



Honourcode, Inc.

Systems Engineering Return on Investment

SE-ROI Research Results Dec10

**Eric Honour
+1 (850) 479-1985
ehonour@hcode.com**

Funding provided by

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



University of
South Australia

**Defence and
Systems Institute**

Agenda

- **SE-ROI Project**
 - **Motivation: How much is enough?**
 - **Goals and methodology**

- **SE-ROI Results**
 - **Demographics**
 - **Primary correlations: success* vs. SE**
 - **Eight SE Activities**
 - **Success vs. SE activities**
 - **Front-end vs. Back-end**
 - **Right-Sizing SE**

**Cost compliance, schedule compliance, stakeholder acceptance, technical quality*

Bottom Line

- **Better programs expend**
 - more SE effort overall
 - more mission definition, more tech leadership
 - **All SE activities correlate well with**
 - Stakeholder acceptance
 - Cost/schedule control
 - **No 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**



Honourcode, Inc.

SE-ROI Project

Methodology
Industry support



University of
South Australia

**Defence and
Systems Institute**

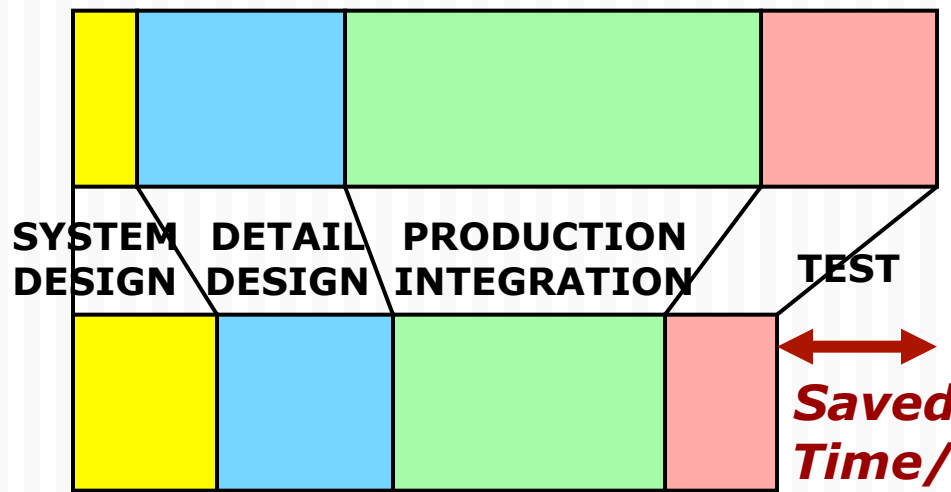
SE Return on Investment

4

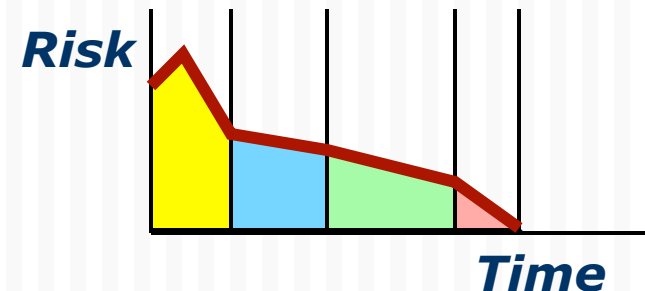
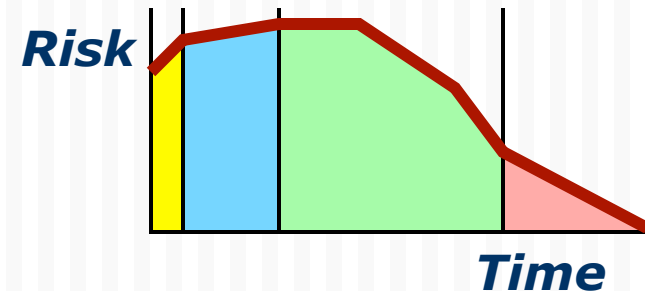
Heuristic Claim of SE

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

Traditional Design



"System Thinking" Design



Not Known: How Much Is Enough?

Project Goals

■ Research objectives

How Much Is Enough?

■ *Find out how much of what type of SE correlates with project success*

- What SE practices are appropriate under what conditions.

■ *Leading indicators*

- Used during a project to assess the project's expected future success and risks based on SE practices used.

■ *Identification of good SE practices*

- Appropriate to generate success under different conditions.

■ Schedule

■ '05-'07 – Technical structuring and definitions

■ Late '07 – Started data gathering

■ Internal reports '08-'09

■ Final reports '10



SE-ROI Project

Interviews

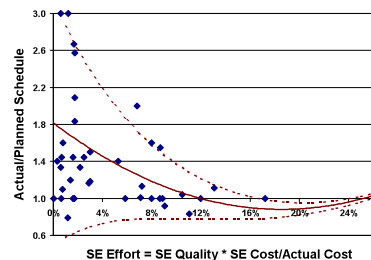
- Just-completed programs
- Key PM/SE/Admin
- Translate program data into project structure

- *Program characterization*
- *Program success data*
- *SE data (hours, quality, methods)*

Desired Results

1. **Statistical correlation of SE practices with project success**
2. **Leading indicators**
3. **Identification of good SE practices**

Statistical correlation



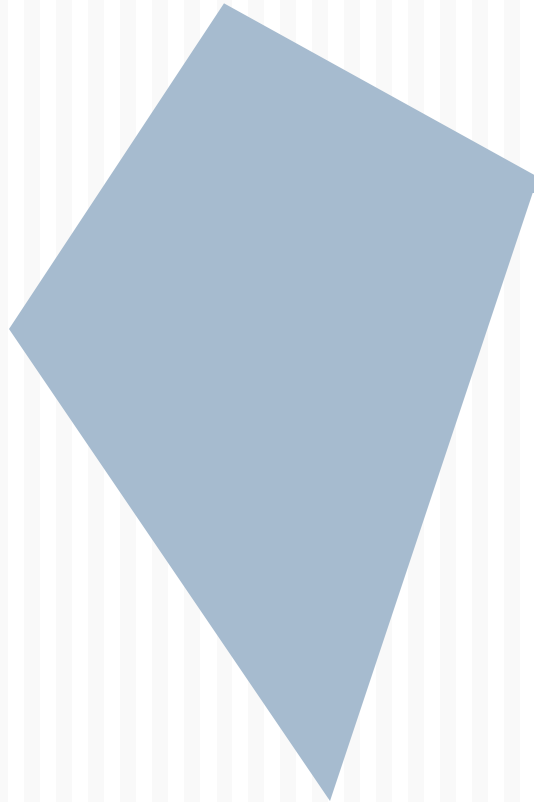
Company Participation

- **Data gathering – *minimal impact***
 - Select 2 to 4 programs
 - One day of interviews
 - 2-hour sessions with PM+SE of each program
 - Strong protection of proprietary data
- **Reports – *effective program benchmarking***
 - Benchmark report within 30 days of session
 - Compares programs against prior data
 - Quarterly reports from all prior data, all sources
 - *Correlations found*
 - *Leading indicators proven*
 - *SE practices proven*



Honourcode, Inc.

