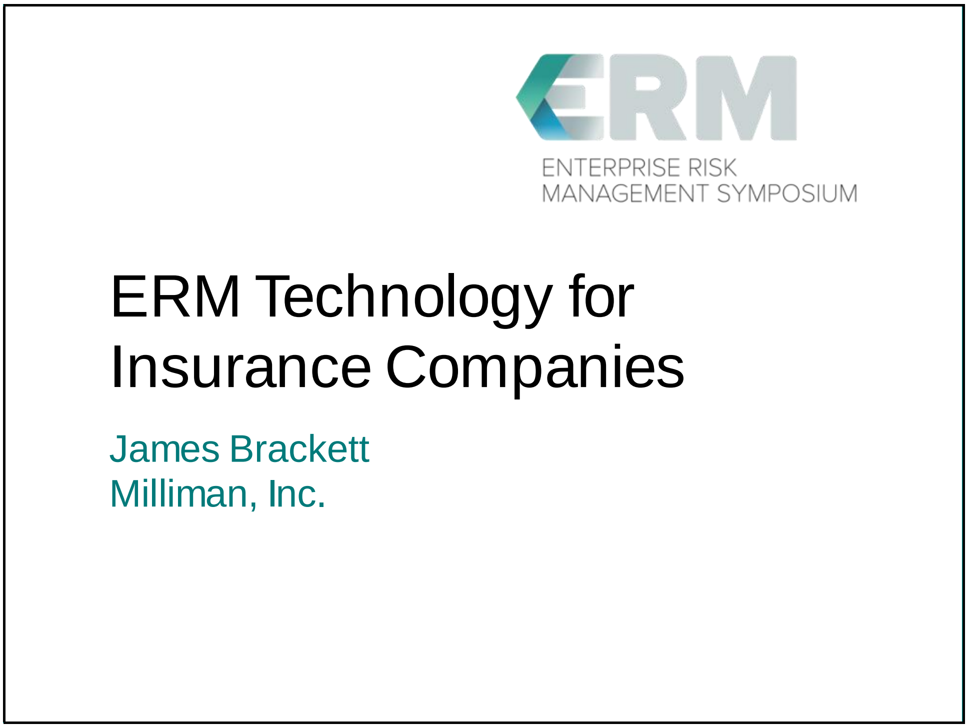

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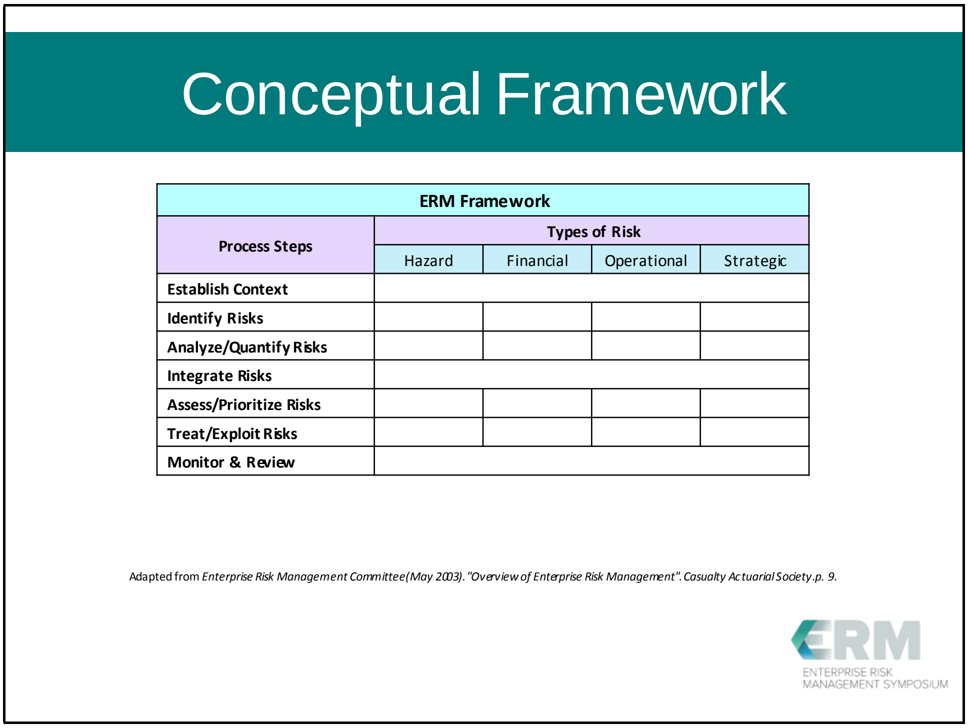
ERM Technology for Insurance Companies

James Brackett
Milliman, Inc.



