



We understand “single point” estimates will be proved wrong, at project completion. The question is, “How wrong?” Cost estimating is a combination of science and art. Cost risk-opportunity analysis is the process of providing decision makers with both estimates and their associated probability.

Cost risk analysis is one segment of the larger process of managing technical, schedule, and cost risk. Risk Management is an organized decision-making process that identifies, assesses, and mitigates risks. Risk management is a tool and can greatly assist the decision process with applications for commercial and government markets. , as part of Boeing’s Management Best Practices.

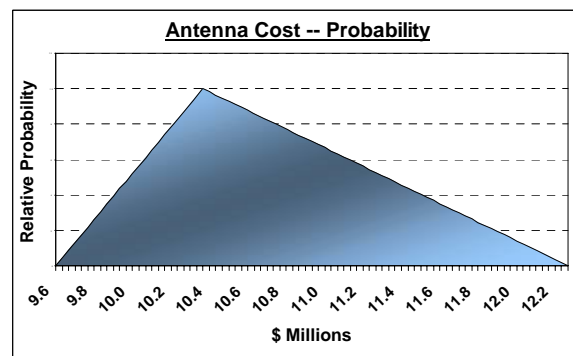
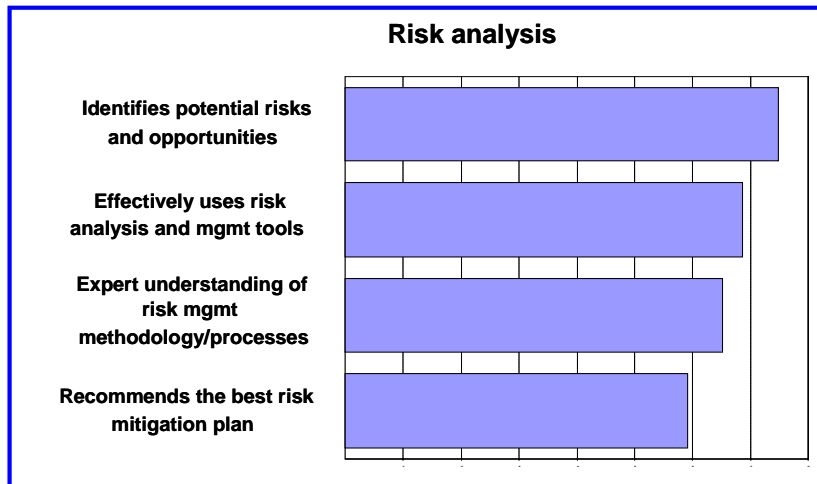
In 1998, at the Toronto SCEA International Conference, a survey was taken of conferees to provide a broad view of cost risk assessment methods in current use. One key finding was that ~75% of the 35 US Aerospace respondees reported that risk analysis findings are accepted, at least to some degree, by the management decision team. Accordingly, the senior estimator should be an astute cost risk analyst, as reflected in the Boeing Chief Estimatorsenior cost estimating survey.

Identifies potential risk and opportunities. The highest-ranking trait is a bit surprising in that it does not involve estimating and cost mathematics at all – it is the ability to identify risks and opportunities. Once again, the senior estimator has unique, important insights which contribute to management’s understanding.

These valued insights pertain to both downside cost risk, and upside affordability opportunities, graphically portrayed as a triangular distribution (see graphic at rightjust below). There are numerous methods for identifying risk: (a) team (“Delphi”) consensus is broad and powerful, (b) risk element surveys are directive, and (c) historical data standard deviations offer empirical evidence of uncertainty. The senior estimator is in the “spotlight” to help identify and assess program risks.

Effectively uses risk analysis tools. We have seen a tremendous range of risk analysis tools in the past 40 years, as computer applications have chased the market need for improved decision information:

- Most parametric cost models now have embedded cost risk Monte Carlo subroutines (e.g., PRICE, SEER, ACE-IT).
- Easy-to-use “shells” can be adapted to financial spreadsheets (@RISK, Crystal Ball).