SE-ROI Results: Demographics



University of
South Australia

**Defence and
Systems Institute**

SE Return on Investment

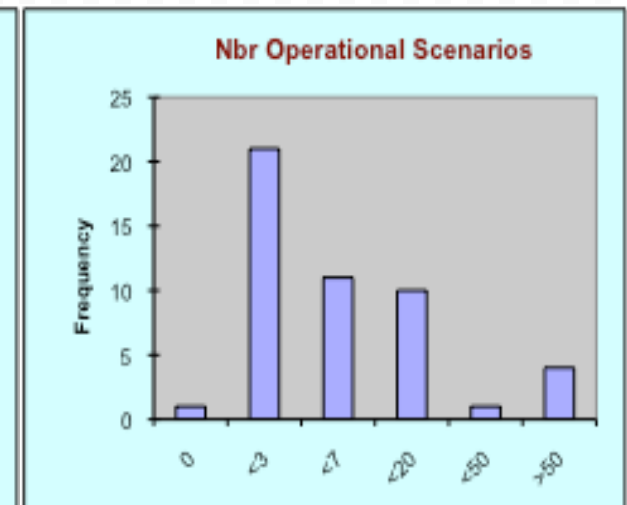
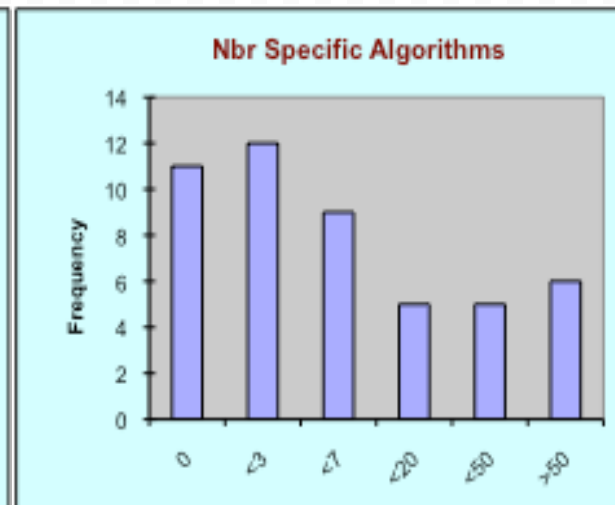
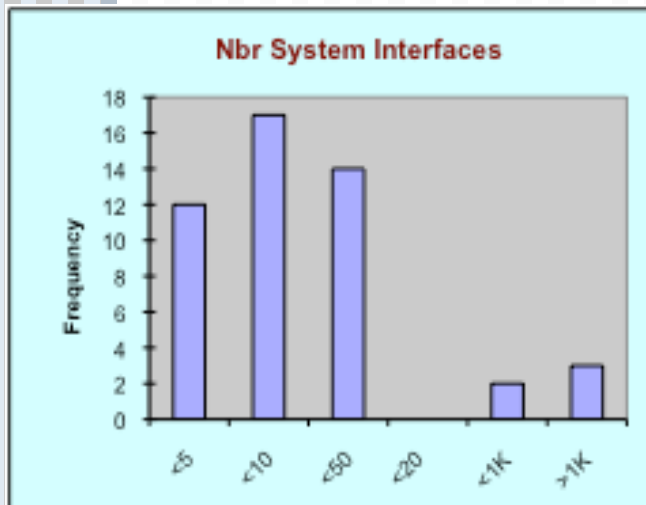
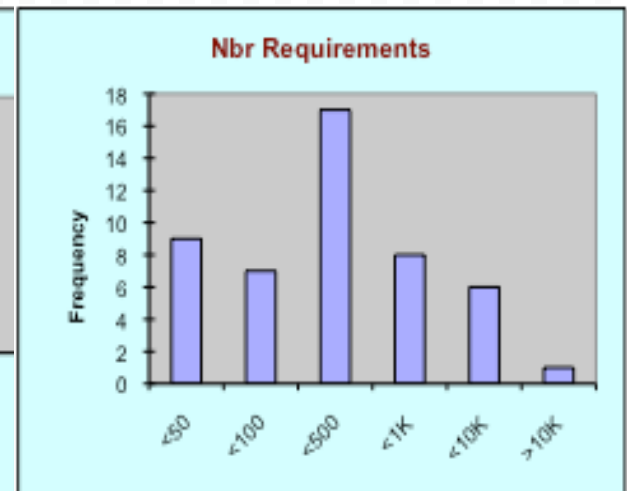
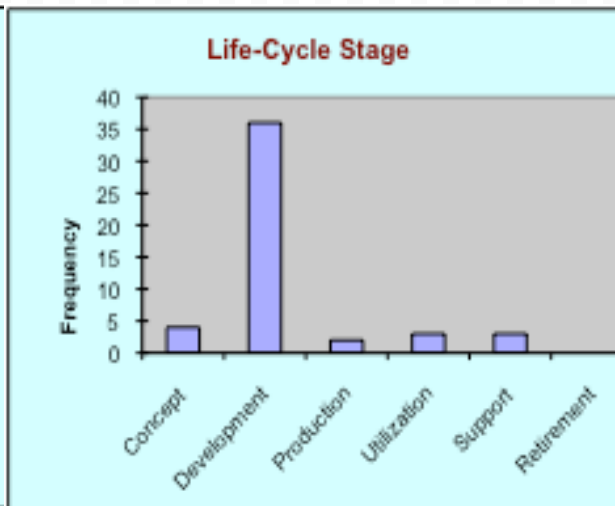
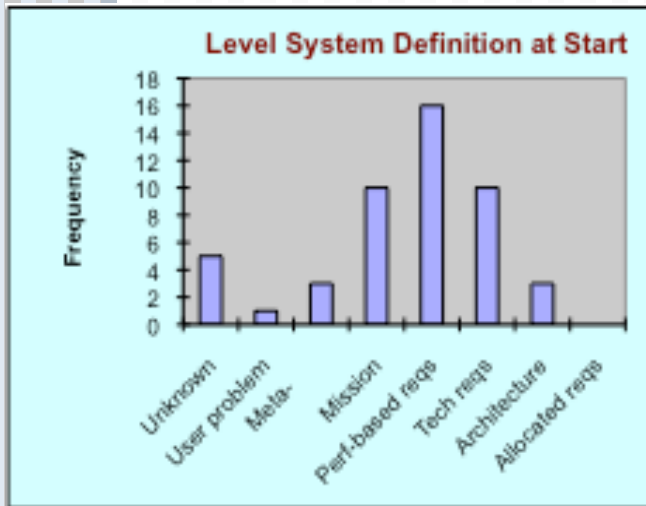
9

Basic Demographics

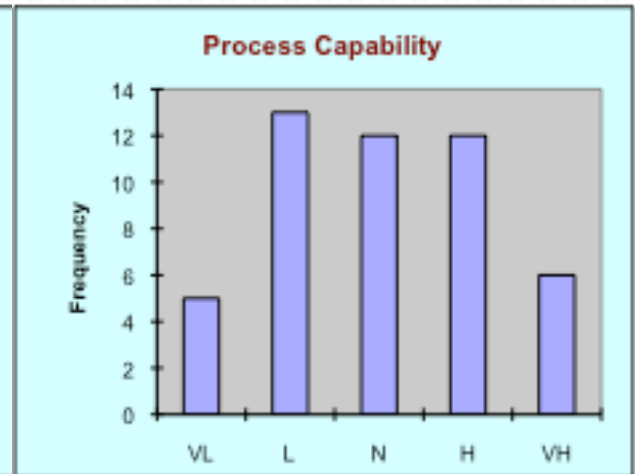
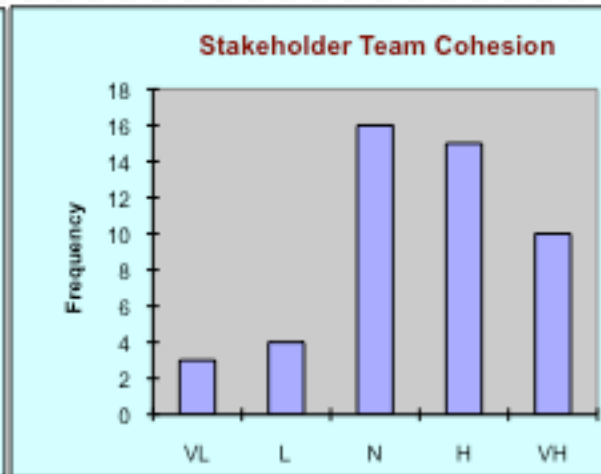
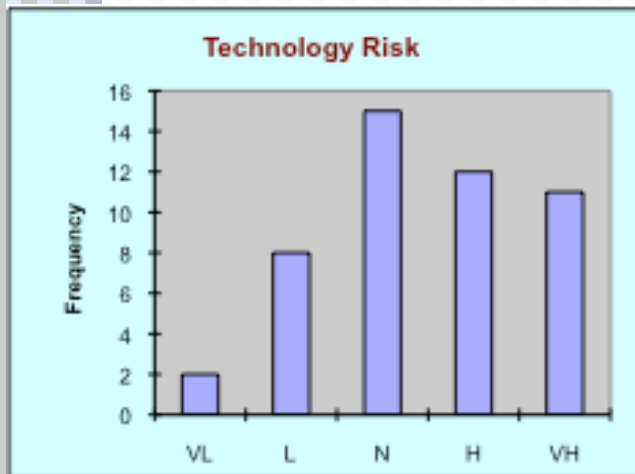
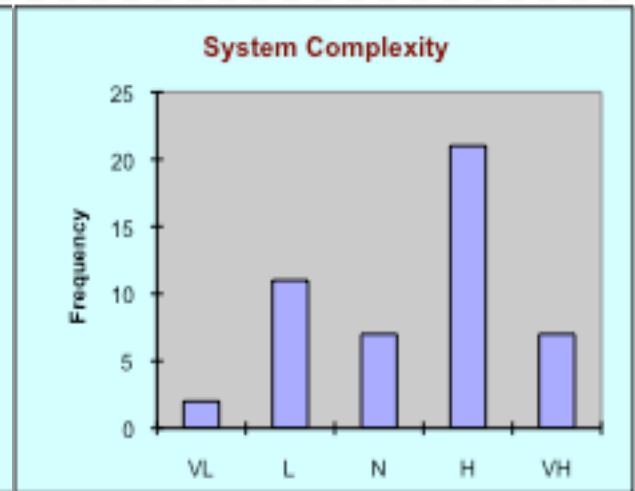
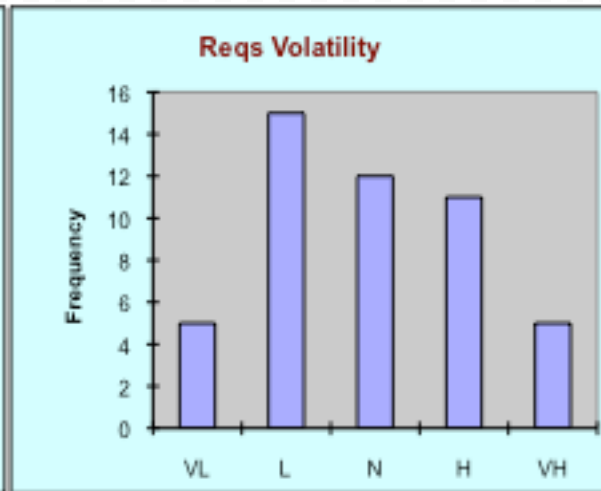
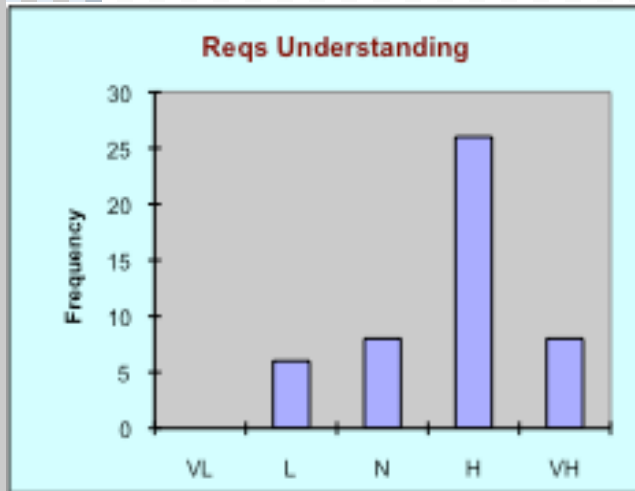
Characteristic	ValueSE Data Set	SE-ROI Data Set
Number of organizations	Unknown	16
Number of data points	44	48
Funding method	Unknown	39 contracted, 9 amortized
Program total cost	\$1.1M - \$5.6B Median \$42.5M	\$600K - \$1.8B Median \$14.4M
Cost compliance	(0.8):1 – (3.0):1 Median (1.2):1	(0.6):1 – (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