Conceptual Framework

ERM Framework				
Process Steps	**Types of Risk**			
	Hazard	Financial	Operational	Strategic
Establish Context				
Identify Risks				
Analyze/Quantify Risks				
Integrate Risks				
Assess/Prioritize Risks				
Treat/Exploit Risks				
Monitor & Review				

Adapted from *Enterprise Risk Management Committee(May 2003). "Overview of Enterprise Risk Management". Casualty Actuarial Society.p. 9.*

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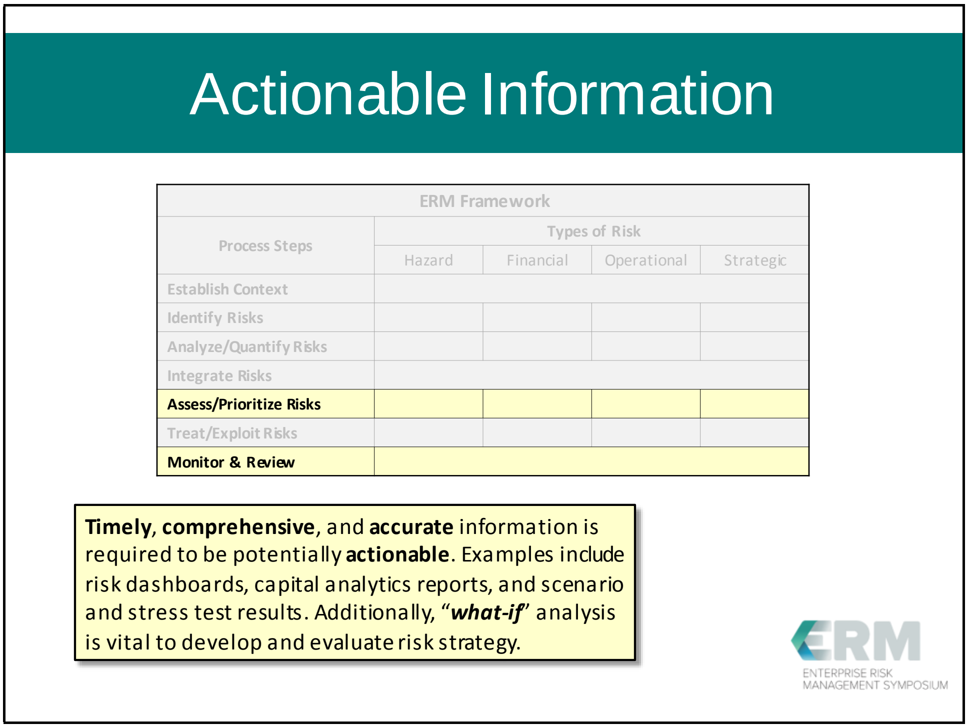

Actionable Information

ERM Framework				
Process Steps	Types of Risk			
	Hazard	Financial	Operational	Strategic
Establish Context				
Identify Risks				
Analyze/Quantify Risks				
Integrate Risks				
Assess/Prioritize Risks				
Treat/Exploit Risks				
Monitor & Review				

Timely, **comprehensive**, and **accurate** information is required to be potentially **actionable**. Examples include risk dashboards, capital analytics reports, and scenario and stress test results. Additionally, "***what-if***" analysis is vital to develop and evaluate risk strategy.

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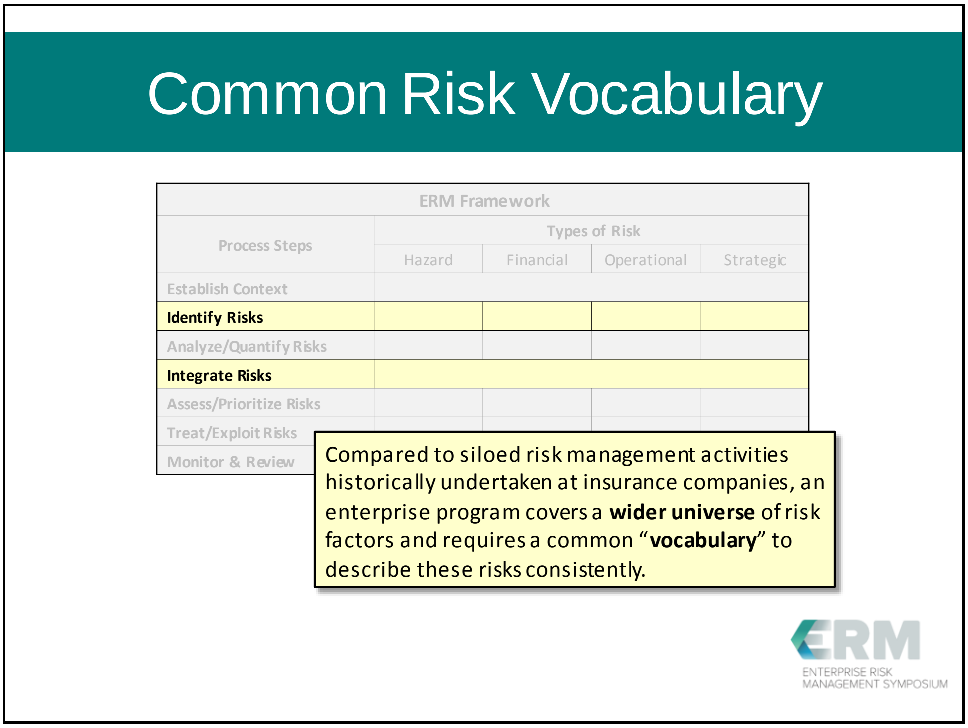

Common Risk Vocabulary

ERM Framework				
Process Steps	Types of Risk			
	Hazard	Financial	Operational	Strategic
Establish Context				
Identify Risks				
Analyze/Quantify Risks				
Integrate Risks				
Assess/Prioritize Risks				
Treat/Exploit Risks				
Monitor & Review				

Compared to siloed risk management activities historically undertaken at insurance companies, an enterprise program covers a **wider universe** of risk factors and requires a common "**vocabulary**" to describe these risks consistently.

