Optimal Project Performance: Factors that Influence Project Duration

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Agenda: Project Duration

- Introduction
  - Causation and the Laugh Test
  - Overview of QSM Database
- Methodology Used
- Influential Factors
- Myths
- Summary

Introduction

- Speedy delivery is almost always a primary project goal.
- Software projects need to quickly deliver reliable software.
- However, it is often difficult to determine which factors have the largest influence on project duration.
- If we want to improve, we need to know where to focus our improvement efforts.

"Too many Government IT projects cost hundreds of millions of dollars more than they should, take years longer than necessary to deploy, and deliver technologies that are obsolete by the time they are completed."
OMB memo, June 28, 2010

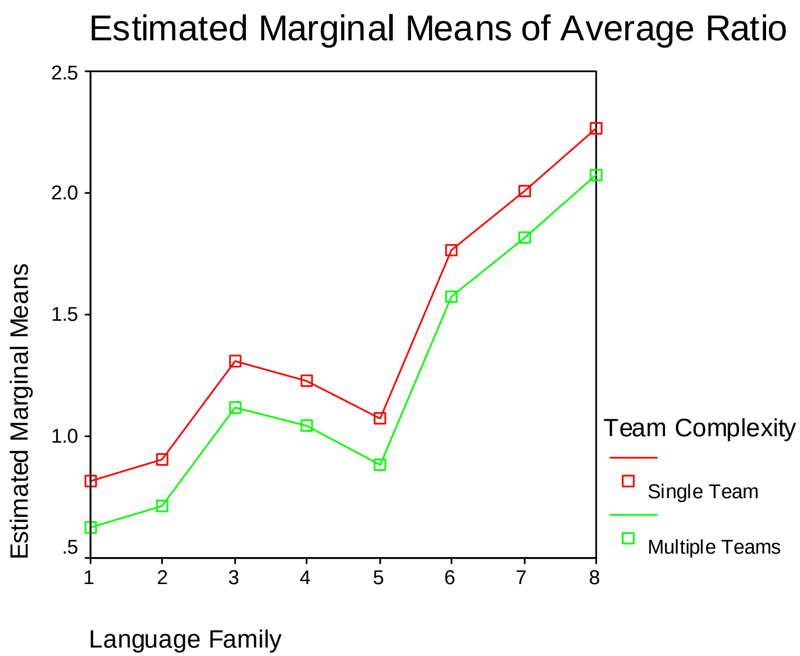
Causation: Post Hoc

Retrospective studies (in absence of DOE) must meet these criteria to make a good case for causality:

- Association
- Temporal Priority
- Non-spuriousness
- Theoretical Adequacy

There are two clocks that keep perfect time.
When “a” points to the hour, “b” strikes.
Did “a” cause “b” to strike? -- D. Huff, 1954

Causation: Confounding Factors



Apparent causation could be due to:

- A third factor, correlated to the supposed cause
- Interaction between two or more factors (higher order effects)

Therefore, potential confounding factors must be investigated

Example of eliminating potential confounding factor: graph shows no interaction between programming language and team complexity.

Data Mining Issue: The Laugh Test

Software cannot discriminate between an important strong association and something that is obvious and trivial.

Your conclusions will have to pass the "laugh test" with the project team.

Twyman's Law: If it looks interesting, it is probably wrong.

Image: photostock / FreeDigitalPhotos.net

QSM Database

- Over 10,000 ***validated*** projects in current set
  - Size regimes
  - Global
  - Application types
  - Industry sectors
- Annual updates, ~ 500 new projects per year
- Metrics
  - Life cycle activities
  - Financial
  - Quality
  - Application

"You better hurry. Management wants the data cleaned up by tomorrow morning."

J.B. Landers ©

A Note on Application Types

- We often group application types into three "super groups", as project performance is similar within each of these groups:
  - The Business group includes business (IT) systems
  - The Engineering group includes: command & control; system software; telecommunications; scientific; and process control
  - The Real time group includes: avionics; real time; microcode & firmware
- This presentation focuses on Business and Engineering super groups

Methodology

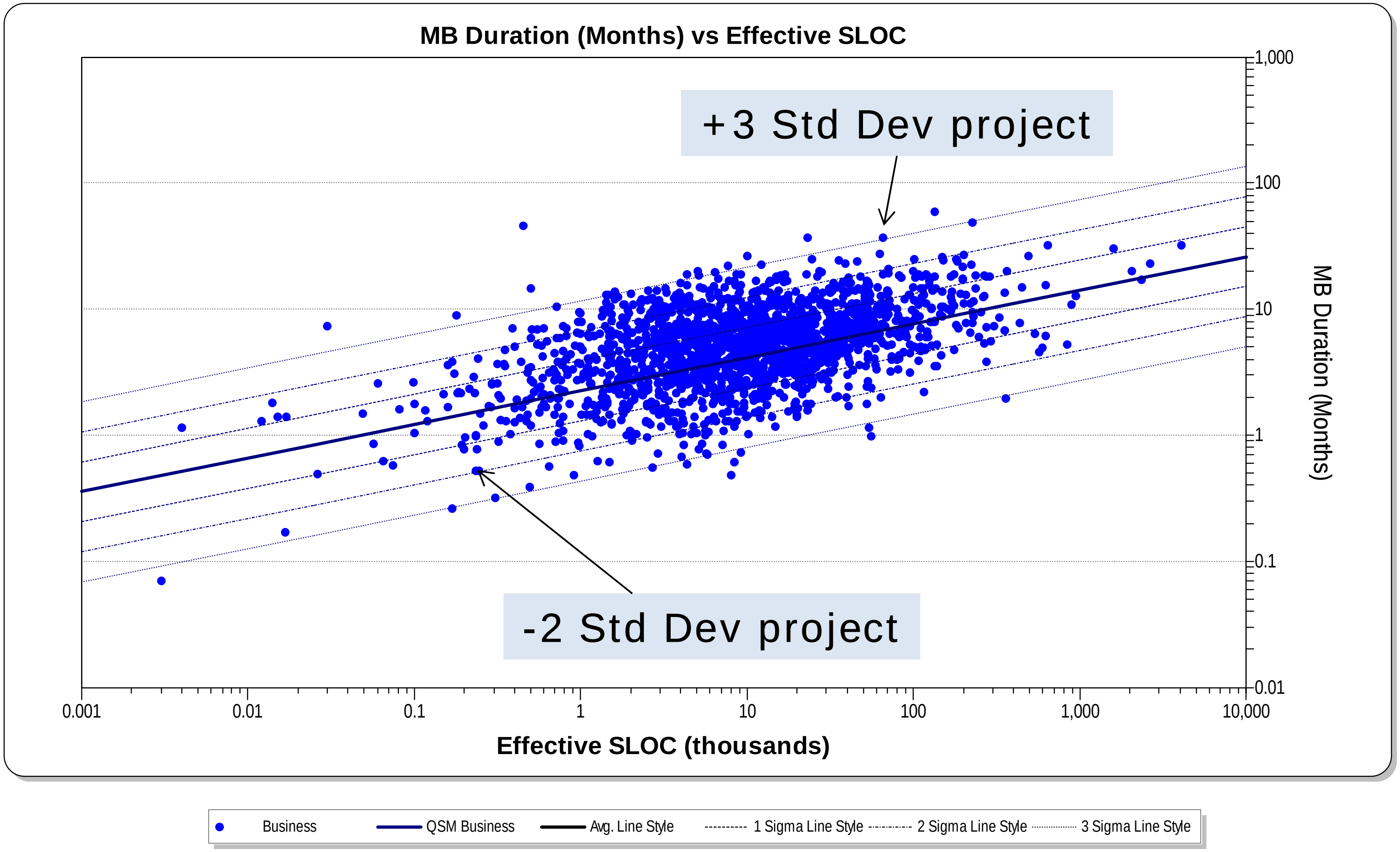
- First step: Create an output variable (Y) that measures project duration
- Y = f(X)
- Key Process Input Variables (X's) drive critical process output variables (Y's)
- Standardize the start and end milestones
- Select a Y that is a normalized measure of project duration...