Program "Size"



Program/Team Parameters





Honourcode, Inc.

SE-ROI Results: Primary Relationships

**SE effort correlates with
3 of 4 success measures**

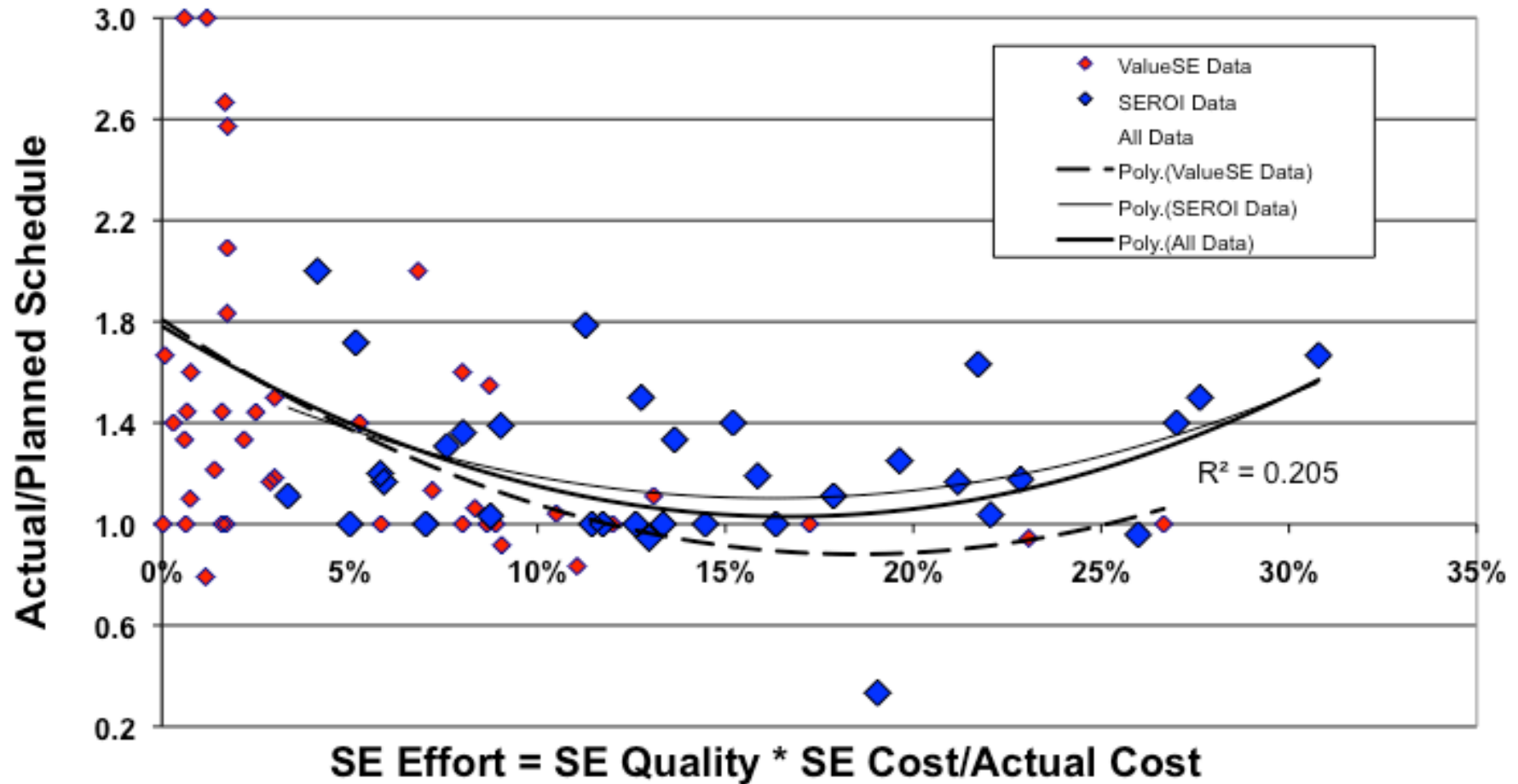
**Optimum SE effort
~15% of total
development cost**



