Honourcode, Inc.

Value of Systems Engineering

NDIA SE Conference

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- *Honourcode, Inc.*
- *DASI (Univ of South Australia)*

University of South Australia

Defence and Systems Institute

Heuristic Claim of SE

- **Better systems engineering leads to**
  - **Better system quality/value**
  - **Lower cost**
  - **Shorter schedule**

Traditional Design

SYSTEM DESIGN   DETAIL DESIGN   PRODUCTION INTEGRATION   TEST

"System Thinking" Design

Saved Time/Cost

Risk   *Time*

Risk   *Time*
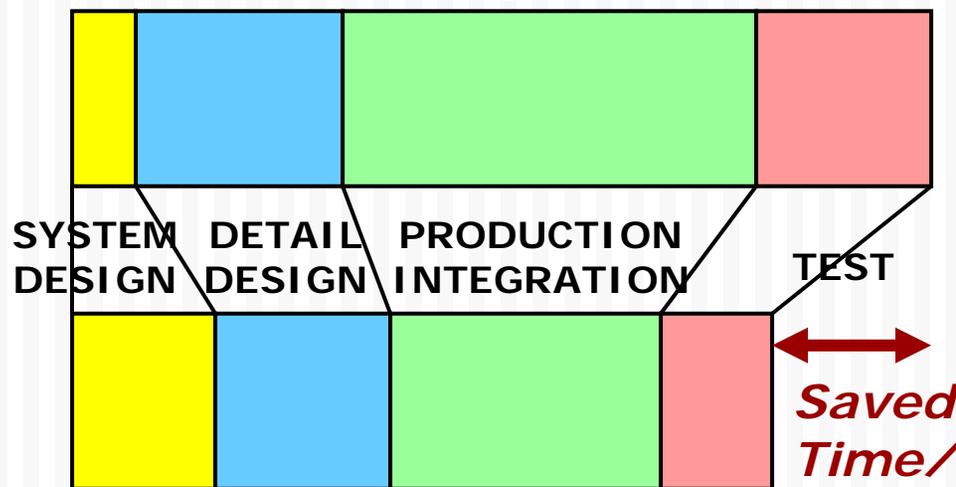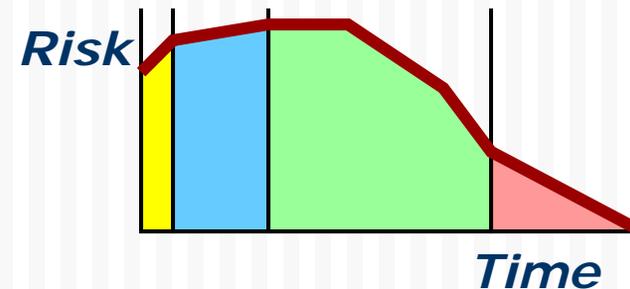
Key Question: How Much Is Enough?

Project History

- **Started working for interviews in 1998**
  - 25 organizations interested, but no one willing to be first – motivation was not strong
  - Developed long-term plan to create motivation
- **Value of Systems Engineering 2000-2004**
  - Survey approach – informal, anonymous
  - Gathered basic data, easy to fill out
  - 2004 results spread widely around world
- **SE Return on Investment 2006-2010**
  - Detailed interviews, common language/concepts
 - Rigorous statistical analysis
  - Strongly reviewed for accuracy

Basic Demographics

| Characteristic	ValueSE Data Set	SE-ROI Data Set
Number of organizations	Unknown	16
Number of data points	44	48
Funding method	Unknown	39 contracted, 9 amortized
Program total cost	$1.1M - $5.6B Median $42.5M	$600K - $1.8B Median $14.4M
Cost compliance	(0.8):1 – (3.0):1 Median (1.2):1	(0.6):1 – (10):1 Median (1.0):1
Development schedule	2.8 mo. – 144 mo. Median 43 mo.	2 mo. – 120 mo. Median 35 mo.
Schedule compliance	(0.8):1 – (4.0):1 Median (1.2):1	(0.3):1 – (2.5):1 Median (1.1):1
Percent of program used in systems engineering effort, by cost	0.1% - 27% Median 5.8%	0.1% - 80% Median 17.4%
Subjective assessment of systems engineering quality (1 poor to 10 world class)	Values of 1 to 10 Median 5	Values of 1 to 10 Median 7

