INCOSE 2004
TOULOUSE FRANCE
20-24 JUNE

Systems Engineering, managing complexity and change

INCOSE SECOE
Systems Engineering
Center of Excellence

Honourcode, Inc.

Honourcode, Inc.

Understanding the Value of Systems Engineering

How can we quantify worth of what we do?

Eric Honour

Honourcode, Inc.

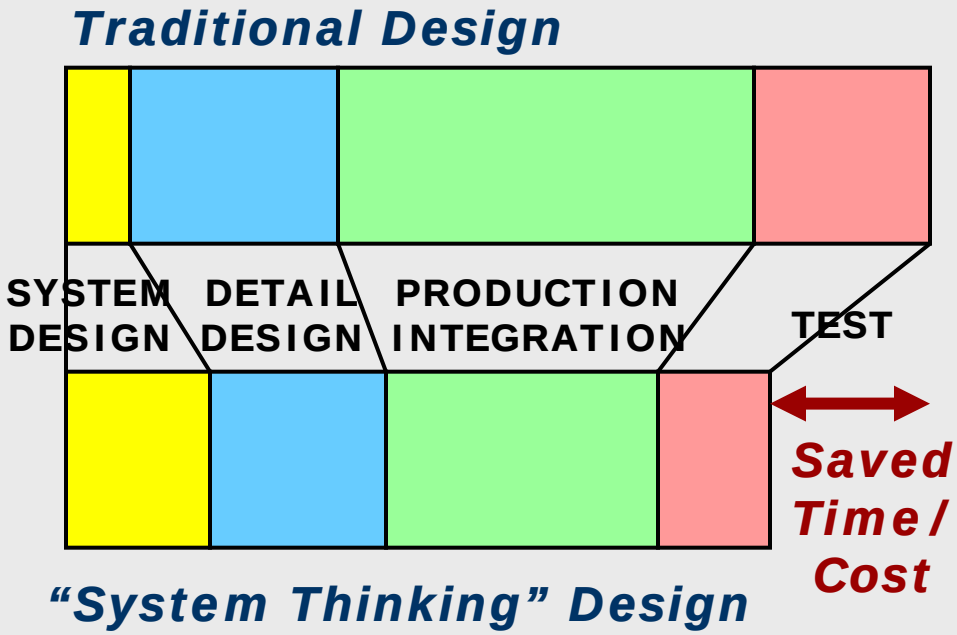
Director, INCOSE Systems Engineering Center of Excellence

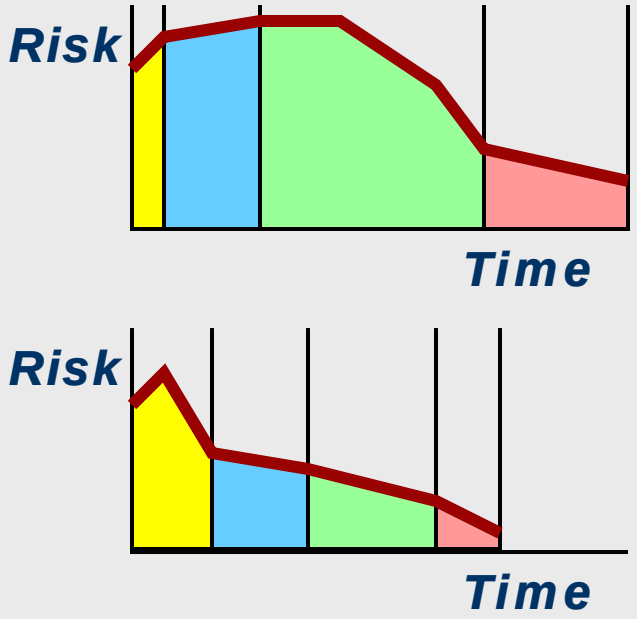
Agenda

- Heuristic Claim of SE
- Gathered results on Value of SE
  - NASA Tracking 1980s
  - "Boundary Management" study
  - "Large Engineering Projects" MIT study
  - "Impact of SE at NASA" (SECOE 02-02)
  - "Impact of SE on Quality & Schedule" Boeing
  - "SE Effectiveness" IBM study
- "Value of SE" research (SECOE 01-03)

