The Importance of Model Verification and Validation

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Outline

I. Overview

- Model verification
- Model validation (support)
- Complexity

II. Real-World Examples

- Radioactive Waste
- Industry
- Others

Audience Quiz

- How many of you have developed a GoldSim model?
- How many of you create a model validation plan/strategy for a new model?
- How many of you have a model verification procedure?
- How many of you have experienced a bug/error in a model?
- How many of you have found an error in your model after it was deployed?

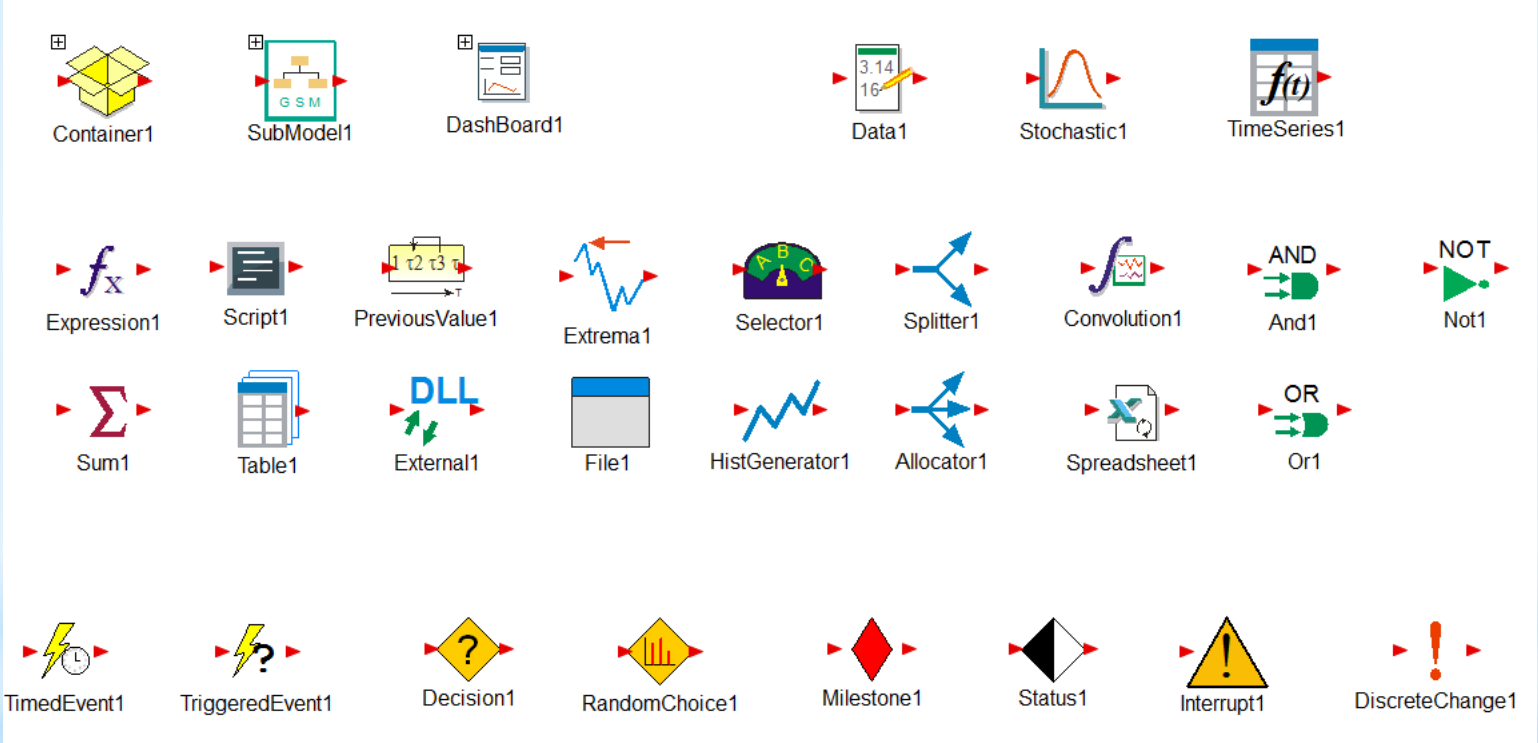
Verification

Verification

- Verification – “Solving the equations right”, but more than that
- Effort scales with size and complexity of your model
- Verification applies to:
  - Operating platform: configuration control
  - Software
  - Input data (quality, units, etc.)
  - Calculations
  - Output modifications
- Verification effort should be on the order of 50-100% of the model building effort

