LMI

GOVERNMENT CONSULTING

THE OPPORTUNITY TO MAKE A DIFFERENCE HAS NEVER BEEN GREATER

Progress Toward the Development of a Reliability Investment Cost Estimating Relationship

James A. Forbes, PhD, Deceased

E. Andrew Long

October 2008

Overview and Outline

- Background
- Development of model
  - Basic model
  - Intermediate model
  - Production/support cost model
- Summary and conclusions
- Next steps and future work

Work Sponsored by:

- Director of Operational Test and Evaluation
- Deputy Director, Assessments and Support, Systems and Software Engineering
- Deputy Under Secretary of Defense (Logistics and Materiel Readiness)

Although the support of the sponsors is gratefully acknowledged, positions expressed are those of LMI Government Consulting, and not official positions of the sponsors.

Study Objective and Approach

<u>OBJECTIVE</u>: Mathematical model that can be used to ***predict the investment*** in reliability required to achieve a given amount of ***reliability improvement***

<u>APPROACH</u>: Four sub-models developed in three phases

Phase I

Empirical Research

- Investigate empirical relationships between reliability investment and life-cycle support costs

Phase II

A. Basic Model

- Develop investment/ reliability improvement CER

B. Intermediate Model

- Develop model to determine effort and cost of reliability engineering process
- Develop production and support cost model

Phase III

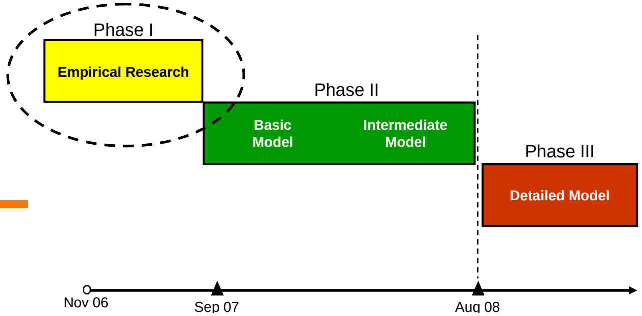
Detailed Model

- Develop model that includes detail on cost drivers and impacts of engineering quality

