Overcoming the Challenges of Estimating in New Development Environments

by

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What Motivates Organizations to Get Serious About Software Estimation?

- **Of the organizations that make a serious commitment to achieve a significant level of estimation competence**

  – **60% have just had a major disaster and decided they never want to live through another**

  – **30% are forced into it by their customer**

  – **10% find it's a natural step in their process improvement initiatives**

Pain is the Most Significant Motivator!

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Major Sources of Pain

- **A failure to communicate and establish realistic expectations** **(mandated schedules that are impossible)**

- **A failure to renegotiate when changes take place** **(your accommodating - willing to accept requirements changes)**

- **Ineffective mid-course corrective action** **(loading people on to accelerate the schedule - Brooks Law effect)**
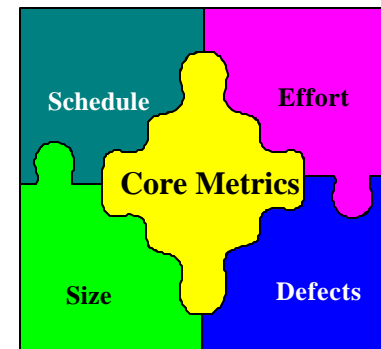
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What is estimation?

- **It is a technical activity used to support a business objective**

| Artifacts of the Product | → | Estimating Relationships | → | Execution Work Plans |

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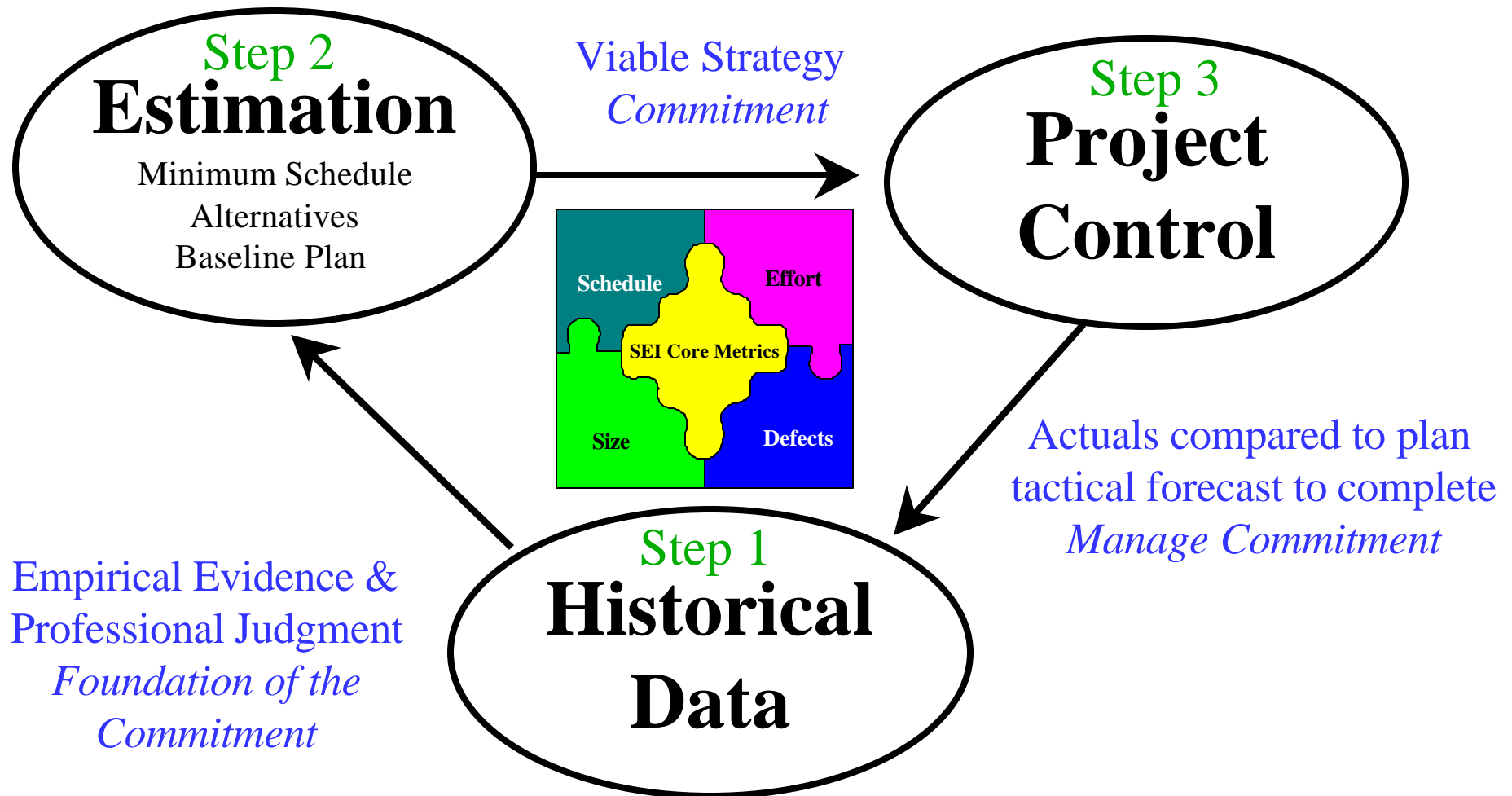
What Business Objectives Does Estimation Support?

- **Win New Business (major contracts & multi-year outsourcing deals)**

- **Schedule negotiations with customer**

- **Functionality negotiations with customer**

- **Warranty negotiations with customer**

- **Cost negotiations with customer**

- **Return on investment analysis**

- **Risk Mitigation**

Schedule	Effort
	Core Metrics
Size	Defects

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Skill Sets for Success

- **To be a successful software estimator**

  – **Good understanding of software project behavior**

  – **Good appreciation of company business objectives**

  – **Good people skills**

  – **Good problem solving skills**

  – **Good communication skills**

  – **Good conflict resolution & mediation skills**

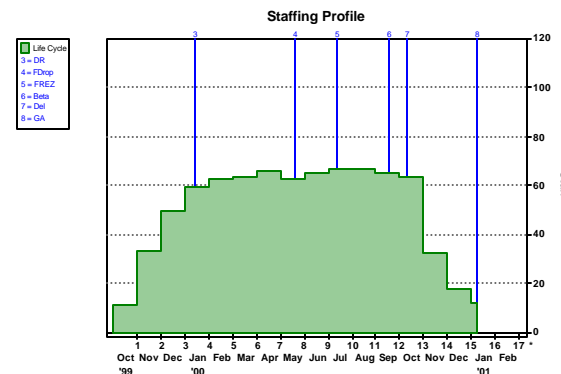 – **Good sales skills**
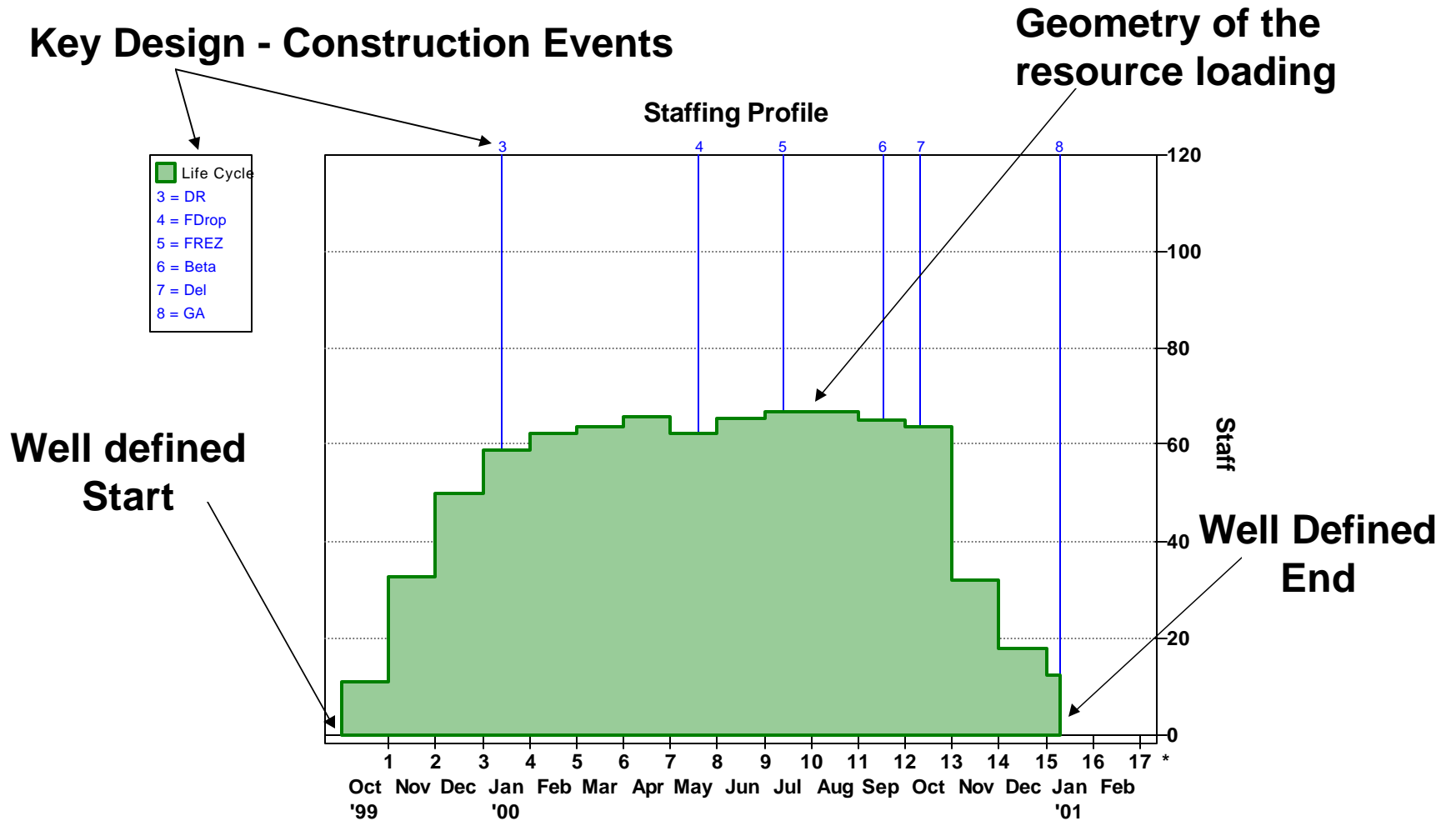
  – **Good data analysis skills**

