Affordability: Best Customer Value In Terms of Cost, Schedule and Performance

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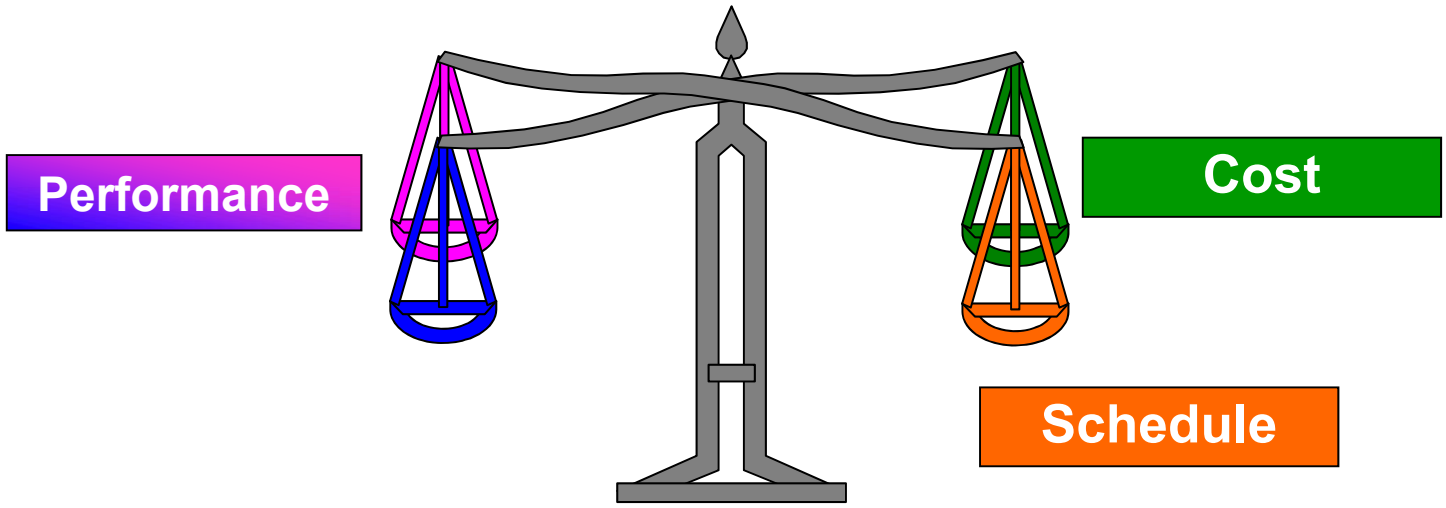
Affordability

- When we speak about “Affordability”
  - Cost often dominates the discussion
    - Can I afford this or that?
  - Sometimes schedule does
    - The sonar MUST be installed before a submarine goes to sea
  - Even less often, we remember the role of performance trades



  - The uncertainty associated with our understanding of each of them introduces risk…

Affordability

- "Affordability" is a measure of a system's effectiveness
- "Affordability" means that a given set of needs (performance requirements) can be met within stated cost and schedule constraints.
- "Affordability" can also be defined as the probability (confidence) of achieving a stated set of needs at a stated cost and schedule (effort).
- The associated "risk" is determined (estimated) on the basis of the capability of the organization to meet this set of needs.
  - "Risk" equals 100% minus "Confidence"

Affordability

- System acquirers tend to have constrained budgets and schedules
  - Can tolerate certain levels of risk
- Often, they do not state what “risk” they can tolerate
- An “affordable system” is one which the specified needs – functionality, performance, design constraints, etc. – can be met within specified cost and schedule budget constraints with a stated confidence
  - In the extreme, a project may be principally cost OR schedule driven

Affordability as a Leading Indicator

What Is A Leading Indicator ? *

- A ***leading indicator*** is a measure for evaluating the effectiveness of how a specific activity is and will be applied on a system or program.
  - The measure and its analysis provide predictive information regarding the potential future state of a system or program
  - May be an individual measure, or a collection of measures
  - Allows management to take action before problems are realized
- What problem do ***SE Leading Indicators*** address?
  - Systems Engineering activities and System Performance
- To express “Affordability as a Leading Indicator”, it is first necessary to determine the “Affordability” of a system
  - Some mathematical combination of cost, schedule, and performance; there are several approaches to this calculation…

