ASSESSMENT OF A BAYESIAN MODEL AND TEST VALIDATION METHOD

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
10 AUG 2009	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Assessment of a Bayesian Model and Test Validation Method	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
Yogita Pia; Michael Kokkolaras; Greg Hulbert; Panos Papalambros; Micheal K. Pozolo; Yan Fu; Ren-Jye Yang; Saeed Barbat	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
University of Michigan US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000 Ford Motor Company	**20152**
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	TACOM/TARDEC
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)
	20152

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

Presented at NDIAs Ground Vehicle Systems Engineering and Technology Symposium (GVSETS), 17 22 August 2009,Troy, Michigan, USA, The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

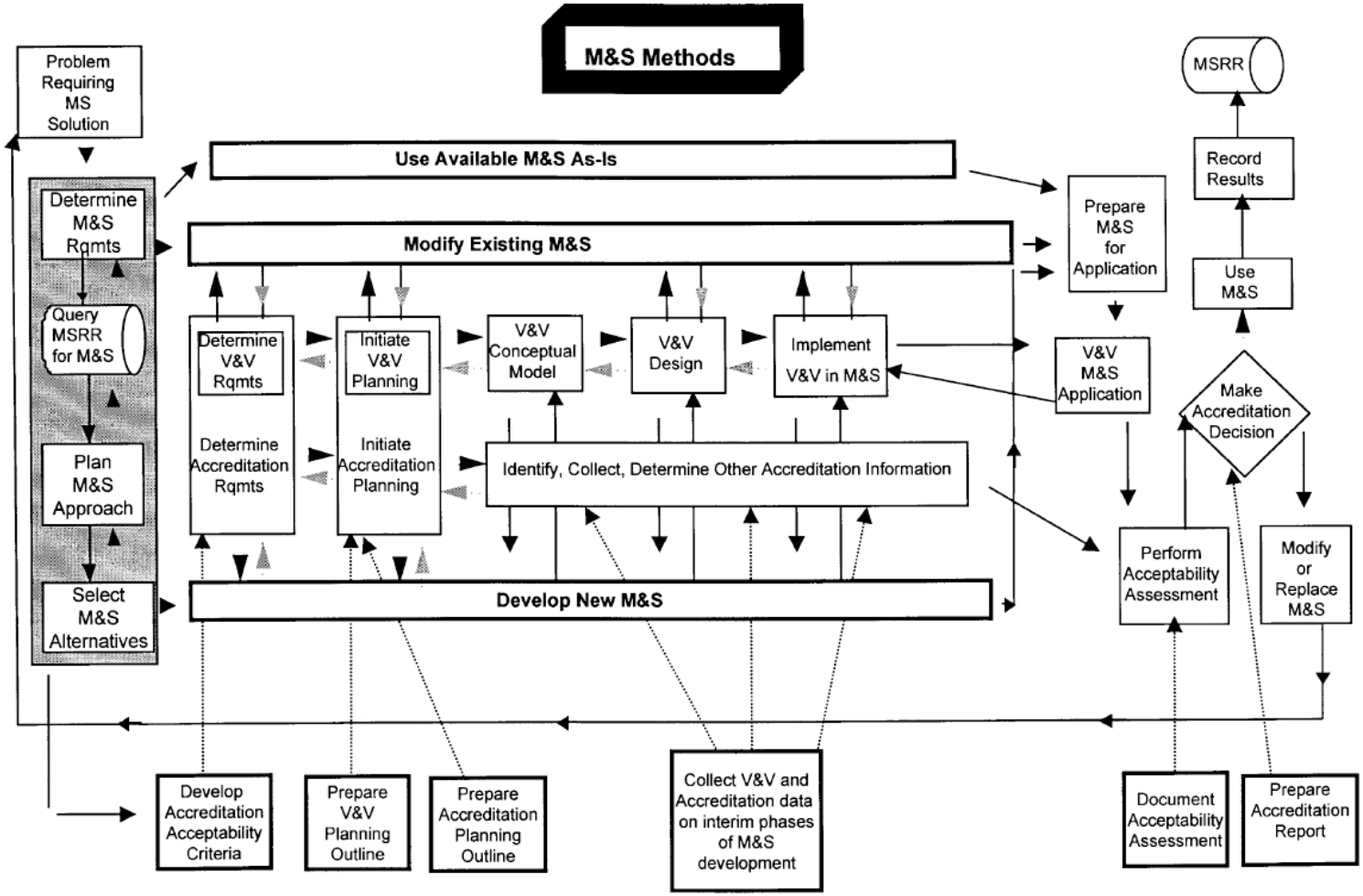
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**16**	

