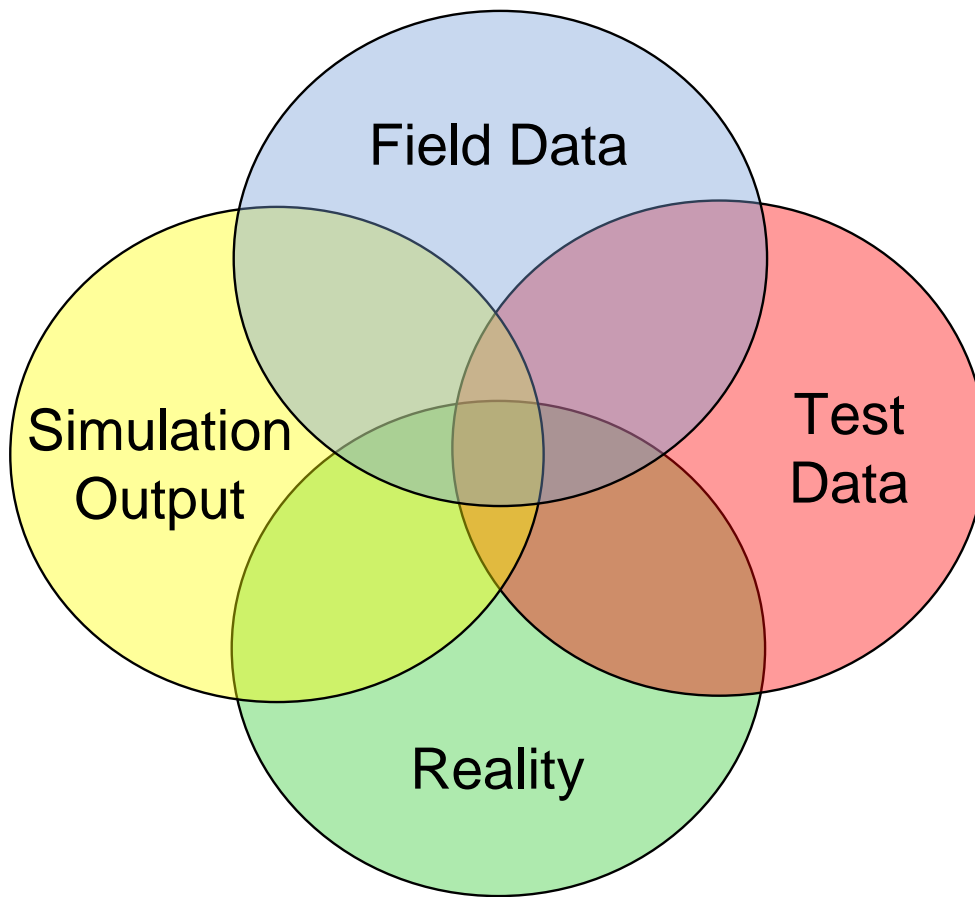# Comments on Physics-Based Modeling & Simulation in Support of T&E Requirements