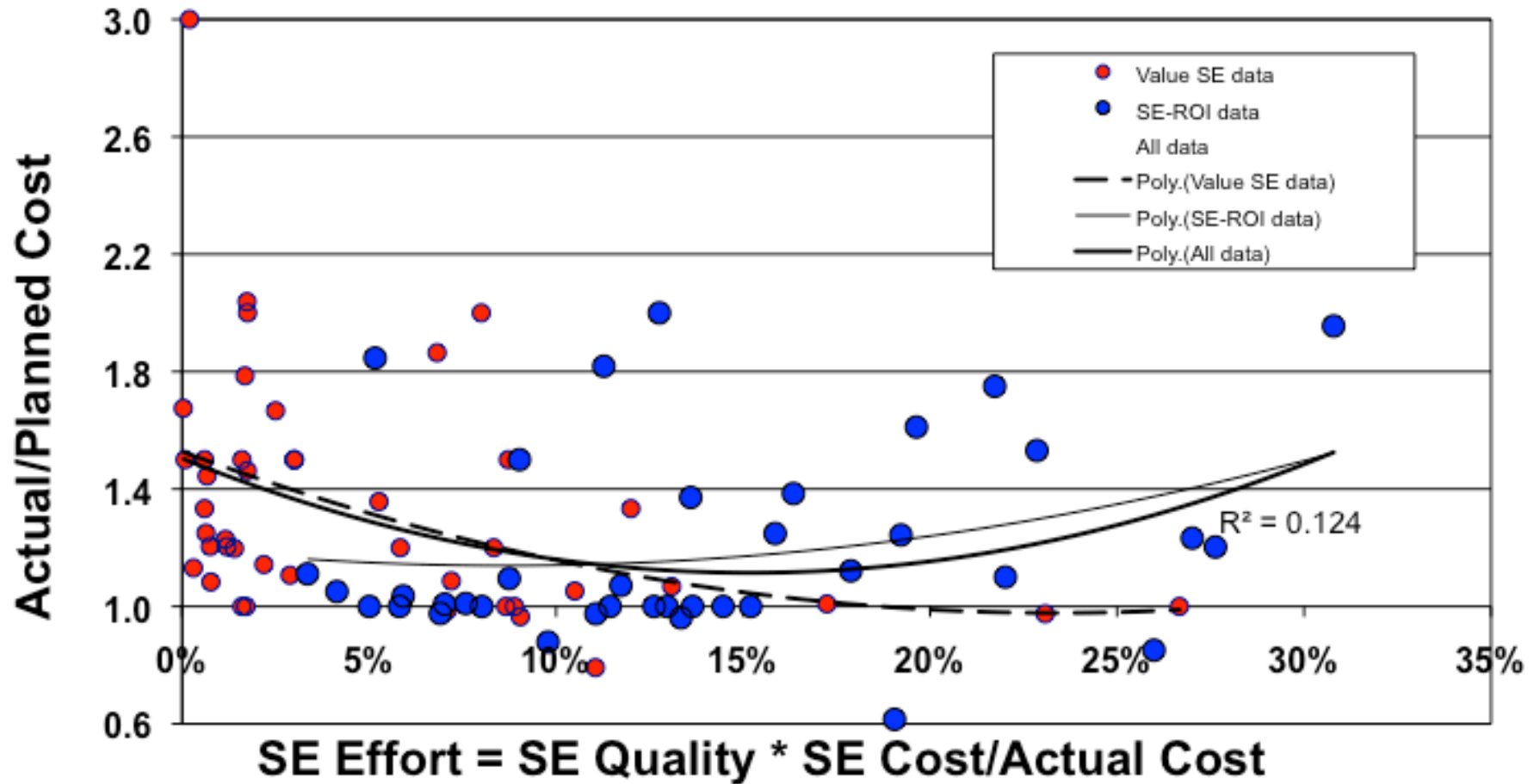
University of
South Australia

Defence and
Systems Institute

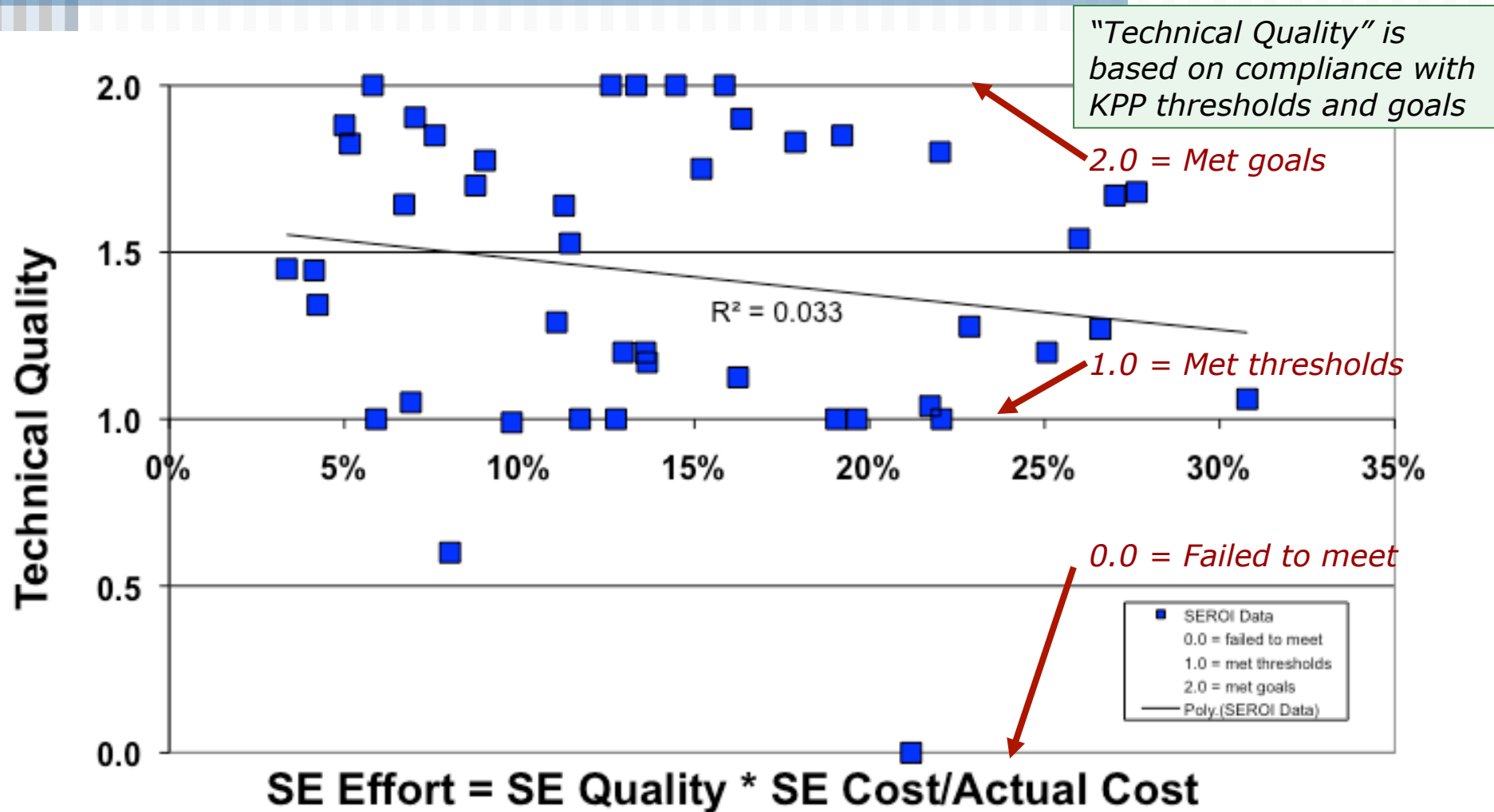
Schedule vs. SE Effort



Cost vs. SE Effort



Technical Quality vs. SE Effort





Honourcode, Inc.