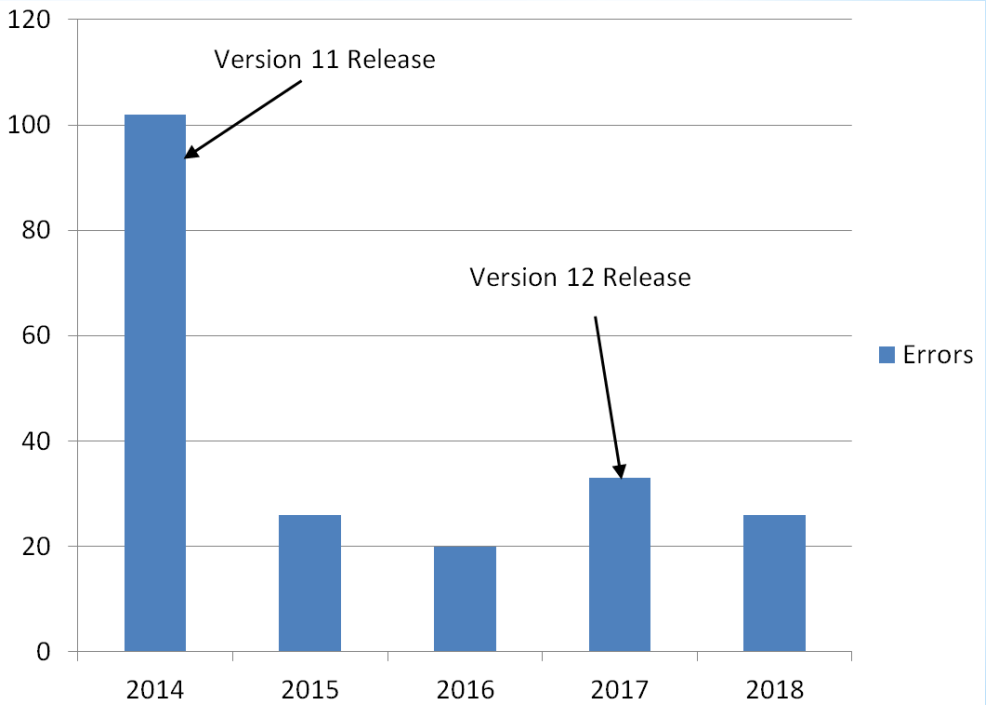
Fanelli D, 2009 – 2% of scientists admitted to falsifying, fabricating, or modifying data

Example: Software Verification



Verification Math

- Version 11.7 of GoldSim has 31 “building blocks”
- How many ways to choose 10 of 31?
- How many ways to connect those 10?
- While there are bugs/errors in each version, the errors are remarkably infrequent considering the complexity of the software.



Data Quality

- Big Data does not mean high-quality data
- Approximately 60% of big data projects are not completed, for a large part, due to poor quality data
- Increased computational power and sophisticated modeling tools results in many data starved, model rich situations
- Example – data quality resulted in mispricing and poor business decisions associated with the great financial collapse.
- Data quality uncertainty should be included in your models

Errors

https://www5.in.tum.de/~huckle/bugse.html

https://www.cs.tau.ac.il/~nachumd/horror.html

http://ta.twi.tudelft.nl/users/vuik/wi211/disasters.html

Chicago cat owners were billed $5 for unlicensed dachshunds. A database search on "DHC" (for dachshunds) found "domestic house cats" with shots but no license. From *ACM SIGSOFT Software Engineering Notes*, vol. 12, no. 3.

Validation

Validation (Support)

- Validation – “Solving the right equations
- Depending on application, may be the most difficult part of modeling
- Calibration ≠ validation
- Validation effort should be on the order of 50-100% but could be 1000%+ of the model building effort

Must try to falsify your model!

Examples: Biases, Errors, and Pitfalls

- **Correlation does not imply causation**
- Sunk costs
- Anchoring
- **Confirmation bias**
- **Framing**
- Blind spot bias
- **Overconfidence**
- Data dredging
- Ambiguity effect
- Risk aversion
- **Kurtosis risk**
- Butterfly effect

Models are imperfect representations created by imperfect people

Validation?

