SOCIETY OF ACTUARIES
MODELING SECTION

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A System-based Approach to Cell Testing

By April Shen and Rich Gracey

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The Modeling Platform

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This newsletter is free to section members. Current issues are available on the SOA website (www.soa.org).

To join the section, SOA members and non-members can locate a membership form on the Modeling Section webpage at https://www.soa.org/sections/modeling/modeling-landing/.

Publication Schedule
Publication Month: Nov. 2018
Articles Due: Aug. 13, 2018

2018 SECTION LEADERSHIP

Chairperson's Corner

By Scott Houghton

It's hard to believe 2018 represents the fifth year for the Modeling Section. As an alternative to a more formal "state of the section" address, I'll give an informal update that illustrates three recent anecdotal signs of our success as a section, and follow with a summary of benefits of being a member of the section.

Our first sign of success is that our dedicated and hardworking *The Modeling Platform* co-editors are putting together an index of past articles. The implication here is that with their help we've already published enough articles to have an index be useful.

Our second sign is that the Program Committee for the Society of Actuaries (SOA) Annual Meeting & Exhibit has increased our allocation of sponsored sessions, so we are now sponsoring five sessions, including our hot breakfast session.

The third informal sign of success requires a bit of background. When I volunteered as webcast coordinator for the section in 2015, I quickly learned that we could raise more money for the section with a webcast if we reached out to and partnered with a larger, more established section. Using precise actuarial terminology, if we partnered with a big section, we needed to share the pie, but the pie was triple (or larger) in size. Our third anecdotal sign of success was that another section recently reached out to us to partner with them on a webcast.

Of course, none of this would be possible without the work of all of our volunteers, so I would like to thank all of them. Their hard work and dedication help bring the following benefits of section membership to you, our members:

1. The section sponsors continuing education sessions at the Life & Annuity Symposium (LAS), Valuation Actuary Symposium and SOA Annual Meeting & Exhibit. The LAS this year is May 7–8 in Baltimore, and we are sponsoring sessions on topics including centralized versus decentralized models and model efficiency. Our sessions for the other meetings are still being planned for 2018.

2. We publish this semiannual newsletter and modeling section e-newsletters.

3. We sponsor and co-sponsor educational webcasts. Our planned topics for 2018 include model governance, model validation, economic scenario generators and International Financial Reporting Standard (IFRS) 17. Section members receive discounts on webcasts.

4. Section members may listen to and view recordings of past webcasts that are more than 1 year old for free as a recently added section member benefit. You can access the free Modeling Section webcast recordings by logging in using your SOA username and password at *https://engage.soa.org*, and look for the Modeling Section Community.

5. The section sponsors and publishes original research of interest to our members. Our members have the opportunity to influence and/or sponsor research topics related to modeling. A research project on "Validation of Predictive Models for Insurance Applications" is currently underway, and we have others we are considering for 2018.

6. Section members have networking opportunities and discounts on section networking events.

7. Section members receive members-only access to LinkedIn discussions.

Please enjoy this issue, and please reach out to me if you have ideas on what the section can do to help you, your colleagues and your employers. ■

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Letter From the Editors

By Mary Pat Campbell and Phillip Schechter

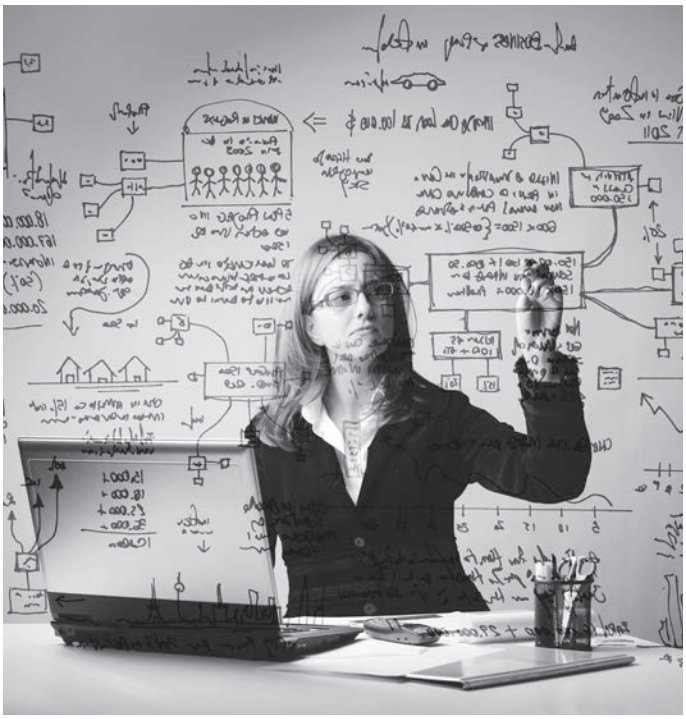
Our cup runneth over! And we want more! Usually, we would be touting the articles in the current issue of *The Modeling Platform*, but as of this writing we're not sure what will be in the final issue! We received a mother lode of great submissions, many of which were so capacious, they've probably been split into two parts.

But that's not enough for our insatiable appetites: We want more! MORE! MORE!!!!!

A bit more seriously, we're always looking for new authors and articles on modeling topics. Here are our requirements:

- The article pertains to modeling issues in some way.
- It's at least 500 words or so and shorter than a Russian novel.

We're being a bit jocular there, but we don't want you to get the impression we are looking for multipage, comprehensive articles alone (those are nice, too).



From the Society of Actuaries (SOA) guidelines on typeset articles, we have these word-count guidelines:

- 500–750 words = 1 layout page
- 1,000–1,500 words = 2 layout pages
- 1,500–2,000 words = 3 layout pages

You can contact either or both of us if you have an idea for submission—we're very happy to chat with you to explore potential topics.

Say you've presented on modeling topics at an SOA or local actuarial club meeting: Why not reuse your material and write a summary of your presentation? Maybe you've attended an actuarial meeting and want to write up the summaries of other people's presentations—that's great, too!

Perhaps you had a sticky model-related problem at work. A narrative about your problem-solving journey is relevant!

Maybe you have a particular graphic related to modeling you'd like to explain; perhaps you have some advice for those new to modeling.

It's fine to explore a systematic framework or explain a particular theory, if you want to go abstract. But shining a light on an important practical detail you've found in the modeling process is also appreciated.

Models are a key tool in actuarial practice, cutting across field and employer type. We contain multitudes . . . and we'd love to hear more from that modeling multitude!

Our next submission deadline is at the beginning of August to be included in the fall 2018 issue, but we're happy to talk with potential authors at any time. Please contact us to explore further.

Give us more! ■

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A System-based Approach to Cell Testing

By April Shen and Rich Gracey

"Let us dismiss the question, 'Have you proven that your model is valid?' with a quick NO. Then let us take up the more rewarding and far more challenging question: 'Have you proven that your model is useful for learning more about . . . ?'"

—James B. Mankin Jr., electrical engineer and computer scientist

Model validation and model risk management have been hot topics in recent years for many actuaries. Single cell testing is a fundamental process of model validation. In this article, we discuss a system-based approach for integrating the various parts of the cell testing process.

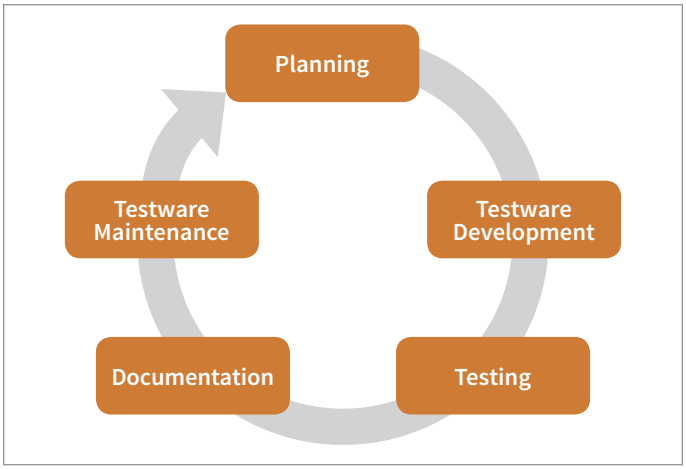
WHY A SYSTEM-BASED APPROACH?

Actuarial models and their corresponding test tools are necessarily interrelated and interdependent. The cell testing process is dynamic, ranging from a simple, time-dependent roll forward to a complex attribution of model changes. This process may include testers from several internal departments and possibly even vendor companies, consulting groups and auditing firms.

A system is defined as a group of interacting, interrelated, or interdependent elements forming a complex whole. In this article, we propose categorizing the cell testing process as a system and argue that cell testing as a system is beneficial for model validation and model risk management.

We'd like to introduce a new term: *testware*. This is comprised of a user guide, test plan, test cases, result summaries, and one or more test tools. Figure 1 illustrates the five deeply connected elements of the cell testing system in our paradigm: planning, development, testing, documentation and maintenance. *Planning* involves drafting a solid test plan to guide the testing process. *Development* includes the writing of the testware, which should conform to the approved test plan. *Testing* consists of a comparison of the model and test tool results and the resolution of any unexplained differences. *Documentation* is written by the model testers so that actuaries may review details about the testware, including simplifications, limitations and testing results. *Maintenance* of the testware rounds out the system and ensures that the testware remains in sync with the model throughout the production cycle.

Figure 1
Cell Testing System Elements



PLANNING

Planning is the initial stage of the system-based approach to cell testing. A test plan is the pivotal component in this phase. Enumerating the components of the testing process by drafting a test plan and allocating dedicated testing resources are the first steps to a successful and meaningful testing exercise. All stakeholders should discuss and agree on the following components.

- **Test plan.** Model owners, model users and model testers should agree on a test plan that delineates the roles and responsibilities of all dedicated resources. Ultimately, the parties need to identify the goals of the testing exercise and tie the company decision-making process to the testing goals.

- **Scope.** This specifies what is tested and what is not tested. Setting scope requires experience with the model and is a necessary prerequisite for budget planning.

- **Sampling.** A sufficient number of cells should be selected to test a large set of model variations. Sample cells should be carefully chosen and the key characteristics of the business should be considered. A coverage ratio may be calculated to reflect the scale of the sample. The sample should be reviewed periodically to accommodate new business and changes to the in-force census.

- **Table and code reviews.** The nature of the model will drive whether a table and code review should be included in testing. Some code can be prewritten and repetitively used by vendors or third parties and could be thoroughly tested in

other applications. If those canned codes are used repeatedly in the model, previous testing evidence may be leveraged.

DEVELOPMENT

Test tools should be built from first principles. Complexities regarding the cell testing process require actuaries to design system-based testing strategies with functional testware.

In recent years, insurance companies have been implementing several actuarial model conversions that require extensive testing on new models. For black box models, reverse engineering and vendor support may be needed to sufficiently understand the model's calculations. For glass box models, technical specifications may assist in describing the model. The reconciliation process depends on the transparency of the calculations. If disagreements arise between modelers and testers, methodological differences should be reconciled during the testing process. In some cases, an existing model with similar functionalities may be leveraged as an alternative to developing a test tool from scratch.

TESTING

The Actuarial Standards Board (ASB) Modeling Task Force provides the following guidance on the use of cell testing:

> The actuary should determine the appropriate degree of checking of formulas and table mapping that is needed (for example, breadth, depth, complexity, etc.), given the intended purpose, context and nature of the model, including its operating environment and controls, and whether there may have been any changes to the model and its environment.[1]

The concept of separation of duties is familiar to actuaries, but we argue further that the testing of the model should be independent from the development of the testware. Single cell testing is comprised of input testing, output testing and calculation testing.

Input Testing

Input testing is critical in the cell testing process. Following the big data trend, a greater number of data management packages are now available, and we foresee input testing becoming more important.

- **Source files.** Inputs, including assumption data, should be validated through comparison with the source files. Stakeholders should agree whether full validation is required or if spot checking is sufficient.

- **Hidden data.** In black box models, inputs and data parameters are often hidden, such as the mortgage prepayment model calibration and logic. These parameters may even include proprietary information, which could be protected from the tester. Some assumptions may be set by departments within the company. In each of these cases, the model testers may need to rely on testing performed by vendors or other departments.

- **Usage.** The correct usage of assumptions needs to be examined. The application of assumptions should be consistent with their development. For example, if lapse assumptions are developed on an end-of-month basis but the model applies lapses at the beginning of the month, it may be necessary to adjust lapse rates prior to their implementation.

- **Assignment.** The correct assignment of assumptions needs to be reviewed, such as what plan code uses what assumptions. This could be done by feeding source inputs and parameters into the testware.

- **Scenarios.** Some models obtain scenario data as an input item, whereas others use an internal scenario generator. In either case, scenarios should be checked for reasonableness and the tester should understand their utilization within the model.

- **Calibration.** Input testing may include checks and balances against other sources, such as the calibration of key assumptions in different departments of the company or in different models.

Output Testing

Output testing in the cell testing process shares many similarities with user acceptance testing (UAT). For single cell testing, additional output testing could be used to accelerate the testing process before releasing the model to end users. This preliminary testing could be used to help explain observations made during the UAT process.

- **Reasonableness.** Running reasonableness checks provides the tester comfort that the output makes sense. Whereas user acceptance testing typically checks model results in aggregate, single cell testing could assess reasonableness at the seriatim level.

- **Sensitivity testing.** Performing sensitivity analysis on a cell basis across key assumptions assists in the validation of assumptions and logic, especially across highly sensitive variables.

- **Attribution analysis.** Completing an attribution analysis at the cell level helps validate the impact of model changes to identify elements contributing to unresolved differences.

- **Trend analysis.** Trend analysis is a time-series comparison. Back-testing can provide valuable information about the model.

- **Actual-to-expected testing.** Obtaining checks and balances with other sources, such as a seriatim-level, actual-to-expected analysis, is often valuable to better understanding the output.

Calculation Testing

Development of test tools from first principles is a key element of calculation testing. Independence between model developers and testware developers ensures that the test tools serve as a solid benchmark for the model.

- **Proof-of-concept tool.** For complex calculations on a block basis, it may not be practical to build testware as that may require building another complete model. In such situations, a simplified proof-of-concept test tool could be developed.
- **Scenarios.** Different scenarios should be tested in the calculation process, especially when the calculation is sensitive to the scenarios.
- **Acceptance criteria.** The testing result threshold should be discussed upfront, such as the absolute dollar difference, percentage difference or present-value measure.
- **Testware performance.** The run-time of the testing process should be considered when building the testing strategy. Single cell testing that runs in Excel could require significant runtime for complicated calculations. Iterations may be very long if the testing process needs to be repeated.

DOCUMENTATION

Testing documentation includes the test plan, testware user guide, testing results summary, approvals and supplemental information, such as slides prepared for management presentations. Model testers should confirm that deferred items, model enhancements and bug fixes are documented in ongoing project plans. Documentation should be reviewed with all the stakeholders and periodically reviewed to ensure it is up-to-date.

The test plan should clearly articulate the scope of the testing. All considerations leading to the decision of a reasonable test scope need to be clarified and agreed upon among stakeholders and management. Either a follow-up test plan or a risk analysis is encouraged to help prioritize testing.

The testware itself should include instructions on how to use the test tools. A version log should contain a summary of updates in each version and the impact of these changes on results.

