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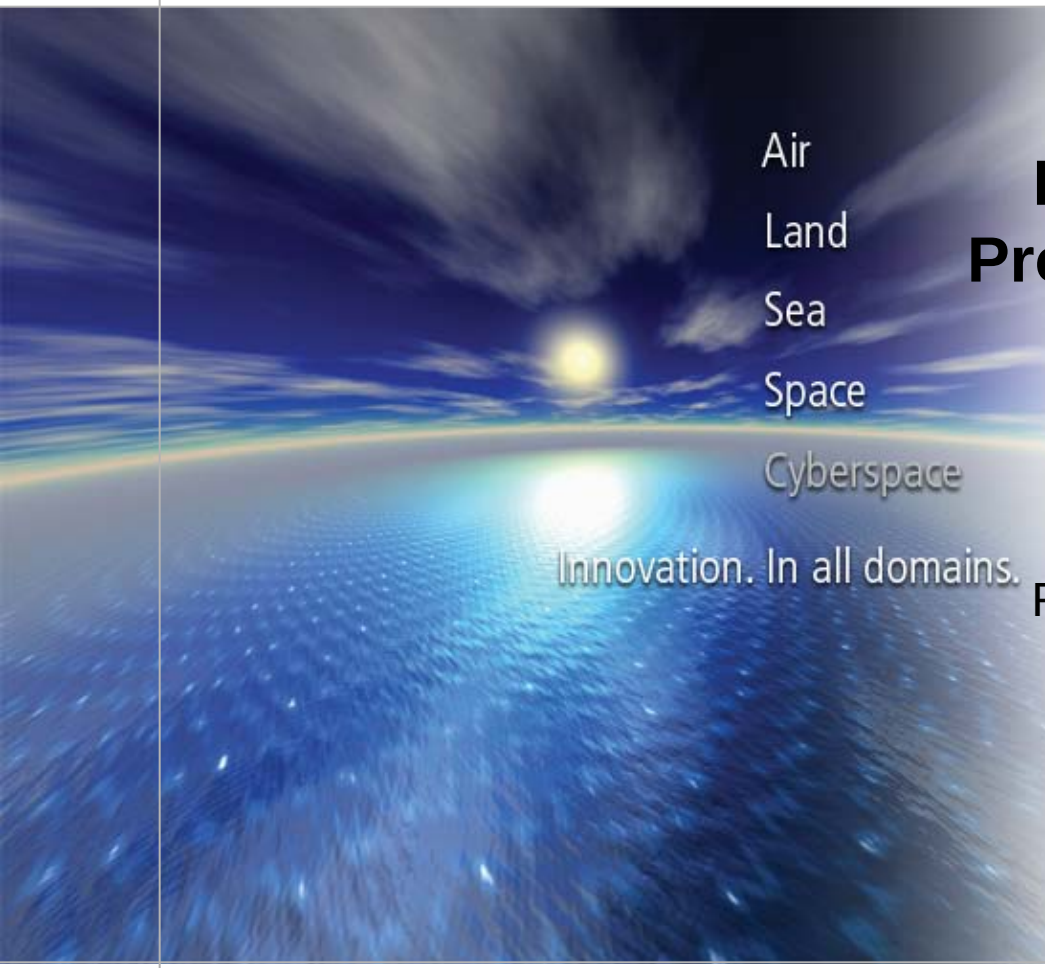


# Horizontal Segmentation of Process Performance Models

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# Overview

- **Raytheon Integrated Defense Systems (IDS) introduced its 2nd Generation of Process Performance Models (2G PPMs) as part of its CMMI high maturity journey**
  - First generation models were developed to address individual lifecycle phase-specific issues
    - Designing for Quality, CAIV, cost models
    - Relationship to business and project objectives often implicit
  - 2G PPMs are used to manage risks related to business and project objectives (cost, schedule, quality) throughout the project lifecycle
    - Relationship of models to goals is explicit and enabled by model-embedded mitigation strategies
    - Supports ongoing, project grass-roots effort to achieve business and project objectives
- **As 2G PPMs began to proliferate, sociotechnical issues emerged**
  - Variation of individual needs became apparent
  - PPM questions related to project context manifested themselves as a series of requests for additional models and features
  - Caused model development and deployment issues related to model "packaging"
- **This presentation will review the use of "horizontal segmentation" as a strategy to support deployment of a "model family" that supports Raytheon business goals and model-user needs**

# System Lifecycle Analysis Model (SLAM)

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- ***Initial 2G Process Performance Model***
- **Models influence of requirements volatility and requirements / design overlap on software / hardware development cost performance**
  - Enables project risk assessment & sensitivity analysis around the likelihood of achieving performance cost objectives, and the development / deployment of mitigation strategies.

- **SLAM Model Inputs**
  - Estimated % Design Complete at Systems Requirements Release
    - Confidence Range (+/- 5, 10, or 15%)
  - Requirements Volatility Estimate
    - Best estimate based on historical baseline for product line, process tailoring, etc.
    - Variance estimates built into model based on historical actuals

- **SLAM Model Outputs**
  - Projected Software / Hardware Cost Performance (CPI)
    - Mean, Standard Deviation
    - 95% Upper & Lower Prediction Interval Limits