0

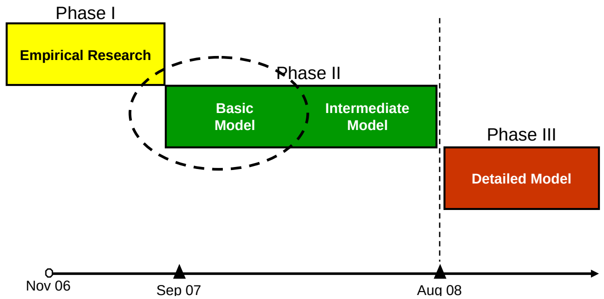
Nov 06 | Sep 07 | Aug 08

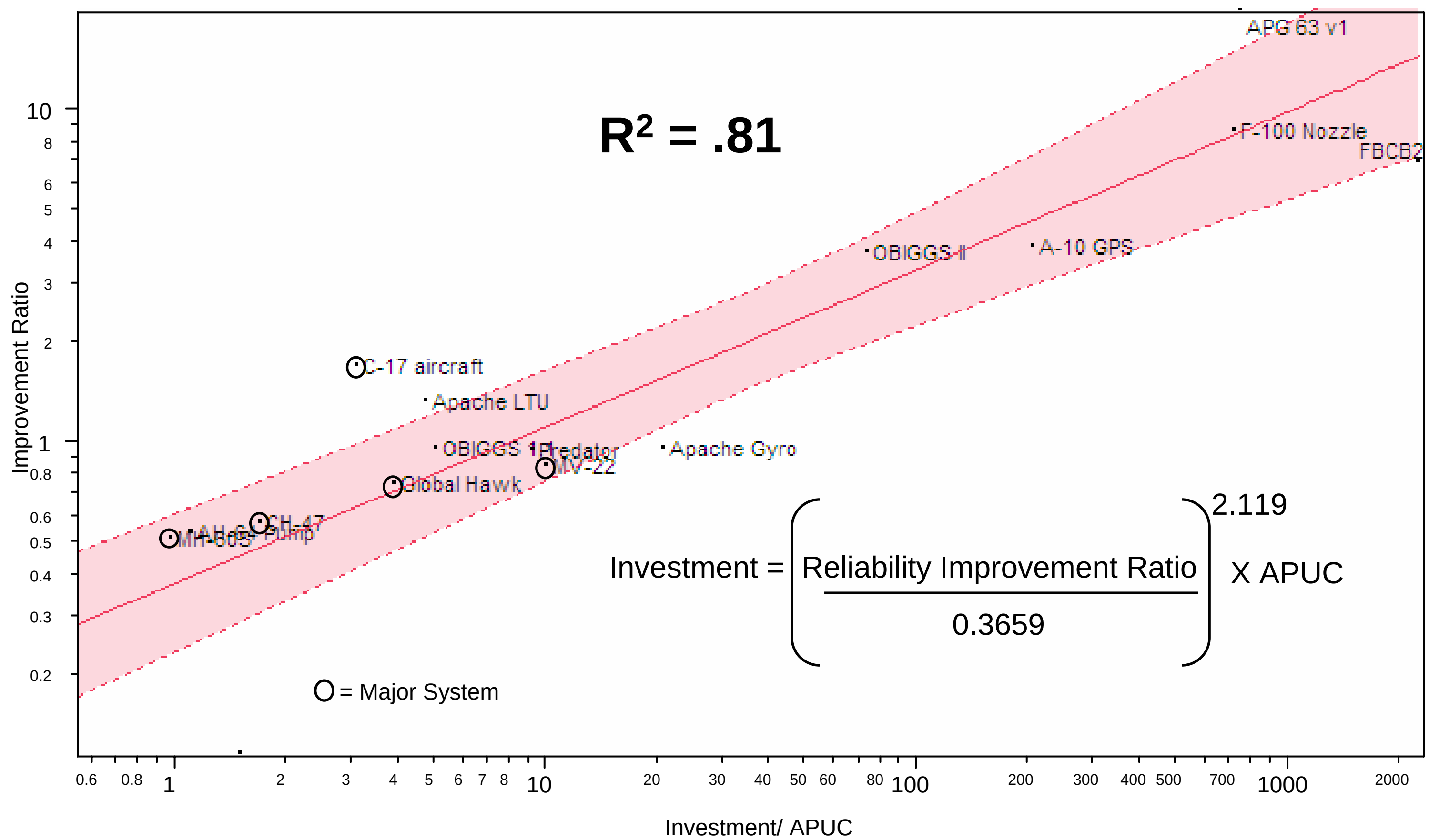
Phase I (Empirical Research)



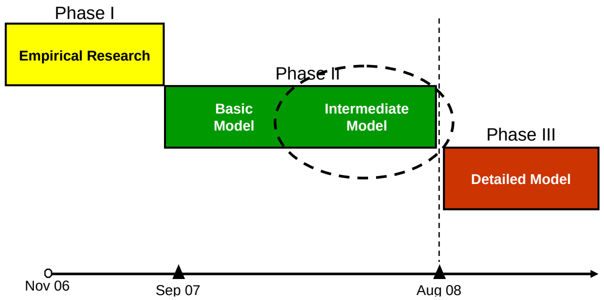
- Developed a preliminary relationship between investment in reliability (normalized by average production unit cost) and achieved reliability improvement
- Also, found that:
  - Generally, programs significantly improved system reliability with investment, though
  - under-investment in reliability may be large
  - Reliability goals, although established and articulated in operational requirements documents, do not appear to be driving either management or engineering effort

