



BOARD FOR ACTUARIAL STANDARDS

**TECHNICAL ACTUARIAL STANDARD M:
MODELLING**

APRIL 2010

MODELLING (TAS M)

Status

This standard (TAS M) is a Generic Technical Actuarial Standard (Generic TAS), as defined in the *Scope & Authority of Technical Standards (Scope & Authority)* of the Board for Actuarial Standards (BAS).

This standard should be read in the context of the *Scope & Authority*.

The *Scope & Authority* sets out circumstances in which material departures from this standard are permitted or required and the disclosures which are required in respect of them.

Scope

This standard, as a Generic TAS, applies to the work specified in the Schedule to the *Scope & Authority*. The scope of this standard will be affected by any amendments to the Schedule to the *Scope & Authority*.

Specific TASs may include provisions that include or exclude particular categories of work from the scope of this standard.

Wider adoption is encouraged.

Commencement

This standard applies to models used in the preparation of aggregate reports completed on or after 1 April 2011.

Earlier adoption is encouraged.

Relationship with other TASs and with Guidance Notes

This standard sets out principles to be adopted across the range of work to which it applies, as described above. Other Generic and Specific TASs may apply to work that is within the scope of this standard, setting out additional principles that should be adopted.

In the event of a conflict between this standard and a Guidance Note adopted by the BAS (as described in the *Scope & Authority*), this standard shall prevail.

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A PURPOSE OF TAS M

A.1 PURPOSE

A.1.1 The BAS's Reliability Objective is 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.

A.1.2 Actuarial information often depends crucially on the results of **models**¹, which are inevitably simplifications of reality, and whose **specifications**, **implementations** and **realisations** must be fit for purpose for the information to be relied on. The purpose of this standard is therefore to assist the achievement of the Reliability Objective by ensuring that **models**:

- sufficiently represent the matters that are relevant to the decisions for which the actuarial information based on them will be used; and
- are fit for purpose both in theory and in practice;

and that the actuarial information based on them:

- includes explanations of the purposes the **models** are intended to serve, how the inputs to the **models** are derived and what the outputs from the **models** are intended to represent; and
- includes explanations of the significant limitations of the **models**.

¹ Terms appearing in **bold** in the text are explained in the Definitions set out in Part B.

B INTERPRETATION

B.1 INTERPRETATION OF THE TEXT

- B.1.1 All text in this standard has equal status unless stated otherwise. Paragraphs setting out explicit principles are emphasised with boxes for convenience.
- B.1.2 The **Scope & Authority**² states that a failure to follow the principles in this standard need not be considered a departure if it does not have a **material** effect. The contents of this standard should be read in that context, even where the term **material** is not explicitly used or where the word “shall” is used.
- B.1.3 The definition of **model** covers a wide range of calculations of varying degrees of complexity performed in many different ways, electronic or otherwise. The **materiality** of outputs, assumptions, checks, **documentation** and other matters relating to **models** depends on their influence on the decisions that they support, not on the complexity of the calculations or how they are performed.
- B.1.4 Nothing in this standard should be interpreted as requiring work to be performed that is not proportionate to the scope of the decision or assignment to which it relates and the benefit that **users** would be expected to obtain from the work.
- B.1.5 The form that is taken by any explanations, rationales, descriptions, indications or other analyses required by this standard will need to depend on the scope of the work being performed and the benefit to the **users**. The level of detail required is a matter for judgement. Unless stated otherwise, analyses may be quantitative or qualitative.
- B.1.6 Lists of examples are not intended to be exhaustive.
- B.1.7 This standard should be interpreted in the light of the purpose set out in Part A.

B.2 DEFINITIONS

- B.2.1 Terms appearing in **bold** in the text are used with the meanings set out below. Some of the definitions are taken from the **Scope & Authority**. The definitions are used consistently in the **Scope & Authority** and other BAS standards.

² Paragraph 23 of the **Scope & Authority**.