Effect of Characterization Parameters

**Equivalent SE Effort (ESEE) as % Program Cost**

Schedule vs. SE Effort
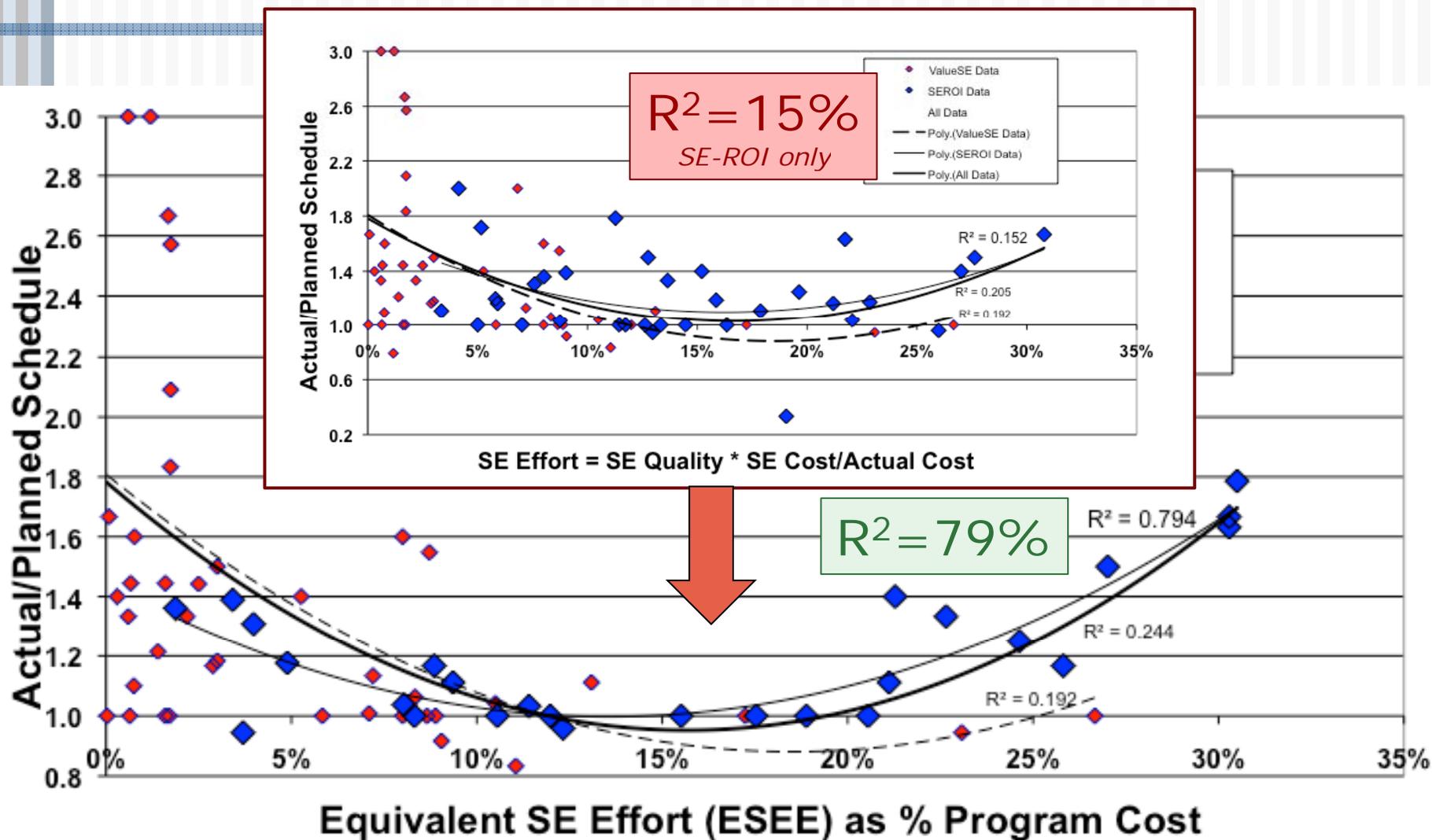
Equivalent SE Effort (ESEE) as % Program Cost
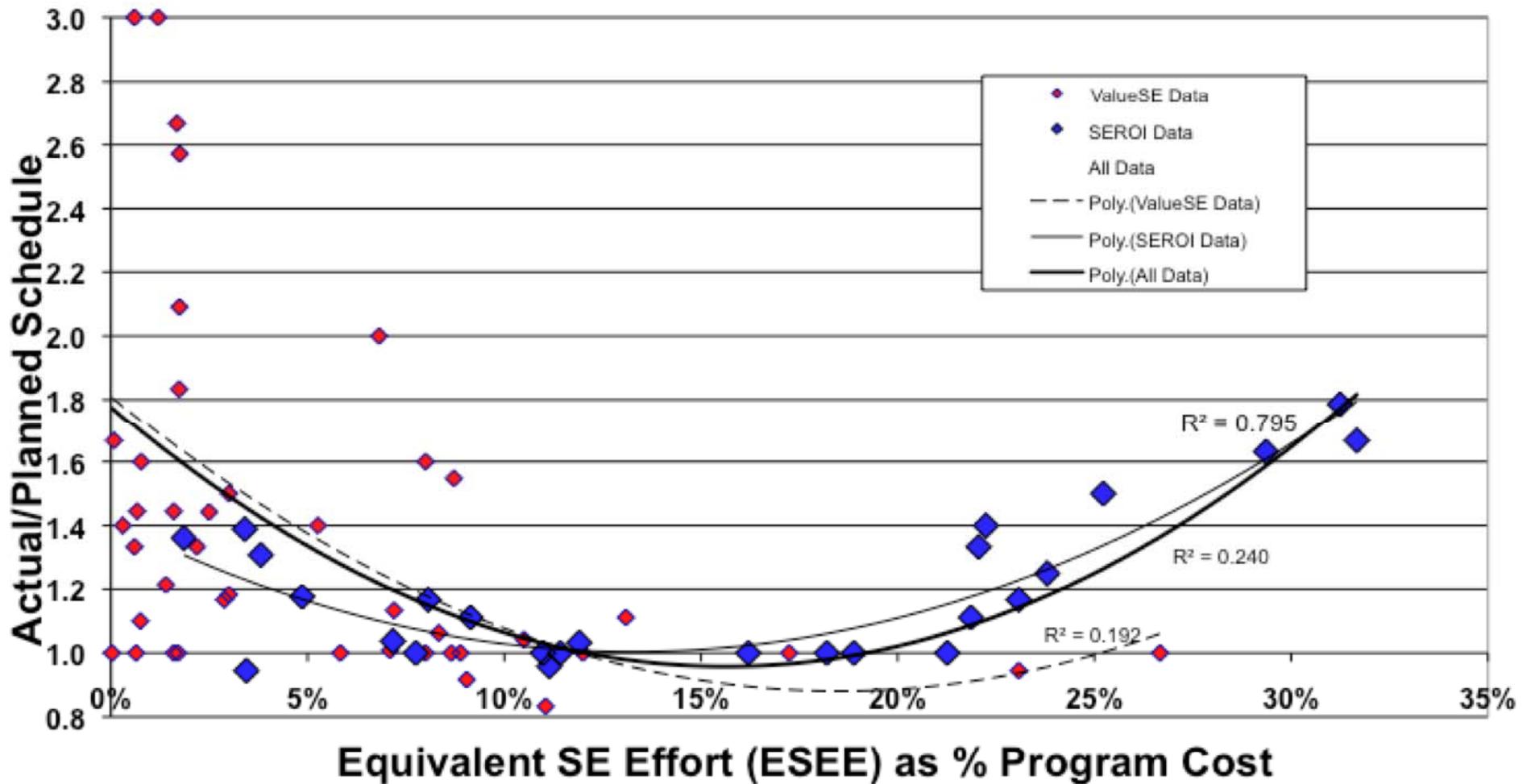
Cost vs. SE Effort

