Session 57 PD, Actuarial Models: Leading Practices

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Actuarial models: leading practices
Model risk management

Life & Annuity Symposium 2014

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Deloitte Consulting LLP
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Speakers’ bios

Ken Crabbs  
*Actuarial Governance and Tools Leader at Genworth Financial*

More than 25 years ago, Ken started working in the insurance industry as an illustration system programmer for Federal Home Life Insurance. Much of his insurance career has been focused on IT where his experience includes: programming, system administration, network engineering, datacenter planning and implementation, operations, vendor management, and application support and management. In addition to Federal Home Life, he has worked for CSC, GE Financial Assurance, and Genworth. Genworth was an early adopter of grid technology in support of actuarial applications. Under Ken, actuarial grid use was significantly improved and expanded. For more than 8 years, Ken has been focused on actuarial. He currently works in Genworth’s US Life division as the Actuarial Leader for Governance and Tools.

Trevor Howes, FSA, MAAA, FCIA  
*VP & Actuary at GGY AXIS*

Trevor Howes is Vice President & Actuary for GGY AXIS, the vendor and distributor of the AXIS actuarial modeling system. Trevor is currently part of the Marketing Team at GGY AXIS, which includes the marketing of both AXIS and GGY Cloud services. Trevor has worked at GGY AXIS for the past 20 years in various capacities, and prior to GGY AXIS, he has been Chief Actuary and Appointed Actuary for both a Life Insurance Company, and a Life Reinsurance company in Canada, and a consulting actuary for a major international consulting firm. Trevor is a frequent speaker on a variety of topics relating to modeling practices and techniques, including Model Efficiency (he is a member of the Model Efficiency Work Group of the American Academy of Actuaries), Model Governance and Control, and Actuarial Systems Implementation.

Alex Zaidlin, FSA, MAAA, ACIA  
*Manager at Deloitte Consulting LLP*

Alex is a Manager at the Actuarial, Risk & Advanced Analytics practice at Deloitte Consulting. He joined Deloitte in 2014 bringing with him nine years of experience with consulting, insurance and reinsurance firms. His actuarial experiences includes modeling, pricing and valuation, actuarial software conversions, actuarial audits, experience analysis, product and assumption development, model enhancement projects and a variety of other actuarial projects. Alex has an extensive working knowledge of various insurance products that include Life, Long-Term Care, Disability Income and Critical Illness insurance in US, Canadian and international markets. Alex is a frequent speaker at industry meetings on topics relating to actuarial modeling, experience analysis and industry trends.
Model risk management

Model risk

A potential for financial loss, poor business and strategic decision making or reputational damage arising from:

- Errors in model design
- Incorrect model inputs or assumptions
- Erroneous implementation
- Poor model change management
- Models do not follow market conditions
- Misuse of or over-reliance on models

Model risk management

To manage this risk, it should be identified, measured, monitored and controlled using processes with appropriate oversight.

Key objectives:

- Reflect the size and complexity of the insurer and its products
- Focus on models that pose material risks to the insurer
- Cover a full model lifecycle including:
  - Software selection
  - Model governance
  - Roles and responsibilities
  - Model development
  - Implementation and approval
  - Ongoing use and updates
  - Performance monitoring
  - Model validation
  - Peer review, compliance and documentation
Today’s focus

We will focus our discussion on the following four key areas:

- **Governance framework**: Discuss an illustrative model governance framework
- **Governance implementation**: Identify key steps to embed and enforce governance standards
- **Model validation**: Highlight the importance of the model validation process
- **Model documentation**: Focus on goals and components of model documentation
Model governance – illustrative framework
Sample structure

Modeling steering committee

Company leading practices policies and control procedures

Modeling team

Model steward

Lead modeler Product A
Lead modeler Product B
Lead modeler Product C

Modeling staff Product A
Modeling staff Product B
Modeling staff Product C

Management and governance procedures

Production team

Pricing
Valuation
Projection

Capital management
Risk management

IT and admin infrastructure and support
Model governance – illustrative framework

Steering committee

- Modeling steering committee gathers modeling requirements from various internal and external stakeholders
- The committee is responsible for:
  - Making strategic decisions
  - Prioritizing modeling requests
  - Communicating the required enhancements to the modeling team
- The modeling steering committee typically consists of senior actuaries across main business functions and meets regularly
Model governance – illustrative framework
Leading practices, policies and control procedures