Normalized Factor

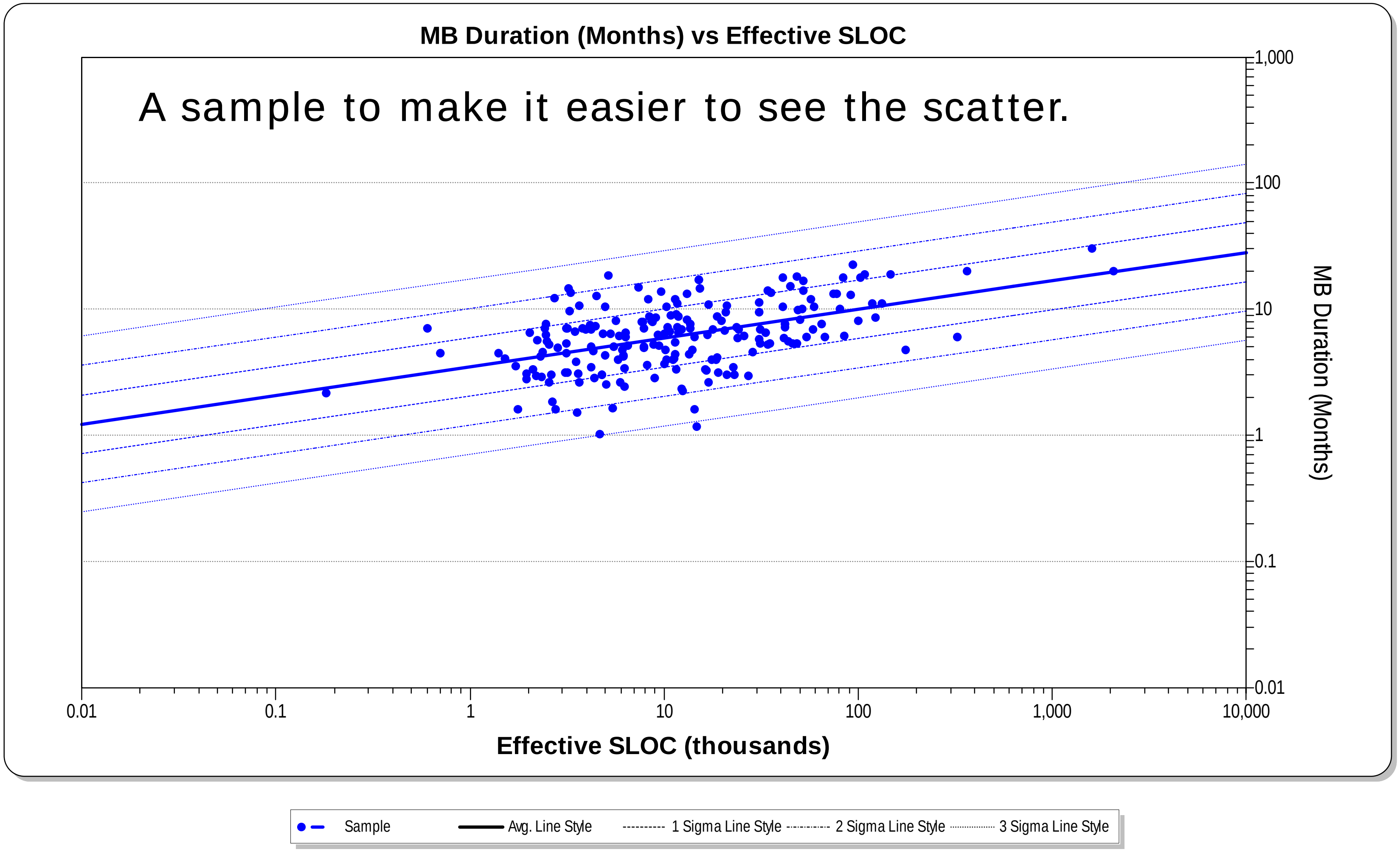
- Stratify for super group
- Normalize for size
  - Larger projects take longer
  - Relationship between size and duration is exponential
- Standardized residual for regression of log ESLOC versus Log Duration for "main build" (code/test).
  - Number of standard deviations the project is above or below the regression line.
  - Graph on next slide…

Standard Deviation is frequently used as a measure of dispersion in a set of data with normal distribution.