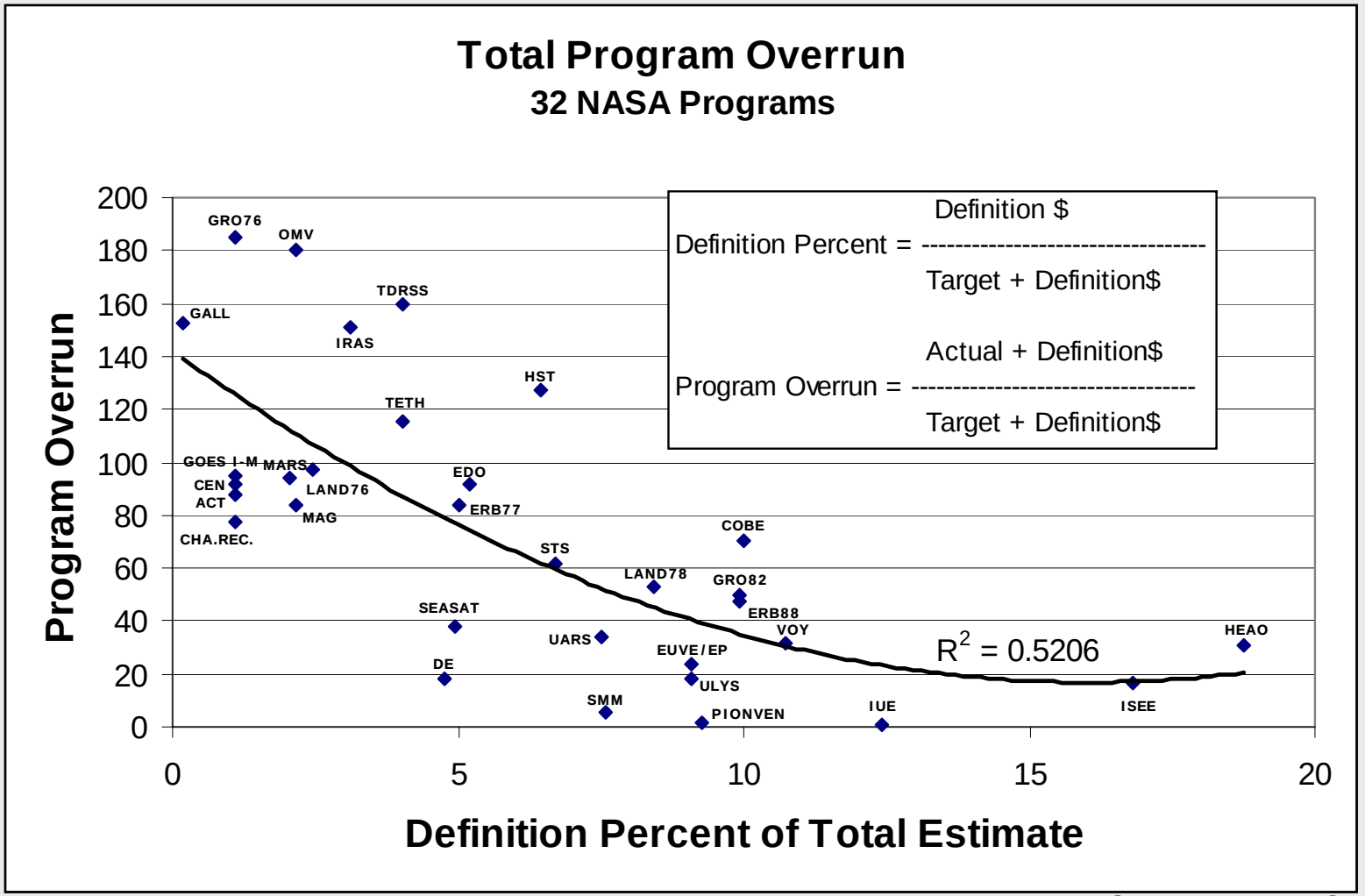
Heuristic Claim of SE

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





NASA Tracking 1980s



Source Werner Gruhl
NASA Comptroller's Office

"Boundary Management" Study

- **Study of 45 high-tech new product development teams**

  ...Ancona and Caldwell, Research Technology Management, 1990

- **Significant portion of time is spent at team boundaries**

Successful teams spent more time in boundary management

Processes used did not correlate with success

Individual Time Spent

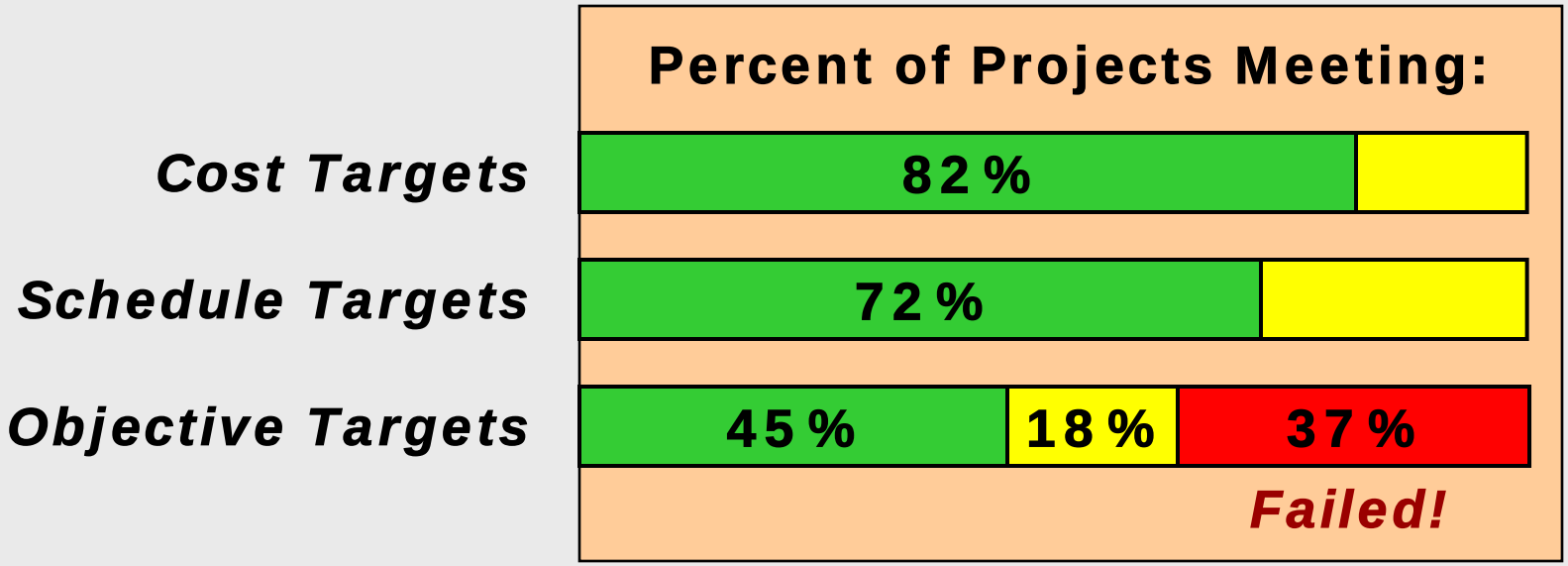
- **Outside Team 14% ***
  - *** Typically limited to few individuals**
- **Within Team 38%**
- **Alone 48%**

"Large Engineering Projects"

- **Study of 60 LEPs (power generation, transportation, oil production, technology)**