- Historically, companies took silo approach to model development and maintenance
- Insurers are now looking to take a more holistic approach to identifying sources of model risk and ensuring that adequate policies and control procedures are in place over the entire model life cycle
- These policies would provide guidance on:
  - Roles and responsibilities
  - General methodologies
  - Model development processes
  - Change management
  - Ongoing performance monitoring
Model governance – illustrative framework

Modelers and model users

**Modelers** are individuals who create, update and manage actuarial models

Responsibilities include:

- Construct models
- Driven by model steward
- Use the modeling platform functionality as intended
- Use model-adjacent technology as intended
- Test the model and report any inconsistencies
- Have the model peer reviewed and ensure controls are in place

**Model users** are individuals who run the models to produce results

Responsibilities include:

- Request current production model from the modelers
- Communicate with the modelers regarding model updates
- Manage the production environment and control user access
- Validate model input and model output
- Hand-off the updated model to the modelers once model runs are completed
Model governance – illustrative framework
Modelers and model users

Modelers are individuals who create, update and manage actuarial models.

- **Inputs**
  - Product specifications
  - Initial assumptions
  - Seriatim data source
  - Model methodology
  - Model change requests
  - Other requests

- **Processes**
  - Design model structure
  - Construct new models and/or address change requests
  - Establish model version control
  - Perform regression testing
  - Work with model users to resolve errors
  - Establish and maintain modeling and coding standards

- **Outputs**
  - Production models:
    - Risk Management
    - Capital Management
    - GAAP and STAT Reporting
    - Forecasting/Budget
    - Pricing
  - Model documentation backed up with supplementary analysis
  - Coding standards and documentation

Model users are individuals who run the models to produce results.

- **Inputs**
  - Production models vetted by the modeling team
  - Updated assumptions
  - Economic scenarios and other asset-related assumptions
  - Sensitivity sets
  - In-force data provided by Admin systems
  - Output requirements
  - Validation requirements

- **Processes**
  - Update models with in-force and assumptions
  - Coordinate with IT and jointly manage the computer grid
  - Aggregate the output according to the functional requirements
  - Perform output validations
  - Communicate issues to modeling teams
  - Performs user acceptance testing

- **Outputs**
  - Model output and cash flows
  - Financial projections
  - Various model analytics
  - Memo detailing any reliances and limitations
  - Documentation on errors and remediations
  - Attribution analysis
# Governance implementation

## Key activities

The key activities will balance short term tactical wins while establishing the long-term framework and enabling the self-sustaining operation of the new governance framework.

<table>
<thead>
<tr>
<th>Vision &amp; Plan</th>
<th>Standards &amp; Policies</th>
<th>Operating Model</th>
<th>Embedding &amp; Executing</th>
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<tbody>
<tr>
<td>▪ Identify data challenges and pain points and determine master model management maturity level</td>
<td>▪ Design a model governance charter</td>
<td>▪ Establish model governance organization, plan recruitment and onboarding</td>
<td>▪ Govern the model</td>
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<td>▪ Review existing organizational structure and governance framework</td>
<td>▪ Design model governance organization structure</td>
<td>▪ Implement model governance processes, interim enabling tools and technology</td>
<td>▪ Implement long-term enabling tools and technology</td>
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<td>▪ Define a value plan</td>
<td>▪ Define model standards</td>
<td>▪ Design model quality management framework</td>
<td>▪ Monitor, measure, and report on model quality, model governance operations and compliance</td>
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<td>▪ Prepare a strategic road map</td>
<td>▪ Design model governance policy</td>
<td>▪ Develop model quality monitoring process</td>
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<td>▪ Determine executive sponsorship</td>
<td>▪ Design model governance processes</td>
<td>▪ Determine touch points and dependencies with reporting, IT, and other governance bodies</td>
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<td>▪ Identify quick wins/hits</td>
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**Change Management, Communication and Learning**
### Governance implementation

**SOA Paper: Actuarial Modeling Controls for a Model-Based Valuation Framework**

The research paper covered the following aspects of the modeling process, regarding the controls and governance needed when using an actuarial projection model for valuation.