MAINTENANCE

Testware maintenance depends on the significance of updates to the model and inputs. For a production model, the accompanying testware needs to go through the change management process concurrently. Periodic review of the testware is encouraged.

Maintenance could also improve the efficiency of the testing process. For example, different scenarios or product groupings could be rotated in each round of testing during the maintenance stage to test the model more efficiently. A robust sampling technique is important in this case.

Periodic code reviews are also encouraged, especially during model or assumption changes.

INTEGRATION OF CELL TESTING ELEMENTS

In summary, we discussed the elements in a dynamic system-based cell testing approach. This system-based approach provides a holistic view of the cell testing process and model risk management. We explored the elements of a cell testing system, but actuaries should not only thoroughly consider each element of the system but also be cognizant of the interdependence of the planning, testware development, testing, testware documentation and maintenance.

Actuaries should consider the maintenance of the testware during its development. Important questions such as the efficient use of the testware and its change management process may lead actuaries to choose one form of development over another. Also, when actuaries perform testing during frequent model releases, documentation of these releases will assist in the testware development. Documentation could also guide future development of the testware and testing process.

Overall, we argue that important knowledge from tacit to explicit could be gained through the cell testing process. Thinking through the testing process from a system perspective will help organizations retain and make better use of the information and improve the efficiencies of the model testing. ■

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Rich Gracey, FSA, MAAA, is a director at Prudential. He can be reached at *rich.gracey@prudential.com*.

ENDNOTE

1 Actuarial Standards Board. 2012. Discussion draft regarding Modeling in Life Insurance and Annuities, *http://www.actuarialstandardsboard.org/asops/modeling-life-insurance-annuities/* (accessed February 21, 2018).

Model Governance Versus Normalized Policy Deviance

By Bob Crompton

Model governance is a formalized decision framework designed to help ensure that models accomplish their intended purpose. But simply establishing and communicating the model governance framework is merely the beginning of governance because of two cruel truths of organizational life:

1. No management communication is 100 percent effective, and
2. Management's intentions will never be 100 percent implemented.

There are a number of reasons for item number two of this list. They include such things as time pressure, lack of understanding, conflicting goals, organizational culture and organizational politics. In any large organization there will be numerous instances where actual policies, practices and procedures deviate from formal policies, practices and procedures. In some cases, these deviations will be flagrant.

Through the standard pathway of socialization, institutionalization and rationalization, these policy deviances become accepted as normal—in some cases even being considered best practices.

One of the challenges of effective model governance is identifying and addressing such deviations before they cause material model failure.

A FEW REFERENCES

The first reference is Dan Luu's blog.[1] This blog is what got me started thinking about the topic of policy deviance. The second reference is a scholarly article by Diane Vaughan from the *Annual Review of Sociology*, "The Dark Side of Organizations: Mistake, Misconduct, and Disaster."[2] This article discusses policy deviance in a general way applicable to all organizations.

Finally, there is John Banja's article, "The Normalization of Deviance in Healthcare Delivery."[3] His article helped me to articulate many of my own ideas.

AN EXAMPLE OF DISASTROUS CHRONIC POLICY DEVIANCE

Banja gives the following example of a catastrophic series of policy deviations in the operating room:

- The surgeon requests the anesthesiologist turn off the ventilator so he can take an x-ray.
- The anesthesiologist either forgets to turn the ventilator back on, or else he mistakenly thought he had turned it back on.
- The ventilator had been programmed to go into indefinite suspend mode, so that no alarms would go off—possibly because the operating room staff found the constant beeping to be irritating and distracting.
- The patient went without oxygen so long that she went into a vegetative state, and died 11 days later.

Anyone who has had much experience in model management can easily analogize this example to insurance models. Some model fail-safe is disabled because it is "never needed" and enabling it causes the model to operate too slowly. Through institutionalization of the disabled fail-safe, the model operators forget about the scenarios for which the fail-safe was designed, so that when one of these scenarios occurs, the model fails—potentially in some disastrous fashion.

Banja points out that many disasters have the following common elements:

- A long incubation period
- Chronic rule violations
- Unnoticed accumulation of discrepant events
- Cultural beliefs about the unlikelihood of hazards

Several observations regarding model governance can be drawn from these common elements:

- **The attitude of, "If it ain't broke, don't fix it" has no place in effective model governance.** Just because a model has not experienced a failure doesn't mean it ain't broke. Some models are disasters waiting to happen. These models are often apparent to knowledgeable reviewers who are not under the spell of socialization, institutionalization and rationalization of policy deviations.
- **The extent and history of policy deviations should be a primary red flag.** A single deviation from model policy is unlikely to cause model failure. However, at some point, the accumulation of deviations combined with a casual attitude toward compliance are often indicators that the model may be ready to go off the rails.

- **Effective governance must address culture.** Culture is all of the unwritten and unspoken rules of behavior inside the organization. Cultural rules are learned before formal rules and are enforced more completely than formal rules. A culture that forbids criticism of a fellow team member is one in which policy deviance can thrive. A culture in which you lose face if you admit there's a problem is one in which policy deviance can thrive. A culture in which model hygiene is perceived as a low-value activity is one in which policy deviations can thrive. Effective governance must uncover such cultural norms so that model compliance and model hygiene are recognized as high-value activities.

REASONS FLAGRANT DEVIATIONS BECOME NORMALIZED

Banja identifies seven avenues by which policy deviations come to be considered normal practice. He acknowledges that the first appears to be the most common reason for normalization.

1. **The formal policies are perceived as inefficient or unresponsive to real problems.** Employees often view rules from on high as being out of touch with the reality of their jobs. Because model operators are more vested in the process of running the model (as opposed to mitigating risk), it is usually easy to create workarounds to formal requirements.

2. **Awareness of model governance standards is imperfect and unevenly distributed through the organization.** This problem is especially true for new employees in organizations that have extensive formal guidance. In fact, the more formal guidance there is, the more likely there will be policy deviations.

3. **Work procedures are sometimes disruptive.** Complex work often results in varying and unpredictable work requirements. Dealing with these requirements may disrupt typical work behavior such that policy compliance is ignored. This is especially true when new products, new processes or new computer systems are installed.

4. **The deviation is viewed as adding value to the organization.** Policy deviations often occur as solutions to immediate problems. When this happens, employees view the deviation as a good thing that adds value to the organization, rather than as a bad thing that could cause serious problems.

5. **Employees see policies as applicable only to others.** Employees often perceive themselves as acting correctly without the policy; therefore, the policy does not apply to them. This is true even when the employee's perceptions have no basis in reality.

> Many policy deviations are viewed by employees as being beneficial to the organization because they are solutions to some particular set of everyday problems.

6. **Employees are afraid to speak up.** If employees refuse to speak up when they observe policy deviations, normalization is encouraged. There are a number of reasons why employees might not speak up. These include lack of assertiveness, fear of retaliation, concern for undercutting a working relationship and a lack of confidence that speaking up will do any good.

7. **Managers understate problems or do not report them at all.** In an organization where politics results in loss of face if a manager admits to problems, identified policy deviations will be soft-pedaled as they are sent up to higher echelons. In addition, any identified problem whose remediation is perceived as a threat to normal work flow might not be sent up the ladder at all. This is especially true when there is an accumulated backlog of policy deviations that must be addressed.

WAYS TO PREVENT DEVIATIONS FROM BECOMING NORMALIZED

Banja also identifies some ways to prevent deviations.

Increase Management's Sensitivity to Early Indications of Deviance

Deviations from model policies and procedures occur more frequently than we like to believe. It is important to sensitize employees to the importance of compliance so that they view deviations as problems.

Resist the Urge to be Optimistic

For many model owners, the calculus of compliance is that addressing a policy deviance results in immediate and certain pain and delay, while ignoring a policy deviance has only a small likelihood of resulting in some hypothetical model failure at some point in the future.

While it is true that a single deviation has a tiny probability of causing model failure, deviations are not rare events. If you find one, you haven't found them all. Allowing any model deviation to remain sets the stage for socialization of deviance.

Teach Employees How to Raise Compliance Issues Even Though This is Uncomfortable

Confronting a model owner or model operator with deviations from formal requirements can be highly stressful. Many employees will avoid this discussion, if at all possible. This is especially true in organizational cultures that value teamwork and consensus.

This is not an area where actuaries typically have expertise, so assistance from the appropriate organizational department—typically human resources—will be necessary.

Provide Employees Safe Ways of Speaking up

There need to be policies that specify when employees are expected to speak up. These policies must promise protection for speaking up. Training sessions need to be conducted throughout the organization.

This is an area where most companies experience difficulties. Both culture and politics usually militate against speaking up, no matter what policies are promulgated. In addition, encouraging employees to speak up can create its own set of problems.

Oversight and Monitoring Must be Continuous

Because of the ease with which policy deviations can occur and become normalized, effective governance must make provision for continuous monitoring. A "once and done" mentality will not result in any change in pathological culture or politics.

Although not discussed by Banja, another important consideration for companies is the ability to perform objective reviews of failures. The ability to sift through the evidence and identify weaknesses is an important organization skill that allows companies to learn from their mistakes. Too many companies have a culture that looks for people to blame for the failures that occur. This approach not only prevents learning from failures; it fails to address the underlying problems.

THE ETHICAL DIMENSION

Most policy deviations are not due to deliberate insubordination or other unethical intent. Most people are virtuous in abstract, but run into ethical uncertainty when competing goals jostle against each other. In fact, many policy deviations are viewed by employees as being beneficial to the organization because they are solutions to some particular set of everyday problems. The deviations allow the employee or team to accomplish its responsibilities, usually with no apparent effect on model integrity.

Effective model governance emphasizes compliance by communicating the importance of model hygiene and the value that it has for the organization. In addition, effective governance provides incentives for employees to value compliance.

Because there is seldom unethical intent in policy deviance, and because model failures are often the result of systemic failure rather than from isolated behavior, organizations must take care that punitive actions are proportional to culpability.

A FINAL CRUEL TRUTH

Effective model governance is neither easy nor cheap. Implementation will often require trade-offs with other desirable organizational activities. Such trade-offs will never have universal support. If history is any guide, most companies will not implement effective model governance until they have suffered some notable model disaster.

CONCLUSION

It is naive to believe that simply promulgating an optimized decision framework with carefully crafted rules and procedures will result in effective model governance. Effective governance requires a sympathetic understanding of how employees perform their tasks and responsibilities, how they assimilate management requirements and directives, and how deviations from the requirements occur in even the best-intentioned employees.

Effective model governance requires the following:

- Implementation of practices that prevent the normalization of policy deviations, which includes education as well as addressing cultural and political norms within the organization
- Functioning feedback loops that allow the organization to learn from mistakes, especially disastrous mistakes
- Continuous oversight and compliance review
- Formal processes for correcting deviations ■

Bob Crompton, FSA, MAAA, is a vice president of Actuarial Resources Corporation of Georgia, located in Alpharetta, Georgia. He can be reached at *bob.crompton@arcga.com*.

ENDNOTES

1 The blog can be found at *https://danluu.com/*. The particular post that started me thinking about this topic is *danluu.com/wat*.

2 Vaughan, Diane. 1999. The Dark Side of Organizations: Mistake, Misconduct, and Disaster. *Annual Review of Sociology* 25:271–305, *http://www.jstor.org/stable/223506?seq=1#page_scan_tab_contents.*

3 Banja, John. 2010. The Normalization of Deviance in Healthcare Delivery. *Business Horizons* 53, no. 2: 139, *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2821100/*.

SOA Explorer Tool

Find Actuaries Around the Globe

The SOA Explorer Tool is a global map showing locations of fellow SOA members and their employers, as well as actuarial universities and clubs.

Explorer.SOA.org

SOCIETY OF ACTUARIES®

2017 SOA Modeling Sessions, Part 1

By Jennifer Wang

Here are modeling-related sessions from some of the major 2017 Society of Actuaries (SOA) meetings: Life & Annuity Symposium, Health Meeting and the Valuation Actuary Seminar. SOA members have free access to audio recordings synchronized with slide presentations from these meetings, so check them out!

2017 LIFE & ANNUITY SYMPOSIUM

SESSION 16 TEACHING SESSION: SOA EXPERIENCE STUDY CALCULATIONS EDUCATIONAL TOOL

Moderator: Cynthia MacDonald, FSA, CFA, MAAA

Presenters: David B. Atkinson, FSA, MBA; John K. McGarry, ASA, Ph.D.

The presenters discussed a paper, initiated by the SOA's Experience Studies Executive Committee, that presents the various rate calculations used in experience studies for different lines of business. The paper was created as an educational tool or resource for SOA members who perform experience studies for the SOA or for their clients or employers. (See session slides at *https://www.soa.org/pd/events/2017/las/pd-2017-05-las-session-016.pdf*)

SESSION 17 PANEL DISCUSSION: ADVANCED MODELING TECHNIQUES FOR LIFE & ANNUITY PRODUCT DEVELOPMENT

Moderator: Ying Zhao, FSA, MAAA

Presenters: Nick A. Komissarov, FSA, FCIA, MAAA; Mark Welchmeyer, FSA, CERA; Ying Zhao, FSA, MAAA

The presenters focused on advanced modeling techniques currently used for life and annuity products. The topics included:

- The Dukes-MacDonald method used to determine post-level term mortality as well as the key parameters of this formula and how to set parameters with limited experience
- Post-level term profitability and the mortality patterns following the initial shock lapse
- State-based modeling for variable annuity withdrawal behavior

(See session slides at *https://www.soa.org/pd/events/2017/las/pd-2017-05-las-session-017.pdf*)

SESSION 26 PANEL DISCUSSION: MODERN DETERMINISTIC SCENARIO RESEARCH

Moderator: Ronora E. Stryker, ASA, MAAA

Presenters: Mark E. Alberts, FSA, MAAA; R. Dale Hall, FSA, CERA, MAAA; Ronora E. Stryker, ASA, MAAA

The Financial Reporting Section, Smaller Insurance Company Section, Modeling Section, and the Committee on Life Insurance Research sponsored a research project to develop deterministic scenario sets reflective of the current life insurance industry environment. These sets were compared to other sets that are

commonly used in asset adequacy testing such as the New York 7 scenarios. In addition, the panelists invited audience participation in a discussion of the current interest rate environment, the prospects for change in that environment, and the impacts on pricing and product design. (See session slides at *https://www.soa.org/pd/events/2017/las/pd-2017-05-las-session-026.pdf*)

SESSION 28 PANEL DISCUSSION: ECONOMIC SCENARIO GENERATOR IN PRICING

Moderator: Dennis Radliff, FSA, MAAA

Presenters: Dariush A. Akhtari, FSA, FCIA, MAAA; Jean-Philippe Larochelle, FSA, CERA; David Moreno Jr., FSA, CERA; Jonathan A. Mossman, FSA

The presenters in this session explored economic scenario generators commonly used to model risks, price products and evaluate hedging strategies. They compared two risk-neutral interest rate models, their pros and cons, and how they impact pricing results. They also discussed advantages and disadvantages of using a stochastic pricing methodology and presented possible solutions to some of the challenges. (See session slides at *https://www.soa.org/pd/events/2017/las/pd-2017-05-las-session-028.pdf*)

