuring risk and uncertainty are discussed.

INPUTS

5.5 The inputs to models include both data and assumptions. Data may be used to derive parameters (possibly through the use of further models), form the input to calculations, or serve some other purpose. The BAS is developing a generic TAS on data, which will set out requirements concerning selecting data, testing it for adequacy and accuracy, and taking steps to address any insufficiency. These matters will not therefore be addressed in the modelling TAS.

5.6 The BAS's generic reporting TAS is expected to include requirements that actuarial information should include a description of the data used, its source, and a description of any uncertainty there may be over the accuracy of the data. It is also expected to require an explanation of the measures taken to avoid data uncertainty causing a misleading presentation of the results of the calculations in which the data is used. These matters will not therefore be addressed in the modelling TAS.

5.7 Assumptions vary widely in both the matters they concern and their source. They may be fundamental to the structure of the model – for example, an assumption that both the direction and magnitude of changes in stock prices are random (ie that prices move in a random walk) is fundamental to the Black-Scholes model for pricing equity options. Assumptions like this are not represented by any single model input or parameter. Other assumptions are more detailed, and may be represented by a single input or set of inputs. In the Black-Scholes model, the implied volatility and risk free rate of return are assumptions of this type.

5.8 Assumptions of all types may be derived from any or all of data (possibly through the use of further models), other information or judgement. More fundamental assumptions, especially, may be either explicit or implicit, quantitative or qualitative.

5.9 The BAS's generic reporting TAS is expected to include requirements that actuarial information should include all material assumptions, an explanation of the reasons for adopting them, and the meaning ascribed to any term such as *best, central* or *prudent* estimate that is used to describe them. The requirement to explain all material assumptions is not intended to be restricted to assumptions that are explicitly part of the model structure or are explicit parameters. There is therefore no need for the explicit inclusion of such requirements in the modelling TAS.

5.10 In some cases, assumptions that are used in models are not derived or chosen directly by the modeller, but are supplied or specified by the user for whom the actuarial information is being prepared, or supplied by a third party. Externally supplied assumptions will be subject to the provisions of the modelling and reporting TASs, but the explanations of the reasons for adopting them may take a different form from that of those concerning assumptions that have been derived or chosen directly by the modeller.

DATA

5.11 It is only a specific realisation of a model, consisting of a practical implementation together with a set of inputs, that actually produces outputs (see paragraph 2.18). The data that is used in a specific realisation may have shortcomings or other characteristics that affect the outputs.

Shortcomings in data

5.12 Shortcomings in the data that is used may significantly influence the extent to which specific realisations are fit for purpose. It may sometimes be possible to estimate the effects of known shortcomings, or to make compensating adjustments to other model inputs or directly to the outputs. (The BAS's generic data TAS is expected to cover matters concerning the making of compensating adjustments to the data itself). Data may fall short of the ideal through incompleteness, inaccuracy or irrelevance.

5.13 Incompleteness of data has a number of possible adverse effects on modelling. Most obviously, it may result in the misstatement of modelled quantities – for instance, missing records for deferred pensioners would lead to an understatement of scheme liabilities.

5.14 Incomplete data, including that obtained by sampling a larger dataset, may also exhibit biases that would not be present if the data were complete. In life insurance, for example, lapsing policies may have different characteristics from those that remain in force. Omitting data for lapsed policies may therefore be misleading in any analysis of the take up of options. Similarly, incomplete data may provide misleading estimates of statistical quantities such as variance or skewness.

5.15 Inaccurate data may have similar effects to those of incomplete data.

5.16 Data should also be relevant to the purpose for which it is being used. For instance, in estimating technical provisions for a line of business that has been written for only a short period it may be necessary to rely on data for another line of business. To the extent to which the two lines of business differ, outputs based on that data will be less reliable.

5.17 The BAS proposes the following principle for inclusion in its modelling TAS:

> Data that is used in models should, as far as possible, be complete, accurate and relevant. Where data is, or is thought to be, incomplete, inaccurate or irrelevant, the approaches used to estimate the effects of its shortcomings or to make compensating adjustments to parameters or outputs should be documented, together with reasons for adopting them.

5.18 It has been suggested to the BAS that its TAS should include a requirement that any known or suspected shortcomings of the data should be documented. As explained in paragraph 5.6, the reporting TAS is expected to include a requirement that actuarial information include a description of any uncertainty there may be over the accuracy of the data, which would, of course, include any shortcomings that were judged to be material. The BAS would be interested in respondents' views on whether additional requirements should be included in the modelling TAS.

5.19 It has also been suggested that there should be requirements to provide an estimate of the effects of any data shortcomings, and that any compensating adjustments to other inputs or to outputs should avoid bias. The BAS is minded not to propose such requirements, on the grounds that they would be too difficult to apply in practice, but would be interested in respondents' views on their desirability and practicality.

Data grouping

5.20 Policy or membership data is frequently grouped for the purposes of actuarial work – that is, instead of carrying out individual calculations on each policy (or each member), the calculations are performed on the aggregate data for groups of similar policies (or similar members). Grouping may be performed in other ways, too. Grouped data may be used because it gives more credibility from the statistical point of view (for example when mortality experience or motor claims experience is being investigated), because it shortens the time taken to run an actuarial model or because it lowers the cost of carrying out the work. Sometimes grouped data is used because it is all that is available.

5.21 Grouping data may affect the outputs that are generated. In some cases it may increase the reliability of the outputs (for example, if it increases the volume of data, and hence statistical credibility, without increasing its heterogeneity), while in others it may have an adverse effect (for example, if it introduces significant bias). It may be difficult to quantify the effects of grouping without running the model on both grouped and ungrouped data, which could well be prohibitive in terms of both cost and time. However, in some cases it is possible to demonstrate that grouping has no material effect, while in other cases the process that is used to determine the groups that are used may provide useful information on the effects.

5.22 There are a number of ways in which grouping data may affect the accuracy with which the outputs of models reflect the intention or the usefulness of the outputs to the decision maker.

5.23 Grouping may increase the volume of data and thus the statistical credibility of the outputs. For example, two insurance products may each have low volumes of policies, but offer similar benefits. Combining the two may result in enough data to support a reasonable statistical analysis.

5.24 Grouping may increase the heterogeneity of the data compared to that present in the ungrouped data. For example, in grouping lives by age band, the wider the age band the more heterogeneity is present in each group. This could well decrease the accuracy of the outputs.

5.25 Grouping may be useful if the grouping criteria that are used reflect distinctions that are of interest to the decision maker, such as segments of business that are the responsibility of different managers, or the way in which business is covered by reinsurance.

5.26 Grouping may reduce accuracy if the criteria are inconsistent with the classification used in the data systems. Such a grouping may require the arbitrary allocation of data into groups.

5.27 The grouping process may introduce bias into the outputs. For example, segmenting GI business into discontinued and ongoing business can lead to survivorship bias in the resulting analysis, depending on the reasons why the business was discontinued. Some London Market underwriters have a practice of renewing only policies where no claims have been reported. The ongoing business therefore looks extremely profitable, but this is misleading.

5.28 The BAS therefore proposes the following principle for inclusion in its modelling TAS:

> If grouped data is used, the approach that has been taken to the grouping, the reasons for choosing it and the effects of using grouped data rather than the ungrouped data from which it is derived should be documented.

5.29 It is important that the user understands that the outputs could be affected by the data grouping that has been used. The BAS therefore proposes the following principle for inclusion in its modelling TAS:

> If data has been grouped and it is not possible to demonstrate that the grouping has no material effect, an explanation of the possible effects of the grouping, and that a different grouping (whether more or less detailed, or using different criteria) could give different outputs, should be included in the actuarial information.

5.30 It has been suggested that the BAS's modelling TAS should include a requirement that, if data is grouped, the effects of the grouping should be quantified and included in the actuarial information. The BAS believes that this would be an unduly onerous requirement. In some cases, grouping is performed in order to ensure that the calculations are manageable – performing the calculations on ungrouped data would be computationally impossible.

CONSISTENCY OF ASSUMPTIONS

5.31 As discussed in paragraphs 5.7 to 5.10, there are many different types of assumption. A single model may require a large number of assumptions, all interacting with each other and with data to produce the model outputs. In some circumstances several different models are used in conjunction, with the outputs of one being used as inputs in another. The total number of assumptions in such a system may be enormous.

5.32 Consistency of assumptions is vital if reliance is to be placed on the outputs of a model or suite of models. It is important for both qualitative and quantitative assumptions. For instance, if one model in the suite assumes that stock prices follow a random walk, so should the others. If one model assumes that pay will increase at the same rate as price inflation, consistency demands that the other models do too.

5.33 Consistency is especially easy to overlook when performing scenario testing (see paragraphs 5.74 to 5.75). It may happen that a very high inflation rate is assumed in one model in the suite, for example, but that the concomitant changes are not made in other models.