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Computational Capacity

ERM Framework				
Process Steps	Types of Risk			
	Hazard	Financial	Operational	Strategic
Establish Context				
Identify Risks				
Analyze/Quantify Risks				
Integrate Risks				
Assess/Prioritize Risks				
Treat/Exploit Risks				
[illegible]				

ERM modeling requirements can exert significant demands on computing infrastructure, both with regard to **processing power** and **data** management. Models must conform to the **common risk vocabulary** and exhibit sufficient **performance** to recalculate risk metrics in response to environmental changes (e.g., market conditions).

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Approaches to Implementation

Transformational

vs.

Additive

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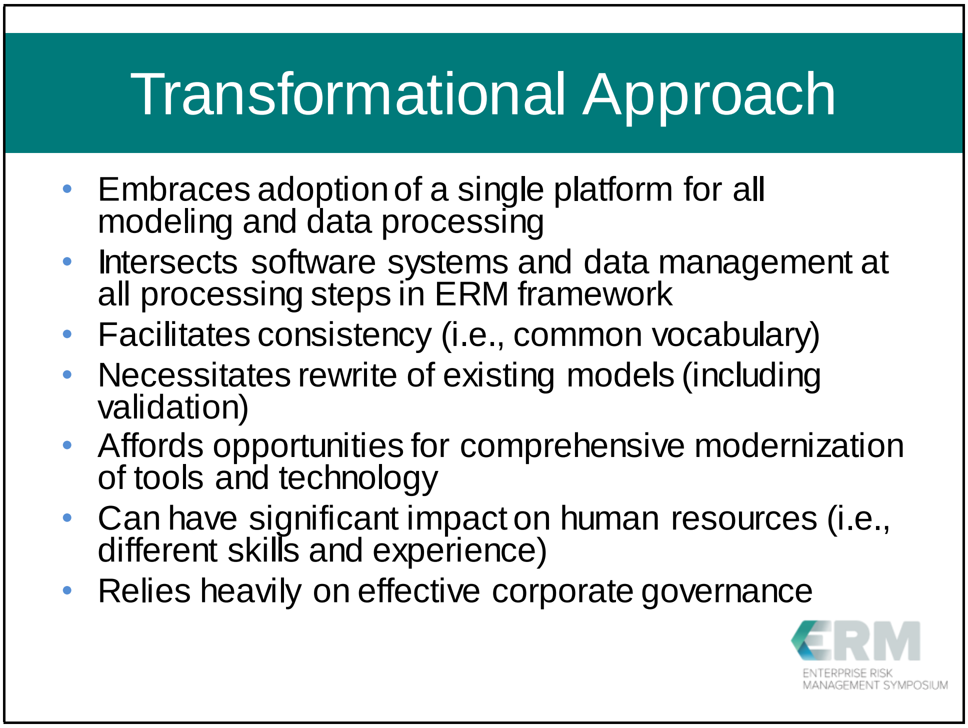

Transformational Approach

- Embraces adoption of a single platform for all modeling and data processing
- Intersects software systems and data management at all processing steps in ERM framework
- Facilitates consistency (i.e., common vocabulary)
- Necessitates rewrite of existing models (including validation)
- Affords opportunities for comprehensive modernization of tools and technology
- Can have significant impact on human resources (i.e., different skills and experience)
- Relies heavily on effective corporate governance

