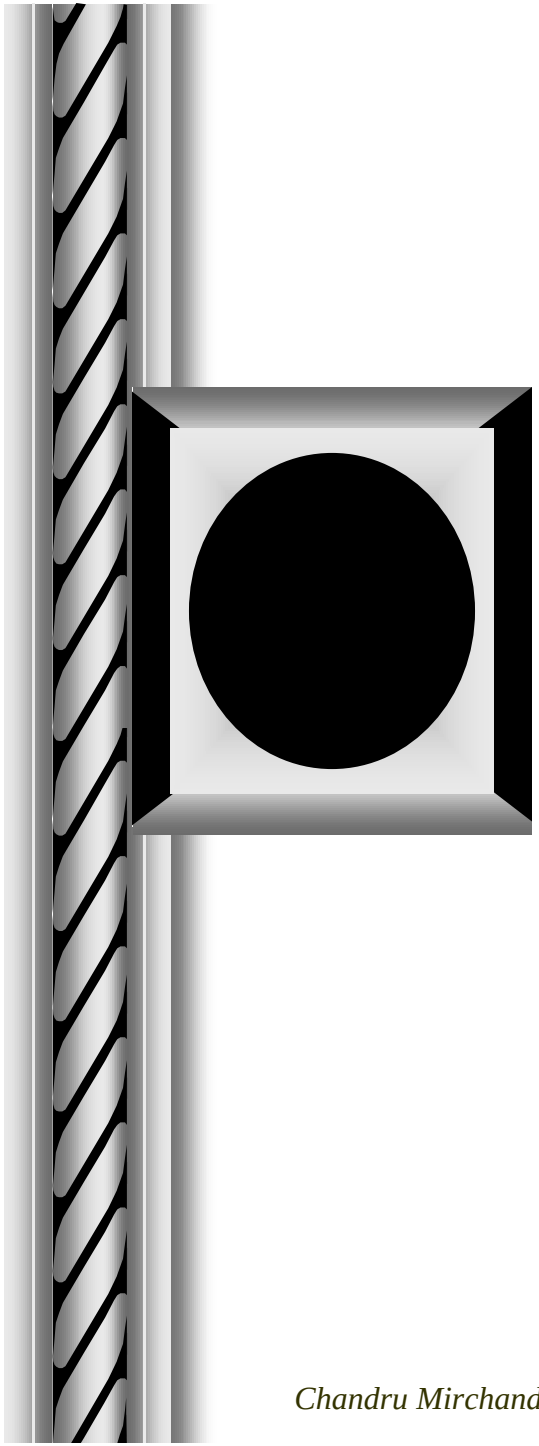

EVALUATING PERFORMANCE FACTORS IN SYSTEM DEVELOPMENT

Chandru Mirchandani
NASA/GSFC - LOCKHEED-MARTIN Code 564

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Agenda

- **Introduction**
- **Methodology**
- **Case Study**
- **Evaluation**
- **Results**
- **Conclusions**

Introduction

- **Prototyping - an integral part of system design**
- **Level of Prototyping is dependent on cost**
- **System Development environments:**
  - **Cost constraint**
  - **Schedule constraint**
  - **Mixed constraints**
- **System Implementation environments:**
  - **Government Research & Development**
  - **Industry Research & Development**
  - **Industry Contractor**

Methodology

- **Develop evaluation criteria to measure the goodness of the design**
- **Quantify these criteria in absolute or relative terms**
- **Select check points to perform these evaluations**
- **Compare these criteria at each check point of the design**
- **Identify the problems based on the evaluations**
- **Re-engineer the design to meet the performance goals**

Performance Measures

- **Functionality: Ability to perform the designed task completely within the time & quality constraints**
- **Flexibility: Ability to meet changing, growing and predicted new requirements**
- **Reliability: Ability to functionally perform the designed tasks to the performance specifications over the system life time**
- **Cost: Ability to meet the cost and scheduling constraints**

Factors of Measurements

Functionality

- **Meet Functional Requirements: Performs the tasks to the extent desired**
- **Meet Performance Requirements: How well it performs the tasks**

Flexibility

- **Testability: Completely testable for all functional and performance need**
- **Re-Engineering: Ease of change to correct, and accommodate changing requirements**
- **Meet New Requirements: Ease of change to enhance and accommodate new requirements**

Factors of Measurement

Reliability

- **Functional Reliability: How much of the objectives are met whether they are repeatable**
- **Performance Reliability: How well these objectives are met and the timeliness over the system lifetime.**

Cost

- **Meet Cost Objective: Meeting the project needs within the funding edicts**
- **Meet Schedule Objective: Conforming to the project needs in a timely manner**
- **Available Skills: Conforming to the available resources in skill, labor, tools and technology**

Functionality Factors

- **Technology: How much can the technology support to implement the task**
- **Complexity: What complexity can the design support to meet the task**
- **State-of-the-Art: How mature is the implementation to meet the requirement**
- **Expertise: How good is the skill/knowledge base to implement a ‘good’ design**
- **Information: How valid and proven is the design implementation**

