A Methodology and Implementation For Software System Cost and Risk Estimation

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Agenda

- Overview
- Software Cost/Effort Models Overview
- The *GABE* Model*
- Project Management using the *GABE* Model
- Summary

*Please note that we show you some nominal data for a large complex system that is in the support or maintenance stage. This data does not represent specific Lockheed Martin productivity rates

Overview

- Described is a cost, schedule, and cost and schedule risk estimation methodology implemented as an excel-based tool, called ***GABE***, that has been developed and is being used to make estimates of major upgrades of software-intensive air traffic management systems for the FAA.
- The methodology and tool:
  - **Provides estimates for the number of defects to be found in the upgraded system.**
  - **Was implemented by Lockheed Martin with the input and support of the FAA.**
  - **Saves a considerable amount of money and time in producing estimates compared to earlier manual methods. This is especially the case in fast turn-around situations.**
  - **Enhances the application of quantitative management techniques to the conduct of the business**

Software Cost/Effort Estimation Models Overview

Major Types of Software Cost/Effort Estimating Methods and Models

- **Holistic or Parametric models**: models based on relationships among size, effort, and schedule
    - Example – COCOMO, SLIM
  - Holistic Models estimate a process as a whole.
    - Top-down view (e.g., a software development process)
    - Deal with top-level relationships among size,cost, and schedule.
- **Activity-based, Work Breakdown Structure-driven models**: detailed data collected for specific activities and then used to estimate values for new systems
  - Activity-based models estimate a process in terms of its constituent activities for each type of software ,e.g., new, reused.
    - Bottom-up view of a process
    - Consider each activity (or a group) individually
  - Overall cost is the sum of the costs of the constituent activities for each type of software
- **Simple estimating relationships**: simplified parametric model, based on local data
    - Example – Organization/project -specific metric, such as 3 labor months per KSLOC

Activity-Based Cost Models Overview, page 1of 3

- Activity-based models enable the estimator to separately consider each activity in the process, and thus provide an intellectual framework for considering the effect of changes (relative to past experience) such as: a new tool, a process change, different skill mix, etc.
  - Users need to identify all of the activities that compose the specific process whose cost is to be estimated.
- In addition to the cost elements that are driven primarily by the size of the product, there are others that are better estimated as proportions (percents) of the cost (effort) determined using the activity-based model.
  - Examples: quality assurance, builds and controls, program office

Activity-Based Cost Models Overview, page 2 of 3

- The cost or effort for the i^{th} activity is given by an equation of the general form :

$$\mathbf{C_i = ((\Sigma U_{i1})*S_1) + ((\Sigma U_{i2})*S_2) + ... + ((\Sigma U_{i\,T})*S_T)}$$

  - **There are T types of code (e.g., new, deleted,..for which the costs are to be assigned.**
  - **There are unit cost (effort) values, the U_{ij} , i=1,2,…n for each of the n activities for each of the T types of code. Some of these unit cost values may be zero.**
  - **The S_j, j=1,2, …, T are the SLOC counts for each of the T types of code, e.g., new, modified,…, reused.**
- Typically, you should base your estimates for the U_{ij} on past experience, and then modify them in accordance with the circumstances of the new project, such as:
  - The use of an improved design method that would reduce the unit cost for design
  - The use of less skilled developers; this might raise the unit effort (or cost) for design and implementation

Activity-Based Cost Models Overview, page 3 of 3

- **Unit cost** of an activity is of the **form *Cost/Size***:
  - LHrs./KSLOC; LM/KSLOC; LHrs/Page; LHrs./Shall
    - **Important property**: **unit cost/effort values are additive**, and **productivities are not**
- Cost (Effort) of one activity:
  - LH=(LH/KSLOC)*(KSLOC); LM=(LM/KSLOC)*(KSLOC)
- Cost of project using the process is the sum of the costs of its constituent activities.
  - **Key point: Separation of concerns: Size and Unit Effort or Productivity**