Return on Investment

Cost Ratio and ROI for Median Program

Overrun 53%
ROI 7:1

Overrun 24%
ROI 4.6:1

Overrun 7%
ROI 1.1:1

Overrun 3%
ROI 0
Optimum
SEE=14.4%

Overrun 15%
ROI 3.5:1
Median of
programs

Actual/Planned Cost

Return on Investment

Actual/Planned Cost
ROI

Equivalent SE Effort (ESEE) as % Program Cost
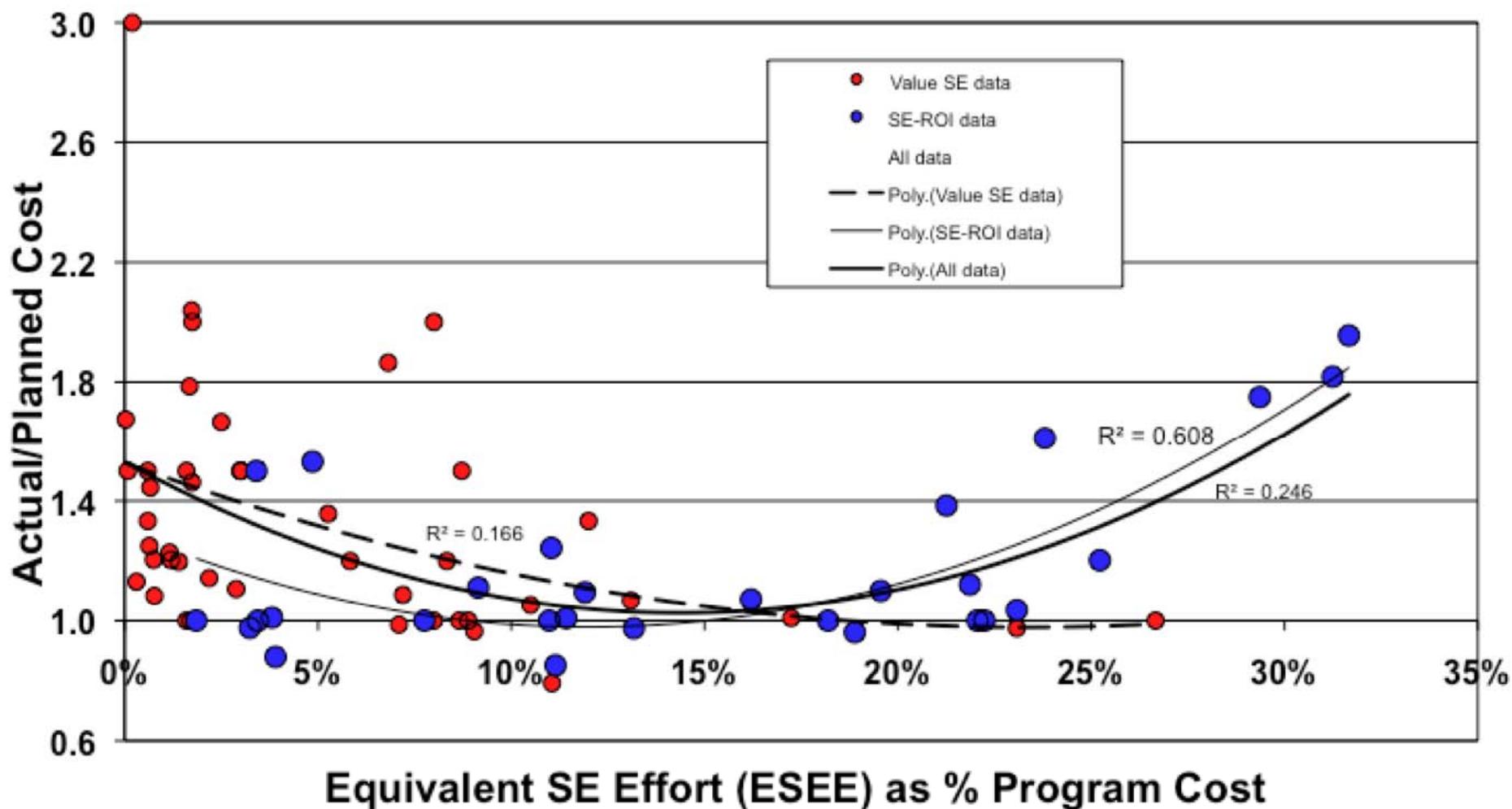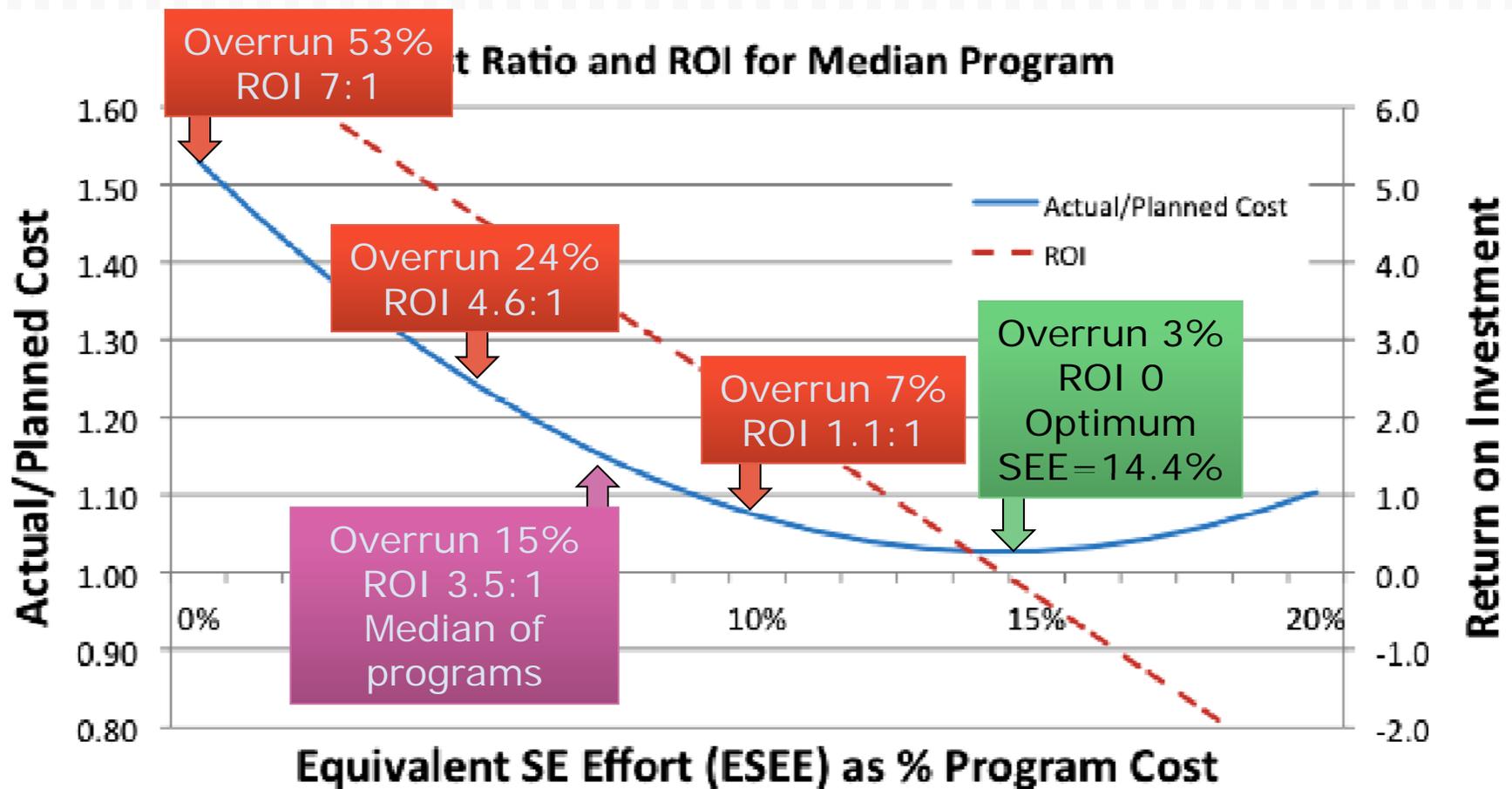
Technical Quality vs. SE Effort

"Technical Quality" is based on compliance with KPP thresholds and goals

2.0 = Met goals

1.0 = Met thresholds

0.0 = Failed to meet

$R^2 = 0.122$

SEROI Data
0.0 = failed to meet
1.0 = met thresholds
2.0 = met goals
Poly.(SEROI Data)