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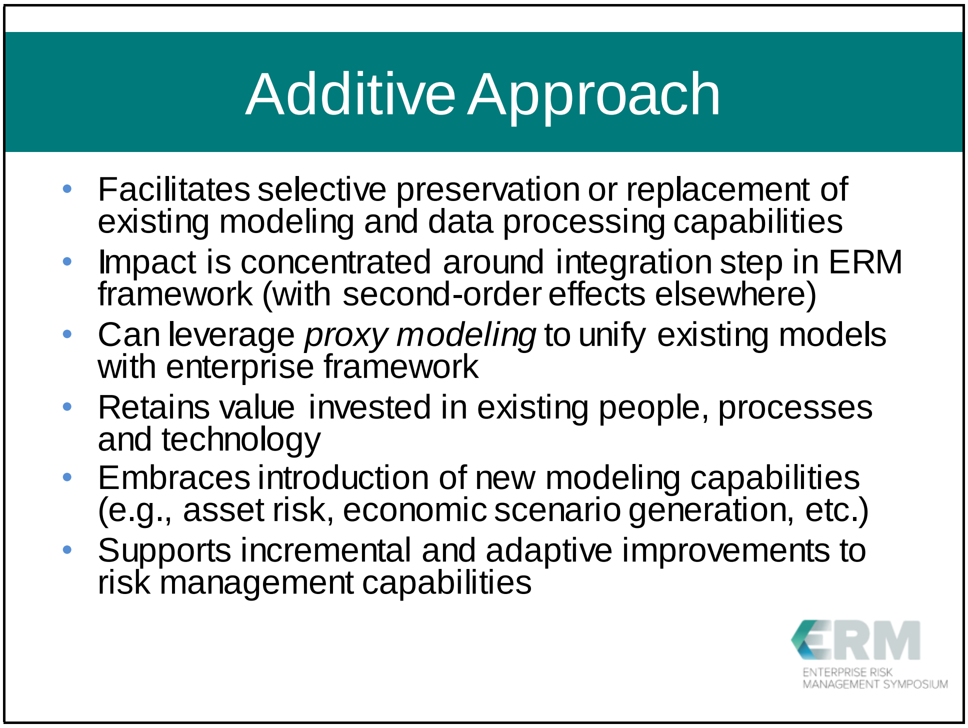

Additive Approach

- Facilitates selective preservation or replacement of existing modeling and data processing capabilities
- Impact is concentrated around integration step in ERM framework (with second-order effects elsewhere)
- Can leverage *proxy modeling* to unify existing models with enterprise framework
- Retains value invested in existing people, processes and technology
- Embraces introduction of new modeling capabilities (e.g., asset risk, economic scenario generation, etc.)
- Supports incremental and adaptive improvements to risk management capabilities

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"Every side attacks when you don't take sides."

— Marty Rubin

"Standing in the middle of the road is very dangerous; you get knocked down by the traffic from both sides."

— Margaret Thatcher

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Where Technology Can Help

- Data Management
- Model Development
- Reporting and Visualization
- Automation
- Computing Platforms
- Services

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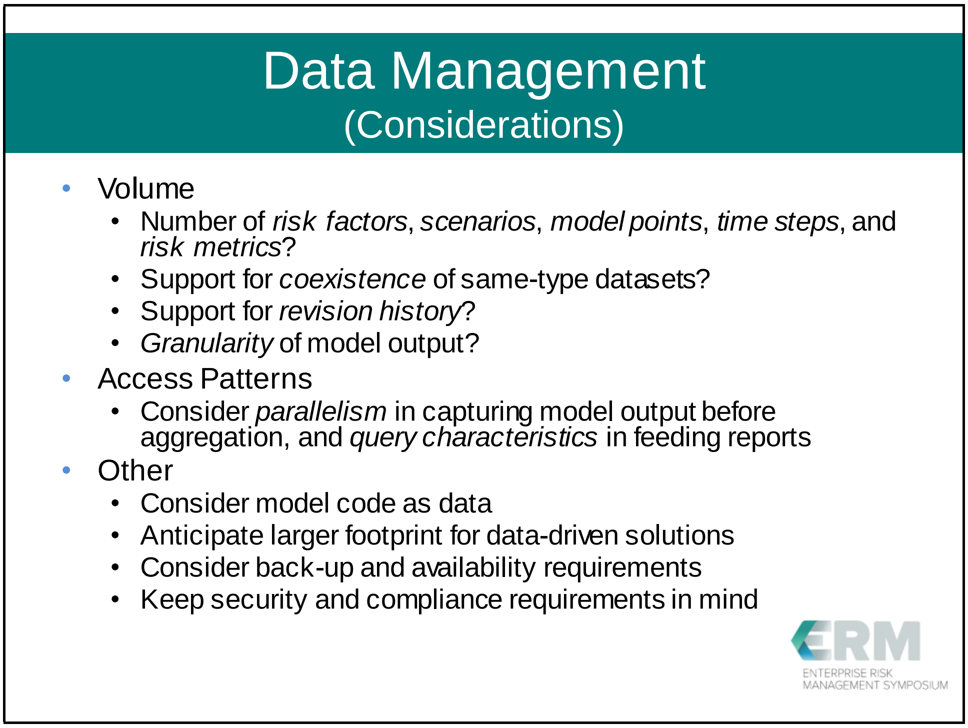

Data Management
(Considerations)

- Volume
  - Number of *risk factors*, *scenarios*, *model points*, *time steps*, and *risk metrics*?
  - Support for *coexistence* of same-type datasets?
  - Support for *revision history*?
  - *Granularity* of model output?
- Access Patterns
  - Consider *parallelism* in capturing model output before aggregation, and *query characteristics* in feeding reports
- Other
  - Consider model code as data
  - Anticipate larger footprint for data-driven solutions
  - Consider back-up and availability requirements
  - Keep security and compliance requirements in mind