SESSION 40 PANEL DISCUSSION: MODEL RISK AND GOVERNANCE

Moderator: Zohair A. Motiwalla, FSA, MAAA

Presenters: Arnold I. Behrmann, FSA, FIA; James M. Hedreen, FSA, MAAA; Zohair A. Motiwalla, FSA, MAAA

There has been strong recent industry focus on model risk, model validation and model governance, typically at the behest of company management and regulators. The presenters discussed these topics, especially pertaining to the production process. The presenters covered best practices for how companies can adopt a well-structured model governance framework that can help to mitigate financial risk. (See session slides at *https://www.soa.org/pd/events/2017/las/pd-2017-05-las-session-040.pdf*)

SESSION 48 PANEL DISCUSSION: REAL WORLD VS. RISK NEUTRAL: PRACTICAL IMPLICATIONS ON MODELS

Moderator: Yuan Tao, FSA, CFA, MAAA

Presenters: Melanie Dunn, ASA, MAAA; Ricky Power, FSA, CERA, FIA; Marcus Szeto, ASA, MAAA

The panel covered the theory behind the risk-neutral and real-world frameworks, and provided an overview of how a scenario set is developed to be real-world or risk-neutral. The panel provided practical guidance for when each framework should be used, with examples from the pricing of variable annuities and other products with embedded guarantees. (See session slides at *https://www.soa.org/pd/events/2017/las/pd-2017-05-las-session-048.pdf*)

SESSION 53 PANEL DISCUSSION: BEST PRACTICES FOR ASSUMPTION SETTING FOR PRODUCT DEVELOPMENT

Moderator: Kimberly M. Steiner, FSA, MAAA

Presenters: Andrew Chong Jenkins, FSA, CERA, MAAA; Ben J. Quiner, FSA, CERA, MAAA; Kimberly M. Steiner, FSA, MAAA

The presenters described how experience studies can be efficiently used for assumption setting in product development and considerations throughout the product development process. The presenters discussed best practices for how product development actuaries can use, document and communicate assumptions that are used in their models. (See session slides at *https://www.soa.org/pd/events/2017/las/pd-2017-05-las-session-053.pdf*)

SESSION 55 PANEL DISCUSSION: INDIVIDUAL LIFE MORTALITY EXPERIENCE STUDY RESULTS

Moderator: Cynthia MacDonald, FSA, CFA, MAAA

Presenters: Roland Fawthrop, FSA, MAAA; Brian D. Holland, FSA, MAAA

The SOA's Individual Life Experience Committee presented the results of its most recent mortality study of fully underwritten individual life insurance. The data behind this study was collected by the statistical agent for the states of New York and Kansas, and covers observation years 2009 through 2013. The study shows how the mortality experience varies by numerous factors and compares the experience to recent standard mortality tables. (See session slides at *https://www.soa.org/pd/events/2017/las/pd-2017-05-las-session-055.pdf*)

SESSION 63 PANEL DISCUSSION: PLATFORM CONVERSION: CONSIDERATIONS, PRINCIPLES AND IMPLICATIONS

Moderator: Ramandeep Nagi, FSA, FCIA

Presenters: Ramandeep Nagi, FSA, FCIA; Hanh Thi Nguyen, FSA, MAAA; Alexander Zaidlin, FSA, ACIA, MAAA

The presenters focused on actuarial software implementations and the lessons learned through the process. The discussion focused on migration from an old modeling software platform to a new platform and how to make this a smooth transition. They also discussed post-conversion considerations and the experience of day two issues with their models. (See session slides at *https://www.soa.org/pd/events/2017/las/pd-2017-05-las-session-063.pdf*)

SESSION 76 TEACHING SESSION: PREDICTIVE MODELING: GETTING OUT OF SQUARE ONE

Moderator: Ricardo Trachtman, FSA, MAAA

Presenters: Eileen Sheila Burns, FSA, MAAA; Jean-Marc Fix, FSA, MAAA

Experts at this hands-on session walked participants through the analytical process of developing a basic generalized linear model. Lessons learned were practical and also provided insights about the process of approaching or evaluating a modeling project. (See session slides at *https://www.soa.org/pd/events/2017/las/pd-2017-05-las-session-076.pdf*)

2017 HEALTH MEETING

SESSION 16 INTERACTIVE FORUM: PREDICTIVE MODELING HOT TOPICS

Moderator: Hans K. Leida, FSA, MAAA

Presenters: Gary Gau, ASA, MAAA; Joe Long; Michael Cletus Niemerg, FSA, MAAA

Predictive modeling and machine learning are rapidly finding applications across many actuarial areas of practice, replacing or complementing traditional tools and approaches. This session gave an overview of some of the trending algorithms and approaches that successful modelers are using, as well as a survey of some of the software platforms that can be used to implement them. (See session slides at *https://www.soa.org/pd/events/2017/health-meeting/pd-2017-06-health-session-016.pdf*)

SESSION 56 PANEL DISCUSSION: FINANCIAL ANALYSIS: IMPAIRMENT, STRESS TESTING AND PREDICTIVE MODELING

Moderator: Andrea Sheldon, FSA, MAAA

Presenters: Missy A. Gordon, FSA, MAAA; Roger Loomis, FSA, MAAA; Sarah Prusinski, ASA, MAAA

Key pillars in a successful pharmacy benefit management (PBM) program include assessing corporate benefit strategy, responding to emerging market trends, monitoring internal claims experience and performing industry benchmarking. This session highlighted current strategies to optimize benefits while managing prescription drug trend rates through benefit design, clinical programs, vendor management and strategic planning. (See session slides at *https://www.soa.org/pd/events/2017/health-meeting/pd-2017-06-health-session-056.pdf*)

SESSION 57 LECTURE: DEVELOPING EFFECTIVE HEALTH CARE PREDICTIVE MODELS

Moderator: Evan Morgan, ASA, MAAA

Presenter: Syed Muzayan Mehmud, ASA, MAAA, FCA

Data is fast becoming a crucial asset, and the companies that leverage it have an edge over others. Knowing tools and techniques is important; however, the application of the skill is crucial to the success of a predictive modeling effort. Ideas are important, but execution is all-important. This session explored the steps and considerations involved in the development of effective health care predictive models. (See session slides at *https://www.soa.org/pd/events/2017/health-meeting/pd-2017-06-health-session-057.pdf*)

SESSION 58 PANEL DISCUSSION: I'LL HAVE HEALTH INSURANCE WITH A SIDE OF HEALTH INSURANCE

Moderator: Gregory G. Fann, FSA, FCA, MAAA

Presenters: Alex Forrest; Shawn Hartman; Dustin David Tindall, FSA, MAAA

As cost sharing for commercial health insurance plans increases, some individuals are seeking additional coverage through increasingly popular gap insurance policies. This session explored the gap insurance market, examined consumer preferences and discussed potential pitfalls for insurance carriers. The latest market activity and modeling techniques were also explored. (See session slides at *https://www.soa.org/pd/events/2017/health-meeting/pd-2017-06-health-session-058.pdf*)

SESSION 60 PANEL DISCUSSION: PREDICTIVE MODELING FOR PHARMACEUTICAL COST GROWTH

Presenter: Joseph Farago

This session provided a closer look into the Canadian pharmaceutical market growth trends and their place in overall health care costs. The focus was centered on the private payer market with a detailed look into future growth trends and forecasting. The speaker shared the 2016–18 Canadian private market forecasting model. (See session slides at *https://www.soa.org/pd/events/2017/health-meeting/pd-2017-06-health-session-060.pdf*)

SESSION 65 LECTURE: MEDICAID RISK ADJUSTMENT: ROLE OF ENCOUNTER DATA AND UNDERSTANDING MODEL-SPECIFIC NUANCES

Moderator: Marlene Therese Howard, FSA, MAAA

Presenters: Bradley Bruce Armstrong, FSA, MAAA; Richard Lieberman

Navigating Medicaid managed care requires an experienced professional to evaluate and/or question how the risk adjustment model establishes payment levels, the role that encounter data plays in terms of both submission and the state's handling of the data, and the importance of encounter data necessary to enhance capitation payment levels and/or avoid financial sanctions imposed by states.

This session explored various scenarios related to the quality of available managed care encounter data and potential implications on managed care program risk adjustment. The speakers described various risk adjustment methodologies, with particular focus on Chronic Illness & Disability Payment System (CDPS), CDPS + MedicaidRx and the Johns Hopkins Adjusted Clinical Groups (ACG) System. (See session slides at *https://www.soa.org/pd/events/2017/health-meeting/pd-2017-06-health-session-065.pdf*)

SESSION 97 PANEL DISCUSSION: SOA LTD EXP COMMITTEE—UPDATE ON RECENT TERMINATION STUDY

Moderator: Paul Luis Correia, FSA, CERA, MAAA

Presenters: Paul Luis Correia, FSA, CERA, MAAA; Mervyn Kopinsky, FSA, EA; David A. Wall, FSA, MAAA

In 2008 the SOA LTD experience committee published a new termination table to replace the 1987 GLTD table. In 2012, the AAA published a new valuation table and valuation standard using the SOA experience table from 2008.

In this session, the speakers compared the latest actual-to-expected results relative to these tables with experience data submitted through 2012. They also explored various predictive modeling approaches applied to this latest SOA study. (See session slides at *https://www.soa.org/pd/events/2017/health-meeting/pd-2017-06-health-session-097.pdf*)

SESSION 101 PANEL DISCUSSION: PANDEMIC MODELING FOR GROUP LIFE INSURANCE

Presenters: Timothy B. Moran, ASA, MAAA; Kimiko Tam

This session briefly touched on the history of pandemics and pandemic modeling, followed by a discussion of modern methods for pandemic modeling. Specific topics included the most important vectors to model, how to weight and prioritize them, and how to deal with co-dependencies. Panelists discussed risk concentrations in group life insurance and used sample data to illustrate modeling approaches, while addressing the potential use of reinsurance to mitigate risk. (See session slides at *https://www.soa.org/Files/e-business/pd/events/2017/health-meeting/pd-2017-06-health-session-101.pdf*)

SESSION 124 PANEL DISCUSSION: NEXT GENERATION RISK ADJUSTMENT

Moderator: Jason Robert Siegel, FSA, MAAA

Presenters: Ian G. Duncan, FSA, FCA, FCIA, FIA, MAAA; Charles S. Fuhrer, FSA, FCA, MAAA; Jason Robert Siegel, FSA, MAAA

The speakers discussed the credibility and variance associated with risk-adjusted claims, some of the biases introduced by traditional models and how they can be fixed, as well as how these models can be customized for nontraditional uses such as in provider reimbursement arrangements. (See session slides at *https://www.soa.org/pd/events/2017/health-meeting/pd-2017-06-health-session-124.pdf*)

2017 VALUATION ACTUARY SEMINAR

SESSION 10 PANEL DISCUSSION: MODEL GOVERNANCE AND MANAGEMENT—ADVANTAGES OF A FORMAL MODEL GOVERNANCE FRAMEWORK

Moderator: Marc Slutzky, FSA, CERA, FCA, MAAA

Presenters: Ryan David Krisac, FSA, MAAA; April Rijing Shen, FSA, CERA, MAAA; Uri Sobel, FSA, MAAA

Management of the development of actuarial assumptions and the assumption change management process are key elements of GAAP model validation. The presenters provided an overview of potential frameworks for developing, governing and managing assumptions across departments. They used sample case studies to show how organizations have improved the consistency and transparency of the assumption setting process by restructuring the way assumptions are approved and monitored. (See session slides at *https://www.soa.org/2017-val-act-seminar-presentations.zip*) ■

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Adding Value With Model Validation: AG43 Model Validation Case Study

By Winston Tuner Hall, Michael Minnes and Veltcho Natchev

In Issue 6 of *The Modeling Platform* (November 2017), we wrote a conceptual article about model validation. We defined what we believe a model validation should entail, the value proposition for stakeholders, the ways in which we gain stakeholder buy-in, and how we work with stakeholders to achieve consensus on issues, findings and mitigations. We asserted that the model validation effort could be used to affect organizational culture change from a routine task-oriented, "production" mindset to a "value-add" perspective that is focused on analysis, risk management and continuous improvement. We also touched on how the control functions in our organization (second and third lines of defense) collaborate and rely on our respective strengths to perform model validations, identify issues and manage mitigation efforts.

This article delves deeper into the tools that should be in place to support a validation program and then covers a case study in the application of our concepts on a validation of an Actuarial Guideline 43 (AG43) model. It should be noted that although we draw on our experiences validating and auditing models to write this article, this article is theoretical in nature and is not about a validation of one of our employer's AG43 models.

MODEL VALIDATION PROGRAM REQUIREMENTS

A sustainable model validation program that facilitates successful validation engagements requires meticulous planning and a clear set of shared expectations from each of the three lines of defense (LODs). To that end, there are certain artifacts, preparation milestones and processes that need to be put in place and maintained by each LOD prior to and throughout each validation engagement. In this section we outline these elements of the program and discuss how their implementation helps achieve the desired goals of model validation in the context of close collaboration among the LODs. Each element is designed to add value to the process and establish a feedback loop for the stakeholders during the actual validation initiatives and post-validation activities through a well-defined, documented and consistent approach.

Model Governance Policy

The model governance policy (the Policy) provides a clear definition of what types of applications, such as spreadsheets and systems, constitute "a model," as differentiated from a "business process" or a "calculation tool," and lays out a framework and guidance on how to treat model structures and operational "model units" residing on various software applications and platforms.

In addition to defining models and outlining the domain and scope of model governance, the Policy also specifies the organization's methodology for model risk assessment and risk-based control standards. This methodology must be designed to cover all models and be consistently applied across all business units, processes and individual model applications. The risk assessment approach has to be well understood by all model owners, as they are the ones to carry it out and, ultimately, to ensure that appropriate and sufficient risk-based control mechanisms are implemented around their models. Instilling risk control mindfulness within the organization, top to bottom, is one of the main objectives of a successful model governance program. Together with subsequent model validation efforts, they are the main agents of affecting cultural change from viewing model risk management as a hindrance to modeling to that of a major benefit in protecting the company.

An integral component of the Policy is documentation guidance. Any deep-dive validation efforts would involve collection of related artifacts from the model life cycle (such as business, functional and technical specifications, test cases, data dictionaries, etc.) and comparing existing model documentation against some sort of a standard (e.g., a documentation template or a set of requirements or guidelines). To a great extent, the success of a model validation depends on the availability of documentation (completeness, appropriateness, accuracy and accessibility), which shortens the discovery phase of the validation and allows the validator to spend more time on analysis and evaluation of the actual model.

Properly created, maintained and updated documentation benefits all model stakeholders as it mitigates key person risk for the first line of defense (i.e., allows non-owners to run the model and shortens training time). In addition, it reduces the burden on the validator who is a member of the second line of defense. Finally, it provides a standard on what the mitigation efforts need to accomplish, enabling Corporate Audit (third line of defense) to plan and monitor mitigation progress.

