# Quantitative Software Management

## Using Metrics to Develop a Software Project Strategy

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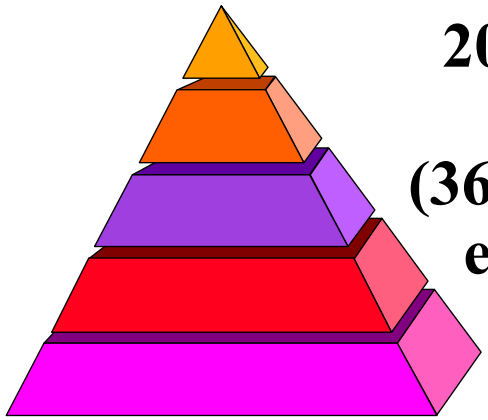

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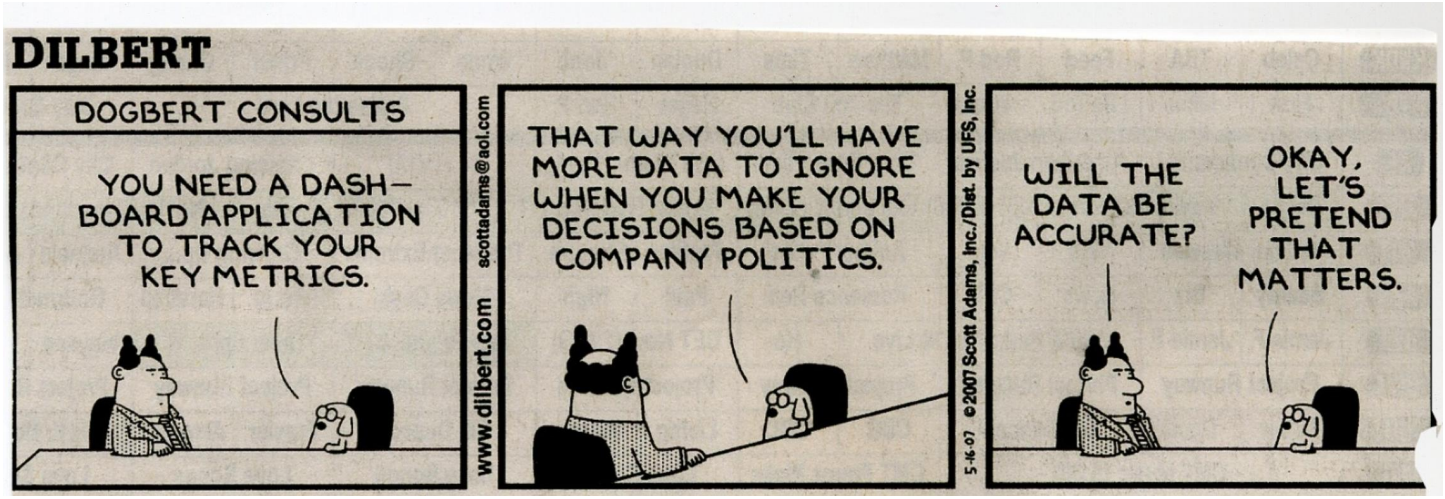
# Outline

- Overview
- Measurement, Expense or Investment
- State of the Industry: Project Estimation
- Staffing and Schedule
- Understanding Trade-offs
- Conclusion
- Questions?

# Overview




**Does this sound familiar?**

# Measurement: Expense or Investment

- **Software measurement (and process improvement) are viewed as <u>expenses</u>: Overhead**
  - **Lean, agile organizations want to reduce overhead**
  - **But, how do organizations become "lean & agile"?**
- **Part of cost of doing business**
  - **3 – 5% on average**
  - **Project management averages 14%**

# Measurement: Expense or Investment

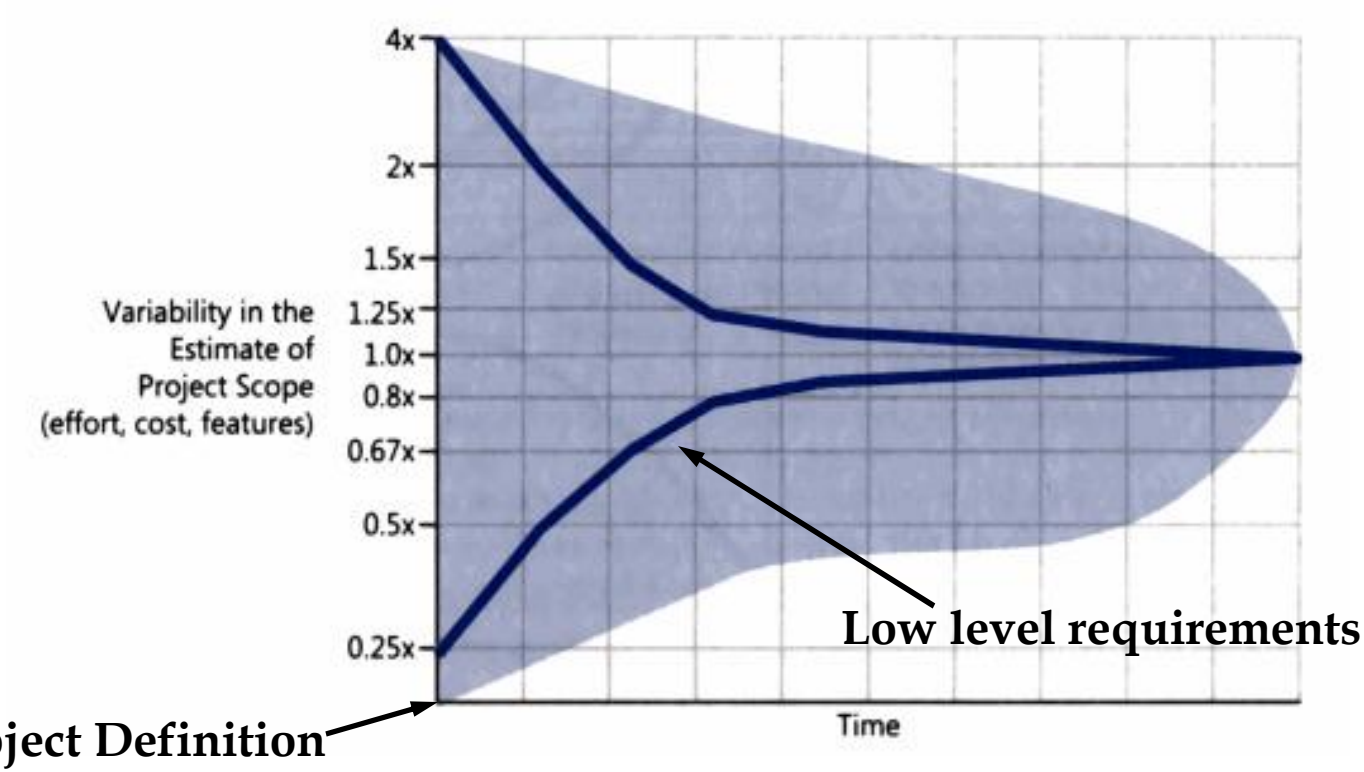
- **What does software measurement provide?**
  1. **Knowledge of an organization's capabilities**
  2. **Identifies patterns and trends (Strengths to leverage and weaknesses to correct)**
  3. **Insight into projects in time to make effective mid-stream corrections**
  4. **Ability to benchmark against competition or "the industry" in quality, productivity, and time to market**
  5. **Quantitative basis for evaluating project and organizational performance**
- **Improves ability to meet commitments, avoid pitfalls, and evaluate trade-offs**

# of the Industry: Project Estimation

- Software estimates are <u>not</u> project plans
- Estimates contain uncertainty about two key components:
  - Scope of the requirements (project size)
  - Team productivity

# The Cone of Uncertainty




- Not enough information is available early in the development lifecycle to make accurate estimates
- Precision is not accuracy