* Adapted from the SYSTEMS ENGINEERING LEADING INDICATORS GUIDE, A Collaborative Project of PSM, INCOSE, LAI, and Industry

An Affordability Leading Indicator Example

Cost-focused
for
Simplicity and Brevity

Customer Expectations

- From a recent RFP…

  *"The Life Cycle Cost (LCC) shall address and quantify/bound the **potential risks and impact** in the proposed contractor **design, implementation, schedule and estimating method**.*

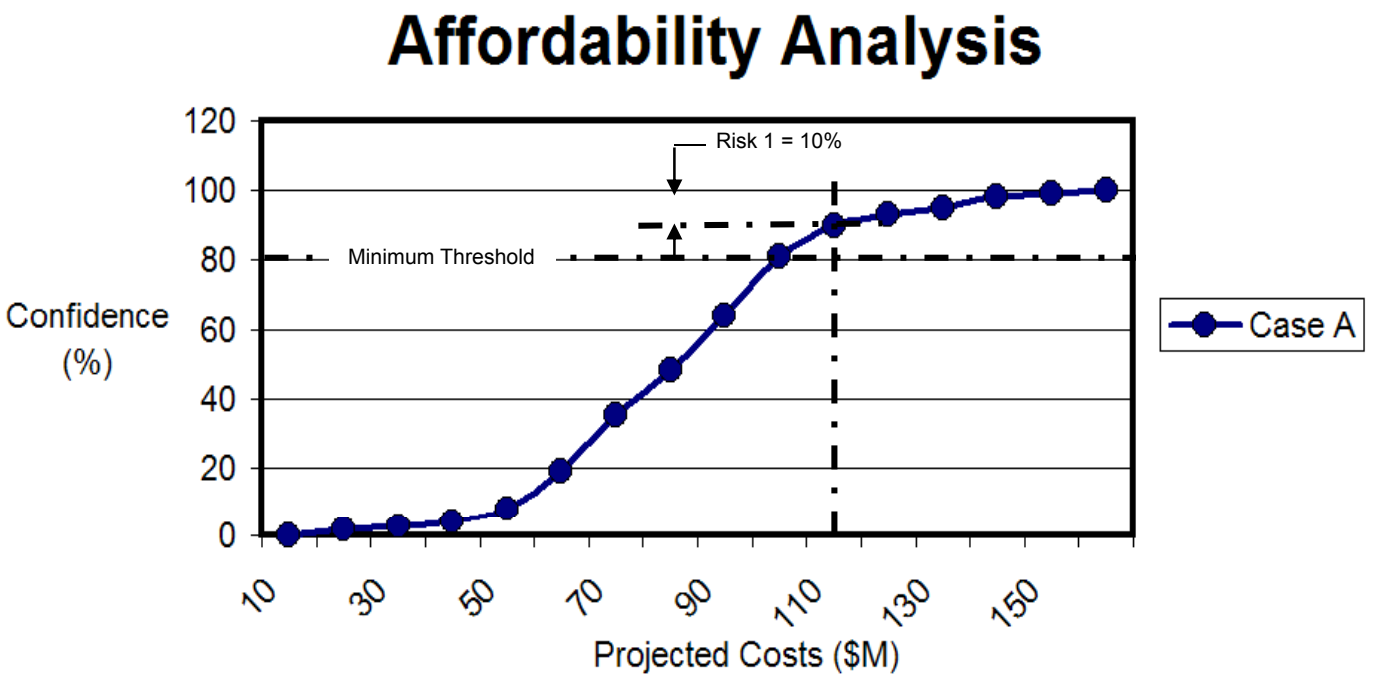
  *As best as possible, the contractor cost model shall: include (and clearly show) the cost associated with program risk: each WBS element should have an associated risk description and an explanation of how the risk translates to cost impacts: **risk analysis should be performed from the 10th to 90th confidence level (typical "S" curve)**; risk analysis should be performed from the highest to lowest level of the WBS typically from as low as WBS level 3 (or lower), to the top tier WBS element: and the LCC estimate risk analysis should use accepted statistical processes.*

  *Updates to the LCC shall reflect the current contractor design developed during the ID Phase, include a risk assessment, and design trade cost and schedule sensitivities. **Design trade cost and schedule sensitivities will track to the Cost and Schedule Risk Analysis data item**."*