Enterprise Model Inventory and Risk Assessment

A model validation program is built around the availability of an accurate and up-to-date Enterprise Model Inventory, covering all models and their supporting applications for the entire organization. This inventory is maintained at the local business

area level but is consolidated at the corporate level. Decisions on how to plan and schedule model validation engagements are primarily based on two inventory requirements:

- Accurate and consistent model risk rankings to enable appropriate selection of models for validation based on their criticality and the company's potential risk exposure (e.g., materiality, reliance for decision-making, complexity)

- Appropriately captured and classified model characteristics (across business areas, products, supported processes, platforms, downstream usage of model results)

Simply being able to have a lens into the complete inventory and the opportunity to analyze it across these dimensions can go a long way in designing an optimal validation agenda that minimizes the burden on local business areas. For instance, the planners may decide to include multiple models in a single validation if, for example, they reside on the same platform (e.g., GGY Axis or Prophet) or support the same business process (e.g., life or annuity reserve valuation) while the model stakeholders will not be excessively burdened by multiple requests for documentation and walk-throughs. Another example is selecting upstream and downstream models for a single validation effort in a case where the upstream model's output is used as the downstream model's input (e.g., interest rate assumptions).

Model Validation Preparation, Planning and Requirements Checklist

The success of any deep-dive validation is rooted in the quality of the validator's preparation and planning for the engagement. Time and efforts spent up front on defining the actual objectives, scope and deliverables of any validation project and communicating this information to all relevant stakeholders will go a long way in defining shared hopes and building validator's credibility. Therefore, coming into each new initiative, the validator is strongly encouraged to put together a validation proposal, including planned timeline and resource requirements. The plan should cover the following elements: objectives and benefits, scope, roles and responsibilities, expectations of each stakeholder and defining the communication channels among all stakeholders.

To further ensure smooth execution, a standard checklist of requirements covering the milestones and deliverables of a deep-dive validation should be created and shared to guide all efforts regardless of the type of model or business area that is being validated. We view each validation as consisting of the following consecutive phases.

Discovery Phase

During this phase the validator collects and systematizes all information required for validation, including:

- Discussions with model owner(s)

- Collection of all model-related documentation (artifacts)

- Discussions with upstream suppliers of model inputs, including assumptions

- Discussions with downstream model users of model results

Analysis and Validation Phase

In the beginning of this phase the validator defines and describes the model components that will need to be analyzed and/or replicated for testing. These include key inputs, such as historic data and assumptions, and main elements of the calculation engine that will transform these inputs into outputs. We find it helpful to develop a model data and processing map/schematic that traces all inbound and outbound data flows and identifies those processes that the validator should independently replicate. Based on these definitions, descriptions and mapping, the validator develops a model blueprint (a simplified replica of the production model) or performs a detailed independent code walk-through (in cases where development of a blueprint model may be excessively time-consuming, such as for complex platforms or systems). In some cases, such as to perform scenario testing, a combination of creating a blueprint for some model components (e.g., programming sub-routines) and doing a code walk-through for others may be appropriate.

In order to properly evaluate the model's functionality, relevance of its assumptions and input data, the validator needs to define, design and document appropriate test cases, including use scenarios and limitations. Based on these test cases, the validator then identifies the differences between the blueprint and the production model and performs stress and sensitivity analysis under various assumptions for significant differences. Results of these tests should be promptly shared and discussed with the model owner.

Findings and Reporting Phase

The validator provides interim progress reports focused primarily on findings to date, prioritized according to their risk probability and severity. The reporting phase concludes with the creation of the Final Report, a validation close-out discussion and coordination with Corporate Audit on the mitigation plan. The Final Report includes the following sections: executive summary, gaps and proposed mitigations, error prevention and handling, and other recommendations or action items. The validation close-out discussion should address sign-offs on the Final Report and risk acceptance on findings that will not be addressed in the immediate future. The validator populates the Governance, Risk and Compliance (GRC) system with mitigations from the mitigation plan and then turns over mitigation management to Corporate Audit. Corporate Audit typically has expertise in mitigation management and can manage mitigations more efficiently than a validation team.

As we have gone through several validation planning phases, we discovered a few practices that can help with clarifying objectives, facilitating the validation and realizing shared hopes with stakeholders. Here are some helpful hints:

- Request the model owner(s) conduct a pre-validation self-assessment, whereby the model owner completes the model scorecard and the scores for each category are later compared to the actual scorecard completed by the validator at the end of the engagement.
- Hold one or more validation kickoff discussions attended by all stakeholders to "set the playing field" and ensure common understanding of the objectives and scope of the project.
- Provide a list of model life cycle artifacts to model owner(s) in advance of the validation so that they can get a head start in collecting documentation expected to reside in the "model space" (e.g., model development project plan, list of model benchmarks, peer review reports, sign-offs documentation).
- To ensure complete transparency of the process, the validator should establish a process and venue for ongoing communication with the model stakeholders throughout the engagement. Periodic sharing of an interim progress report, covering such items as upcoming deliverables, outstanding questions, new findings and potential findings being investigated helps keep all parties engaged in the process, informed of the status of validation and reduces the risk of surprises when reporting the findings or having to escalate potential issues.
- Ask stakeholders to fill out a short survey on their interactions with the validator and effectiveness of the validation itself, as this informs future engagements and serves as a confirmation of value placed on their opinions.

Model Validation Scorecard

Transparency, objectivity and consistency of evaluating a model are the principles ensuring that different independent validators with similar experience and expertise come up with roughly the same, or similar, scores for all model categories. These principles help build trust and credibility with the stakeholders, achieve a collaborative (non-adversarial) environment and improve the likelihood of achieving consensus on findings. The model validation scorecard should cover the following dimensions:

- **Fit for purpose.** The model is conceptually and methodologically sound for each model use.
- **Accuracy of calculations.** The modeling methodology is implemented correctly with accurate inputs and appropriate outputs.
- **Design and data processing.** The modeling environment, tools and design are appropriate for model uses.
- **Model governance and documentation.** Model control standards are implemented and the modeling process and technical functionality are accurately and comprehensively documented.

> Transparency, objectivity and consistency ... help build trust and credibility with the stakeholders.

Scoring Standards and Guidelines

The validation professionals are encouraged to define a set of general model scoring standards to be consistently applied across all validations, and share them with model stakeholders in advance of each engagement. These are best illustrated with an example from the "Fit for Purpose" category. The model is scored by the validator based on the following standard:

> The model achieves its overall objectives in support of specific business purpose(s)—e.g., process, domain, product, outcome—and satisfies requirements set for it in business, functional and technical specs. This metric should also consider the model's intended scope and robustness vs. functional limitations.

In addition to definitions of standards, scoring guidelines should be put in place outlining the scale of how models are evaluated for each category. There are two alternative scales that can be considered in designing scoring guidelines (let's assume a 1–5 rating, with 5 as the best score):

- Assume a score of 3 to be "average," whereby improvements can move the model to an "industry-leading" category.
- Assume a score of 5 to mean "fully compliant with the validation requirements," and any lower scores to indicate progressively larger deviations from requirements.

Validation findings can constitute a wide range of opinions, but typically can be classified into three main categories. Validators can use a standard H/M/L risk probability and severity scale or, instead, focus on benefits from implementing a solution or a recommendation to apply to these categories. We believe that findings fall into the following three broad categories:

- **Deficiency.** An adverse finding (e.g., methodology or calculation error) that presents an immediate or continued risk to the company if not corrected for a period of time.
- **Model risk.** An observation noted by the validator of a potentially risk-bearing finding that does not constitute an error, but which does create a risk for the company if not addressed.
- **Improvement recommendation.** An opportunity for improvement identified as carrying little or no risk to the company if not completed.

AG43 VALIDATION PROCESS

To illustrate the concepts and approach to a deep-dive model validation mentioned in the previous sections, we will walk you through a hypothetical AG43 validation example and phases, focusing on the various scorecard categories. For each of the phases, the validator would go through a set of steps to evaluate the model's compliance with these categories.

Fit-for-Purpose

The model produces reasonable AG43 reserves, and is expected to continue to do so in the future as well as be able to apply modifications and updates to react to potential future regulatory changes with reasonable ease.

Discovery Phase

- Discuss with the model owner any product features, such as company-specific variable annuity guaranteed living benefits (VAGLBs) and how they are implemented in the model. What type of hedging strategy is used? What are the expectations for it?
- Collect model artifacts related to the VAGLBs (e.g., technical documentation, sensitivity and model change testing, results monitoring).

Analysis and Validation Phase

- Ensure that model concepts and their implementation comply with existing regulations, laws, company policies and industry practices.
- Verify reasonability and internal consistency of assumptions (e.g., dynamic lapses and annuitization, base benefit growth, expenses and fund charges).
- Review the process of setting assumptions (e.g., how often they are reviewed, what sources are used, who is responsible for the process) and evaluate their consistency with standard industry practices.
- Validate that model results are distributed to downstream users and decision-makers with appropriate and complete supporting data to be used in the relevant context (e.g., reserves, trend analysis, sensitivities).

Findings and Reporting Phase

- **Deficiencies.** The model contains a material error or is noncompliant with the existing regulation by a government body, professional governing association, company policy or standard industry practice (hopefully this is not the case); a noncompliance finding should immediately trigger remediation efforts.
- **Model risks.** Mostly assumptions related (e.g., assumptions are not being reviewed as often as the regulations or industry standards require, they are not consistent, or the process of changing them is not well documented).
- **Model improvements.** Examples may include a validator proposing implementation of new product features, standard scenario changes, tax reserve calculations changes and so on. Doing this proactively will also help actuaries on value-added activities, such as analysis rather than coding, data manipulation or administration.

Accuracy

There are no technical errors in the model. The inputs and outputs are controlled and calculations match expectations.

Discovery Phase

- Discuss with the model owner the process of calculating the reserves. Are the Standard Scenario Amount (SSA) and the conditional tail expectation (CTE) amount calculated on the same software package or different ones? If the latter, how are the in-force extracts reconciled, where is hedging applied, and where is the final result calculated? Also are there any limitations to the calculations (e.g., running fewer than 1,000 scenarios for CTE because it is "too time-consuming"; missing data for some calculations, such as certain product features not included in the in-force file)?

- If any limitations are disclosed, ask for any top (down) side adjustment made to account for these limitations.

Analysis and Validation Phase

- **Technical issues.** Make sure there are no coding errors (e.g., base benefit resets or dynamic lapses can be very complicated; creating a spreadsheet to mimic them would help with the checking). Request audit files from the software, especially for SSA calculations, and replicate the calculations from first principles. Audits should cover a wide variety of cases including all LBs offered by the company.

- **Outside adjustments.** If there are any outside adjustments to the model results due to system limitations, make sure they are reasonable.

- **Accuracy of data inputs.** What controls are in place? How are assumption changes tested? Items to look for here include in-force extract reconciles to the sources; after an assumption(s) change the following three steps are completed: (1) assumptions match the sources, (2) the new assumptions are being read by the model properly and (3) regression testing is performed.

- **Accuracy of outputs.** How are they assessed? How is analysis done? Is there data to support conclusions from the analysis? Items to look for here are reconciling outputs to the inputs, reserve trends with thresholds triggering investigation, FV roll-forward, attribution analysis of the impact after assumption(s) change, sensitivity testing, and so on. If the CTE amount is greater than the SSA, what are the reasons for it (e.g., market conditions, too-rich guarantees)?

Findings and Reporting Phase

- **Deficiencies.** These are technical errors, missing controls, questionable testing of the assumptions.

- **Model risks.** Undocumented top (down) side adjustments to the results, poor rationale for variances and assumption inconsistencies, visual rather than automated testing of the inputs.

- **Model and risk improvements.** Examples may include an improvement of the hedging of LBs if the company does not use a clearly defined hedging strategy.

Design and Processing Phase

The modeling platform as well as the model allow for ease of future changes and maintenance.

Discovery Phase

Discuss with the model owner the platform or the programming language used for the model; companies usually use a vendor software package for the AG43 calculations and a home-office-designed hedge program. If the outputs are summarized separately, review the process as well. Discuss who is responsible for making model changes, testing them, sign-offs and running the model.

Analysis and Validation Phase

- **Version controls, space storage.** Every model change has it is own version; all old versions are archived; testing documentation, change management controls, and so on.

- **Ability to make future changes.** For the system: whether it is open or closed, vendor support; for the model itself: whether it was created to allow for changes. Is the model design easy to understand? Review past changes and efforts to make them; review the documentation of the model functionality.

- **Assess the efficiency of the model.** Is it easy to maintain? Is it optimized for runtime? Review runtime tests, automated assumption changes and testing.

Findings and Reporting Phase

- **Deficiencies.** Manual processes that can be automated (e.g., if the model has several different uses, set up a batch process to run all of them automatically); poor change management controls.

- **Model risks.** The model is not robust enough to make changes to it; there are system limitations that require adjustments to the results; only the last few versions of the model are being kept.

- **Model improvements.** Examples may include processes that can be done by other personnel rather than actuaries (e.g., in-force extracts can be created by IT who also can run the models allowing actuaries more time for analysis).

Model Governance and Documentation

ERM Model Validation and Corporate Audit collaborate on model governance. To ensure that there is consistency in model governance assessments and to facilitate leveraging each other's work product, Corporate Audit and ERM Model Validation developed a standard risk and control matrix (RCM). Corporate Audit has scale and expertise in assessing compliance with corporate policy. Therefore, it is preferable Corporate Audit perform model governance assessments rather than ERM Model Validation. This is a more efficient use of the enterprise's resources. As shown in Figure 1, the sample RCM has 10 controls that span the requirements documented in the Corporate Model Governance Policy (CMGP).

For this article, we will focus on the following controls: Enterprise Model Inventory, Change Controls and Model Documentation.

Enterprise Model Inventory

Every model has been risk-assessed and recorded in the Enterprise Model Inventory. The Policy identifies which controls are required for high-, medium- and low-risk models. Figure 2 shows this information included in the RCM to guide the auditor in determining which controls should be in scope of an audit.

During the planning phase of the audit, the auditor should identify the AG43 model owner's Model Governance Lead and verify that the Enterprise Model Inventory is current. The auditor

Figure 1
Sample RCM

Control Procedures			
Control Number	**Control Procedure Description**	**Control Number**	**Control Procedure Description**
1.1	**ERM Model Inventory**—There is a Model Governance Lead who catalogued the model within the Enterprise Risk Management (ERM) Model Inventory and risk-ranked the model in accordance with ERM's risk-ranking methodology.	**1.6**	**Data Backup & Version Control**—Model data and code is appropriately backed up, restorable and version controlled.
1.2	**Fit for Purpose**—When designing, building or developing a model, the user confirms the capability and constraints of the model (based on underlying methodology and assumptions) are consistent with the intended purpose. Ongoing oversight and testing of key aspects of the model are validated, reviewed and approved by an independent manager or modeling committee.	**1.7**	**Input & Output Validation**—Data that is input to the model, and the output generated, are reviewed for completeness and accuracy.
1.3	**Assumptions**—Assumptions are reviewed (or approved, depending on risk level) prior to model results being relied upon. Assumptions are evaluated periodically (frequency based on risk level) to verify they are still relevant and reasonable.	**1.8**	**Data Integrity**—A process exists to prevent or identify accidental or malicious overrides (of data, formulas, processing functionality, etc.) within models.
1.4	**Change Controls**—A formal process is used to establish, approve, analyze, test, communicate and record model changes (including assumption changes).	**1.9**	**Model Documentation**—Documentation is sufficient for other individuals to run the model, understand how it works, and understand the intended objective of the model.
1.5	**Restricted Access**—Access to models is appropriate for job responsibilities.	**1.10**	**Process Documentation**—Step-by-step instructions of the process (including folder locations, file names, file owners and controls) are sufficient to allow another user with an appropriate level of systems access to perform the process and reproduce prior results.