Model Evaluation

- **Based on the System Objectives, the Performance Measures for each System are evaluated for each task level.**
- **The ranking given in each case for each of the factors within the measure are based on 1 being the highest and 10 being the lowest**
- **The report indicates some methods of evaluating these factors based on the type of design**

Case Studies

- **Background:**
  - **Three different systems are evaluated**
    - **System A - In Operation**
    - **System B - Soon to be in Operation**
    - **System C - Proof of Concept Prototype**
  - **Analysis carried out at same level of design cycle**
  - **Comparisons are carried out at the same functional level with the same constraints**
  - **Only similar functional elements have been compared**
  - **Performance metrics when available have been used**
  - **When metrics were unavailable, the information was qualified with a degree of confidence**
  - **Only the Front-End Systems will be analyzed**

Ranking Definition

Systems were qualitatively ranked as follows:

Ranking	Qualitative Definition of Ranking	C*S
1	Meets the objective completely (critical and system level)	1.0
2	Critical elements are at 100%, and system level are at 90%	0.9
3	Critical elements are at 90%, and system level are at 80%	0.72
4	Critical elements are at 80%, and system level are at 70%	0.56
5	Critical elements are at 70%, and system level are at 60%	0.42
6	Critical elements are at 60%, and system level are at 50%	0.3
7	Critical elements are at 50%, and system level are at 40%	0.2
8	Critical elements are at 40%, and system level are at 30%	0.12
9	Critical elements are at 30%, and system level are at 20%	0.06
10	Critical elements are at 20%, and system level are at 10%	0.02

C*S = Critical Elements met x System Level Met

Ranking 1 is the highest and 10 is the lowest

For Functionality

- **Will the system (element) functionally perform the task it was designed for? That is, will the front-end correctly ingest, correct, account for, and deliver the data to the next subsystem?**

- **Will the system (element) meet the timing and performance constraints? That is not only must it meet the functional requirement but also the performance requirements.**

Systems A, B and C

A	S2	Front-End System	HW synchronizes & corrects data HW monitors data SW maintains quality accounting HW outputs data HW provides interface SW controls data output interface
	S3	FDDI Network	HW provides interface SW implements interface
B	S2	FDDI Network	HW Interface SW Interface
	S3	LZPF Data Capture System	HW synchronizes & corrects data HW monitors data SW maintains quality accounting HW outputs data HW provides interface SW controls data output interface
	S4	FDDI Network	HW Interface SW Interface
C	S1	Frame Sync. System	HW receives the data input HW synchronizes & corrects data HW outputs the data HW maintains quality accounting
	S2	Error Correction System	HW receives the data HW decodes and corrects the data HW outputs the data HW maintains quality accounting

Analyses for Systems A, B & C

- **Performance factors evaluated based on design type, and performance measures scored thereof.**
- **Weighting(wt) for factors derived using pair-wise comparisons (AHP techniques).**
- **The overall score for each system element is sum of the weighted factor ranking values:**

  $score_a = (tech_a.wt_a + comp_a.wt_a + \ldots\ldots\ldots\ldots + info_a.wt_a)$

- **Overall score for Front-End System calculated as simple average of the system element scores**
- **AHP validated by Saaty's Eigen vector method**

Modeled Rankings for Systems A, B, & C

- **From the overall score for each of the factors, the average ranking of the Performance Measure was evaluated as a geometric mean**

	System A	System B	System C
Functionality	**1.62**	**1.85**	**1.54**
Functional Requirements	*1*	*1*	*1*
Performance Requirements	*2.62*	*3.43*	*2.37*
Flexibility	**3.85**	**3.93**	**1.55**
Testability	*3.34*	*4.06*	*1.49*
Re-Engineering & Enhancement	*4.46*	*3.81*	*1.62*
Reliability	**4.09**	**4.17**	**1.48**
Functional Reliability	*4.00*	*3.89*	*1.38*
Performance Reliability	*4.18*	*4.47*	*1.58*
Cost	**2.35**	**1.95**	**1.67**
Cost Objective	*3.11*	*2.23*	*1.30*
Schedule Objective	*2.56*	*2.29*	*1.93*
Resource Budget	*1.63*	*1.46*	*1.85*

Performance Evaluation - System A

Front-End for System A

- **Average Overall Rank for System A Front-End = 3.5**

Function	Element	System	Rank
a) Ingest data correctly	100	100	1.0
b) Synchronize data stream	90	80	3.0
c) Maintain quality statistics	30	20	9.0
d) Transfer data from Ingest to detect/ decode/correct	100	90	2.0
e) CRC Decoding/Detecting	100	100	1.0
f) Reed Solomon Decoding/Detecting	100	100	1.0
g) Reed Solomon Correction	100	100	1.0
h) Deliver data from detect/decode/correct	20	10	10.0
			3.50