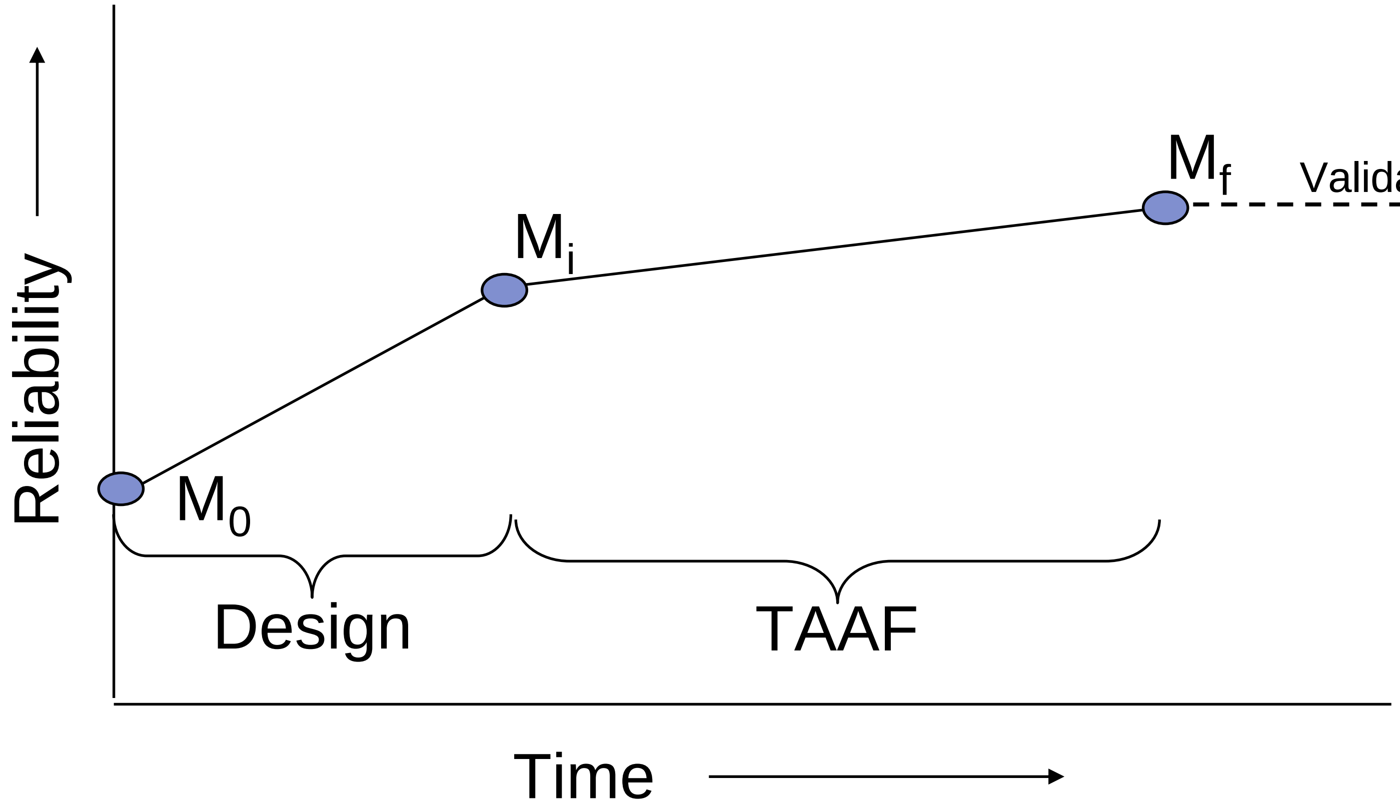
Phase IIA (Basic Model)