“Erosion Protection. Water and wind erosion surface cover material can impact the integrity of a surface cover. The low precipitation, the low intensity of precipitation events, the absence of surface run-on features at the Hanford Site, and stability monitoring (PNNL-18845) all support the assumption that water erosion will not be a significant factor at WMA C barrier. Wind erosion, however, has been observed at the Hanford Site, primarily in exposed sandy areas and in the sand dunes to the southeast of WMA C.

Validation Example

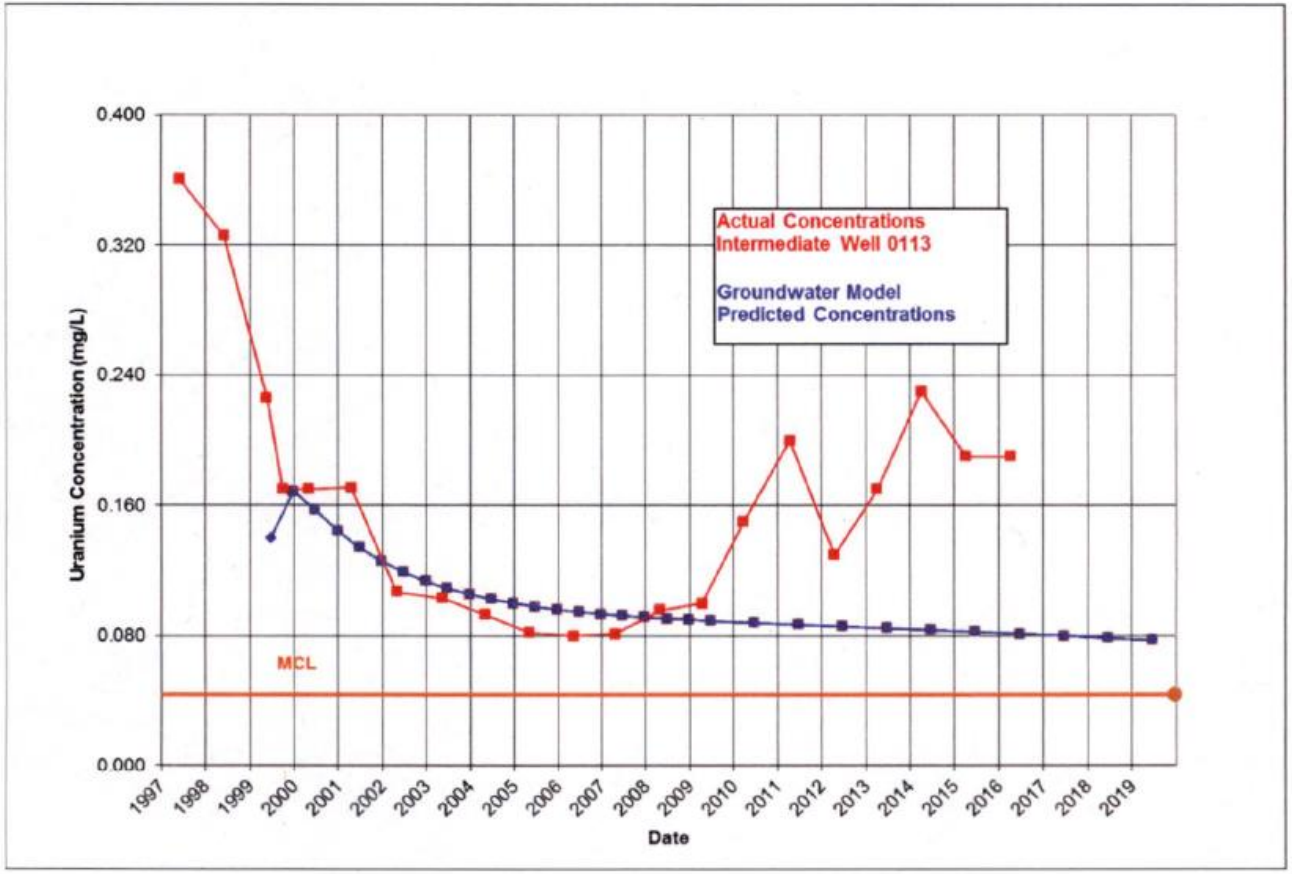


Figure 4. Predicted (Blue) and Actual (Red) Uranium Concentrations in Monitoring Well 0113