Normalized Factor

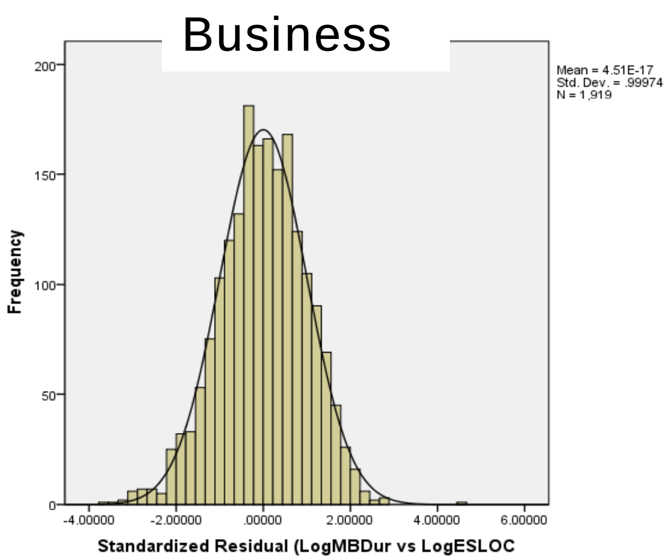


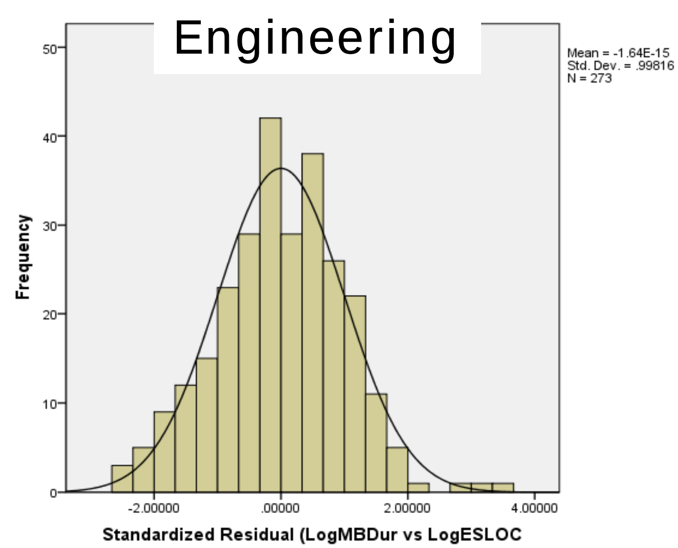
Sample Projects



Normalized Factor

- Negative numbers denote number of standard deviations project is below the predicted value, so negative numbers are shorter durations.
- Standardized residuals fit a normal distribution, can be used for project comparisons.

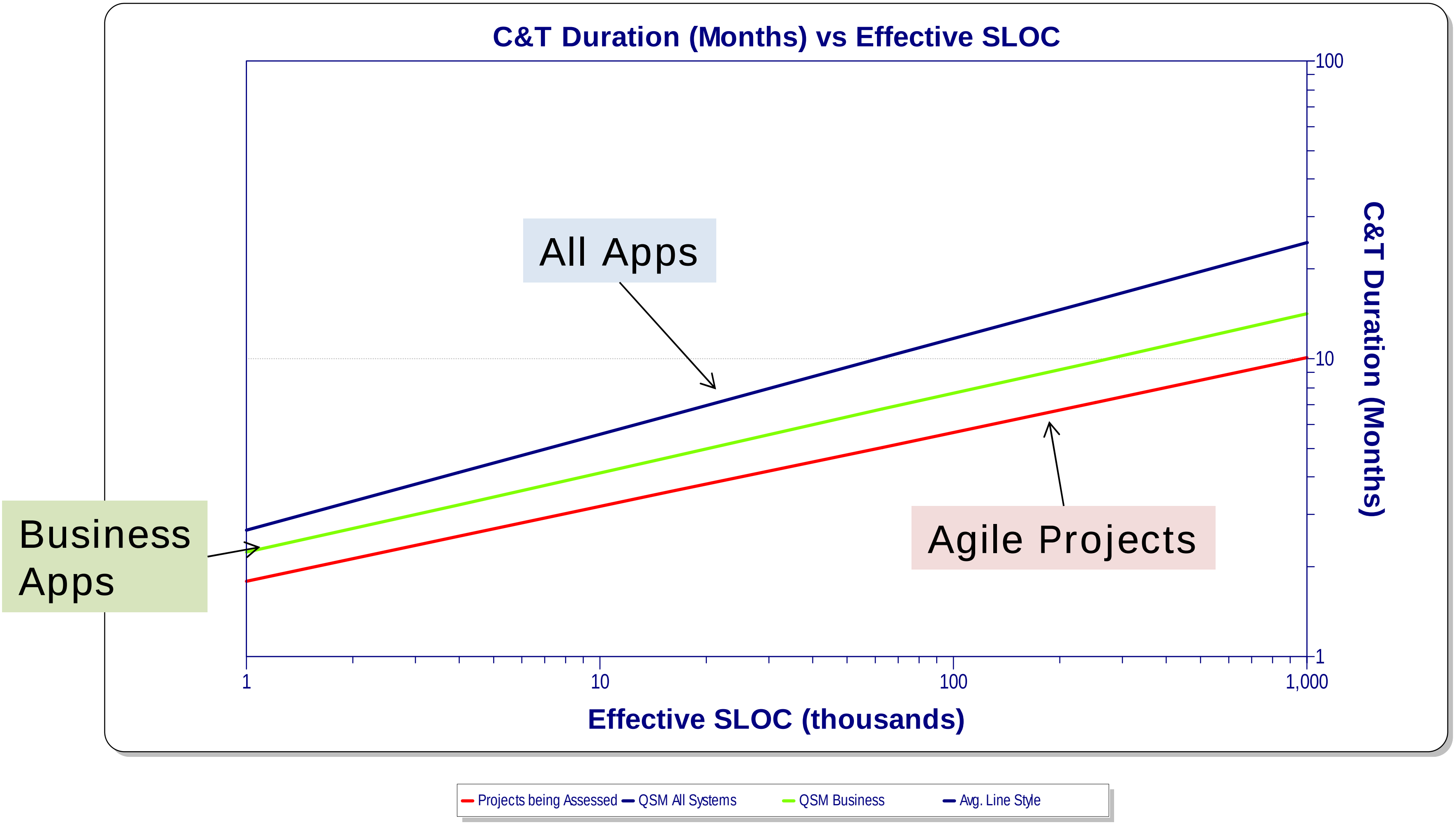




Influential Factors

- 40 Quantitative Variables examined, two general observations:
  - Overlap in months correlates positively with duration
  - Error and reliability metrics correlate with duration
- 45 Qualitative Variables examined, general observations for Business and Engineering projects:
  - Motivation and Leadership more important for Business
  - Tooling is more important for Engineering
  - Look at Myths
- But first, Agile…

Agile Project Duration



Agile Project Duration

Comparison of Projects being Assessed to QSM Business
C&T Duration (Months) vs. Effective SLOC