***The Strategic Management of Large Engineering Projects*, MIT Press 2000**

- **Evaluation by interviews and by objective and subjective quality measures.**



"Large Engineering Projects"

Significant Findings:

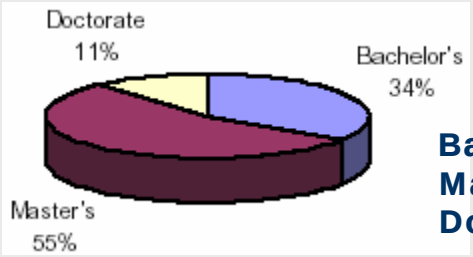
- Most important determinant was a coherent, well-developed organizational/team structure
  A structure of leadership creates greater success
- Technical difficulties, social disturbance, size were not statistically linked to performance
  - *All projects had turbulent events*
- Technical excellence could not save a socially unacceptable project
  Process definition is important but not sufficient.

Impact of SE at NASA (SECOE 02-02)

Participating Organization

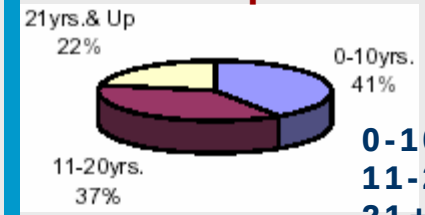
NASA	136
INCOSE	243
Total	379

Education Level



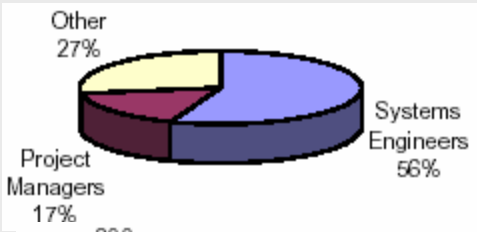
Bachelor	34%
Master	55%
Doctor	11%

Work Experience

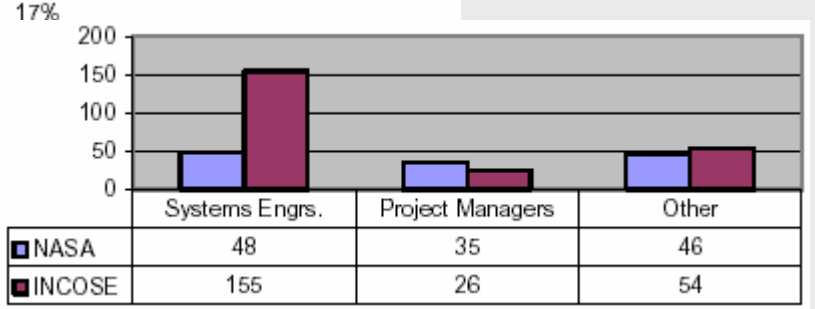


0-10	41%
11-20	37%
21+	22%

Job Titles

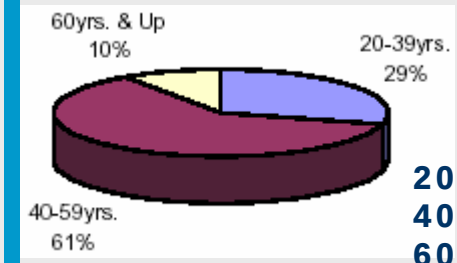


SE	56%
PM	17%
Other	27%



...significant differences by organization

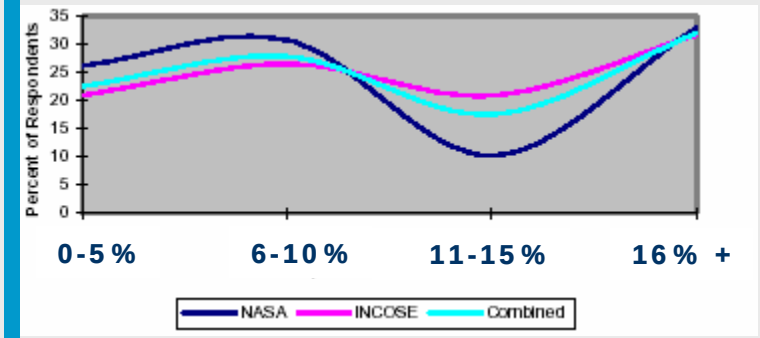
Age Groups



20-39	29%
40-59	61%
60+	10%

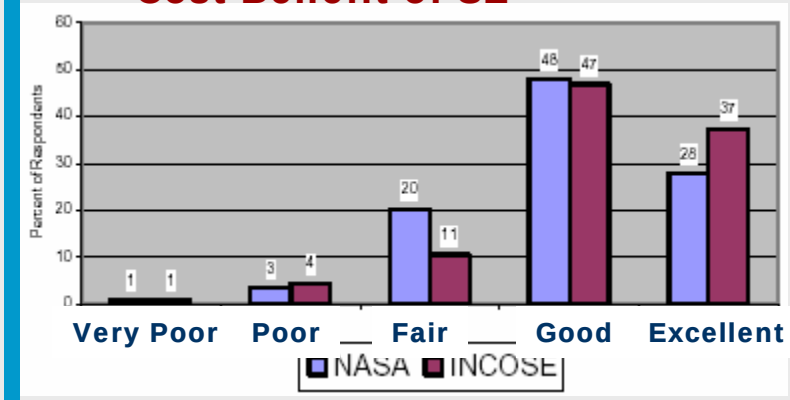
Key Survey Results - Cost

Percent Spent on SE



- Respondents marked bracket to show percent of total cost spent on SE on last project.
- Mode at 6-10% of project
- Few projects spent 11-15%
- Unexplained bimodal response >16% (perhaps interpretation of "project")

Cost Benefit of SE



- Respondents believe strongly in cost benefit of SE
- In secondary question, few respondents could quantify
- INCOSE respondents much higher % SEs, had more positive beliefs