<table>
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<th>Model Governance</th>
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<td><strong>System Access and Change Control</strong></td>
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<td><strong>Model Input Management</strong></td>
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<td><strong>Model Output Management</strong></td>
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- **Modeling Process**
  - Structure of the modeling systems and personnel

- **System Access and Change Control**
  - Personnel with access to modeling systems and procedures for updating model code

- **Assumption Management**
  - Determination, communication, input, and validation of model assumptions

- **Model Input Management**
  - Inforce files, asset files and other inputs to models

- **Model Output Management**
  - Results, reports, and analysis of output

Model validation

Model validation is a process of verifying that the model is set up appropriately, executes correctly and produces reasonable results. The goals for a model validation process can be thought of as four pillars of assurance:

- **Consistency**
  - Consistency of business and model objectives
  - Consistency of processes across models and business units
  - Consistency between models and assumptions
  - Consistency of data collection, aggregation and preparation procedures
  - Consistency in model reporting

- **Compliance**
  - Compliance of models and documentation with regulatory requirements
  - Compliance of processes and controls with policies and guidelines
  - Compliance with model testing procedures

- **Appropriateness**
  - Appropriateness of modeling techniques and key modeling components
  - Appropriateness of assumptions – in line with observed reality and suitable for context
  - Appropriateness of implementation

- **Limitations**
  - Limitations due to particular modeling approaches
  - Limitations due to particular assumptions made
  - Limitations due to poor data quality
Model validation

Some of the model validation activities include:

- Sensitivity / stress testing
  - Test the stability and robustness of the model
  - Understand the dependencies between risks
- Risk attribution
  - Conduct profit and loss attribution within risk categories
- Model change
  - Evaluate model change process consistency with management approved processes in other practices
- Benchmarking
  - Benchmark the model against industry leading practices
  - Evaluate alternative industry used modeling approaches
- Replication
  - Replicate policy / cell / block of business results independently using another tool
Model documentation

Comprehensive documentation across the model lifecycle improves transparency of model and ensures model is used as intended. Effective documentation also helps assure model results are properly used. It is an essential tool to support model validation and peer review.

Effective model documentation includes:

- Model theory and design
- Sources of data and inputs
- Model performance and integrity
- Implementation
- Ongoing monitoring, outcome analysis, and performance
- Model use, reporting, and output
- Model governance and controls (including change management)
- Relationships with other models

Documentation should be detailed so that parties unfamiliar with a model can understand how the model operates, its limitations and key assumptions
Challenges Impacting Actuarial Software

**Actuarial Models**

- **Economic Environment**
  - Rapidly changing & new risks
  - Scarce capital; risk aversion
  - Volatile markets
  - Low interest rates

- **External Stakeholders**
  - Regulators
  - PBA
  - C3P2,3
  - MAR
  - ORSA

- **Insurance Industry**
  - New products and pricing
  - Ratings agencies
  - Demand for higher dividends or ROC

- **Technology Innovation**
  - IT support
  - Multi-core chips
  - Grid/Cloud processing
  - Rapid changes
  - HR costs

- **Actuarial support**

- **Regulators**
  - SEC/FASB
  - SOX
  - FASB 133, 157, SOP 03-1, etc.

- **External Stakeholders**
  - IASB/IAIS convergence
Handle conflicting priorities in model design

Increase model realism
- More detail, granularity
- Asset/liability interaction
- Holistic, integrated models
- Reduce/control shortcuts

Increase model flexibility
- Multiple applications
- Production/ad hoc use
- Constant evolution as needs, technology change

Reduce model expense
- Reduce maintenance and validation effort
- Use technology efficiently
- Optional model efficiency techniques

Improve model control
- Reduce model risk
- Assure run-time reliability
- Support auditability and transparency standards
Increasing Attention to Modeling Standards


- Current initiative to petition the SOA to form a new Modeling Section within SOA

- June, 2013 Exposure Draft on “Modeling”
  - Actuaries “selecting, designing, building, modifying, developing or using models”
  - Assumptions vs. data vs. parameters
  - Models meet intended purpose?
  - Understand model risk
  - Reporting and disclosures
Increasing Attention to Modeling Standards

- 2008 – “Canadian Vision for Life Insurer Solvency Assessment” (industry and CIA participation)
- March 2012 – Regulation on “Use of Internal Models for Determining Required Capital for Segregated Fund Risks (MCCSR)”
- June 2011 - Notice of Intent to develop a new SOP on “Modelling” (reissued in May, 2014)
- Feb 2013 - New SOP Introduced “Relating to Appointed Actuary Opinions with Respect to Use of Internal Models to Determine Required Capital for Segregated Fund Guarantees”
Increasing Attention to Modeling Standards