Software Size,Cost/Effort, and and Cost and Schedule Risk Estimation

- Often, only single point estimates of costs for major programs are developed.
  - This means that there is no knowledge of the exposure that a program manager would assume by bidding such an estimate.
- It is preferable to estimate ranges and **risks** for the software size, cost, and schedule (duration).
  - The availability of risk information should aid the customer/acquirer and the supplier program and technical personnel in making more informed decisions, and facilitate performing tradeoffs involved in making program decisions.
  - **The idea is to make better informed decisions**
- **Cost risk=probability that the cost target will be exceeded**
- **Schedule risk= probability that the schedule/duration target will be exceeded**

The ***GABE*** Model/Tool

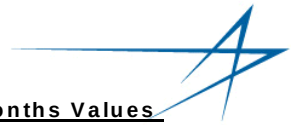
GABE Architecture

GABE consists of 7 primary tool (excel) sheets plus subsidiary sheets. They are:

1. Development Labor Estimator (Activity-Based)
2. PTR (Program Trouble Report) Count and Labor Estimator
3. Overall Project Labor Estimator (Includes labor for: Development, Overhead Functions, and PTRs).
4. Development Labor and Schedule Risk Estimators
5. Overall Project Labor Risk Estimator
6. Development Labor Spread (For Each of 5 Activities)
7. Total Project Labor Spread

Example ***GABE*** tool sheets for: Development Labor Estimator, Total Project Labor Spread, Development Labor and Schedule Risk Estimators, and Total Project Labor Spread are now presented.

Development Labor Estimator, page 1 of 2



Estimate of Most Likely Labor Months Values

CR Activity-Based Cost Estimator, Estimate For: **Project X** **30-Jul-04**

Release Implementation Process Activity		Baseline		N/A/M Code					
				N/A/M Activity Unit Effort					
Number	Name	Baseline Unit Effort Per Activity, LHrs./KSLOC	Baseline Modifier	L Hrs/KSLOC	L Mo./KSLOC	SLOC/LMo.	Activity % of Total of N/A/M Effort	Total L Hrs Per Activity	Total L. Mo. Per Activity
1	Prep.and Reqmt's. Generation	60.0	1.000	60.0	0.375	2667	9.4	1500.0	9.4
2	System Implementation	250.0	1.000	250.0	1.563	640	39.4	6250.0	39.1
3	System Integration	150.0	1.000	150.0	0.938	1067	23.6	3750.0	23.4
4	Requirements Verification	100.0	1.000	100.0	0.625	1600	15.7	2500.0	15.6
5	System Support & Delivery	75.0	1.000	75.0	0.469	2133	11.8	1875.0	11.7
	Totals	635.0		635.0	3.969	252.0	100.0	15875.0	99.2

25.000 **KSLOC of new/added/modified code.**

For LHr /L Month= **160.0**

15875.0 LHrs.= **99.2 L Mo., for N/A/M code.**

SLOC/L Mo.= 252.0

Deleted Code

Baseline Unit Effort as % of N/M Modified Baseline Values	Baseline Unit Effort Per Activity, LHrs./KSLOC	Baseline Modifier	Deleted Activity Unit Effort			Activity % of Total Deleted Effort	Total L Hrs Per Activity	Total L. Mo. Per Activity
			L Hrs/KSLOC	L Mo./KSLOC	SLOC/LMo.			
80.0	48.0	1.000	48.0	0.300	3333	9.5	480.0	3.0
60.0	150.0	1.000	150.0	0.938	1067	29.8	1500.0	9.4
100.0	150.0	1.000	150.0	0.938	1067	29.8	1500.0	9.4
80.0	80.0	1.000	80.0	0.500	2000	15.9	800.0	5.0
100.0	75.0	1.000	75.0	0.469	2133	14.9	750.0	4.7
	503.0		503.0	3.144	318.1	100.0	5030.0	31.4