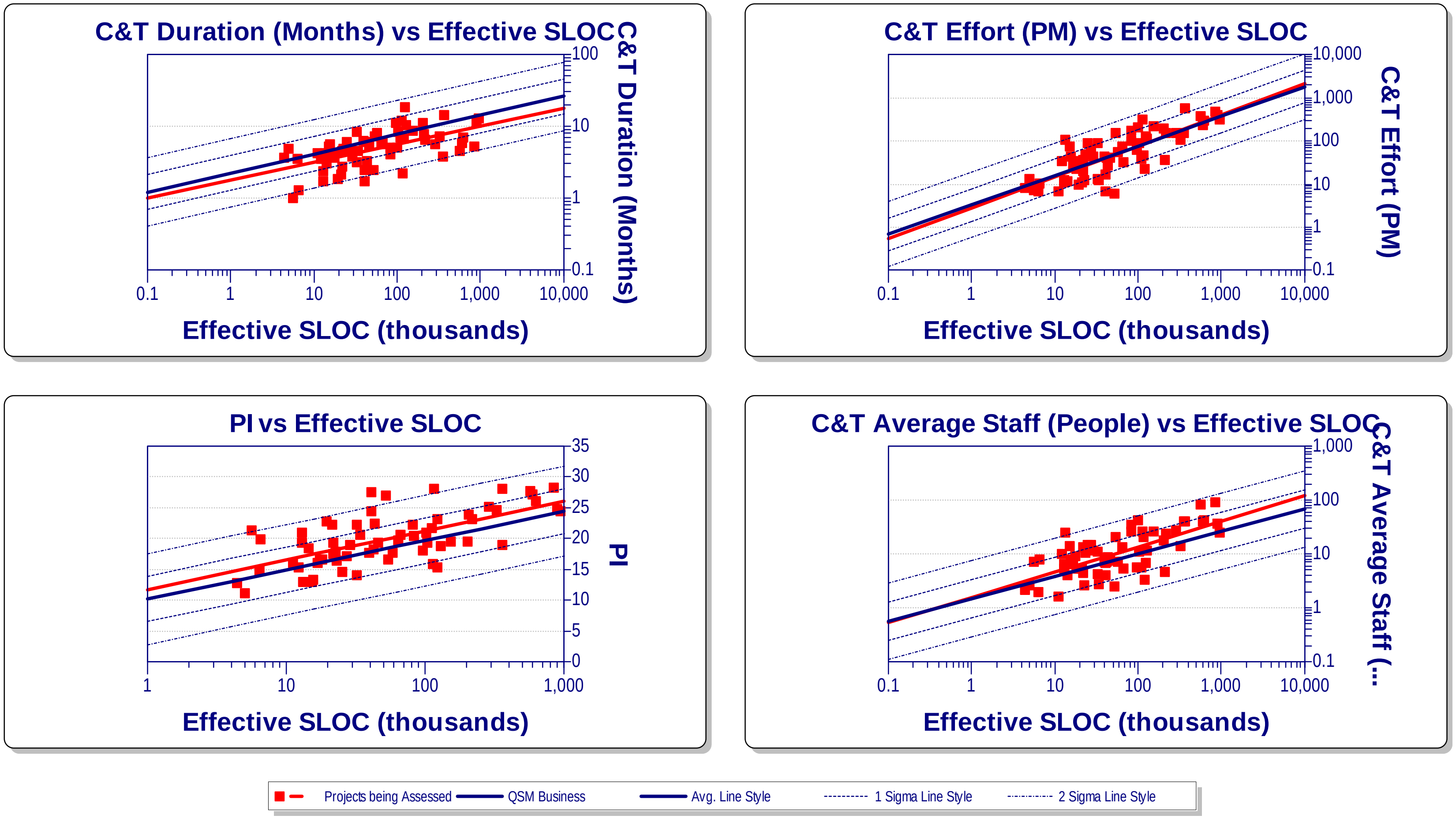
	C&T Duration (Months) Values				
	at Min Effective SLOC: 4400	**at 25% Quartile Effective SLOC: 18000**	**at Median Effective SLOC: 42870**	**at 75% Quartile Effective SLOC: 122888**	**at Max Effective SLOC: 952614**
Benchmark Reference Group: QSM Business	3.33	4.84	6.10	8.08	13.94
Comparison Data Set: Projects being Assessed	2.59	3.69	4.58	5.96	9.95
Difference From Benchmark	-0.74	-1.16	-1.52	-2.12	-3.99

- Smaller projects, ~ 1 month shorter
- Median size projects, ~ 1.5 months shorter
- Larger projects, ~ 2 to 4 months shorter