- May 2010 “Stochastic Modeling – Theory and Reality from an Actuarial Perspective”
- November 2010 - “Note on the Use of Internal Models for Risk and Capital Management Purposes by Insurers”
Actuarial Modeling Controls: A Survey of Actuarial Modeling Controls in the Context of a Model-Based Valuation Framework

- Produced by Deloitte Consulting LLP in December, 2012
- Sponsored jointly by
  - SOA Financial Reporting Section
  - SOA Committee on Finance Research
  - SOA Committee on Life Insurance Research
- Report was based on a self-assessment survey and included:
  - An evaluation of the current state against the leading practices expected under a model-based valuation (MBV)
  - Identification of key steps needed to move from current state to leading practices within 6 Governance themes
Researchers found that
- a wide variety of actuarial model governance and controls were currently in place with significant enhancement needed
- companies that had experienced an adverse event caused by actuarial modeling errors were generally further along

14 key next steps were proposed to close the gaps between current and identified leading practices in areas of:
- Governance Standards
- General Modeling Process
- System Access and Change Control
- Model Assumption Management
- Model Input Management
- Model Output Management
Key Steps: Governance Standards

• Few companies have a holistic, formal and documented model governance structure.
• Information technology (IT) involvement in the modeling process is currently minimal in the industry.

Key Steps to a narrow the gap:

1. Establish a formal and documented governance policy for actuarial modeling processes
2. Regularly review models and the modeling process against the governance policy
3. Develop a corporate culture that values and aligns with the governance policy
Current state of actuarial software in use:
- Variety of home-grown and 3rd party (open and closed) in use
- Different software for different applications
- Modeling performed mostly on desktops
- Spreadsheets often used for input and output

Key Steps to a narrow the gap:

4. Consolidate models to a single platform or a single modeling system where feasible. Where this is not feasible, implement additional controls to ensure model integrity across all modeling platforms.

5. Establish a model steward with clearly defined responsibilities for ensuring adherence to the model.
Key Steps to a narrow the gap:

6. Implement a formal change management process for governing model code changes and model updates

7. Determine the calendar for internal model releases to ensure consistency of the model of record across the organization
Key Steps: Model Assumption Management

- Most companies test the accurate input of assumptions and have some oversight and regular review of assumptions used in models
- Some companies have a centralized location for storing assumptions
- Almost all companies input some assumptions manually or use tool such as Excel, Access, etc.

Key Steps to narrow the gap:

8. Automate the input of assumptions into the models
9. Implement a formal signoff process for the setting of model assumptions
10. Analyze and document the impact of each assumption change
Key Steps: Model Input Management

- Most companies rated controls on model input process as adequate
- Often complex process used to prepare business data, including compression, which required manual steps
- Back end analysis relied on to catch potential input problems

Key Steps to a narrow the gap:

11. Obtain model input data feeds automatically from a centralized data warehouse
12. Automate and standardize a set of test analytics performed to test model input
Key Steps: Model Output Management

- Quality of control process on results dependent partly on use in financials.
- Risks apparent in use of external reporting tools and manual steps to prepare model results for downstream use.

Key Steps to a narrow the gap:

13. Automate and standardize model output used for reporting and analysis
14. Store model output in a data warehouse that can be queried to allow for additional analysis and evaluation of model results
Production vs. Modeling Environments Historically

Production Actuarial Applications …
• Valuation, Required Capital
• Time sensitive, scheduled
• Simpler calculations, less changes
• High volume, file processing
• Managed by IT; actuarial role restricted

Modeling Applications …
• Pricing, research, ad-hoc investigations
• Complex calculations, many inputs/outputs
• Subject to frequent change, rapid response
• PC level technology
• Actuarial sandbox; IT role often minimized
Challenges: Relationship between Actuarial and IT

• Information technology (IT) involvement in the modeling process is currently minimal in the industry.