# System Lifecycle Analysis Model (SLAM)

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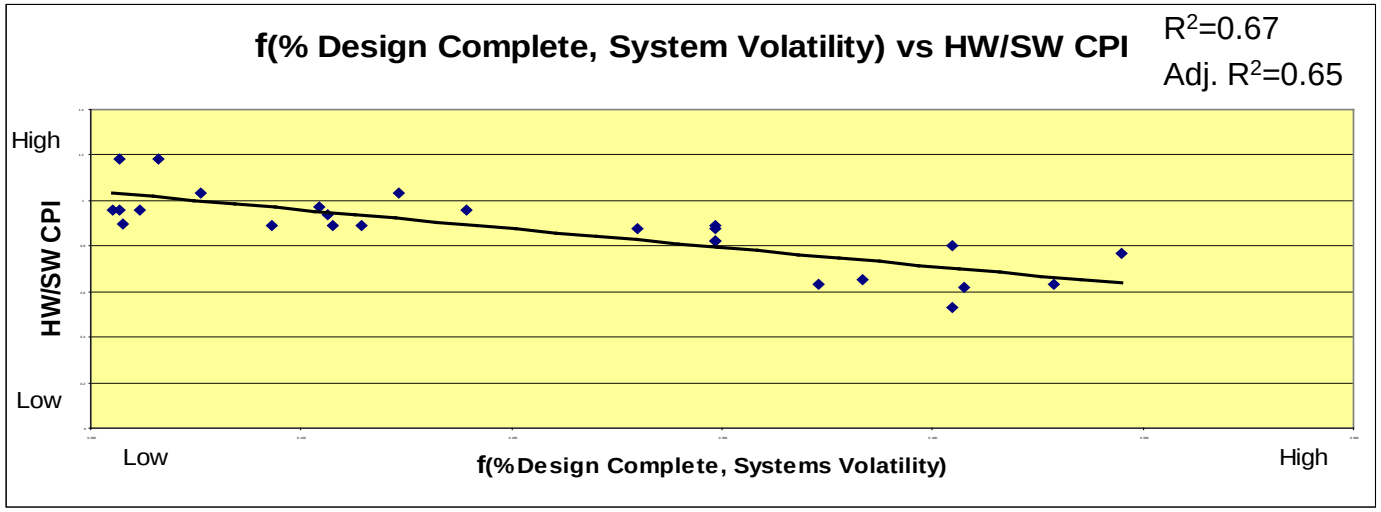
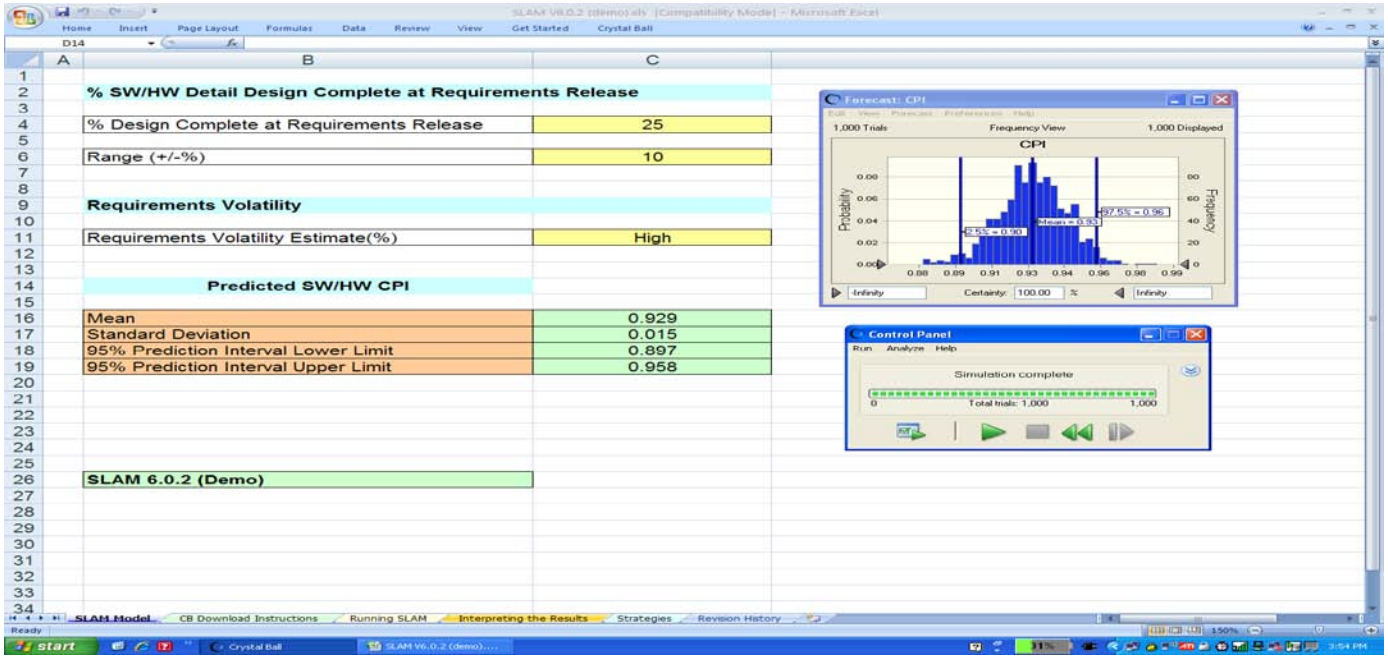
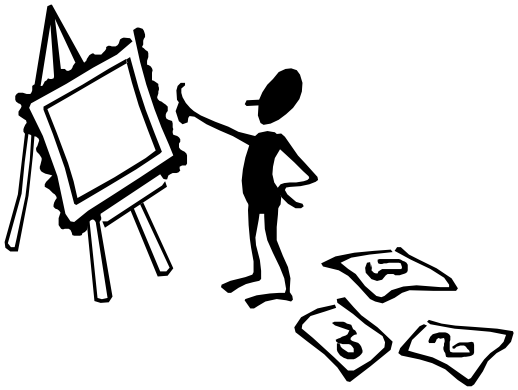


# Post-SLAM

- **Feedback from the SLAM deployment included requests for additional features**
  - Can we predict requirements volatility?
  - Can we predict rework?
  - Can we predict IVV performance?
  - Can we predict likelihood of meeting schedule?
- **The Process Performance Models Team began considering how to meet the needs of different users**
  - Build additional features into SLAM?
  - Create separate models?
  - Bundle separate models into one supermodel?
- **Decision made to create a schedule risk model**
  - Used a SLAM-derived, similar look and feel approach
  - Provided an opportunity for further feedback



# Scheduling Analysis of Variability Engine (SAVE)

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- ***Can we predict likelihood of meeting schedule?***
- **Models influence of individual task cycle time variation on our ability to deliver on-time against defined scheduling requirements**
  - Enables projects to statistically quantify risk associated in meeting schedule and perform sensitivity analysis
  - Enables project identification of process changes that reduce risk (model contains potential mitigation strategies)
  - May be used during planning, re-planning, Estimate at Complete (EAC) activity
- **SAVE Model Inputs**
  - Estimated individual task activity duration (typically defined in terms of their shortest, most likely and longest cycle time expectations)
  - Individual task activity predecessors (defines which tasks feed which tasks)
  - Target overall schedule duration (deadline)
  - Number of task activities
- **SAVE Model Outputs**
  - Probability of meeting target duration
  - Average Duration (Cycle Time)
  - 95% Upper & Lower Prediction Intervals
  - % of time each task is on the critical path