Impact of Systems Engineering on Quality and Schedule

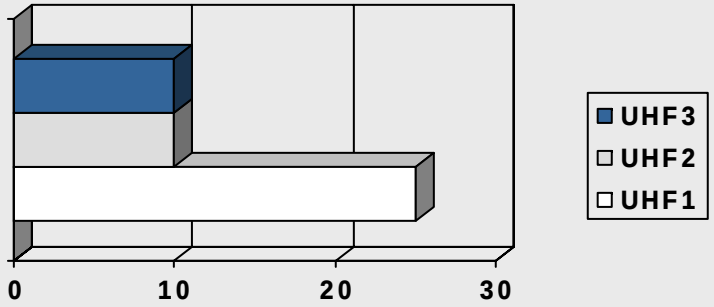
- **Empirical evidence obtained from three parallel (same time) projects**
  - **Each developed a complex, robotic Universal Holding Fixture (UHF)**
  - **Each used a different level of SE**
  - **Results are compared**

Trait	UHF1	UHF2	UHF3
Size	10' x 40'	8' x 50'	6' x 14'
Accuracy	±0.005"	±0.003"	±0.003"
Contact Sensors	None	57	108
Vacuum Sensors	1	70	108
Real-time checks	No	Yes	Yes
Probe contours	No	Yes	Yes
NC interface	No	Yes	Yes

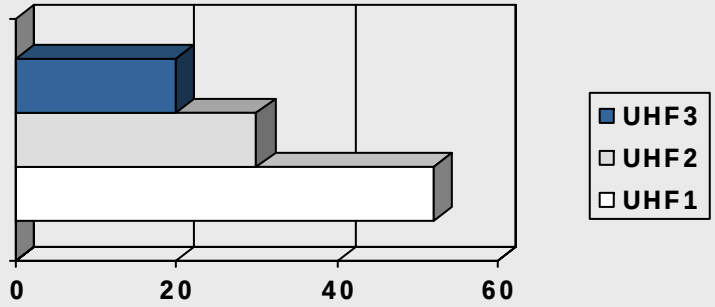
***Impact of Systems Engineering on Quality and Schedule – Empirical Evidence*, W. Forrest Frantz, Boeing Corp. 1995**

Impacts

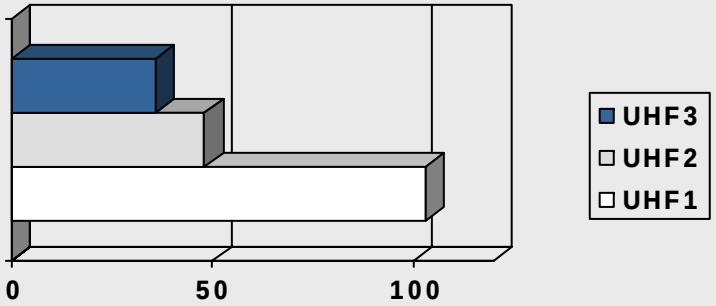
Requirements to RFP (weeks)



Design to Production (weeks)



Overall Development Time (weeks)



- **Use of better SE reduced**
  - **Overall cycle time**
  - **Time to create req's**
  - **Time to design / produce**
  - **Time to test**

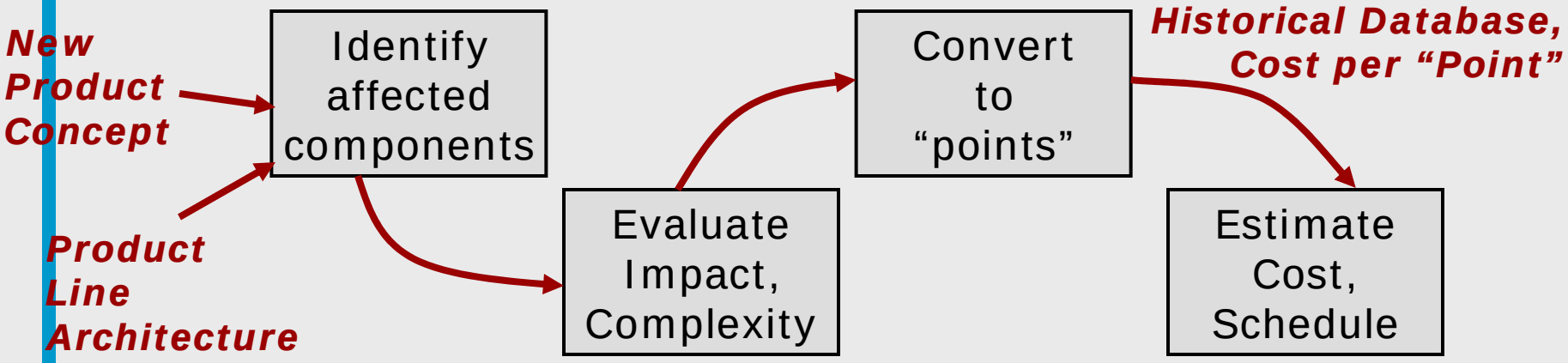
...even in the face of more complex, higher quality systems!

Systems Engineering Effectiveness

- **Study of 8 software product development projects during upgrade of SE processes**

  ***Determining Systems Engineering Effectiveness*, Bruce Barker, IBM Commercial Products, Conference on Systems Integration, Stevens Institute 2003**

- **Evaluation by cost and schedule against a standard estimating method.**



Costing method applies only to project management, business management, systems engineering, system integration, and delivery into production. Application development costs are not included.

Systems Engineering Effectiveness

Significant Findings:

- Impact and complexity provide an effective method to perform parametric costing.

  Early parametric costing works.

- Preliminary data indicates that the use of Systems Engineering will improve project productivity when effectively combined with the Project Management and Test Processes.

  Systems engineering improves productivity.