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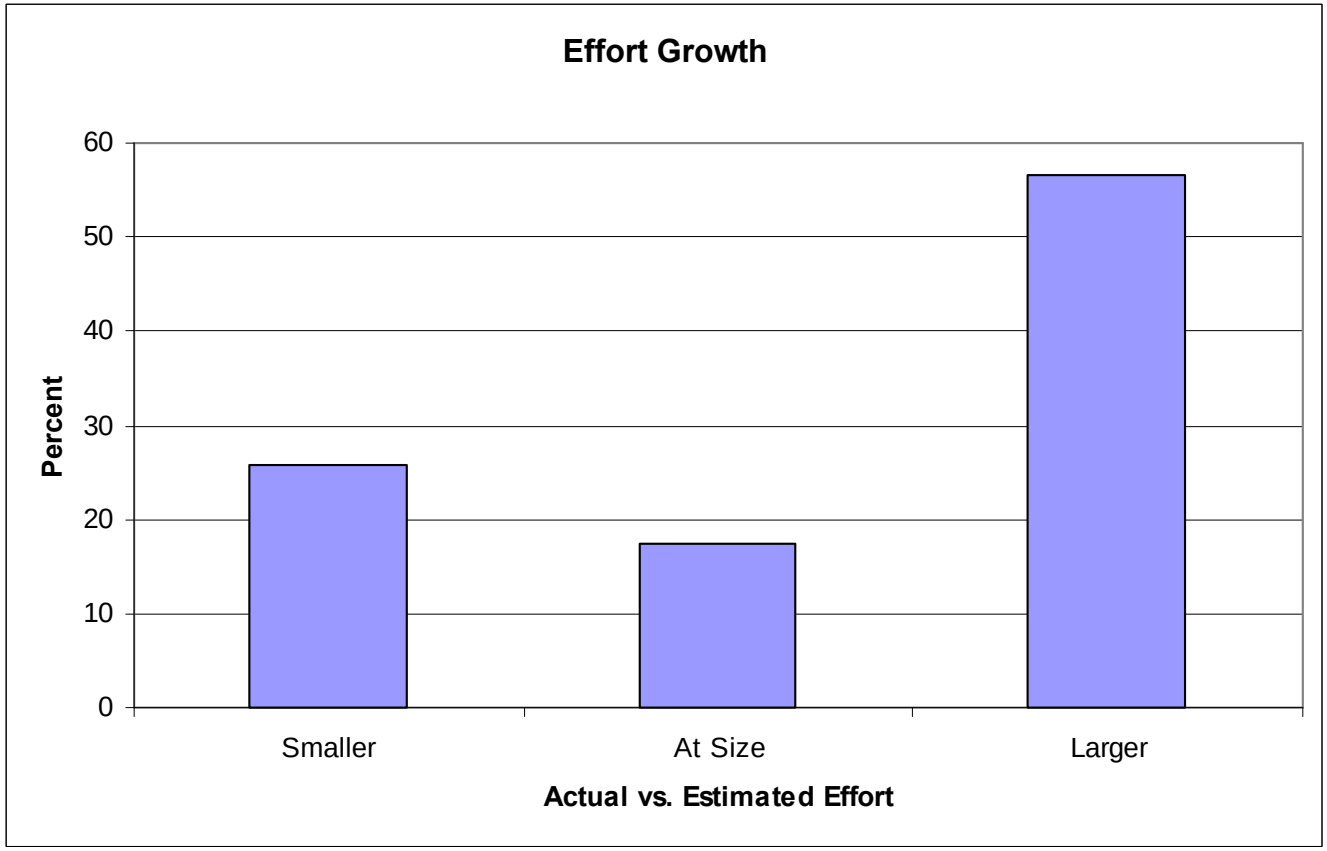
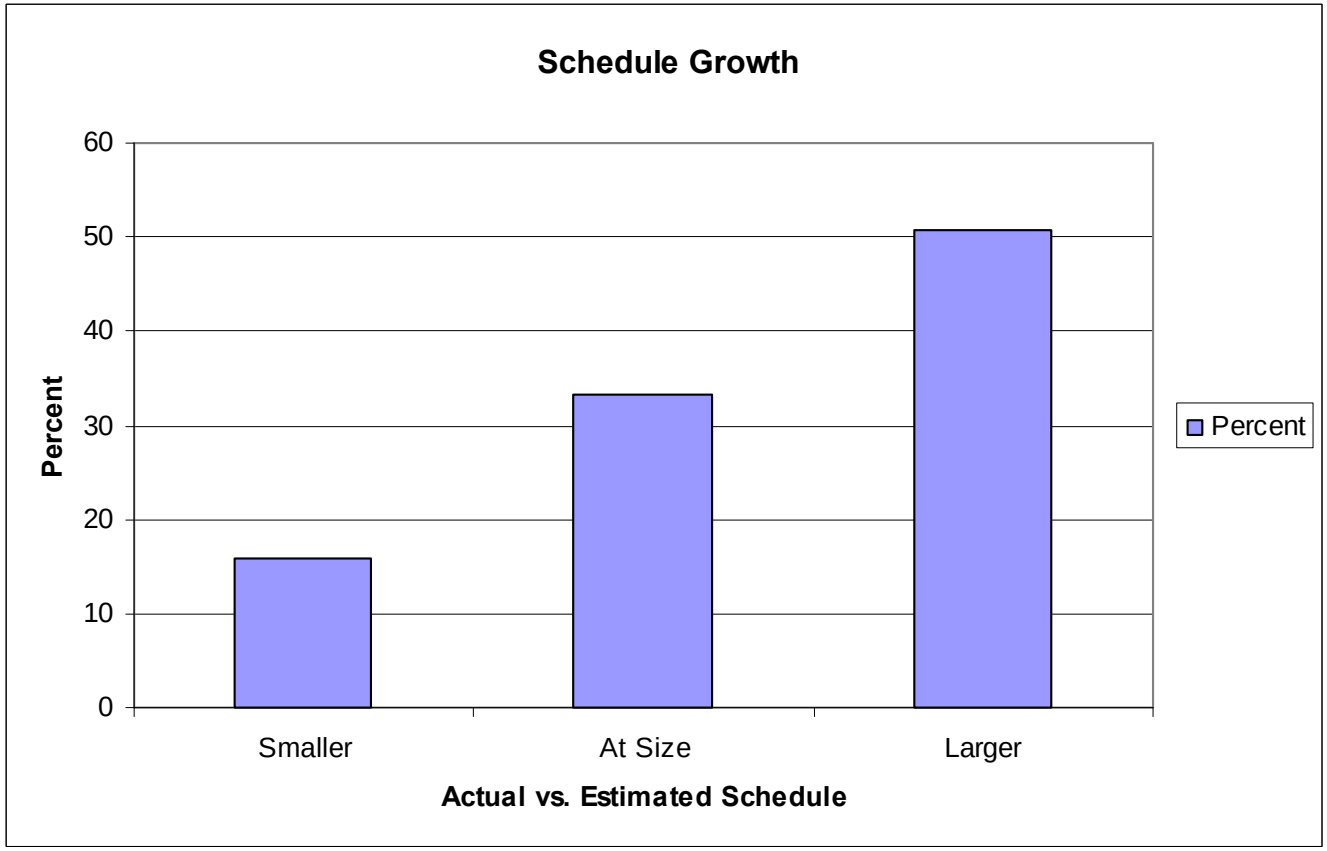
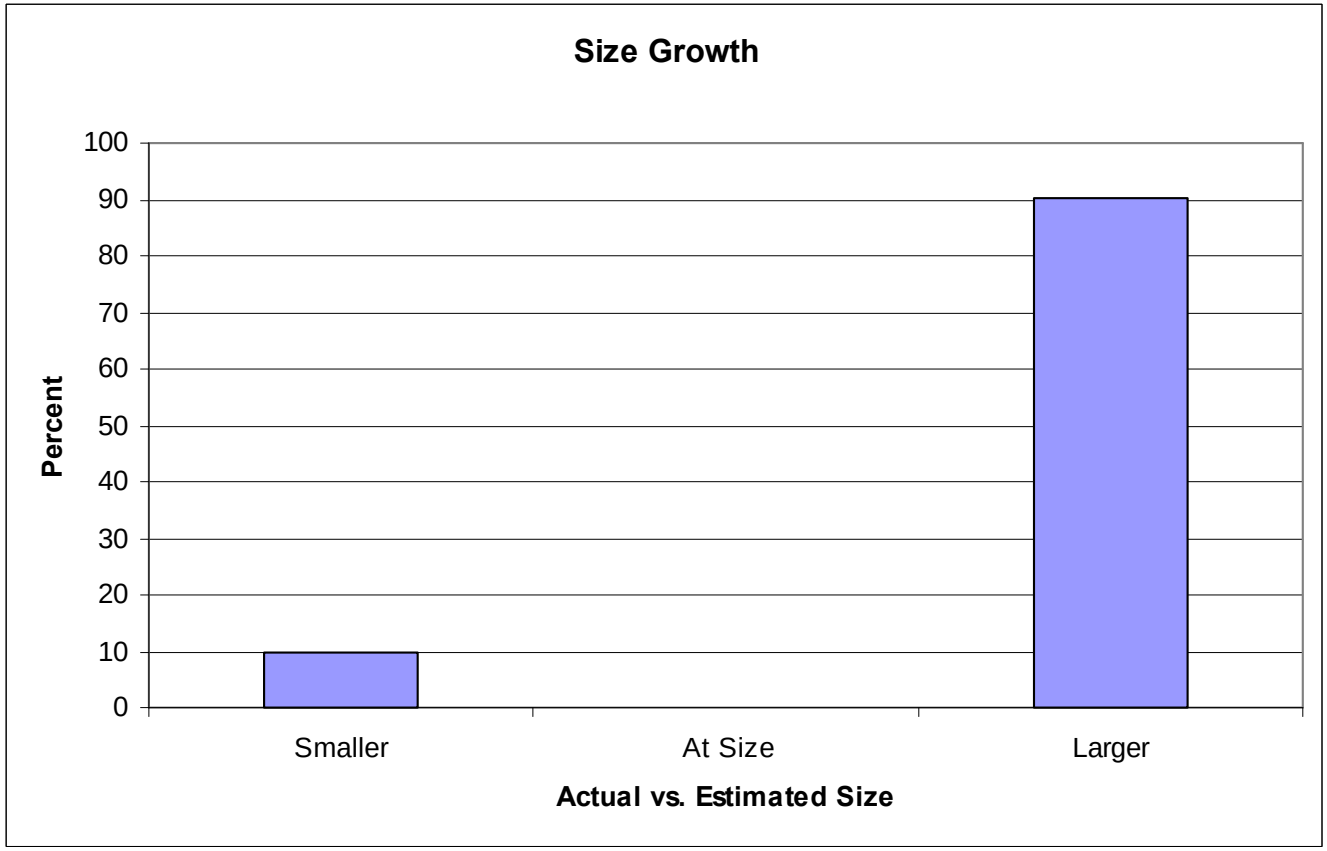
# Actual vs. Estimated Effort