Barely significant correlation
12% against required 11% for α=0.05
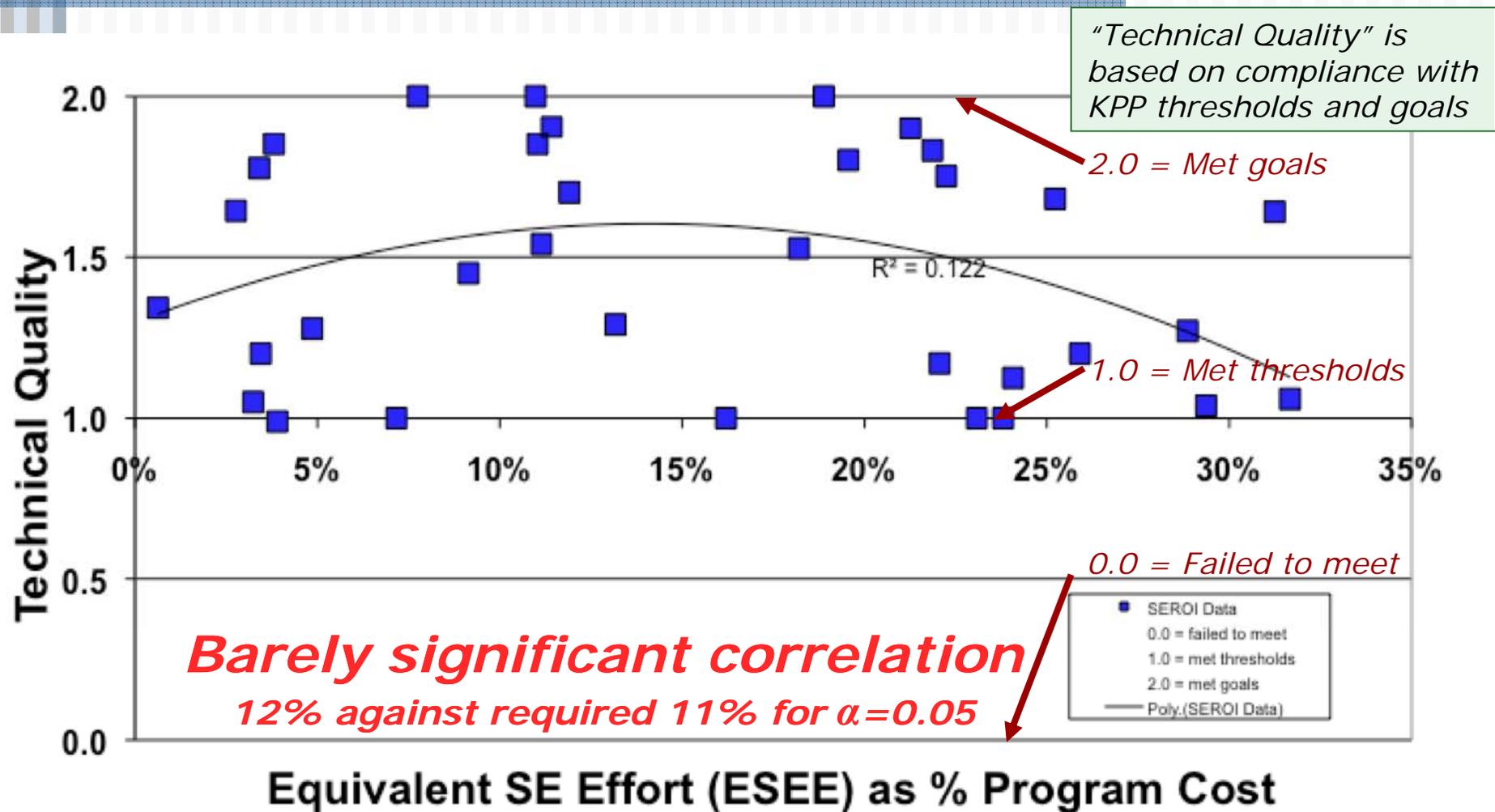
Breakout by SE Activities

MD Mission/Purpose Definition
RE Requirements Engineering
SA System Architecting
SI System Integration
VV Verification & Validation

TA Technical Analysis
SM Scope Management
TM Technical Leadership/Management

Breakout by Success

SE Cost over "Successful" Programs

Legend:
- MD
- RE
- SA
- SI
- VV
- TA
- SM
- TM

Y-axis: Percent of End-to-End Program Cost Expended During Each Phase
X-axis: Begin MCR SRR SDR PDR CDR TRR End