aggregate report	The set of all component reports relating to a piece of work within the scope of this standard. The aggregate report for a decision taken by a user in connection with work within the scope of this standard is the set of all component reports containing information material to that decision.
component report	A document given to a user in permanent form containing material information which relates to work within the scope of this standard. Formal written reports , draft reports , emails and presentations are examples of component reports . Possible contents of component reports include tables, charts and other diagrammatic presentations as well as or instead of text. A component report may form part of one or more aggregate reports .
data	Facts or information usually collected from records or from experience or observation. Examples include membership or policyholder data, claims data, asset and investment data, operating data (such as administrative or running costs), benefit definitions and policy terms and conditions.
document	To record in documentation .
documentation	Records of facts, opinions, explanations of judgements and other matters. Documentation may be paper or electronic based. It is not necessarily provided to users . Documentation is material if it concerns a material matter.
Generic TAS	A Technical Actuarial Standard which applies to all work specified in the Schedule to the Scope & Authority .
implementation	The formulae and algorithms of a model in a form that will perform the calculations required by the specification. In many cases an implementation is a computer program, but other types of implementation are possible – for instance, manual calculations are often used for simple models.
material	Matters are material if they could, individually or collectively, influence the decisions to be taken by users of the related actuarial information. Assessing materiality is a matter of reasonable judgement which requires consideration of the users and the context in which the work is performed and reported.
measure	The approach that is used to define how an (uncertain) asset or liability amount is quantified. Two different measures of the same asset or liability may produce different results.
method	The mechanism that is used to quantify an (uncertain) asset or liability amount. Two different methods of calculating the same asset or liability measures should produce similar results.

model	A representation of some aspect of the world which is based on simplifying assumptions. A model is defined by a specification that describes the matters that should be represented and the inputs and the relationships between them, implemented through a set of mathematical formulae and algorithms, and realised by using an implementation to produce a set of outputs from inputs in the form of data and parameters.
neutral	A neutral measure, assumption or judgement is one that is not deliberately either optimistic or pessimistic and does not incorporate adjustments to reflect the desired outcome. A neutral estimate is one that is derived using neutral measures, assumptions and judgements. There may be a range of neutral estimates, reflecting inherent uncertainty.
realisation	An implementation together with a set of inputs and the corresponding outputs. For an implementation that is a conventional computer program, a realisation is a run of the program, together with the inputs used and the outputs produced. Runs with different data or parameters are different realisations even if the program itself has not changed.
report	An aggregate report or a component report .
Scope & Authority	The BAS's <i>Scope & Authority of Technical Standards</i> .
Specific TAS	A Technical Actuarial Standard that is not designated by the BAS as a Generic TAS . A Specific TAS is limited to a specific, defined context.
specification	A description of a model that describes the matters to be represented, the inputs and their interactions with each other, and the outputs to be produced.
users	Those people whose decisions a report is intended (at the time of writing) to assist. Those to whom the report is addressed, regulators and third parties for whose benefit a report is written are examples of possible users .

C MODELLING

C.1 INTRODUCTION

- C.1.1 This Part contains principles that support the purpose of this standard set out in Part A. It should be interpreted as described in Part B.
- C.1.2 Work that is within the scope of this standard may also be within the scope of other BAS standards. In particular, other **Generic TASs**, including those on *Reporting Actuarial Information* and *Data*, apply to all such work.
- C.1.3 Other principles concerning modelling may be contained in **Specific TASs**.
- C.1.4 Section C.2 describes how this standard should be applied.
- C.1.5 Sections C.3 to C.5 contain principles that contribute to the achievement of the purpose set out in Part A, addressing the fitness for purpose of **models** (section C.3), their inputs (section C.4) and how they and their results are reported to **users** (section C.5).

C.2 APPLICATION

C.2.1 This standard shall apply to all **models** used in preparing actuarial information which is presented in a **report**.

- C.2.2 This standard applies to all **models** regardless of their provenance. The extent and nature of the **documentation** required and the checks that are performed for externally developed **models** will need to depend on the reliability of any **documentation** that has been supplied and checks that have been performed by others.
- C.2.3 This standard applies to all **models** regardless of their size or complexity. It applies to each **model** as a whole, rather than to individual components of a **model**. The judgement whether a collection of computer programs (such as modelling packages or spreadsheets) together constitute the **implementation** of a single **model** or a suite of separate **models** will need to take into account the purpose being served and the **materiality** of the individual components.
- C.2.4 **Models** might be used for purposes such as:
- calculating a policy surrender value;
 - projecting the liabilities and assets of a pension scheme from one date to a later date;
 - calculating the value of the liabilities in a Scheme Funding exercise; and
 - estimating the capital requirements of an insurer.

Judgement

C.2.5 Judgements concerning the application of this standard shall be exercised in a reasoned and justifiable manner.

C.2.6 Examples of matters on which judgement might be needed include applicability of the **model** to the purpose, the suitability of the assumptions and **data** to be used, the **materiality** and relevance of the outputs and the form that indications or explanations might take.

C.2.7 Judgements will need to be kept under review. Judgements might need to be reconsidered when, for example:

- a significant period of time has elapsed since the **specification** was developed or the **implementation** last used;
- a previously unexpected event has occurred; or
- a **model** is being used for purposes other than those originally intended.