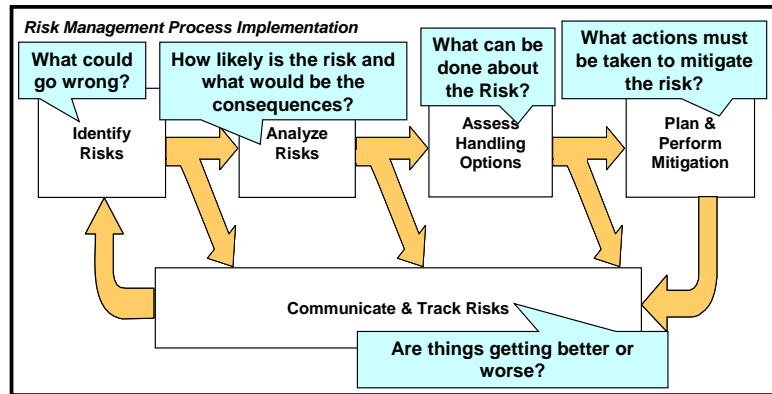




- Cost risk analysis training is readily available, and much of it is cost free. ISPA and SCEA offer cost risk training in conjunction with national conferences and regional one-day seminars.
- Dr. Stephen Book and Dr. Paul Garvey frequently provide comprehensive one-day training seminars, sponsored by regional SCEA chapters.
- SCEA offers risk training in a 3-segment video series.

Accordingly, the senior estimator has powerful tools and the underlying training needed to analyze all elements of market, cost, and price uncertainties.

Expert understanding of risk management methodology and procedures. This chart, presented at the June 2005 ISPA-SCEA conference, (Denver) depicts Boeing a’s Risk Management Process Flow.. The senior estimator, as part of the Finance team, performs important roles in each of the 5 sequential steps, from identifying to tracking. Step 2, “Analyze risks,” is the one area where Estimating can shine brightly, because they have unique, powerful historical data, statistical methods, and computer tools.



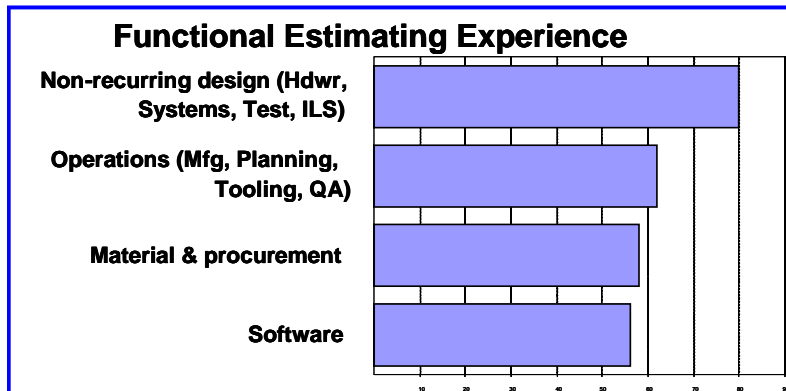
No other function can match Finance Estimating’s premier role in Step 2, “Analyze.” The authors have found in their decades of cost risk analysis that most aerospace employees are intimidated in trying to quantify cost risk, and generally ‘guestimate’ low-high ranges. The senior estimators’ extensive cost database and experience are tremendously powerful tools to assist the manager/customer in assessing business alternatives.

Recommends the best risk mitigation plan. The estimator often has unique and broad insights into the causes of cost risk, and appropriate mitigation strategies. He/she has discussed both the causes and solutions of risk with engineering and manufacturing specialists, and can play an important part of communicating mitigation tactics to the customer/management team.

Techniques and Tools

Functional Estimating Experience

The experience gained from functional estimating provides an excellent foundation for the future career development of the senior estimator. It is in this area that the estimator is exposed to all aspects of the estimating function. He/she achieves a significant knowledge





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base for the product or service being estimated.