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A Closed Loop Process is Essential

Step 2
Estimation
Minimum Schedule
Alternatives
Baseline Plan

Viable Strategy
Commitment

Step 3
Project Control

Schedule

Effort

SEI Core Metrics

Size

Defects

Actuals compared to plan
tactical forecast to complete
Manage Commitment

Empirical Evidence &
Professional Judgment
*Foundation of the
Commitment*

Step 1
Historical Data

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A Macro Software Project Model

- **Many popular software estimation techniques model the way people solve design intensive problems**

  - **Software production equation**

  - **Resource allocation equation (time based distributions - staffing, defects, product construction)**

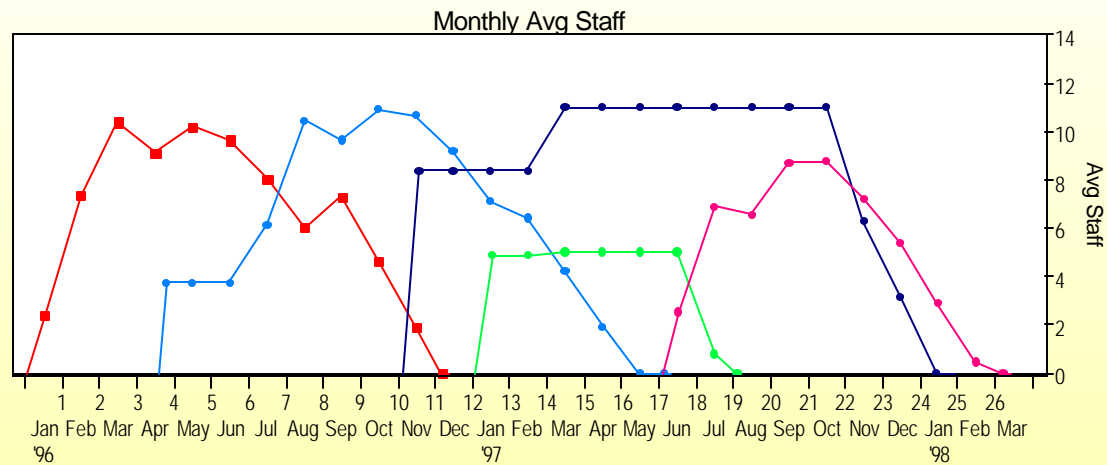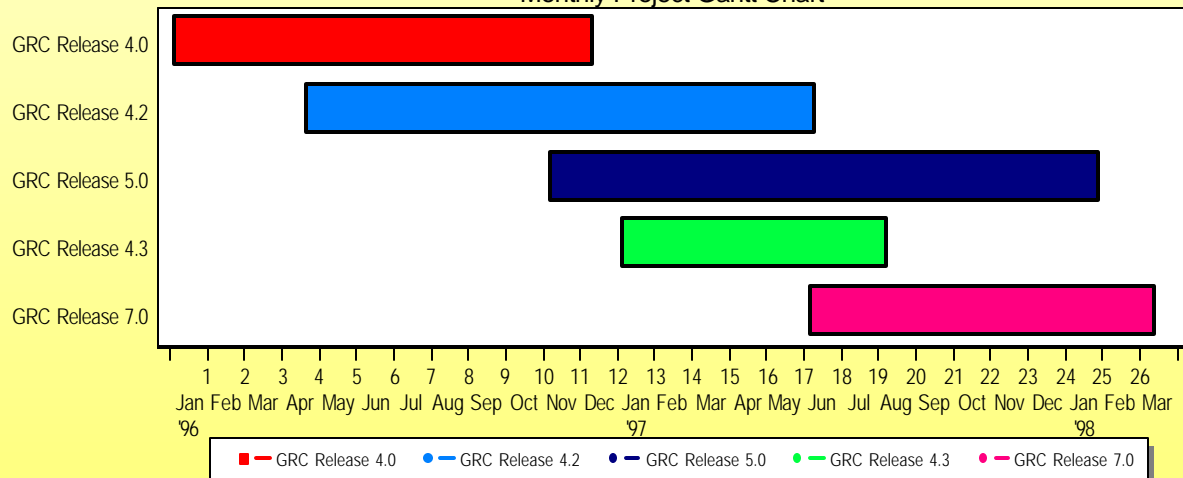$$\frac{\text{Functionality}}{\text{Efficiency}} = \text{Effort}^x \text{ x Time}^y$$

Staffing Profile

Life Cycle
3 = DR
4 = FDrop
5 = FREZ
6 = Beta
7 = Del
8 = GA

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Anatomy of Single "Release"

Key Design - Construction Events

Geometry of the resource loading

Staffing Profile

Life Cycle
3 = DR
4 = FDrop
5 = FREZ
6 = Beta
7 = Del
8 = GA

Well defined Start

Well Defined End

Staff

120
100
80
60
40
20
0

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	*
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	
'99			'00												'01		

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"Multiple Releases" the way most systems evolve today

Single Product Release Plans

Monthly Avg Staff

Monthly Project Gantt Chart

GRC Release 4.0
GRC Release 4.2
GRC Release 5.0
GRC Release 4.3
GRC Release 7.0

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar
'96 '97 '98

■ GRC Release 4.0   ● GRC Release 4.2   ● GRC Release 5.0   ● GRC Release 4.3   ● GRC Release 7.0

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Collecting Project Data

Fear of Measurement
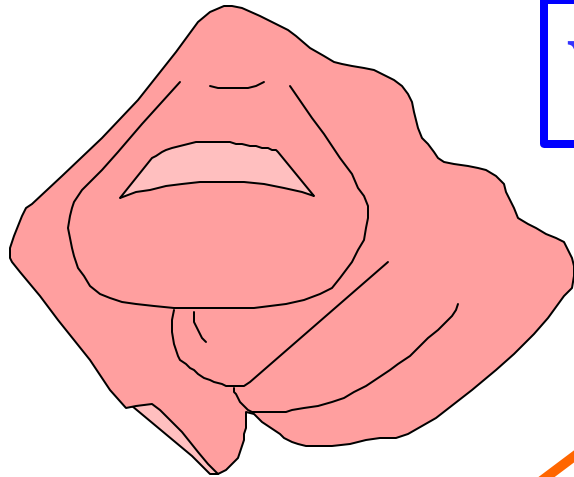
We Don't Have Any Data!

Facts are Friendly
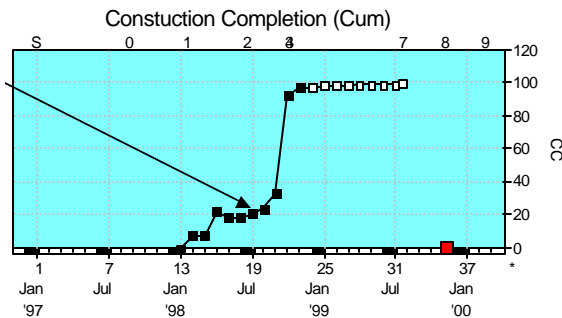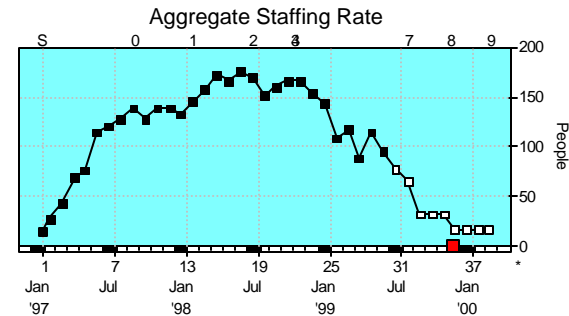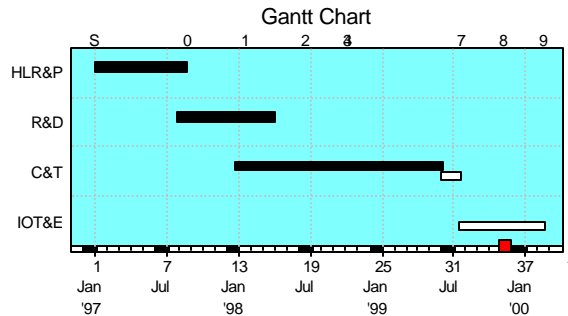
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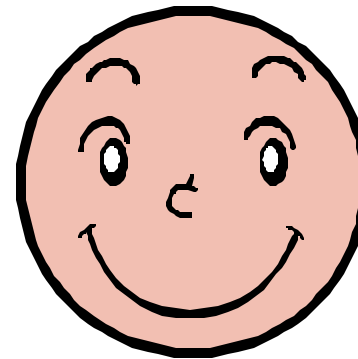
Project Artifacts

- **Staffing Plans (schedule and effort)**

- **Trouble Reports (defects discovery rates)**

- **Configuration Management Reports (size artifacts & mapping relationships)**

- **Requirements Management Reports (size artifacts)**

- **Time Report Reporting Systems (effort)**

- **Schedule reports (time line, milestones & phases)**

- **A subset of these are available on most projects (they aren't 4 decimal places accurate but they are good enough to get you started now)**

- **Sketch a staffing plan during a 30 minute interview with the project manager**

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Sample Project Artifacts

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COTS Human Resource Application

What happened here?