5.34 Sometimes, several independent models are used in conjunction to provide better estimates than any one model could provide on its own. In such cases, inconsistent assumptions may be chosen deliberately. This inconsistency is a result of the purpose for which the models are being used. Consistency is therefore not desirable in all circumstances.

5.35 The BAS therefore proposes the following principle for inclusion in its modelling TAS:

> The assumptions used in a model, or in a suite of models that operate in conjunction, should be consistent, taking into account the purpose of the model or models in question.

POINT ESTIMATES

5.36 Many of the outputs that are provided by stochastic models take the form of point estimates of values that depend on underlying probability distributions. Examples of such point estimates include, but are not limited to, means, medians, modes, percentiles, standard deviations, values at risk (VaRs), and tail values at risk (TVaRs). In some cases these outputs may then be used as assumptions in other models.

5.37 In most cases, there is considerable uncertainty about the underlying distributions. Neither the form of the distribution (such as gamma, Normal, or Pareto) nor its parameterisation can be known with certainty. There is often some data that can be used, but in many cases it is insufficient to provide high levels of confidence in the fitted distribution. It is possible to come up with data sets for which two distributions, having very different forms, provide equally good fits. It is especially rare to have sufficient data to provide good estimates of the tails of distributions (see also paragraph 7.32).

5.38 Under these circumstances, a significant level of judgement has to be used in estimating the mean, standard deviation, VaR or any other such value. For example, the length of the distribution's tail is often underestimated. People find it very difficult to reason about the very low levels of probability that are encountered in the tails of distributions. In addition, overall reasonability checking in the context of current experience may exacerbate the problem since by their nature the events or phenomena in the tails of distributions have not generally been experienced. If a longer tail generates outputs that appear to be out of line with current experience (for example by indicating the need for large increases in the capital required to support the business) it may be tempting to produce plausible reasons why the tail should, after all, be shorter.

5.39 The judgements involved in selecting these point estimates will, like other judgements involved in the modelling process, be subject to the principle proposed in paragraph 3.27. In addition, such judgements may be based on assumptions, including those concerning the form of the underlying distribution. As discussed in paragraph 5.9, the reporting TAS is expected to require the disclosure of material assumptions.

5.40 Point estimates, as well as being the outputs of stochastic models, may be used as assumptions in both deterministic and stochastic models. They may be derived from models of varying levels of sophistication and complexity, from judgement, or from a mixture of the two.

5.41 Although rigorous computations of statistical estimates are rarely possible, given the uncertainties surrounding the underlying distributions (as discussed in paragraphs 5.37 to 5.38) the BAS believes that it is important to have a clear goal. For example, actuarial models often require assumptions to be made about interest rates. If the model requires a single assumption that is intended to represent the average rate over the long term, clarity is needed over what is meant by this.

5.42 The BAS therefore proposes the following principle for inclusion in its modelling TAS:

> All estimates derived from model outputs, or used as assumptions in models, should be given statistical definitions and those definitions should be documented. Actuarial information should include explanations of the estimates and of their implications.

5.43 A statistical definition may well not convey all the necessary information to the user about what an estimate represents and its implications. For instance, it is often important that users understand that a Value at Risk (VaR) is not the maximum loss that is possible with the stated probability, but is the level of loss that is expected to be exceeded with that probability.

5.44 If there is uncertainty surrounding assumptions, they are estimates and therefore subject to the principle in paragraph 5.42, regardless of the model in which they are used. For example, assumptions about future levels of mortality may be used in a deterministic model (ie one that does not produce information about the probability distribution of possible outcomes). However, future levels of mortality are unknown and so the assumptions are estimates.

BEST ESTIMATES

5.45 The term *best estimate* is one that is often used when describing the intended outputs of a model or assumptions that feed into it. The term is widely used in legislation, regulations, and accounting and actuarial standards, but is not always defined. Other terms that are used, with similar (and sometimes identical) meanings, are *central estimate*, *current estimate* and *reasonable estimate*. As with all forms of point estimates, best estimates are only necessary if there is some uncertainty surrounding the quantity in question. If the quantity were known for sure, the actual value could be used and there would be no need for an estimate.

5.46 In an actuarial context, *best estimate* is often defined as the mean[11] of the possible outputs (or assumptions). It has been used in this sense in a paper on best estimates in the context of Solvency II (prepared for the Treasury by an actuarial working group), and in the Solvency II Framework Directive. The CFO Forum's *Market Consistent Embedded Value Principles* also use the mean, and it appears that IFRS will do so as well. Several research papers in the field of General Insurance, and GN20 (which applies to Lloyd's), also define *best estimate* as a mean.

5.47 In other cases, *best estimate* is undefined but is often interpreted as the median[12] of the possible outputs or assumptions – for example, the BAS understands that most practitioners interpret the "best estimate of the initial cash equivalent" in the 2008 transfer value regulations as a median estimate of the cash equivalent.

5.48 *Central estimate*, a term sometimes used by those wishing to avoid the pitfalls associated with the use of *best estimate*, is also ill-defined. It can mean any one of mean, median or mode.

5.49 *Reasonable estimate* is usually used in the context of the Casualty Actuarial Society concept of a *range of reasonable estimates*. The latter term has a number of possible meanings, including the range of estimates that are considered reasonable by a given person, or the possible range of estimates produced by reasonable people, but they all depend on a definition of *reasonable* which is not supplied.

5.50 One view is that a *best estimate* is one that minimises a loss function describing the utility of the possible outputs or assumptions. Such a loss function may be very complex, especially if it takes into account all the different possible users of the outputs. In practice, the BAS is not aware that loss functions are ever used in deriving best estimates in actuarial work. In this view, the best estimate will depend on the use to which the outputs will be put, as the loss function depends on the user. This would mean that, for example, the best estimate of future mortality rates for a given group of people would be different if it was to be used for valuing annuities held by

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[11] The *mean* of a set of numbers, each of which has a probability attached to it, is the probability-weighted average. The mean is sometimes called the *expected value*.

[12] The *median* of a set of numbers, each of which has a probability attached to it, is the value that has a 50% chance of being exceeded.

members of the group from that which would be used for valuing life insurance policies.

5.51 Another view, more consistent with the everyday (non statistical) use of the term, is that the *best estimate* should be independent of the use to which the outputs or assumptions will be put. On this view, the best estimate of future mortality rates for a particular group of people over a particular period of time would be the same whether the rates were to be used for annuities or life insurance policies. The BAS is minded to take this view, and proposes the following principle:

> Outputs or assumptions that are described as best, central or reasonable estimates, or other similar terms, should be derived using methods, assumptions and judgements that are independent of the purpose of the model.

Means and medians

5.52 If a statistical measure is to be used to define what is to be used as a best estimate, the three principal possibilities are the mean, median or mode[13] of the possibilities. Each of these can be applied to either the assumptions or the outputs. For example, if the goal is a best estimate of a VaR, the estimate to be used could be the VaR derived by using, for each assumption, the mean of the possibilities, or it could be the mean of the possible VaRs. The two are by no means always equivalent.

5.53 The BAS has found no consensus on the issue of whether the mean or median is the most appropriate statistical definition to use for a best estimate (there appear to be few, if any, proponents of the mode). Both the mean and median have advantages and drawbacks.

5.54 In many areas in which actuarial models are used, distributions cover only positive values and are very skew[14], with long tails. Under these circumstances the median is significantly less than the mean, so many people favour using the mean in order to give full, probability-weighted, recognition to the less likely outcomes. Moreover, the mean is additive, whereas for skew distributions the median of the distribution of (A+B) will be greater than the sum of the median of (A) and the median of (B).

5.55 On the other hand, many models involve non-linear (eg logarithmic) transformations of input variables, for which the use of the mean of the input variables does not give the mean output variable. The median is invariant under the transformations that are often used. If the inputs are means of symmetric distributions (ie distributions for which the mean and median are the same) and logarithms are involved, the output will be the median but not the mean.

[13] The *mode* of a set of numbers, each of which has a probability attached to it, is the one with the highest probability.

[14] A *skew* distribution is one that is asymmetric. The *tails* of a distribution are the parts at either end, in which the outcomes are relatively unlikely. A long tail is one that covers a wide range of values.

5.56 In many cases, there is significant uncertainty about the form of the underlying distribution. Under these circumstances, the estimation of both the mean and median (and, indeed, many other statistics – see paragraph 5.36) is fraught with difficulty and will invariably involve much use of judgement. Some people believe that it is easier to estimate the median of an unknown distribution than it is to estimate the mean.