Need for Validation Methodology

MSTV
MODELING AND SIMULATION, TESTING AND VALIDATION

- Systematic method for validation necessary
  - Modeling and Simulation
  - Laboratory test
  - Validation of designs
- Reduce need for Subject Matter Experts
- Reduce number of field tests
- Assess cost of validation and certification
- Use existing data mines of tests, M&S, and designs

VV&A of Army M&S

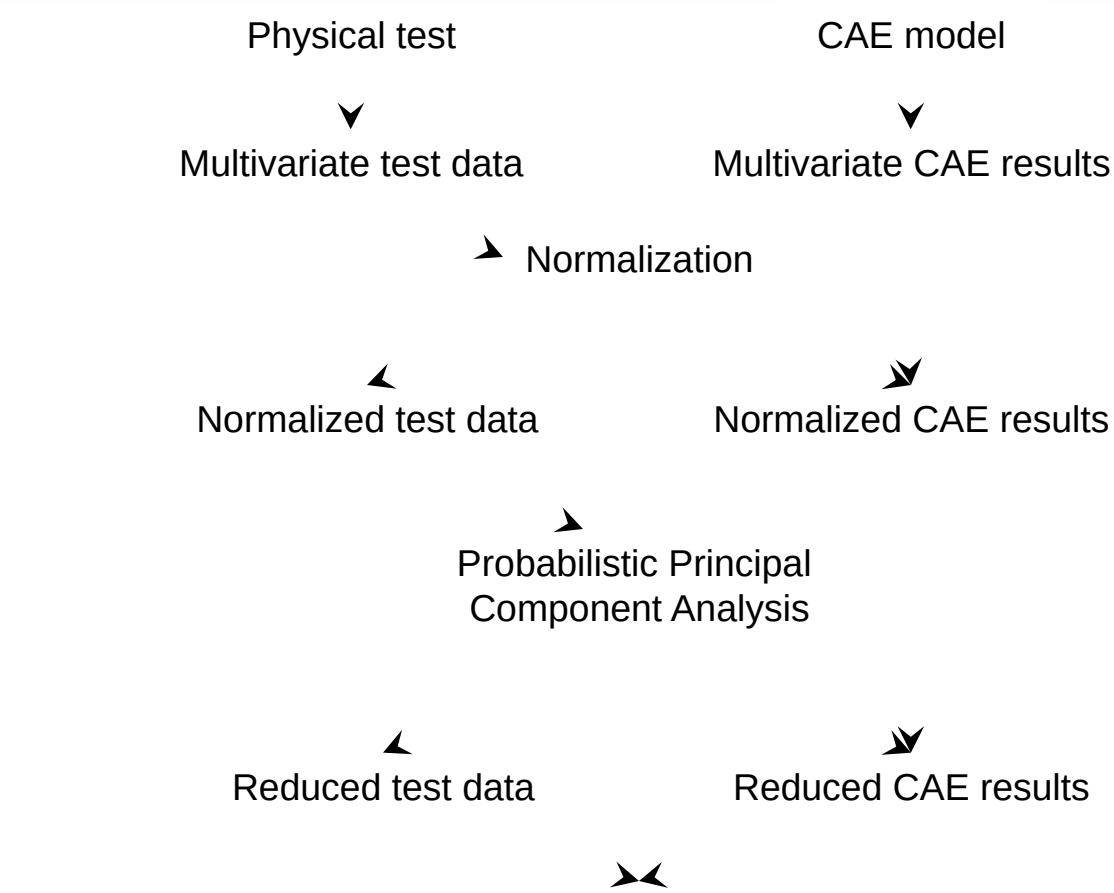


Dept. of Army pamphlet 5-11: *VV&A of Army M&S*

Bayesian Confidence Method

- Model validation under uncertainty
  - Uncertainty in field data
  - Uncertainty in model data
  - Validation of designs
- Multiple, incompatible data channels can be evaluated
- Interval-based method provide more robust evaluation