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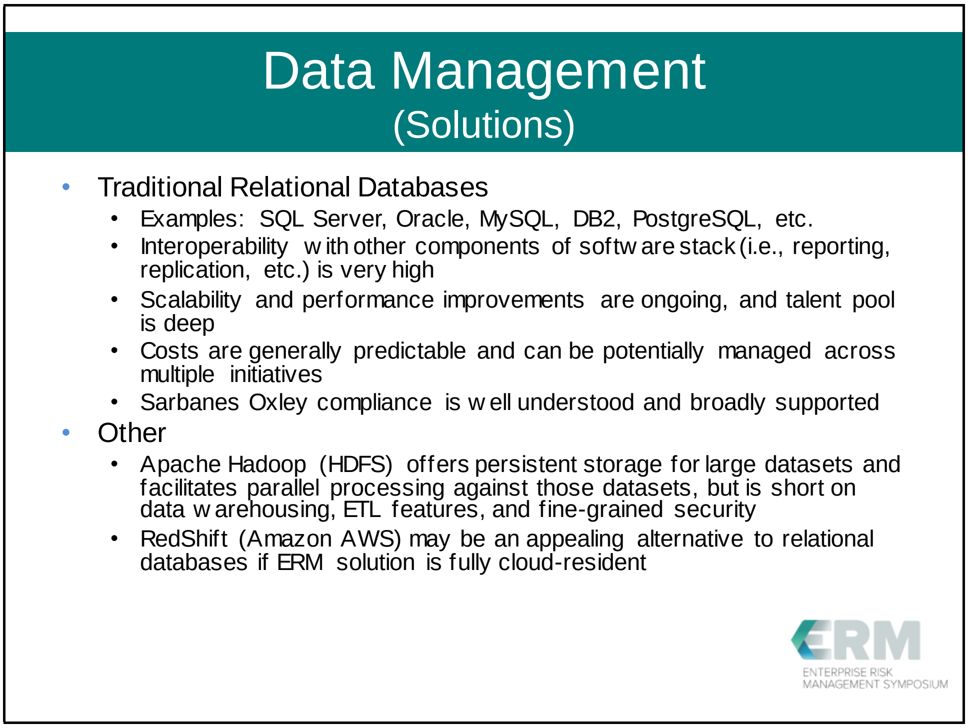

Data Management
(Solutions)

- Traditional Relational Databases
  - Examples: SQL Server, Oracle, MySQL, DB2, PostgreSQL, etc.
  - Interoperability with other components of software stack (i.e., reporting, replication, etc.) is very high
  - Scalability and performance improvements are ongoing, and talent pool is deep
  - Costs are generally predictable and can be potentially managed across multiple initiatives
  - Sarbanes Oxley compliance is well understood and broadly supported
- Other
  - Apache Hadoop (HDFS) offers persistent storage for large datasets and facilitates parallel processing against those datasets, but is short on data warehousing, ETL features, and fine-grained security
  - RedShift (Amazon AWS) may be an appealing alternative to relational databases if ERM solution is fully cloud-resident