SE Cost over "Poor" Programs

X-axis: Begin MCR SRR SDR PDR CDR TRR End
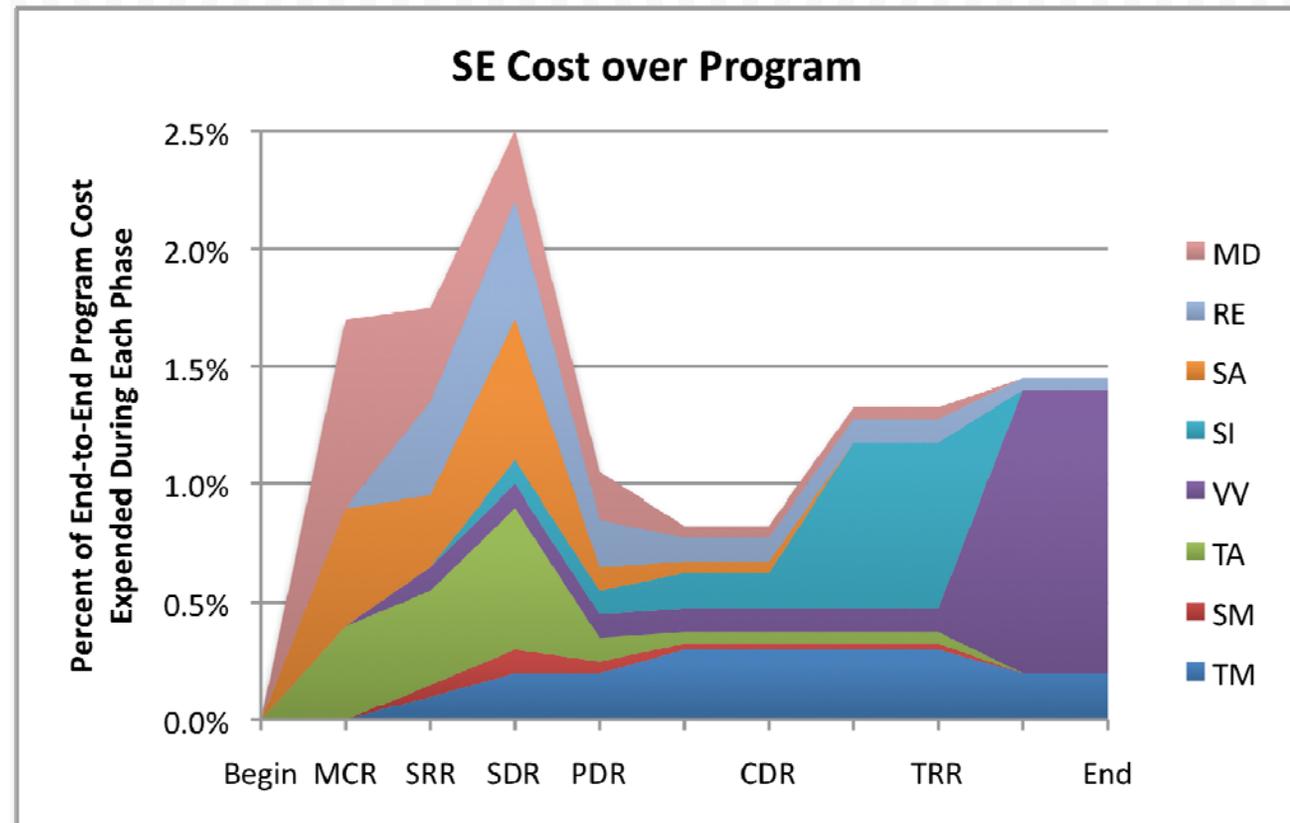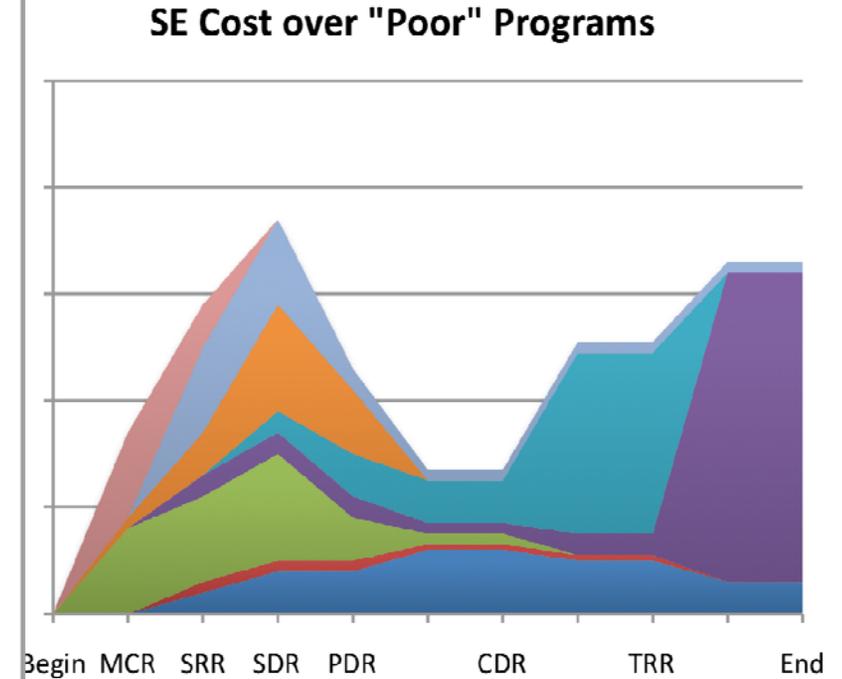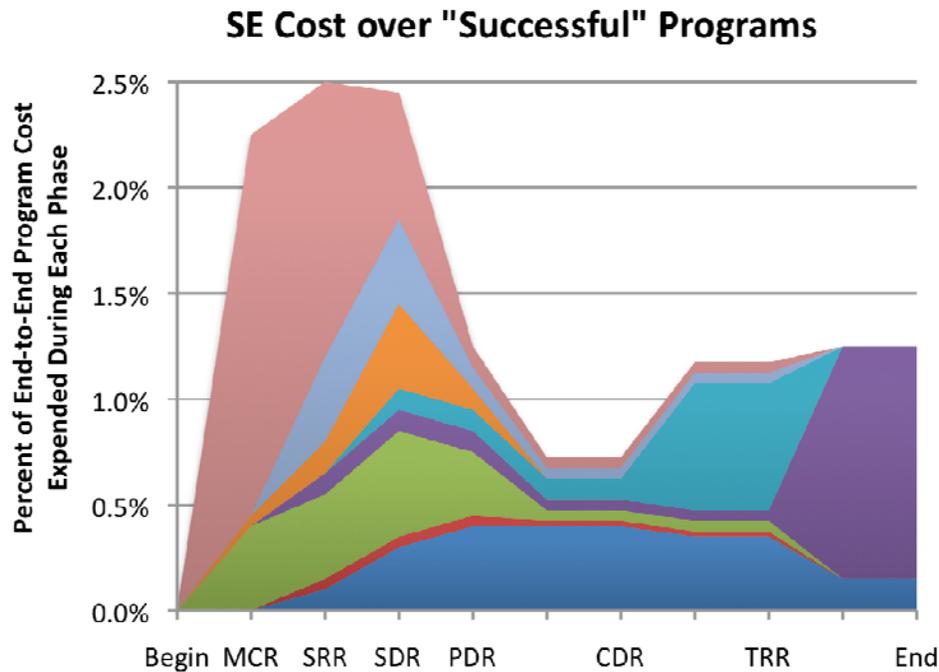
Successful *(~on cost)*
- More mission/purpose defn
- More tech leadership/mgmt
- More Systems Engineering