Defining best estimates

5.57 In the light of these conflicting factors, the BAS does not believe that it is practicable to use a single definition of *best estimate* for all work falling within the scope of its standards. However, it does believe that it is important that the users of actuarial information should have a clear understanding of what the estimates (whether assumptions or outputs) presented to them represent, including their implications. This is the case whether the estimates are presented as best, central, or indeed any other kind of estimates. The principle proposed in paragraph 5.42, that estimates should be defined and explained, would apply to best estimates.

5.58 The generic modelling TAS will apply across a wide range of work. There may be some areas of work in which a particular definition of best estimate, such as the mean or median, is to be preferred. The BAS expects that the TASs specific to practice areas which it will develop in due course may address this issue.

BIASED ESTIMATES

5.59 It is not always best estimates that are used in actuarial work. In some cases prudent estimates are required, or other estimates that are not best or central estimates may be used for various reasons.

5.60 The principle proposed in paragraph 5.42, that estimates should be defined and explained, would apply to biased estimates as well as to best estimates.

Prudence

5.61 The possibility or desirability of using prudent estimates only arises because of the uncertainty surrounding the estimates in question. If it were known in advance precisely what would happen, the actual outcomes could be used instead of estimates, and no allowance would need to be made for potential differences between estimates and actual outcomes.

5.62 In many cases current actuarial practice in respect of prudence stems from the requirements of regulators or accounting standard setters. For example, FSA rules require insurance firms to include appropriate margins for adverse deviation in determining mathematical reserves,[15] and pensions regulations require trustees to consider whether, and if so to what extent, account should be taken of a margin for adverse deviation when choosing prudent economic and actuarial assumptions.[16]

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[15] Eg PRU 7.3.10R(4) and PRU 7.3.13R.

[16] Eg Occupational Pension Schemes (Scheme Funding) Regulations 2005, sub-paragraph 5(4)(a).

5.63 With the development of more risk sensitive methodologies the current trend is for both regulators and accounting standard setters to move away from requiring margins for adverse deviation in assumptions for valuing liabilities, determining capital requirements and assessing solvency. Instead, there are requirements for economic, realistic market consistent values or “fair values”, together with the calculation of current or best estimates and explicit capital requirements.

5.64 Unlike best estimates (see paragraph 5.51), prudence depends on context and, especially, the purpose of the model in question. In actuarial work prudence in the selection of outputs, or the use of prudent assumptions, is usually taken to be the deliberate skewing of outputs or assumptions to give more weight to adverse outcomes. This is a more onerous requirement than mere carefulness, which can be the meaning of prudence in other contexts. For example, when setting technical provisions for annuities, it is prudent to under-estimate future rates of mortality, as lower mortality will result in more annuity payments. When setting technical provisions for term life insurance, on the other hand, it is prudent to over-estimate future rates of mortality, as high mortality will result in more payments of sums insured.

5.65 Prudence may be applied in a number of ways – for instance, by choosing prudent assumptions, or by applying an adjustment to the best estimate output. The degree of prudence can also vary widely.

5.66 The BAS believes that it is impractical to use a single definition of prudence for all work falling within the scope of its standards. It intends that prudent estimates will, like any other point estimate, be subject to the principle proposed in paragraph 5.42.

5.67 It has been suggested to the BAS that the equivalent best estimate should be presented alongside every prudent estimate. This suggestion is clearly intended to assist the users of actuarial information, as it would help them in forming their own opinion of the degree of prudence that is present. The BAS is interested on hearing respondents’ views on this, especially from users of actuarial information. It would also be interested in respondents’ views on the practicality of such a requirement.

MEASURING RISK AND UNCERTAINTY

5.68 Whatever the type of model that is being used, there is likely to be some uncertainty surrounding its outputs. There are a number of ways in which risk and uncertainty can be measured and communicated.

5.69 Stochastic models (ie models that produce information about the probability distributions of possible outcomes) are specifically designed to measure risk and uncertainty, and have a number of advantages. However, they also have limitations – a stochastic model can only measure the risk and uncertainty that is represented within it.

5.70 In particular, no stochastic model (or any other kind of model) can measure uncertainty that is inherently unquantifiable. As models are increasingly used to investigate the likelihoods and effects of unusual events and circumstances, this limitation may be extremely significant in some cases.

5.71 However, even when uncertainty cannot be measured either because it is inherently unquantifiable or because the information that would be needed in order to quantify it is not available, it may be possible to provide useful information about it.

5.72 Stress and scenario testing are often useful tools in this context. There are some difficulties associated with their use: for instance, it is often difficult to estimate the probability of rare scenarios, and rare scenarios may involve unusual correlations.

5.73 Stress (or sensitivity) testing is the process of varying the values of individual parameters in order to investigate the effects on the outputs of the model. It can be used to identify parameters to which the outputs are particularly sensitive, and thus to identify significant sources of uncertainty in the outputs.

5.74 In a scenario analysis, a wide range of parameters are varied at the same time in order to simulate a specific turn of events, such as a stock market slump, a dramatic change in demography, or natural catastrophes. Scenarios can be used to investigate the effects of several rare occurrences happening simultaneously.

5.75 Scenarios are often useful in assisting users of actuarial information to understand the outputs of models. For example, one of the outputs of models exploring the capital requirements of insurance companies is often the magnitude of the total losses that will only be exceeded in, say, one out of every two hundred years. Presenting a scenario that results in losses of that size may help users to understand the level of the rarity that one in two hundred implies (but see also paragraphs 6.51 and 7.32).

5.76 Although scenarios may not always be able to assist in the quantification of uncertainty, they are often helpful in analysing its effects and implications. For instance, the FSA expects insurers to identify plausible scenarios that they would wish to survive with no change to business plans, scenarios which would trigger a realignment of the business strategy and scenarios that would lead to financial failure.

5.77 The BAS's generic reporting TAS is expected to include a requirement that actuarial information should include an indication of any material uncertainty inherent in the information.

Ranges

5.78 By their very nature point estimates of outcomes, such as most of those listed in paragraph 5.36, provide only limited information about the possibilities. A mean, for example, may be the expected value in the statistical sense, but (depending on the distribution) there may be many other outcomes that are equally or nearly as likely.

5.79 A common way of providing more information than is possible using a point estimate is to use a range. Ranges are often very useful in helping to explain the level of possible variability in the outcomes. However, there is a danger that the use of a range may provide a spurious impression of accuracy. In many cases, the end points of the range depend on the same types of assumptions about the form of the underlying distribution as does the point estimate itself – indeed, the end points are themselves point estimates.

5.80 The BAS would wish to encourage the use of ranges, when they are appropriate, as it believes that in most cases the advantages outweigh the disadvantages. However, it believes that it would be impractical to require the use of a range alongside every single point estimate, and is therefore not proposing that a principle to that effect should be included in the modelling TAS.

5.81 If a range is used, it is important that there is clarity surrounding what it represents and its limitations. For example, the end points of the range may be minimum and maximum values that are possible, or the range may be such that it is centred on the point estimate with the possible values being equally likely to fall inside the range as outside. The possibilities are infinite.

5.82 As the end points of a range are themselves point estimates, they would be subject to the principle proposed in paragraph 5.42.

Section **5** discusses ways of meeting the objective that actuarial information should include explanations of how the inputs to models are derived and what the outputs from models are intended to represent.

Paragraphs 5.11 to 5.19 describe how shortcomings in data may affect models. The BAS is proposing that the modelling TAS should require documentation of the approaches used to estimate or compensate for the effects of data shortcomings. However, the BAS is not proposing to require specific documentation of the existence of known or suspected shortcomings, as it believes that the requirements that are expected to be included in the reporting TAS will be sufficient.

Paragraphs 5.20 to 5.30 discuss the grouping of data and its possible effects. The BAS is proposing that the approach taken to grouping should be documented, and that the material effects should be explained. The BAS does not believe that it would be practicable to require that the effects should be quantified.

Paragraphs 5.31 to 5.35 discuss the need for assumptions to be consistent, both within a model and across a suite of models used together.

Paragraphs 5.36 to 5.44 describe how point estimates may be either assumptions or model outputs, and proposes that all estimates used in or derived from models should be given statistical definitions.

Paragraphs 5.45 to 5.58 describe a number of issues relating to best estimates. The BAS does not believe that it is practicable to use a single definition of *best estimate* for all working falling within the scope of its standards. However, it does believe that best estimates should be independent of the purpose of the model. Paragraphs 5.59 to 5.67 discussed biased estimates. Prudence is a form of bias, and depends on context.

Paragraphs 5.68 to 5.82 discuss approaches that can be taken to risk and uncertainty. Although the BAS would wish to encourage the use of ranges when they are appropriate, it is not minded to require that they be always used.