Gantt Chart

Aggregate Staffing Rate

Constuction Completion (Cum)
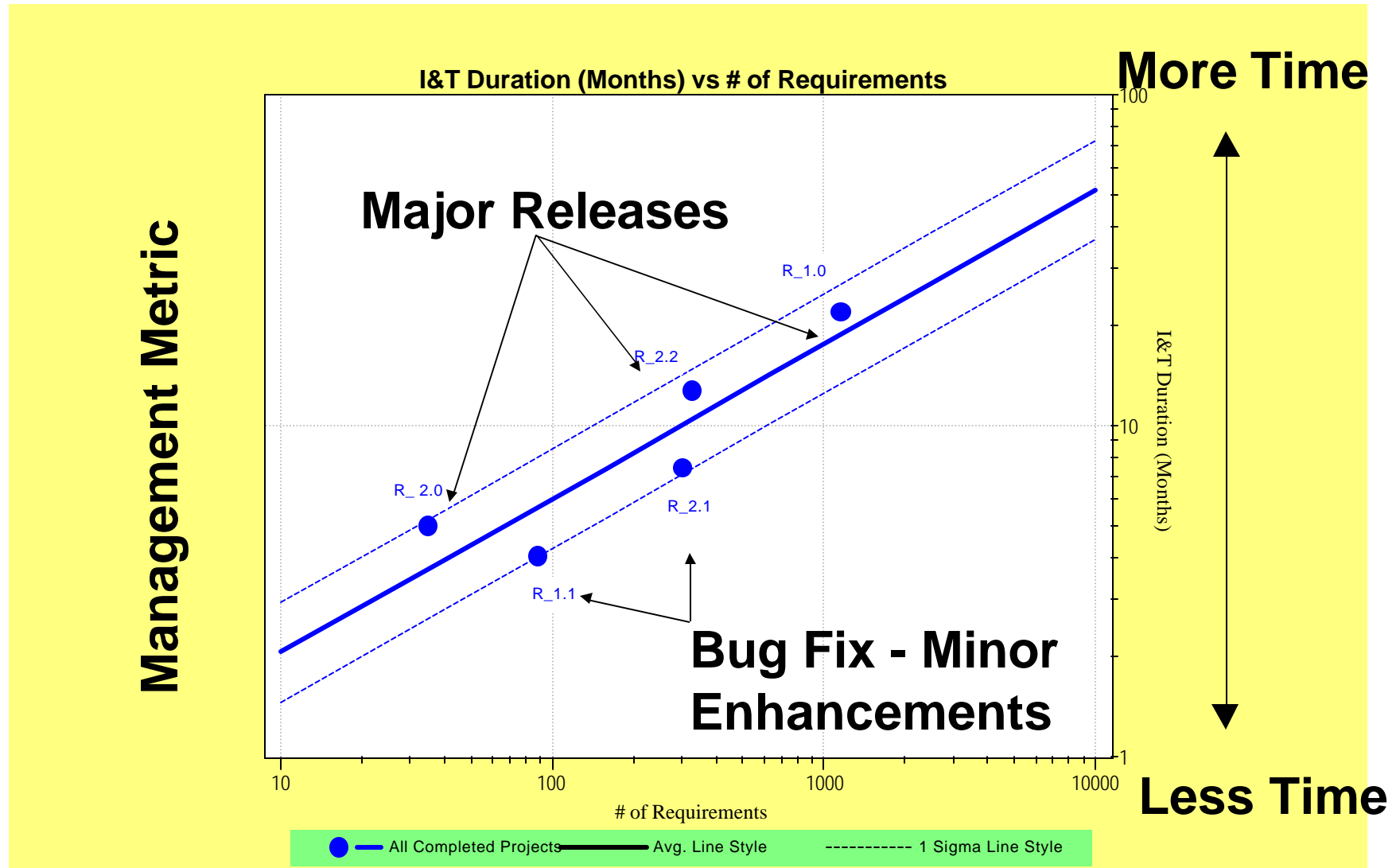
Total Defect Rate

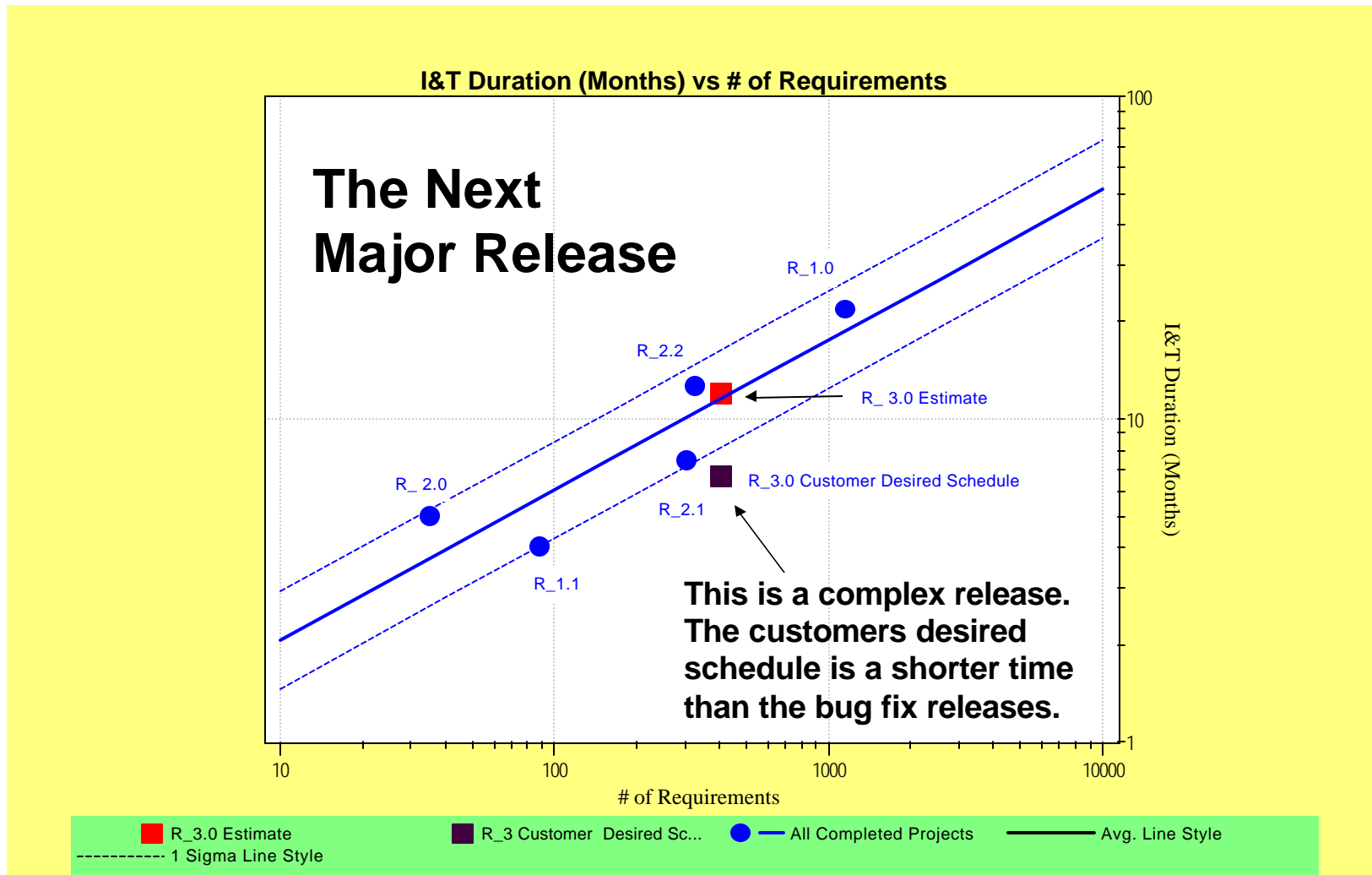Total Cum Effort
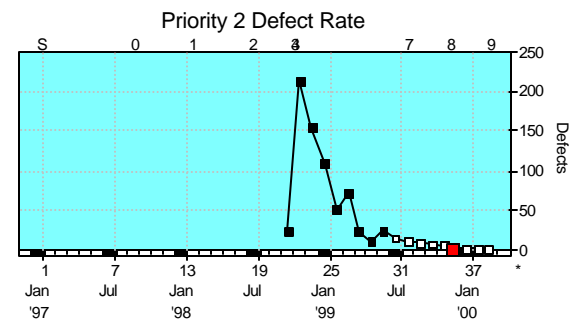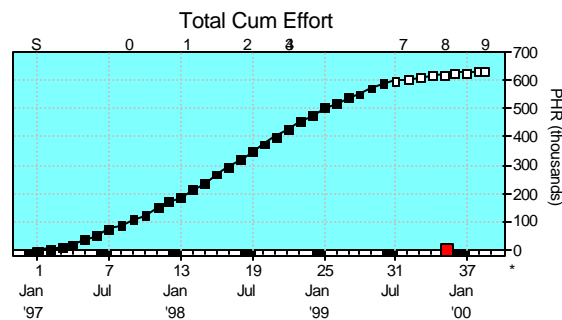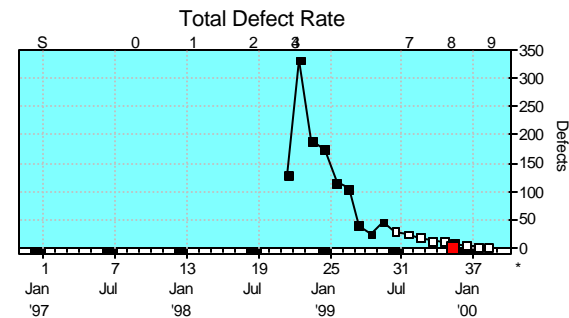
Priority 2 Defect Rate