Agile Projects Software Types: 56 business, 8 other

Agile

Phase 3 Trends

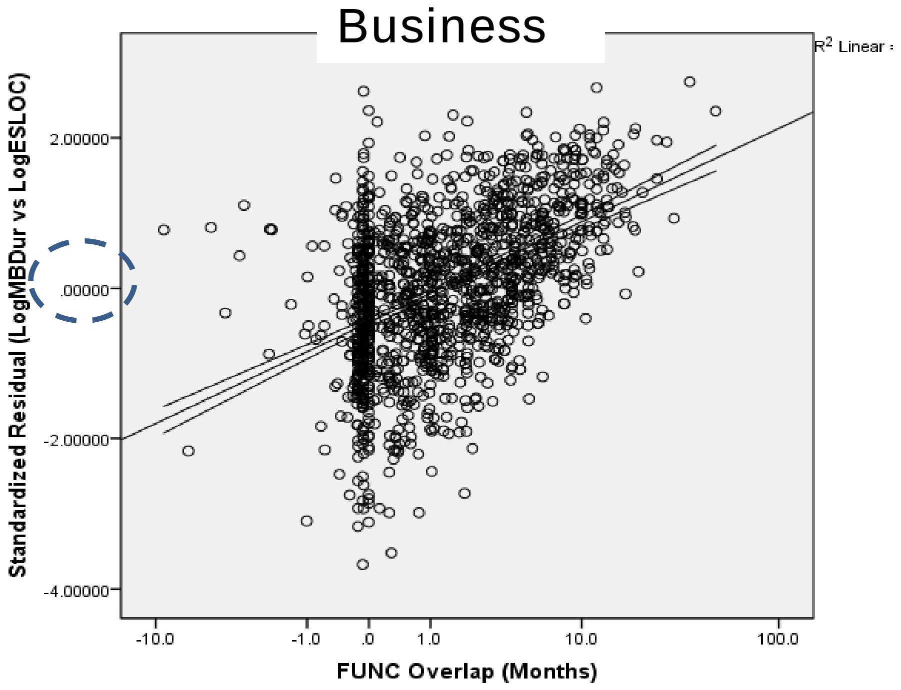


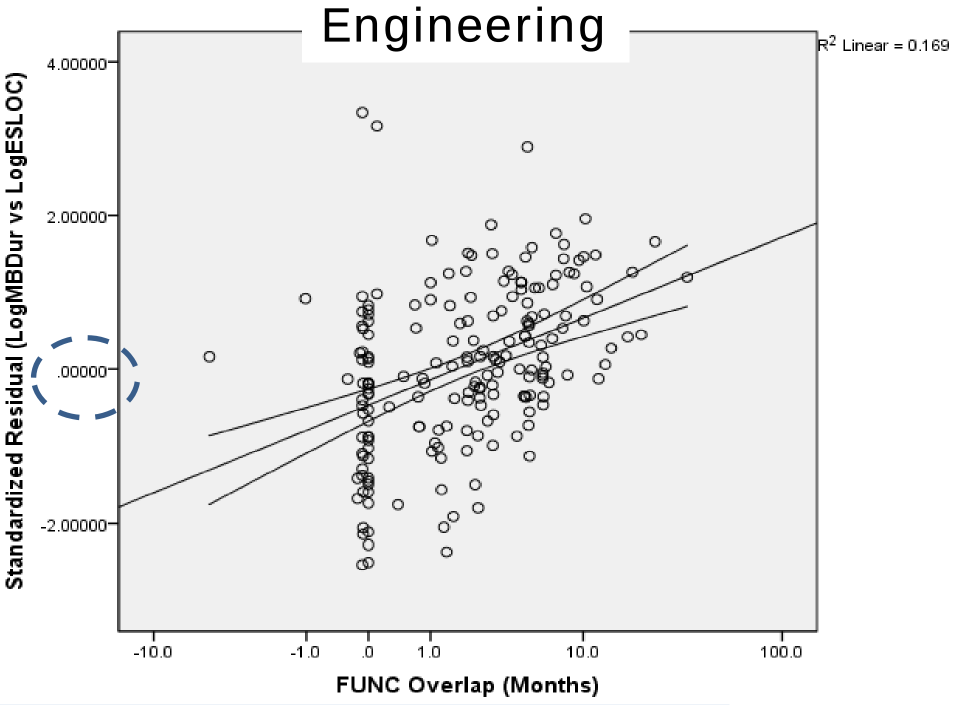
Phase Overlaps

- Phase overlaps occur in attempt to shorten overall project duration
- Major phase overlaps are associated with longer durations!
- The following two graphs have the months of phase 2 overlap (Functional Design) on the horizontal axis. This is the number of months that Functional Design overlapped with Main Build. The vertical scale is the standardized residual of duration where higher values represent projects that had longer duration than predicted by project size.

Phase Overlaps

In general, longer overlaps result in longer overall duration.





Sloping lines are linear regression and 95% confidence interval on the mean

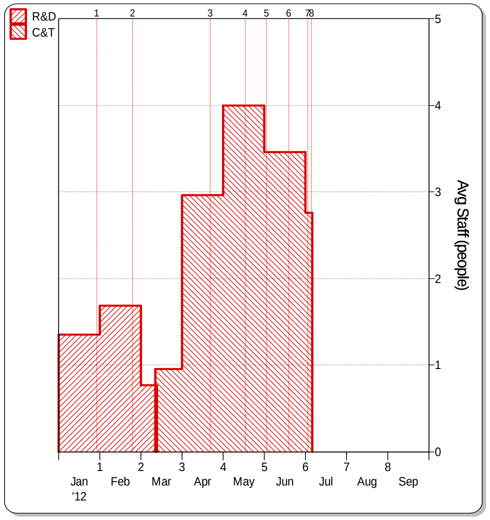
What does overlap look like?

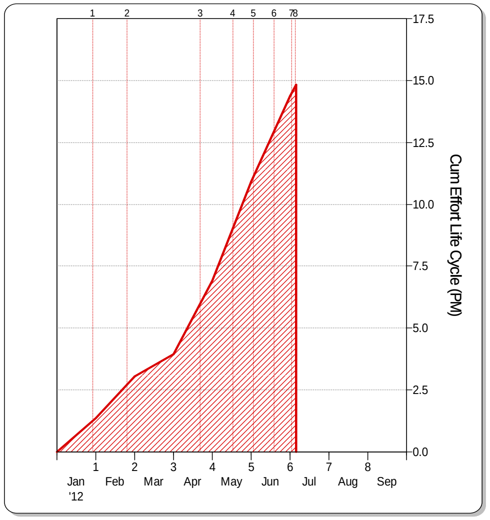
- Key metrics of effort, staff, duration and size
- Low overlap <= median overlap

Super-group	Functional Design Overlap		FUNC Overlap (Months)	MB Effort (MM)	MB Duration (Months)	MB Peak Staff (People)	Effective SLOC	Standardized Residual (LogMBDur vs LogESLOC)
Business	Low	Median	.0	11.6	3.8	8.0	7714	-.35
		Mean	.2	37.8	4.6	14.0	20183	-.37
	High	Median	3.8	26.9	7.4	10.0	10809	.48
		Mean	5.2	68.4	8.4	18.2	48331	.47
Engineering	Low	Median	.0	27.5	5.2	7.8	12319	-.35
		Mean	.1	71.6	7.6	13.7	48087	-.38
	High	Median	4.5	178.8	16.0	15.8	79677	.29
		Mean	5.4	536.3	17.6	45.6	169833	.30