# Actual vs. Estimated Schedule



# Actual vs. Estimated Size

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# In Summary

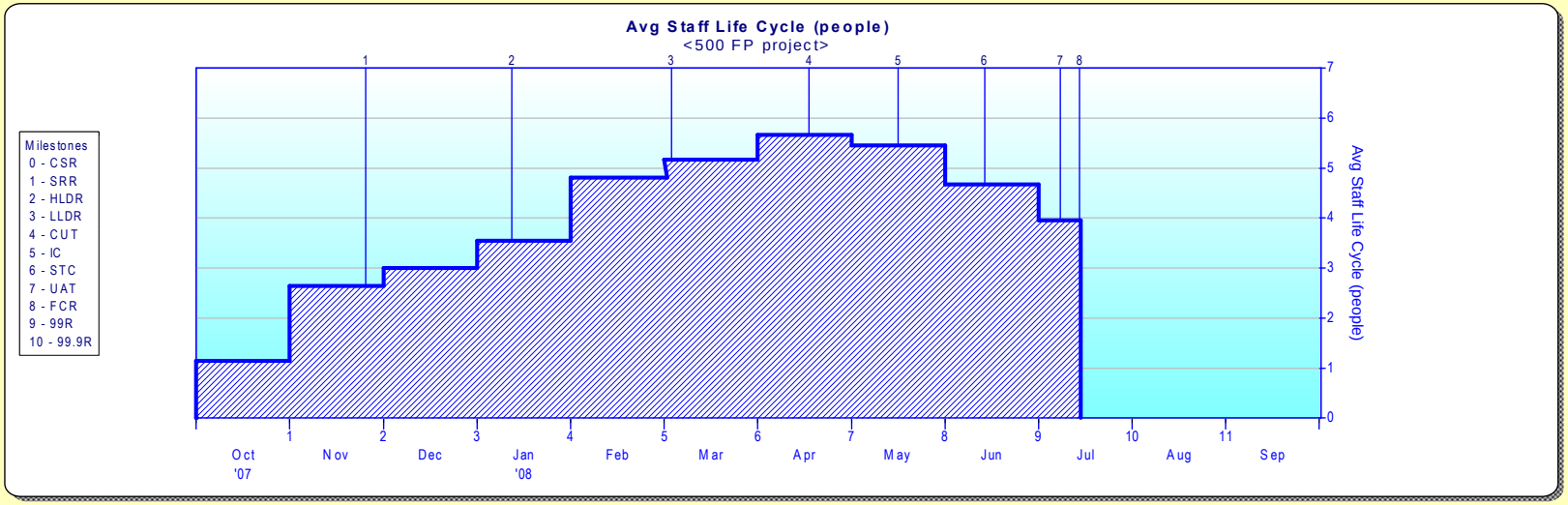
- Average schedule growth is 8%
- Average cost/effort growth is 16%
- Average size growth is 15%
- So how can we use this information to create more accurate estimates?

# Modeling Increased Size

- Create best project estimate based on proposed size
  - Use historically based productivity
  - Account for project constraints (staff, effort, schedule)
- Create estimate based on 15% size growth
  - Does this account for projected schedule & effort growth?

# 500 FP Project

**Staffing & Probability Analysis**




**SOLUTION PANEL - <500 FP project>**

| | C&T | Life Cycle | |
|---|---|---|---|
| Duration | 6.7 | 9.4 | Months |
| Effort | 29 | 37 | PM |
| Cost | 493.4 | 643.6 | $ (K) |
| Peak Staff | 5.7 | 5.7 | people |
| MTTD | 1.823 | 1.823 | Days |
| Start Date | 12/23/2007 | 10/1/2007 | |