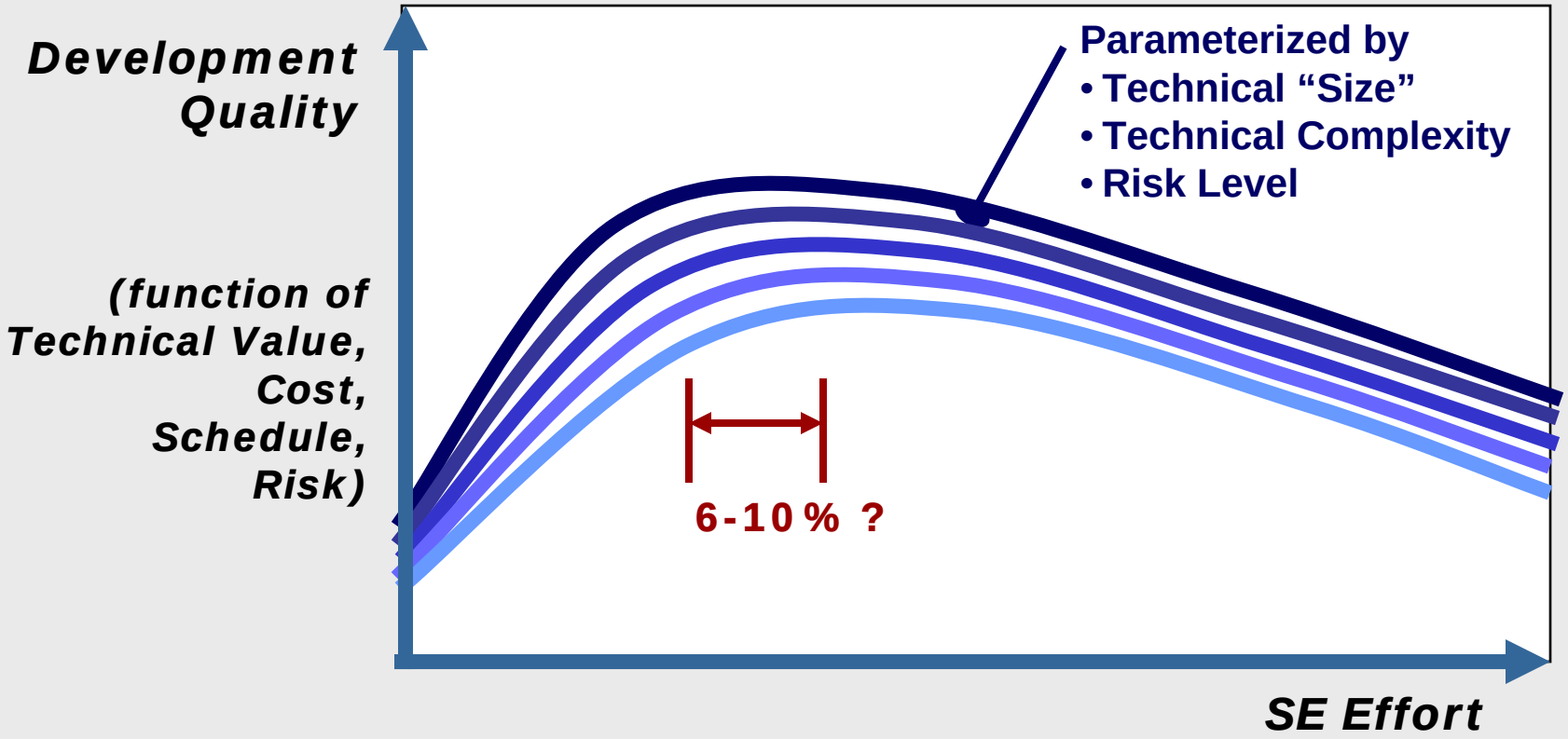
$/Point Averages

Without SE	$1,350/pt
With SE	$944/pt

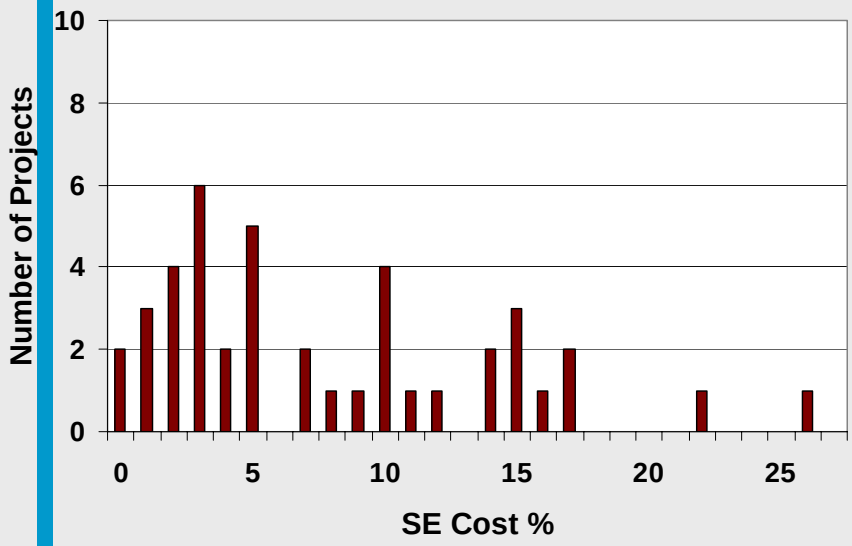
2000	$1,454/pt
2001	$1,142/pt
2002	$818/pt

"Value of SE" (SECOE 01-03)