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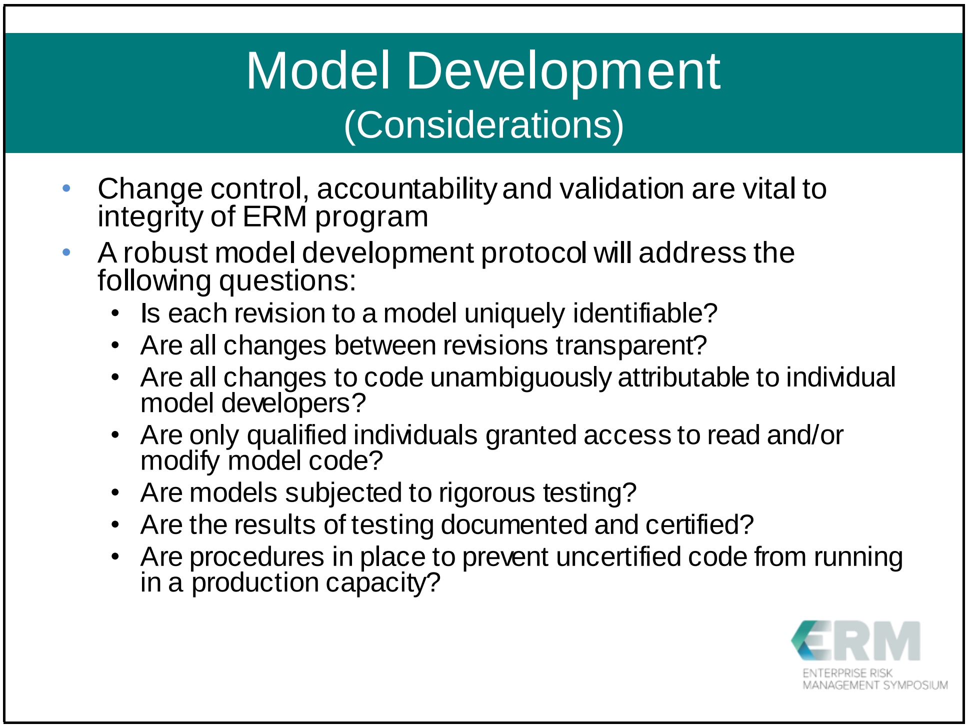
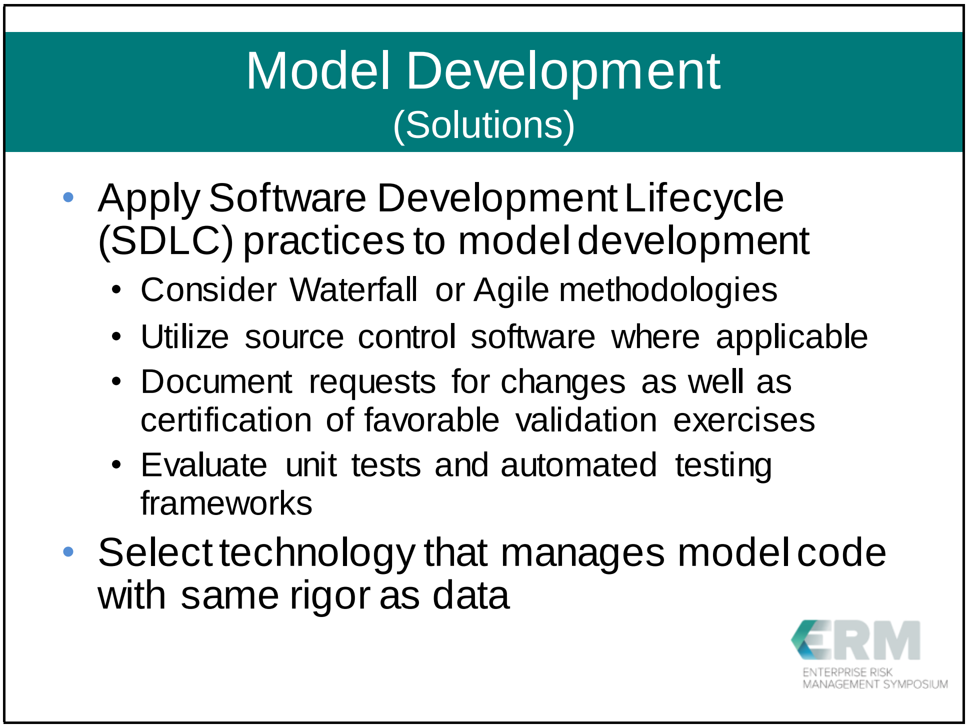


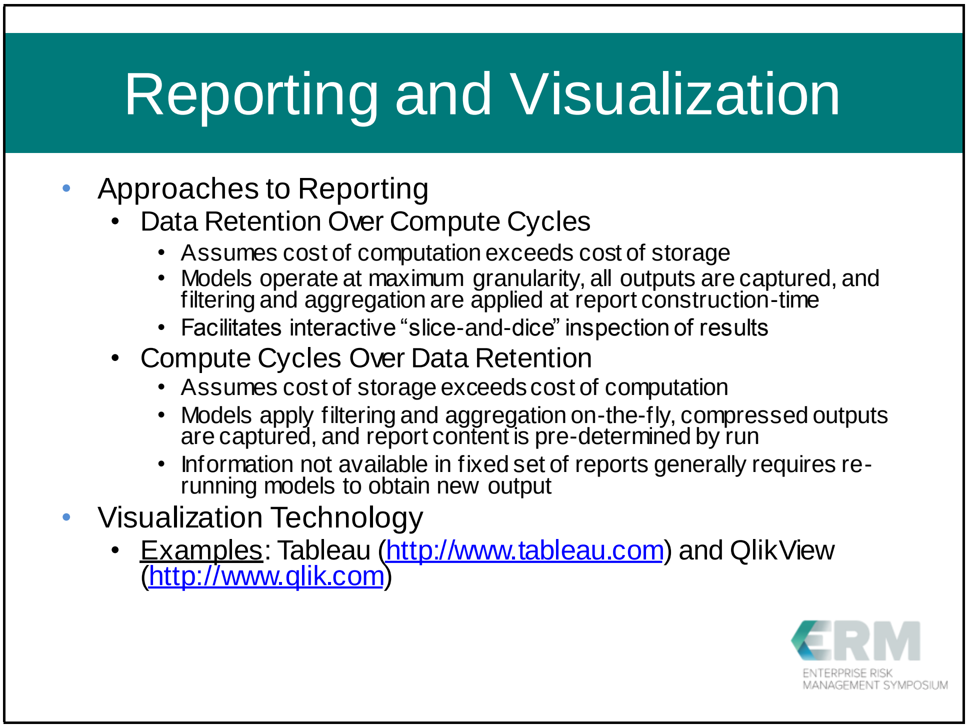
Model Development
(Considerations)

- Change control, accountability and validation are vital to integrity of ERM program
- A robust model development protocol will address the following questions:
  - Is each revision to a model uniquely identifiable?
  - Are all changes between revisions transparent?
  - Are all changes to code unambiguously attributable to individual model developers?
  - Are only qualified individuals granted access to read and/or modify model code?
  - Are models subjected to rigorous testing?
  - Are the results of testing documented and certified?
  - Are procedures in place to prevent uncertified code from running in a production capacity?