Documentation

C.2.8 All **documentation** required by this standard shall:

- a) contain enough detail for a technically competent person with no previous knowledge of the particular **model** being **documented** to understand the matters involved and assess the judgements made;
- b) include a statement of the purpose of the **documentation**; and
- c) be clear, unambiguous and complete for that purpose.

C.2.9 **Documentation** might take many forms, including separate physical or electronic documents (such as files or collections of files produced by modelling packages), comments in the code of an **implementation** and annotations to the output of a **realisation**. **Documentation** might consist of or include documents prepared by others, such as documents provided by systems developers, policy documents and pension scheme deeds or booklets. **Documentation** might serve a variety of purposes, including forming part of an institution's risk management structure.

C.2.10 The level of detail of **documentation** is a matter for judgement, and will need to depend on matters such as the size and complexity of the **model** and the context in which it is being used.

C.2.11 In some cases, **documentation** required by this standard might need to describe individual components instead of the **model** as a whole.

C.2.12 Principles concerning specific requirements for matters to be **documented** are contained in other sections of this standard.

C.3 FITNESS FOR PURPOSE

Satisfactory representation

C.3.1 The **model** shall be a satisfactory representation of some aspect of the world in the context of the purpose for which it is being used. The explanation of how it is a satisfactory representation shall be **documented**.

C.3.2 The explanation of how the **model** is a satisfactory representation might need to include factors such as:

- the relevance of the aspect of the world that is modelled to the purpose for which the **model** is being used;
- the extent to which all phenomena relevant to the purpose and structure of the **model** have been modelled;
- the compliance of the **model** with regulatory requirements;
- the rationales for fundamental qualitative assumptions and prior beliefs; and
- records of calibrations for quantitative assumptions.

C.3.3 The relevance and **materiality** of a phenomenon, and other aspects of whether a **model** is a satisfactory representation, are matters for judgement at the time the work is performed. For example, a phenomenon that is relevant to the purpose of a **model** that is intended to provide a detailed analysis of an issue might be irrelevant to that of a **model** that is intended to provide an overview or rough estimate. A phenomenon that is relevant to the purpose of one **model** might be irrelevant to that of another **model** serving the same purpose but with a different structure. For example, a decrease in deaths due to circulatory diseases might be relevant to a causal **model** of future mortality but not to a **model** based on time-series extrapolation of overall mortality rates.

C.3.4 The explanation of how the **model** is a satisfactory representation can be supported by techniques such as:

- comparing the outputs of **realisations** with actual experience;
- quantitative analysis of the predictive properties of the **model** using back-testing;
- analysis of movements; and
- sensitivity testing.

Checks

C.3.5 A set of checks shall be constructed and performed in order to determine the fitness for purpose of the **model** as a whole and of its **specification, implementation and realisations**.

C.3.6 The checks that have been performed shall be documented .
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C.3.7 The nature and level of detail of the checks that are performed will need to reflect the purpose for which the **model** is being used and the complexity of the **model**. For example, a **model** being used to perform a detailed analysis might require more thorough checking than one being used to provide an approximate result.

C.3.8 Some checks might need to be performed when any changes are made to the **specification** or **implementation**. Other checks might need to be performed less frequently, or for specific **realisations**.

C.3.9 The fitness for purpose of the **model** can be assessed through the use of checks such as:

- checking that a **specification** accounts for a specific aspect of the world;
- checking that an **implementation** accurately meets the **specification**;
- checking that an **implementation** accepts all possible valid inputs and handles invalid inputs appropriately;
- checking that a **realisation** uses the intended inputs;
- performing a quantitative analysis of the predictive properties of the **model**; and
- comparing the outputs of the **model** with those of a different **model**.

Choice of methods

C.3.10 Neutral measures , assumptions and judgements shall be used to derive any estimates described as “best estimate”, “central estimate” or other similar terms.
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C.3.11 Estimates described as “prudent”, “not excessive”, “pessimistic”, “optimistic” or other similar terms will need to be derived using **measures**, assumptions and judgements that are not **neutral**.

C.3.12 If legislation, regulation or another legal obligation specifies that an estimate described as a “best estimate” or other similar term should be derived using methods, assumptions and judgements that are not **neutral**, paragraph C.3.10 shall not apply but the **aggregate report** will need to explain that the estimate includes elements of pessimism, optimism or other subjective adjustments as the case may be.

C.3.13 The **Generic TAS** on *Reporting Actuarial Information* includes a principle requiring the disclosure of the intended meaning of terms that are not uniquely defined, such as “best estimate” and “prudent”.