The BAS would welcome responses to the following questions:

7. **Do respondents have any comments on the proposals concerning inputs and outputs that are presented in section 5, especially those in paragraphs 5.17, 5.28, 5.29, 5.35, 5.42 and 5.51?**

8. **Should the modelling TAS include:**
   a) **any requirements relating to the disclosure of known or suspected shortcomings in data, over and above those expected to be included in the reporting TAS?**
   b) **requirements to provide an estimate of the effects of any data shortcomings, and that any compensating adjustments should avoid bias?**

9. **Should the modelling TAS include a requirement that, if data is grouped, the effects of the grouping should be quantified?**

10. **Do respondents agree that best estimates (and other similar estimates) should be independent of the use to which they will be put?**

11. **Do respondents have any views on:**
    a) **whether biased estimates such as those concerning prudence depend on context?**
    b) **the practicality or otherwise of requiring that the equivalent best estimate be presented alongside every prudent estimate, and the benefits to users of actuarial information of doing so?**

12. **Do respondents have any views on the practicality or otherwise of requiring the use of a range in conjunction with every single point estimate?**

6 FIT FOR PURPOSE

INTRODUCTION

6.1 The third part of the proposed purpose of the modelling TAS, as set out in paragraph 2.9c, is that actuarial information should be based on models that are fit for purpose.

6.2 By this, the BAS means that the model outputs that are included in the actuarial information will assist the user of the information – that they will be relevant to the decisions that are to be made, and will be informative. This will be the case if the theoretical construct is suitable for the use to which it is being put and has been implemented correctly, and if the specific realisations that produce the outputs are themselves suitable – in other words, they are based on appropriate assumptions and data.

6.3 This section starts with a general discussion of checking models, and the need to keep doing it. It goes on to discuss the notion of reproducibility, which is a prerequisite for checking of any kind, and particular considerations that apply when checking theoretical constructs, practical implementations and specific realisations. There is a discussion of the checks that should be applied to models that have been obtained from external suppliers, and the section concludes with discussions of the concepts of robustness and reasonableness, both of which have been suggested as important components of fitness for purpose.

CHECKING MODELS

6.4 The outputs of a model may fail to be those that were intended because of problems with any of the three aspects – the theoretical construct, practical implementation or specific realisation. Likewise, any of the three aspects can be *checked* – reviewed or tested in order to look for unintended behaviour.

6.5 The BAS believes that checking is vital if models are to be fit for purpose. However, checking is not effective unless it covers all the areas in which problems are possible. The easiest checks to perform are not necessarily the ones that are most likely to be productive.

6.6 An awareness of the checks that have been performed assists in understanding the possible limitations of models. If a particular aspect has not been checked, it is not possible to state with confidence that the relevant outputs are valid.

6.7 It is not enough to check any aspect of a model just once. Models are dynamic, used for different purposes, at different times, and with different data. They may be changed to correct errors, to add new functionality, to improve their ease of use or for some other reason. They should be checked each time they are used, although the checks that are performed may vary depending on the circumstances.

6.8 The BAS therefore proposes the inclusion of the following principle in its modelling TAS:

> A set of checks should be constructed and performed whenever a model is used in order to determine the fitness for purpose of the theoretical construct, practical implementation and specific realisations. The checks that have been performed on a model should be recorded and documented. The documentation should include the objectives of the checks.

6.9 The BAS recognises that there are many advantages to checking being performed by someone other than the model developer. However, this is not a technical actuarial matter and is therefore not within the BAS's remit.

REPRODUCIBILITY

6.10 A *reproducible* model is one that can reproduce exactly the same outputs from strictly identical inputs. A practical implementation or specific realisation that is not reproducible cannot be checked. Another aim of reproducibility is to ensure that the model in question is stable. It may be impossible to determine how the outputs change, if at all, with any change in the inputs if the model is not reproducible.

6.11 The BAS believes that all types of models, including those that use Monte Carlo simulation, can be reproducible. For instance, a way of ensuring reproducibility for Monte Carlo simulations is to use a random number generator that can be seeded in order to generate the same sequence of pseudo-random numbers on demand. If this is done, the implementation is fully reproducible. If for any reason random numbers cannot be reproduced, reproducibility can be achieved through the ability to run the model on a deterministic basis, to check whether the calculations are correct for a given set of random numbers. Combined with the use of enough simulations to provide stability in the overall outputs, it is then possible to say that the overall realisation (ie the outputs generated by analysing all simulations in the set) is reproducible.

6.12 The BAS believes that the checking of models is vital, and therefore proposes the following principle for inclusion in its modelling TAS:

> Practical implementations and specific realisations of models should be reproducible.

THEORETICAL CONSTRUCT

6.13 Model validation[17] is the process of determining how closely the theory represented in the model matches the reality that is being modelled. However, validation can only ever determine how closely the model fits the past, whereas models are often used to inform decisions about the future. The fact that a model is an accurate reflection of past experience does not imply that it will match future experience equally closely. Indeed, ensuring that the model is a close match to the recent past may preclude reflection of the

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[17] The sense in which the term *validation* is used in the context of Solvency II is rather broader than that described here.

future, if major changes occur in the real world whose possibility has been excluded in the model because of the way in which it has been set up.

6.14 It is difficult to separate the validation of the theoretical construct from the calibration of parameters or the testing of the practical implementation. Any method of model validation that requires a practical implementation may expose errors in the implementation as well as problems with the underlying theoretical construct. One way of checking the underlying theory without depending on the correctness of the implementation is to review it. Reviews can vary enormously in thoroughness and in the extent to which they rely on the judgement of the reviewer.

6.15 There are a number of validation techniques that can be used. Their feasibility and utility depend on both the characteristics of the model being validated and the availability of data. In order for any type of model validation to be feasible, the model must make predictions that are in principle observable in the real world.

6.16 A common approach is to use back testing, in which the model is used only on the data that was available at a particular date in the past. The outputs from the model are then compared to what actually occurred in the period after the date in question. Back testing goes beyond merely testing how well the model fits past data, as it provides a test of the model's predictive performance. However, although back testing is often useful, and is often thought to be essential, it is not on its own enough to determine that a model is fit for purpose.

6.17 It has been suggested to the BAS that its modelling TAS should include a principle that back testing should always be performed. We would appreciate respondents' views on whether there are any models for which back testing is impossible, and on any practical difficulties that might arise if back testing were to be a requirement in the TAS.

6.18 A less direct method is to analyse the differences between the outputs generated by the model at two different dates in the light of the actual events that have occurred in the meantime. In life insurance and pensions this procedure is often known as an analysis of surplus. The BAS's reporting TAS is expected to contain a requirement that actuarial information contain a comparison, explaining the differences, of the outcomes of any quantification exercise with the outcomes from the previous occasion (if any) on which the equivalent exercise was carried out.

6.19 Sometimes it may be possible to derive an independent estimate of one or more of the model outputs. If there is a good agreement between the model prediction and the independent estimate, this helps validate the accuracy of the model.

6.20 The BAS proposes that the modelling TAS should include the following principle:

> The reasons for believing that the theoretical construct of a model is a satisfactory representation of reality should be documented.

6.21 The principle proposed in paragraph 6.8 would apply to any checks that have been performed and that contribute to the belief that the theoretical construct is a satisfactory representation of reality.

PRACTICAL IMPLEMENTATION

6.22 One way of ensuring the validity of the outputs generated by a model is to ensure that the practical implementation is correct for all valid inputs. This can be done by *testing* the implementation – controlled execution with inputs for which the expected outputs are known.

6.23 There are many types of testing that may be useful, including unit testing (testing individual components) and regression testing (comparing the results after a change to those that were produced from the same inputs before the change). Each type of testing has its own limitations. For example, regression testing will not identify problems that were present in the previous version as well as in the current version.

6.24 Sensitivity testing is the process of varying the values of individual parameters to investigate the effects of doing so on the outputs of the model. (When this process is used in the measurement of uncertainty it is usually known as stress testing – see paragraph 5.73.) It can be used to check the fitness for purpose of a practical implementation by observing the sensitivity of one or more outputs to a particular parameter. Unexpected over-sensitivity or insensitivity to a parameter may indicate that the implementation contains errors. Alternatively, it may indicate faulty expectations on the part of the person doing the checking (see also paragraphs 6.44 to 6.52 and paragraphs 7.28 to 7.29).

6.25 The fitness for purpose of a model implementation is a judgement based partly or wholly on the checks that have been performed. Like other judgements concerning models, it should be reassessed from time to time (see paragraph 3.25). Those making the judgement should be aware that changes to implementations that are thought to be insignificant may in fact not be so, if they result in the introduction of unsuspected errors.

SPECIFIC REALISATION

6.26 The fitness for purpose of a specific model realisation generally depends on both the implementation and the specific assumptions and data that it uses.

Correct use of data

6.27 A not uncommon source of problems with models is the misuse or misunderstanding of data. This often occurs because it is not clear what the data actually represents. For example, data on beneficiaries (policyholders or pension scheme members) may include age (rather than birthday). If the age is actually age at the nearest birthday, but is assumed to be age at the last birthday, the model outputs will be wrong.