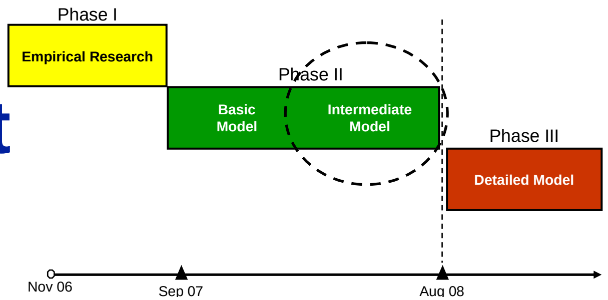


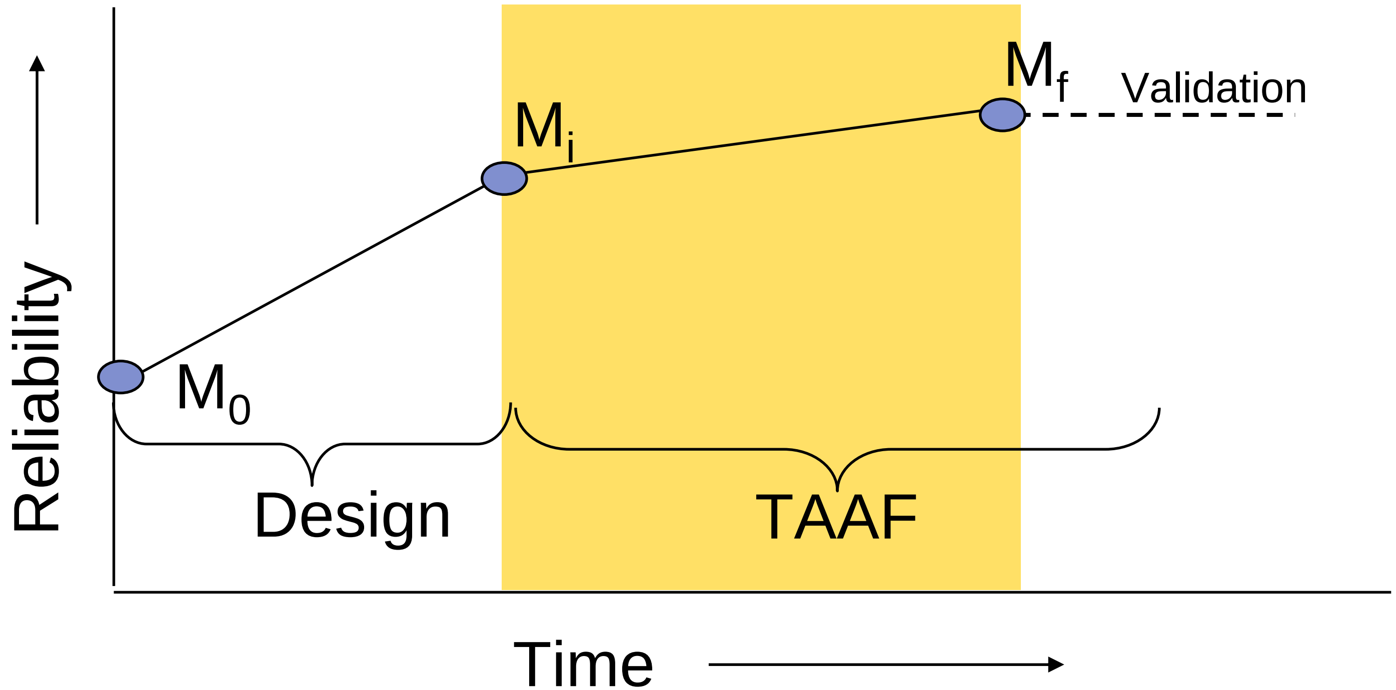
Phase IIB (Intermediate Model)





TAAF Period Equation Development





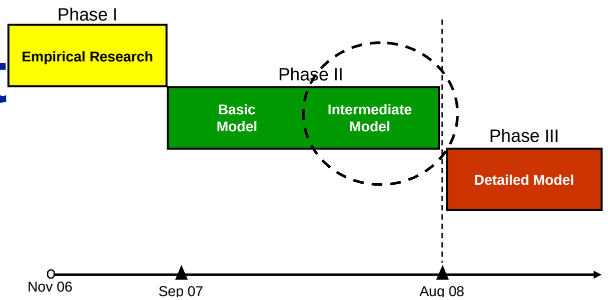
$$\frac{1}{M(\tau)} = \frac{1}{M_A} + \frac{1}{M_i}\left[(1-\mu_d) + \frac{\mu_d}{1+\tau}\right]$$