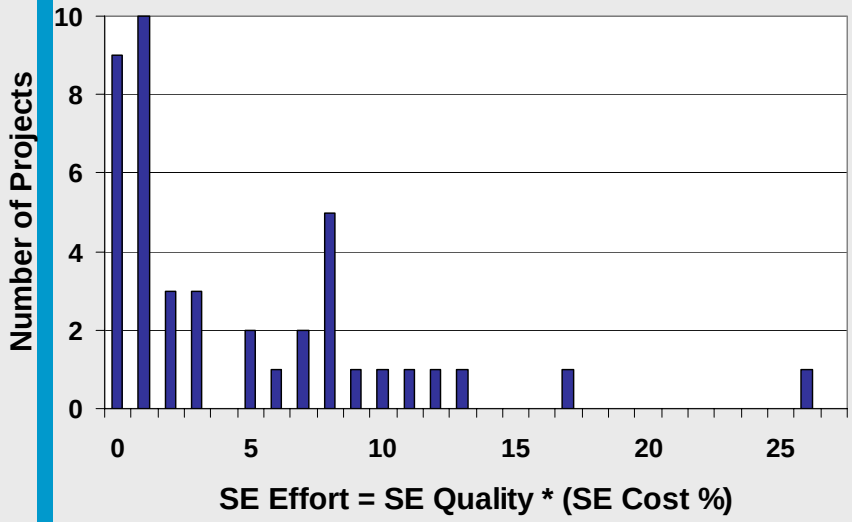
- Multi-year effort to obtain statistical data
- Correlate amount/quality of SE with project quality/success



Respondent Data

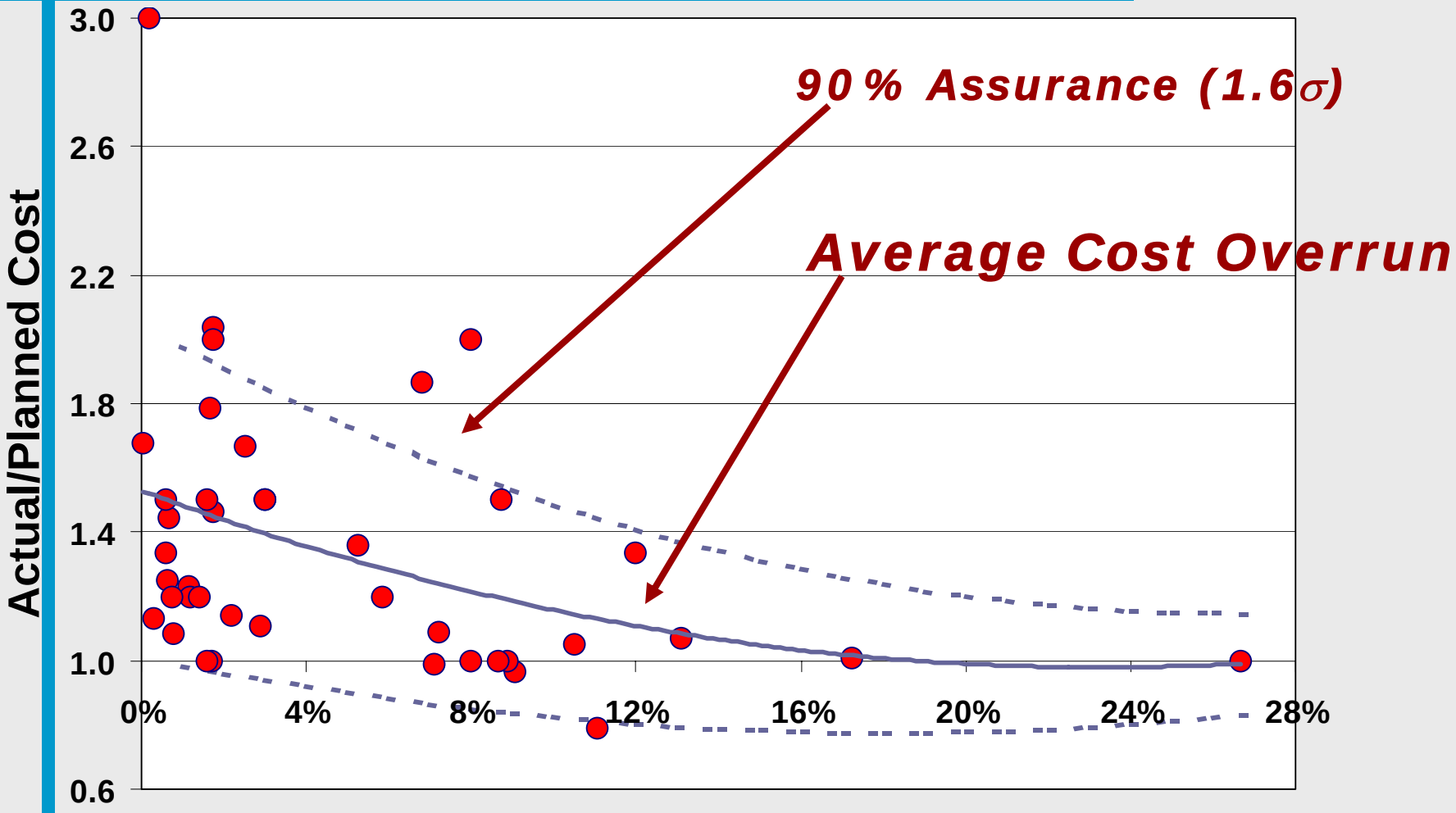


- 43 respondents
- 1 project not completed
- Values $1.1M - $5.6B
- SE Cost 0.3% - 26%