6.28 The BAS therefore proposes that the modelling TAS should include the following principle:

> The definitions of all items of data that are used in models should be documented.

6.29 The same model may be used with data from the same source but drawn up at different times or for different purposes. However, two similar sets of data from the same source may have differences in detail. The requirement in paragraph 6.28 would apply to each data set that is used, regardless of whether it closely resembles another data set.

Data outliers

6.30 A data outlier is a data point that is significantly different from other data points in some way. There are two possible reasons for their occurrence. First, they may represent data errors – either errors in the information for the data point in question, or the omission of other, similar, data points. Second, they may be genuine – in other words, the information about the data point in question is accurate, and the data set is complete. In the latter case, it might be thought that the outlier is an anomaly, for example if it represents an event that it is thought cannot happen again in the future. However, one can seldom be certain that something can definitely never occur; and even though a particular event or combination of circumstances may not occur, it may be more realistic to view the outlier as an instance of a more general class of events which, although individually unlikely, are much more likely as a group (see also paragraph 4.6).

6.31 The presence of outliers may be an indication of underlying data errors. Simply accepting them or removing them without investigation may therefore detract from the model's fitness for purpose. On the other hand, the absence of outliers may in some circumstances indicate data errors.

6.32 The removal of genuine outliers may have significant effects on the outputs, as the data will then be incomplete. However, in some circumstances it might be appropriate to remove them from one or more specific realisations, for example in order to quantify the effect of their presence.

6.33 The BAS therefore proposes the following principle for inclusion in its modelling TAS:

> If outliers are removed from the data used for a specific realisation other than because they are erroneous, the reasons for their removal should be documented, and the actuarial information should include an explanation of the implications.

Inputs derived from models

6.34 In many cases outputs from one model may be used as inputs to another model, or as information on which inputs to another model are based. For example, a mortality model may be used to supply assumptions about mortality rates that are used in a model of pension scheme liabilities. The various models may not be developed by the same team, and indeed the model that is used to produce inputs for another model may well be obtained from an external supplier (see paragraphs 6.36 to 6.38).

6.35 The BAS believes that it is important that material uncertainties surrounding inputs to models should be explained in actuarial information whether those inputs consist of data (see paragraph 5.6) or assumptions (see paragraph 5.9). This applies equally to inputs that are themselves the outputs of other models.

EXTERNAL MODELS AND FRAMEWORKS

6.36 In many cases models, or modelling frameworks, are obtained from external suppliers. The outputs from these external models may be used as inputs to other models or may themselves be the outputs communicated to the users of actuarial information.

6.37 Modellers usually cannot understand a model obtained from an external supplier in as much detail as one that they have constructed themselves. In many cases this is because some information about the external model is not available to its users in order to preserve the intellectual property rights of the model developer. However, the objectives set out in paragraph 2.9 are independent of the provenance of the models on which actuarial information is based. The use of an external model will not provide exemption from compliance with the modelling TAS.

6.38 It follows that the users of external models should document the judgements they make, the checks that they perform and other relevant matters, and include explanations of the derivation of the inputs, what the outputs represent and significant limitations, in just the same way as they would for models that they themselves have developed. The judgements and the grounds on which they are made may differ from those that are made in respect of internally developed models, but the need to make them remains. Similarly, the checks that are performed are unlikely to be the same as those performed on an internally developed model.

6.39 Because materiality depends on the use to which the information will be put, in the form of the decisions that will be made based on it, the relevant documentation and explanations will not be the same for all uses of the external model (see also paragraphs 2.30 to 2.31).

6.40 The BAS believes that this requirement should not discourage the use of external models. In some areas external models are readily available and have been developed with the use of specialist expertise. In such cases the use of an external model would be likely to result in better quality actuarial information than the use of a model developed internally by those without the relevant expertise. Common examples of external models that are used in the preparation of actuarial information include natural catastrophe models (requiring expertise in the natural hazard itself, vulnerability to the hazard of the insured objects and the details of the financial structure of insurance coverage) and economic scenario generators.

ROBUSTNESS

6.41 It has been suggested to the BAS that the modelling TAS should include requirements covering the robustness of models.

6.42 A *robust* model is usually considered to be one whose outputs are insensitive to minor changes in the inputs. For example, some mortality models are sometimes considered to be insufficiently robust because they are oversensitive to the most recent mortality rates that have been experienced (the “edge effect”). However, what is meant by a minor change in the inputs (ie one to which the outputs should not be too sensitive) depends very much on context.

6.43 The BAS does not believe that robustness should be required of all models. Some models are deliberately designed not to be robust, but are nevertheless extremely useful. In some cases, extreme sensitivity to certain inputs is a positive virtue, rather than a drawback. For example, the weather at any point in the future is extremely sensitive to the conditions now, and weather forecasting models are designed to reflect this sensitivity. The use of robust models may result in fewer extreme events appearing in model outputs, or a failure to model fundamental changes in the regime underlying the phenomena of interest.

REASONABLENESS

6.44 It has also been suggested to the BAS that the modelling TAS should include requirements covering the reasonableness of assumptions and the need to check the overall reasonability of models.

6.45 The terms *reasonable* and *reasonableness* are used in several other contexts in modelling, for instance in connection with assumptions or with checks that should be performed on models. Statements such as the need for reasonable assumptions seem eminently sensible when taken at face value. However, it is easy to find examples of situations in which a requirement for reasonableness would lead to unreasonable results.

6.46 For example, in the mid 1970s the inflation rate rose above 25%. Such a forecast, if produced even a few years earlier, would not have seemed remotely reasonable in the light of past experience even though it would have turned out to be accurate. But people who based their analysis on movements in the money stock would have forecast high rates of inflation.

6.47 A requirement that assumptions or outputs are reasonable is likely to mean that it is only current or recent experience that is reflected in models, as it is only too easy to consider an assumption or output that lies outside current experience as unreasonable. Models that rely on assumptions that are thought to be reasonable, and that pass overall reasonableness checks, are therefore likely to have only a limited range of outputs. In particular, they are unlikely to reflect the possibility of significant changes in underlying conditions from those prevalent at the time the model is developed.

6.48 On the other hand, there are at least two desirable characteristics of models and modelling that are difficult to express without the use of a term such as *reasonable*.

6.49 First, when checking a model the relationship between its inputs and outputs should be investigated. The checks depend on some sort of preconceptions about what the relationship should be – for example, in most financial models a change in the inflation rate from 0% to 5% should, all other things being equal, have a significant effect on many of the outputs.

6.50 Second, it may be thought undesirable for an extreme scenario, such as one that is intended to be at the 1-in-200 level or less, to be set at a level that has actually occurred in the recent past. For example, the UK equity market fell by 55% in 1974, so that positing the 1-in-200 level at 40% may be understating the potential problems. Inflation is another area in which we might expect recent or current experience to be reflected when considering possible extreme scenarios. Current experience includes annual inflation rates of many millions percent in Zimbabwe, 25% in Pakistan, 15% in Russia, and 12% in Turkey and Indonesia. In Britain, inflation was between 15% and 20% in the late seventies and early eighties, only thirty years ago.

6.51 Judging the reasonableness of any assumption about low probability events or circumstances is extremely problematic (see also paragraph 7.32). For example, suppose that we have 200 years of data. The chance of observing an exactly one 1-in-200 year event in this data is 0.37. The chance of observing either no such events, or more than one, is therefore 0.63 – nearly double that of observing the "correct" number.

6.52 In view of all these problems, the BAS believes that notions of reasonableness are clearly important, but that any requirements for reasonableness that might be included in the modelling TAS would not be enforceable and could be dangerous. It is therefore intending not to include such requirements.

Section 6 discusses ways of meeting the objective that actuarial information should be based on models that are fit for purpose both in theory and practice.

Paragraphs 6.4 to 6.9 explain why the BAS believes that the checks that have been performed on models should be recorded and documented, and paragraphs 6.10 to 6.11 set out the reasons for requiring models to be reproducible.

The types of checks that can be performed on theoretical models and model implementations are covered in paragraphs 6.13 to 6.25. Specific model realisations depend on data and assumptions as well as on implementations (paragraphs 6.26 to 6.35). Some issues surrounding the use of external models and frameworks are discussed in paragraphs 6.36 to 6.40.

The concept of robustness and whether it is required in order for models to be fit for purpose is discussed in paragraphs 6.41 to 6.43.

The concept of reasonableness and how it might be used in judging the fitness for purpose of models is discussed in paragraphs 6.44 to 6.52.

The BAS would welcome responses to the following questions:

13. Do respondents have any comments on the proposals concerning the fitness for purpose of models that are presented in section 6, especially those in paragraphs 6.8, 6.12, 6.20, 6.28 and 6.33?