PI=16.5 MBI=3.6 Eff FP=500

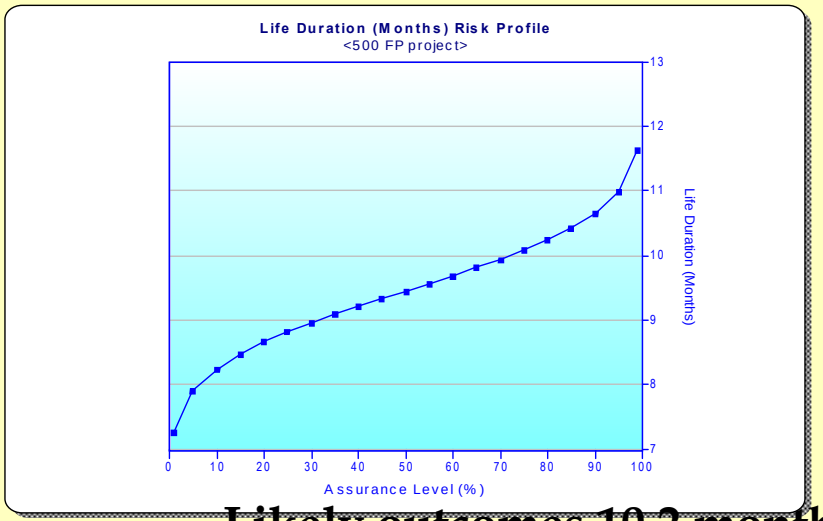
**9.4 months duration**

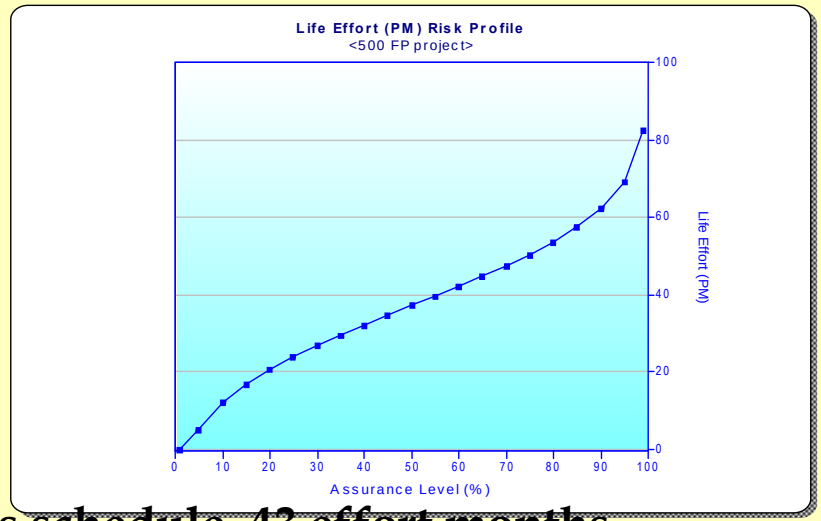
**37 person months effort**

**50% probability**

# 500 FP Project

Evaluate Probability of Current Estimate




## Likely outcomes 10.2 months schedule, 43 effort months

**Life Duration (Months) Risk Profile - Probability demo**
**<500 FP project>**

| Assurance Level (%) | Life Duration (Months) |
|---|---|
| 1 | 7.26 |
| 5 | 7.90 |
| 10 | 8.25 |
| 15 | 8.48 |
| 20 | 8.66 |
| 25 | 8.82 |
| 30 | 8.96 |
| 35 | 9.09 |
| 40 | 9.21 |
| 45 | 9.33 |
| 50 | 9.45 |
| 55 | 9.57 |
| 60 | 9.69 |
| 65 | 9.81 |
| 70 | 9.94 |
| 75 | 10.08 |
| 80 | 10.24 |
| 85 | 10.42 |

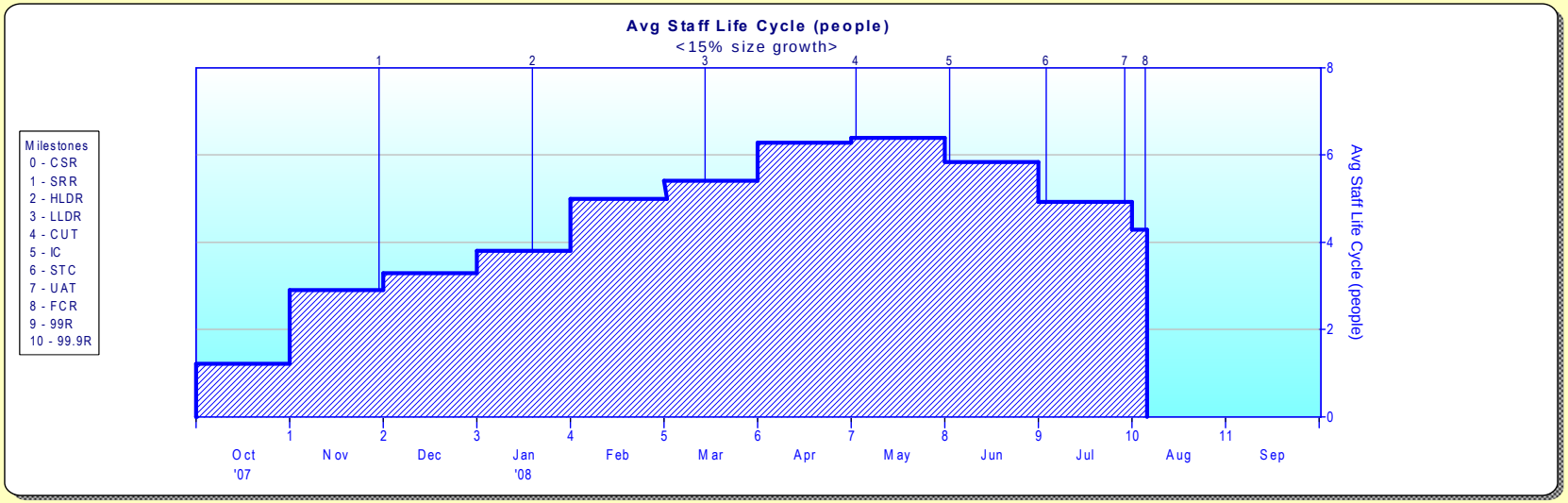
**Life Effort (PM) Risk Profile - Probability demo**
**<500 FP project>**

| Assurance Level (%) | Life Effort (PM) |
|---|---|
| 1 | 0.00 |
| 5 | 5.11 |
| 10 | 12.20 |
| 15 | 16.99 |
| 20 | 20.79 |
| 25 | 24.05 |
| 30 | 26.98 |
| 35 | 29.69 |
| 40 | 32.27 |
| 45 | 34.75 |
| 50 | 37.20 |
| 55 | 39.65 |
| 60 | 42.13 |
| 65 | 44.71 |
| 70 | 47.42 |
| 75 | 50.35 |
| 80 | 53.61 |
| 85 | 57.41 |

Project: Probability demo

# 15% Growth (575 FP)

**Staffing & Probability Analysis**




SOLUTION PANEL - <15% size growth>

| | C&T | Life Cycle | |
|---|---|---|---|
| Duration | 7.3 | 10.2 | Months |
| Effort | 35 | 46 | PM |
| Cost | 603.7 | 787.5 | $ (K) |
| Peak Staff | 6.5 | 6.5 | people |
| MTTD | 1.681 | 1.681 | Days |
| Start Date | 12/28/2007 | 10/1/2007 | |