Based on math that underlies AMSAA's MPM

$$\gamma(\tau) = \frac{1}{cv^2}\left[C_0\tau + \mu_b \ln(1+\tau)\right]$$

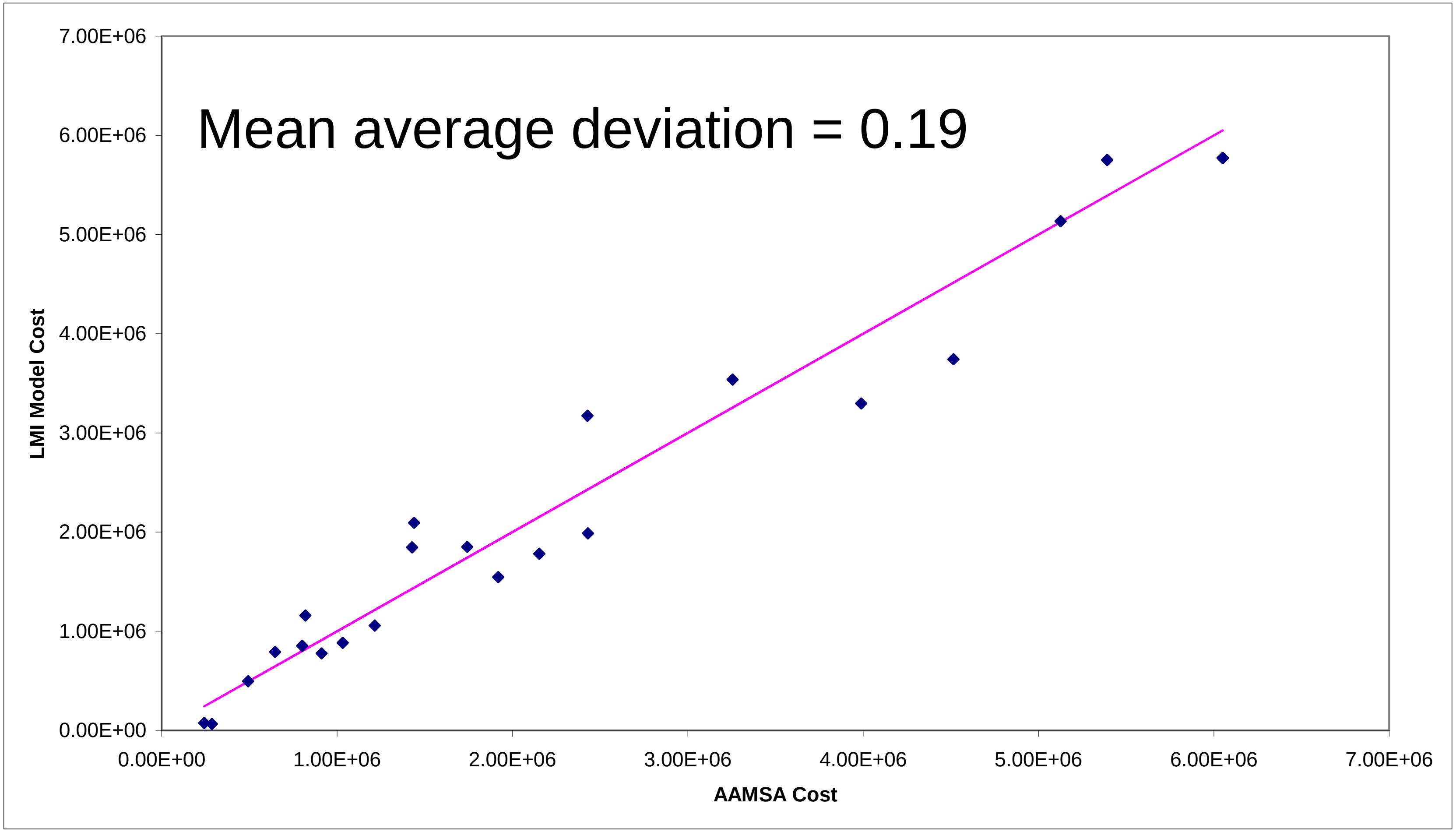
LMI cost extension to AMPM

Comparing LMI Model of TAAF Cost with AMSAA Data



- Using 25 data points from eight platforms, inferred non-dimensional TAAF time τ from the AMPM and M_F/M_I (neglect λ_A) ratio of each data point
- Determined LMI model cost for each τ
  - Calibrated model by adjusting two parameters
- Compared costs estimated by model with AMSAA costs