Figure 2
Enterprise Model Inventory

Control Procedures						Test Procedures
Control Number	Control Procedure Description	Inherent Risks	High	Med	Low	Test Step Detail
1.1	**ERM Model Inventory** There is a Model Governance Lead who catalogued the model within the Enterprise Risk Management (ERM) Model Inventory and risk-ranked the model in accordance with ERM's risk-ranking methodology.	**General risks**—Model misspecification of relationships, missing risk factors or ignoring material factors, leading to a business decision/recommendation not reflecting management intentions. **Loss of key employees**—leading to disruption in processes or inaccurate execution of processes that rely upon model results.	X	X	X	1. Confirm the model has a Model Governance Lead responsible for performing a model risk-assessment and updating the ERM Model Inventory. 2. Confirm the model has been inventoried, is risk-assessed, and there is an annual refresh of the assessment. 3. Perform an independent risk assessment using the ERM Model Risk Score Calculator. If Auditor assessment differs from business/ERM assessment, auditor to work with both parties to gain agreement.

accesses the inventory and extracts the model risk assessment. Assume that the self-reported risk assessment is 4.6 out of 5, which translates to a "High." This score should be a weighted sum of scores for several risk factors: materiality, complexity, key person risk, identified limitations or errors, user access and so on. The auditor performs an independent risk assessment of 4.75 out of 5, which also translates into a "High." The auditor works with the Model Governance Lead to come to a consensus on the risk factor scores where they differ. In this example, the differences are minor and changing the model owner's risk assessment would not change the overall risk score of the model. Therefore, the auditor documents in the test results that Model Governance Lead's risk assessment has been validated and the inventory is current. No issues or mitigations would be created. However, because the model is high-risk the auditor should include all 10 RCM controls within the scope of the audit.

Change Controls

During the planning phase of the audit, the auditor requests from the Model Governance Lead an inventory of all changes made to the model over the last four quarters. Figure 3 illustrates the associated considerations for Change Control. The model owner provides an inventory of six changes made during the development periods between valuation dates. The auditor uses sampling methodology and determines that 2 of 6 should be tested. The auditor decides that the sampling should be risk-based and selects the most complex change and the most impactful change.

The auditor's objective is to evaluate whether or not the model is subjected to a development life cycle. Figure 4 details the steps in a sample model development life cycle.

For each of the changes the auditor requests the following evidence from the model owner:

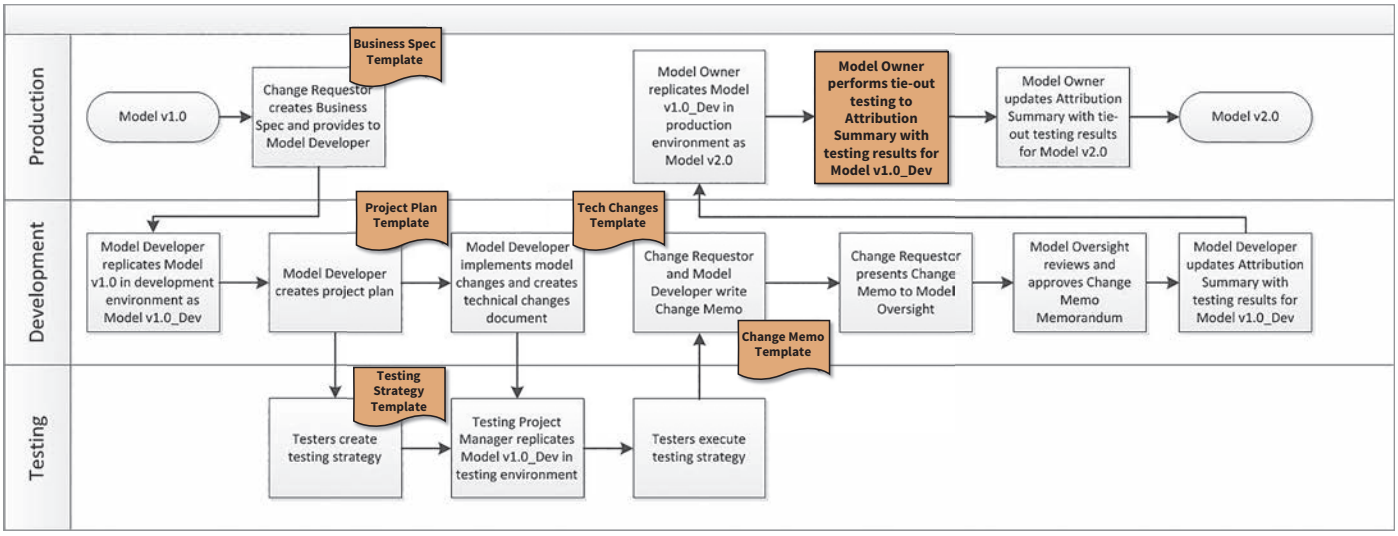
- **Business specification.** Provides the model developer with specifications for the change, example or prototype of the change and a quantification of the expected impact.
- **Project plan.** A project plan is usually only required for large, complex changes.
- **Testing strategy.** Documents the testers (must be different from the model developer), defines unit testing, User Acceptance Testing (UAT) and attribution testing requirements.
- **Technical changes.** Documentation of the changes made to the model and the purpose for each.
- **Change memo.** Provides a summary of the business reason for the change, support for how the model owner gained comfort with the impact.
- **Tie-out testing evidence.** Evidence that the production model produced the same results contained in the change memo.

For the complex change, the model owner may only provide a business specification and a change memo. For the most impactful change, the model owner may provide only a change memo. The auditor determines if the amount of analysis of the impacts is sufficient. The auditor also tests if the model was subject to a well-controlled development life cycle.

Figure 3
Change Controls

Control Procedures						Test Procedures
Control Number	Control Procedure Description	Inherent Risks	High	Med	Low	Test Step Detail
1.4	**Change Controls** A formal process is used to establish, approve, analyze, test, communicate and record model changes (including assumption changes).	**Inadequate change management of the model**—leading to unauthorized or unintended changes. **Model changes are not sufficiently tested**—leading to changes that do not meet business requirements and produce unexpected results.	X			1. Changes are documented, submitted and approved to oversight committee 2. Formal process for communicating errors into the model governance structure 3. Appropriate testing of the change 4. Formal process for communicating changes to model users, model output users 5. Impacts are calculated and recorded by version (it should be clear which changes were implemented in a production cycle and how each change impacted model results)

Figure 4
Model Development Life Cycle



For instance, what if development often took place in the production version of the model and at times during the production cycle? The auditor should then determine if changes were well-communicated and whether or not the lack of change controls exposed the enterprise to model risk. The auditor should discuss the identified issues with the model owner, as well as the business area's senior leader, and explain how implementation of change controls would mitigate model risks.

A best practice is to have Corporate Audit create a Model Governance Center of Excellence (MGCoE). Auditors skilled in assessing a model's compliance with CMGP can create the RCM, collaborate with second line of defense and assist model owners to comply with the CMGP. The MGCoE relies on existing resources in Corporate Audit and should not result in additional costs. The MGCoE should develop change control templates for business specification, project plan, testing strategy, technical

changes and change memo. In addition, the auditor can explain how the MGCoE could advise the business area on how to set up a model oversight committee and implement change controls. The auditor and the business should come to a consensus that change controls should be improved. The auditor should create the following mitigation in the enterprise's GRC system.

Hypothetical issue: Change controls are not sufficient and expose the enterprise to model risk.

Potential mitigations: The Valuation business area and the AG43 Model Governance Lead will:

- Implement a local model governance framework that will create a model oversight committee responsible for reviewing and approving changes to models
- Implement development life cycle for the AG43 model that will require all development is performed in a development version of the model and cease development prior to the beginning of a production cycle
- Create templates for business specification, project plan, testing strategy, technical changes and change memo for all changes
- Require a business specification, testing strategy and change memo for all changes
- Require evidence of tie-out testing when a development model is promoted into production

Model Documentation

During the planning phase of the audit, the auditor requests model documentation from the Model Governance Lead. Figure 5 further explains the Model Documentation control procedure. The Model Governance Lead may provide AG43 memorandum and assert that the memorandum was used to document the model. The auditor should then rely on the MGCoE's model documentation template and evaluate the AG43 memorandum to determine if it sufficiently documents the model. The auditor may conclude that although the AG43 memorandum does partially address model functionality, data, assumptions and parameters, it is not sufficient to be considered model documentation.

Model documentation should significantly mitigate model risk and key person risk. These risks are mitigated by documenting functionality, model and input limitations, the modeling flowchart, data dictionary and ongoing monitoring activities. By having such information documented, the business area creates opportunities for mobility of model ownership and knowledge transfer, ensures reusable training and smooth transition, and enables others to learn the model while freeing up key people to work on continuous improvement projects and add value to the enterprise.

Figure 5
Model Documentation

Control Procedures						Test Procedures
Control Number	Control Procedure Description	Inherent Risks	High	Med	Low	Test Step Detail
1.9	**Model Documentation** Documentation is sufficient for other individuals to run the model, understand how it works, and understand the intended objective of the model.	**General risks**—Model misspecification of relationships, missing risk factors, ignoring material factors, incorrect application or implementation, incorrect calibration, programming problems, etc., leading to a business decision/ recommendation not reflecting management intentions.	X	X	X	1. Compare content in model documentation to model documentation template. 2. Evaluate content in model documentation for accuracy and completeness.
		Loss of key employees—leading to disruption in processes or inaccurate execution of processes that rely upon model results.				

The auditor should again meet with the model owner and the business area's senior leader. The auditor presents testing results that demonstrate that the AG43 memorandum does not contain sufficient information to be considered model documentation. The auditor should explain how the memorandum compares to the MGCoE's model documentation template and that the template was designed by Corporate Audit and Model Validation to comply with model documentation standards in the CMGP and adheres to model documentation guidance from the current regulatory authority.

Finally, the auditor should explain how model documentation is essential to an enterprise's control functions in its efforts to assess and manage model risk. Documentation should be detailed enough such that auditors, stakeholders and other interested parties can understand how the model operates, its limitations and its key assumptions. The business area may concur but could express concerns regarding time and effort to produce ideal model documentation. The auditor agrees that the enterprise would benefit significantly from effective and complete model documentation but time and effort could be reduced by utilizing the MGCoE's template and populating the most valuable sections first. The auditor should walk them through the MGCoE's template and point out how each section contains guidance on content that should save the model owner time in determining what was appropriate or expected. After several follow-up discussions, the auditor and the business area should agree to create model documentation and target the most valuable sections.

The auditor creates the following mitigation in the enterprise's GRC system:

Hypothetical issue: Create model documentation for the AG43 model.

Potential mitigations: The Valuation business area and the AG43 model governance Lead will use the MGCoE template for model documentation and populate the following sections:

- **Model use.** Identify the business processes that utilize the model.
- **Model theory and calculation.** For each model use provide a high-level description of the model design and how it was implemented.
- Reliance on upstream models and impact on downstream models
- Model limitations
- **Alternate approaches.** Identify alternative constructs and reasoning to support the current construct used in the model rather than the alternative.
- **Model flowchart.** Inputs, model routines and outputs.
- **Model functionality.** Identify and document the critical functions that make this model fit-for-purpose. Documentation should be sufficient to allow the reader to utilize the model functionality.
- Data dictionary, limitations and weaknesses
- Assumption catalog, limitations and weaknesses
- Model development life cycle
- Ongoing monitoring activities

CONCLUSION

We hope that this article has demonstrated our holistic approach to model validation and how the first, second and third LODs work collaboratively. The second LOD (risk management) and the third LOD (audit) assume ownership of the components of a model validation where they have expertise and scale. In addition, they work in unison to assess compliance with the Policy. We designed our validation program to affect culture change in the direction of risk management and to add value to the business by providing an independent view into the credibility of the model. ■

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Model Governance: Controls and Culture

By Ryan Krisac, Zohair Motiwalla and Uri Sobel

As actuaries rely on increasingly complex models to influence decisions and calculate financial statements, model validation has become simultaneously increasingly difficult and crucial. In response, many insurers have instituted a Governance or Controls function that oversees these models. That impetus has been accelerated by regulations that mandate calculating reserves with actuarial models based on periodically unlocked assumptions, and reporting requirements supporting those models and assumptions. Regulators and auditors also expect certain reporting requirements and potential calculation demonstrations, which will be facilitated by proper controls.

Numerous studies, surveys and opinions have been published regarding implementing effective controls for maintaining and using complex models. It is important, however, to focus on the goals of an effective governance structure rather than simply craft or follow a set of prescriptive rules. This article identifies several ideas for an effective governance structure that may enhance the capabilities and validity of models, help fulfill regulatory demands, and provide feedback to gauge if the structures are effective.

THE GOALS OF MODEL GOVERNANCE

Why do companies invest significant resources in model governance?

1. **Modeling efficiency.** Strong model governance reduces runtime, since model code will be written to execute efficiently. Model maintenance, updates and upgrades will become streamlined. Human capital will be deployed with the appropriate skill sets and pay grades aligned with the appropriate stages of modeling. New users will become familiar with models faster. Digging up existing models for sensitivity and "what-if" testing will be easier.

2. **Consistency of results across the organization.** Conflicting and/or confusing model results drain company time and resources, and undermine confidence in the models. Solid governance ensures that model results deliver coherent and consistent messages.

3. **Validity, accuracy and applicability of model results.** Model results are only as useful as the validity of the model design and accuracy of its calculations. A robust baseline and ongoing review structure ensures that model design, inputs and calculations are implemented as intended, and that the model is fit for the purpose of its given application(s).

4. **Providing an audit trail.** No matter how thorough the governance structure and model reviews are, questions regarding model results will arise. A strong governance structure will help a company easily identify the source and calculations underlying model results. Many of the questions will have already been anticipated and answered in advance (and if not, companies will have an indication of where to begin to find the answer).

MODEL INVENTORY

Implementing an effective model controls framework starts with a company's basic definitions of what a model is, how many it has, and taking stock of the key features of each.

Different definitions of a model have been presented in various publications. For this article, a model is defined as any tool that involves inputs, calculations and result reports. This is intentionally vague. Actuaries must review the tools they employ for decision-making, reporting or other purposes valuable to the company and decide whether to consider these tools as models.

Consider the following when assessing a tool: Does the tool perform tasks beyond reorganizing inputs provided? Does the tool perform calculations that are either directly or indirectly reported, or are used by management for decision-making? Does the translation from inputs to outputs require review to ensure correctness? If "yes," then the tool may be considered a model.