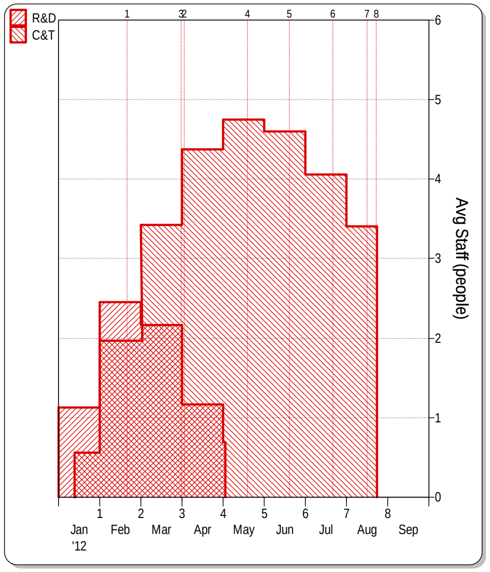
Staffing Curves for Median Projects

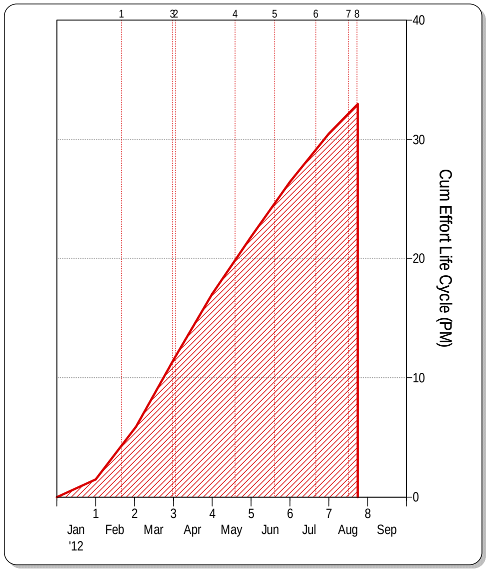
Low overlap
PI = 14.5





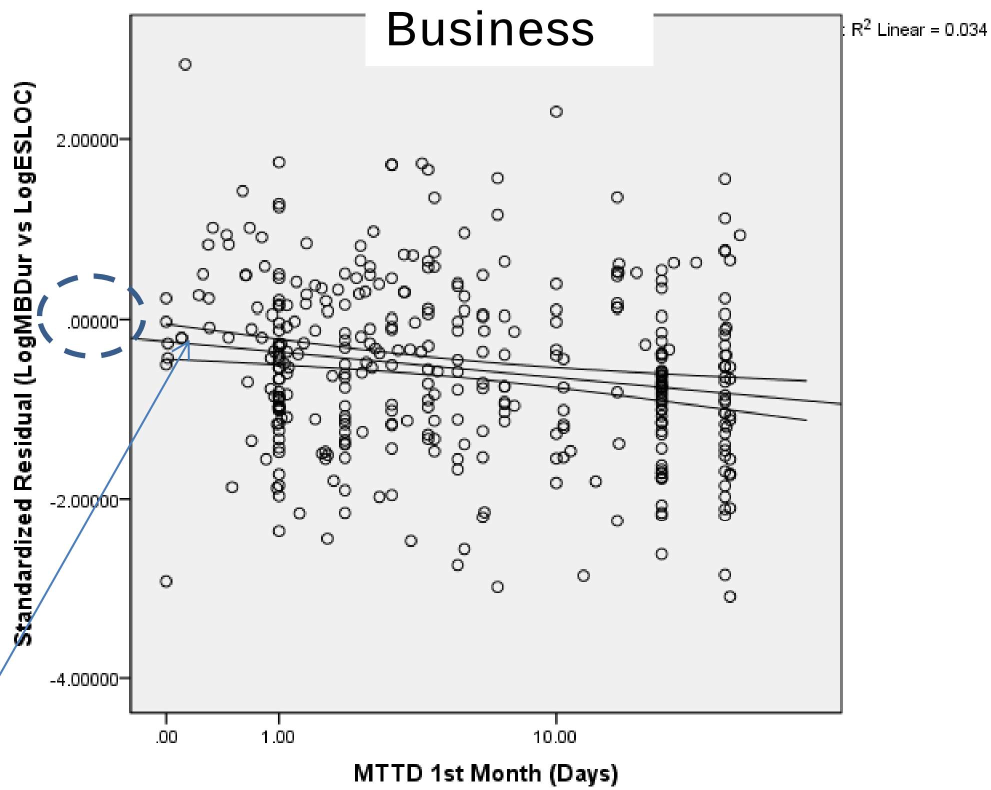
High overlap
PI = 11.1





Quality Correlations

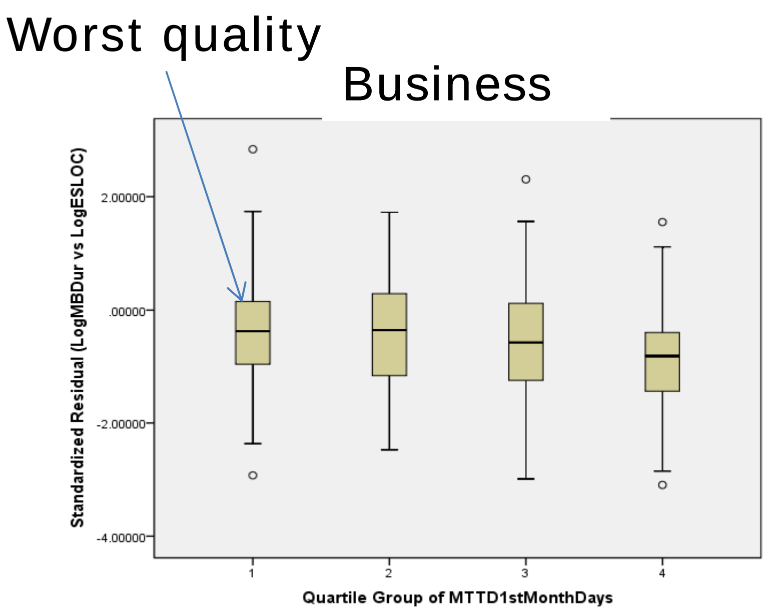
- More errors result in longer durations, and higher reliability results in shorter durations
- Reliability for business applications, trend line with 95% confidence interval on the mean

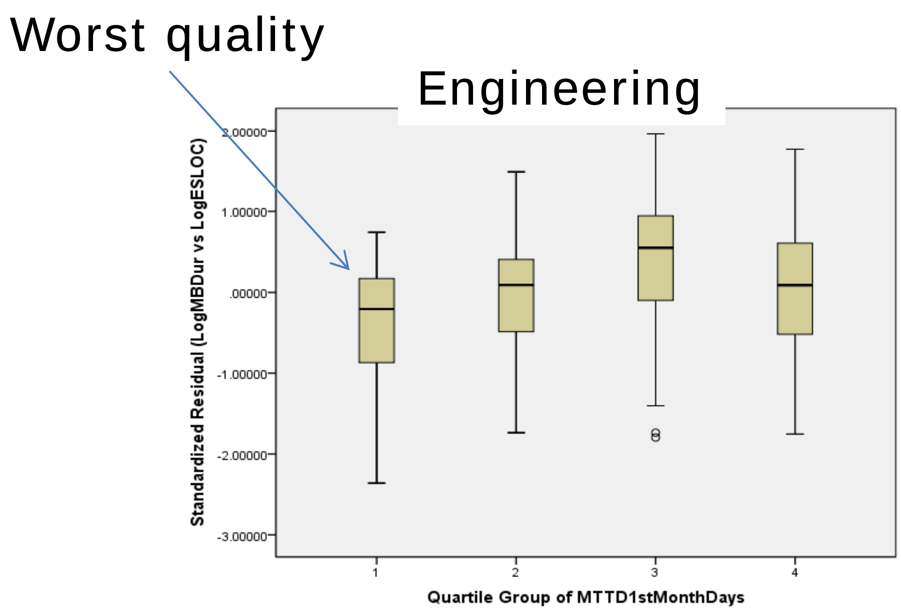


Trend line is under zero because standard was computed on all projects, while those projects that reported MTTD typically had shorter durations than those that did not.

What About Engineering Projects?

- Each box represents a quartile of MTTD
- Vertical scale is duration residual





Quality Recap

- For Business Applications, initial quality of the product is key for achieving shorter durations
- For Engineering Applications, result is different. Quality is more commonly created by extending the duration (except for some of the highest quality systems). The quality requirement drives the duration by impacting test/fix time.

"As the Japanese learned in 1950, productivity moves upward as the quality of process improves." W. E. Deming

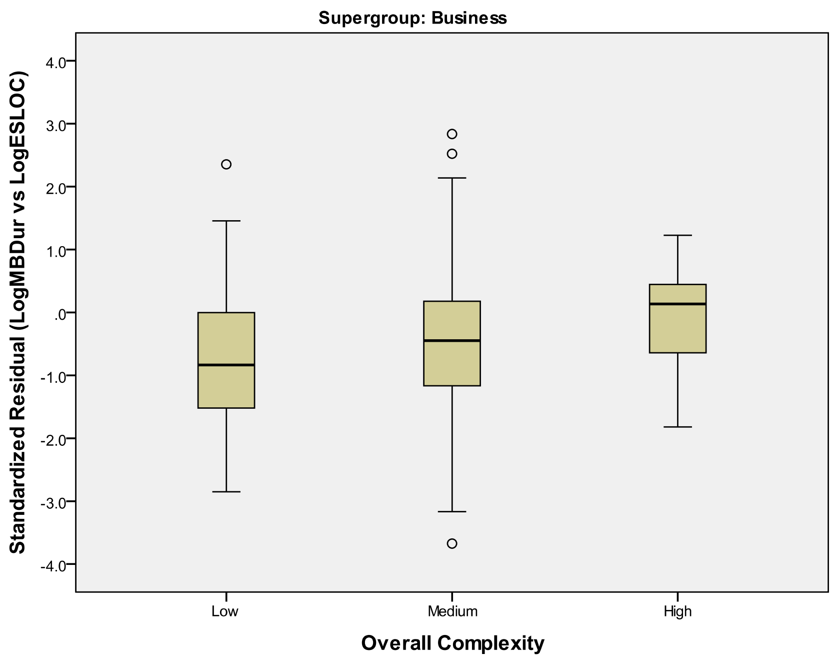
Qualitative Factors

- Scale of 0 to 10, from none to high
- 45 factors examined
- Assessment factors are qualitative and somewhat objective, however:
  - Operational definitions used
  - General conclusions can be drawn from looking at large differences and groups (clustering, association) of ratings
- Differences noted for Business versus Engineering