10.000 **KSLOC of deleted code.**

For LHr /L Mont **160.0**

5030.0 LHrs.= **31.4 L Mo., for deleted code.**

SLOC/L Mo. 318.1

Development Labor Estimator, page 2 of 2

Reused or Carry Code											
Baseline Unit Effort as % of N/M Modified Baseline Values	Baseline Unit Effort Per Activity, LHrs./KSLOC	Baseline Modifier	Reused/Carry Activity Unit Effort L Hrs/KSLOC	L Mo./KSLOC	SLOC/LMo.	Activity as % o Total Carry Effort	Total L Hrs Per Activity	Total L. Mo. Per Activity	Overall Total LHrs. Per Activity	Overall Total L Mo. Per Activity	Activity % of Total N/M/D/C Effort
20.00	12.0	1.000	12.0	0.075	13333	17.0	6600.0	41.3	8580.0	53.63	14.34%
5.00	12.5	1.000	12.5	0.078	12800	17.7	6875.0	43.0	14625.0	91.41	24.45%
15.00	22.5	1.000	22.5	0.141	7111	31.8	12375.0	77.3	17625.0	110.16	29.46%
5.00	5.0	1.000	5.0	0.031	32000	7.1	2750.0	17.2	6050.0	37.81	10.11%
25.00	18.8	1.000	18.8	0.117	8533	26.5	10312.5	64.5	12937.5	80.86	21.63%
	70.8		70.8	0.442	2261.5	100.0	38912.5	243.2	59817.5	373.86	100.00%

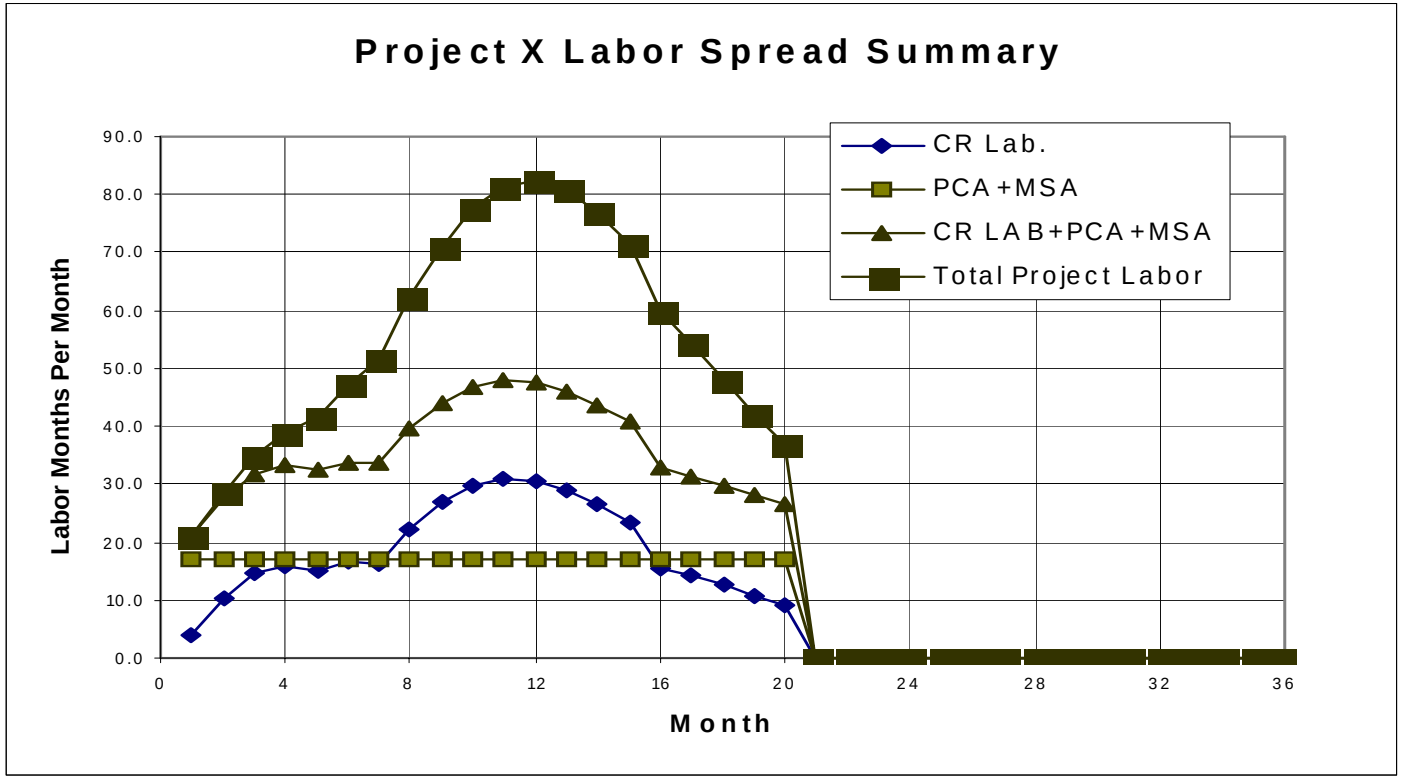
550.0 KSLOC of carry code.