■ Actual   ▲ Interpolated   ☐ Current Forecast   Life Cycle includes HLR&P, R&D, C&T, IOT&E
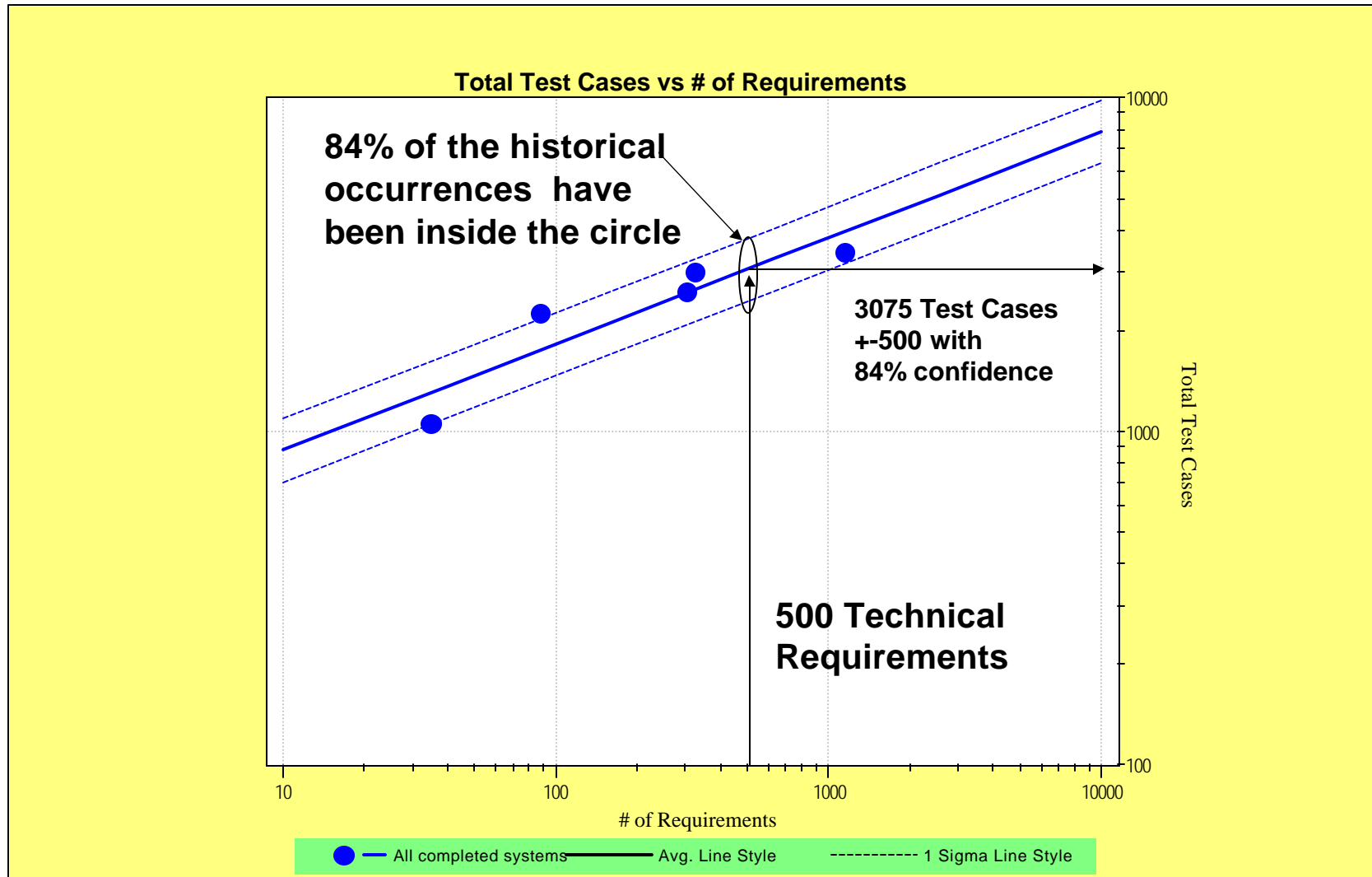S = Start, 0 = REQT, 1 = PDR, 2 = CDR, 3 = CC, 4 = SIT, 7 = SIOTE, 8 = EIOTE, 9 = 99.9R

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Making Sense out of Groups of Data

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Graphing the Data - Project Positioning

I&T Duration (Months) vs # of Requirements

More Time

Less Time

Management Metric

I&T Duration (Months)

Major Releases

R_1.0

R_2.2

R_ 2.0

R_2.1

R_1.1

Bug Fix - Minor Enhancements

100

10

1

# of Requirements

10   100   1000   10000

Size

● — All Completed Projects   —— Avg. Line Style   ---------- 1 Sigma Line Style

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Positioning Estimates on History to Build a Defensible Position

I&T Duration (Months) vs # of Requirements

The Next Major Release

R_1.0

R_2.2

R_3.0 Estimate

R_2.0

R_3.0 Customer Desired Schedule

R_2.1

R_1.1

This is a complex release. The customers desired schedule is a shorter time than the bug fix releases.

I&T Duration (Months)

# of Requirements

■ R_3.0 Estimate	■ R_3 Customer Desired Sc...	● — All Completed Projects	— Avg. Line Style
----------- 1 Sigma Line Style			

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Using the raw data for prediction

Total Test Cases vs # of Requirements

84% of the historical occurrences have been inside the circle

3075 Test Cases +-500 with 84% confidence

500 Technical Requirements

10000

1000

100

Total Test Cases

10   100   1000   10000

# of Requirements

● — All completed systems ——— Avg. Line Style   - - - - - - - - 1 Sigma Line Style

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Patterns in the Data
Based on Analysis of over 5,000 Projects

Influencing Factor   **Duration**   **Total Effort**   **Errors**

Product Size ↑
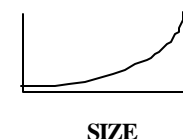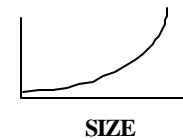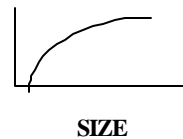
Efficiency ↑

Staffing/ Schedule

Accelerator ↑

Problem - Schedule is what customers always want to compress & it is the least compressible variable !!!

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2 Key Input Variables of the Estimate

Software Size
&
Development Team Efficiency

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Estimating Software Size - A Key Variable

- **Size is a major input to all the software estimation methods**

- **Estimating size is one of the most challenging aspects of the estimation process**

  - **Choice of appropriate measures (COTS, OO, Web)**

  - **You are guaranteed to be wrong no matter how well you do it**

  - **The state of the design is always at a higher level of abstraction than what you are trying to quantify**

  - **Requires input from engineers who are generally more detail oriented and like precision**

  - **It takes some thinking and little hard work**

  - **Usually must be accomplished in a short period of time**

  - **Must consider new, changed and plug and play**

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Size Estimation Practical Approaches

- **Try to size the system using at least 2 different methods - confirms results and helps to quantify variability**

- **Use size metrics that are readily available or easy for the project engineers to relate to - eliminates resistance**

- **Look for relationships between different sizing artifacts they provide transforms into the units you need (there is usually good consistency within a product team)**

- **Sample from early prototype development when moving into a totally new environment**

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Example of a Transform Number of Classes per Function

Size Estimation

Effective Obj vs # of Requirements
SLIM-Metrics Product

Average function = 8 classes
Average Object =343 C++ SLOC

Super heavy weight functions

Graphics Engine

Heavy weight functions

Report Manager

Middle weight functions

Color Manager

Reference Group Manager

Light weight functions

Resources

Classes Per Function

Visual C++ SLOC (thousands)

● ━━━ ALL Systems ━━━━ Avg. Line Style ---------- 1 Sigma Line Style ─·─·─·─ 2 Sigma Line Style

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Example of transform in an OO Environment Relationship of Methods to SLOC

Methods

19.4 C++SLOC/Method

Methods (thousands)

Source Code (thousands)