Qualitative Factors, Business

- Technical and communication complexity is important to the duration of business application development projects.
- **Overall complexity** is the overall technical complexity, higher numbers represent higher complexity. The coefficient is positive, meaning that higher complexity is longer duration.
- **Team Comm Complexity** is the level of team communication complexity. Higher numbers mean more complexity. The coefficient is positive, meaning that higher complexity is longer duration.

Business: Overall Complexity



Overall Complexity	Median	Mean
High	**.14**	-.10
Medium	-.45	-.49
Low	**-.83**	-.74
Total	.02	.00

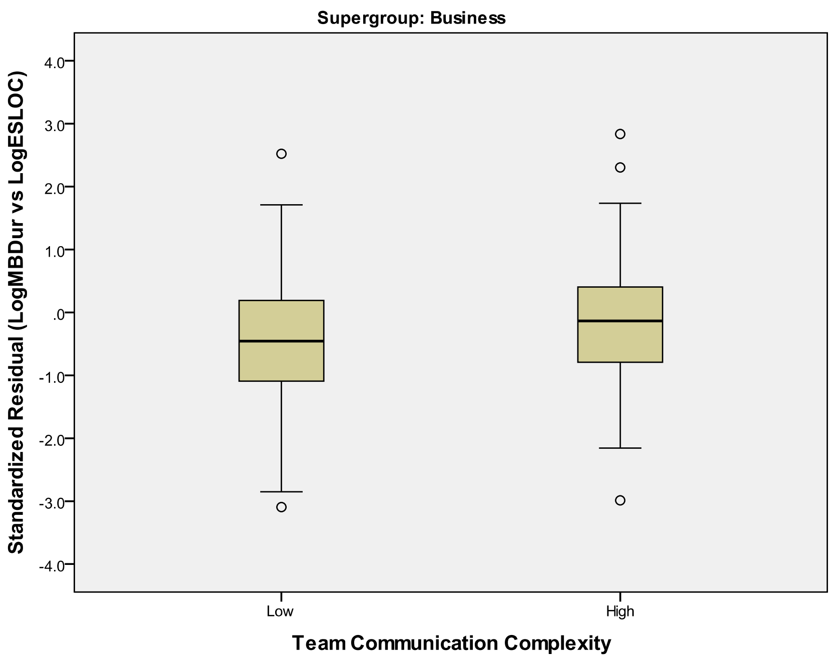
Overall complexity of 1 to 4 is "Low", 5 to 8 is "Medium" and 9 to 10 is "High".

The lowest complexity projects tend to have the shortest durations.

The median business project with high complexity is 0.14 standard deviations above the duration trendline, whereas the median low complexity project is 0.83 standard deviations below the duration trendline.

That is a difference of almost a full standard deviation.

Business: Team Communication Complexity



Projects with low team communication complexity tend to have the shortest durations.

Team Communication Complexity of 1 to 4 is "Low" and 5 to 10 is "High".

Team communication complexity is a significant factor, although it does not have as strong an influence as overall complexity.

Qualitative Factors, Engineering

- Factors that had the highest significance to duration are:
  - **Design tooling** is the capability of the design tool, 10 is high capability. The correlation is negative, so that higher capability results in shorter duration.
  - **Closeness arch limit** is how close to the architectural limits of the development environment (memory, storage, etc.) The correlation is positive so that a higher closeness results in a longer duration.
  - **Construction tooling** is the capability of the construction tool, 10 is high capability. The correlation is positive so a higher capability results in shorter duration.

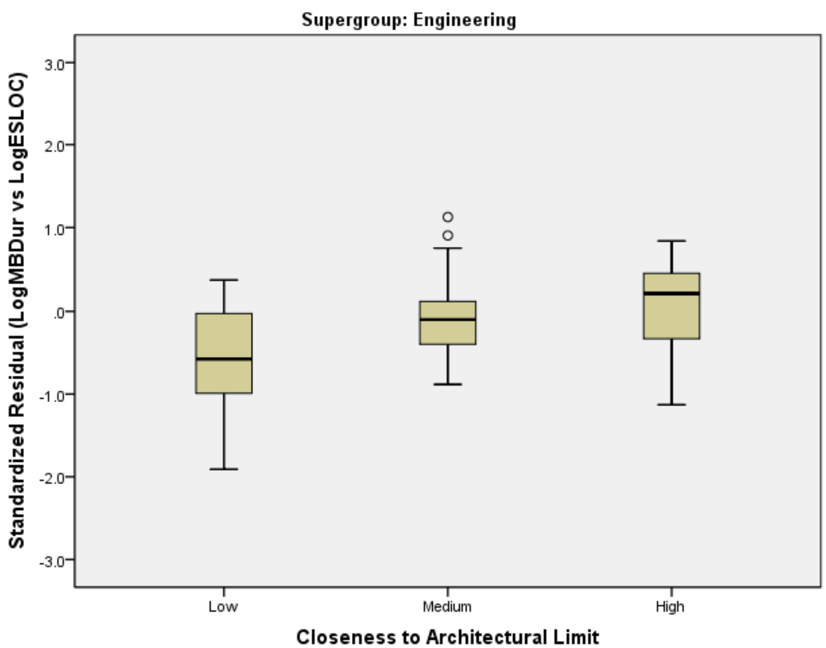
Engineering: Design Tooling

Design Tooling	Median	Mean
High	**-.76**	-.74
Medium	-.09	-.20
Low	**.32**	.15
Total	-.00	.00

Engineering projects with the best design tools tend to have shorter durations.

In the box plot, Design Tooling of 1 to 3 is "Low", 4 to 6 is "Medium" and 7 to 10 is "High".