Non-recurring design. Based on our survey, the most valued functional estimating skill was identified as engineering estimating. This estimating experience allows the estimator to learn the multiple disciplines required for the non-recurring design, test, qualification and acceptance of the item. These disciplines include System Engineering, Electrical Design, Mechanical Design, Avionics, etc. In support of these functions the estimator is exposed to detailed basis for estimates requiring technical support.



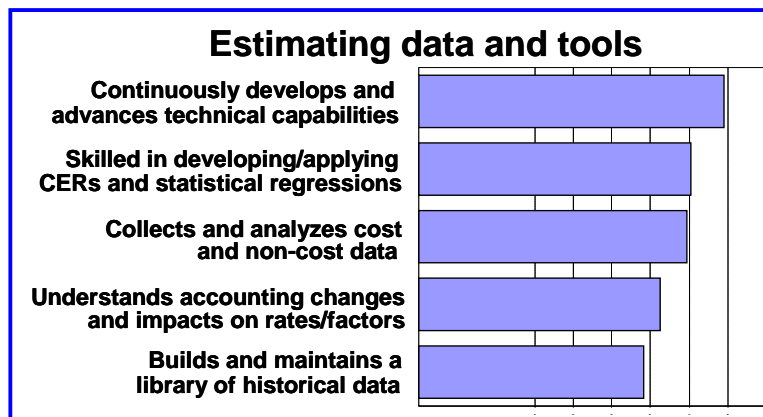
Operations (Manufacturing, Planning, Tooling, Quality Assurance). In addition to non-recurring design, the experience in the actual manufacturing and assembly of the product also becomes a strength for the senior estimator. Operations estimating provides us with experience in estimating manufacturing, quality assurance, tooling, and production support. We become familiar with data sources such as drawings, parts lists, standards, learning curves and cost estimating relationships (CERs).

Material and Procurement. Experience in material estimating allows us to learn to develop bills of material (BOMs) with various categories such as raw material, purchased parts, and major subcontracted items. The material estimator also gains knowledge of data sources through vendor quotations, purchase order history, and catalog pricing. Understanding cost/price analysis of vendor quotations is an additional desired capability.

Data and Tools

Obtaining the detailed knowledge associated with functional estimating is a good beginning. However, the senior estimator continues their journey by improving his/her ability to develop and use estimating tools and supporting data.

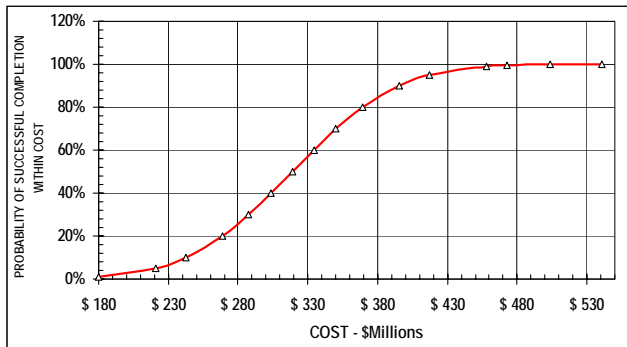
Continuously develops and advances technical capabilities. Our survey indicates a consensus that the senior estimator be a ‘champion’ for continuously developing and advancing technical capabilities. In today’s modern world this skill is an absolute requirement for the successful senior estimator. Math models can be used for many purposes, including estimating costs, validating estimates, and performing regression analysis to establish confidence levels.





In order to build or effectively use models from another source, computer proficiency is mandatory. These skills are necessary for spreadsheets, databases, presentations, and word processing capabilities. Proficiency enables the senior estimator to analyze data, run models, generate results and effectively present the findings.

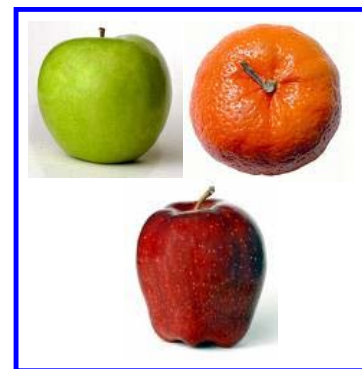
Skilled in developing and applying CERs and statistical regressions. Cost Estimating relationships (CERs) are important because they describe correlation between cost elements. They may be used for estimating and/or validation. One example is the relationship between software development hours and lines of code (LOC). In this example, the estimate could be enhanced by differentiating the LOC estimate by categories such as new design and reuse – or the rework of existing code. This analysis can then be extrapolated from historical data in order to produce the aforementioned estimate.