• Historically, actuaries and IT departments have drifted apart as actuaries
  o Developed their own applications for research, pricing, risk analysis needs.
  o Shifted to desktop environments and desktop software
  o Did not want the restrictions of typical systems development process management methodologies used by IT areas

• Actuaries needed direct access to data for flexibility and speed of response,

• Used manual processes to further modify and use model results
Challenges: Relationship between Actuarial and IT

• Actuarial may need IT and/or vendor assistance to achieve:
  o Automation of a full model based valuation process including integration of the modeling function with enterprise systems
  o Implementation of formal model governance policy with defined roles and permissions on access, change, promotion to production
• Transition back from desktops to a centralized server-based user environment which would facilitate both of the above, but again will require IT and/or vendor assistance

• Relations between IT and Actuarial may need to be rebuilt
• Embed IT expertise in actuarial areas to effectively understand and support modeling applications
Challenges: Overcoming the Actuarial Silo Problem

Lines of Business

Life
Annuity
LTC

Functional area:
Pricing
Valuation
Planning/ALM
Challenges: Overcoming the Actuarial Silo Problem

• “Consolidate models to a single platform or a single modeling system where feasible”
  o Model steward concept and consistent model governance policy are more difficult to apply with multiple models and platforms
  o Move to centralized storage and control of assumptions and input may be motivated by proliferation of different models and platforms
    ➢ Consolidation of platform and models may save complex and unnecessary steps in production process (and maintenance)
References

- SOA report on Actuarial Modeling Controls:
  http://www.soa.org/Research/Research-Projects/Life-Insurance/Actuarial-Modeling-Control.aspx

- ASB Exposure Draft on Modeling
  http://www.actuarialstandardsboard.org/pdf/exposure/Modeling_exposure_draft_June%202013.pdf

- CIA Report Risk Assessment Models
  http://www.cia-ica.ca/docs/default-source/2008/208061e.pdf?sfvrsn=4

- IAA Note on the Use of Internal Models for Risk and Capital
Governance – A Real Life Perspective

Ken Crabbs

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The Ways Things Were…

- Actuary makes required model changes
- Changes are peer reviewed
- Changes are tested
- In-force data are manually retrieved from admin system(s)
- In-force data are scrubbed and formatted for valuation system
- Valuation model is run
- Model output is reviewed and tested
- Model output is formatted for downstream user(s)
- Output is provided manually to downstream user(s)
Actuaries acted a bit like cottage industries

A one man show (Almost)

Models were relatively simple

It was all about getting the numbers out

If the output was good, the models were good
What’s Changed?

• Products (and models) have gotten more complex
• Modeling tools have become more capable
• Processing power has improved substantially
• Management demands for predictive analysis has intensified
• Regulators demand more sophisticated models
  • VA CARVM, C3 Phase II, PBR, Solvency II, etc.
• Regulator and auditor scrutiny of models has increased

New Types of Models Require
New Types of Governance
What is a Well Governed Model?

Controls exist to ensure that output is valid, accurate and reliable. One can readily demonstrate that:

- All data and assumptions sources are valid, reliable and appropriate.
- The processes and configuration items are understood, well documented, and applied as intended.
- The model uses the selected actuarial tool to accurately translate actuarial specifications and user requirements.

Procedures exist to ensure the models are preserved in a known state for an appropriate retention period:

- Software, data, configuration files & documentation to reproduce output are retained and cannot be altered.
All data and assumptions sources are valid, reliable and appropriate.

Controlled (Production) Environment

1 – Input Controls
a) Files come only from sanctioned source with no manual touch and no ability to make changes, or have clear lineage & approvals.
b) Validity and completeness checks are applied to ensure in-force is complete and correct.

2 – Output Controls
a) Output comes only from production environment.
b) Validity and completeness checks are applied to ensure in-force is complete and correct.
The processes & configuration items are understood, well documented, and applied as intended.

**3 – Model Change Control**

a) All Model changes are made in a separate development area where they are peer reviewed and tested.

b) Changes, testing and peer review are documented, and model is approved for promotion to the production environment by a qualified approver (not the developer, tester or production operator).
The model uses the selected actuarial tool to accurately translate actuarial specifications and user requirements.

Model Validation – What is it?
Ensuring model output is useful to those who receive and consume it. What question does it answer and how? What are its limitations?

Models should be validated on regular cycle
• Have all new rules, regulations and products been incorporated?
• Are latest company approaches and standards in place?
• Have enhanced platform capabilities been leveraged?
• Are assumptions valid and appropriate?

Not the same as regression or parallel testing
• Earlier model may be wrong or circumstances may have changed

Potential Model Validation Tools
• Back-testing (testing results against actuals)
• Independent peer review
• Sensitivity, stress and scenario testing
Software, data, configuration files & documentation to reproduce output are retained and cannot be altered.

**Controlled (Production) Environment**

1. **In-Force Files**
   - Model with all components required for a future rerun are moved directly to a read-only location as soon after run as practical
   - Documentation required to recreate run is included.