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March 15, 2012

Walbert's view of the world**

Field Data

Test Data

Simulation Output

Reality

**Not to scale

Walbert's view of the world
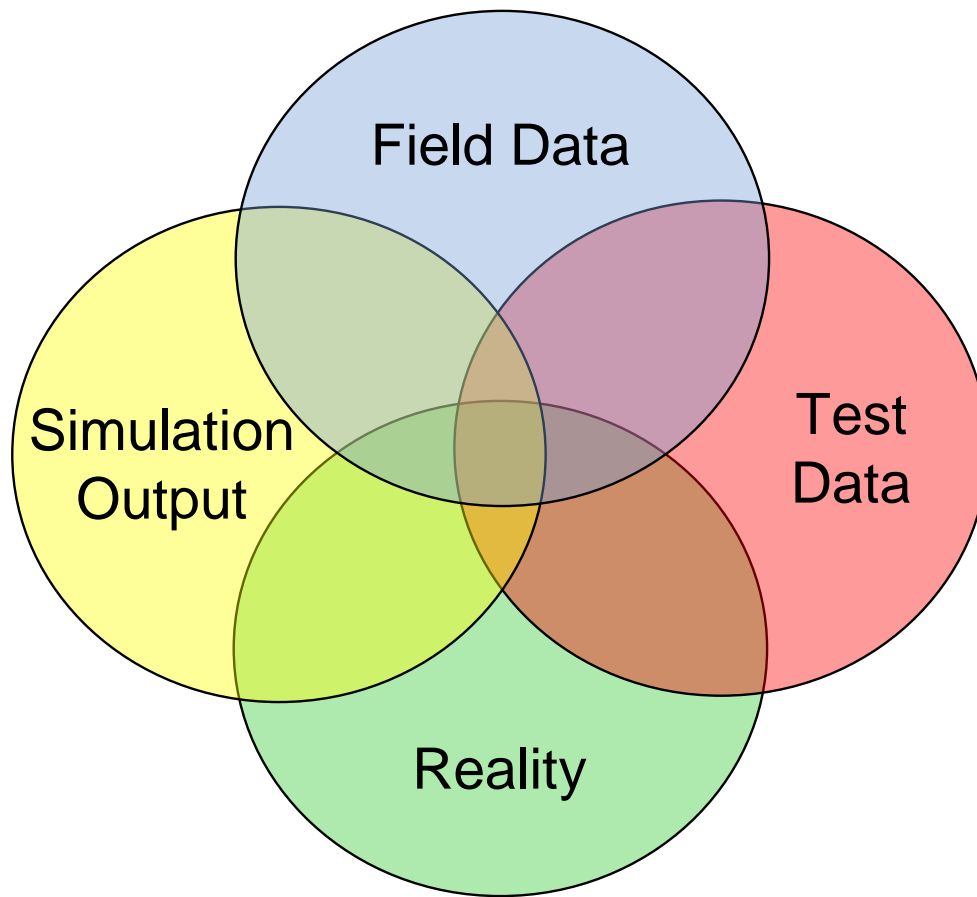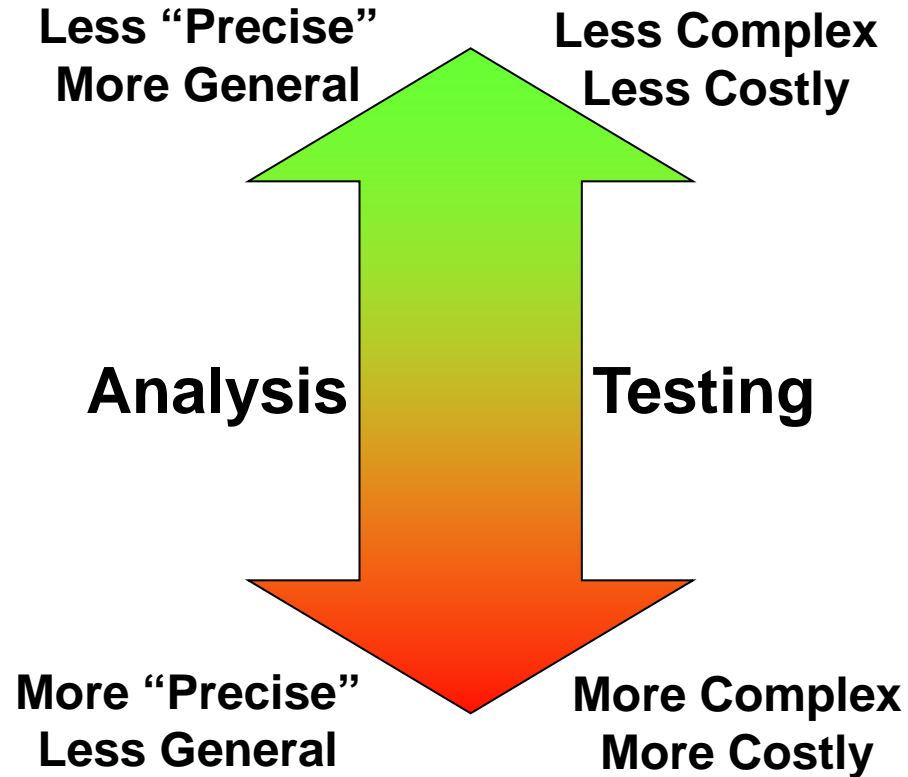
#1:

$$E = mc^2$$

#2:

Penetration Depth = Penetrator Length $\sqrt{\text{Penetrator Density / Target Density}}$

Mission-Based T&E and M&S
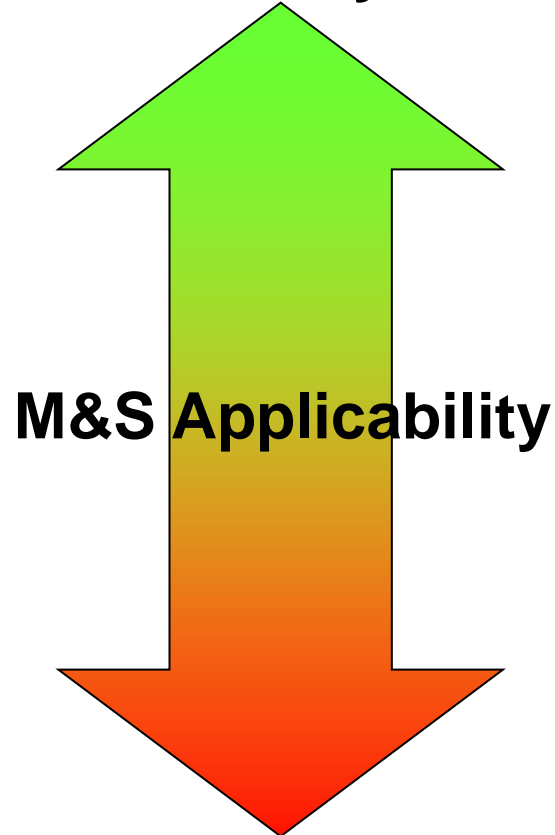
Less "Precise"
More General

Less Complex
Less Costly

Analysis   Testing

More "Precise"
Less General

More Complex
More Costly

Do you want to be precisely incorrect or approximately correct?

More Universally Accurate

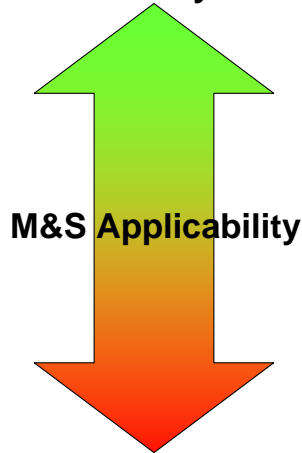**M&S Applicability**

Less Universally Accurate

A President was Elected
(very general, but correct)

Thomas Dewey was
Elected President
(very specific, but incorrect)