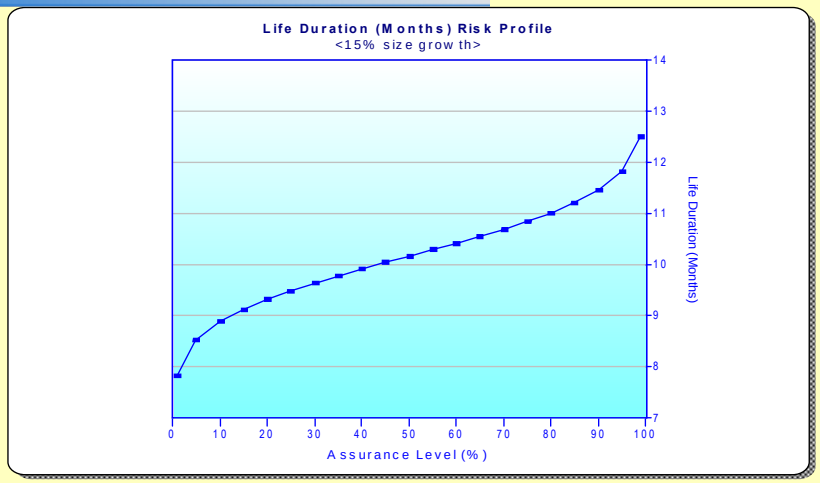
PI=16.5 MBI=3.4 Eff FP=575

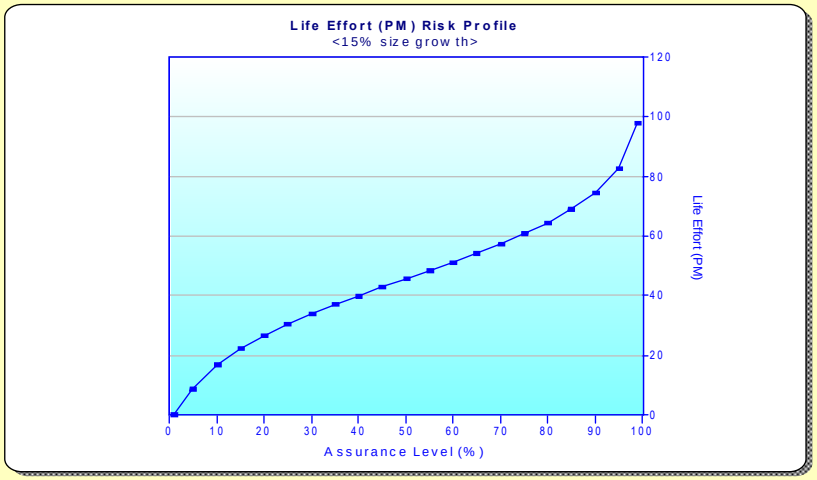
**10.2 months duration**

**46 person months effort**

# 15% Growth (575 FP)

Evaluate Probability of Current Estimate




**Life Duration (Months) Risk Profile - Probability demo**
**<15% size growth>**

| Assurance Level (%) | Life Duration (Months) |
|---|---|
| 1 | 7.83 |
| 5 | 8.51 |
| 10 | 8.88 |
| 15 | 9.12 |
| 20 | 9.32 |
| 25 | 9.48 |
| 30 | 9.63 |
| 35 | 9.77 |
| 40 | 9.91 |
| 45 | 10.03 |
| 50 | 10.16 |
| 55 | 10.2 |
| 60 | 10.41 |
| 65 | 10.55 |
| 70 | 10.69 |
| 75 | 10.84 |
| 80 | 11.00 |
| 85 | 11.20 |

**Life Effort (PM) Risk Profile - Probability demo**
**<15% size growth>**

| Assurance Level (%) | Life Effort (PM) |
|---|---|
| 1 | 0.00 |
| 5 | 8.61 |
| 10 | 16.76 |
| 15 | 22.27 |
| 20 | 26.64 |
| 25 | 30.39 |
| 30 | 33.76 |
| 35 | 36.89 |
| 40 | 39.85 |
| 45 | 42.71 |
| 50 | 45.52 |
| 55 | 48.33 |
| 60 | 51.19 |
| 65 | 54.15 |
| 70 | 57.28 |
| 75 | 60.65 |
| 80 | 64.40 |
| 85 | 68.77 |

Project Probability demo

**Averages close to numbers predicted for effort and schedule growth (10.2 duration and 43 staff months of effort)**

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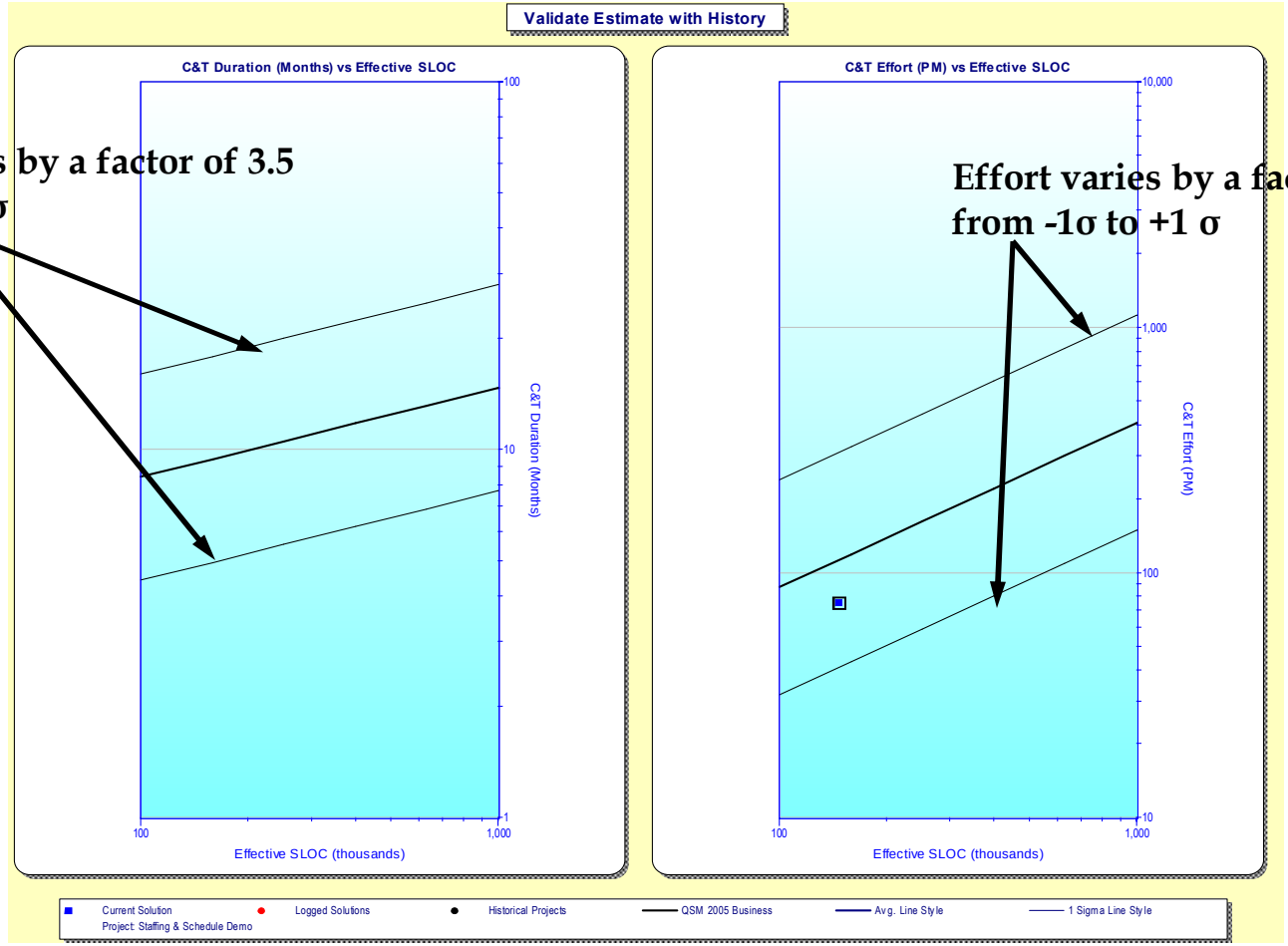
# Staffing & Schedule

Schedule varies by a factor of 3.5 from -1σ to +1 σ

Effort varies by a factor of 8 from -1σ to +1 σ




**What is "normal" variability?**

# d Project Effort Be Expended A Case Study

- 838 projects that had data reported for Analysis/Design as well as Construction and Test phases
- Average Effort applied to Analysis/Design = 20%
- 474 projects in the sample used <= 20% design effort
  - Average Analysis/Design Effort = 11%
- 364 projects in the sample used > 20% design effort
  - Average Analysis/Design Effort = 33%
- Size profiles of samples very similar

# Observations

- **Projects with <20% effort in Requirements and Design**
  - **Took 12% longer to complete**
  - **Averaged 5.6% more effort (median 24.4% greater)**
  - **Had an average staff 14.6% higher**
- **But these projects did excel at one thing:**
  - **Found 63.7% more defects in systems test**
  - **Had 127% more defects in the first 12 months after delivery**