Example: Affordability Leading Indicator

- A system acquirer has a budget of $115M for a project that is principally cost driven.
- It is believed that the acquirer might be able to tolerate a risk exposure of 20% (or a 80% confidence) that the $115M budget will not be exceeded
  - However based on organization capability and other factors, the supplier estimated and proposed that the system costs should meet the $115M budget with 90% confidence (10% risk)
  - If the performance and schedule criteria are also met, then the system is said to be "**Affordable**"
  - The Case A graph shows the confidence values for a range of possible costs, determined at some particular time; for example, when the proposal is developed for the acquirer

Example: Affordability Leading Indicator



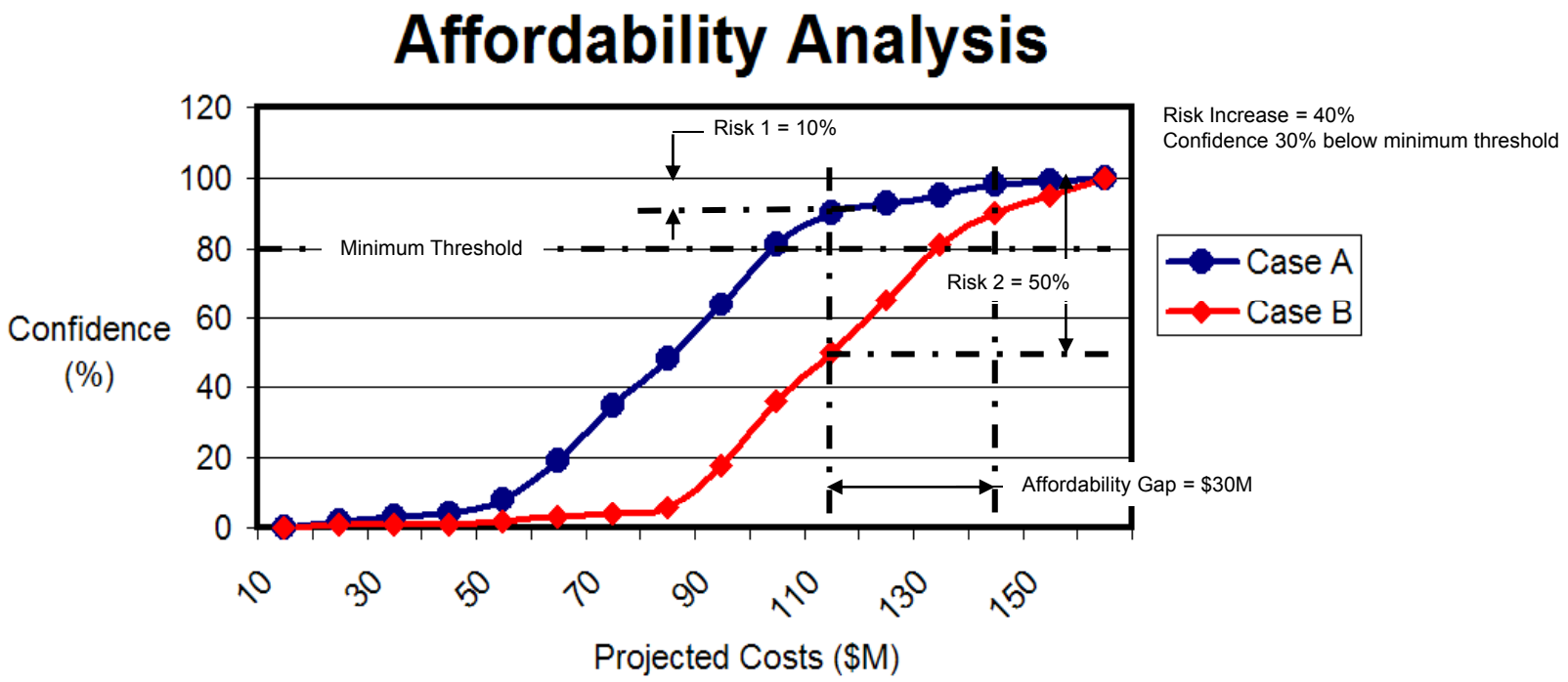
Confidence=Probability[Actual Cost Will Be ≤ Projected Cost]

Risk=100%- Confidence=Probability [Actual Cost Will Be >Project Cost]