Once a complete list of models is formed, the company can develop a model inventory. A helpful model inventory provides insight into the uses and operational risks of those models, as well as commentary on other important properties. Suggested characteristics for an effective model inventory are listed here:

- Operational risk rating, based on dimensions such as:
  - Reliability of calculations
  - Audience, particularly internal and external visibility
  - Capability of attribution analysis
  - Efficiency of calculations
  - Software-based user or vendor errors
  - Scope/materiality
  - Documentation rigor
  - Manual adjustments
  - Consideration in company decisions

Table 1
Model Inventory Sample Scorecard

Score	Reliability of Calculations and Data Input	Audience	Capability of Attribution Analysis	Efficiency
1 (low risk)	Highly reliable that model ran correctly; transparent calculations	Internal only/limited audience	Roll-forward process exists, easily built from production run	Little user intervention, timely results
2	Reliable after analysis		Roll-forward process exists, can be pulled from production run	Some user intervention, generally timely
3	Somewhat reliable after analysis; includes black-box calculations	Internal only/wide audience	Roll-forward process exists, but requires some additional work	User intervention, acceptable processing time
4	Somewhat unreliable; multiple simplifications and approximations		Roll-forward process exists, but requires significant work	Significant user intervention, long but predictable processing time
5 (high risk)	Unreliable; highly approximate methods used to gain comfort with results	External	Roll-forward process does not exist or is unreliable	Significant user intervention, unpredictable processing time

- Model confidence rating
- Model owner
- Eligible applications for the model
- Known limitations/exceptions
- Testing, vetting history
- Links to documentation (process for running, change history, financial impacts, etc.)
- Locations for published modeling files and model results

Often, building a sound inventory falls to a company's model steward in consultation with model owners, who will decide on the most appropriate dimensions to apply in determining the operational risk rating. The roles of model steward and model owner are discussed more fully later in this paper. Common definitions are required for the risk dimension conversation to be constructive. A scoring system—for example, on a scale of 1 to 5—in each dimension based on objective, observable information will clarify the relative model risks. An example scoring rubric is provided in Table 1.

Discussing the operational risk ratings in a group setting, such as in committees that span the organization, is recommended in order to eliminate bias and ensure that scales are applied consistently across models. Those responsible for a given model may be inclined to understate risk or overstate confidence so as to maintain their model status quo, rather than venture into a potentially complex, time-consuming model reconstruction project. However, an inventory must contain honest and consistent risk ratings to be credible.

The conversations to establish risk ratings are crucial for legitimizing the inventory as an effective means of comparing models in terms of operational risk. The inventory can then aid in prioritizing which models to review, improve, retire or change in some other way. By fostering understanding of model purpose, the inventory will help mitigate the risk of misuse.

Each model can also be assigned a confidence score. The difference between the two scores can help prioritize model improvements. An example of this model inventory gap analysis exercise is provided in Table 2.

In this case, work on the ULSG GAAP reserve model may be considered higher priority than long-term projections because the gap between overall risk and overall confidence is greater for the ULSG GAAP reserve model. This may be explained by having disparate models or fewer reliable testing tools, as reflected in the capability of attribution analysis and efficiency scores.

"Confidence" is a subjective term that indicates the comfort the owner and steward have in a certain model, counterbalancing

Table 2
Model Inventory Gap Analysis

Model	Reliability of Calculations and Data Input	Audience	Capability of Attribution Analysis	Efficiency	Overall Risk	Overall Confidence
Illustration actuary	4	4	3	1	**3.00**	**4**
Pricing model	4	3	2	4	**3.25**	**4**
Stat Vx	1	5	5	2	**3.25**	**3**
Cash-flow testing	3	5	4	4	**4.00**	**2**
Long-term projections	5	4	5	5	**4.75**	**3**
ULSG GAAP reserve	5	5	4	4	**4.50**	**2**

its inherent risks. Conversations regarding these ratings will help determine which models to review and the prioritization of those reviews.

MODELING ROLES

Another major decision for the governance framework is access—that the necessary people have the ability to change a given model (and that others do not). The underlying principle is as models become increasingly wide-ranging, nuanced and important, auditing those models becomes more complex. Controlling change-level access to models, therefore, limits the number of disparate, unnecessary or unintentional modifications and helps allocate the staff with the appropriate expertise to the appropriate tasks. This, in turn, promotes supportability and consistency.

Depending upon the complexity of the software involved, access may be easily segregated by an IT administrator. If model access can be granted via normal IT account management techniques, a natural audit trail will exist for all model changes.

Regardless of platform, all modelers may be classified in a role relative to the models they run or review. Consider four fundamental roles:

- User
- Developer
- Owner
- Steward

The typical delineation of responsibilities between users and developers lies in access to calculation code. The owner is the actuary designated with responsibility for a given model. The steward (who may or may not be an actuary) acts as a gatekeeper for the production environment of models, tasked with granting access approvals, updating the model inventory, and monitoring the overall effectiveness of the controls in place.

MODEL STEWARD IN THE COMPANY ORGANIZATIONAL CHART

When building out a formal model controls team, a decision must be made regarding where the model steward role fits in the organization. While there is no universal answer, a well-designed steward role maintains independence from the functional areas of the actuarial structure. In other words, the steward does not directly report to any owner, developer or user.

Thereby, the steward can provide unbiased opinions on all actuarial models—including any changes. In this sense, the steward must be able to challenge changes recommended by functional areas. This may range from revealing flaws in code during a focused review, to recommending coding standards that improve legibility. A strong steward role drives company models to achieve the goals of model governance and, in the process, reinforces the roles of actuaries in important company decisions.

PRODUCTION STATE FOR MODELS THAT ARE RECOGNIZED AND ACTUALLY USED

A tenet of model governance is the establishment of certain models as official (sometimes referred to as "published" or "productionized"), and that those models are recorded as such in the company's model inventory. These models generally receive the highest level of scrutiny and review and, therefore, carry expectations of being reliable, accurate, transparent and efficient.

An important corollary to this idea is that model *results* produced and provided throughout the organization are based on those official models directly (running the official model and capturing and summarizing output) or indirectly (with changes from the official models entirely defined and laid out). How should a company ensure that a user does not provide results from an unauthorized model?

One solution is to expand the concept of the model inventory to include model lineage. To establish clear lineage, model results

are annotated to indicate which model was the basis for the results, and to describe how (and why!) that model was developed from any of the officially published company models.

The level of review of the changes from the officially published models can also be documented with the model lineage. In many companies, a grade is assigned to a model that determines the level of review it requires. How far removed a model is from the officially published model may be a factor in determining the model's grade. The level of review in the model lineage is ideally commensurate with the model's grade.

An important key is for expectations to permeate the culture of the organization. In some cases, this can be accomplished by consistent messaging—for example that model results will not be considered unless they contain such model lineage. In other cases, technology can be leveraged such that model results can only be obtained from a results warehouse, and results can only be posted to the results warehouse if they contain such model lineage. The good news for modeling actuaries is that such a framework serves to underscore the importance of the work they do.

APPROVALS PROCEDURES

One must not associate model governance with the feeling that someone is looking for mistakes. Model governance is designed to help ensure the validity, accuracy and applicability of model results. A well-designed approvals process for model changes and model results has the potential to improve the overall quality of company models significantly. However, achieving buy-in across the organization may be a harder challenge than designing and implementing the governance structure itself.

First, let's review some items to address the specifics of an approvals process.

Authority

Clearly articulate which persons or groups are authorized to make model changes. Removing any ambiguity regarding who set the assumptions and endorsed the methodologies creates a reference point if and when questions arise.

Library/History of Decisions

A record of when significant model changes were made and the rationale behind them will help answer any questions. If any authorized party decides to revise a previous decision, such written history will help make decisions more efficient and transparent.

Review of Model Change Implementation

Once a model change is authorized, a strong governance process includes a structure to ensure that the model change is implemented correctly. Such a structure features independent roles responsible for

a. making the change,
b. checking the change and
c. reviewing the impact of the change.

The individuals responsible for each of these steps may differ depending on the nature of the model change. Errors can be introduced at either the formula coding or data input level, or both! Some modelers' expertise extends to understanding the formulas in the model coding, while others are assigned to implement or check inputs. Certainly, care needs to be taken that the people checking the model have the appropriate expertise to do so. Too often, the checking role is given to "higher-level" staff who do not understand the inner workings of the model, which can lead to missed problems and a less-than-thorough check. On the other hand, giving the task of input-checking to coding experts is an inefficient allocation of resources.

After a model change has been implemented, it is wise to circle back to the party that authorized the change for a final endorsement that the change matched its intentions (see "User Acceptance Testing" on page 31).

Documentation of Model Change Implementation

It is important to document how model changes were implemented and to include the authority under which they were implemented. Depending on the actuarial software, some of this documentation may exist or even be created on demand within the model itself. Developing separate documentation outside the model provides guidance to new and less familiar users. Evidence of unit testing, no-harm tests and appropriate levels of both technical and high-level peer review are critical to ensure confidence in the model change implementation.

This may be a good time to review the model code itself, in that well-written code can often serve as its own documentation. Modern code is usually easy to read, even for novices to a particular syntax. If an experienced actuary cannot read the code and understand the logic, consider rewriting the code.

Production

After a model change has been authorized, implemented, checked, reviewed and endorsed, it needs to be incorporated into the production version of the model—depending on the structure of a company's models—so that it will be promulgated to all other uses of the model throughout the organization. Such incorporation needs its own level of testing. The model must produce the expected results in the scenarios in which the model changes were developed, and must also produce reasonable results in other potential scenarios (including no-harm tests for certain business or situations where results are not expected to change). Again, a structure of checking and reviewing for this incorporation step will help reduce unexpected, or incorrect, model results.

Exceptions

If an off-production version of a model is needed, prominent documentation in the model inventory and on any results produced by the model must be created. The rationale behind this exception must be included to be considered sufficiently documented. The governance policy may specify who has the authority to grant such exceptions.

Model Lineage

As discussed earlier, having the model lineage attached to all the models and model results will bolster confidence that they are based on officially approved assumptions and methodologies, and will help improve the consistency of results throughout the organization.

Model Results Review

Given all the above, it is still important to review the results of the model before distributing them. The reviewer might consider whether the appropriate margins are reflected, or whether the model has an appropriate level of granularity. Also consider the level of detail provided to an intended audience, consistency with other results within the organization, and reasonability. This level of review ensures that all the prior governance policies were adhered to, including basing results on the latest production model, or understanding the rationale for any exceptions.

Cultural Aspects

Once the appropriate model governance structure has been laid out, model review responsibilities must be defined and carried out in a way that is transparent and educational rather than bureaucratic and prescriptive. Effective review policies also lead to clearer modeling best practices, which developers can readily understand and employ. This reduces key person dependencies and bolsters modeling knowledge across the company.

Reviewing results from a regular modeling project inherently requires expertise; therefore, the model owner will likely be responsible for that activity. Clear modeling roles can help steer the owner in their review. For example, if users can only modify model inputs, tools can be created to check these against desired assumptions, population metrics and other sources. If those inputs have been checked and have not identified the cause of the problem, the owner can then consult the inventory for a repository of coding changes and associated testing. Effectively controlled models have traceable change logs that facilitate model investigation.

What happens when a model change is not implemented as expected or does not produce expected results? Do reviewers and implementers become defensive? Are there attempts to convince each other of one's position just to be right? Are decisions based on power struggles? Such situations will not aid in producing the most efficient model. Here are a few ideas to help an organization maintain a strong model governance structure in these situations:

- **Start early.** From the beginning of a person's tenure, preach review as part of the organizational culture, applicable to everyone. Look to hire people open to this type of collaboration.

- **Normalize.** During group meetings or modeling user-group communications, regularly show mistakes (or less efficient implementations) that were found. Discuss why it was normal or subtle to make such a mistake, how it was found, and why the ultimate solution was better. This will help instill a sense throughout the modeling organization that "we're in it together."

- **Rotate roles.** If possible, make sure people serve in both implementation and checking/reviewing roles (for different model changes). This will help ensure nobody is always in the role of being picked on.

MODEL DOCUMENTATION

A full exploration of what to include in model documentation is beyond the scope of this article; however, here are a few questions to consider in this regard:

- Thorough model documentation includes statements of model purposes and limitations. For what applications can the model be used? For what uses is the model inappropriate, or what changes are necessary for it to be made appropriate?

- Are the authorities for model changes discussed earlier recorded and included in the documentation?

- Are the model governance policies and structures themselves documented, with details of model owners and users included?

Typically, commercial actuarial software includes general user guides and documentation, but a company-specific process manual, detailing step-by-step instructions on how to update each element of the model (specific inputs and/or code) and specifying precedent and dependent code is immensely helpful documentation. In general, more detail is better, with descriptions of any internal checks to confirm throughout the process. However, such reliance on step-by-step instructions and internal checks must not lead to a sense of complacency regarding one's own model. Occasionally, it is prudent for a reviewer to observe the process of following the documentation to update the model, in order to provide fresh eyes and question any existing approaches that may no longer be appropriate.

MODEL LIFE CYCLE

Models go through life cycle stages, and a model's life cycle stage informs how the model fits in the governance structure. Broadly, models progress through the following stages:

- Defining purpose
- Initial development
- Vetting and implementation
- Putting into production
- Ongoing review
- Modification
- Retirement

Models in the model inventory are assumed to be in the "ongoing review" or "modification" stages, and will likely alternate between those stages until "retirement." Model reviews are commonly dictated by scores on the model inventory, an audit request, or the desire for a new modeling tool. Given available resources, model reviews can also be preventive as scheduled; focused reviews may reveal problems or opportunities that were previously overlooked.

Choosing who is responsible for performing a model review will be guided, in part, by the balance between expertise required and time available. A centralized steward role is likely to have more time to research but may require significant education on the nuances of the model. On the other hand, the steward may be in a better position to leverage new and outside perspectives or other related model improvement projects.

Regardless of the responsible party, a test plan clarifies the testing and documentation requirements necessary before signing off that the model may be placed back into production. Some common types of testing include:

- **Regression testing.** Run a set of production models that are not directly related to the new code, and confirm zero financial impact.

- **Match testing.** Run the model(s) associated with the coding change. Verify that the change in results matches a company published source.

- **Impact testing.** Run the model(s) associated with the coding change, and gauge reasonability of financial impact, seeking sign-off from model owner.

- **User acceptance testing (UAT).** Confirm the outcomes of the other tests and review any requirements not yet approved. The key is to maintain independence in the final UAT step. Production model changes must not be unilaterally dictated. Instead, they are joint efforts toward commonly understood goals. UAT ensures that owner and steward mutually agree that the model review was performed according to the test plan and that, if necessary, any changes were appropriate.

The steward updates the inventory to reflect the outcomes of the review, with new rankings and details. Findings, especially resulting changes, are communicated with all model owners. Modeling is improved as the findings shed light on better modeling or testing methods to be employed elsewhere.

OTHER BENEFITS OF MODEL GOVERNANCE

The primary advantages of an effective model governance program were described earlier in this paper: efficiency, consistency, validity, applicability and supportability. If too audit-driven—especially to satisfy bare minimum standards—model governance can veer into bureaucracy and superficiality. If designed toward broader model understanding, though, governance provides benefits across the actuarial teams and beyond.

Thus, one of the great benefits of governance is model literacy, with far-reaching effects on the ability of actuaries to understand what their models are calculating, how they can be modified and how to validate results. With a shared model inventory, all the modeling participants become more familiar with the risks, purposes, capabilities, limitations and vulnerabilities of the company's models. With effective governance, subject-matter experts rightly leverage their expertise on products and processes, rather than focusing on manipulating modeling software. As increasingly complex calculations are becoming standard, more actuarial models will rely on complicated coding modules in order to maintain reasonable runtime. The actuarial group must keep pace with understanding and, when necessary, debugging those modules.