AMSAA Cost vs. Model Predicted Cost to Achieve a Given Reliability

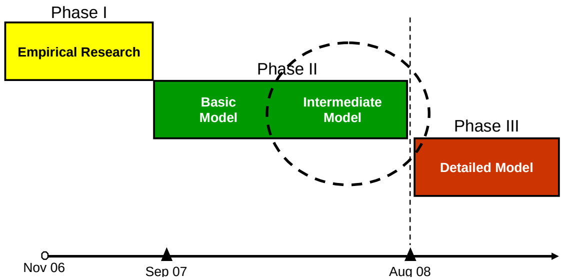


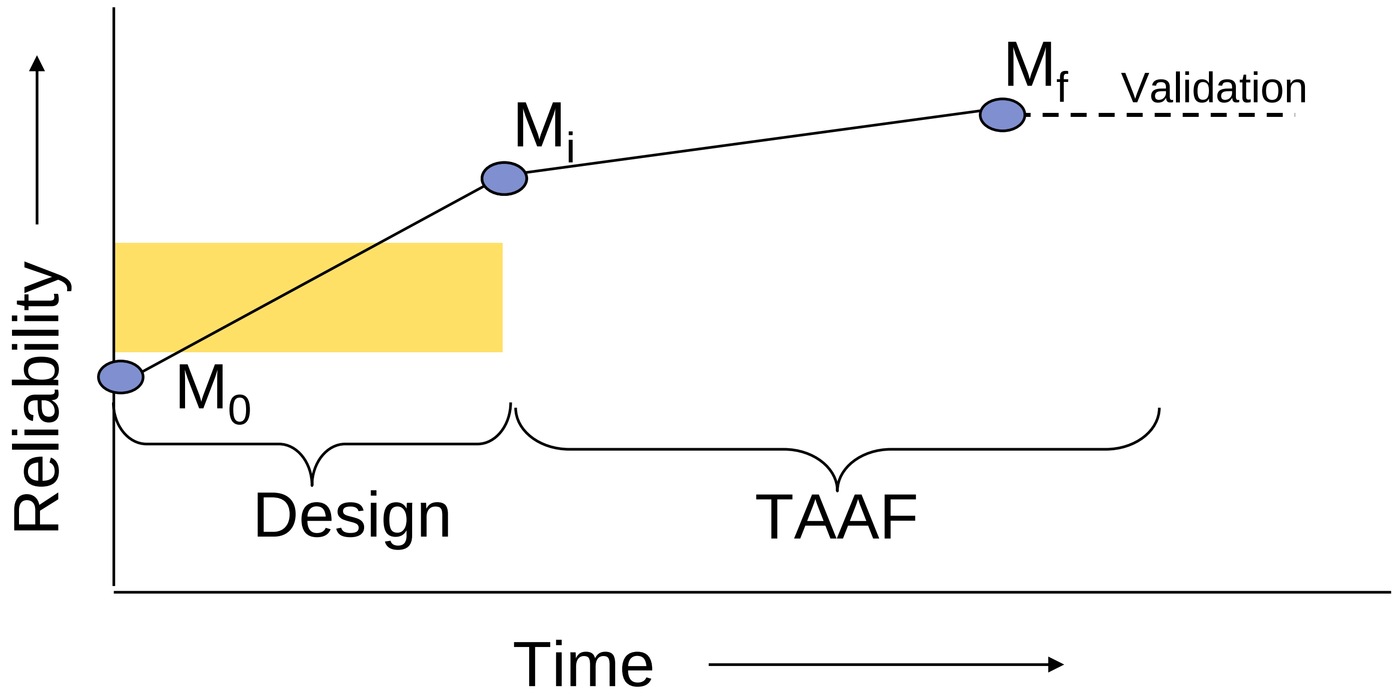
LMI GOVERNMENT CONSULTING

Approach to Design Phase Model

- Adopt A-mode, B-mode scheme from TAAF (and AMSAA) Model
  - Assumes process for identifying and removing B-modes is similar to TAAF
  - Engineering labor applied to PoF, HALT, durability, etc. plays role similar to test operation in TAAF
- Obtain improvement data from programs that implemented or are implementing proactive tasks (assumes will see only limited improvement if proactive tasks not performed)