14. Are there any types of model that cannot be implemented in such a way that they exhibit reproducibility?

15. Should the modelling TAS include a principle concerning back testing?
  a) Are there any models for which back testing is impossible?
  b) Are there any practical difficulties that might arise if back testing were to be a requirement?

16. Would it be desirable and practical for users of external models to document the judgements they make, the checks that they perform and other relevant matters, and include explanations of the inputs, outputs and limitations in the same way as they would for models that they themselves have developed? Respondents who believe that this would not be practical should suggest alternative ways in which the objective set out in paragraph 2.9 could be met by users of external models.

17. Do respondents agree that requirements for robustness and reasonableness would not be enforceable and could have undesirable consequences?

7 LIMITATIONS OF MODELS

INTRODUCTION

7.1 The fourth part of the proposed purpose of the modelling TAS, as set out in paragraph 2.9d, is that actuarial information should include explanations of the significant limitations of the models that have been used.

7.2 Models are invariably simplifications of the real world, with a variety of limitations. For their outputs to be used effectively, the limitations should be clearly understood. Many limitations are very general in nature, applying to all models; others are specific to the individual model in question.

7.3 The limitations of models depend crucially on the purposes for which those models are being used. A feature that is a virtue in one context may be a significant limitation in another.

7.4 The existence of limitations, often extremely significant ones, should not undermine the use of models and the presentation of their outputs. Despite their problems, models provide useful information which cannot be obtained in any other manner. However, it is important that those making decisions based on the outputs of models realise what it is that those outputs are intended to represent.

7.5 The checks that are performed to determine the fitness for purpose of models may highlight limitations in them (see paragraphs 6.13 to 6.35), but may well not expose weaknesses that have not been foreseen by either the model developer or checker.

7.6 The principal reasons that will cause model outputs to deviate from what happens in the real world are modelling error, parameter error, random variations, data error and errors arising from expert judgements. We discuss each in turn.

MODELLING ERROR

7.7 Modelling error occurs when an inappropriate theoretical construct is used, or when the practical implementation or specific realisation does not reflect the theoretical construct.

Theoretical constructs

7.8 To take theoretical constructs first, there will always be aspects of the real world that are not covered by the model because the modeller is unaware of them, or because they have been judged to be immaterial or too complex. For instance, in a model being used to determine capital requirements for an insurance company, there will always be unknown or unidentified risks that have not been modelled. If any of these risks crystallise and are material, the actual outcome will differ materially from the model outputs.

7.9 If a model has been designed in order to address a very narrowly defined problem there are likely to be many aspects of the real world that it does not cover. For example, a model that is intended to investigate the effects of investment returns and inflation on future levels of pension contribution may well not cover aspects such as changes in demographic factors or changes in expense levels. Such a model would have material limitations if it were used for another purpose, such as analysing the possible overall variability in future contribution rates.

7.10 In many of the areas in which models are used in actuarial work, our understanding of the underlying phenomena is incomplete, inevitably leading to model error.

7.11 Any differences between the model and reality are often magnified over time – a model that provides a satisfactory approximation over the short term may be far from accurate over the long term. Many of the models that are used in actuarial work have very long time horizons.

7.12 Modelling error is often particularly significant in unusual circumstances. A model that works well during a period of financial stability may break down during a period of turmoil, as it ceases to correspond to reality. There are many reasons why it may be difficult to develop a theoretical model that handles unusual events and circumstances effectively, not least that each unusual circumstance is different, so there is little data or other information that can help. It is a natural human tendency to over-estimate the extremity of a scenario, leading to models that under-estimate the severity or frequency of extreme events or circumstances (see also paragraphs 4.7 to 4.8 and paragraphs 6.44 to 6.52).

7.13 The recent credit crunch has highlighted the significance of modelling error in theoretical models. Modellers in the 1970s assumed possible levels of inflation much higher than would normally be included in models nowadays. Models often fail to model potential changes in underlying conditions such as these.

Implementations and realisations

7.14 There are usually many different ways in which any given theoretical construct can be implemented. For example, a stochastic model (one that attaches probability distributions to the outcomes) may be implemented either analytically or through Monte Carlo simulations. Many theoretical constructs cannot be implemented exactly, but require numerical approximations to be used, for which a number of different algorithms are available. Different practical implementations will introduce different limitations – for instance, the various algorithms may differ in the conditions under which they produce accurate approximations.

7.15 Even though computers continue to become ever more powerful, computational limitations often affect the level of detail that is practicable. Large Monte Carlo simulations involving many independent variables may take days to run. Computational constraints may therefore result in the use of simpler (although still very complex) models than would otherwise be the case.

PARAMETER ERROR

7.16 Every model realisation depends on parameters that are used to align the theoretical framework with the concrete situation in which it is applied.

7.17 Numerical parameters such as those describing probability distributions are often derived from a separate modelling exercise that involves analysing data. Inevitable data limitations mean that the parameter values that are used will differ from the theoretical values. In some cases, there may be few if any robust techniques available for deriving parameters from data. This is especially likely in the case of the more advanced theoretical models.

7.18 Data is likely to be especially scarce or unreliable in the tails of distributions, making parameter error both more likely and more significant in those areas.

7.19 Model outputs are more sensitive to some parameters than to others. Shortcomings in the parameters to which the outputs are less sensitive are therefore less significant limitations of the model.

RANDOM VARIATION

7.20 In most areas of the real world covered by models, the outcomes are not fully determined – there are random variations. For example, even the knowledge of the true underlying rates of mortality would not enable an accurate prediction of the number of deaths in a given year to be made. This means that, regardless of the type of model being used, deterministic or stochastic, the model outcomes are most unlikely to be borne out in practice.

7.21 This phenomenon is often known as *process error*, and it becomes more significant if the model is one in which the outcome in one period influences the outcomes in later periods.

DATA ERROR

7.22 Inaccurate or incomplete data can affect the model outputs in several ways (see paragraphs 5.11 to 5.15). As well as affecting model parameters, as discussed in paragraphs 7.16 to 7.19, they can mean that the model fails to start from a position that matches reality.

EXPERT JUDGEMENT

7.23 Expert judgement may be used in many different ways during the development of a model. The decisions that must be made include the phenomena that should be modelled, fundamental assumptions leading to the choice of model structure, the data and parameters that should be used, and so on. Each decision is a potential source of differences between the model output and reality.

7.24 Judgement may be an especially significant source of differences between the model and reality if the modeller is not familiar with all the modelling techniques being used. There is sometimes a trade off between using a familiar technique and one that is technically superior but less well understood.

GENERAL LIMITATIONS

7.25 The discussion in paragraphs 7.7 to 7.24 can be summarised by observing that all models have the major limitation that their outputs will be valid only if all the assumptions underlying the model are correct.

7.26 The assumptions underlying a model may be either conceptual or quantitative, and are represented in the model in a number of ways, including as input data, formulae, parameters, or algorithms. They may be either implicit or explicit. Assumptions about the factors that are not material, and so need not be modelled, for example, are often implicit. Implicit assumptions are just as likely to affect the validity of the model as explicit assumptions.

7.27 Assumptions may be derived from data or other information, based on a modeller's prior beliefs, or a combination of the two. The BAS's generic TAS on reporting is expected to include a requirement that all material assumptions should be explained to the user, with a justification for their adoption.

7.28 The materiality of assumptions, in other words the extent to which they affect the decisions that are supported by the actuarial information, is closely linked to how much they influence the model outputs. An assumption to which the outputs are extremely sensitive is also likely to be highly material. Sensitivity testing – investigating the sensitivity of model outputs to specific assumptions – is therefore an extremely valuable tool in considering the limitations of models. Many models have enormous numbers of assumptions, so that it might not be possible to perform sensitivity testing on them all, but limiting such testing to those assumptions that are believed in advance to be material may mean that the materiality of other assumptions is overlooked.

7.29 The BAS therefore proposes the following principle for inclusion in its modelling TAS:

> The sensitivity tests that have been performed, and the reasons for performing them, should be documented. The reasons for believing those assumptions (or classes of assumptions) for which sensitivity tests have not been performed to be immaterial or otherwise inappropriate for sensitivity testing should also be documented.

7.30 There are many reasons why model outputs are less likely to match reality in unusual circumstances, as discussed in paragraphs 7.12 to 7.13. In brief, there is, by definition, little information available, and the judgements that are used to compensate for the shortage of information are notoriously fallible. This is an especially significant limitation of the validity of models that are intended to provide information about what might happen in unusual circumstances, or indeed what unusual circumstances or events might occur.

7.31 In this context, the BAS notes that consistency between different models does not necessarily provide comfort that they are reliable. There is sometimes an unwillingness to stand out from the crowd, and the resulting herd instinct may lead to clusters of similar models all sharing the same shortcomings.