Poor *(overran cost)*
- More system integration
- More verif & valid
- Less Systems Engineering

Cost vs. Tech Lead'ship/Mgmt

Effective TM Effort as % Program Cost (ETME)
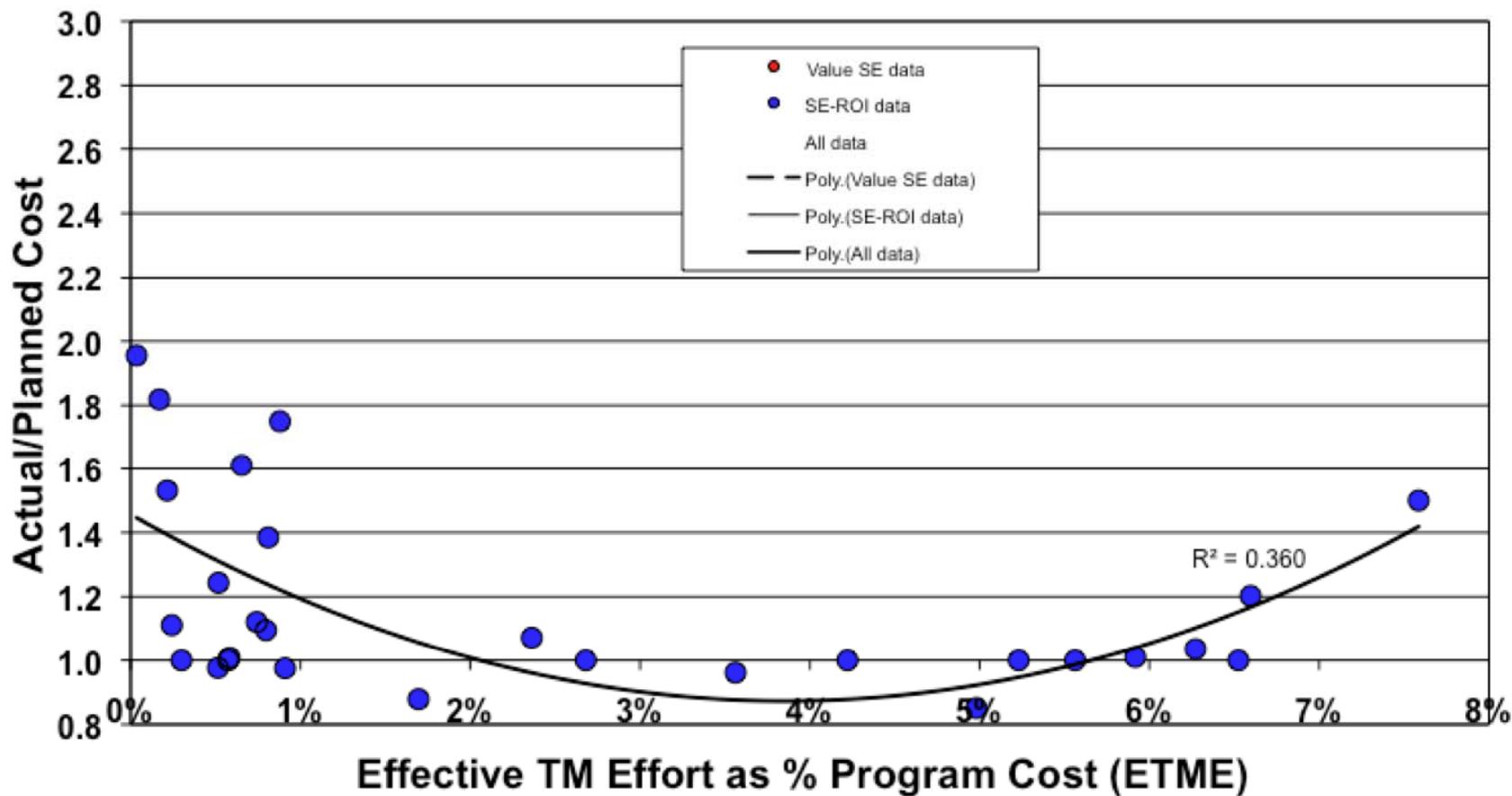
Effect of SE Activities