Example: Affordability Leading Indicator

- At some time in the future, after some portion of the development has been completed, updated estimates indicate that to achieve the proposed performance and schedule, the 10% risk level does not occur until $145M
  - At the $115M target price and the confidence is 50% (50% risk)
  - The confidence is well below the minimum threshold of 20%
  - The system could then be said to be "**Unaffordable**" at the $115M target price and 10% risk level
    - However, it would be appropriate to describe the project as affordable at the 50% risk level; that level may or may not be acceptable to the acquirer to the developer
  - The Case B graph shows the confidence values for a range of possible costs, determined at some time later than illustrated in Case A

Example: Affordability Leading Indicator



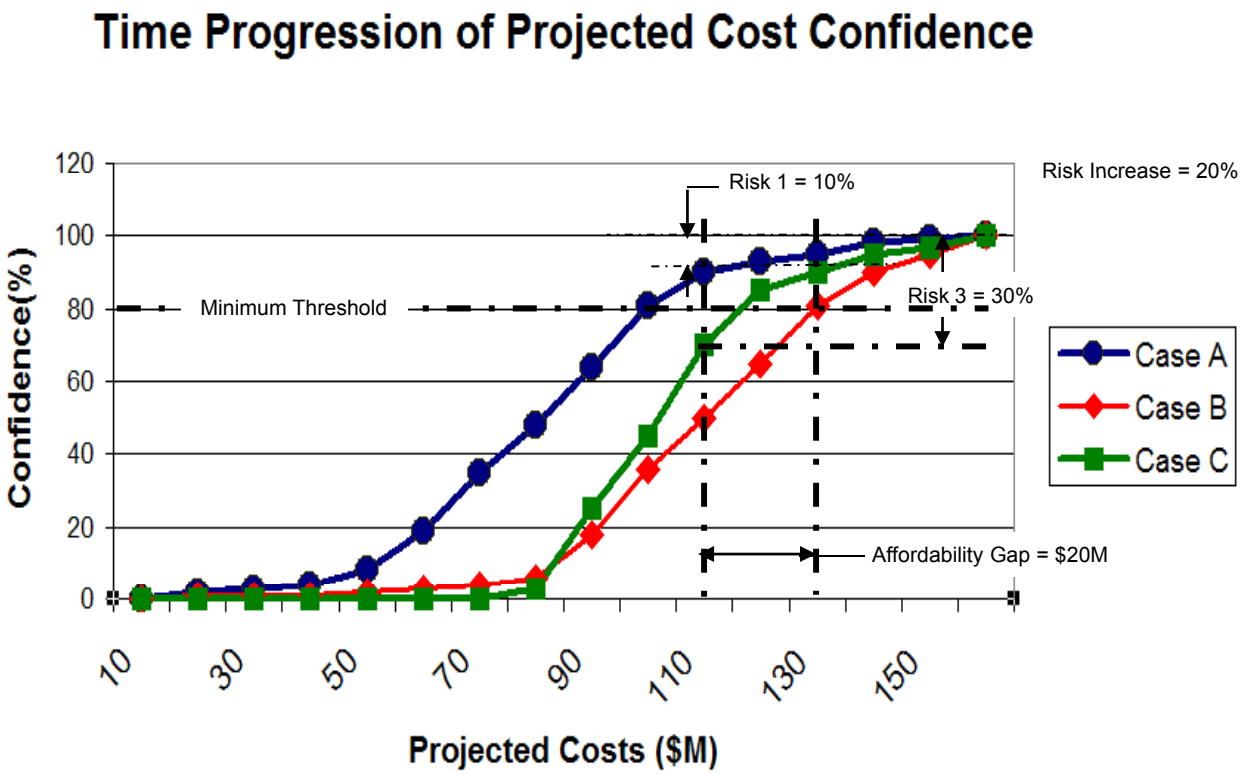
Affordability Trend/Leading Indicator

- The two affordability confidence graphs depicted in Cases A and B represent an increasingly adverse situation for the project
  - Each graph, obtained at a particular point in time, is a leading indicator of final project cost
  - The graphs taken together are a stronger leading indicator, as they show a trend
  - In the present example, an increasing estimate of the risk of attaining the cost (affordability) objective
  - This would prompt some management action(s)