The dangers of a very specific model

More Universally Accurate

M&S Applicability

Less Universally Accurate
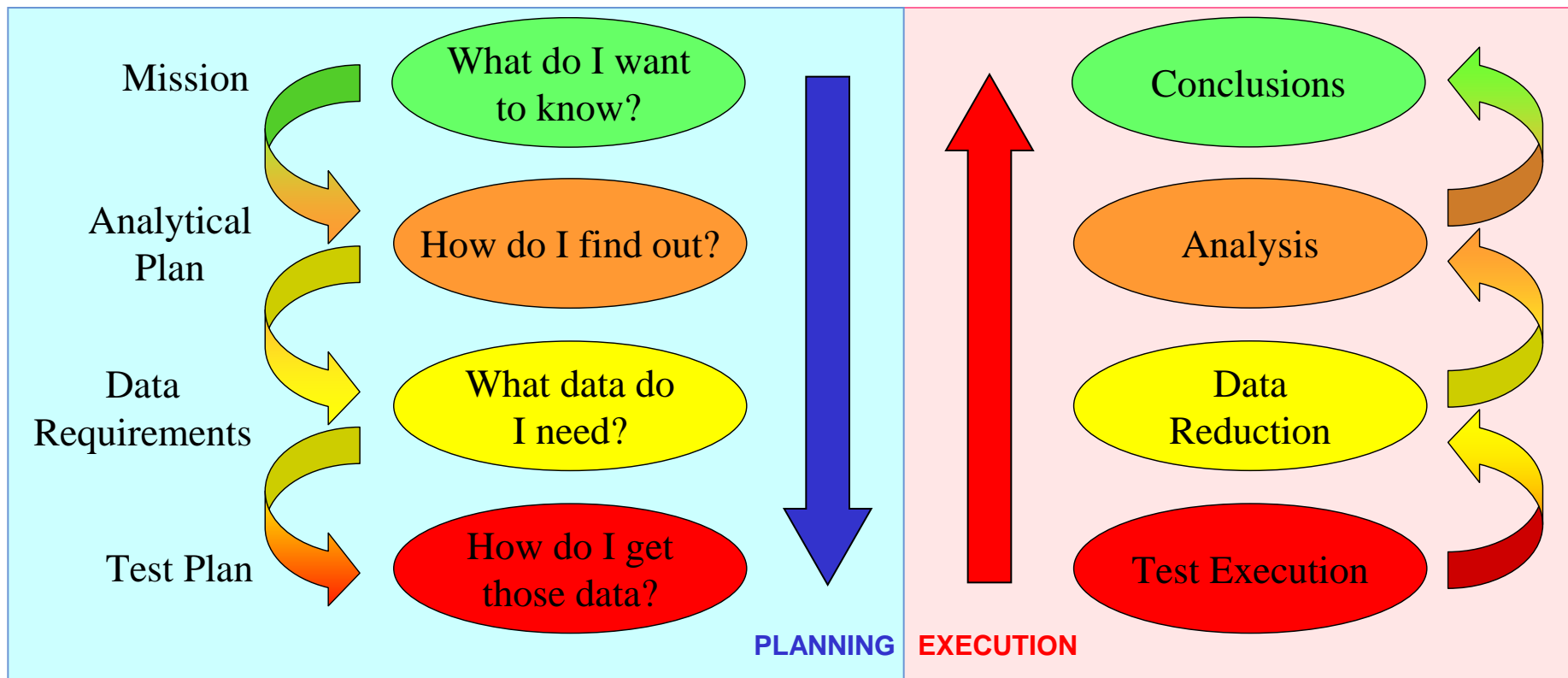
A President was Elected

Thomas Dewey was Elected President

This very precise model does ***not*** explain ***how*** the President was elected. The model of at least part of the process is flawed; everything that follows is probably incorrect, such as ***by how much*** (how many votes).

If the prediction was precisely incorrect because 17 precincts voted the opposite from the assumption, then "tweaking" the model to change the way those 17 precincts vote may or may not to produce "better" results in the next election.

A *Very* Old Concept

PLANNING	EXECUTION

Mission → What do I want to know?

Analytical Plan → How do I find out?

Data Requirements → What data do I need?

Test Plan → How do I get those data?

Conclusions

Analysis

Data Reduction

Test Execution

The analytical plan is based on the mission.
The data requirements are based on the analytical plan.
The test plan is based on the data requirements.

ANY OTHER ORDER FOR THESE EVENTS IS NONSENSE!

Organize the M&S and T&E using the same logic flow.
(I highly recommend MMF.)

Determine the number of levels (intermediate outputs) required.

Align the data collection (instrumentation) with the levels.

Develop the M&S to output the same intermediate levels (values).

$$Don't \begin{Bmatrix} \textbf{test} \\ \textbf{model} \end{Bmatrix} \textit{more detail than you need, and}$$

$$don't \begin{Bmatrix} \textbf{model} \\ \textbf{test} \end{Bmatrix} \textit{more detail than you} \begin{Bmatrix} \textbf{test} \\ \textbf{model} \end{Bmatrix}.$$

Should we always design a $\left\{ \begin{array}{c} \textbf{test} \\ \textbf{model} \end{array} \right\}$ that fits all missions?

(just in case…*Scope, Time, Budget*)

Is it better to be ***precisely incorrect*** or ***approximately correct***?

(The Chicago Tribune is not remembered because of its superbly detailed model for predicting the outcome of a presidential election.)

Are we doing a certain level of M&S because we can, or because we need it to answer the mission (question)?

(How did we get to the moon without finite element codes?)

Two *very* different questions:

1) How well did the model predict the outcome of the test?

2) Was the test outcome a member of the population of possible outcomes predicted by the model?

The first question is mathematically intractable; the second question is the correct one to ask.

Simulation & Modeling

has the same acronym as

Smoke & Mirrors

Or, *no single test event has ever had as its outcome a probability distribution*