Creation Series   Avg. Line Style

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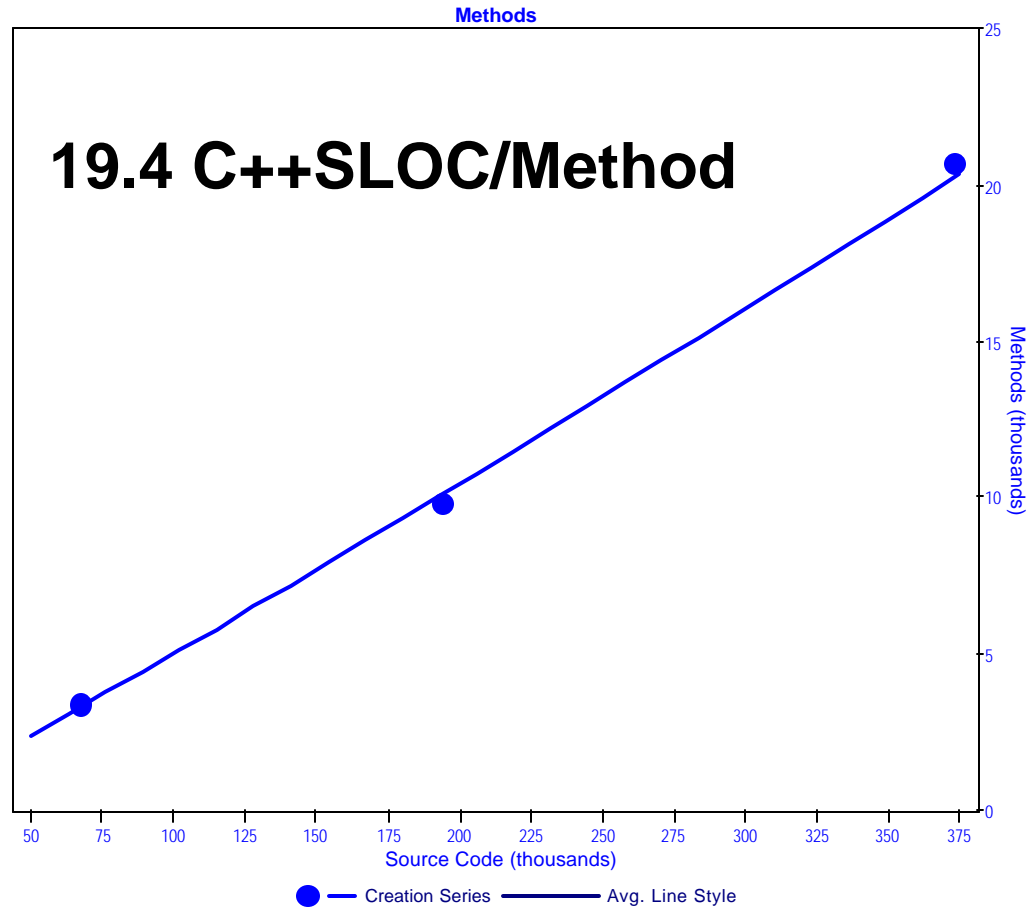
Partial data can provide insights
SmallTalk Billing System

Sub-system	SLOC	Classes	Avg SLOC/Class
Business Model	4312	74	58.27
User Interface	3200	17	188.24
Use Case Framework	1893	13	145.62
Use Cases	6585	54	121.94
Other Classes	1323	14	94.50
Total	17313	172	
Average SLOC/CLASS			**100.66**

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Sizing Quarterly Maintenance Releases Request For Service Sizing

Customer asks for capability in a formal request for service.

The developer quickly scopes the effort into time required to implement the request

Average SLOC size statistics from past developments are used

		RFS Number	SLOC/RFS	Quantity
1	☒	< 1 Week RFS #1	86.0	1
2	☒	< 1 Week RFS #2	86.0	1
3	☒	< 1 Month RFS #1	348.0	1
4	☒	< 1 Month RFS #2	348.0	1
5	☒	< 3 Month RFS #1	1043.0	1
6	☒	< 3 Month RFS #2	1043.0	1
7	☒	< 6 Month RFS #1	2007.0	1
8	☒	< 6 Month RFS #2	2007.0	1
			Total RFS	8

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SAP Implementation (Single Site)

Accounts Payable - General Ledger 161 SAP Transactions

Staffing Profile

Legend:
- Feas
- F D
- MB
- Maint

- 0 = FSR
- 1 = PDR
- 2 = CDR
- 3 = FCC
- 4 = SIT
- 5 = UOST
- 6 = IOC
- 7 = FOC
- 8 = 99R

Staff (y-axis: 0 to 12)

Timeline (x-axis): 1–14, Apr May Jun Jul Aug Sep Oct '98, Nov Dec Jan Feb Mar Apr May Jun Jul '99

SAP Transactions
Avg 29 hours/Transaction
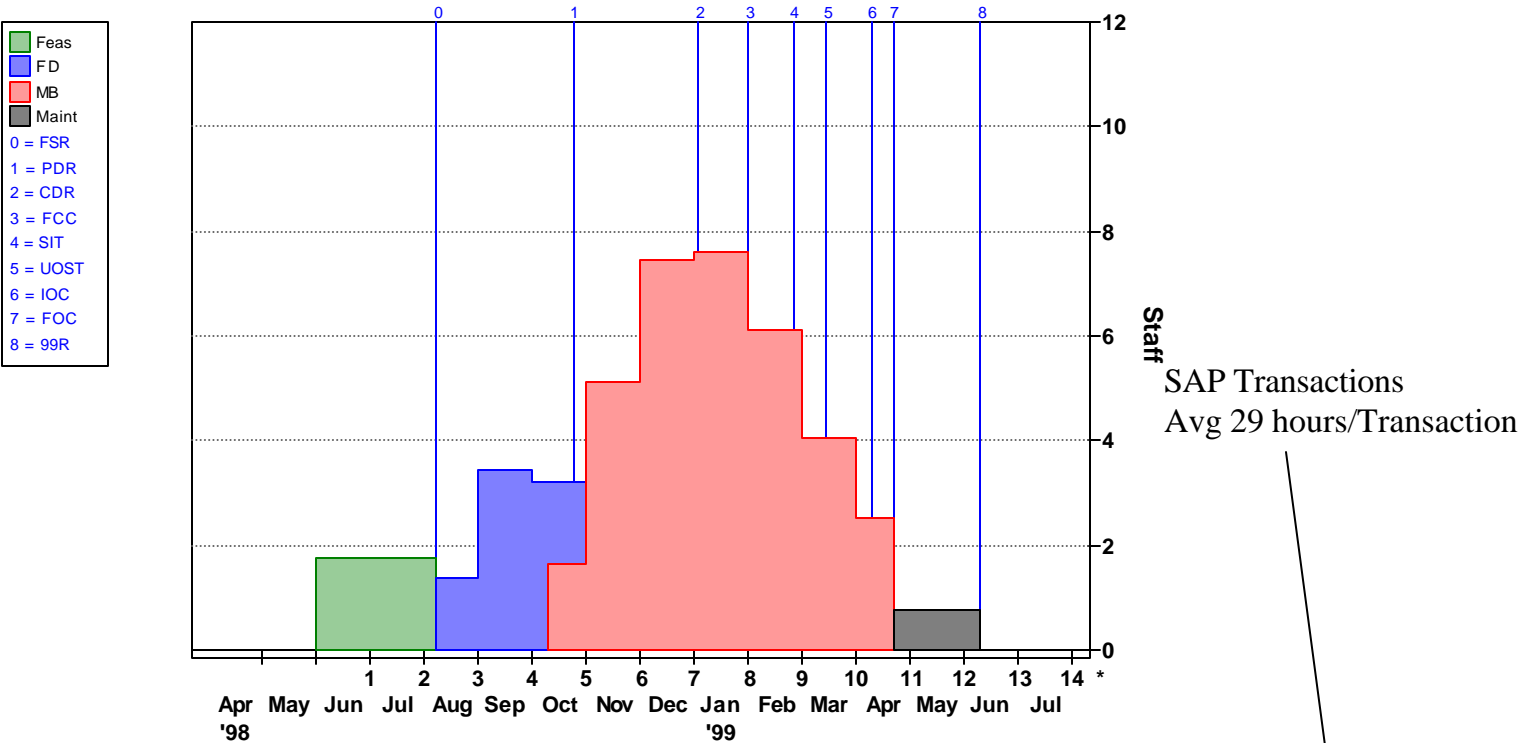
RISK
- Time
- Effort
- Uinf Cst
- Min Pk Staff
- Max Pk Staff
- FOC MTTD
- % : 0 10 20 30 40 50 60 70 80 90 100

MB Life Cycle			Size	
Time	6.40	12.30 Months		
Effort	4888	7028 PHR	161	
Uinf Cst	405	582 $ 1000	Ents	
Pk Staff	7.78	7.78 People		
MTTD	1.78	7.69 Days	MBI 4.8	
Start	10/10/1998	06/01/1998 Date	PI 13.2	

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Determining Development Team Efficiency

$$\text{Developer Efficiency} = \frac{\text{Functionality Developed}}{\text{Effort x Time}}$$

A Higher value means less time and effort

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Analyzing the Data

- **Homogenous Data Set**

- **Try to get a sample of 4-6 projects if possible. However one is better than none!**

- **Sketch the staffing plan - often uncovers unique behavior**

- **Capture the contextual information - this helps you understand the project behavior**

- **Capture the core metric (size, schedule, effort, defects)**

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Using the Data to Learn - Frequency Distribution

PI Distribution

Typical Capability 11.8

Outstanding Performance - Why?