Management Actions

- A root cause analysis would likely be initiated
  - Perhaps, the performance specification was allowed to "creep" without appropriate oversight
    - A justification/challenge could be imposed on both the customer and supplier's technical teams
  - Perhaps, given updated delivery schedules, certain features must be expedited (at a resulting higher cost) to maintain the proposed schedule
    - Schedule relief could be requested
  - Since the affordability criterion is some combination of cost, schedule, and with performance perhaps, different priorities or thresholds might be considered
    - With a new understanding of the customer priorities, the system could be reevaluated as "Affordable"
- The graphs on the next page depict the effect of the management actions

Affordability Trend/Leading Indicator

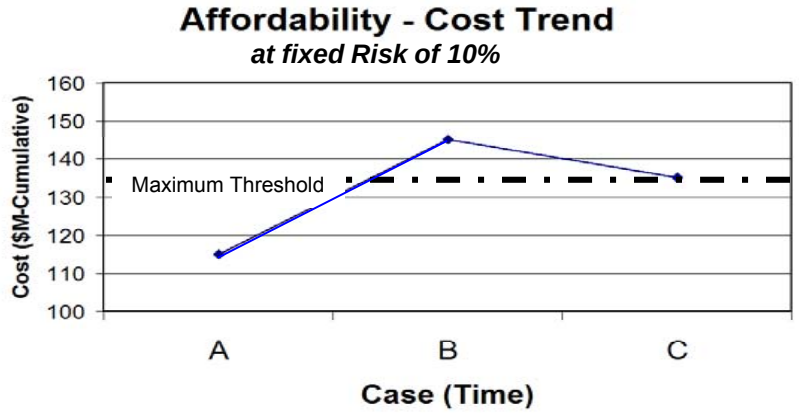


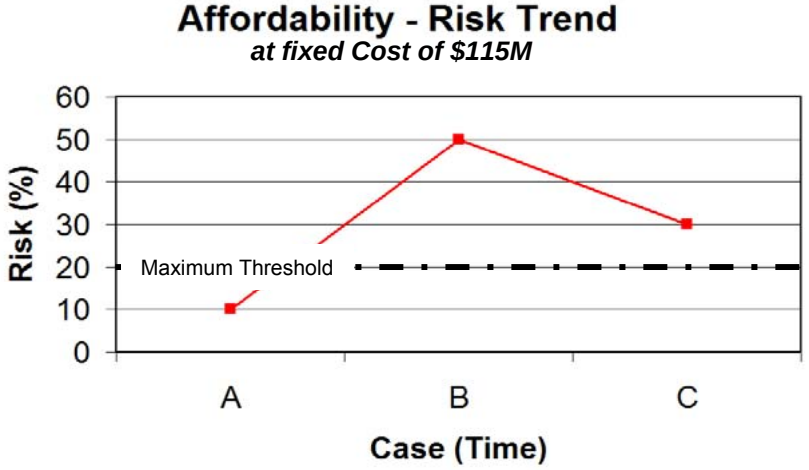
Affordability Cost Confidence estimated at three times during the project.
Here, the 90% confidence point moves from $115M at Case A to $145M later at Case B.

Subsequently, at a later time, Case C, some management action is taken, say a redefinition of requirements (with the concurrence of the acquirer), and the 90% Confidence point is reduced to more acceptable level of $135M or the $115M target price has a 30% risk level.