Design Period Model Equation Development

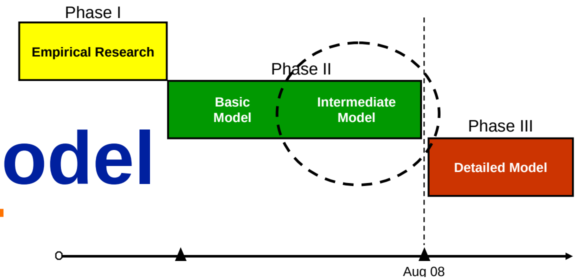


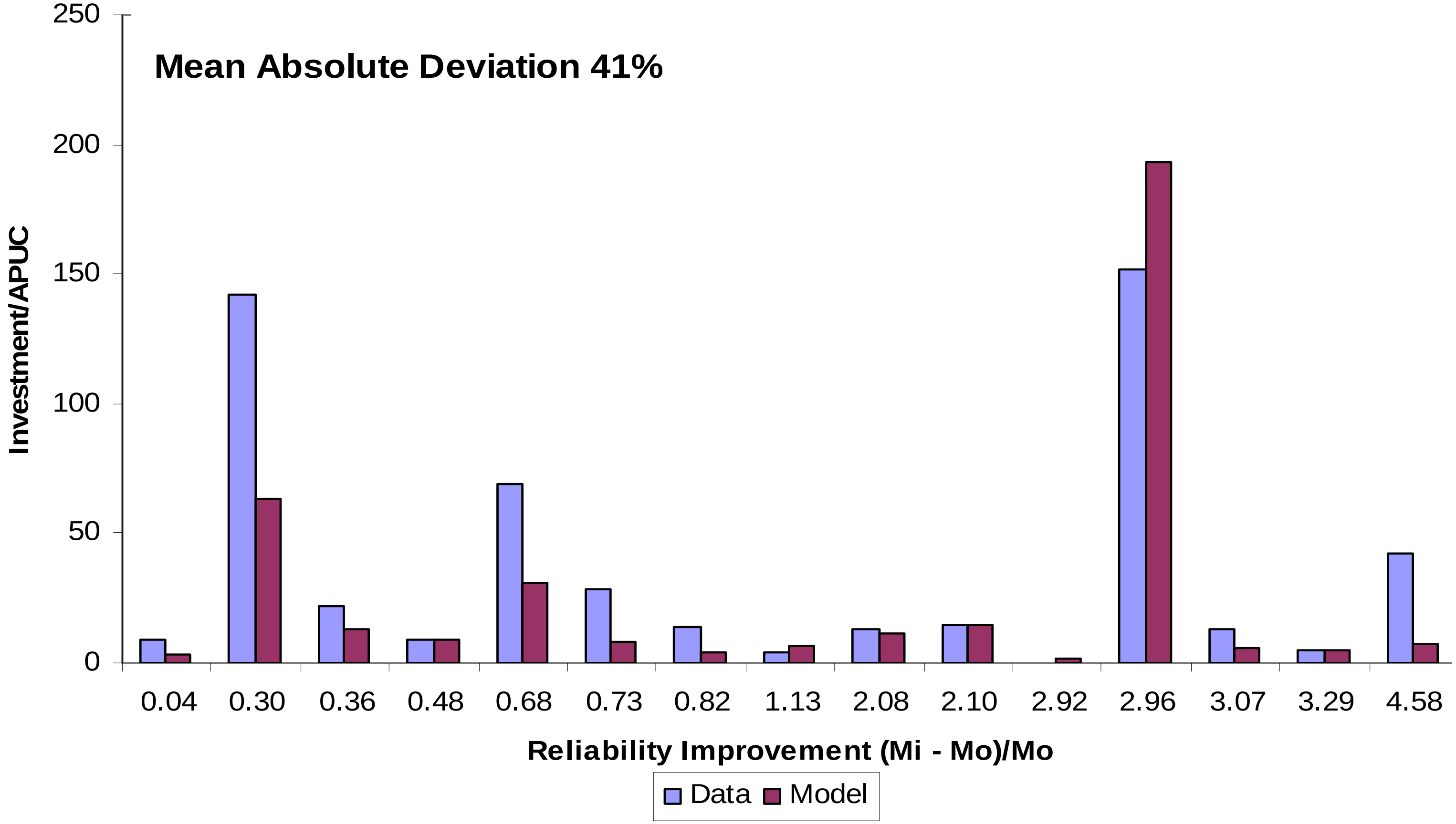


$$\frac{1}{M(\tau)} = \frac{1}{M_A^2} + \frac{1}{M_0}\left[(1 - \mu_D) + \frac{\mu_D}{1+\tau}\right]$$

$$\gamma(\tau) = \frac{1}{cv_D^2}\left[C_0^D \tau + \mu_B^D \ln(1+\tau)\right]$$

Initial Calibration of Design Period Model





13 data for EFV, 1 datum for AIM-9X, 1 datum for MGS Stryker

Used 4 values for “goodness” parameter

Support Cost Model (+)