1. Important customer really need a feature
2. Assembled top talent
3. Long hours
4. Design Process Improvements

PI

Number of Projects

All Systems

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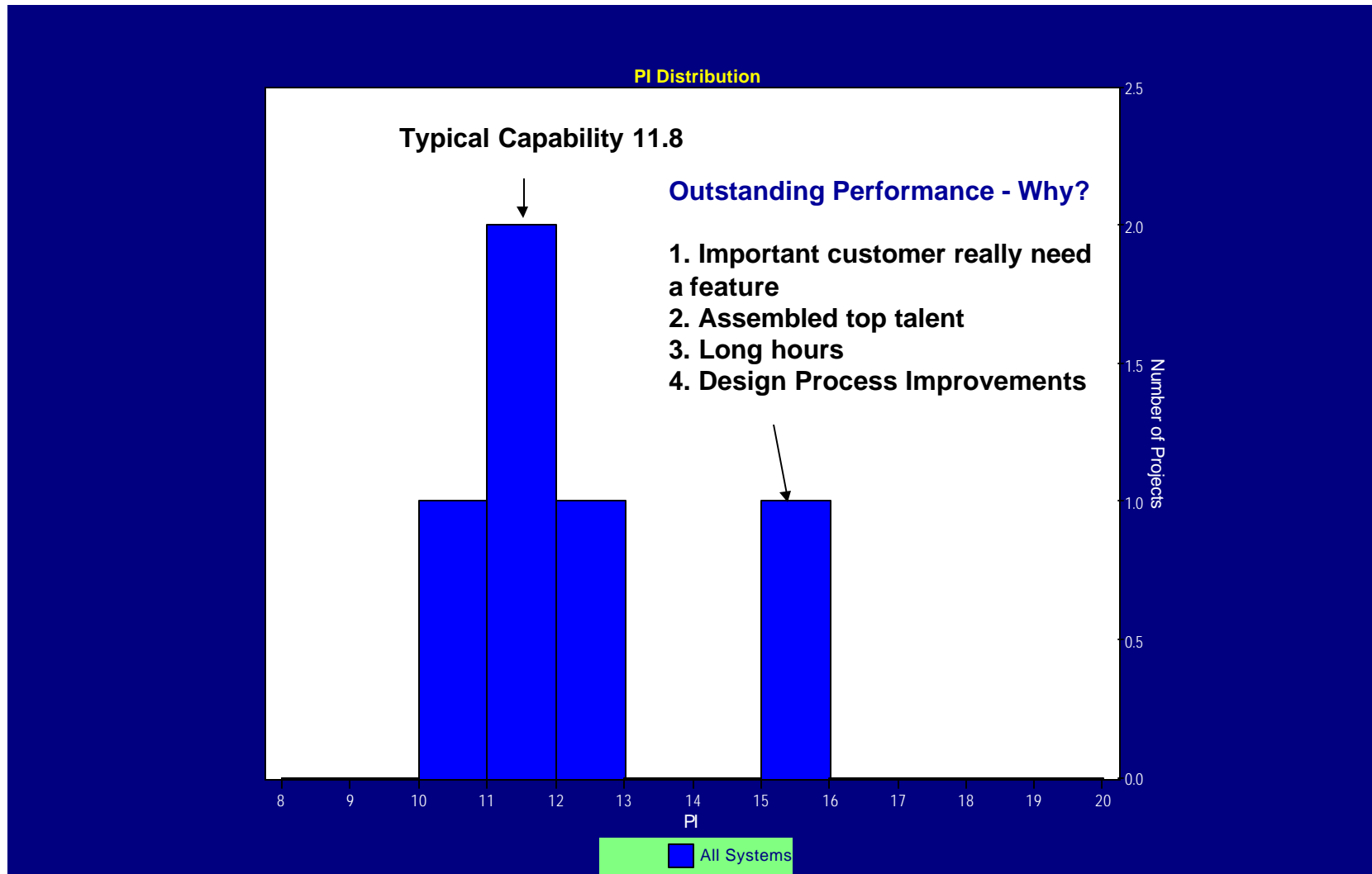
Project Analysis
Schedule, Cost & Reliability Analysis

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Project Estimation Process

- **Develop major inputs (size & efficiency)**

- **Identify customer and project constraints (schedule, staffing, reliability, cost)**

- **Identify the "Impossible Zone" Minimum Build Schedule**

- **Develop alternative scenarios**

  – **How much can we build? Does it provide enough capability?**

  – **What if we add or reduce staff?**

  – **What efficiency is required to meet the schedule? Is there any evidence that can be achieved?**

  – **Should we adopt a multi release plan?**

- **Sensitivity Analysis - Impact if our major inputs assumptions are off**

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Project Analysis - Big Payoffs

- **Consider a group problem solving session (ala JAD)**

  - marketing, engineers, customer, business managers

  - Often uncovers issues but facilitates a consensus solution

- **High Bandwith Analysis ala Edward Tufte**

  - Processing information in parallel

  - Visualize interrelated data

  - Focus on bringing absolute attention to the data

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Information Design
A Single View of the Data
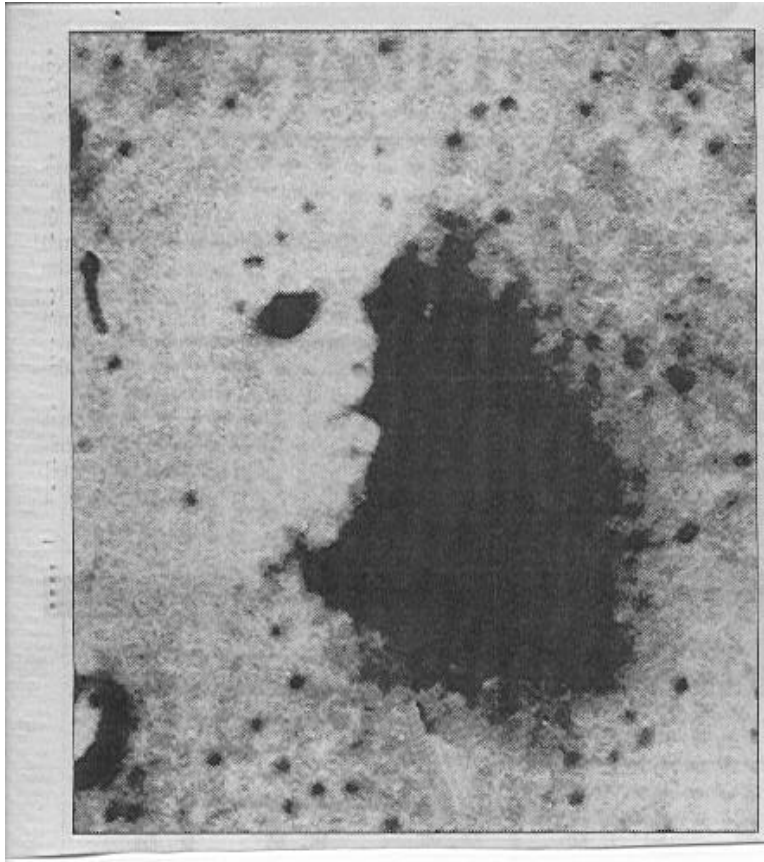
Aha!
There was
Civilization on Mars!

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Information Design
Multiple Views Provide a More Complete Picture

Oops
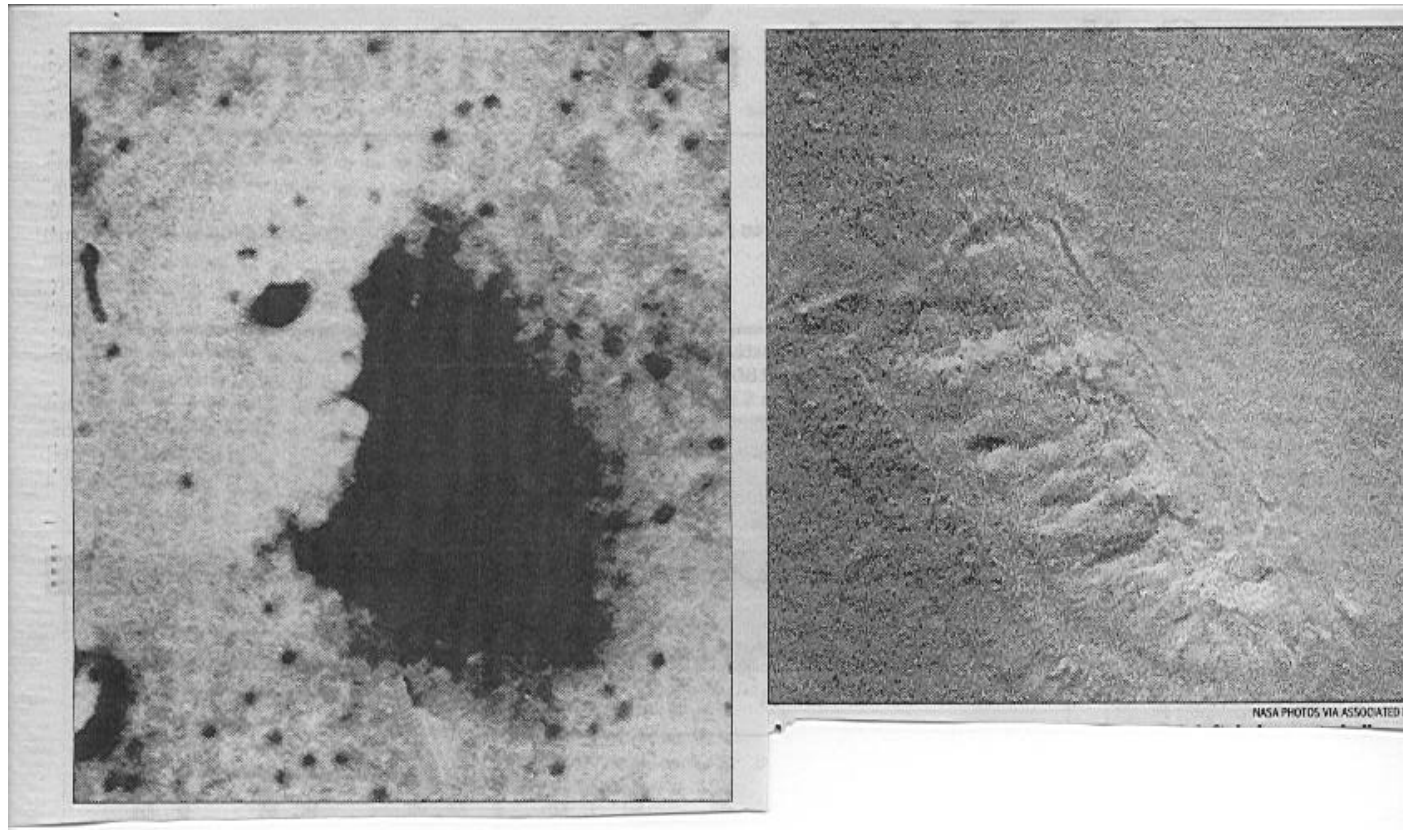
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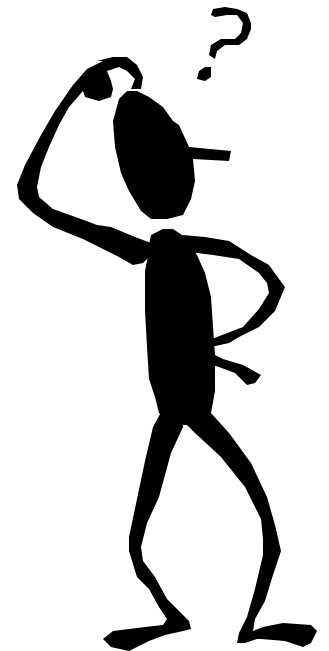
Analyzing Data in Parallel