Parsimony

C.3.14 Models shall be no more complex than can be justified.
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- C.3.15 Examples of possible justifications include a **material** difference to the outputs of the **model**, a **material** reduction in its limitations and the availability of an **implementation** which, although more complex than necessary, will serve the purpose at hand.
- C.3.16 The presence of irrelevant inputs might indicate that the structure of the **model** is more complex than necessary.

Reproducibility

C.3.17 Implementations and realisations shall be reproducible.
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- C.3.18 A reproducible **implementation** is one that produces the same outputs from identical inputs. A reproducible **realisation** is one that produces the same outputs each time it is run. Reproducibility enables the checking of **implementations** and **realisations**.
- C.3.19 For Monte Carlo simulations, reproducibility can be demonstrated by methods such as:
- the use of a random number generator that can be seeded in order to generate the same sequence of numbers on demand; and
 - the production of enough simulations to demonstrate stability in the statistical distributions of the outputs, for instance by comparing the outputs from two sets of simulations.

C.4 MODEL INPUTS

Data

- C.4.1 The **Generic TAS** on *Data* contains principles concerning the preparation and checking of **data**.
- C.4.2 The **Generic TAS** on *Reporting Actuarial Information* contains principles concerning the reporting of the source and shortcomings of **data**.

C.4.3 The data used for any realisation shall be suitable for the purpose of the model .

C.4.4 The data used for each realisation shall be documented .

- C.4.5 **Data** is suitable for the purpose of the **model** if it is both directly relevant to the purpose of the **model** and available. If insufficient directly relevant **data** is available, alternative **data** will need to be used. In this event, an explanation of why this **data** has been used and the implications of its use will need to be **documented**.

C.4.6 **Data** might be unsuitable for the purpose of the **model** for reasons such as:

- the **data** is inconsistent with assumptions that form part of the **specification**;
- the **data** definitions are inconsistent with those assumed or set out in the **specification**; and
- the **data** is insufficient to be statistically useful.

C.4.7 Sufficient statistically useful **data** may be unavailable for the **implementation** for reasons such as:

- the volume of business in-force or the size of the pension scheme is too small for statistically useful **data** to become available; or
- the incidence of the event being measured is too infrequent for statistically useful **data** to become available.

C.4.8 Possible methods of **documenting** the **data** used for a **realisation** might include recording the name and location of the input file or files for a computer program and listing the values used for a manual calculation.

C.4.9 Grouped **data** shall be clearly identified and:

- a) the reasons for the grouping and the criteria used to determine the groups shall be documented; and
- b) the **aggregate report** shall include an explanation of the rationale underlying the grouping if it is not possible to demonstrate that the grouping has no **material** effect.

C.4.10 Possible reasons for grouping heterogeneous **data** and criteria for determining the groups include improving statistical usefulness, simplifying computation and reducing the level of uncertainty surrounding the results.

C.4.11 An explanation of the rationale underlying **data** grouping will need to cover both the advantages and the disadvantages of doing so, including the effects on uncertainty. The explanation may include a quantification of the effects of grouping or may take some other form.

C.4.12 The extent to which **data** grouping is **material**, and the level of detail required in **documentation** or **reports**, are matters for judgement.

C.4.13 If any **data** points are removed from the **data** used for a **realisation** other than because they are erroneous:

- a) the **data** points that have been removed shall be **documented** and the aggregate report shall describe them;
- b) the rationale for their removal shall be **documented**; and
- c) the **aggregate report** shall explain the implications of their removal.

C.4.14 Paragraph C.4.13 applies to all **data** points, including outliers (**data** points that differ significantly from other **data** points) and **data** points used in previous **realisations** but now excluded on the grounds that they are no longer representative of the current state of the phenomenon being modelled.

C.4.15 Paragraph C.4.13 does not require separate **documentation** of each of a number of **data** points removed for the same reason.

C.4.16 **Data** points might be removed for reasons such as:

- analysing claims other than those relating to catastrophes;
- analysing only administrative or running costs that are expected to recur; and
- analysing mortality only for ages for which there is statistically useful **data**.

C.4.17 The extent to which the removal of **data** points is **material**, and the level of detail required in **documentation** and **reports**, are matters for judgement.

Assumptions

C.4.18 The assumptions used in a **specification**, its **implementation** and **realisations** shall be **documented**.

C.4.19 Examples of assumptions used in **specifications**, which may be implicit or explicit, include qualitative assumptions about the relationships between phenomena and prior beliefs about the future behaviour of the phenomena being modelled (such as assumptions about the mean reversion of equity returns).