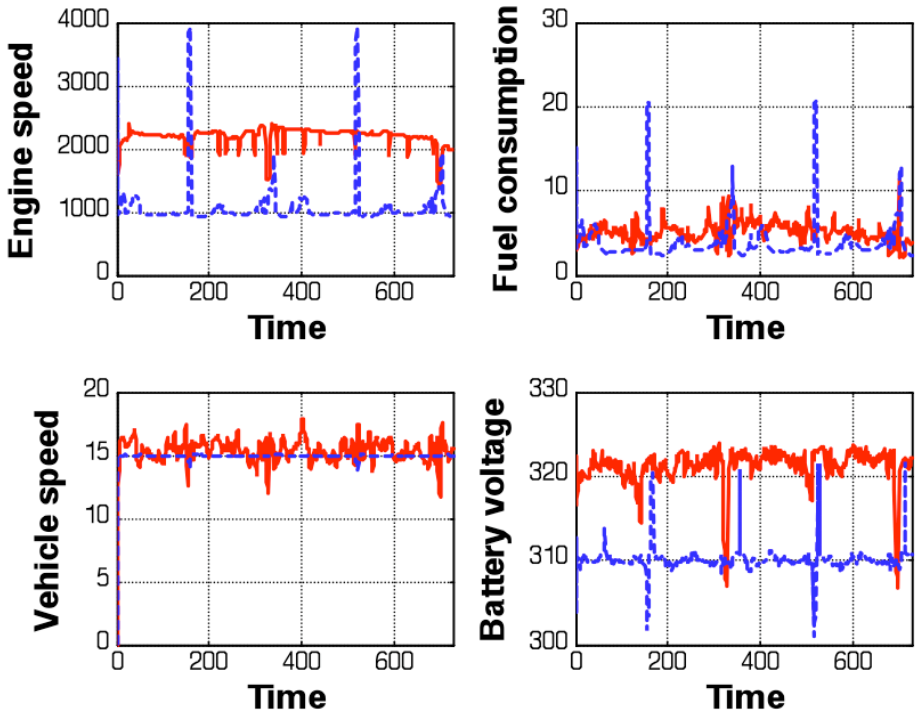
Bayesian Confidence Method



Jiang, Fu, Yang, Barbat, Li, Zhan, SAE 2009 World Congress

Comparison of Model and Test

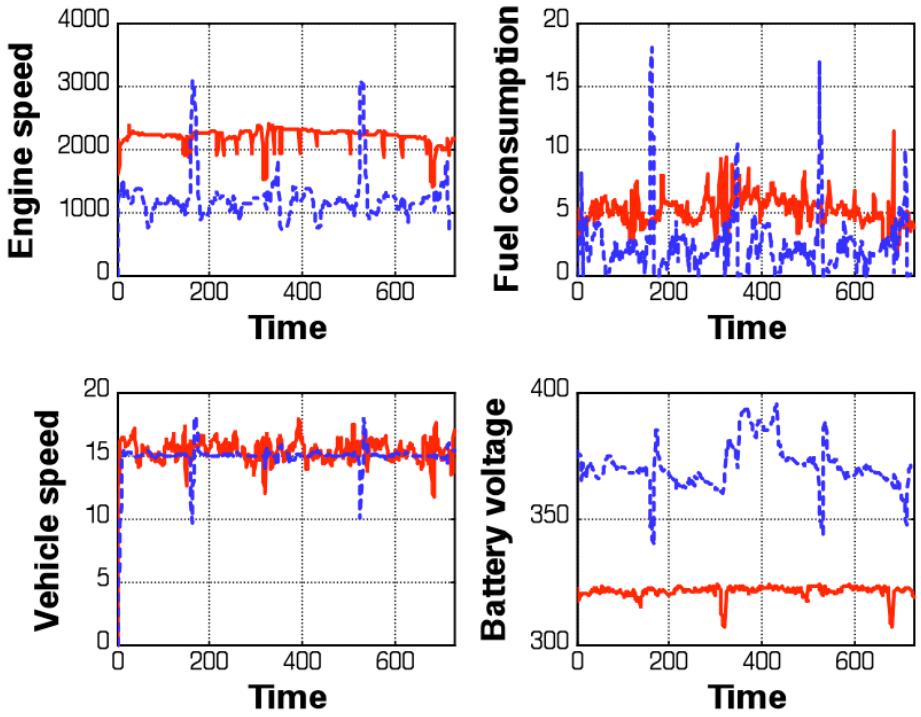
- Model 1, Course 1



Blue = model 1
Red = test

Comparison of Model and Test

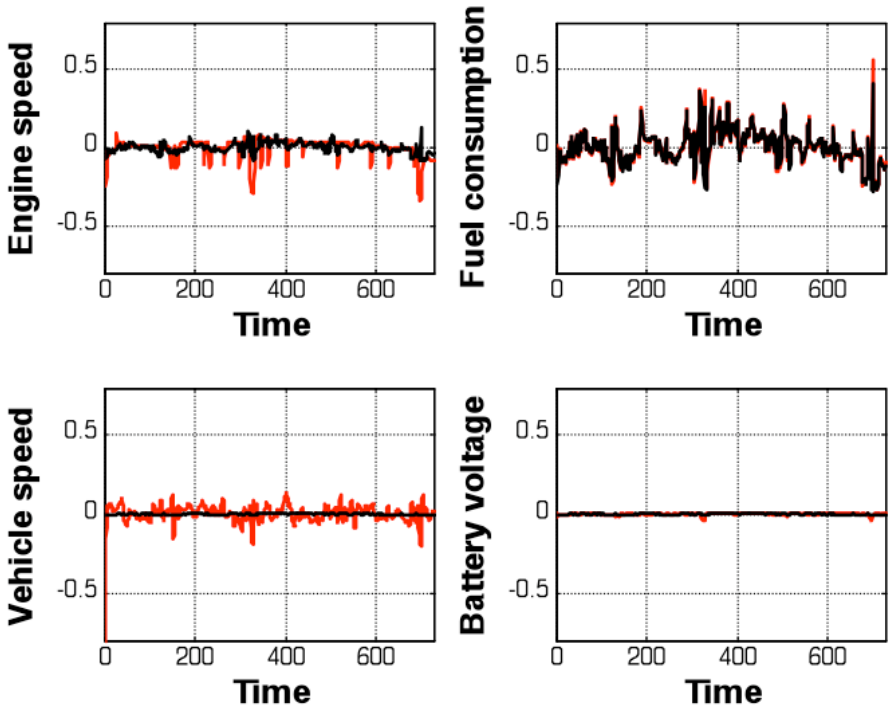
- Model 2, Course 1



Blue = model 2
Red = test

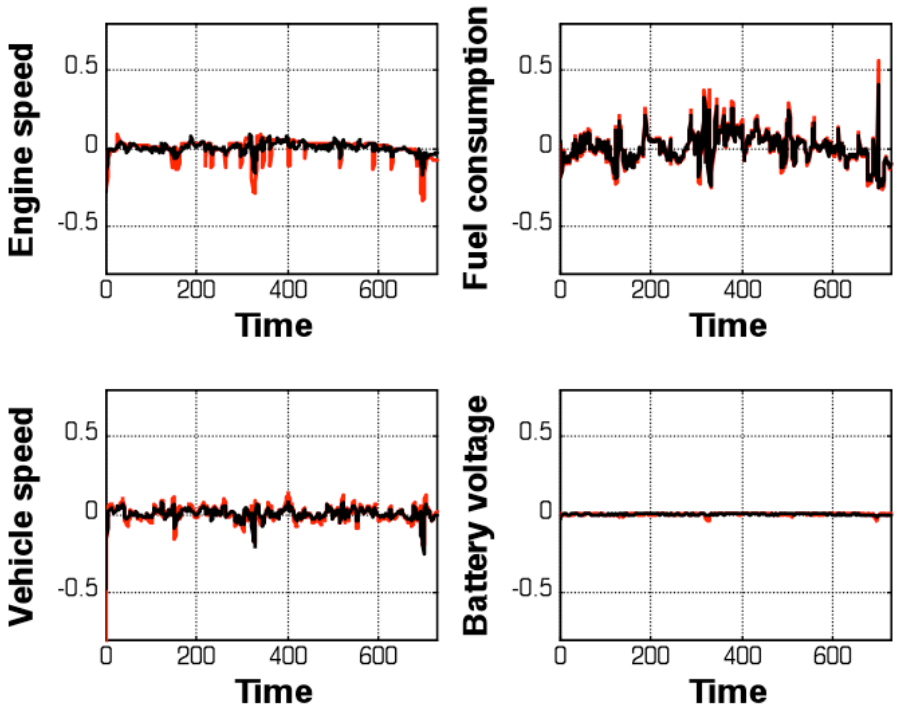