Affordability Trend/Leading Indicator

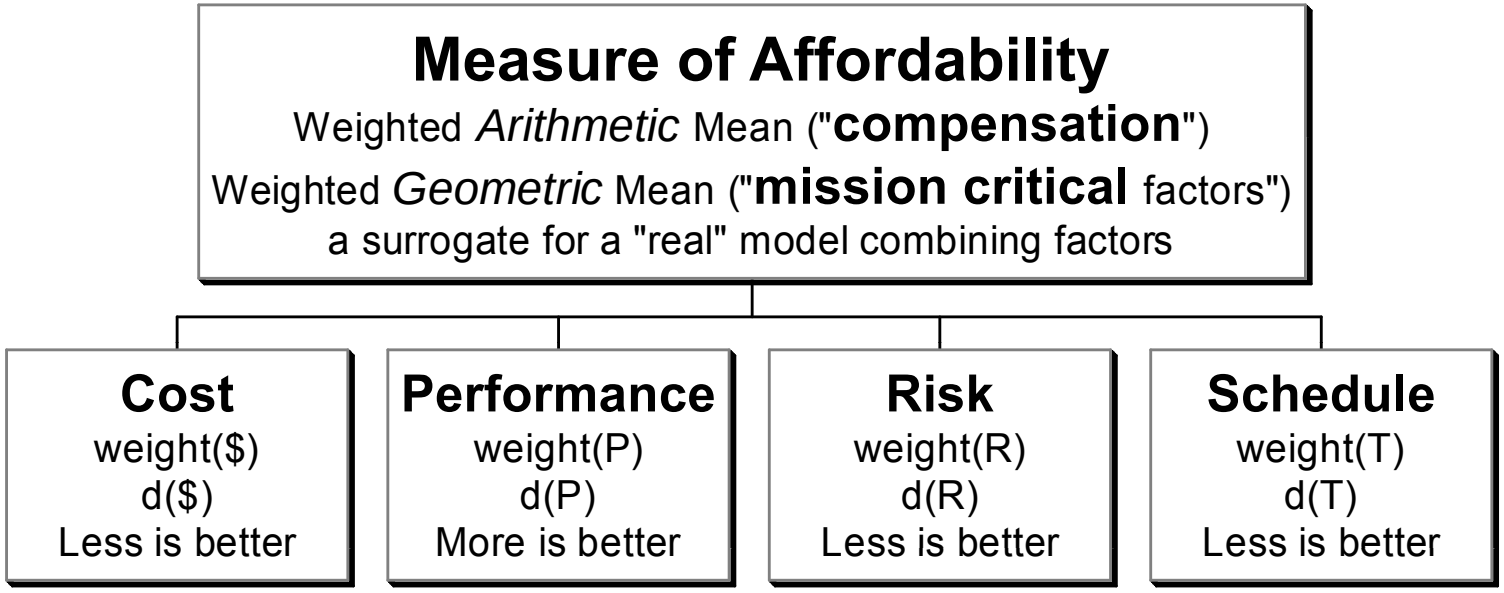
- Perhaps, the acquirer could now accept a cost risk of 30%
  - The system would then be re-classified as "**Affordable**" at the $115M point – Not likely!
  - Still more work to be done!
- Furthermore, if the risk increases (confidence decreases) as the project progresses, this is a ***leading indicator*** of cost, schedule, and performance misalignment
  - Ideally, affordability confidence should not be a low value, such as 50%
  - A low confidence value is also a ***leading indicator*** of impending problems, such as a high likelihood of exceeding the budget





Backup

Affordability: How is it quantified?: Approach 1



$$Compensation: \quad WAM = \sum w_i d_i \qquad (d_i = 0 \text{ can be compensated by larger } d_j)$$

$$Mission = Critical\ Factors: \quad WGM = \prod d_i^{w_i} \quad (any\ d_i = 0 \Rightarrow 0\ value)$$