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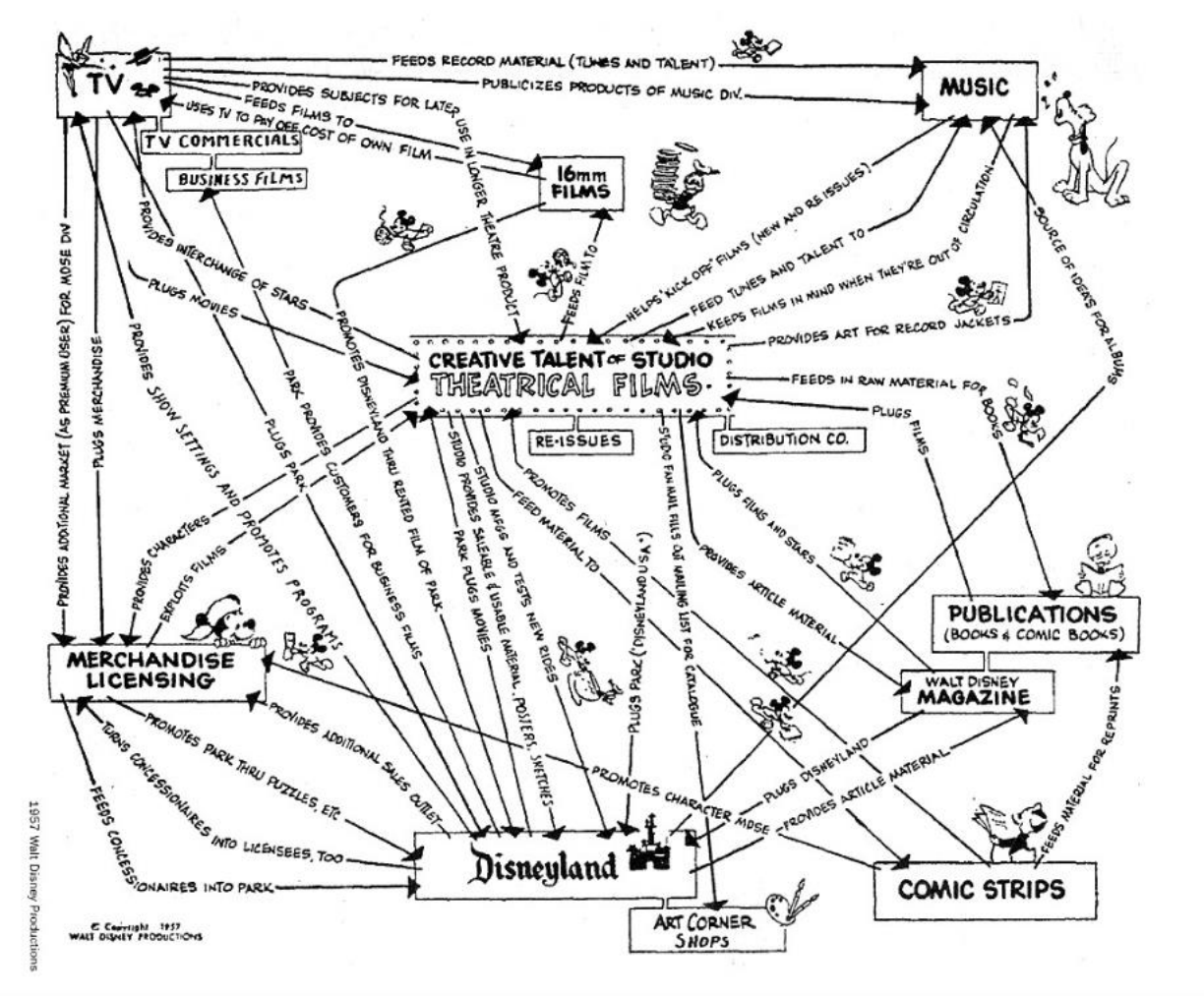
Complexity

Complexity

- Complexity can take many different forms:
  - Spatial and temporal characteristics
  - System dynamics (feedback, shelf and cliff responses)
  - Coupling – what and how
- Usually you are modeling a system because there is complexity, otherwise you could rely on intuition and experience
- Can be extremely challenging to determine what level of complexity is necessary to model
- Validation strategy can help

Example: Walt Disney Business Model



1957 Walt Disney Productions

Example: Philadelphia Row House Fire

- Row house was being remodeled
- Electricity was turned off
- Row house caught fire and burned down (including neighboring houses)
- Fire started in the remodeled house with the power off and no tools/etc. left that would cause it. Nobody was in the house at the time of the fire
- Parties involved were trying to determine who was at fault