For LHr /L Month= 160.0

38913 LHrs.= 243.2 L Mo., for carry code.

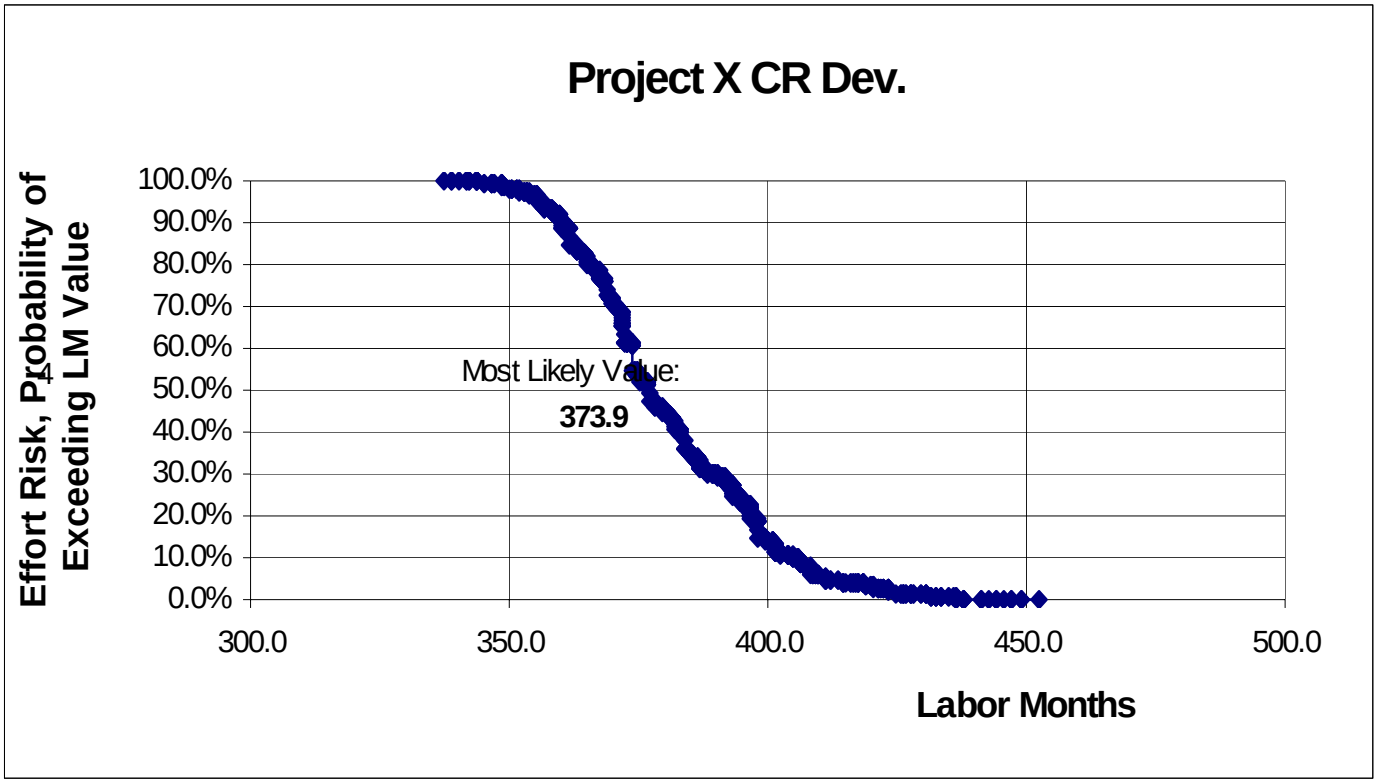
SLOC/L Mo.= 2261.5

Total Project Labor Spread