Monthly Avg Staff (people)
<Working Solution>

Gantt Chart By Sub-Phase
<Working Solution>

Sub-Phases:
- Requirements
- High Level Design
- Detailed Design
- Coding/Unit Test
- Integration
- Test
- Certification
- Fix Latent Defects
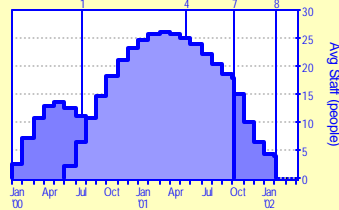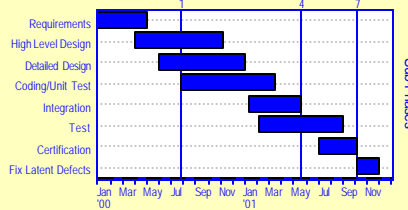
Monthly Cum Cost ($)
<Working Solution>
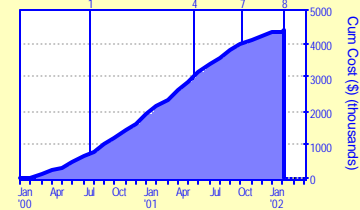
Monthly MTTD (Days)
<Working Solution>
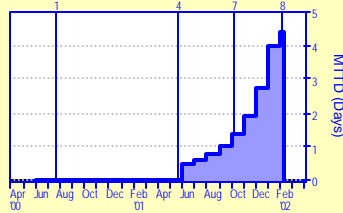
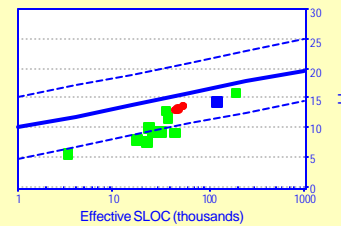**Sensitivity of Life Duration to Size**
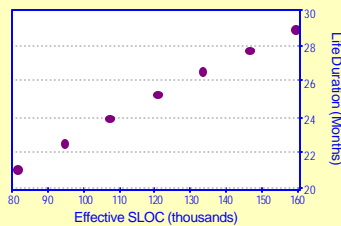
Sensitivity of Life Cost to Size
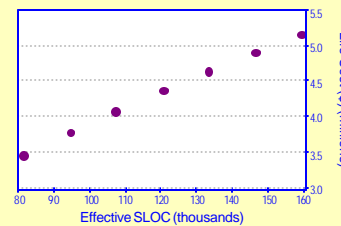
MB Duration (Months) vs Effective SLOC
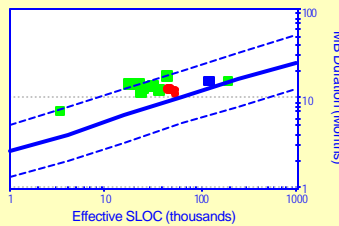
MB Effort (MM) vs Effective SLOC

PI vs Effective SLOC

RISK GAUGE <Working Solution>

- Duration
- Effort
- Peak Staff
- Quality
- Joint Prob

% 0 10 20 30 40 50 60 70 80 90 100

MB Time <= 14 months   Effort: na
Peak Staff <= 15 ppl   Mttd >= 21.65 Days

CONTROL PANEL <Working Solution>

14.6	26.0	120.7
12.4 ... 16.8	18.2 ... 33.8	84.5 ... 156.9
PI	Peak Staff	Eff SLOC (K)
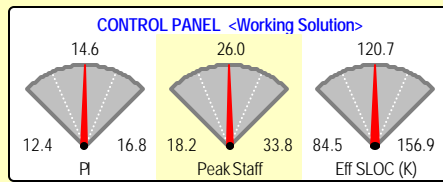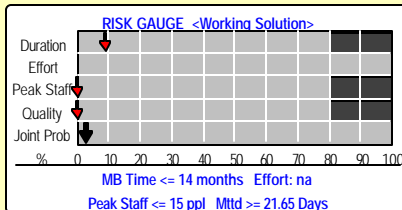
SOLUTION PANEL <Working Solution>

	Main Build	Life Cycle	
Time	16.13	25.21	months
Effort	310.49	435.08	MM
Cost	3.1	4.4	$ (M)
PI=14.6	MBI=2.8	Eff SLOC=120701	

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Communicating Results

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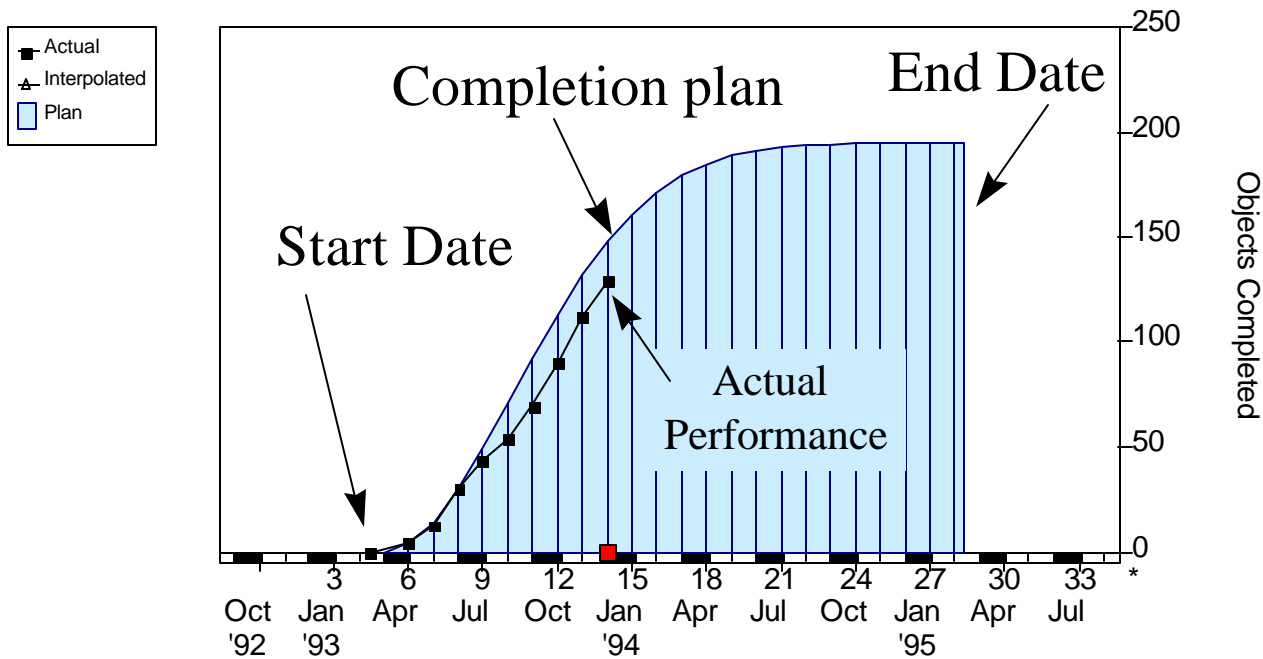The Intelligence Behind
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Key Points on Communicating the Results

- **Make sure the audience understands the analysis method**

- **Briefing should be concise and stress a few main points**

- **Support your analysis with facts and historical data!!!**

- **Provide decision makers with recommended solution along with alternative solutions**

- **Provide execution work plans (basis project monitoring)**

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Project Monitoring
&
Tactical Plan Adjustments

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Rate Charting to Visualize Progress

Product Constuction in Objects vs Time

Legend:
- Actual
- Interpolated
- Plan

Chart labels: Completion plan, End Date, Start Date, Actual Performance

Y-axis (right): Objects Completed — 0, 50, 100, 150, 200, 250

X-axis: 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, *
Oct '92, Jan '93, Apr, Jul, Oct, Jan '94, Apr, Jul, Oct, Jan '95, Apr, Jul

Date 12/31/93 (14.00 mos)