7.32 In the future, it is likely that the introduction of Solvency II will mean that much actuarial information used in insurance will be required to use models that produce estimates of various outputs at the 99.5% confidence level. Other regulatory environments require modelling at the 95% confidence level or higher. The levels of uncertainty surrounding such estimates will inevitably be extremely high for a number of reasons, not least of which is that there is very little, if any, relevant data. Indeed, some recent work[18] suggests that even the best possible data allows virtually nothing to be deduced about the 99.5% level of the distribution. In the BAS's view, this uncertainty is a material limitation of models used for this purpose.

USERS OF ACTUARIAL INFORMATION

7.33 The BAS believes that it is important that the users of actuarial information are aware of the limitations and shortcomings of the models on which that information is based, as they can significantly affect the decisions that are made.

7.34 It has been suggested to the BAS that a requirement for explanations of the limitations that apply to all models, such as an explanation that the validity of the outputs of models depends on that of the assumptions that have been used to produce them, or indeed any emphasis on model limitations, could result in communications that are overloaded with provisos and hedges, and give the impression that the information is not to be relied on.

7.35 This would conflict with the BAS's aim that users of actuarial information should be able to place a high degree of reliance on its relevance, transparency of assumptions, completeness and comprehensibility. The BAS's generic reporting TAS is expected to include a requirement that material information should not be obscured by the inclusion of items that are not material or not relevant.

7.36 Another point that has been made is that a requirement for explanations of generally applicable limitations could lead to large amounts of boilerplate text that would be ignored by most readers of the information. The BAS does not accept this argument, believing that actuaries and others who prepare actuarial information are capable of communicating the subject matter in a way that genuinely conveys the necessary information to the reader. The reporting TAS is not expected to require that all information be contained in a single communication, so that it would be open to those seeking to comply with the modelling TAS to refer users to a separate statement of common limitations.

7.37 The BAS believes that, despite their inevitable limitations, models are valuable, even vital, tools in the provision of actuarial information. Indeed, as discussed in the FRC's discussion paper on *Promoting Actuarial Quality*, the BAS believes that the use and interpretation of mathematical models is an underlying feature of actuarial work.

7.38 There are three options open to the BAS.

7.39 The first is to include no explicit principle about model limitations in the modelling TAS, leaving it to those preparing actuarial information to decide whether they include any explanations either of limitations that apply to all models, or of limitations that are specific to the models on which the actuarial information depends. This option would not, in the BAS's opinion, achieve the objective of the modelling TAS as described in paragraph 2.9.

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[18] *The case of the credulous actuary: Rediscovering the importance of judgement*, Mark Graham and Alex Glencross, GIRO 2008.

7.40 The second option, at the other extreme, is to include a principle that actuarial information derived from the outputs of models should always include an explanation of the limitations of modelling, together with explanations of any significant limitations that are specific to the model or models that have been used.

7.41 The third option is to include a principle that covers the necessity of the user understanding the limitations that affect the decisions to be taken, but also covers the benefits provided by using the model or models in question. This should make it less likely that the explanations of the limitations will overshadow the benefits. Such a principle might, for example, take the following form:

> Actuarial information should include an explanation of why the models on which it is based address the needs of the user. It should also include explanations of the material limitations of the models that have been used and their implications.

7.42 The BAS is minded to take the third option, but welcomes discussion of the other two, and suggestions for the form that any principle should take.

7.43 It has been suggested that the modelling TAS should identify specific types of limitation that should be explained in actuarial information. The BAS believes that this would not have the desired effect, as it might lead to the belief that it is only those limitations that the BAS has identified that can be material.

Section 7 discusses ways of meeting the objective that actuarial information should include explanations of the significant limitations of the models on which it is based.

Paragraphs 7.7 to 7.24 describe the principal reasons that will cause model outputs to deviate from what happens in the real world. Paragraphs 7.25 to 7.43 discuss their implications, and the desirability of ensuring that the users of actuarial information are aware of the major limitations without being overwhelmed by irrelevant detail.

The BAS would welcome responses to the following questions:

18. Do respondents have any comments on the proposals concerning the limitations of models that are presented in section 7, especially those in paragraphs 7.29 and 7.41?

19. Does the discussion in paragraphs 7.7 to 7.24 include all the major sources of limitations in models?

20. Do respondents have any comments on the advantages and disadvantages of the options set out in paragraphs 7.38 to 7.42?

21. Should the modelling TAS identify specific types of limitation that should be explained in actuarial information?

8 INVITATION TO COMMENT

QUESTIONS

8.1 The BAS invites the views of those stakeholders and other parties interested in actuarial information who wish to comment on the content of this document. In particular the BAS would welcome views on the following issues:

1 Will the proposed purpose of the modelling TAS as set out in paragraph 2.9 help to ensure that users of actuarial information can place a high degree of reliance on its relevance, transparency of assumptions, completeness and comprehensibility?

2 Will the definition of a model given in paragraph 2.13 encompass the full range of models that contribute to actuarial information?

3 Do respondents have any comments on the proposals in section 3, especially those in paragraphs 3.15, 3.22 and 3.27?

4 Do respondents have any views on the definition of materiality that is proposed in paragraph 3.5?

5 Should the modelling TAS include principles concerning the need for documentation as discussed in paragraphs 3.9 to 3.18?

6 Do respondents have any comments on the proposals concerning relevance and parsimony that are presented in section 4, especially those in paragraphs 4.12 and 4.17?

7 Do respondents have any comments on the proposals concerning inputs and outputs that are presented in section 5, especially those in paragraphs 5.17, 5.28, 5.29, 5.35, 5.42 and 5.51?

8 Should the modelling TAS include:

a) any requirements relating to the disclosure of known or suspected shortcomings in data, over and above those expected to be included in the reporting TAS?

b) requirements to provide an estimate of the effects of any data shortcomings, and that any compensating adjustments should avoid bias?

9 Should the modelling TAS include a requirement that, if data is grouped, the effects of the grouping should be quantified?

10 Do respondents agree that best estimates (and other similar estimates) should be independent of the use to which they will be put?

11 Do respondents have any views on:

a) whether biased estimates such as those concerning prudence depend on context?

b) the practicality or otherwise of requiring that the equivalent best estimate be presented alongside every prudent estimate, and the benefits to users of actuarial information of doing so?

12 Do respondents have any views on the practicality or otherwise of requiring the use of a range in conjunction with every single point estimate?

13 Do respondents have any comments on the proposals concerning the fitness for purpose of models that are presented in section 6, especially those in paragraphs 6.8, 6.12, 6.20, 6.28 and 6.33?

14 Are there any types of model that cannot be implemented in such a way that they exhibit reproducibility?

15 Should the modelling TAS include a principle concerning back testing?

a) Are there any models for which back testing is impossible?

b) Are there any practical difficulties that might arise if back testing were to be a requirement?

16 Would it be desirable and practical for users of external models to document the judgements they make, the checks that they perform and other relevant matters, and include explanations of the inputs, outputs and limitations in the same way as they would for models that they themselves have developed? Respondents who believe that this would not be practical should suggest alternative ways in which the objective set out in paragraph 2.9 could be met by users of external models.

17 Do respondents agree that requirements for robustness and reasonableness would not be enforceable and could have undesirable consequences?

18 Do respondents have any comments on the proposals concerning the limitations of models that are presented in section 7, especially those in paragraphs 7.29 and 7.41?

19 Does the discussion in paragraphs 7.7 to 7.24 include all the major sources of limitations in models?

20 Do respondents have any comments on the advantages and disadvantages of the options set out in paragraphs 7.38 to 7.42?

21 Should the modelling TAS identify specific types of limitation that should be explained in actuarial information?

22 Are there any matters not covered in this consultation paper that should be addressed in the BAS's modelling TAS?

8.2 In addition to the specific questions listed above, the BAS invites respondents' views on any other aspects of the proposed generic TAS on modelling. To ensure that the significance of their point is fully appreciated by the BAS, respondents are asked to indicate how their comments would address the BAS's aim of increasing the reliance that users of actuarial information can place on it.

RESPONSES

8.3 For ease of handling, we prefer comments to be sent electronically to **basmodelling@frc.org.uk.**

Comments may also be sent in hard copy form to:

The Director
Board for Actuarial Standards
5th Floor, Aldwych House
71-91 Aldwych
London
WC2B 4HN

8.4 Comments should reach the BAS by **23 February 2009**.

8.5 All responses will be regarded as being on the public record unless confidentiality is expressly requested by the respondent. A standard confidentiality statement in an e-mail message will not be regarded as a request for non disclosure. We do not edit personal information (such as telephone numbers or email addresses) from submissions; therefore only information that you wish to publish should be submitted. If you are sending a confidential response by e-mail, please include the word “confidential” in the subject line of your e-mail.