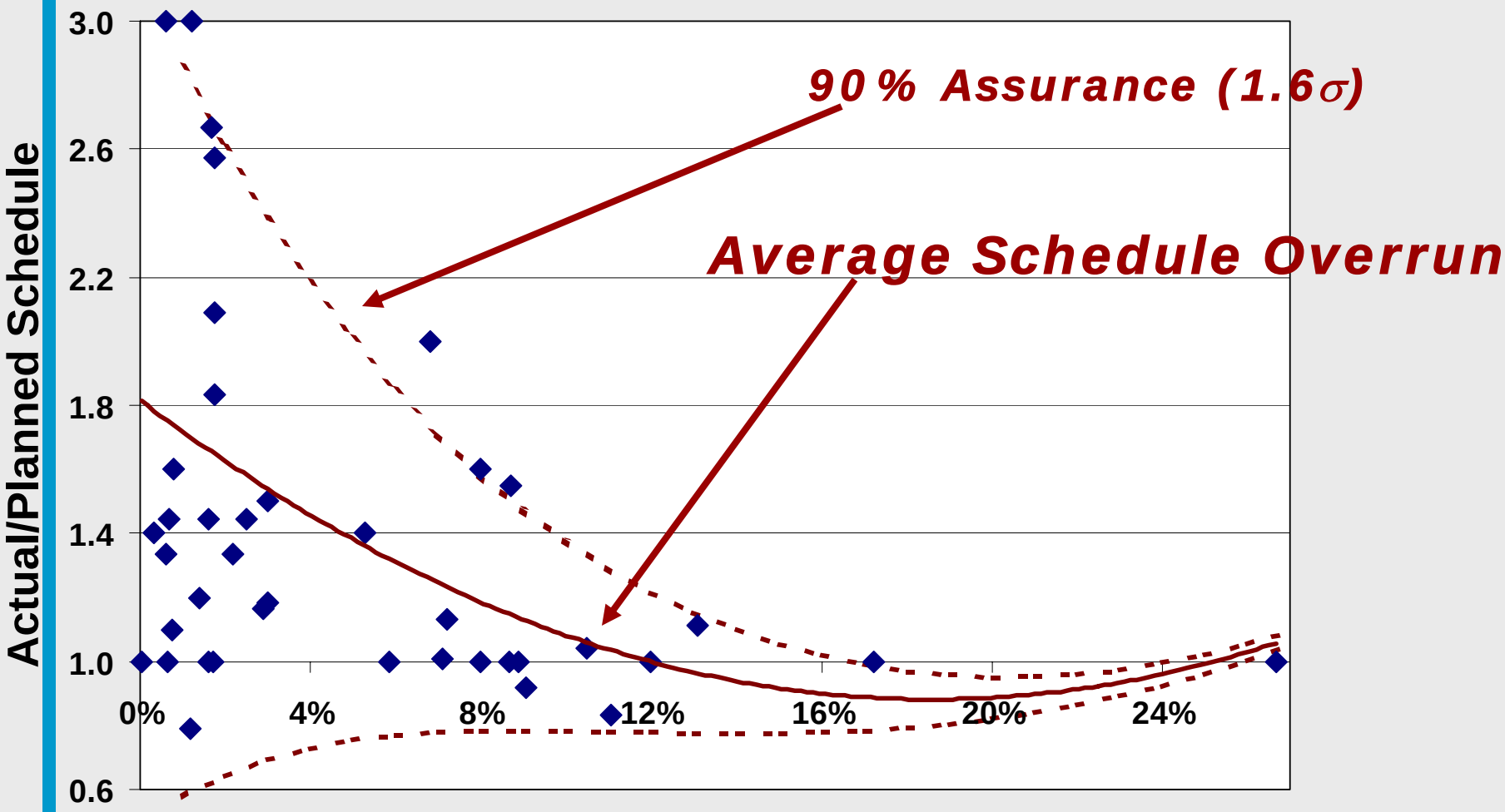
- Cost, schedule, quality correlate better with "Systems Engineering Effort":
- SEE = SE Qual * (SE Cost %)