SE-ROI Results: Eight SE Activities

**All SE activities correlate w/
cost, schedule, acceptance**

None correlate w/ quality

**Successful programs use
front-end; poor programs
use back-end**



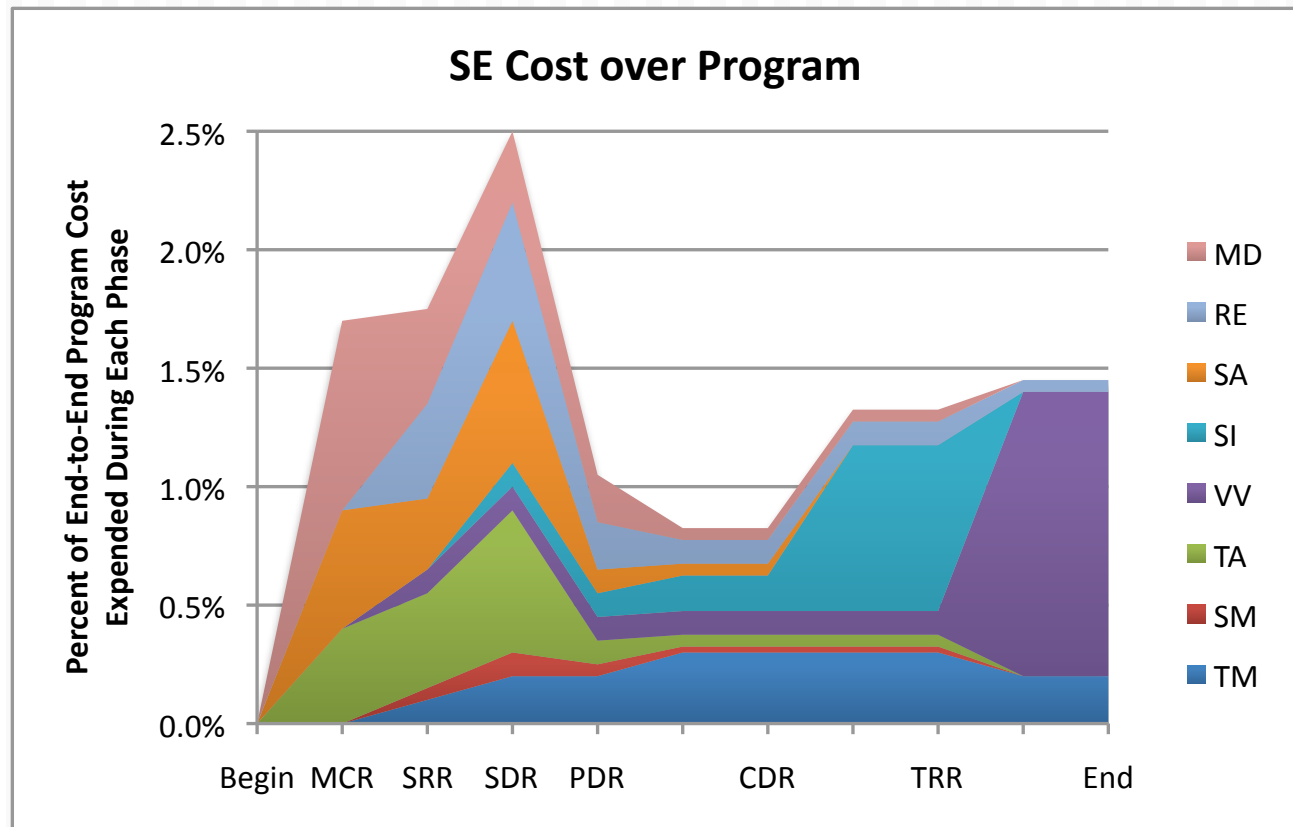
University of
South Australia

Defence and
Systems Institute

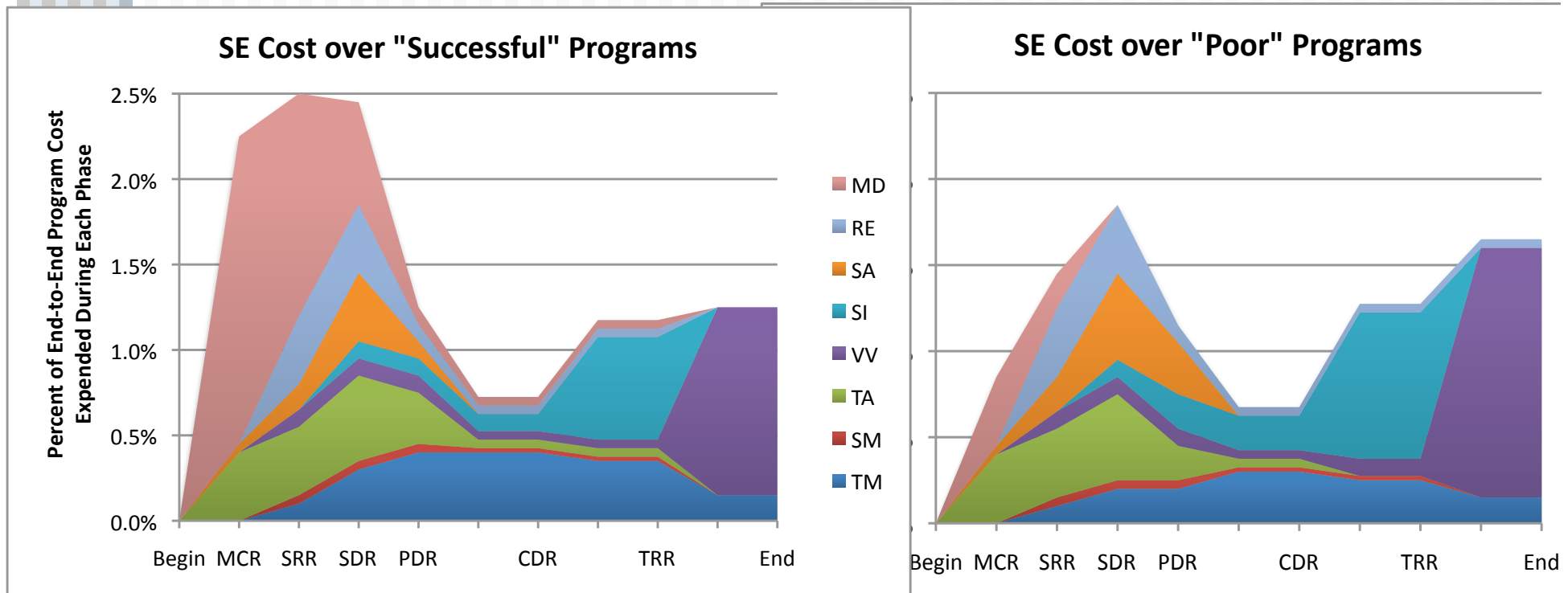
Breakout by SE Activities

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



Successful (*~on cost*)

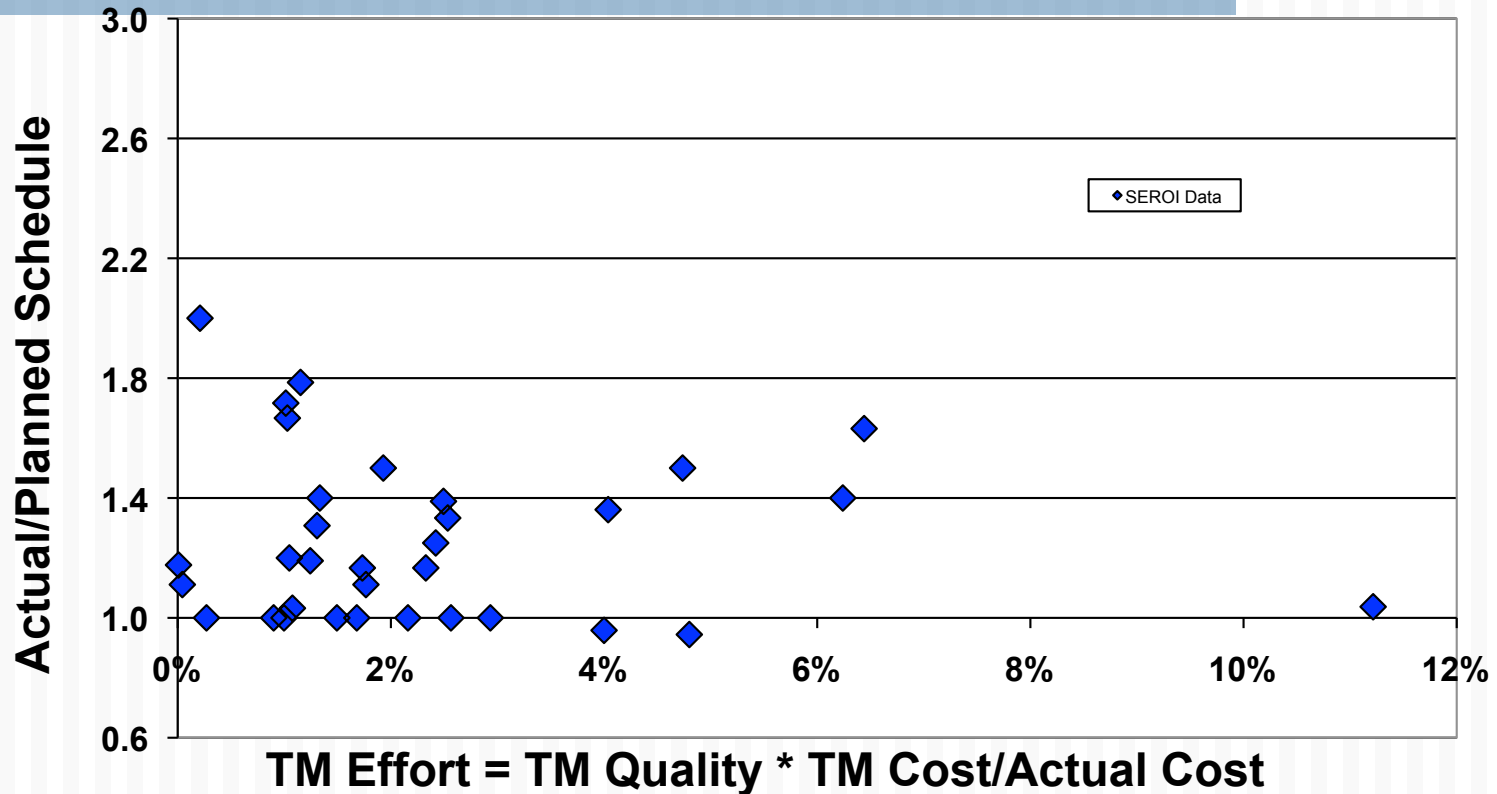
- More mission/purpose defn
- More tech leadership/mgmt
- More Systems Engineering

Poor (*overran cost*)

- More system integration
- More verif & valid
- Less Systems Engineering

Typical Data:

Schedule vs. Tech Lead'ship/Mgmt

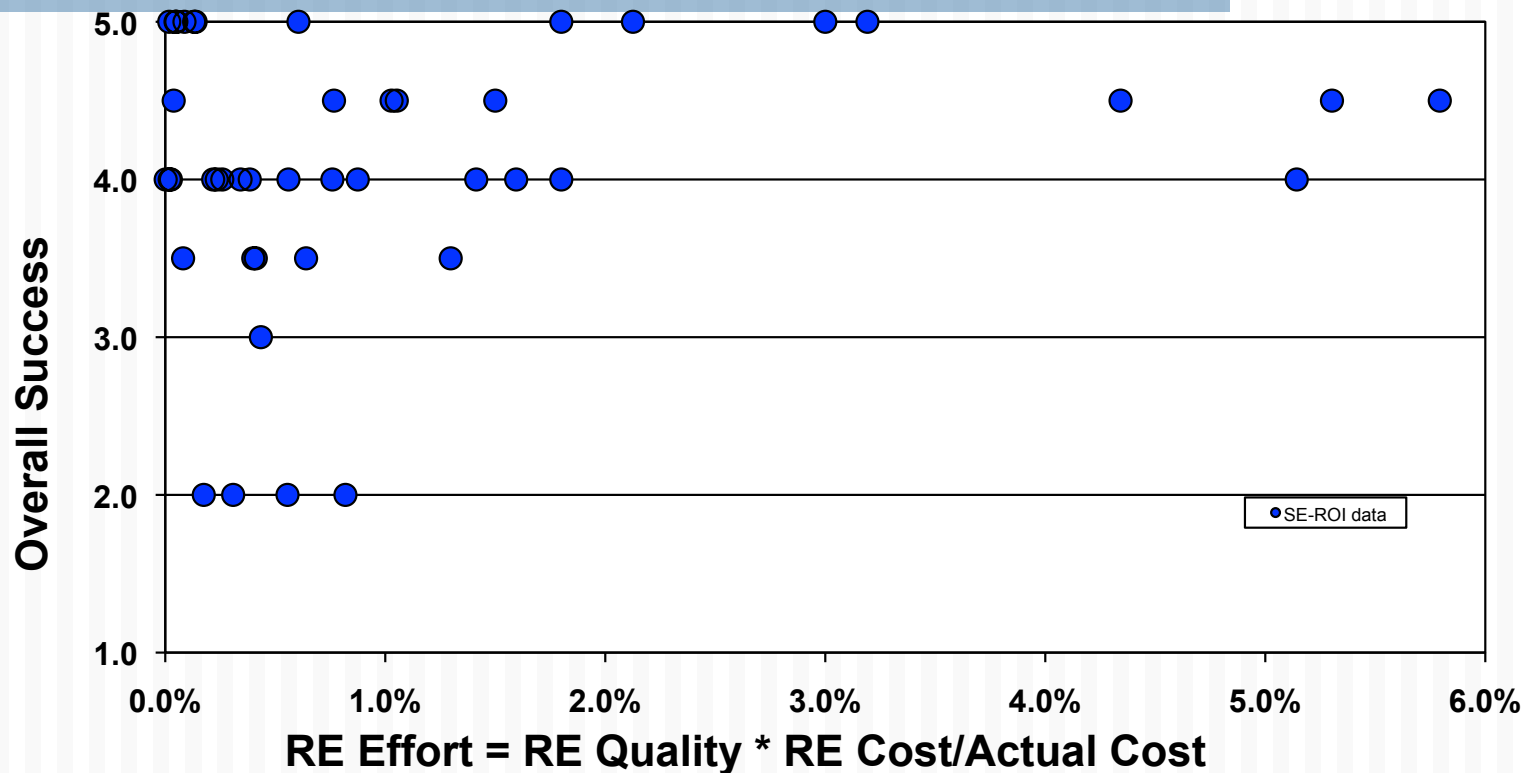


*Weaker visual correlation observed for:
SI System Integration*

*Strong visual correlation observed for:
ALL other activities*

Typical Data:

Overall Success vs. Reqs Engr

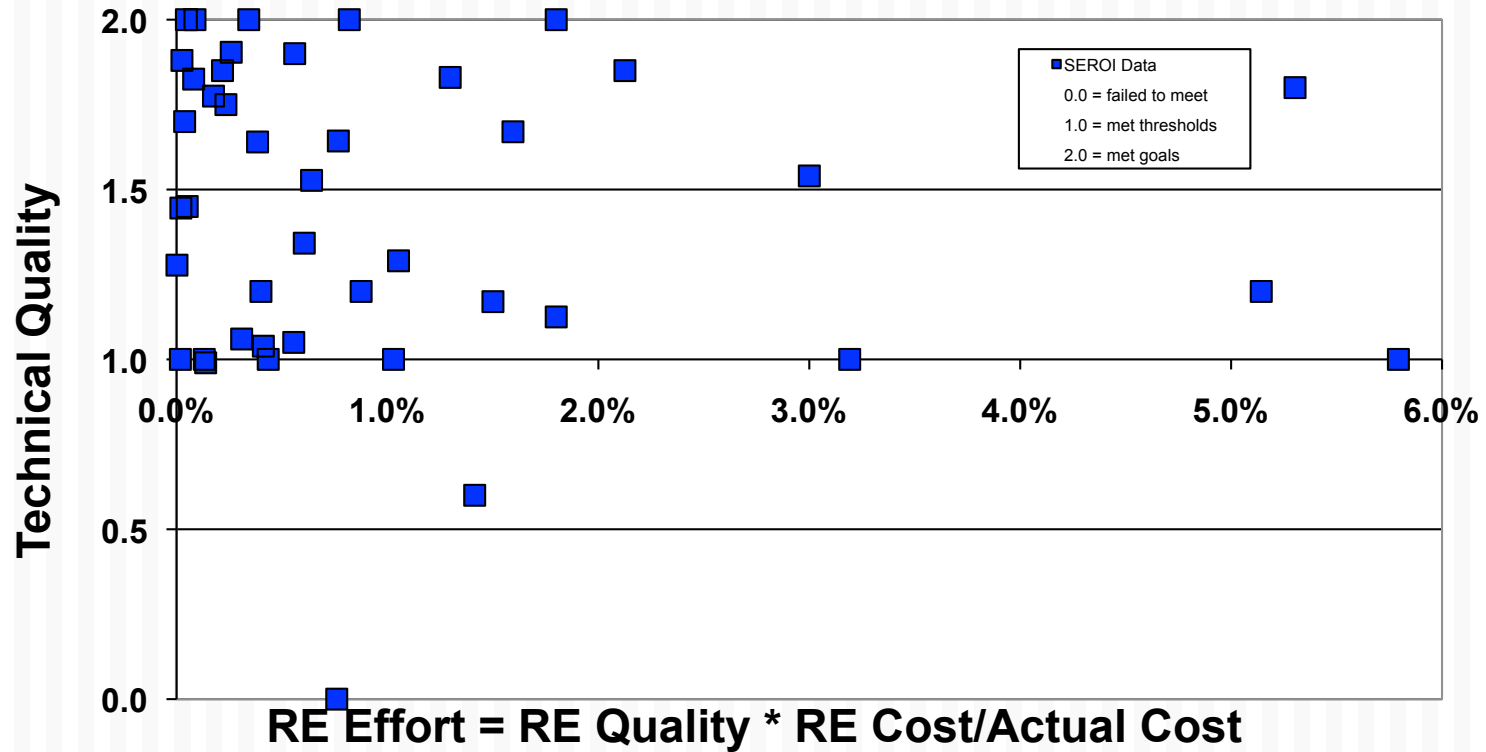


*Weaker visual correlation observed for:
SI System Integration*

*Strong visual correlation observed for:
ALL other activities*

Typical Data:

Tech Quality vs. Reqs Engr



No significant correlation observed for ANY activities.

Effect of SE Activities

■ Which activities correlate to better quality?

Activity	Cost	Schedule	Overall	Technical
Missn Defn*	Perhaps	Yes	Yes	No
Reqs Engr	Yes	Yes	Yes	No
Sys Arch	Yes	Yes	Yes	No
Sys Integr	Perhaps	Perhaps	Perhaps	No
Tech Anlysis	Yes	Yes	Yes	No
Tech Mgmt	Yes	Yes	Yes	No
Scope Mgmt	Yes	Yes	Yes	No
Ver & Val	Yes	Yes	Yes	No

* For most projects, MD was performed in an earlier phase





Honourcode, Inc.