C.4.20 Examples of assumptions used in **implementations** and **realisations** include numerical and other parameters. **Documentation** will need to include records of the assumptions that were used for each **implementation** and **realisation**.

C.4.21 If an assumption has a description that is not uniquely defined, such as “best estimate” or “prudent”, a statistical or other definition of the term in question will need to be **documented**. The **Generic TAS on Reporting Actuarial Information** requires descriptions of the intended meanings of such terms to be included in **aggregate reports**.

C.4.22 The assumptions used in a **model** or in a suite of **models** that operate in conjunction shall be consistent with each other, taking into account the purpose of the **model** or **models** in question.

C.4.23 An example of the need to avoid inconsistencies is when the changes to assumptions that are required in order to investigate the effects of a scenario, such as high inflation, need to be made in all parts of the suite of **implementations** and to all related assumptions (such as future levels of administrative or running costs).

C.4.24 Different assumptions are not always inconsistent. For example, if several independent **models** are used in conjunction to provide better estimates than any one **model** could provide on its own, different assumptions might be chosen deliberately.

C.4.25 If the purpose of a **model** is to calculate estimates in accordance with regulation, and the assumptions that are required to be used in the **model** or in a suite of **models** of which it is one are inconsistent with each other, the reasons for the inconsistency will need to be explained to the **user**.

C.4.26 The **Generic TAS** on *Reporting Actuarial Information* requires a statement of any differences between the assumptions used or recommended in different parts of the work.

C.5 REPORTING

C.5.1 Principles for matters that should be reported to **users** in respect of modelling are contained in the **Generic TAS** on *Reporting Actuarial Information*.

C.5.2 The **Generic TAS** on *Reporting Actuarial Information* requires an indication of the nature and extent of any **material** uncertainty inherent in the information contained in an **aggregate report**. The uncertainty inherent in point estimates might be indicated through the use of ranges, sensitivity analyses or other means.

C.5.3 Principles for matters that should be reported to **users** in respect of modelling may also be contained in **Specific TASs**.

Non neutral estimates

C.5.4 An **aggregate report** that includes estimates that are not **neutral** shall indicate their relationship to **neutral** estimates.

C.5.5 Paragraph C.5.4 applies to both estimates derived from outputs and estimates used as assumptions.

C.5.6 Paragraph C.5.4 applies to estimates using both **neutral** and prudent **measures**. For example the cost of buying out pension scheme liabilities might be a prudent **measure** for an ongoing scheme. An estimate of this cost might itself be **neutral** or might deliberately include a margin for prudence. In the latter case paragraph C.5.4 applies.

C.5.7 The relationship between an estimate that is not **neutral** and a **neutral** estimate might be indicated using methods such as:

- describing the level of pessimism or optimism in the estimate;
- explaining how the derivation of the estimate differs from that of a **neutral** estimate, for example by including a specific margin for prudence;
- comparing the estimate with a **neutral** estimate and explaining the differences; and
- quantifying the probability of the estimate being exceeded.

Limitations and users' needs

C.5.8 If an **aggregate report** includes information derived from **models**, it shall include explanations of:

- a) any **material** limitations of the **models** that have been used and the implications of those limitations; and
- b) how the **users'** needs are addressed by the **models** that have been used.

C.5.9 The limitations of the **model** might be closely related to its purpose and the needs of the **users**. For example, if a **user** has asked for an approximate answer to be prepared in a short period of time, the **model** that is used might be less detailed and have undergone less thorough checks (and therefore have more limitations) than one that is used for a more detailed study.

C.5.10 The level of detail at which limitations are explained is a matter for judgement, and will need to depend on matters such as the purpose for which the **model** is being used. An explanation of the limitations of a **model** used to provide approximate answers might be less detailed than for one used for a more detailed study.

C.5.11 Explanations of the limitations of **models** and the implications of those limitations might include descriptions of:

- the exclusion of relevant phenomena from the specification;
- simplifying assumptions that have been made;
- the extent to which the **implementation** might not fully meet the **specification**;
- the sensitivity or otherwise of the outputs to key assumptions (both quantitative and qualitative);
- the suitability or otherwise of the outputs for purposes other than those intended;

- the extent to which the system-wide effects of individual actions and other systemic risks have been taken into account;
- the number and variety of **realisations** that have been used; and
- the amount of checking that has been performed and the degree of reliance that can be placed on the outputs of the **model**.

C.5.12 Explanations of how the **models** address the **users'** needs will need to cover the relevance of the outputs to those needs and their completeness with respect to them.

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