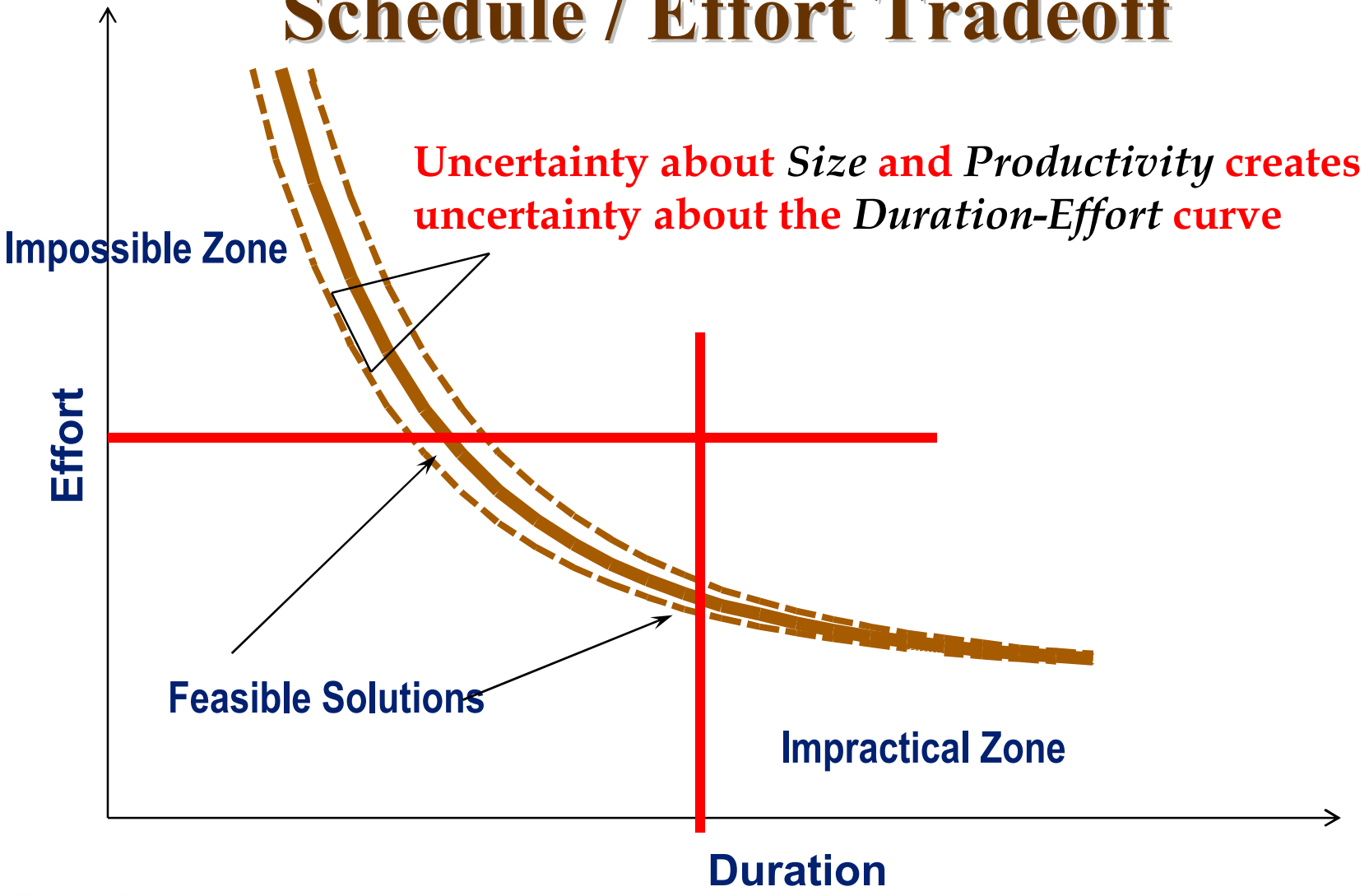
# Understanding Trade-offs

$$\text{Size} = \text{Effort}^{a} \times \text{Time}^{b} \times \text{Productivity}$$

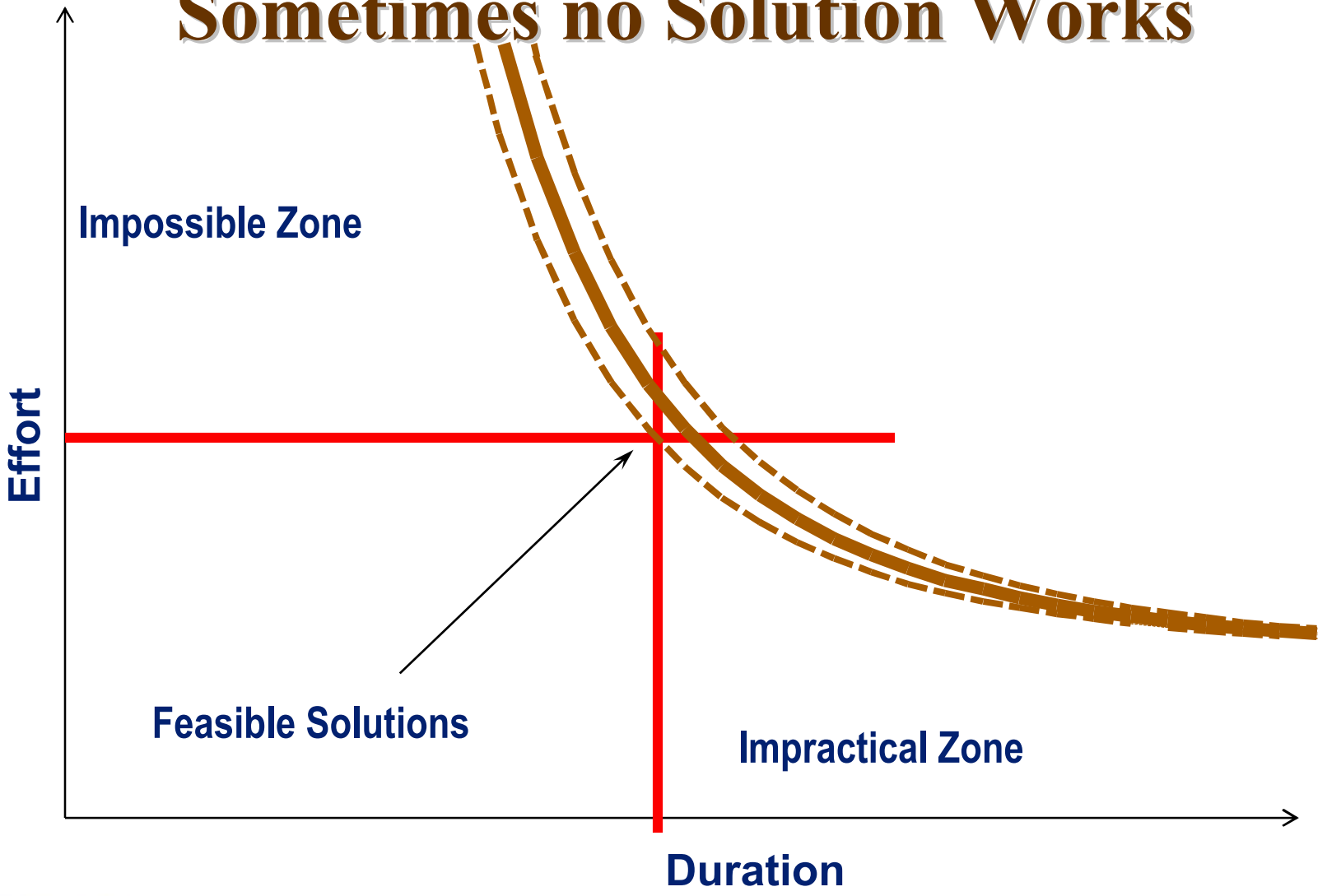
where $a = \frac{1}{3}$ and $b = \frac{4}{3}$