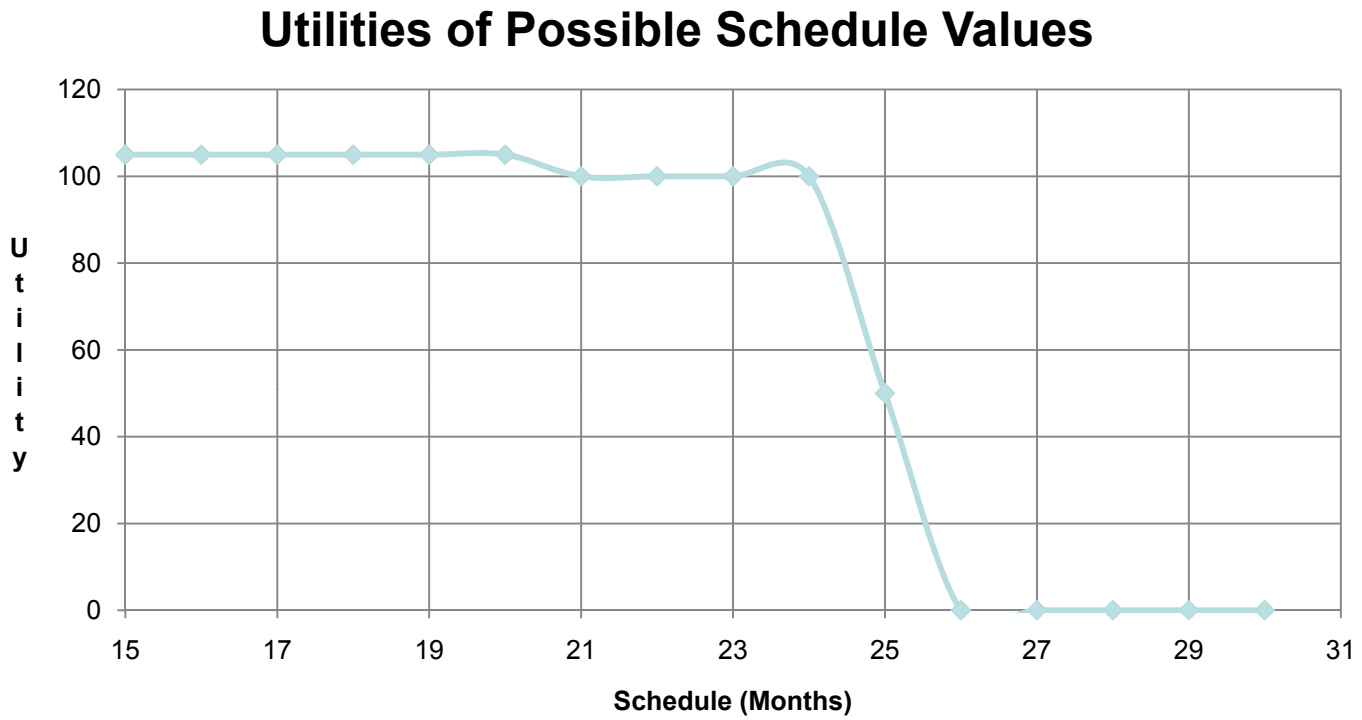
Affordability: How is it quantified?: Approach 2, Multi-Attribute Utility Approach

- Affordability can be expressed as an index by combining measure of cost, schedule, and performance
- For example, one approach might be to compute an Affordability Index as the weighted sum (multi-attribute utility) of the utilities of the cost, schedule, and performance at risk levels associated to a given product baseline.
  - A utility (see next page for example) is the value, often on a scale of 0 to 100, of a given variable, e.g., cost or schedule. Note: the largest possible utility might be >100, indicating "extra value" or "extra credit" for a certain value of parameter, e.g., lower cost than target or shorter schedule than target.

$$U=\sum w_i\, u_i$$ for i=1 to n, n= 3 if the variables are cost, schedule, and performance

- Where the u_i's represent the utilities of the cost, schedule, and performance
  - With the upper and lower thresholds representing the maximum and minimum goals
- Where weights w_i represent the relative importance of risk associated with cost, schedule, and performance

Example of Utility Values Corresponding To Schedule Values



Here, the desired value of schedule is 24 months, with a utility of 100. A schedule of 25 months (one month slippage) has a utility of only 50. A schedule of 26 or more months would have a utility of 0, meaning completely unacceptable. A somewhat shorter schedule than the 24 months target would have a slight premium, indicated by a utility of 105.

Characterizing Organizational Capability

- An organizational capability can be characterized in various ways
- One way is a “production function”
- It relates organizational output, say the development of S SLOC given inputs of K $ or labor hours (cost) and T months (schedule)
  - K,T are factors of production
- Example: $S=A*S^{p}*T^{q}$;A=generalized productivity; p,q=other organizational capability defining parameters

Measures of Performance

- Measures of Performance are the quantifiable measures that characterize physical or functional attributes related to the system operation
  - Measures of Effectiveness (MOEs)
    - *Measures used by the customer to determine the level of satisfaction with the product(s)*
    - *MOEs are generally measures of the system ability to meet mission needs for*
      - *performance,*
      - *suitability, and*
      - *affordability across the life cycle*
  - Key Performance Parameters (KPPs)
    - *KPPs are the subset of the MOEs that are absolutely essential for success*
    - *KPPs have a* threshold *requirement and an* objective
    - *If the threshold requirement cannot be met, the concept or system must be re-assessed*
  - Are used to derive Technical Performance Measures (TPMs)
    - *Quantify attributes of a system element to determine how well it is satisfying or expected to satisfy a technical requirement or goal*