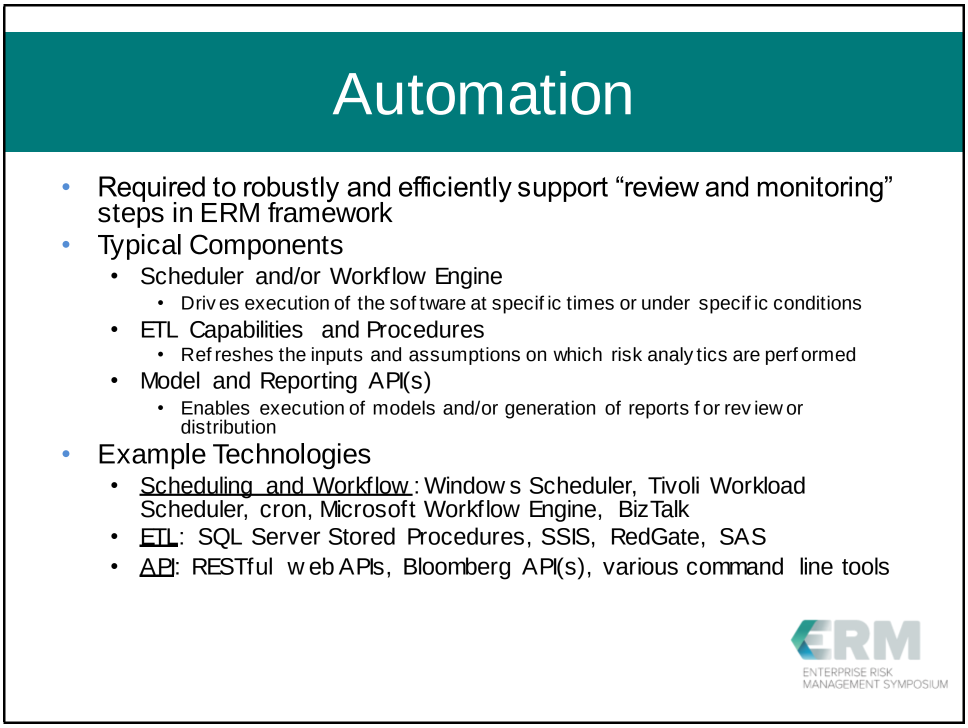
Model Development
(Solutions)

- Apply Software Development Lifecycle (SDLC) practices to model development
  - Consider Waterfall or Agile methodologies
  - Utilize source control software where applicable
  - Document requests for changes as well as certification of favorable validation exercises
  - Evaluate unit tests and automated testing frameworks
- Select technology that manages model code with same rigor as data



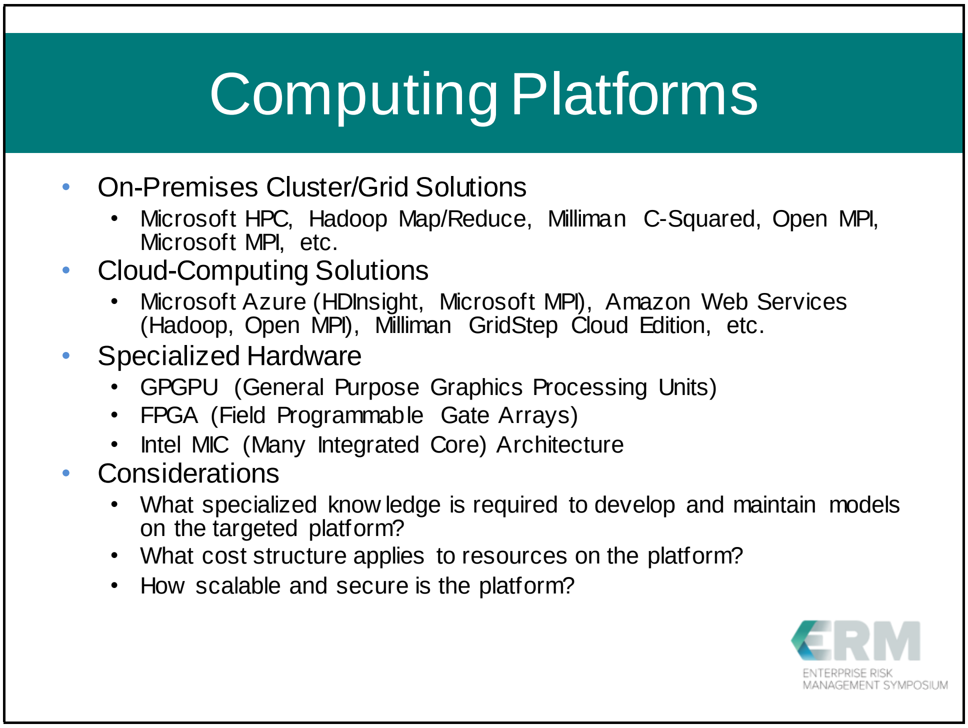
Reporting and Visualization

- Approaches to Reporting
  - Data Retention Over Compute Cycles
    - Assumes cost of computation exceeds cost of storage
    - Models operate at maximum granularity, all outputs are captured, and filtering and aggregation are applied at report construction-time
    - Facilitates interactive "slice-and-dice" inspection of results
  - Compute Cycles Over Data Retention
    - Assumes cost of storage exceeds cost of computation
    - Models apply filtering and aggregation on-the-fly, compressed outputs are captured, and report content is pre-determined by run
    - Information not available in fixed set of reports generally requires re-running models to obtain new output
- Visualization Technology
  - Examples: Tableau (http://www.tableau.com) and QlikView (http://www.qlik.com)