Occasionally (or for some companies, frequently), a model improvement project may be too disruptive, time-consuming or complex for a specific functional area to tackle. In these situations, a dedicated team can perform the coding work and initial testing, consulting with the functional area for its expertise and UAT. When sharing the end result with other model owners, this collaboration further contributes to the common knowledge of a given modeling improvement and how it might be leveraged elsewhere.

Another benefit of effective governance is increasing management's understanding of the inherent risks of the company's actuarial models, relative to other enterprise risks. In a broader sense, model governance can be incorporated with company-wide controls programs, Own Risk and Solvency Assessment (ORSA) modeling and change management procedures. Merging with these other programs helps communicate model risk to nontechnical audiences and executives. A sound model inventory

demonstrates how models are performing without requiring extensive knowledge of the calculations. Also, incorporating standard IT change management procedures can strengthen the connection between actuarial and IT teams, potentially revealing many opportunities for automation. Links outside actuarial teams underscore the value that model governance provides, while also clarifying model risk for upper management.

A well-functioning model governance program enables the company to steer conversations with auditors better. Actuaries can provide evidence of controls and tests from readily available materials. Necessary sign-offs, documentation and validations can be provided for model updates in consistent formats, while change management procedures and documentation confirm that no unintended alterations were made to production models. These materials can be presented as self-audit findings and demonstrations of comfort developed in the normal course of business, instead of being instructed to prove, after the fact, that calculations were correct.

GOVERNANCE OF GOVERNANCE

We conclude with some suggestions for confirming that the company's controls and governance structures are working, and improvement ideas if they are not—essentially, governance of the governance process (in these authors' opinion, governance of governance just becomes silly). Consider the following:

- Incorporate "incidence reporting" into the model inventory, tracking errors and responding to questions such as:
  - How were the errors discovered? By whom?
  - What steps were taken previously to attempt to prevent such an error? Why were they not effective? What will we now do differently, and why will it be more effective?
  - In what other models might this error reside?
  - What impact does discovering this error have on the risk score of the model under consideration, or other models?

  An "incident" does not need to be limited to the discovery of a mistake. It could also be when conflicting (or even misunderstood) results are provided, or when validation issues were overlooked until a later point. Crucially, incidence reporting should not be practiced as a blame game, but as an opportunity to improve the governance, modeling and efficiency of the company.
- Incorporate runtime statistics as part of the model inventory. Runtime is influenced by many factors other than governance, but maintaining such statistics may help determine general trends in governance efficacy.
- Maintaining metrics on cost and hours required for model upgrades and enhancements can indicate if the appropriate personnel are allocated to the appropriate tasks. Narrative descriptions of the pitfalls and efficiencies realized during upgrade and enhancement efforts can indicate the efficacy of the governance process and structure. Further, sharing these narratives among company modelers promotes teamwork, standardization and education.
- Are they the right people running company models?
- Regularly review notes from modeling group meetings. Are people struggling to understand the controls and governance? Are there patterns to modeling challenges that point to holes in the governance structure?
- Consider occasionally shifting staff to test the thoroughness and reliability of existing documentation. Similarly, having subject-matter experts (who typically serve in a reviewing role) run through the whole modeling process themselves may uncover issues that lower-level users may not notice.

Einstein had it right: E = MC², or, Efficiency = Model Control times Culture. ■

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SOCIETY OF ACTUARIES®

Hand Over, not Fall Over: Focus on Actuarial Model Handoff From Development to Production

By Alex Zaidlin and Youn Kim

Whether it is a simple Excel formula-driven spreadsheet or a complex stochastic model calculating variable annuity projections under thousands of scenarios, actuarial models go through multiple distinct stages in their lifetime. Collectively, these stages are commonly referred to as *model life cycle*. From scoping and planning to model retirement, multiple modelers and model users build, run, modify, validate and archive actuarial models.

There are typically model governance policies that dictate the roles and responsibilities of each of the individuals and teams interacting with models. These critical policies are in place to govern various modeling processes and help ensure model sustainability through the various stages and transition points in the model life cycle.

One of the most delicate transition points in the model life cycle that often requires special attention and unique considerations in the model governance framework is the model handoff from development team to production team. While a handoff is typically thought of as a relatively quick exchange or transaction, a successful model handoff from one team to another is often an extended process that could take months from start to successful completion. The initial model handoff from development to production occurs once the core model build is complete and the model is tested, reconciled and validated. However, throughout the production stage the model typically transitions as often as quarterly between development and production teams as ongoing model modifications and updates resulting from introduction of new products, regulatory changes, refinements of modeling approaches and ongoing model updates are required. A successful handoff allows for easier, more streamlined model maintenance processes in the short term; but more important, it significantly reduces model risks and contributes to extended model sustainability in the long term. This article will discuss key considerations to take into account while planning for and executing the initial model handoff from development to production.

There are many modeling team and environment structures that exist across the insurance industry today. To level-set, we would like to illustratively define key responsibilities of the development and production teams throughout the model life cycle. At a high level, the two teams can be differentiated as modelers (development team) and model users (production team). Modelers are responsible for creating, updating, testing and releasing the actuarial master models into a locked-down production environment. These are individuals with deep technical knowledge of the modeling tools, model architecture components and modeling approaches used. Model users are responsible for updating the model with current data, running the models, and producing and analyzing results. Model users typically belong to the companies' financial reporting departments, and their focus is on model results rather than on the technical aspects of the model. Figure 1 illustratively summarizes responsibilities of the development and production teams for a typical two-team modeling environment.

There are many ways one can approach the model handoff process discussion. The framework proposed in the article focuses on six key components of the model management process and discusses each of these through the lens of a three-step process. While some overlap in activities exists across its various components, this framework should be viewed as a holistic three-step process to manage the handoff process. The six components of the model management process are:

- **Model governance policies and standards.** Policies and standards that can be applied consistently to various modeling activities. These policies should guide modeling decisions and model management activities throughout model life cycle.

- **Model structure.** Models should be transparent and easy to follow with built-in flexibility to accommodate future changes. Subsequent model updates should result in minimal changes to model infrastructure. Modular model development generally tends to result in more sustainable model structures than linear model development.

Figure 1
Illustrative Responsibilities of the Development and Production Teams

Development Team	Production Team
Modelers—Individuals who create, update, test and release actuarial master models • Driven by the model steward • Build, update and release master models • Test the model and report any inconsistencies • Use the modeling platform functionality as specified in technical and business requirements • Use model-adjacent technology as specified in technical and business requirements • Have the model peer-reviewed and ensure controls are in place to catch unintended changes to the model • Periodically validate the model to ensure model functions as intended	**Model users—**Individuals who run the production models to produce and analyze results • Driven by the managing valuation actuary • Check out a copy of the master production model • Communicate with the development team regarding model updates to agree on approach for modeling updates consistent with model architecture • Manage the production environment and control user access • Validate model inputs and model outputs for production cycles • Run production models and consolidate results • Analyze model results • Archive production versions of the models following production runs • Communicate with development team to make updates to the master model consistent with the latest updates made to production copy

- **Data.** Complete and accurate data should be used in the model. Controls over data should be embedded in the production process, and any deviation in data quantity or values from expectation should be explained. Both input and output of the model should be considered under this component.

- **People.** Both the development team and the production team should have the required technical skills for their roles and good understanding of each other's responsibilities.

- **Controls.** Functional and effective model controls over data and calculations facilitate model transparency and provide additional confidence in model output.

- **Documentation.** Sufficient and relevant model functionality documentation helps users understand the model, run routine processes and debug the model with minimal additional guidance. Technical model documentation focuses on model architecture, modeling approaches taken and issues tackled during model build, and describes any model limitations and approximations made within the model in question.

For each of the components of model management, a three-step model handoff process can be defined to facilitate a successful model handoff from development to production. As shown in Figure 2, each of the steps should be sequentially considered and executed in accordance with model governance policies within the organization. The model handoff steps follow the model life cycle stages and can be classified as prepare, transition and maintain.

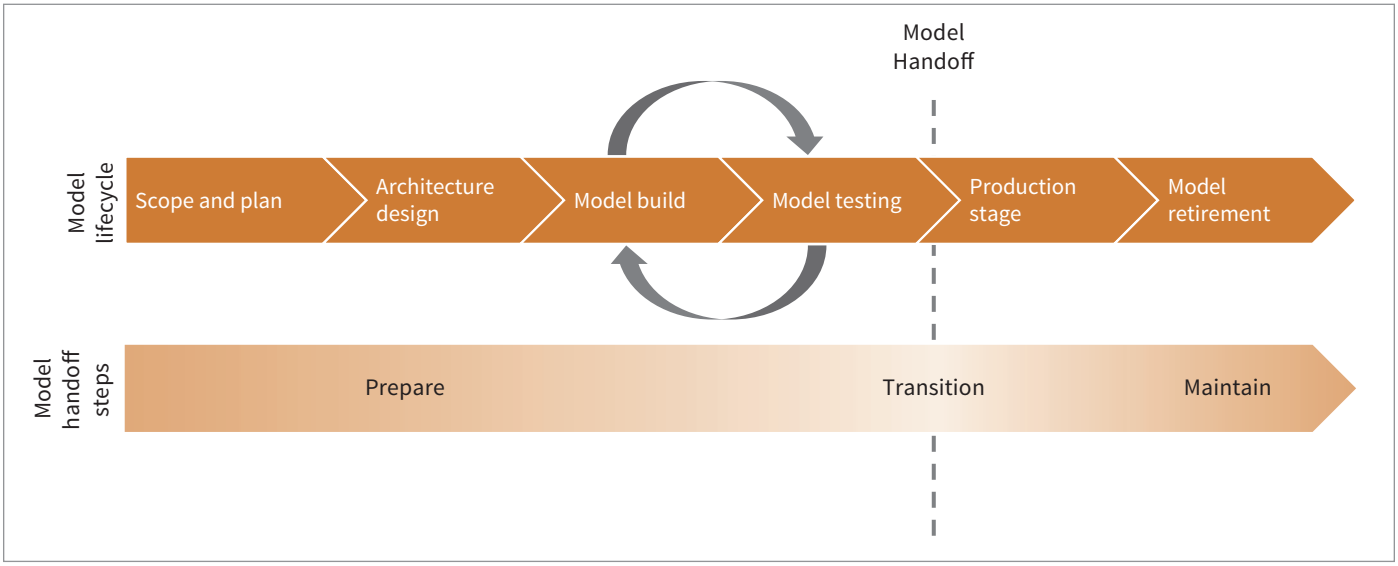
1. **Prepare.** This step should commence at the start of model life cycle, during the scoping and planning phase. It should address items like consistency in model build, naming convention, development documentation and other artifacts that will benefit the handoff process. In the event that relevant preparation activities do not take place throughout the development phase, it is often more challenging and time-consuming to carry out these activities at the time of transition.

2. **Transition.** This step is a pivotal step that will help determine key guidelines and activities for future model runs, updates and troubleshooting. This is a communication-heavy step, during which discussions between development and production teams should take place to help the production team get comfortable with the model structure and related processes. A smooth transition phase results in streamlined and effective model maintenance activities in the future.

3. **Maintain.** If sufficient preparation takes place and the transition step is successfully carried out, model maintenance should be a streamlined, mostly automated process with minimal incremental effort from the production team. Model updates should be carried out consistently across model components and over time.

The remainder of this article expands on each of the model management components in detail by discussing the activities throughout the three-step handoff process for each of the components.

Figure 2
Three-Step Initial Model Handoff Process



MODEL GOVERNANCE POLICIES AND STANDARDS

Model governance policies and standards will define the processes around model development and management. These policies should be developed and enforced by the model steward team and should be periodically updated to remain current. Established model standards should guide the development team in taking a consistent approach to model development and updates, which in turn can make it easier for the production team to quickly identify, review and get comfortable with the updates. Model governance should focus on routine and ad hoc production processes defining model ownership and other responsibilities, model update processes, change management protocols, and model testing and documentation procedures. The benefit of model governance policies and standards is model transparency and consistency, both within model components and across models. Transparency and consistency in modeling approach would significantly streamline and ease the model handoff process.

- **Prepare.** Model standards should be developed and discussed prior to start of the development phase. These should be top-down standards, originating in the business and technical requirements for the model. The development team should design model architecture and make modeling decisions based on the standards throughout the development phase. Model standards should guide future model modifications and updates, resulting in a consistent approach to modeling across the entire model life cycle.

- **Transition.** For the transition phase, model governance policies should define model reconciliation standards and thresholds, user acceptance testing, parallel runs requirements and embedding of the model into the production environment. They should define the production acceptance criteria and process and the protocol for communication between development and production teams when additional model build efforts are required.

- **Maintain.** Model governance policies should help guide the model maintenance procedures. These policies should define model update processes, change management protocols and model update documentation requirements. They also should clearly define model ownership and other model-related responsibilities and sign-off processes for model management activities including model runs, updates and troubleshooting. Model governance and standard policies should be continuously reviewed and updated as needed to keep them current and applicable.

MODEL STRUCTURE

Model structure would directly impact model sustainability and ease of running, updating and troubleshooting the model. Model structure would include elements like consistency in modeling approaches, automation and efficiency of modeling processes, leveragability, and auditability of the model and its components.

- **Prepare.** Effective model structure begins with model architecture design. Model design should be consistent in intent

and execution throughout various modeling approaches within a single model and also across different models. The development team should have recurring discussions with the production team to identify opportunities to automate current processes and subsequently minimize possible human errors. The development team should focus on increasing efficiency in model design by ensuring the model contains only the components that are being used in model runs. This would eliminate unnecessary model rework and reduce model size and runtime. In order to increase model sustainability, the development team should consider model leveragability and ease of modifying existing and adding new model components throughout this step.

- **Transition.** During the transition phase, the production team should be trained on the model structure and the impacts of change in various model components on model execution and results. Supporting documentation on model architecture and modeling choices should benefit the production team greatly in understanding model design.

- **Maintain.** The master model structure should remain locked down in the production environment. Unless a structural change has been explicitly approved following the governance policies, model structure should remain intact. Model review and validation should be done periodically, especially when new and significant changes are implemented, to ensure the model structure and its components remain functioning as intended.

DATA

Accuracy and completeness of model data will have a significant impact on model sustainability in the production environment. Ideally, by the time the model is moved to a production environment, all data sources, destinations and formats should be finalized. These should remain locked down in the production stage, unless an explicit approval has been given for structural changes in model data. Both input data and output data should be considered as part of this component.

- **Prepare.** All model data should be reviewed by the development team to determine the fields to be brought into the model and their respective formats and limitations. These should be clearly defined in the model as input fields and documented in a data dictionary. Data processes within the model should be clearly defined by the development team to support production processes. The development team should also make an effort to understand the production team's downstream process and be aware of data elements that the model should output into the financial reporting process data repository. Understanding the required output should help companies optimize data processes within the model and eliminate manual processes and adjustments external to it.

- **Transition.** The responsibility for model data processes should be transitioned along with the model to the production team, as the production team will become the owner of these processes following the transition. All input data should be validated in the production environment and reconciled against the data previously used in the development environment. Test protocols focused on model output should be established to assess its compatibility with the downstream processes and reporting tools should be confirmed. The production team should identify their contacts in the administration and IT teams to support their data needs in the future.