**Additional schedule has a much larger impact on a software project than increased effort**

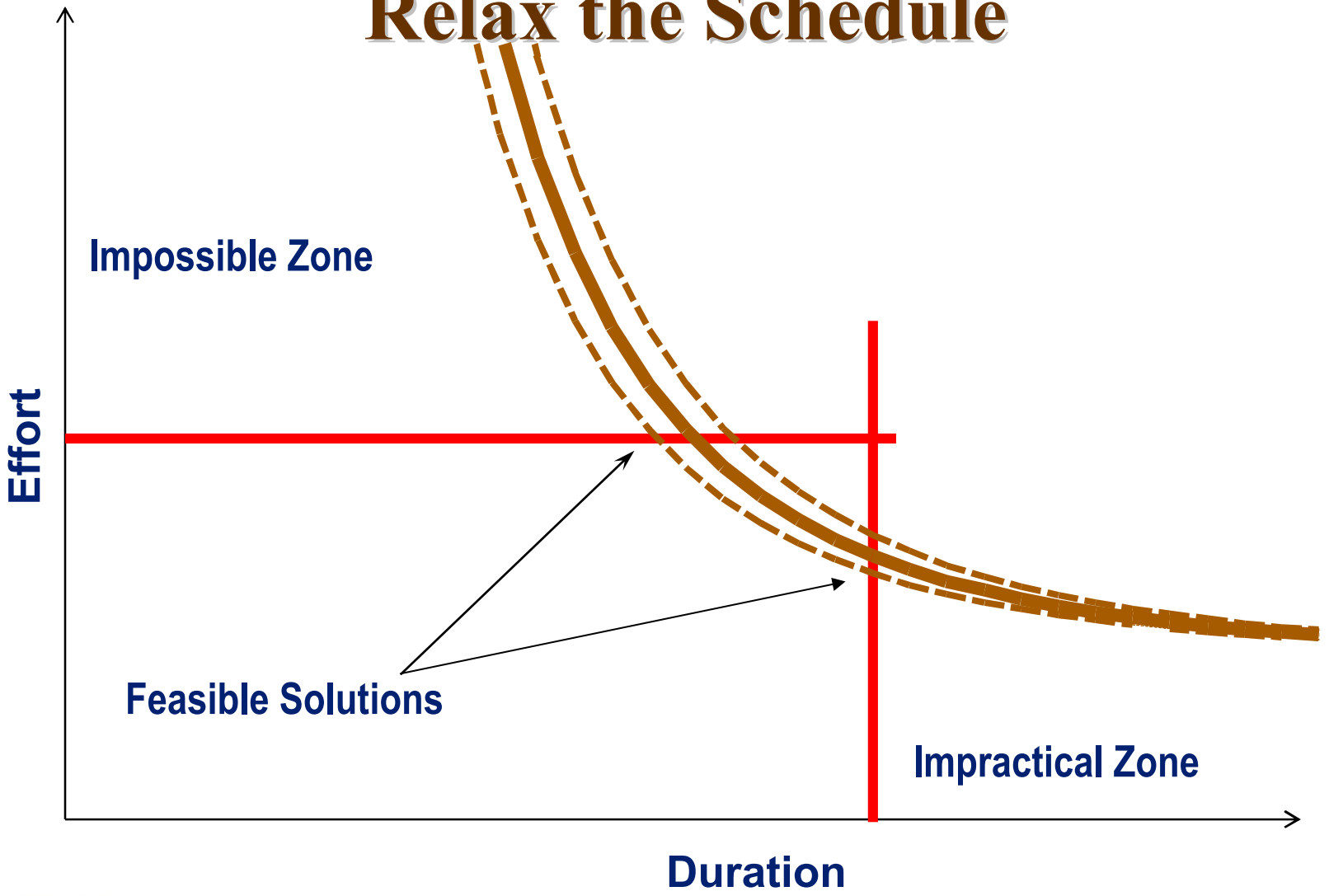
# Estimating Conundrum
# Schedule / Effort Tradeoff



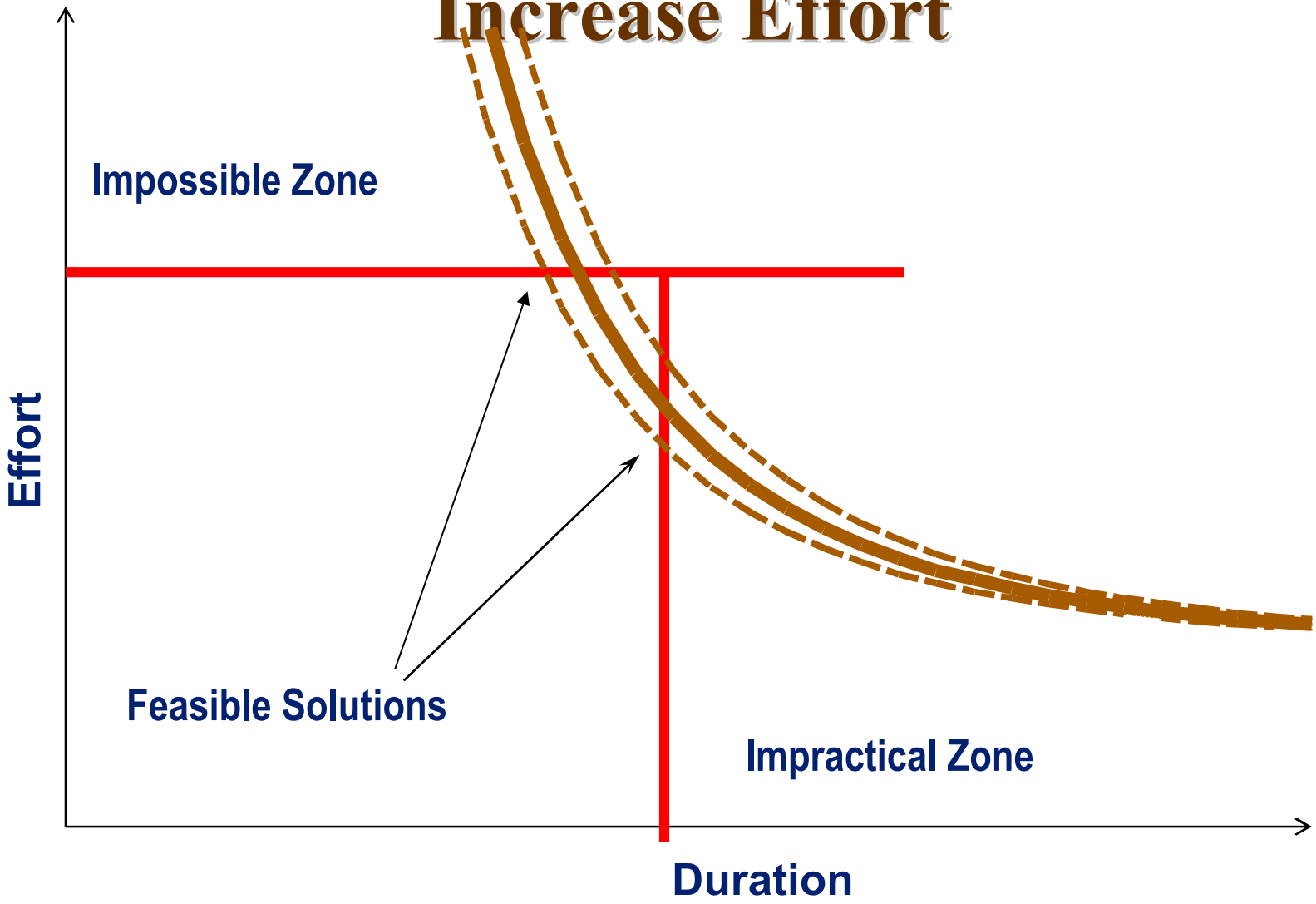
# Estimating Conundrum
# Sometimes no Solution Works