SE-ROI Results: Right-Sizing SE

**Results are further
optimized using
characterization
parameters**

**Parametric sizing of SE
to optimize success**



University of
South Australia

**Defence and
Systems Institute**


SE Return on Investment

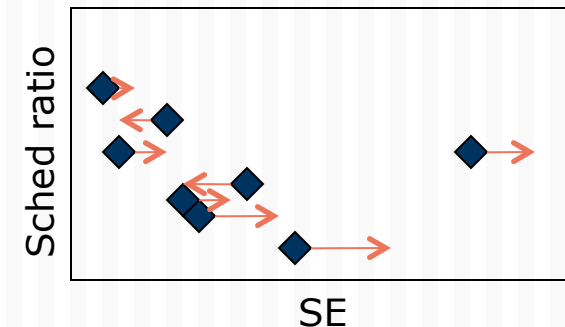
25

Adjustment to SE Effort

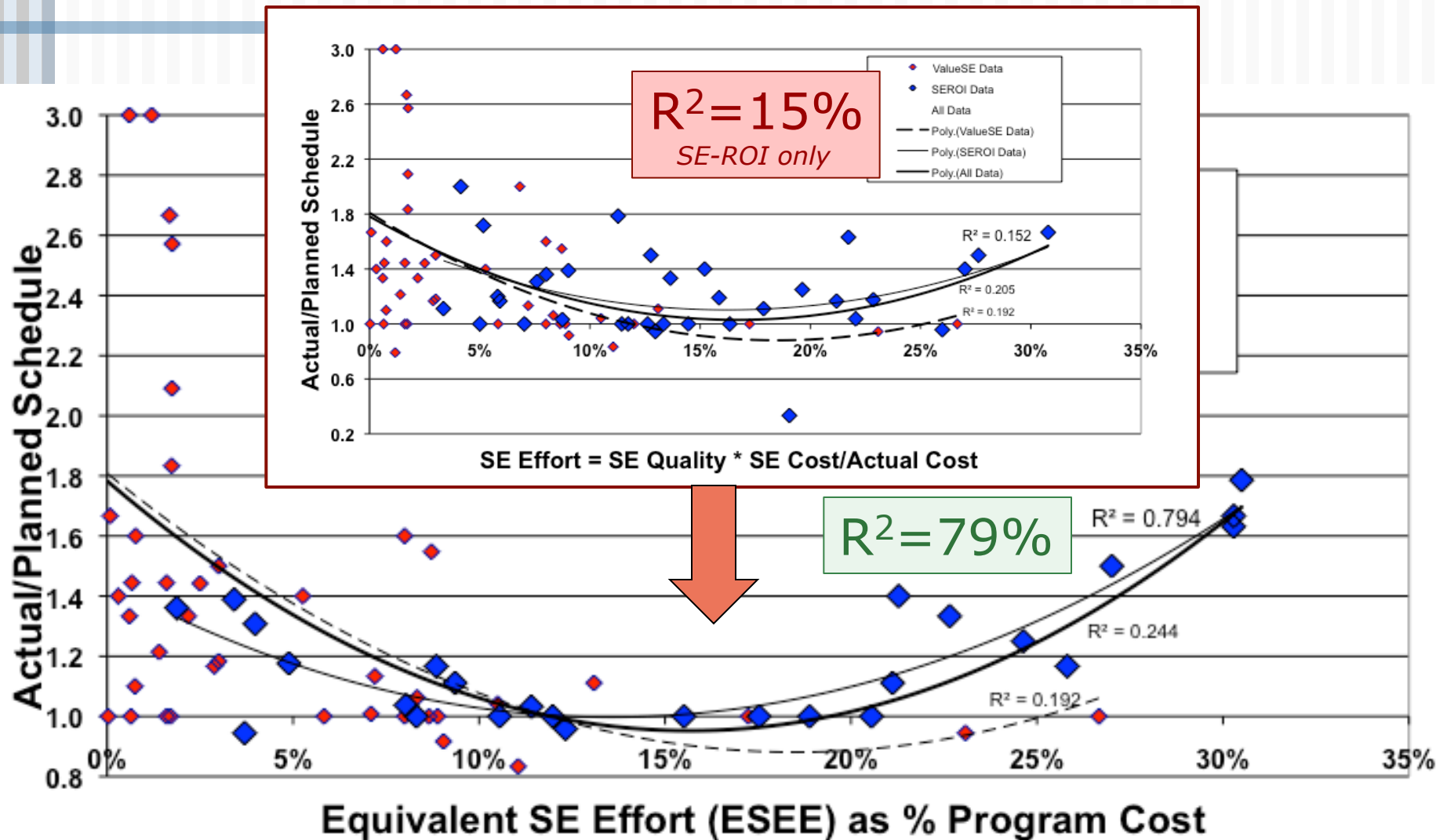
- **“Equivalent SE Effort” – adjust for 14 characterization parameters**
 - **Multiplicative factors as in COSYSMO**
 - **Select weights to optimize correlation**
 - **=0 for no effect; >0 to increase; <0 to decrease**

$$ESEE = SEE * \prod_{j=1...14} \left(\frac{PP_j}{.5} \right)^{\frac{-Weight_j}{100}}$$

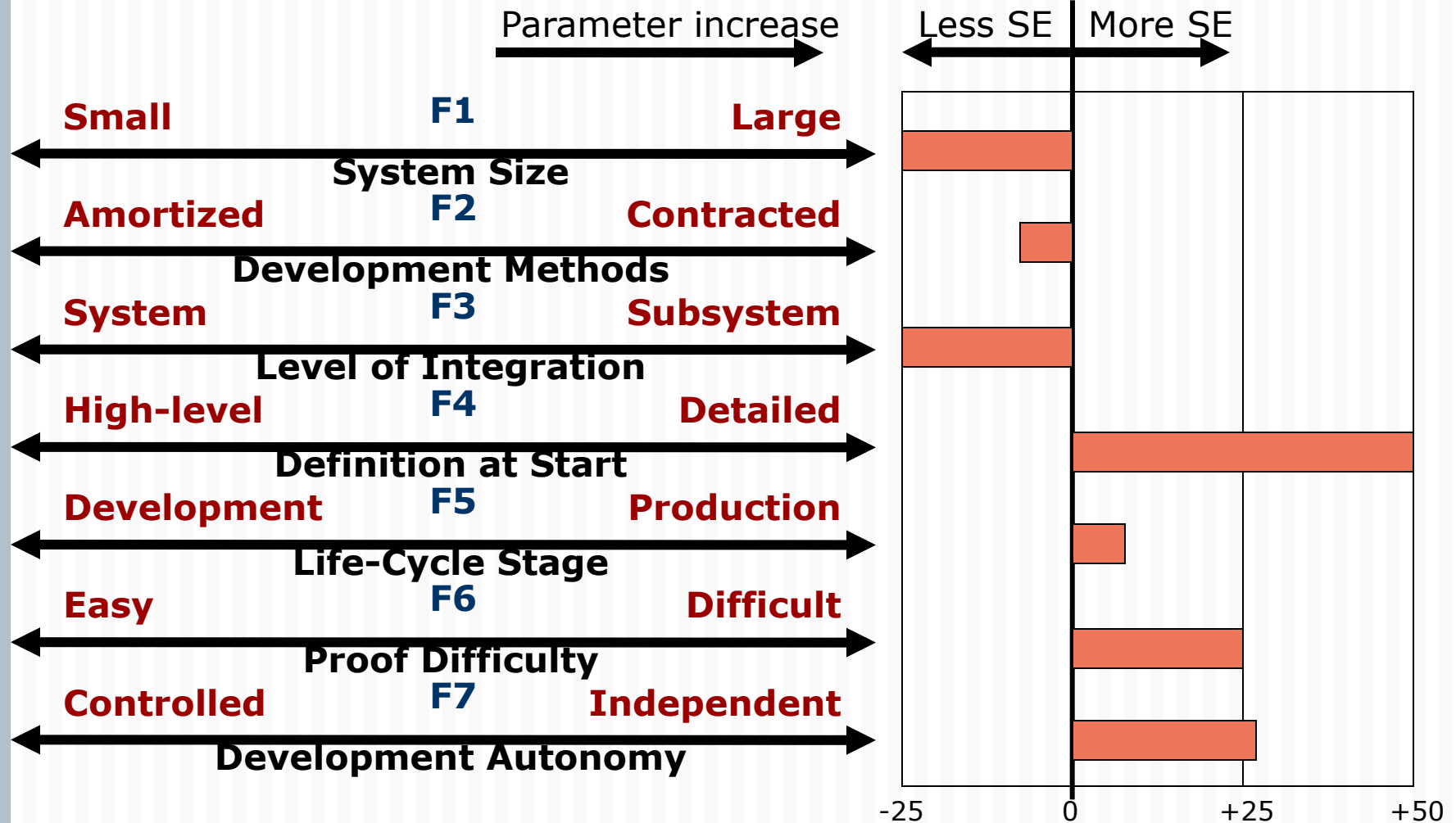
Typical effect of adjusting any $Weight_j$ 