	Plan	Actual	%Diff
Size (Objs)	147.82	129.00	-12.7
PI	10.8		
MBI	1.2		

Variation from Plan

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Control Bounds & Acceptable Variation

Green Zone = Accepable Variation

Product Construction in Ojects vs Time
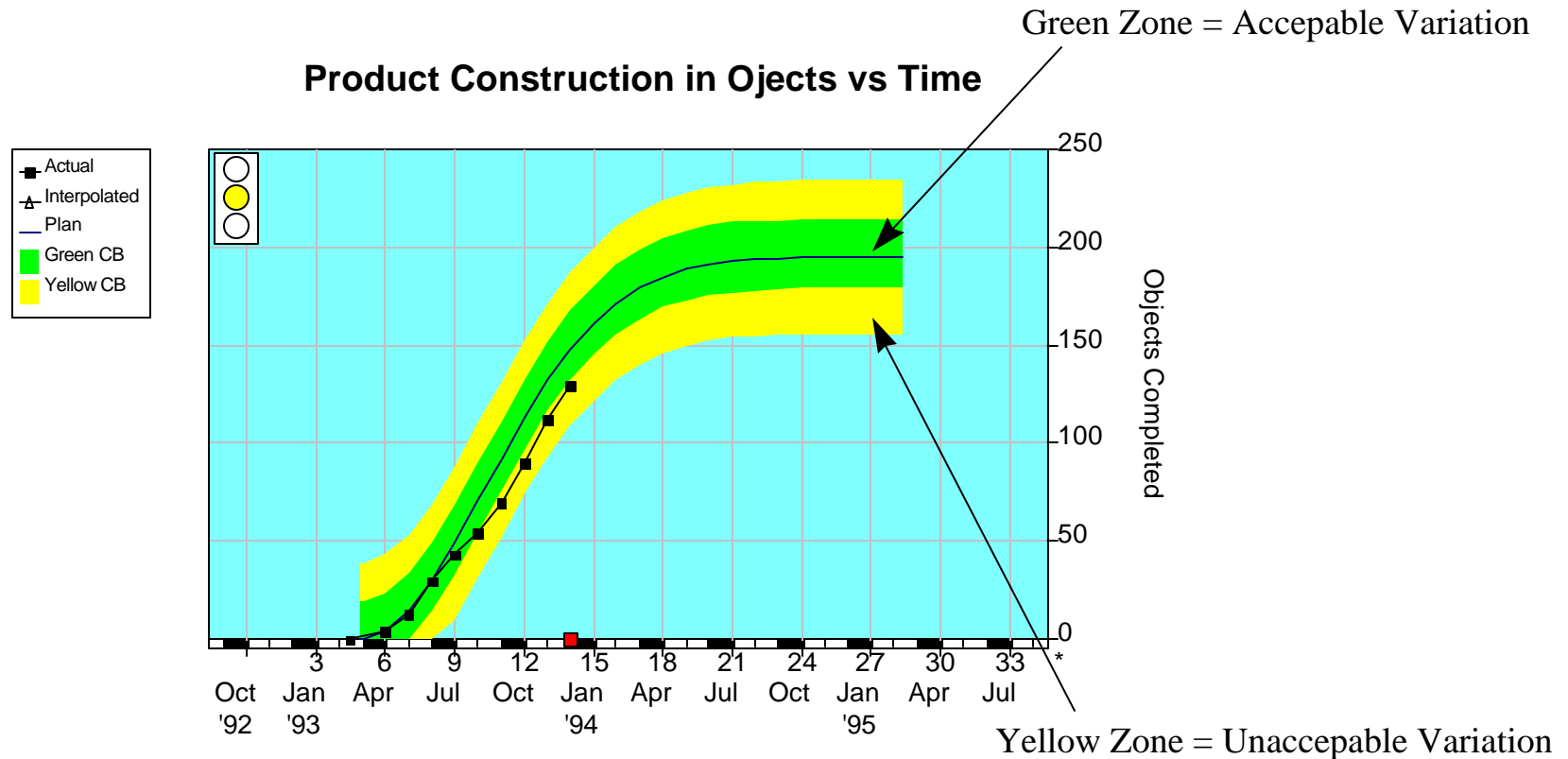
Legend:
- Actual
- Interpolated
- Plan
- Green CB
- Yellow CB
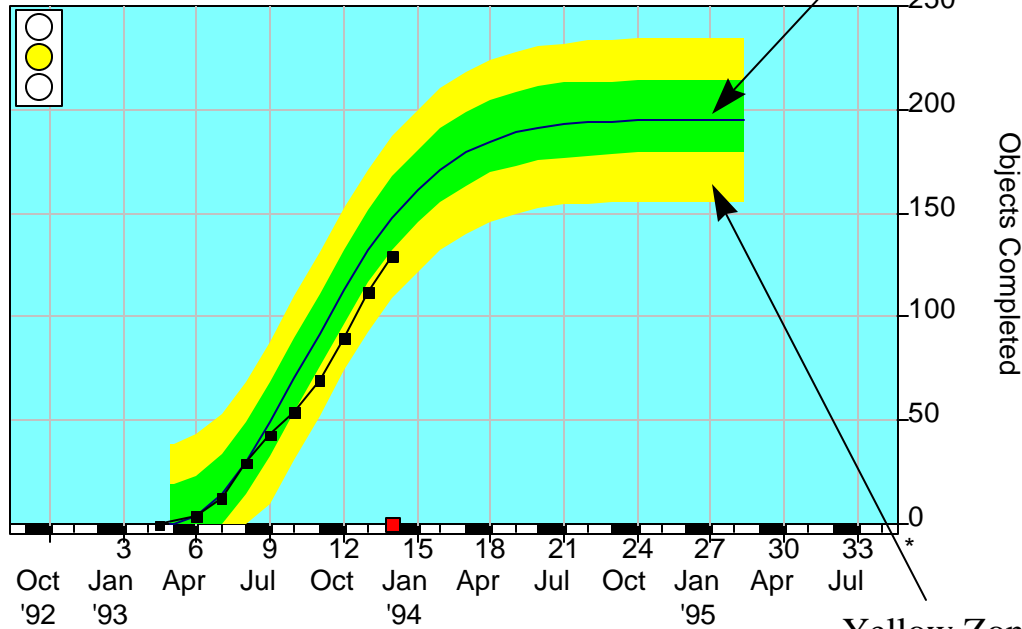
Objects Completed

X-axis: 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33
Oct '92, Jan '93, Apr, Jul, Oct, Jan '94, Apr, Jul, Oct, Jan '95, Apr, Jul

Yellow Zone = Unaccepable Variation

Date 12/31/93 (14.00 mos)

	Plan	Actual	%Diff
Size (Objs)	147.82	129.00	-12.7
PI	10.8		
MBI	1.2		

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Multiple Metrics Give a More Complete Picture

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Tactical Adjustments When Required

Design Units (Cum)

Unit Tested (Cum)
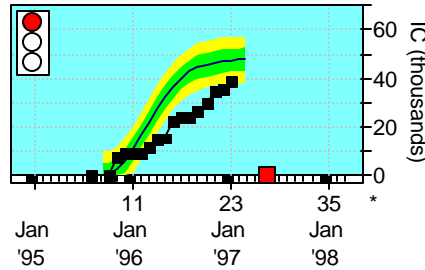
Aggregate Staffing Rate

Unit Coded (Cum)

Integrated Code (Cum)

Total Cum Effort

Gantt Chart

Forecast to Complete

RQ_D

C&T
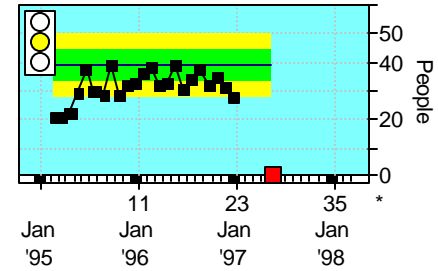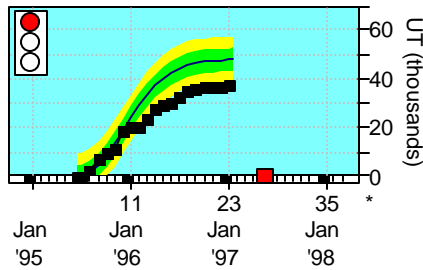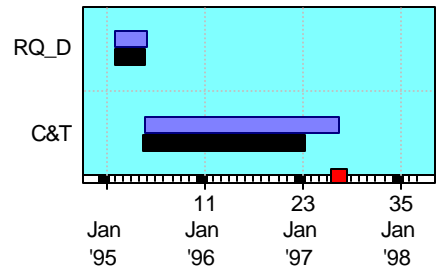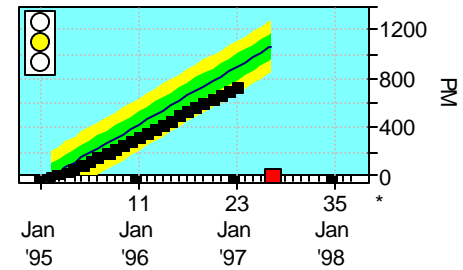
rent Plan ■ Actual ▲ Interpolated □ Current Forecast   Life Cycle includes RQ_D, C&T

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Estimation is about Knowledge, Analysis, Communication & Negotiation

- **It all boils down to who can make reasonable inferences, communicate, and negotiate**

- **The people who do it best are the ones that have some facts**

- **You always have a stronger negotiating position when they are based on fact rather than emotions**

- **Data is the key to good estimation**

Facts are Friendly

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