# Scheduling Analysis of Variability Engine (SAVE)

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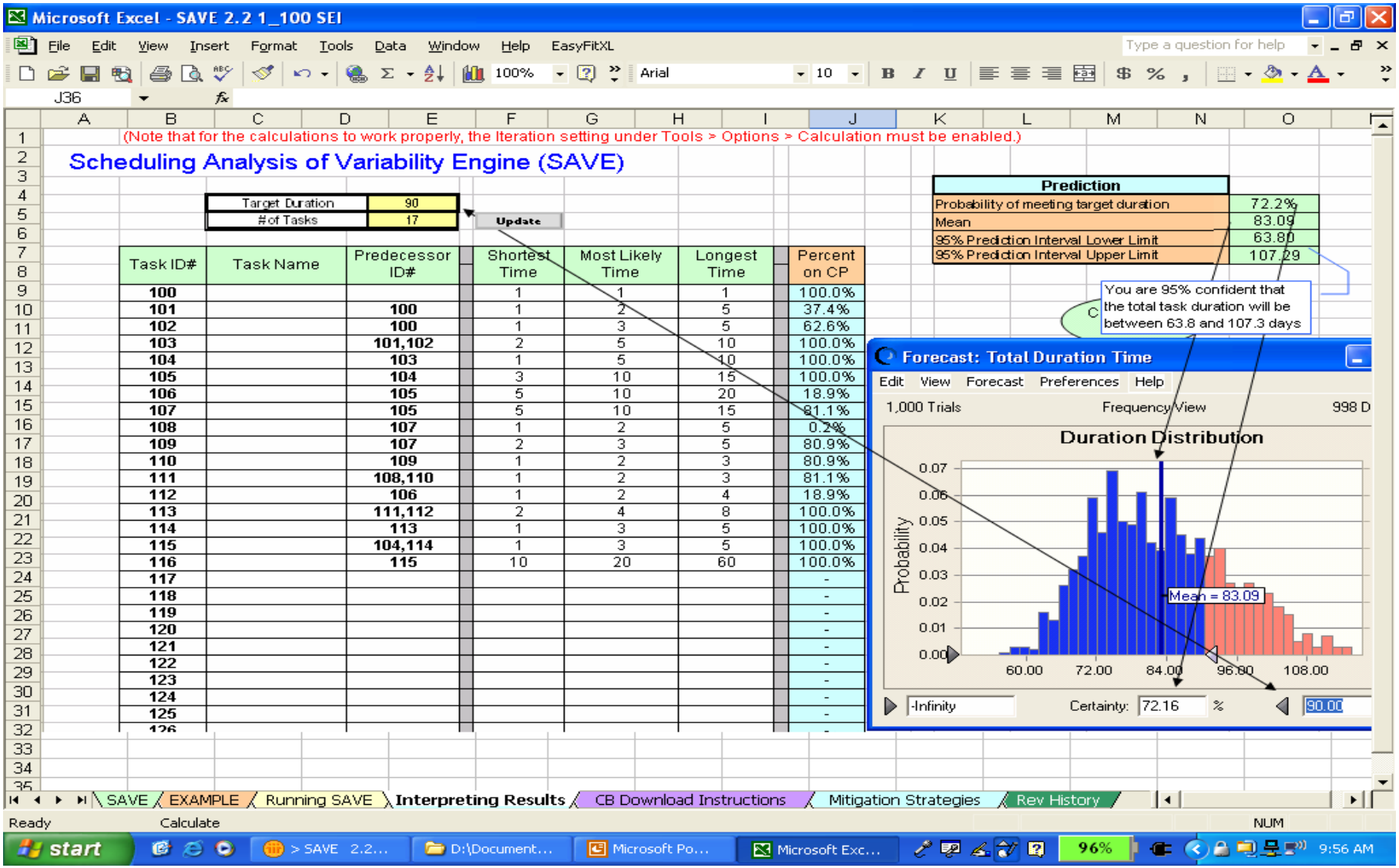
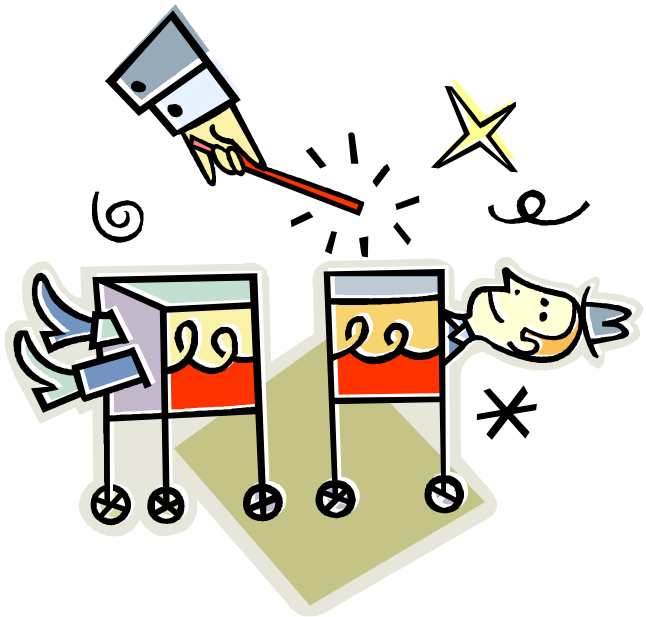



| Task ID# | Task Name | Predecessor ID# | Shortest Time | Most Likely Time | Longest Time | Percent on CP |
|---|---|---|---|---|---|---|
| 100 | | | 1 | 1 | 1 | 100.0% |
| 101 | | 100 | 1 | 2 | 5 | 37.4% |
| 102 | | 100 | 1 | 3 | 5 | 62.6% |
| 103 | | 101,102 | 2 | 5 | 10 | 100.0% |
| 104 | | 103 | 1 | 5 | 10 | 100.0% |
| 105 | | 104 | 3 | 10 | 15 | 100.0% |
| 106 | | 105 | 5 | 10 | 20 | 18.9% |
| 107 | | 105 | 5 | 10 | 15 | 81.1% |
| 108 | | 107 | 1 | 2 | 5 | 0.2% |
| 109 | | 107 | 2 | 3 | 5 | 80.9% |
| 110 | | 109 | 1 | 2 | 3 | 80.9% |
| 111 | | 108,110 | 1 | 2 | 3 | 81.1% |
| 112 | | 106 | 1 | 2 | 4 | 18.9% |
| 113 | | 111,112 | 2 | 4 | 8 | 100.0% |
| 114 | | 113 | 1 | 3 | 5 | 100.0% |
| 115 | | 104,114 | 1 | 3 | 5 | 100.0% |
| 116 | | 115 | 10 | 20 | 60 | 100.0% |
| 117 | | | | | | - |
| 118 | | | | | | - |
| 119 | | | | | | - |
| 120 | | | | | | - |
| 121 | | | | | | - |
| 122 | | | | | | - |
| 123 | | | | | | - |
| 124 | | | | | | - |
| 125 | | | | | | - |

# Post-SAVE

- **Feedback from the SAVE deployment included requests for further model refinements**
  - Can we model probability of achieving cost targets?
  - Can we interface SAVE with Microsoft Project?
  - Can we integrate cost and schedule probability models?
  - Can we go below cost and schedule, and model size and productivity?
- **The answer to all the questions is "yes", but returns us to the model/supermodel dilemma**
- **Solution: Horizontal Segmentation**