8.6 We aim to publish non confidential responses on our web site within ten working days of receipt. We will publish a summary of the consultation responses, either as a separate document or as part of, or alongside, any decision.

A MODELLING PROBLEMS

INTRODUCTION

A.1 Paragraphs 1.11 to 1.27 describe a number of problems that have been identified in connection with the development and use of models. This Appendix discusses how the proposals in this consultation paper address them.

WHAT IS MODELLED AND HOW

A.2 The BAS shares the common view that the omission of vital factors from models is a significant problem, and one of the objectives of the proposed standard is to ensure that models represent sufficient aspects of the real world that are relevant to the decisions for which the model outputs will be used (see paragraph 2.9). Section 4 discusses the problem of determining what the relevant factors are, and the proposal in paragraph 4.12 is intended to make it less likely that vital factors are omitted. However, many factors are vital only with hindsight, and the BAS has been unable to propose a principle that would require modellers to include all the factors that, in the event, turn out to have been significant.

A.3 The difficulties caused by faulty assumptions are also recognised by the BAS, and are discussed throughout the paper. There are a number of proposals that are intended to encourage the use of suitable assumptions, including those in paragraphs 3.26 (exercise judgements in a reasoned and justifiable manner, document the reasoning and revisit them from time to time), 5.42 (estimates that are used as assumptions should be given statistical definitions, and they should be explained to users), 5.51 (assumptions that are best estimates should be independent of context) and 7.41 (explanations of material limitations should be given). However, it is important to realise that decisions about assumptions have to be made without the benefit of hindsight, and that sometimes those decisions will be wrong.

A.4 The question of reasonableness is discussed in paragraphs 6.44 to 6.52. The BAS believes that although notions of reasonableness are clearly important, it is impossible to come up with clear, enforceable principles on the matter that would not result in undesirable modelling practices.

UNDERSTANDING

A.5 The problems caused by the use of inappropriate models are addressed in the proposals in paragraphs 4.12 (judgements about the structure of the model) and 7.41 (provide an explanation of why the model addresses the needs of the user).

A.6 The BAS hopes that the proposals in paragraphs 3.25 (reconsider judgements when a model is used for a new purpose), 7.29 (sensitivity testing) and 7.41 (explain the material limitations and their implications) would help prevent problems caused by using models outside the range in which they are applicable. These proposals may also help to ensure that users of actuarial information do not overestimate the power of models.

A.7 The use of poorly understood models brought in from outside is addressed in paragraphs 6.35 to 6.37. The BAS does not believe that the use of an externally supplied model should provide exemption from compliance with the modelling TAS.

A.8 The BAS's reporting TAS is expected to include a provision that all material assumptions, whether explicit or implicit, should be explained (see paragraph 5.9). We hope that this will help to ensure that there are fewer hidden assumptions.

OPERATIONAL RISK AROUND MODELS

A.9 The BAS has made a number of proposals that would require the documentation of certain matters (see paragraphs 3.27, 5.17, 5.28, 5.42, 6.8, 6.20, 6.28, 6.33 and 7.29). In addition, paragraph 3.15 sets out a proposed standard that all model documentation should meet. We hope that these proposals will go some way towards addressing the issue of poor documentation.

A.10 The proposals in paragraphs 6.8 (perform and document checks on the model), 6.12 (models should be reproducible) and 7.29 (sensitivity testing) should help to ensure that adequate testing is performed on models.

A.11 The BAS hopes that the application of the proposal in paragraph 6.28 would reduce the incidence of errors due to the misuse of data.

B LIST OF DEFINITIONS AND PRINCIPLES

B.1 This appendix lists the principles that the BAS is proposing to include in its generic TAS on modelling, together with the associated definitions. This list is for convenience only. Readers should note that the principles cannot be seen in isolation, but should be read in the context of the discussion that explains them. Moreover, the proposals are intended to convey the general sense of the requirements that may appear in the TAS rather than the precise words that are likely to be used.

PURPOSE OF THE TAS

B.2 Actuarial information based on models should:

a) be based on models that sufficiently represent those aspects of the real world that are relevant to the decisions for which the actuarial information will be used;

b) include explanations of how the inputs to models are derived and what the outputs from models are intended to represent;

c) be based on models that are fit for purpose both in theory and in practice; and

d) include explanations of the significant limitations of the models (paragraph 2.9).

GENERAL CONCEPTS AND PRINCIPLES

B.3 (Definition) A model is an abstract and simplified representation of some aspect of the real world consisting of a set of mathematical formulae and algorithms, together with inputs in the form of data and estimated parameters (paragraph 2.13).

B.4 (Definition) A departure from the modelling TAS should be considered material if, at the time the work is performed, the effect of the departure (or the combined effect if there is more than on departure) could influence the decisions to be taken by the intended recipients of the work product. If the departure concerns documentation, it should be considered material if it concerns an assumption, data item, or other piece of information contributing to the development or use of a model whose effect on the model outputs is such that it could influence the decisions to be taken by the intended recipients of the work product (paragraph 3.5).

B.5 Documentation of a model should state both its purpose and its intended readership, and be complete for that purpose and clear and unambiguous for that readership. It should contain enough detail for a technically competent person with no previous involvement to understand the matters to which the documentation is relevant and assess the judgements that have been made (paragraph 3.15).

B.6 The development and use of models should be proportionate to the scope of the actuarial information that has been commissioned and the benefit the user would be expected to obtain from the models, striking a balance (where necessary and appropriate) between the interests of those who pay for the information and those who use it (paragraph 3.22).

B.7 Judgements about matters concerning models should be exercised in a reasoned and justifiable manner, taking into account the purpose of the model or models in question. The reasoning behind such judgements should be documented. Judgements should be reconsidered when the models are used for purposes other than those originally intended, after a period of time has passed, or after a previously unexpected event (paragraph 3.27).

REPRESENTING THE REAL WORLD

B.8 Models should cover all materially relevant phenomena, taking into account the purpose and structure of the model or models in question (paragraph 4.12).

B.9 Increasing degrees of complexity should be introduced into models if and only if they make a material difference to the outputs or materially reduce the limitations of the model in question (paragraph 4.17).

MODEL INPUTS AND OUTPUTS

B.10 Data that is used in models should, as far as possible, be complete, accurate and relevant. Where data is, or is thought to be, incomplete, inaccurate or irrelevant, the approaches used to estimate the effects of its shortcomings or to make compensating adjustments for shortcomings to parameters or outputs should be documented, together with reasons for adopting them (paragraph 5.17).

B.11 If grouped data is used, the approach that has been taken to the grouping, the reasons for choosing it and the effects of using grouped data rather than the ungrouped data from which it is derived should be documented (paragraph 5.28).

B.12 If data has been grouped and it is not possible to demonstrate that the grouping has no material effect, an explanation of the possible effects of the grouping, and that a different grouping (whether more or less detailed, or using different criteria) could give different outputs, should be included in the actuarial information (paragraph 5.29).

B.13 The assumptions used in a model, or in a suite of models that operate in conjunction, should be consistent, taking into account the purpose of the model or models in question (paragraph 5.35).

B.14 All estimates derived from model outputs, or used as assumptions in models, should be given statistical definitions and those definitions should be documented. Actuarial information should include explanations of the estimates and of their implications (paragraph 5.42).

B.15 Outputs or assumptions that are described as best, central or reasonable estimates, or other similar terms, should be derived using methods, assumptions and judgements that are independent of the purpose of the model (paragraph 5.51).

FIT FOR PURPOSE

B.16 A set of checks should be constructed and performed whenever a model is used in order to determine the fitness for purpose of the theoretical construct, practical implementation and specific realisations. The checks that have been performed on a model should be recorded and documented. The documentation should include the objectives of the checks (paragraph 6.8).

B.17 Practical implementations and specific realisations of models should be reproducible (paragraph 6.12).

B.18 The reasons for believing that the theoretical construct of a model is a satisfactory representation of reality should be documented (paragraph 6.20).

B.19 The definitions of all items of data that are used in models should be documented (paragraph 6.28).

B.20 If outliers are removed from the data used for a specific realisation other than because they are erroneous, the reasons for their removal should be documented, and the actuarial information should include an explanation of the implications (paragraph 6.33).

LIMITATIONS OF MODELS

B.21 The sensitivity tests that have been performed, and the reasons for performing them, should be documented. The reasons for believing those assumptions (or classes of assumptions) for which sensitivity tests have not been performed to be immaterial or otherwise inappropriate for sensitivity testing should also be documented (paragraph 7.29).

B.22 Actuarial information should include an explanation of why the models on which it is based address the needs of the user. It should also include explanations of the material limitations of the models that have been used and their implications (paragraph 7.41).

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