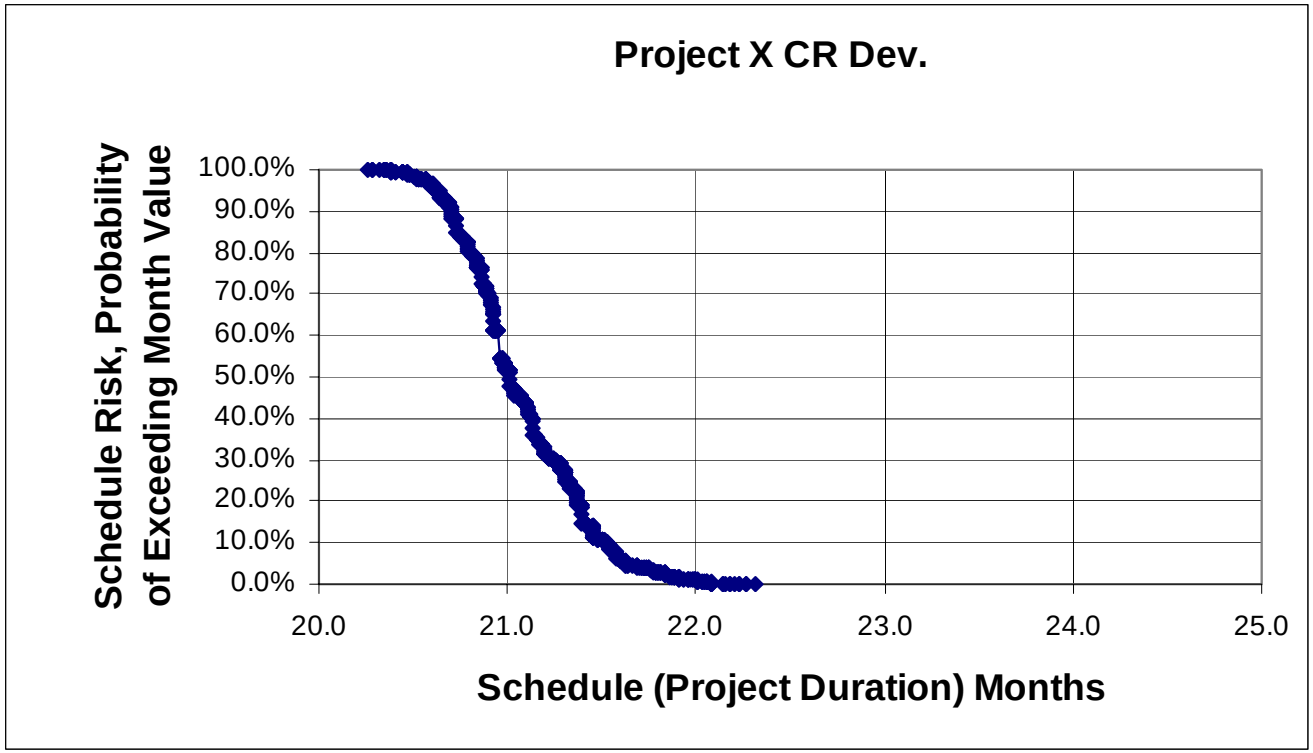


Note: CR means “change request.” PCA means “program control allocation.” MSA means “maintenance support allocation.”