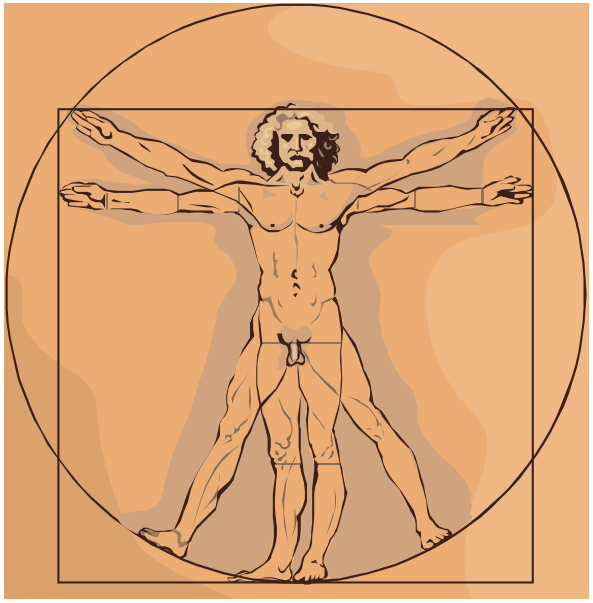
# Horizontal Segmentation

- **In 1986, Psychophysicist Dr. Howard Moskowitz was hired by Campbell's Soup Company to increase market share of Prego spaghetti sauce over arch-rival Ragu.**
  - Prego sales lagged and Campbell's wanted to change the sauce and improve its consumer appeal
  - Through earlier work in the 1970s with Pepsi and Vlasic Pickles, Moskowitz had suspected that a universal "one sauce fits all" solution was not the answer
  - The answer instead was in the understanding and leveraging of variability
  - Moskowitz had 45 different sauces created and taste-tested
    - Results indicated that consumers had different concepts of the perfect spaghetti sauce that could be segmented into groups
    - Main preferences: plain, spicy, extra chunky
    - No extra chunky sauce was marketed at the time
    - Campbell's made $600M over the next 10 years on extra chunky
- **Moskowitz' breakthrough approach, known as Horizontal Segmentation, revolutionized the spaghetti sauce, soft drink and multiple other consumer markets**

# Horizontal Segmentation

- **Horizontal Segmentation – groups people by preference patterns**
  - Contrasts with more traditional social stratifications (age, income, gender, race, etc.)

- **Lessons of Horizontal Segmentation**
  - There is no perfect sauce. There are perfect sauces.
  - There is no perfect pickle. There are perfect pickles.
  - There is no perfect process performance model. There are perfect process performance models.

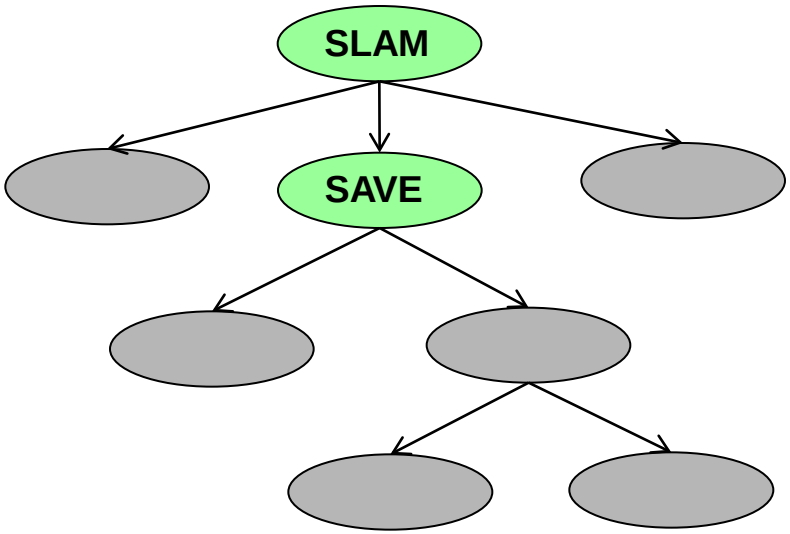


- **Creating a suite of process performance models tailored to meet user preferences can facilitate deployment**
  - Offering users multiple model options empowers users
  - Enables model selection based on innate primal sensibilities (freedom of choice, personal preferences, contextual project differences)

# PPM Horizontal Segmentation

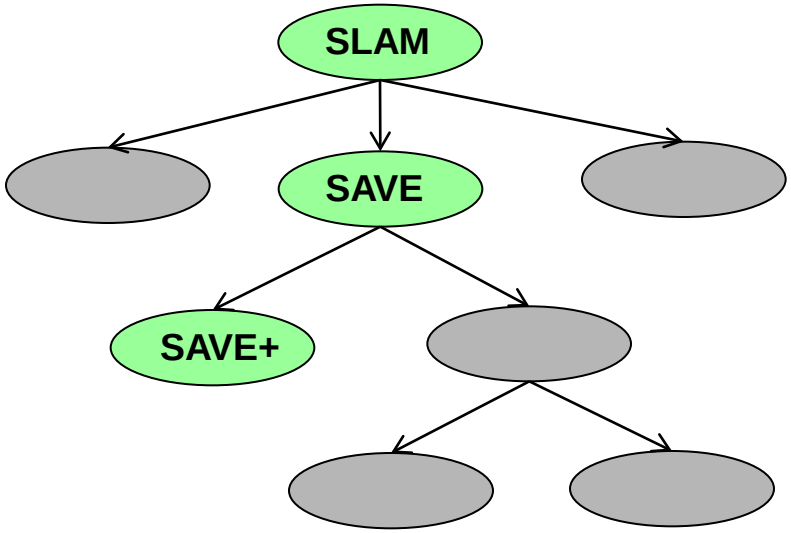
- **Users of process performance models want options that support personal or project preferences**
  - Combinations of cost, schedule, quality, integrated with other project tools

- **Based on feedback and the concept of Horizontal Segmentation, Raytheon IDS has created a cost & schedule model suite derived from SLAM and SAVE**
  - Supports business goals
  - Address individual project objectives, risks, and preferences