Cost Overrun vs. SE Effort



SE Effort = SE Quality * SE Cost/Actual Cost *Honour, "Value of SE" INCOSE 2004*

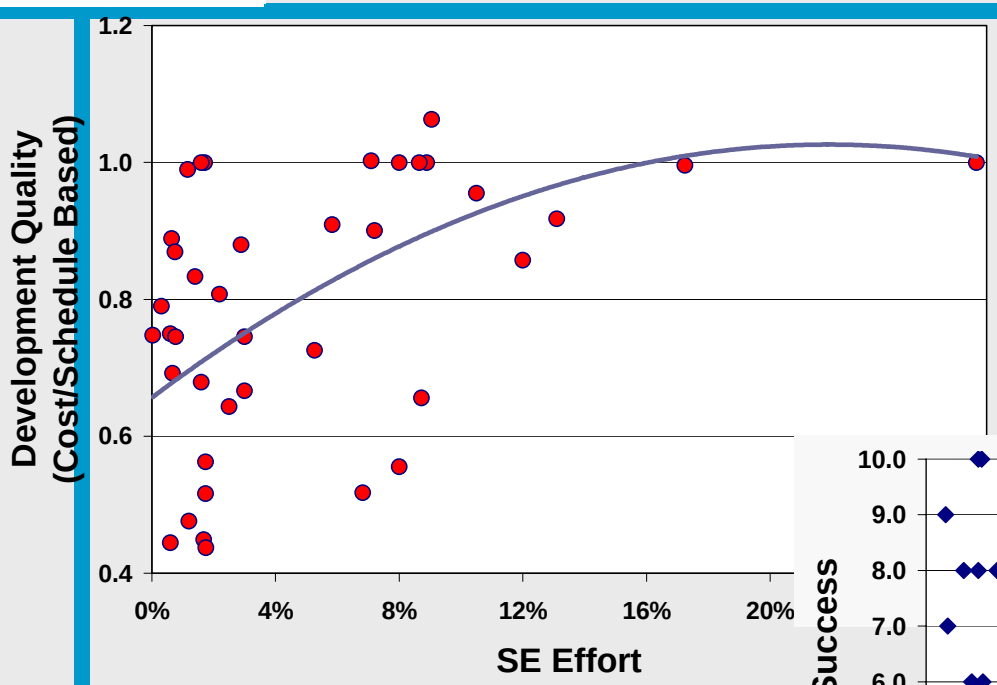
Schedule Overrun vs. SE Effort

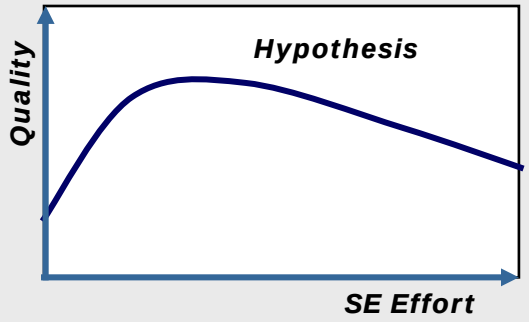


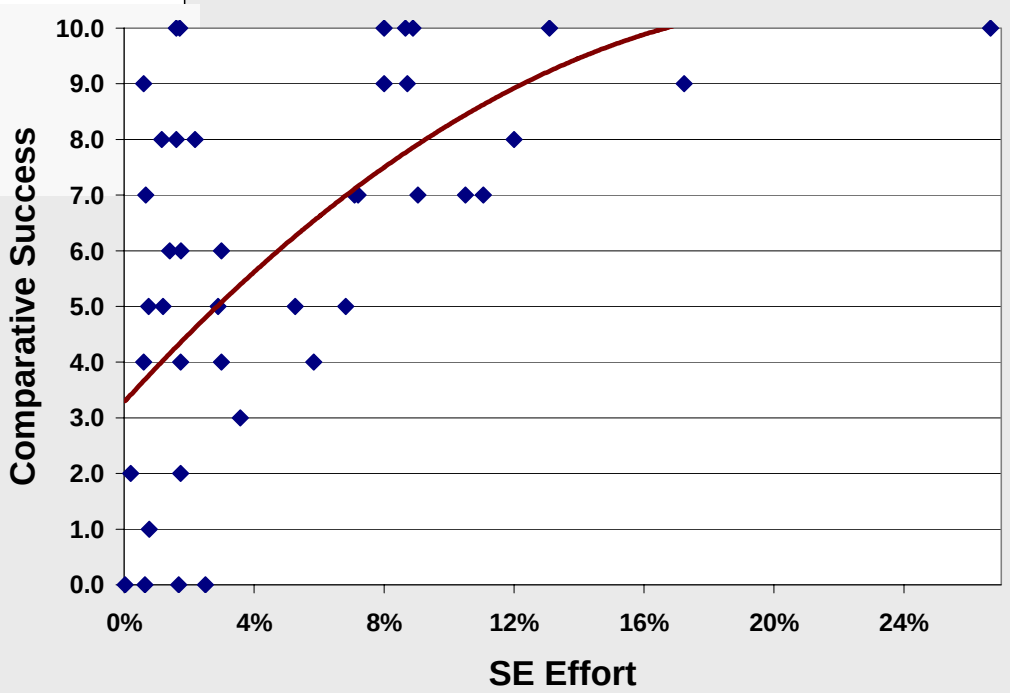
SE Effort = SE Quality * SE Cost/Actual Cost

Honour, "Value of SE" INCOSE 2004

Test Hypothesis: Quality







Honour, "Value of SE"
INCOSE 2004

Conclusions "Value of SE"

- **SE effort improves development quality**
  - Cost, schedule, subjective
  - Hypothesis is supported by the data
- **Optimum SE effort is 10-15% or more**
  - Cost, schedule overruns are minimized
  - However, note wide dispersion of data
  - Also note few data points at this level; most projects spent far less
- **Quality of the SE effort matters**
  - Lower quality SE reduces effectiveness

Honour, "Value of SE"
INCOSE 2004

Questions?

Eric Honour
Honourcode, Inc.
Director, INCOSE SECOE
Pensacola, FL, USA
+1 (850) 479-1985
ehonour@hcode.com

Survey Data

Total Development Project Data

Fill in these fields for one project. Provide end-project estimates if the project is not yet complete.

Planned Cost		**Actual Cost**	
Thousands US$		*Thousands US$*	
Planned Duration		**Actual Duration**	
Decimal months		*Decimal months*	
Sys Engr Cost		**Sys Engr Quality**	
Thousands US$		*Subjective 0(none)-5(normal)-10(unexcelled)*	

Project Success Measures

Fill in these fields for one project. Provide end-project estimates if the project is not yet complete.

Objectives Success		**Comparative Success**	
Normalized to 1.0 (subjective if necessary)		*Subjective 0(none)-5(normal)-10(unexcelled)*	
Production Quantity		**Unit Life Cycle Cost**	
Count		*Thousands US$*	

Survey Definitions

- ***Systems Engineering Cost*** **- all costs to perform traditional SE tasks, no matter who performs them. Typical:**
  - **Technical management and coordination**
  - **Mission and/or need analysis**
  - **System architecting**
  - **System-level technical analysis**
  - **Requirements management**
  - **Risk management**
  - **...and other tasks associated with these.**

Survey Definitions

- ***Systems Engineering Quality*** **- subjective evaluation of the overall quality of the systems engineering effort. Scale of 0-10**
  - **0 represents SE having no useful value,**
  - **5 represents a normally effective SE effort,**
  - **10 represents unexcelled, world class quality.**

- ***Comparative Success*** **- subjective evaluation of the overall project success against other comparable projects. Scale of 0-10**
  - **0 represents a failed project,**
  - **5 represents a project comparable in success to most other projects**
  - **10 represents unexcelled, world class success.**

Known Limitations

- **Self-reported, unchecked data**
  - **Subjective data items**
  - **No quality controls**
- **Definition of "Systems Engineering"**
  - **"SE Cost" dependent on respondent perception**
- **Respondent base not controlled**
  - **Respondents primarily systems engineers**
- **Perceptive influences are likely**
  - **Hypotheses well known, widely accepted**
  - **Respondents likely to have subconscious bias**