Data Reconstruction

- Course 1
- First principal component, 62% total variability captured



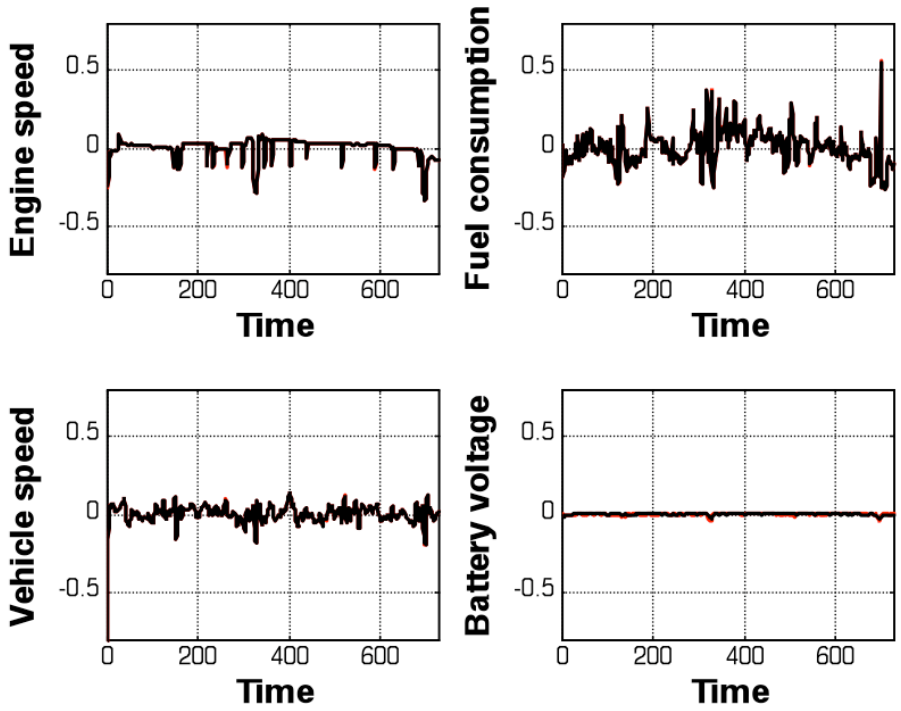
Data Reconstruction

- Course 1
- First 2 principal components, 86% total variability captured



Data Reconstruction

- Course 1
- First 3 principal components, 99.9% total variability captured



Bayesian Hypothesis Testing

MSTV