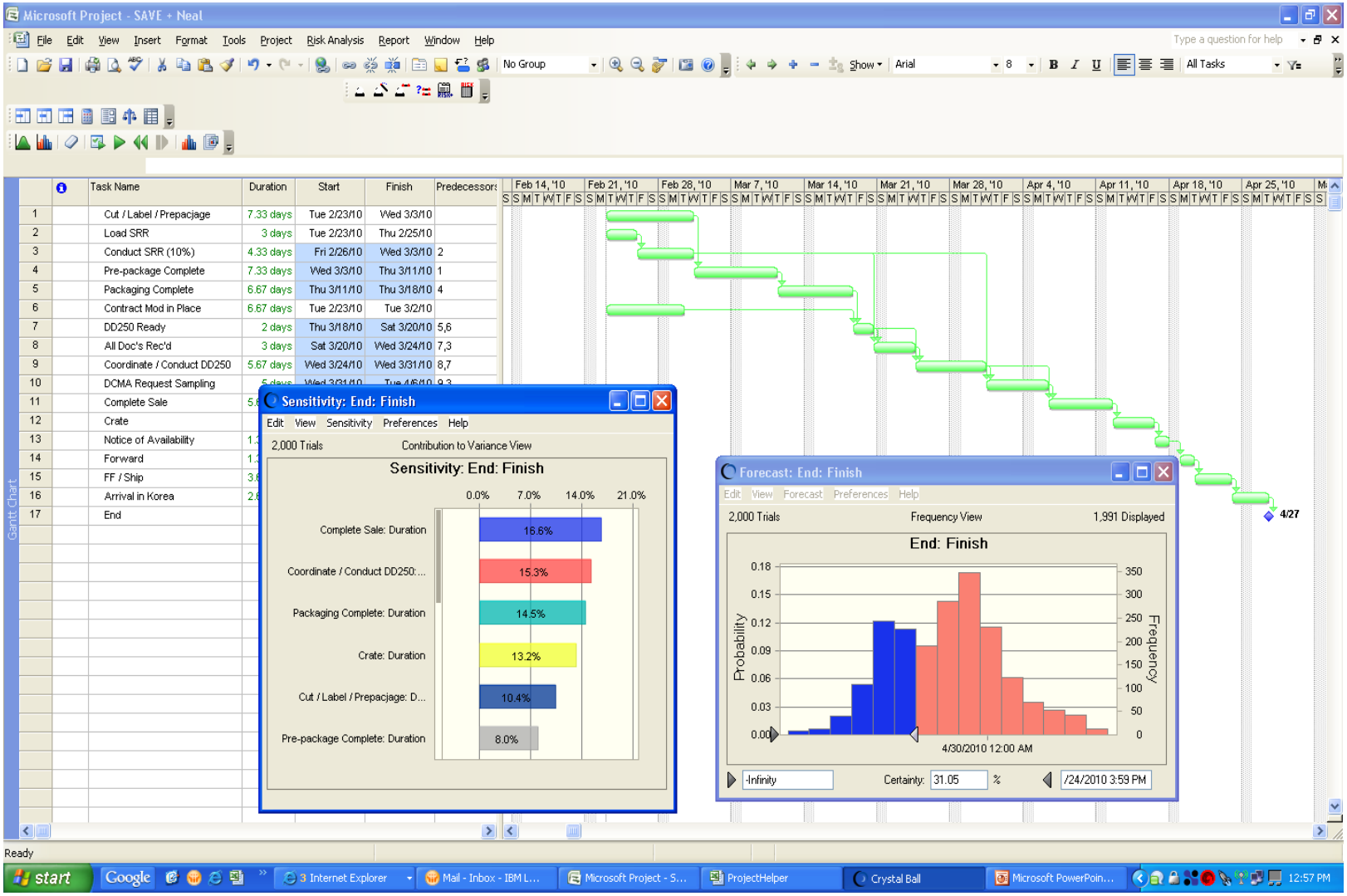


# SAVE+

- ***Can we integrate SAVE with Microsoft Project?***
  - Uses a Crystal Ball interface to MS Project
  - Similar to Risk+



# SAVE+

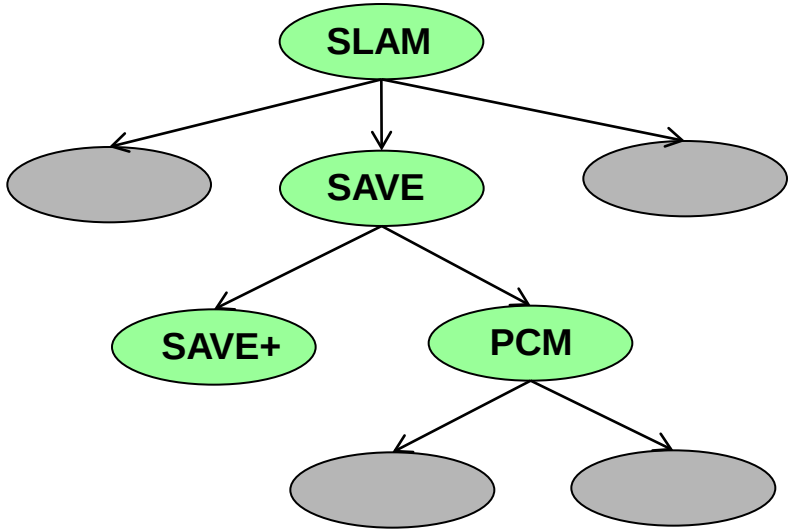

Microsoft Project - SAVE + Neal
File Edit View Insert Format Tools Project Risk Analysis Report Window Help
Task Name Duration Start Finish Predecessors
1 Cut / Label / Prepacjage 7.33 days Tue 2/23/10 Wed 3/3/10
2 Load SRR 3 days Tue 2/23/10 Thu 2/25/10
3 Conduct SRR (10%) 4.33 days Fri 2/26/10 Wed 3/3/10 2
4 Pre-package Complete 7.33 days Wed 3/3/10 Thu 3/11/10 1
5 Packaging Complete 6.67 days Thu 3/11/10 Thu 3/18/10 4
6 Contract Mod in Place 6.67 days Tue 2/23/10 Tue 3/2/10
7 DD250 Ready 2 days Thu 3/18/10 Sat 3/20/10 5,6
8 All Doc's Rec'd 3 days Sat 3/20/10 Wed 3/24/10 7,3
9 Coordinate / Conduct DD250 5.67 days Wed 3/24/10 Wed 3/31/10 8,7
10 DCMA Request Sampling
11 Complete Sale
12 Crate
13 Notice of Availability
14 Forward
15 FF / Ship
16 Arrival in Korea
17 End
Feb 14, '10 Feb 21, '10 Feb 28, '10 Mar 7, '10 Mar 14, '10 Mar 21, '10 Mar 28, '10 Apr 4, '10 Apr 11, '10 Apr 18, '10 Apr 25, '10
4/27
Gantt Chart
Sensitivity: End: Finish
Edit View Sensitivity Preferences Help
2,000 Trials
Contribution to Variance View
Sensitivity: End: Finish
0.0% 7.0% 14.0% 21.0%
Complete Sale: Duration 16.6%
Coordinate / Conduct DD250:... 15.3%
Packaging Complete: Duration 14.5%
Crate: Duration 13.2%
Cut / Label / Prepacjage: D... 10.4%
Pre-package Complete: Duration 8.0%
Forecast: End: Finish
Edit View Forecast Preferences Help
2,000 Trials
Frequency View
1,991 Displayed
End: Finish
Probability
Frequency
4/30/2010 12:00 AM
-Infinity
Certainty: 31.05 %
/24/2010 3:59 PM
Ready
start
Google
3 Internet Explorer
Mail - Inbox - IBM L...
Microsoft Project - S...
ProjectHelper
Crystal Ball
Microsoft PowerPoin...
12:57 PM