Activity	Code	Quantifiable Correlation Exists With			
		Cost Compliance	Schedule Compliance	Overall Success	Technical Quality
Total Systems Engineering Effort	SE	Yes	Yes	Yes	Perhaps
Mission/Purpose Definition Effort	MD	Yes	Yes	No	No
Requirements Engineering Effort	RE	Yes	Yes	Yes	No
System Architecting Effort	SA	Yes	Yes	Yes	No
System Integration Effort	SI	Yes	Yes	Yes	No
Verification & Validation Effort	VV	Yes	Yes	No	No
Technical Analysis Effort	TA	Yes	Yes	Perhaps	No
Scope Management Effort	SM	Yes	No	Yes	No
Technical Management/ Leadership Effort	TM	Yes	Yes	Yes	No

Optimum Levels, Median Program

Activity	Code	Optimum	Median of data
Total Systems Engineering	SE	**14.4%**	8.5%
Mission/Purpose Definition	MD	**1.3%**	1.6%
Requirements Engineering	RE	**2.0%**	0.8%
System Architecting	SA	**3.9%**	1.4%
System Integration	SI	**2.8%**	1.5%
Verification & Validation	VV	**2.4%**	2.0%
Technical Analysis	TA	**1.8%**	1.3%
Scope Management	SM	**1.4%**	0.3%
Technical Leadership/Management	TM	**3.9%**	1.9%

Total of activities=19.5%

Honour, EC, "Systems Engineering Return on Investment, UniSA'12

Example: "Space System"
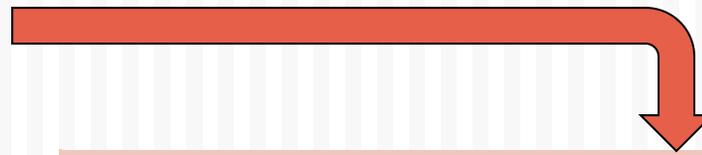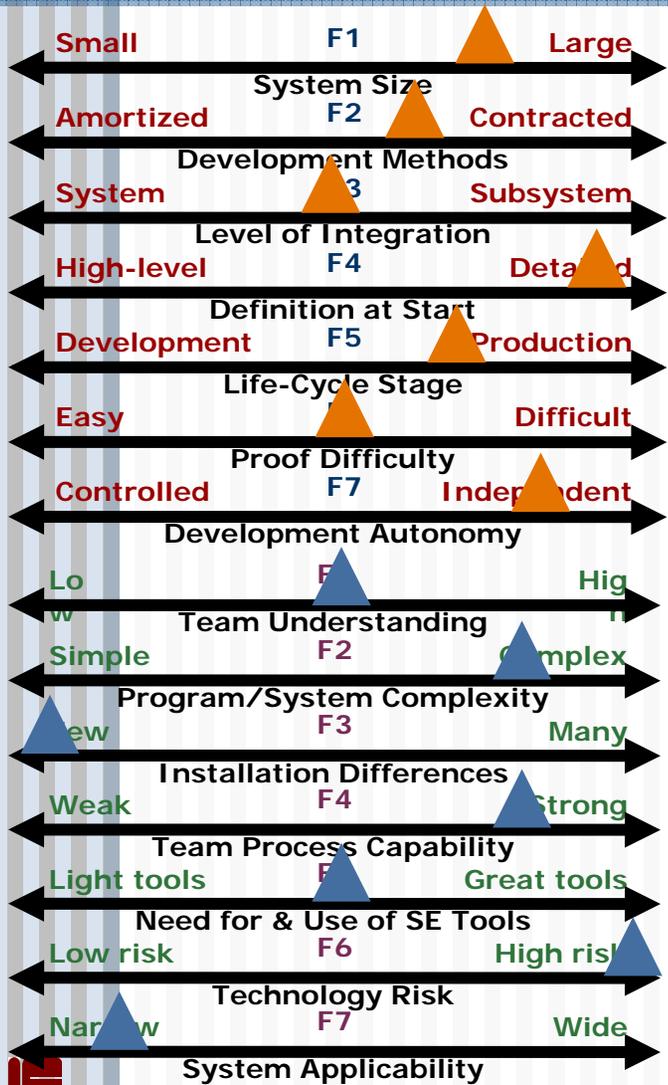
	Median Optimum	Adjustment	Program Optimum
MD	1.3%	0.38	0.5%
RE	2.0%	0.50	1.0%
SA	3.9%	0.69	2.7%
SI	2.8%	0.50	1.4%
VV	2.4%	0.68	1.9%
TA	1.8%	0.79	1.3%
SM	1.4%	0.72	1.2%
TM	3.9%	1.41	5.5%
SE	**14.4%**	**1.08**	**15.6%**

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Bottom Line

- **Better programs expend**
  - more SE effort overall
  - more mission definition, more tech leadership
- **<u>Nearly all</u> SE activities correlate well with**
  - Cost/schedule control
  - Stakeholder overall success
- **<u>No</u> SE activities correlate with**
  - System technical quality

    SE today leads to better programs
    – but does not lead to better
    systems.

- **Results can be used to right-size SE**
  - New cost modeling based on optimum success

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Questions?

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