Simplified UAV Example

Investment (or lack of investment) in reliability improvement

Realized reliability

Platform dependability

Number of platforms required to achieve required system dependability

Per platform support cost

System production cost

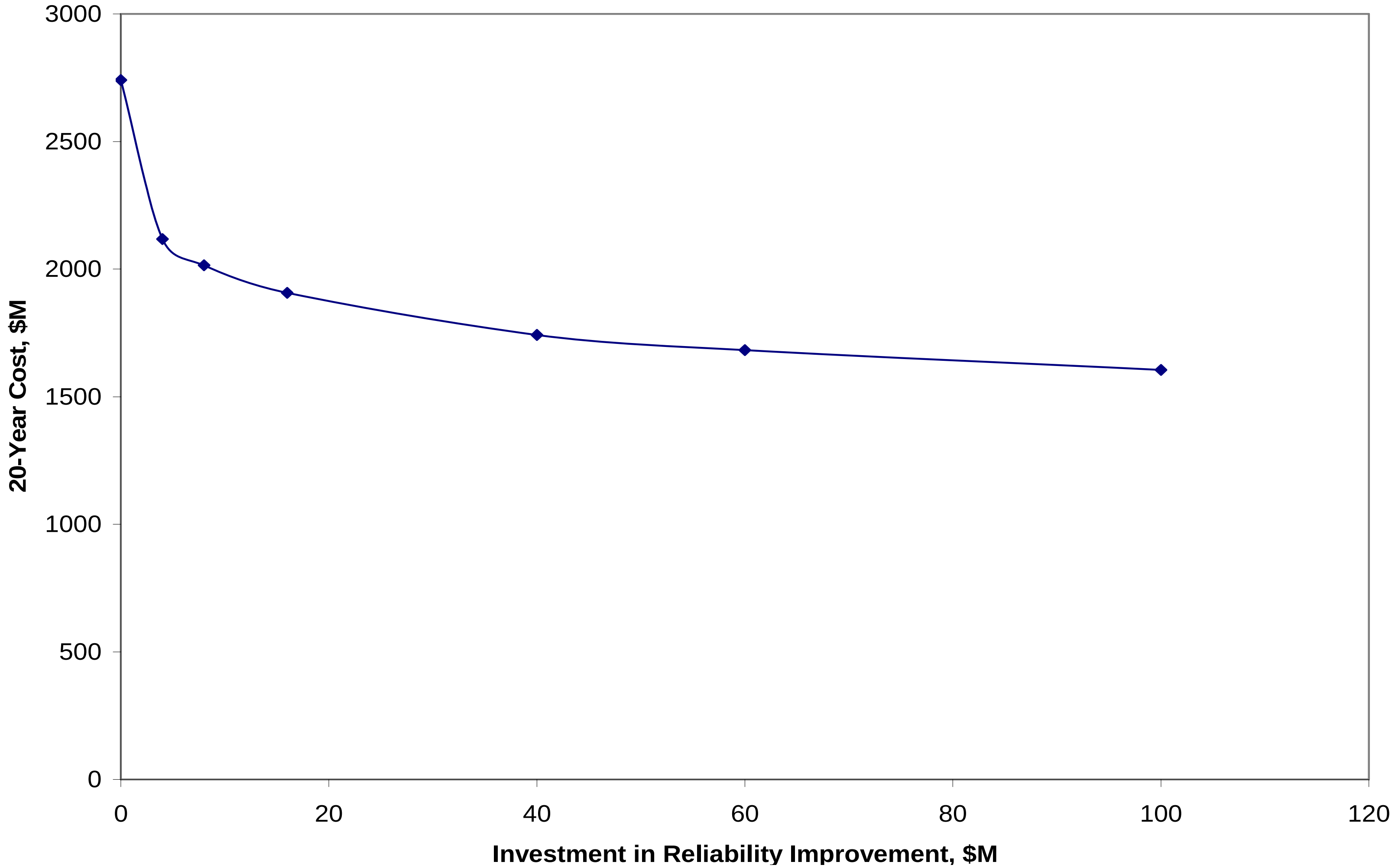
System support cost

$$\text{Platform Dependability} = \frac{\text{Operational time + ready time}}{\text{Operational time + ready time + downtime}}$$

- Assume 20 hour operational + ready time.
- How large does a “flight” of n platforms need to be to assure at least one platform will be operational for 20 hours with a given confidence level?
- Intend to buy 20 flights.

LMI GOVERNMENT CONSULTING

LCC vs. Reliability Investment
Notional UAV Example



Summary and Conclusions

- Reasonably mature basic model, 17 data points, all of which were historical actuals
- Demonstrated that basic A-mode, B-mode premise of AMPM can be extended to cost estimating
  - TAAF period model well behaved, but limited by use of estimates rather than historical actuals
  - Design period model feasibility demonstrated, limited by use of estimates and number of data points
- Coupled basic model to LCC model

Next Steps and Future Work

- Continue adding additional data points to basic model
- In intermediate model
  - Replace TAAF period estimates with historical actuals and add additional platform types
  - For design period: more data points, more platform types, historical actuals
- Begin work on detailed model
- For all models, look for disconfirming evidence. Where do the models not work?