# Predictive Cost Modeling (PCM)

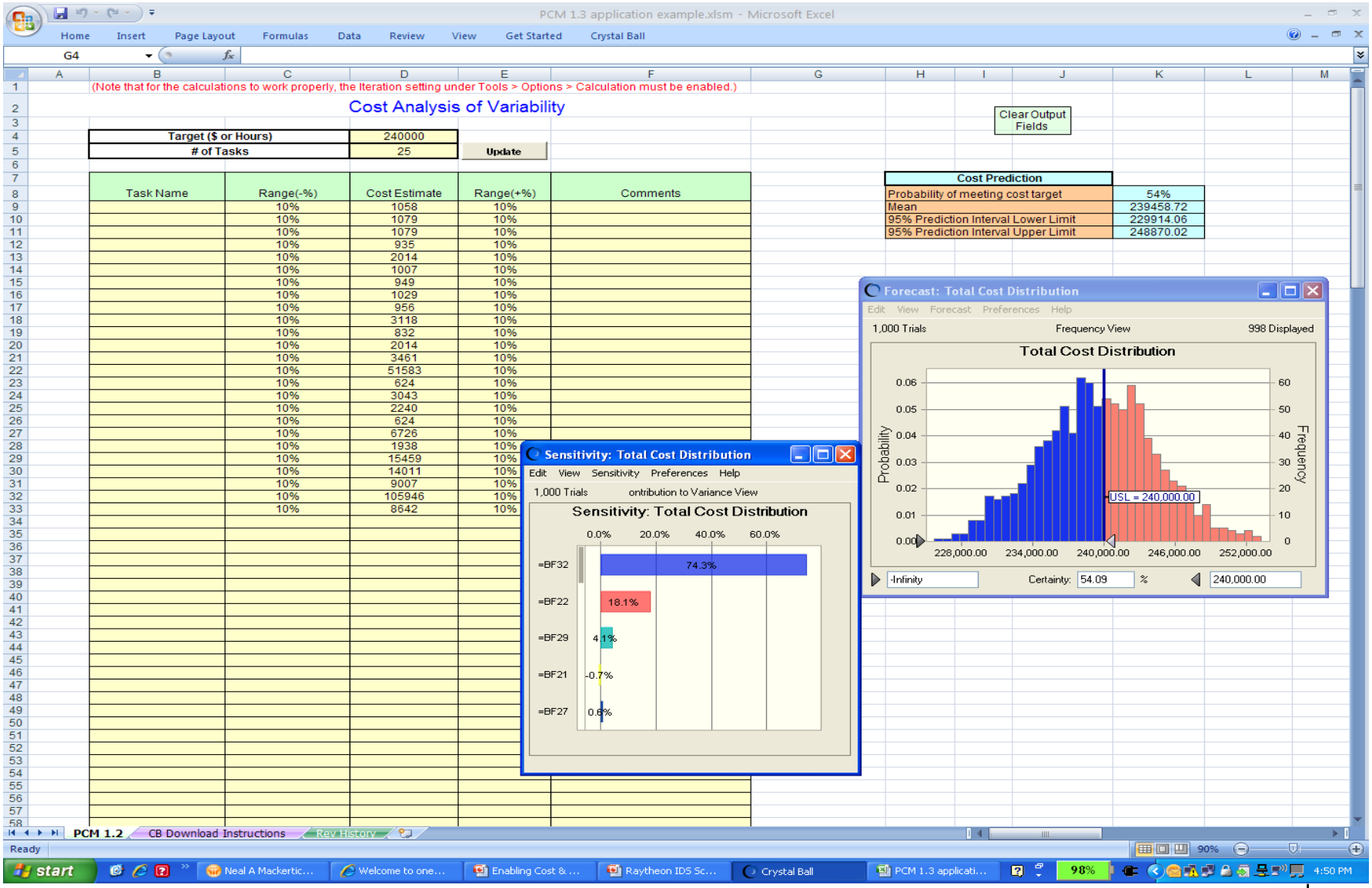
- ***Can we model probability of achieving cost targets?***
- **PCM models the influence of individual cost element variation on our ability to meet cost targets / budget requirements**
  - Enables projects to statistically quantify risk associated in meeting cost targets / budgets and perform sensitivity analysis
  - Enables project identification of process changes that reduce risk
  - May be used during planning, re-planning, EAC activity

- **Predictive Cost Model Inputs**
  - Estimated mean cost for each individual cost element
  - Associated expected range of performance for each individual cost element (min / max for the default triangular distribution)
  - Overall cost target

- **Predictive Cost Model Outputs**
  - Predictive average cost
  - 95% Upper & Lower Prediction Intervals
  - Probability of meeting cost target / budgets
  - Total cost estimate per task



# Predictive Cost Modeling (PCM)



# Integrated Predictive Cost & Scheduling (IPCS)

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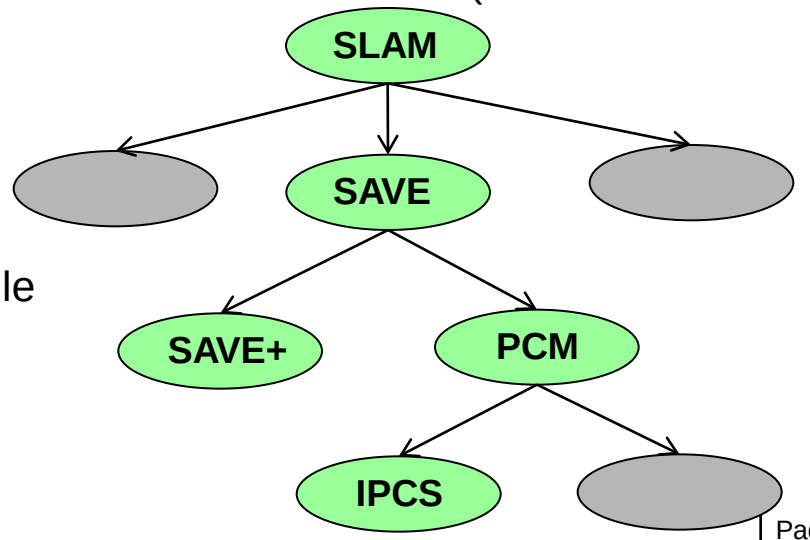
- ***Can we integrate cost and schedule probability models?***
- **IPCS integrates the Schedule Analysis of Variability Engine (SAVE) and the Predictive Cost Model (PCM)**
  - Enables projects to statistically quantify risk associated in meeting cost & schedule targets and perform integrated sensitivity analysis
  - Enables project identification of process changes that reduce risk
  - May be used during planning, re-planning, EAC activity
- **IPCS Cost Model Inputs**
  - Estimated mean cost and duration expectations for each individual element
  - Individual task activity predecessors (defines which tasks feed which tasks)
  - Associated expected range of performance for each individual element (min / max for the default triangular distribution)
  - Overall cost & schedule targets
- **IPCS Cost Model Outputs**
  - Probability of meeting cost & schedule targets
  - Predictive mean expectation for cost & schedule
  - 95% Upper & Lower Prediction Intervals
  - % of time each task is on the critical path
  - Total cost estimate per task