Engineering: Closeness to Architectural Limit

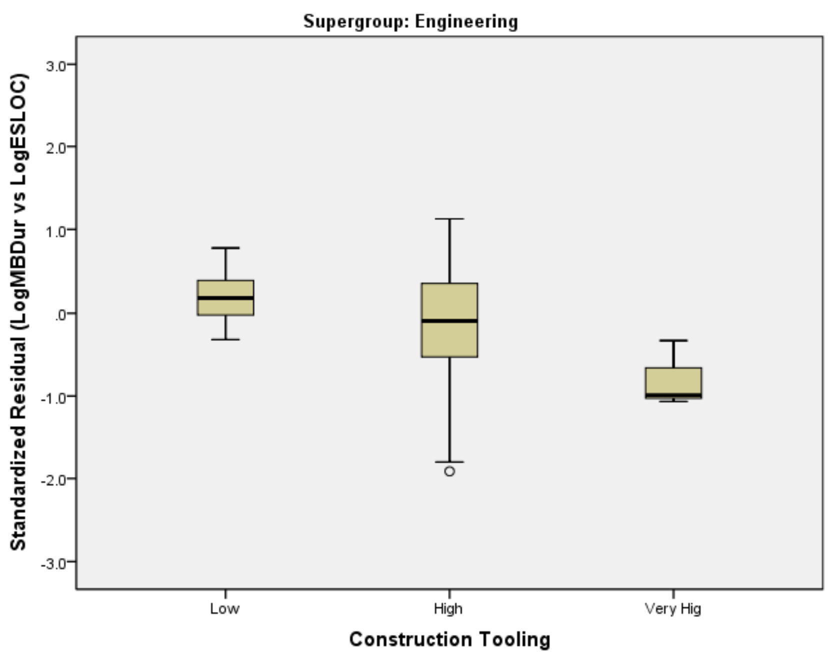


Closeness to Architectural Limit	Median	Mean
High	**.22**	.05
Medium	-.10	-.00
Low	**-.58**	-.57
Total	-.00	.00

For engineering projects, as the system approaches the architectural limits the duration increases.

In the box plot, Closeness to Architectural Limits of 1 to 2 is “Low”, 3 to 5 is “Medium” and 6 to 10 is “High”.

Engineering: Construction Tooling



Construction Tooling	Median	Mean
Very High	**-.99**	-.80
High	-.09	-.16
Low	**.18**	.20
Total	-.00	.00

Durations become gradually shorter as Construction Tooling ratings increase from five to ten. Improving the tools from 1 to 6 makes little difference.

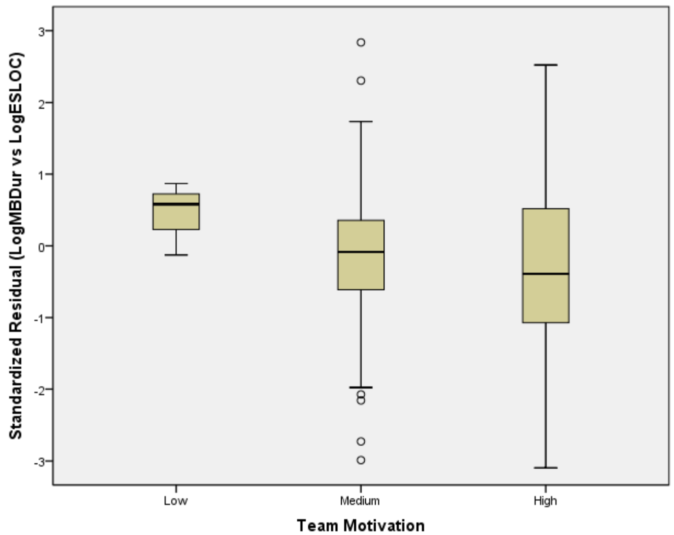
In the box plot, Construction Tooling of 1 to 6 is "Low", 7 to 9 is "High" and 10 is "Very High".

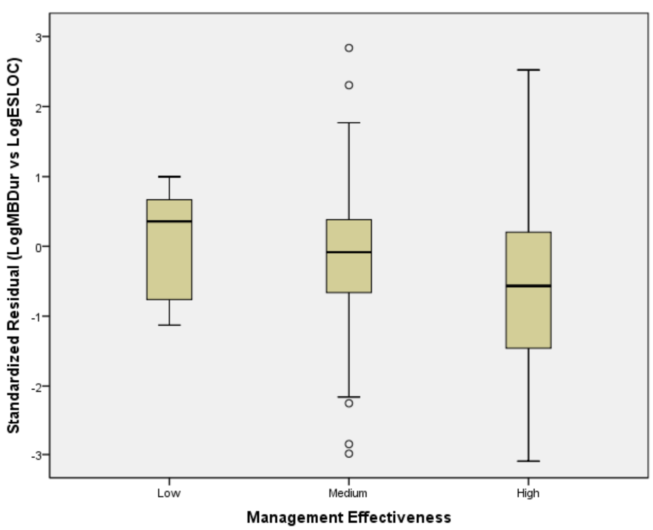
A typical engineering project with construction tools rated as 10 has a duration that is a full standard deviation shorter than the typical engineering project.

Myths

- A number of factors are considered to be important in shortening software project duration
- These include team size and team skill levels
  - There is a significant statistical relationship between average team size and duration, however it explains less than 3% of variation in the standardized residual. Staff size is more important for other output measures than it is for duration.
  - A skilled experienced team is important for many reasons, however team skill alone does not significantly affect project duration
  - Instead, team motivation and management effectiveness are important for project duration…

Non-Myths (People)





Team motivation and management effectiveness have a relationship with duration.

The significance factor is sufficient to provide evidence that the relationships are real.

Both correlation coefficients are negative, which means that, in general, as team motivation or management effectiveness increase, duration decreases.

Correlation with Standardized Residual			
Team Motivation	Correlation Coefficient	-.095
	Sig.	.035
Mgmt Effectiveness	Correlation Coefficient	-.106
	Sig.	.020

QSM® The Intelligence behind Successful Software Projects

Summary

- Project duration (time to market) is often an important constraint
- Process improvements can shorten project durations. It is important to:
  - Improve the upstream quality of the product (inject fewer defects into the constructed product)
  - Improve testing efficiency (especially in engineering applications)
  - Track and use measures of product quality
  - Minimize the overlap between major phases (the 4 SLIM phases)

Summary, continued

- Process improvements can shorten project durations. It is important to:
  - Reduce technical complexity and communication complexity where possible (especially for business application projects)
  - Improve tools for design and construction (especially for engineering application projects)
  - Either improve the architecture or modify designs so that the engineering projects are not close to the limits of the architecture (memory, storage, speed, etc.)
  - Keep the development team motivated
  - Retain effective managers and leaders

Resources

- Performance Benchmark Tables: http://www.qsm.com/resources/performance-benchmark-tables/index.html
- *Data Mining for Process Improvement*, Paul Below, Crosstalk, Jan/Feb 2011, pp 10-15. http://www.crosstalkonline.org/
- *The Keys for Long-Term Agile Success*, Chris Lucca and Larry Putnam, Jr., Webinar: http://www.accurev.com/webinars/20120216-Agile-Keys-to-Success, 2012.
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