MODELING AND SIMULATION, TESTING AND VALIDATION

Reduced test data, $\mathbf{x}_t$ with variability Σ_t

Reduced CAE results, $\mathbf{x}_c$ with variability Σ_c

Difference $\mathbf{d} = \mathbf{x}_c - \mathbf{x}_t$

➤ sample statistics: $\bar{\mathbf{d}} = mean(\mathbf{d})$ ➤

$$\boldsymbol{\Sigma} = cov(\mathbf{d}) + \boldsymbol{\Sigma}_t + \boldsymbol{\Sigma}_c$$

˅

Multivariate hypothesis test: Assuming prior $\mathbf{d} \sim N(\boldsymbol{\mu}, \sum)$

H_o:$|\boldsymbol{\mu}| \leq \boldsymbol{\varepsilon}$ (accept) *versus* H_a:$|\boldsymbol{\mu}| > \boldsymbol{\varepsilon}$ (reject)

˅

Bayesian factor calculation

$B_M = P(\mathbf{d}|H_o) / P(\mathbf{d}|H_a)$ (likelihood ratio)

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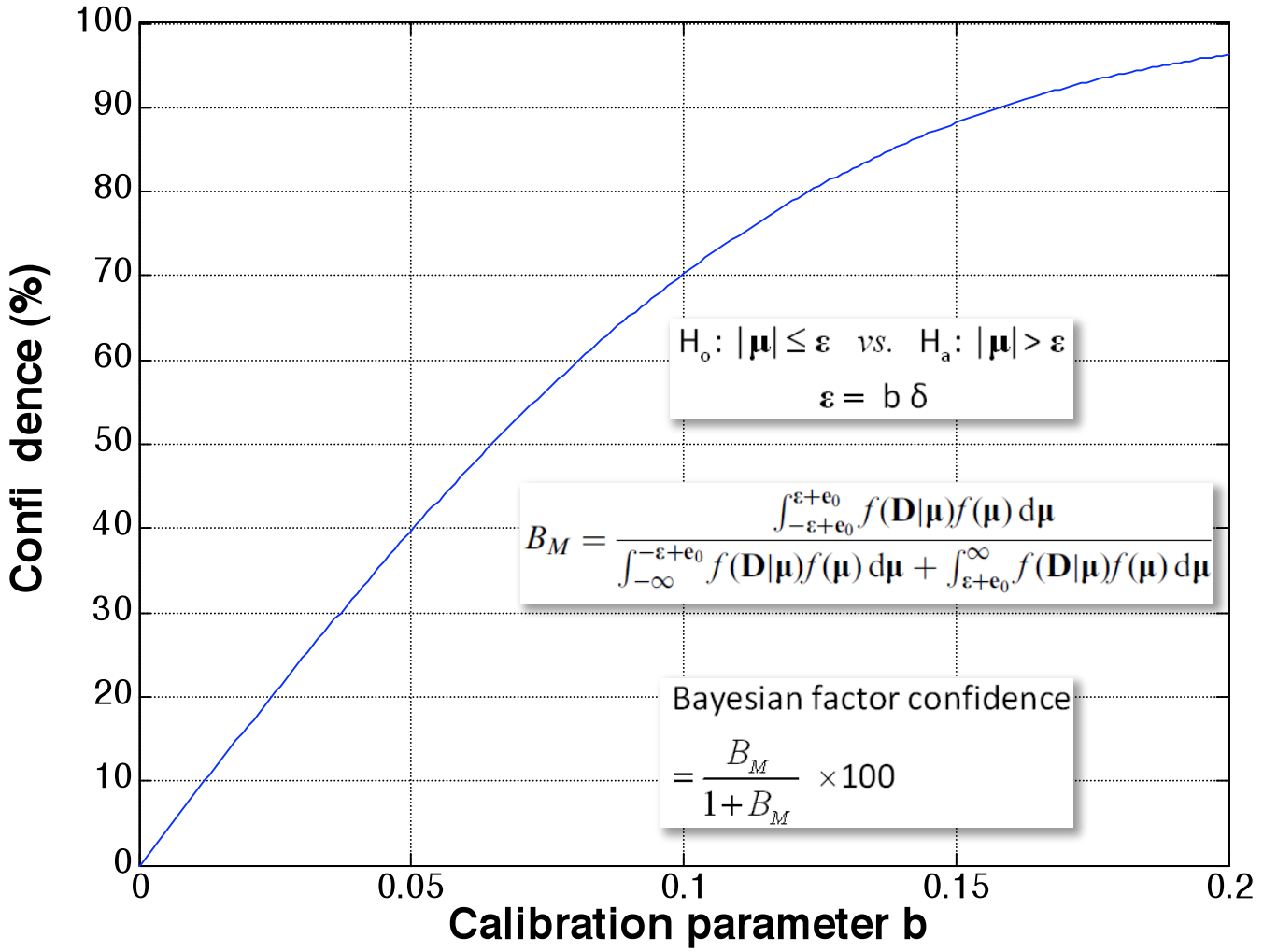
BF confidence quantification