Automation

- Required to robustly and efficiently support "review and monitoring" steps in ERM framework
- Typical Components
  - Scheduler and/or Workflow Engine
    - Drives execution of the software at specific times or under specific conditions
  - ETL Capabilities and Procedures
    - Refreshes the inputs and assumptions on which risk analytics are performed
  - Model and Reporting API(s)
    - Enables execution of models and/or generation of reports for review or distribution
- Example Technologies
  - Scheduling and Workflow: Windows Scheduler, Tivoli Workload Scheduler, cron, Microsoft Workflow Engine, BizTalk
  - ETL: SQL Server Stored Procedures, SSIS, RedGate, SAS
  - API: RESTful web APIs, Bloomberg API(s), various command line tools



Computing Platforms

- On-Premises Cluster/Grid Solutions
  - Microsoft HPC, Hadoop Map/Reduce, Milliman C-Squared, Open MPI, Microsoft MPI, etc.
- Cloud-Computing Solutions
  - Microsoft Azure (HDInsight, Microsoft MPI), Amazon Web Services (Hadoop, Open MPI), Milliman GridStep Cloud Edition, etc.
- Specialized Hardware
  - GPGPU (General Purpose Graphics Processing Units)
  - FPGA (Field Programmable Gate Arrays)
  - Intel MIC (Many Integrated Core) Architecture
- Considerations
  - What specialized know ledge is required to develop and maintain models on the targeted platform?
  - What cost structure applies to resources on the platform?
  - How scalable and secure is the platform?

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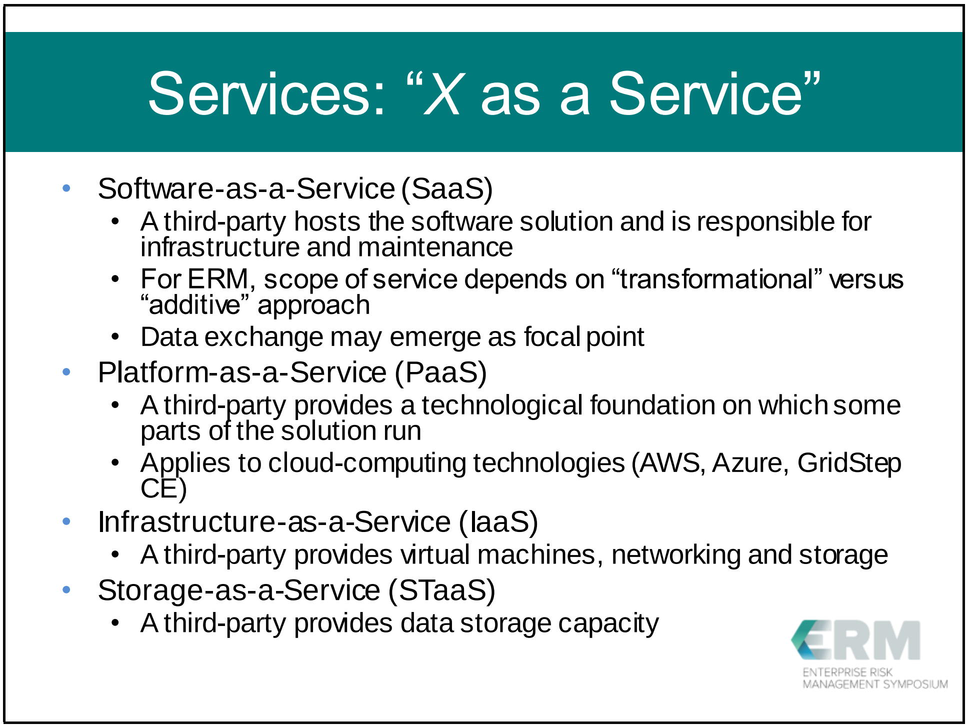

Services: “*X* as a Service”

- Software-as-a-Service (SaaS)
  - A third-party hosts the software solution and is responsible for infrastructure and maintenance
  - For ERM, scope of service depends on “transformational” versus “additive” approach
  - Data exchange may emerge as focal point
- Platform-as-a-Service (PaaS)
  - A third-party provides a technological foundation on which some parts of the solution run
  - Applies to cloud-computing technologies (AWS, Azure, GridStep CE)
- Infrastructure-as-a-Service (IaaS)
  - A third-party provides virtual machines, networking and storage
- Storage-as-a-Service (STaaS)
  - A third-party provides data storage capacity

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