# Integrated Predictive Cost & Scheduling (IPCS)

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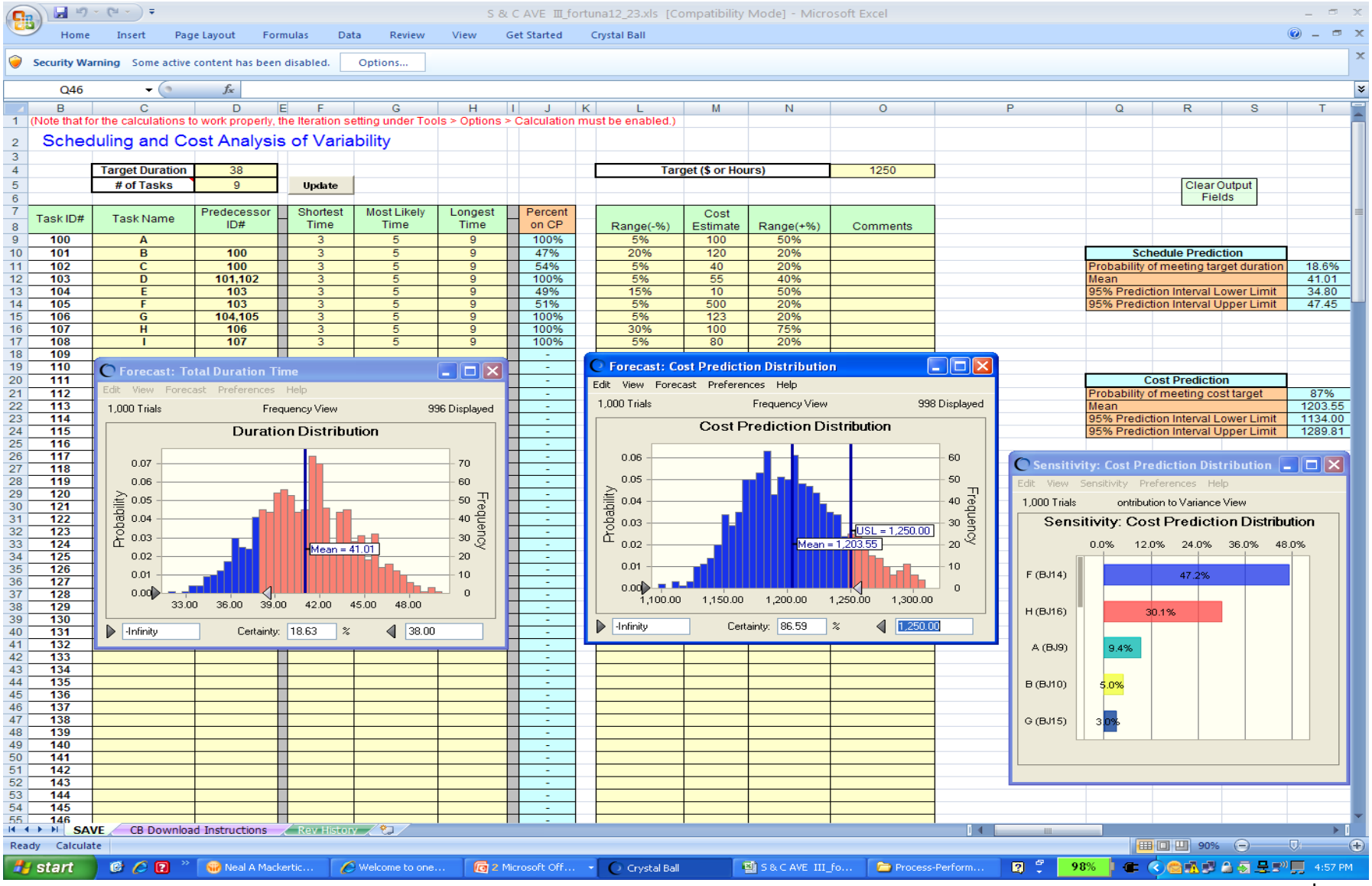

# Effort based on Size & Productivity (ESP)

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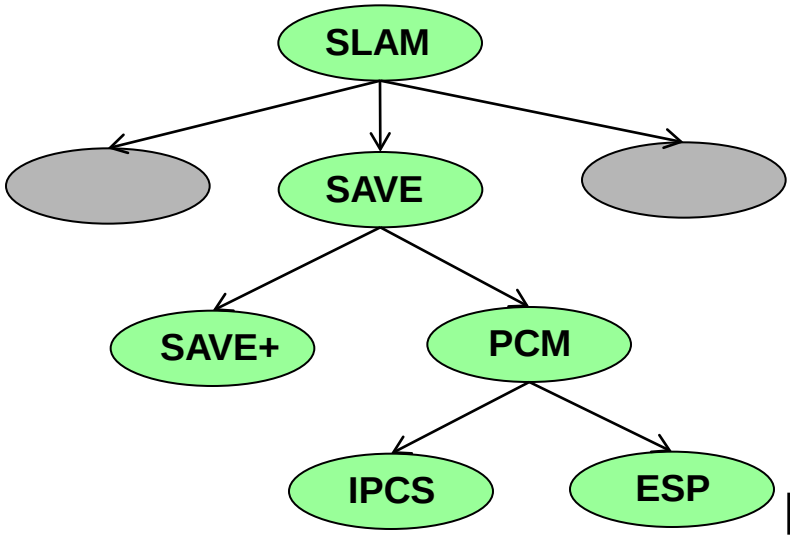
- ***Can we go below cost and schedule, and model size and productivity?***
- **ESP models the influence of size and productivity variability on our ability to meet cost targets / budget requirements**
  - Enables projects to statistically quantify risk associated in meeting cost targets / budgets and perform sensitivity analysis
  - Enables project identification of process changes that reduce risk
  - May be used during planning, re-planning, EAC activity
- **Size and Productivity Cost Model Inputs**
  - Estimated mean size and productivity for each individual cost element
  - Associated expected range of performance for each size and productivity estimate (min / max for default triangular distribution)
  - Overall cost target
- **Size and Productivity Outputs**
  - Predictive average cost
  - 95% Upper & Lower Prediction Intervals
  - Probability of meeting cost target / budgets
  - Total cost estimate