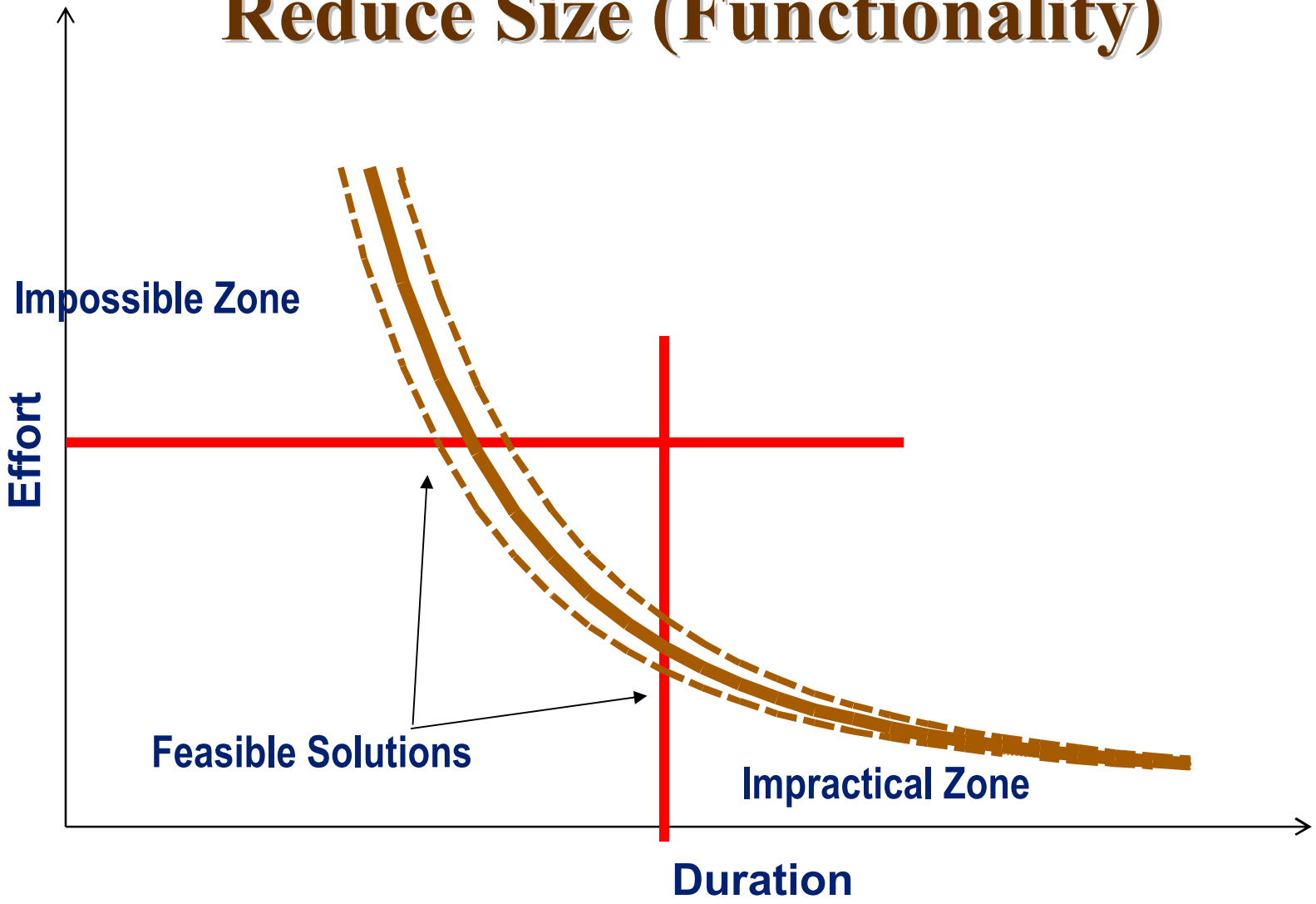
# Estimating Conundrum
# Relax the Schedule



# Estimating Conundrum
# Increase Effort



# Estimating Conundrum
# Reduce Size (Functionality)

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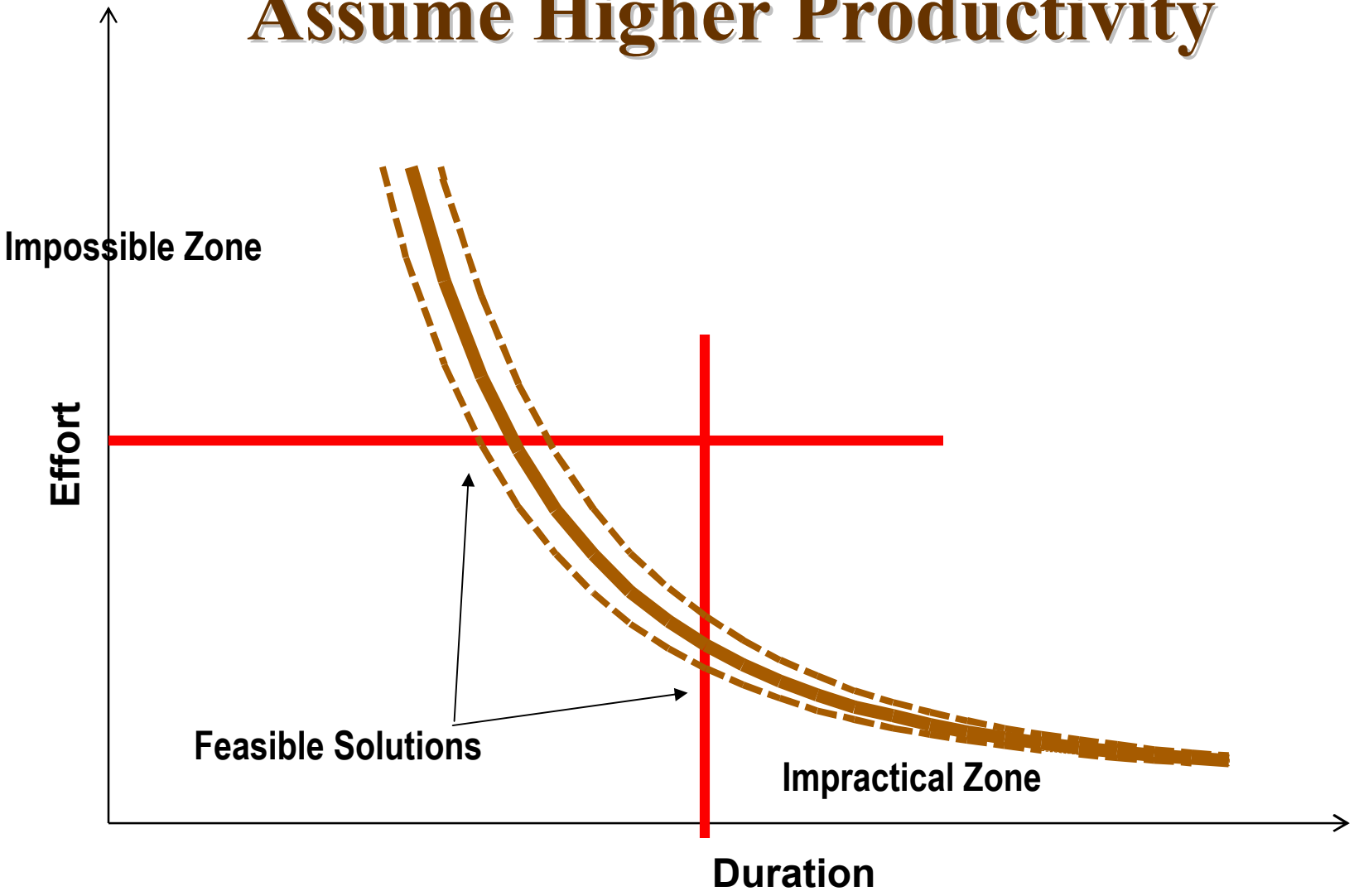
# Estimating Conundrum
# Assume Higher Productivity



# Conclusions

- **Measurement is an integral part of management**
- **Information required to make precise estimates is unavailable at project start-up**
  - **Estimate uncertainty decreases rapidly with more information**
- **Project estimates understate effort, schedule, & size**
  - **Estimating based on a larger size or at a higher assurance level can account for this**
- **The trade-off between schedule & cost/effort is non-linear**

# Conclusions

- **Effort spent in Analysis & Design pays big dividends**
  - **Reduces overall project effort (cost$$$$)**
  - **Reduces overall project schedule**
  - **Improves project quality**

# Questions ?