2. **Valuation Model**
   - Files come only from sanctioned source with no manual touch and no ability to make changes, or have clear lineage & approvals.
   - Validity and completeness checks are applied to ensure in-force is complete and correct.

3. **Downstream Uses**
   - Output comes only from production environment.
   - Validity and completeness checks are applied to ensure in-force is complete and correct.

4. **Model Archive**
   - 4 – Move to Archive
     a) Model with all components required for a future rerun are moved directly to a read-only location as soon after run as practical
     b) Documentation required to recreate run is included.
More to Governance than Managing Files, Restricting Access and Controlling Changes

Good Governance Includes:

✓ A Facilitating Organization
  ✓ Senior Management Support
  ✓ Clear Model Ownership – both managerial and technical
  ✓ Separation of Duties – separate developers, reviewers and approvers
  ✓ Independent Oversight – someone outside of the “production” group

✓ Adequate Tools
  ✓ Provided by Actuarial Software vendors – integrated into modeling platforms
  ✓ Built in-house – environments, tools and processes built around modeling platforms
  ✓ Automation – to facilitate governance and streamline actuarial work. Manual processes are error-prone and hard to control.
More to Governance than Managing Files, Restricting Access and Controlling Changes

Good Governance Includes:

✓ **Appropriate Standards and Processes**
  ✓ Governance Standards
  ✓ Modeling Standards
  ✓ Peer Review Standards
  ✓ Documentation Standards
  ✓ Standard Operation Procedures
  ✓ Validation Cycle
  ✓ Archiving Processes

✓ **A Governance Mindset**
  ✓ It’s in our blood (we do it even when no one’s looking)
How Do We Get There?

✓ Rethink the organization and the culture
✓ Put controls around model changes
✓ Control the inputs and outputs
✓ Build/Enhance Standards and Processes

These things are likely to be done concurrently, with twists and turns along the way.
Rethink the Organization

• There should be at least one person on your team formally responsible for Governance.

• Governance leader(s) must have strong management backing.

• Create a “Model Steward”, responsible for independent review & model optimization. Outside of “Production” team.

• Ensure every model has a clear technical owner, not just an owning manager.

• Think about how people are evaluated, rewarded (and punished).
Put Controls Around Model Changes

• **Inventory Your Models**

• **Wall off production. Remove modeler ability to make changes in production.**
  • Identify changes made during production. Automate them, move them to development, or be creative.

• **Establish a formal model approval process.**
  • Track model changes.
  • Create a way to track model versions.
  • Formally track model approvals (work flow system)

**Institute an independent promotion process.**
• Those promoting models shouldn’t be modelers. Ideally, they should not be able to change models.
Control the Inputs

• Inventory Your Inputs
• Ensure all sources are appropriate & approved
  • Direct feed from production systems where possible
  • Ensure manual sources are approved and versioned
  • Develop a clear and transparent assumption process with clear-cut lineage, approvals & versions.
• Validate data integrity and completeness
  • Partner with IT
  • Use control / hash totals
  • Eliminate manual data manipulation & reformatting - move to source provider, modeling tool or ETL tool
  • Where manual process remains, do a double check.
Control the Outputs

- **Inventory Your Outputs**
- **Output only from approved model instances.**
  - Direct feed to downstream systems where possible
  - Ensure manual output is approved and versioned
  - Implement a results database or at least a common results repository
- **Validate data integrity and completeness**
  - Partner with IT
  - Use control / hash totals
  - Eliminate manual data manipulation & reformatting - move to source provider, modeling tool or ETL tool
  - Where manual process remains, do a double check.
Build/Enhance Standards and Processes

- Modeling Standards
  - Risks to be considered
  - Preferred methodologies
  - Variable naming
  - Use of comments, white space and indentation
- Peer Review Standards
  - Templates, Documentation, Approval & Retention
  - Levels of peer review – Methodology change vs. Simple table update
  - Qualifications to perform
  - Accountability when a model goes wrong
Build/Enhance Standards and Processes

• Documentation Standards
  • Internal – comments embedded in code and notepads within the modeling tool.
  • External – Documents describing the overall model, its theory, methodologies, intended uses, limitations and history of changes.

• Standard Operating Procedures – written and maintained at an appropriately granular level, and actually used.

• Archiving Standards – What goes in, when it goes in and how long it stays. How it is accessed and protected from changes.
Governance is a Journey, not a Destination

There may be no end in sight…

…but the direction is clear.