$\kappa = B_M / (1+B_M) \times 100$

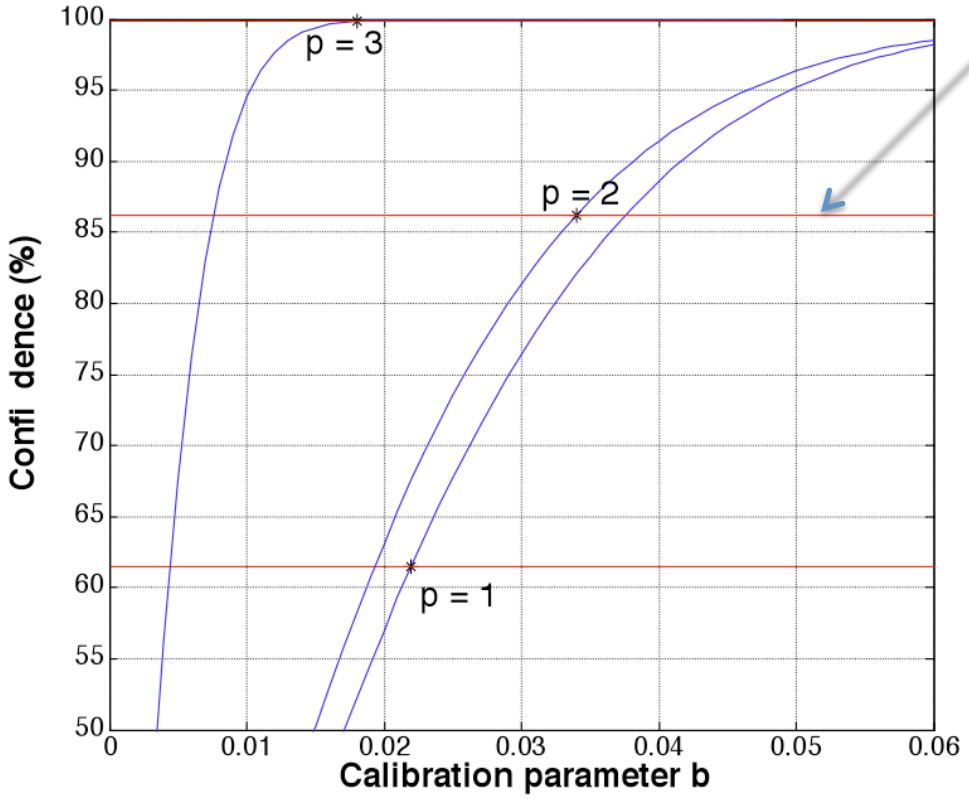
Calibration Parameter Selection



Calibration Parameter Selection

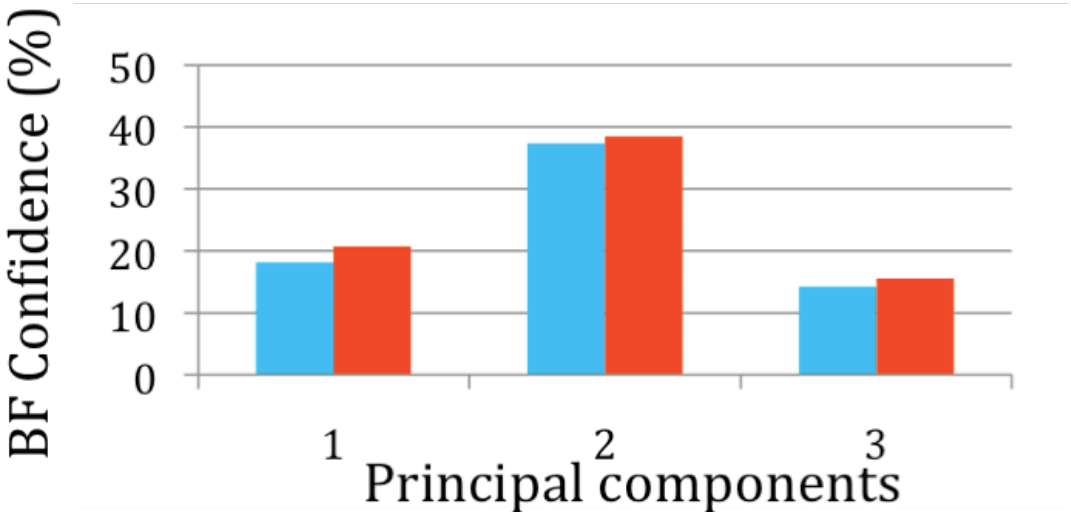
p = # of principal components

% of variability captured



Effect of Principal Components

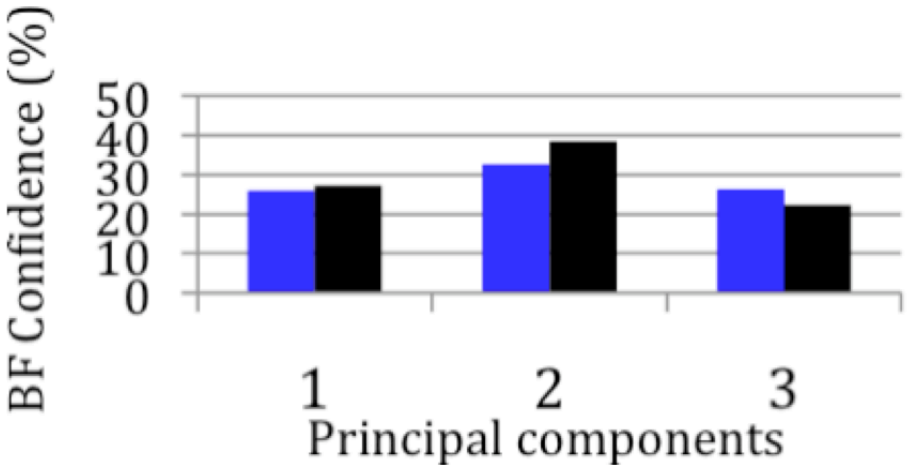
- Course 1



Blue = model 1
Red = model 2

Effect of Principal Components

- Course 2



Blue = model 1
Black = model 2

Closing Remarks

- Bayesian framework promising for validation
  - Incorporates statistics of field data
  - Incorporates statistics of M&S
  - Enables systematic evaluation of data variability
- Systematic method for accepting M&S
- Systematic method for comparing M&S
- Further refinement needed for calibration and sensitivity
- Further research required for accreditation use