* information obtained from reports, interviews, measurements

Performance Evaluation - System B & C

Similarly:

Front-End for System B

- **Average Overall Rank for System B Front-End = 2.49**

Front-End for System C

- **Average Overall Rank for System C Front-End = 2.02**

Measured Rankings for Systems A, B & C

SYSTEM A		SYSTEM B		SYSTEM C	
AVERAGE	3.5	AVERAGE	2.49	AVERAGE	2.02
$func_A$	4	$func_B$	4	$func_C$	8
$flex_A$	3	$flex_B$	4	$flex_C$	6
rel_A	8	rel_B	8	rel_C	3
cs_A	1	cs_B	3	cs_C	2
FRONT-END	SCORE	FRONT-END	SCORE	FRONT-END	SCORE
Functionality	4.47	Functionality	2.25	Functionality	3.92
Flexibility	3.35	Flexibility	2.25	Flexibility	2.94
Reliability	8.95	Reliability	4.50	Reliability	1.47
Cost/Schedule	1.12	Cost/Schedule	1.69	Cost/Schedule	0.98

Note: $Functionality_A = func_A$. $Overall\ Rank_A$ / $4\sqrt{func_A.flex_A.rel_A.cs_A}$
= 4.47

Results

Comparisons for A, B & Front-End Systems

- **Modeled values from analyses**
- **Measured values based on information***

Performance Measures	SYSTEM A FRONT-END		SYSTEM B FRONT-END		SYSTEM C FRONT-END	
	Modeled	Measured	Modeled	Measured	Modeled	Measured
Functionality	*1.62*	4.47	*1.85*	2.25	*1.54*	3.92
Flexibility	*3.85*	3.35	*3.93*	2.25	*1.55*	2.94
Reliability	*4.09*	8.95	*4.17*	4.50	*1.48*	1.47
Cost/Schedule	*2.35*	1.12	*1.95*	1.69	*1.67*	0.98

* obtained from reports, interviews, measurements

Analysis of Results

Assumptions

- **Mixed System Model - System A**
- **Distributed System Model - System B**
- **Single Element Model - System C**

- **Performance Measures pairwise compared to determine relative priorities for each**

System A		System B		System C	
Functionality	4	Functionality	4	Functionality	8
Flexibility	3	Flexibility	4	Flexibility	6
Reliability	8	Reliability	8	Reliability	3
Cost	1	Cost	3	Cost	2

Relative Priorities for Front-End Systems

System A

	Functionality	Flexibility	Reliability	Cost/Schedule	R.P.
Functionality	1	1.33	0.5	4	0.24
Flexibility	0.75	1	0.38	3	0.188
Reliability	2	2.67	1	8	0.5
Cost/Schedule	0.25	0.33	0.13	1	0.063

System B

	Functionality	Flexibility	Reliability	Schedule/Cost	R.P.
Functionality	1	1	0.5	1.33	0.21
Flexibility	1	1	0.5	1.33	0.21
Reliability	2	2	1	2.67	0.422
Schedule/Cost	0.75	0.75	0.38	1	0.138

System C

	Functionality	Flexibility	Reliability	Cost	R.P.
Functionality	1	1.33	2.67	4	0.421
Flexibility	0.75	1	2.00	3	0.316
Reliability	0.375	0.50	1	1.5	0.158
Cost	0.25	0.33	0.67	1	0.105

Risk Score Calculation

- **Each Front-End System has a Risk Score given by:**
  - **(Relative Priority of the Performance Measure) x (Average Ranking of the Performance Measure)**
  - **e.g. System A Reliability = 0.5 x 4.09 = 2.045**

- **To lower this value, reduce the high valued system element score:**
  - **Reduce element ‘d’ since it has the highest average ranking: $\sqrt{FU \cdot PE} = \sqrt{6.94 \times 7.89} = 7.4$**
  - **Thus the highest risk score = 0.5 x 7.4 = 3.7**

Model Validation

- **To reduce the Risk Score for System A**
  - **Reduce ranking in the high valued Reliability factors**
  - **Technology through the increased validation of new modules**
  - **Expertise through training, in the absence of choice, increased verification at the elemental level**
  - **Information through rigorous in-house bench-marking and validation**
  - **Complexity through prototyping at the sub-task levels**

Conclusions

- **In all three systems Functionality digresses most from the modeled value**
  - **Dependent on technology, complexity and SOA, where the greatest contributing factor is prototyping**
  - **Validated on interviews with the technical personnel involved in testing**
- **Common trend in all three systems, with the exception of Flexibility in System C**
  - **System C proof of concept system and requirements were not changed to accommodate capabilities, and the cause was inadequate information which could have been overcome with prototyping**

Conclusions

- **The exception in the trend for Reliability for System C**
  - **Prototyping paradigm was used to a greater extent and hence the almost equal scores**
  - **Since it was a prototype system, the test phase was not unduly stressed**