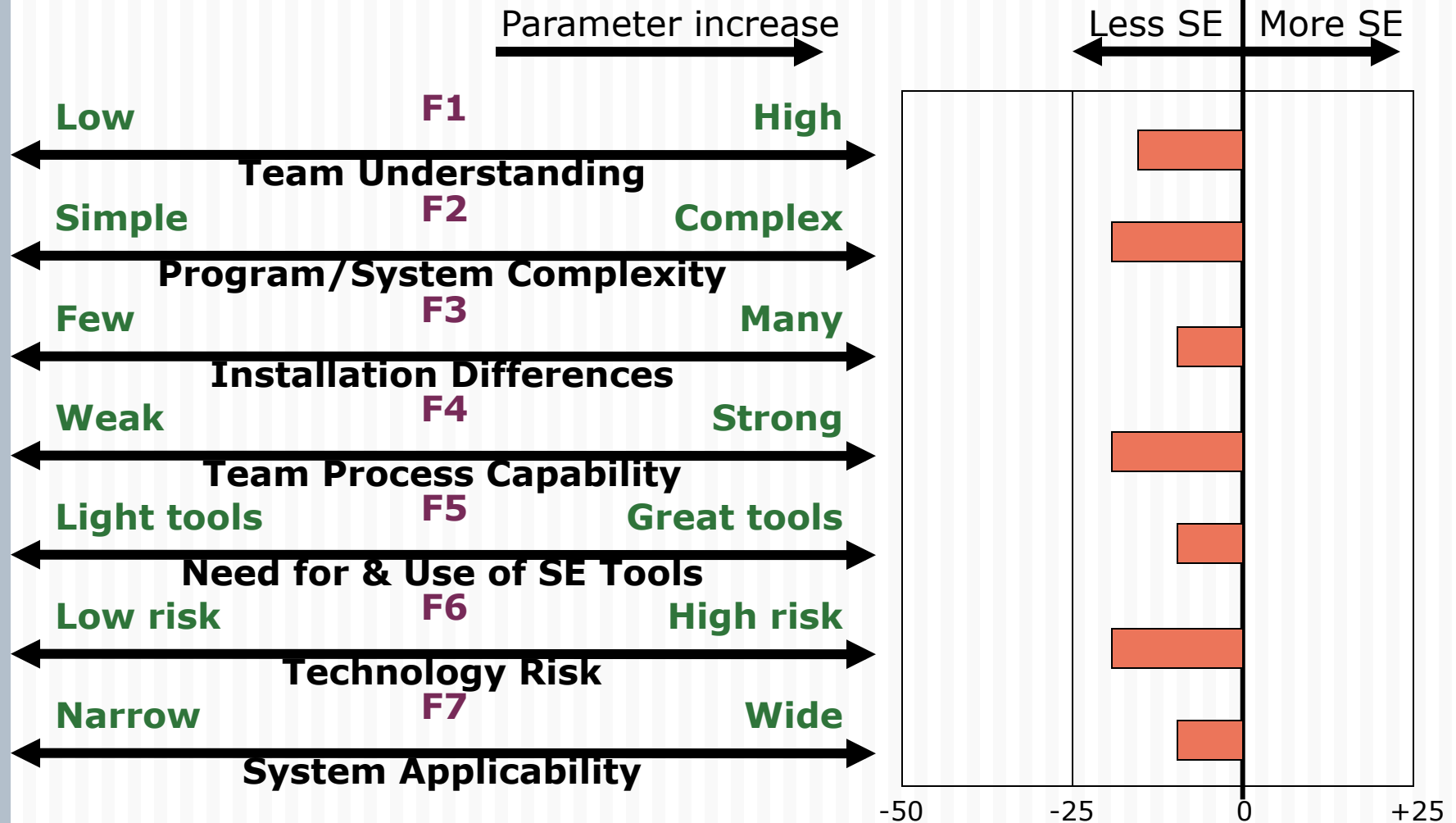
Effect of Characterization Parameters



Quantified Parameter Weights



Subjective Parameter Weights



Summary: SE Modifications

Each transformation improves the correlation of SE with success factors

- Number of requirements
- Number of interfaces
- Number of algorithms
- Number of scenarios
- Number of components
- Number of test locations
- Number of developing orgs
- Number of customer agencies

PCA → System Size

...

$$\frac{\text{SE Activity Cost}}{\text{Total Program Cost}}$$



SE%
 $R^2 \sim 8-12\%$

SE Quality



SE Effort (SEE)
 $R^2 \sim 15-20\%$

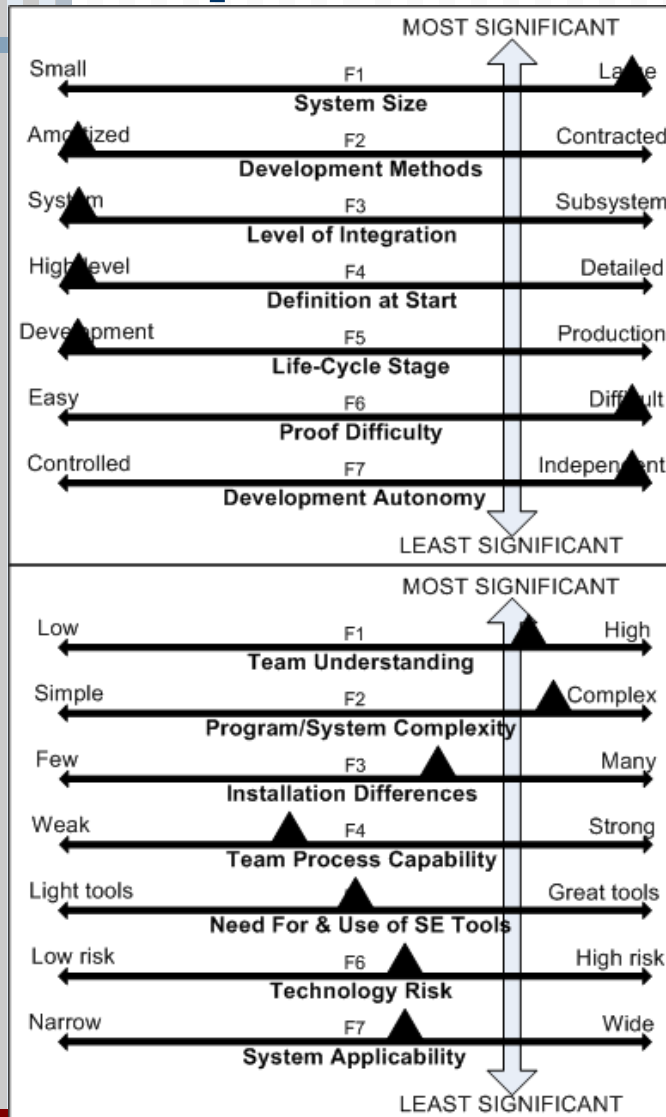
14 adjustment factors



Equiv SE Effort (ESEE)
 $R^2 \sim 40-80\%$



Optimum "President George"

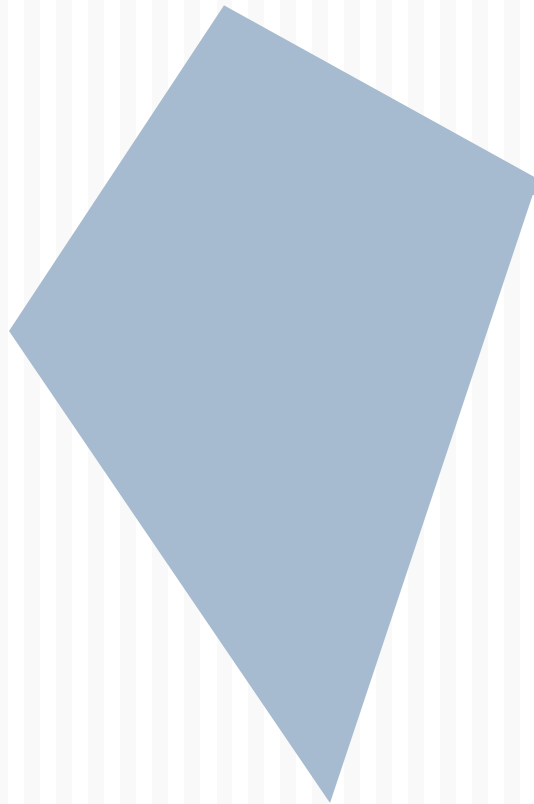


	Median Optimum	Adjustment	Program Optimum
MD	1.5%	0.82	1.2%
RE	2.2%	0.58	1.3%
SA	3.9%	0.26	1.0%
SI	3.0%	0.74	2.2%
VV	3.4%	0.68	2.3%
TA	2.1%	0.61	1.3%
SM	1.6%	0.27	0.4%
TM	3.5%	0.66	2.3%
SE	15.5%	0.76	12.0%



Honourcode, Inc.

Summary



University of
South Australia

**Defence and
Systems Institute**

SE Return on Investment

32

Quantified, Proven Results

- **Better programs expend**
 - more SE effort overall
 - more mission definition, more tech leadership
- **All SE activities correlate well with**
 - Stakeholder acceptance
 - Cost/schedule control
- **No 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**





Honourcode, Inc.

Systems Engineering Return on Investment

Questions?

Eric Honour

+1 (850) 479-1985

ehonour@hcode.com



University of
South Australia

**Defence and
Systems Institute**