# Effort based on Size & Productivity (ESP)

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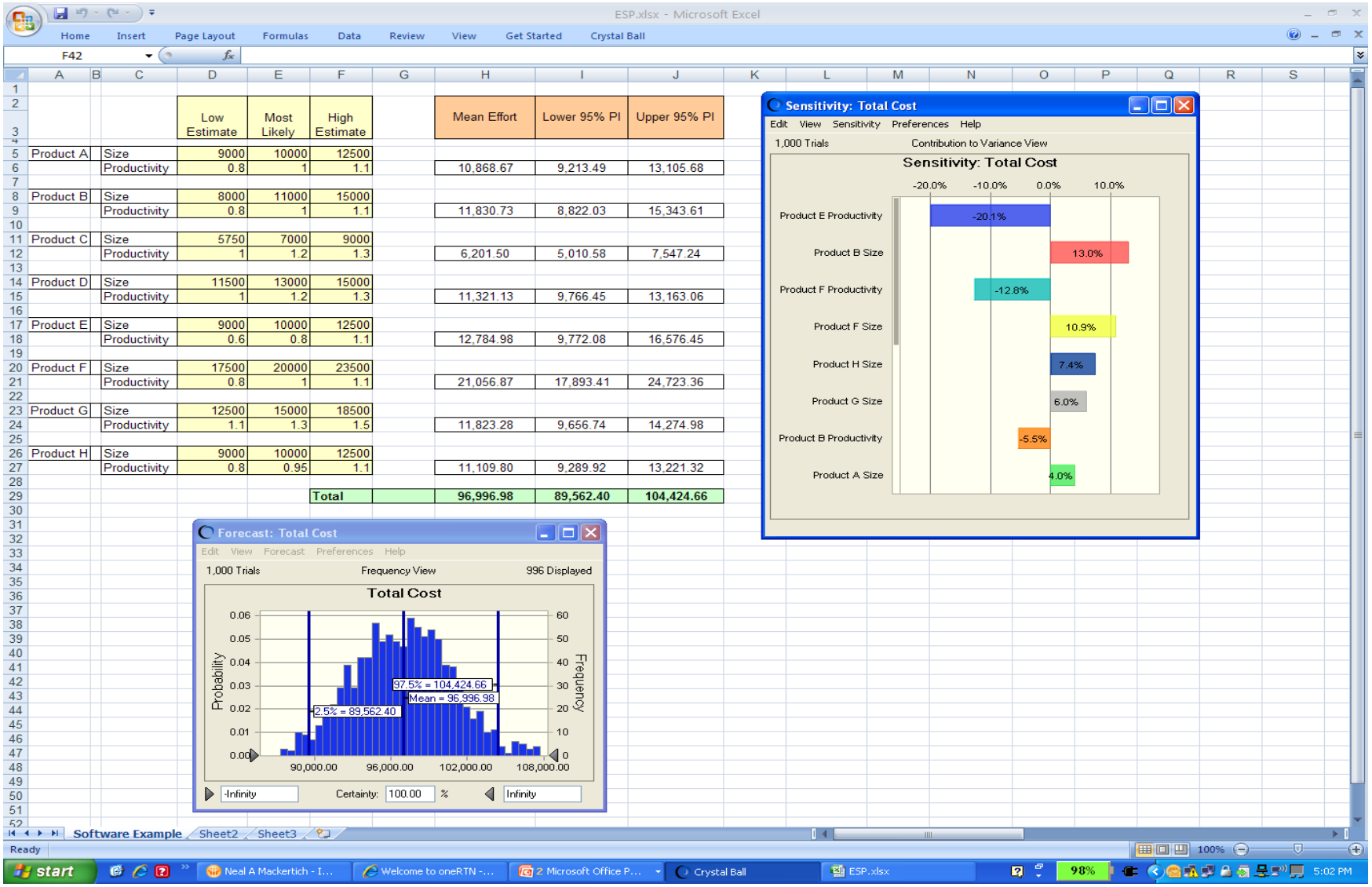


| | | | Low Estimate | Most Likely | High Estimate | Mean Effort | Lower 95% PI | Upper 95% PI |
|---|---|---|---|---|---|---|---|---|
| Product A | Size | | 9000 | 10000 | 12500 | | | |
| | Productivity | | 0.8 | 1 | 1.1 | 10,868.67 | 9,213.49 | 13,105.68 |
| Product B | Size | | 8000 | 11000 | 15000 | | | |
| | Productivity | | 0.8 | 1 | 1.1 | 11,830.73 | 8,822.03 | 15,343.61 |
| Product C | Size | | 5750 | 7000 | 9000 | | | |
| | Productivity | | 1 | 1.2 | 1.3 | 6,201.50 | 5,010.58 | 7,547.24 |
| Product D | Size | | 11500 | 13000 | 15000 | | | |
| | Productivity | | 1 | 1.2 | 1.3 | 11,321.13 | 9,766.45 | 13,163.06 |
| Product E | Size | | 9000 | 10000 | 12500 | | | |
| | Productivity | | 0.6 | 0.8 | 1.1 | 12,784.98 | 9,772.08 | 16,576.45 |
| Product F | Size | | 17500 | 20000 | 23500 | | | |
| | Productivity | | 0.8 | 1 | 1.1 | 21,056.87 | 17,893.41 | 24,723.36 |
| Product G | Size | | 12500 | 15000 | 18500 | | | |
| | Productivity | | 1.1 | 1.3 | 1.5 | 11,823.28 | 9,656.74 | 14,274.98 |
| Product H | Size | | 9000 | 10000 | 12500 | | | |
| | Productivity | | 0.8 | 0.95 | 1.1 | 11,109.80 | 9,289.92 | 13,221.32 |
| | | Total | | | | 96,996.98 | 89,562.40 | 104,424.66 |

# Results & Benefits

- Stakeholder groups and projects have found the family of developed 2G PPMs both easy to use and conceptually aligned with project issues.

- Projects have identified and implemented specific improvements as a direct result of the integrated deployment of 2G PPMs that have enabled their execution. Resulting improvement efforts include:
  - Increased up-front investment in *integrated* Engineering planning & analysis
  - Process Performance trade studies
  - Process redesign
  - Enhanced peer reviews
  - Resource reallocation and conflict resolution

- In addition to deployed projects, 2G PPMs have been used up-front during the bid & proposal phase and are utilized by Engineering Management during schedule negotiations with program management.

- Significant qualitative benefits from integrated deployment of these models cannot be underestimated as projects leads / teams are clearly thinking and behaving differently with respect to their analysis of risk & opportunity.

# Summary

- Oddly enough, while project practitioners may tend to *overestimate* contextual differences (your model does not apply to me because my project is different!), analysts may tend to *underestimate* contextual differences and preferences in search of universal solutions that may or may not exist.

- Leveraging the concept of Horizontal Segmentation enables our development and deployment of Cost & Schedule Risk Analysis Models by
  - Sharpening our focus on understanding and serving our projects
  - Enabling our understanding of contextual differences between differing product types, project challenges and personal preferences
  - Increasing project team understanding of the benefits of statistical modeling and igniting their passion for more…
  - Reinforcing the need for data stratification
  - Challenging and reinventing our existing proposal / project management measurement & analysis processes and tools

"There is no perfect Process Performance Model.
There are perfect Process Performance Models."

# References

1. Mackertich, Campo, Beitz, *"System Lifecycle Analysis Model (SLAM)"*, 2nd SEI High Maturity Measurement and Analysis Workshop, November 2008.
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4. Malcolm Gladwell on spaghetti sauce, http://www.ted.com/talks/lang/eng/malcolm_gladwell_on_spaghetti_sauce.html

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