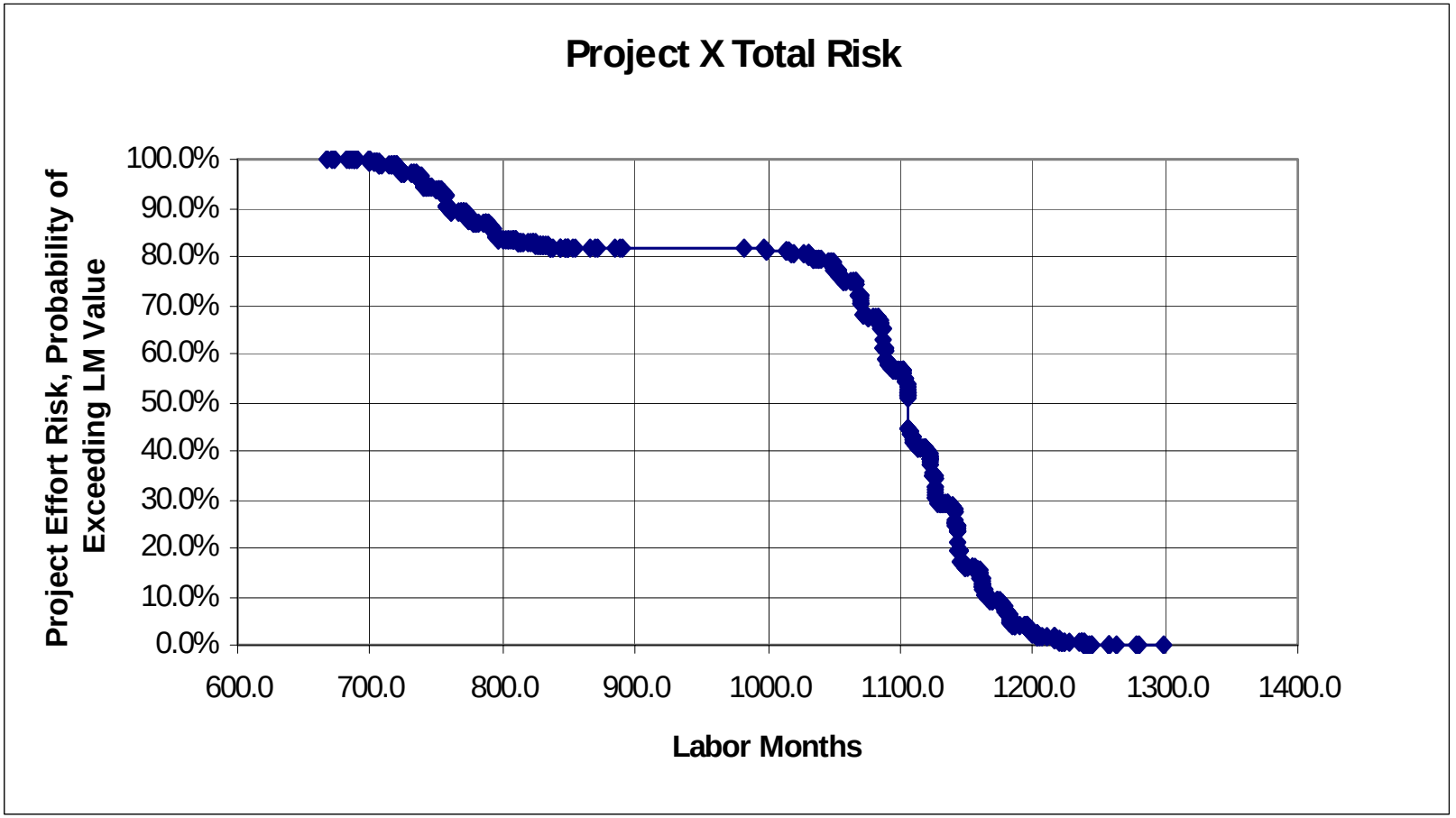
Development Labor Risk Estimator



Development Schedule Risk Estimator



Total Project Labor Risk Estimator



Project Management Using GABE, page 1 of 2

- **Project data used as Input for *GABE* estimates**:
  - System Complexity
    - Complexity tool is available with the GABE toolset
  - Size (KSLOC) of Operational and Support code
    - Estimate of adds,mods,deletes, and reused code
  - Estimated productivity rates of project for lifecycle activities
    - Based on prior project data if available
  - Number and content of releases to be developed, tested and deployed
    - # of anticipated Change Requests (CRs) or Program Trouble Reports (PTRs) to be included in releases
  - Estimate of processes and maintenance work items to be included
  - Statement of work or RFP - if available

Project Management Using GABE, page 2 of 2

- GABE provides an easy way for Project Managers to manage staffing for PTRs and CRs
- Provides fast turnaround for Workload assessments, Proposals, and ROMs, without performing bottoms up estimates
- Allows updates from project measurement data to be incorporated into the model's basis of estimate
  - Enables continuous process improvement and can be used to see affect of process changes on projects

Summary

- ***GABE***:
  - Provides an estimate of the **cost and schedule risks** for the project for which the estimate is being developed.
  - The "risks" are the probabilities that the actual cost (labor) and schedule (project duration) will exceed stated values.
  - Knowledge of these risk figures can be very valuable to program managers and others involved in developing estimates and making business decisions, such as in connection with bidding.
- **There are always uncertainties in estimation and in performing a project. It is far better to use all of the information available to appraise their extent than to simply ignore them.**

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