Philadelphia Row House Fire

Hint #1 – a week prior a neighbor said they smelled the faint smell of smoke

Hint #2 – a different neighbor reported problems with raccoons

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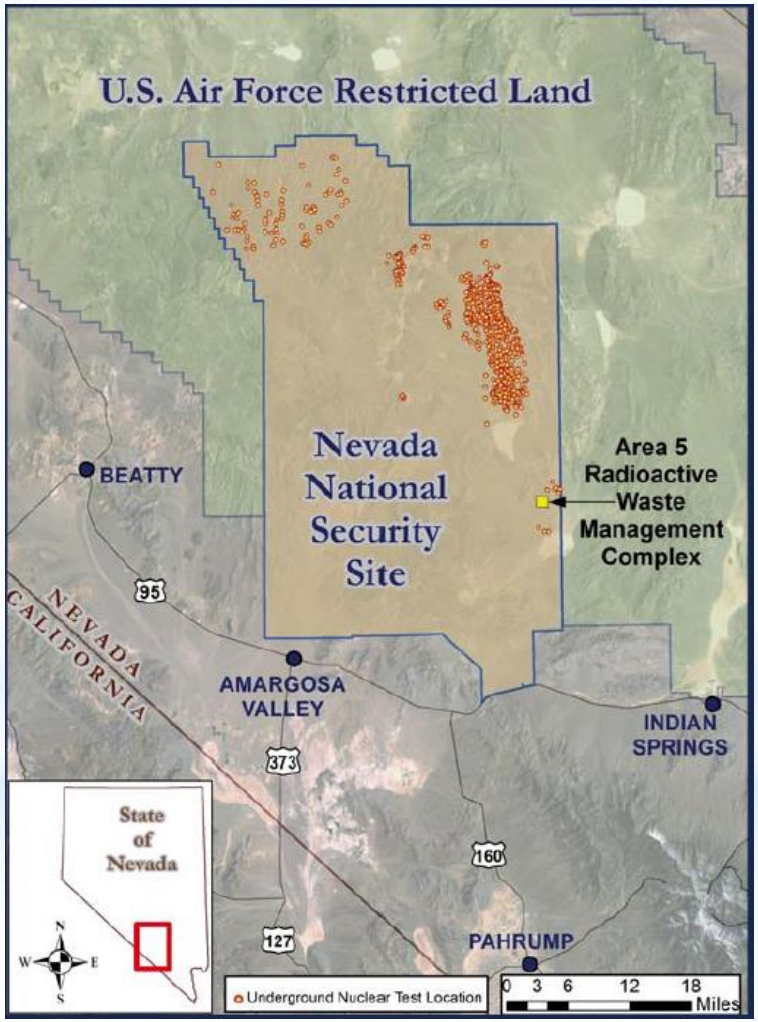
Example: Radwaste Disposal

Beatty, Nevada
October 18, 2015

Beatty NV Low-level Waste Disposal Facility



Beatty NV Background

- Low-level radioactive waste disposal facility licensed in 1962
- Nevada took over licensing in 1972
- Facility closed in 1992
- Arid location 6 to 13 cm of precipitation per year
- Over 250 cm of evaporation (potential) per year
- Doesn’t have what one would consider a modern performance assessment

Initial Report

As a result of a large rain storm, a low-level waste disposal facility caught fire and exploded

*This scenario is not included in any performance assessment that I am aware of

Beatty NV – Post Event Analysis

- Two weeks prior to the event there was 3.3 cm of rain over an ~ two day period (October 4 to 6)
- During the event (October 18) there was 1.4 cm of rain
- Cover had experienced subsidence and erosion
- Metallic barrels containing metallic sodium had corroded over time
- Metallic sodium reacted with infiltration, igniting and exploding
- Barrels ejected from disposal facility

Beatty NV – Post Event Analysis

Beatty NV – Modeling Lessons Learned

- Corrosion rates much higher than would have been modeled
- Subsidence can have major impacts on infiltration
- Must consider spatial and temporal variability in long-term assessments

Summary

- GoldSim is a powerful tool, but that does not obviate the need for model verification and validation
- The effort devoted to verification and validation should generally equal or exceed the effort devoted to model develop
- The system that you can model and the system that you must model may be significantly different

Thank You!