- **Maintain.** Data validation should be conducted with every data update to ensure completeness and accuracy. Evolving data business requirements and any changes in data sources or formats should be monitored periodically. Automated controls over data should be established to alert the production team of any unexpected results.

PEOPLE

Having a balanced skill set within the respective teams is key to improving model sustainability in the development and production environments. The two teams have to "speak the same language" and understand each other's goals, processes and challenges. Often other functional areas, like IT, are involved in the production process—they too need to be on the same page with the actuarial teams responsible for the model.

- **Prepare.** It is beneficial to include the production team in the early communications of the development process, if possible. Periodic high-level discussions around project status, potential limitations of the model, as well as modeling decisions made throughout the development process would help the production team start building a high-level perspective on model functionality and limitations.

  It is valuable to have both a technical expert and an institutional guru on the development team. A technical expert can foresee obstacles or complications in the modeling process and help the team prevent these. An institutional guru can bring the product- and company-specific knowledge to the project and work closely with the team to make sure complex product features and regulations are modeled consistently with company guidance.

- **Transition.** Model overview and production run training should be provided to the production team assuming

responsibility for the model. Rotation of one or more individuals from the development team to the production team can facilitate the learning process.

- **Maintain.** A development team contact should be available to the production team in order to support production processes, at least for the several initial production cycles. Ongoing involvement of the development team should include routine model updates and enhancements and support, as well as ad hoc model change tasks as needed.

CONTROLS

Model controls are key to ensuring the model produces appropriate calculation results. Controls are critical to long-term model sustainability and should be embedded and automated as part of the modeling process. There are multiple layers of controls that should be implemented and maintained throughout the model life cycle. Control layers will include access controls, controls over data, controls over calculations and error handling controls. Control guidance should be part of model governance policies and should be maintained and updated as the model changes over time.

- **Prepare.** The model should be built in a transparent way with accompanying documentation outlining the model control framework. Controls over data should validate that the data fed into the model is reconciled with the appropriate data source. Controls over calculations should be set up both at the policy level for a subset of select test policies and at an aggregate level. Error handling controls should be designed to consider the magnitude of error and its impact on model results.

- **Transition.** Control documentation should be delivered to the production team accompanied with control walkthroughs and training on calibrating controls and reviewing their outputs. Access and read/write controls should be reviewed and approved and assigned to individuals or groups interacting with the model at various capacities. User groups should be set up, allowing unique access privileges for each.

- **Maintain.** Model controls should be reviewed for effectiveness and updated as needed periodically. As new product features and model components are added, additional controls may be required to be added to ensure effectiveness of the overall control framework.

DOCUMENTATION

Documentation is a valuable artifact to facilitate the handoff of the model to the production team and model maintenance from that point on. There are multiple components to model documentation; each of them is important on a stand-alone basis, each for its own purpose. Some documentation can become outdated, and it is important to keep documents updated for model changes following the handoff.

- **Prepare.** The documentation process should begin at the start of the development phase and evolve as development progresses. Primary documents and secondary documents should be identified and separated during the process. Primary documents will remain applicable in the production phase and will continue to be used and routinely updated, while secondary documents are static documents from the development phase, used as sources of additional supplementary information.

- **Transition.** Documentation handoff should accompany model handoff. The development team should ensure that all documents are up-to-date at the time of handoff. A documentation walk-through of the available documents is often beneficial during the transition step.

- **Maintain.** The production team should own the documentation and make necessary updates as the model is updated and run over time. Model documentation types and templates should be included in the model governance policies for the company. Model documentation should reside in a centralized location and be protected from unintended changes.

A successful model handoff process should address all of the model management components in its design and execution—model governance and standards, model structure, data, people, controls and documentation. This is a systematic approach that spans from the very early stages of scoping and planning and concludes when the model is retired. It requires close collaboration between the development and the production teams throughout the model life cycle in order to facilitate appropriate knowledge transfer. In the event that the model handoff is not successfully executed, complications in production modeling processes may arise, which in turn would result in additional risks and costs to the organization. ■

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Actuarial Models in an IFRS 17 World

By Trevor Howes

And you thought your models were important before? Wait to see how vital models become to insurers around the world in the next few years.

The importance of and reliance on actuarial models has increased significantly over the past decade with moves to principle-based reserves and increasingly risk-focused solvency assessment regimes globally. Equity-linked guarantees and hedging programs, increasing demand by management for realistic what-if investigations, and sophisticated asset-liability management (ALM) risk analysis all contribute to the need for higher corporate dependence on the actuary and the models actuaries control.

But suddenly in the past year, a new International Accounting Standard has raised the bar immensely. Over the next few years, compliance with this standard promises to bring the greatest disruption ever seen to insurers' financial reporting systems and processes, by forcing companies to integrate actuarial models deeply within public and management reporting processes. Why is this happening, and what are the keys to successful transformation of the total financial reporting process for insurers?

After many years of discussion, the International Accounting Standards Board released new International Financial Reporting Standard (IFRS) 17—*Insurance Contracts* in May 2017, with an effective date of January 2021. This standard impacts publicly listed insurers in many countries around the world, and, in cases such as Canada, South Africa, Malaysia, Portugal and some others, all insurers are required to file statements under IFRS accounting rules, whether listed or not. Companies domiciled in the United States are typically not impacted unless they are subsidiaries of or own subsidiaries in affected countries. Nonetheless, the changes under IFRS 17 are fascinating to all actuaries.

A primary motivation for the development of the new IFRS was to bring consistency and transparency to the financial statements

used by insurers across jurisdictions and product types. It is a difficult challenge. Actuaries have long coped with varied methods of calculating policy or claim liabilities across jurisdictions and by products and also between regulatory, GAAP and tax accounting frameworks. While imposing a common framework, IFRS 17 also changes the playing field with fundamental impact both on the balance sheet liabilities and on the reporting of earnings.

WHAT CHANGES IN FINANCIAL REPORTING ARISE FROM IFRS 17?

At its heart, the standard applies a General Measurement Model for calculating the policy liabilities of long-term contracts as the sum of three components: (1) a forward-looking present value reserve reflecting current estimate assumptions; (2) an extra provision reflecting the level of risk assumed; and (3) a final provision designed to defer, if necessary, all profit at issue. While the first two components are familiar point-in-time calculations performed by a capable valuation or modeling platform, the final component, referred to as the *contractual service margin* (CSM), has several complicating features.

In particular:

- The CSM must be established for a group of policies in total as at their initial recognition, and the value of the CSM must be calculated at this group level at all future reporting dates by rolling forward the previously reported value with a multiple-step formula. Some components of that formula can only be obtained by multiple projections of member policies by an actuarial system that must be then aggregated to the identified groups.

- Insurance companies expect to have hundreds or thousands of individual groups each with their own CSM balances to store and roll forward.

- The basic policy reserve and risk margin components are adjusted regularly for changes in current and assumed future experience, with portions of these adjustments impacting earnings and the remainder offset by increases or decreases in the CSM.

- A portion of the CSM balance for a group is released into profit each period using an allocation ratio that reflects the current and future service patterns of all surviving member policies.

The need to manage the CSM balance storage and recalculation is a major focus of companies' reassessment of their financial reporting systems and processes under IFRS 17, and the actuarial elements of these calculations are pervasive.

Another fundamental change under IFRS 17 is the definition of reported revenue. This is no longer based on insurance premiums paid, but rather on the expected costs of those benefits in the reporting period based on the actuarial estimates in the latest valuation. This again requires a timely actuarial calculation reflecting detailed policy characteristics, and most likely based on both the opening in-force file and policy transactions during the period.

The remainder of any paid premium above the reported revenue must be accounted for by a change in one of the three components of the liability, and again an actuarial calculation is needed to decide how much each component is adjusted. Remember that the CSM component is deferred future profit, which is regularly amortized into income, but since its balance is also being adjusted by regular experience gains and losses and by assumption changes, this pattern becomes rather difficult to predict or explain.

Insurance companies have long lived with complex reserve calculations that have been managed and explained ... by valuation actuaries, typically days or months after the reporting has been done.

Accordingly, an intrinsic feature of the new standard is a requirement for disclosures that help to reveal the movement of the various components of liabilities and their contributions to revenue and earnings. This again will require a multiple-step analysis of the various components of the liability calculations and the impacts of changes in assumptions from the prior reporting date, which is effectively a much more sophisticated movement of reserves analysis than has been seen before.

HOW WILL THIS IMPACT FINANCIAL REPORTING PROCESSES?

Insurance companies have long lived with complex reserve calculations that have been managed and explained (with varying degrees of success) by valuation actuaries, typically days or months after the reporting has been done. The actuarial processes within the reporting cycle culminated in much simpler communication from actuary to accountant that confirmed the new reserve balance for each reporting line of business. The accountant would report the general ledger premiums and investment income as revenue, and deduct the claims, expenses and increase in reserves. The net balance essentially was the earnings before tax. It was up to the actuary to maintain controls, and satisfy the auditors on his reserve calculation systems and processes, and his impact on statements were not much more than that one line.

Now the game is changing. Actuarial systems must track possibly thousands of group-level CSM balances, perform multiple projections on starting and ending in-force files that contribute to income statements, balance sheets and required disclosures. They contribute key elements to the initially recognized CSM balances from new business actually issued, generate multiple other components of CSM changes, and help support the amortization of CSM into earnings. Yet it is likely that the actual roll forward of the CSM balances at group level will be done in a new engine outside the actuarial platform.

In addition to the generation of the CSM and other components of the actuarial policy liabilities, the actuarial systems must produce detailed calculations of expected insurance service costs to feed the revenue lines of the income statement and any related disclosures or reconciliations.

All these calculations must be performed in a timely and controlled fashion and the results must be aggregated from policy to group level, or to portfolio and other reporting levels, according to reporting needs. This will most likely require a new comprehensive IFRS 17 subledger that smoothly and reliably feeds posting entries to the general ledger to drive the new financial statement formats. In addition, that subledger must support all the public disclosures and internal analyses that will be required.

Clearly it must be friendly to multiple actuarial systems and to the actuaries who manage them, yet meet auditing standards. And those standards will imply a pervasive governance and control framework, transparency and auditability of all data lineage, and runtime efficiency.

It is no wonder that as this article is being written, a mere eight months after the publication of IFRS 17, companies, by and large, are still wrestling with many thorny questions. How will we accomplish the enhancement and integration of these complex calculations and data management processes in an efficient and controlled way?

It will take time to come to a full understanding of this new standard, and learn how to explain the earnings volatility and patterns of emerging financials to both management and the public. We will need to adapt our assumption-setting processes, reconsider accounting policy decisions, and develop new insurance policy design and pricing. And all that adaptation will require a progressive and complementary evolution in our analytic tools and reporting processes.

The answer will almost certainly involve adopting a flexible and scalable technology backbone. This technology backbone must be well-understood and controlled across the full solution—that is, a combination of actuarial modeling software driving the production of needed reporting data and the accounting subledger and data management solution that accepts, aggregates and generates reports from that actuarial data. Clearly a complete integration of the actuarial engine and IFRS 17 accounting assembly system into a single product solution is extremely unlikely as long as companies depend on multiple actuarial platforms. At a bare minimum, however, there must be strong actuarial input into the initial design of the data layer and continuing actuarial coordination of the inevitable evolution in the overall solution design that will occur. ■

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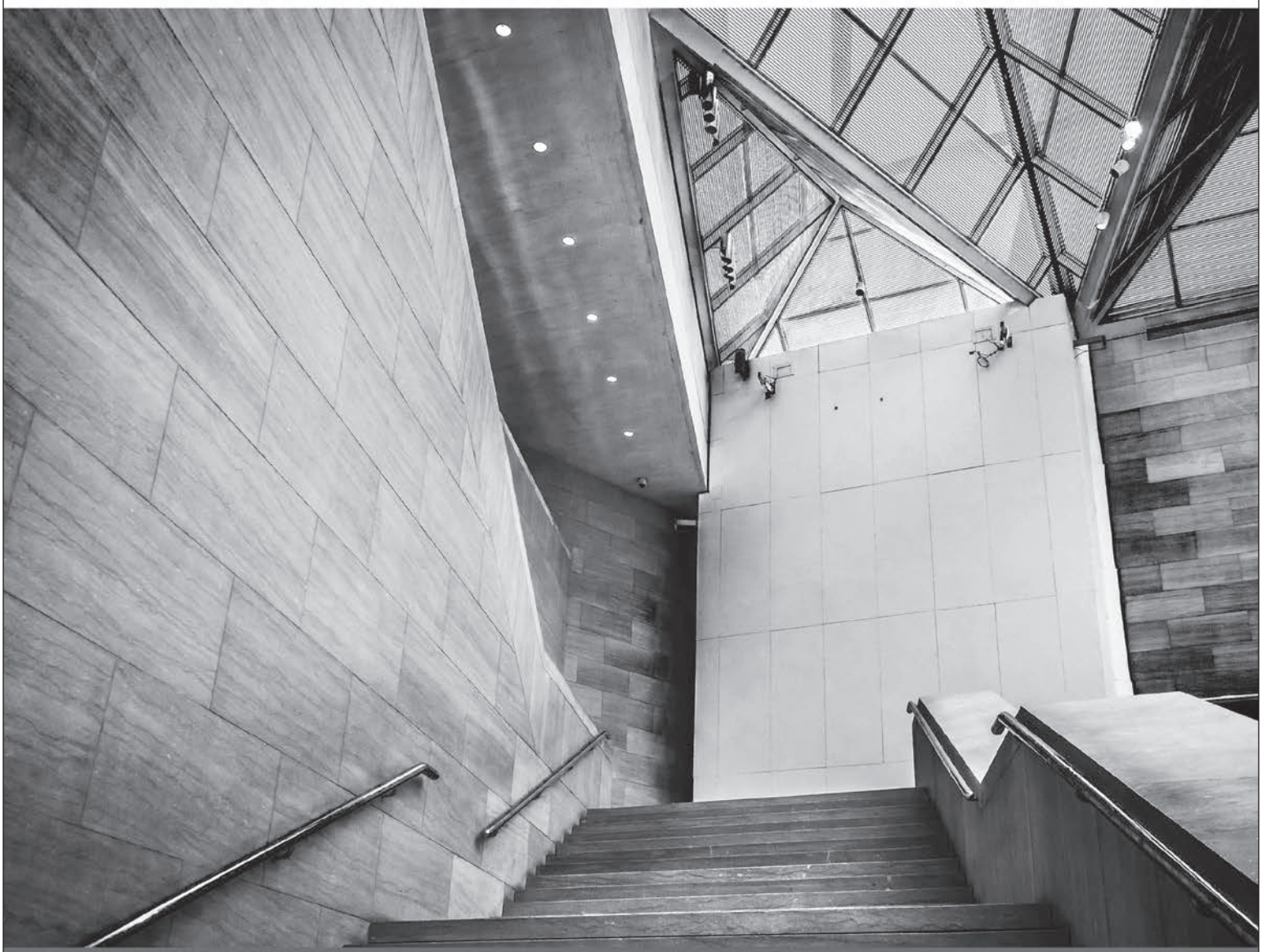

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