Statistical regression establishes both correlation and estimating confidence. This determination is very beneficial to management during the final decision process for proposal approval and submittal. The probability of meeting the proposed target price has a profound affect on factors such as contract type, terms and conditions, bid price and profit rate.

In today’s competitive environment, the contractor who can consistently win proposals with a high probability of success meets two important objectives: (a) customer satisfaction by reducing the cost risk of overrun and (b) shareholder value by broadening the company business base commensurate with appropriate levels of financial return.

Collects and analyzes cost and non-cost data. In order to effectively analyze historical costs, the senior estimator must understand accounting structures and how to normalize data. Normalization of historical data precludes the cost variance occurring from comparing ‘apples to tangerines’. The senior estimator knows their job is difficult enough when they compare a new ‘Red Delicious’ program with a historical ‘Granny Smith’ program. Similarities between two ‘apple’ programs are obviously better than a comparison of ‘Red Delicious’ to the historical ‘Tangerine’ program. The better the correlation of the estimate to historical data, the more reliable the estimate is for the proposed program.



- Examples of Non-Cost Data**
- Weight
 - Volume
 - Software lines of code
 - Quantity
 - Drawing count
 - Schedule milestones
 - Software parameters
 - Document pages
 - Technical specs
 - Test program

Non-cost data is important for a number of different estimating analyses, including parametric estimates. Furthermore, non-cost data is a key variable to generating and using CERs. Factoring relationships such as hours per pound and hours per drawing have often been utilized by the senior estimator for estimating purposes. There are many types of non-cost data, and we have listed a few at the left. As with historical cost data, the senior estimator recognizes the need to normalize the historical non-cost data in order to assure



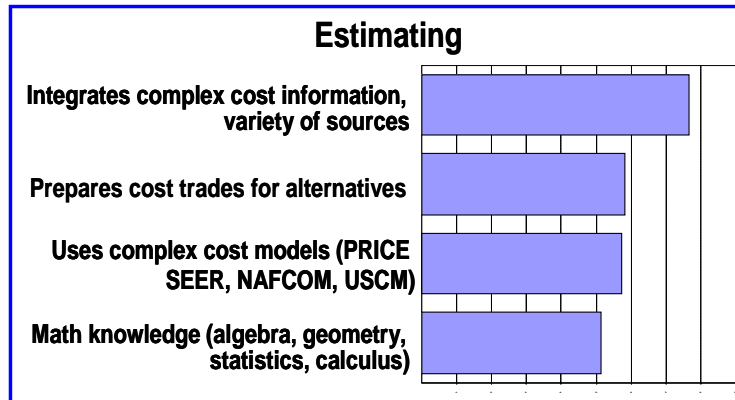
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that his non-cost comparison is being conducted in a similar ‘apples to apples’ basis.

Estimating

Integrates complex cost information from variety of sources. Estimating is the necessary skill for the senior estimator to produce their final products: estimate, cost analysis or risk assessment. This skill enables him/her to select an appropriate estimating methodology which integrates complex cost information from numerous sources.

Prepares cost trades for alternatives. Another desired trait for the senior estimator is the ability to conduct trade studies for a variety of design and/or manufacturing alternatives for the product.

Uses complex cost models. The senior estimator increases their value to the organization by learning and developing the skills necessary to become proficient in one or more commercial or US Government cost models, such as PRICE, SEER, NAFCOM or USCM.



In many cases potential customers may require such modeling and results as part of the proposal submittal package. Even if a model is not required by the request for proposal, the ability to run a model and present the results allows the senior estimator to validate the proposal. Such modeling skills increase their value to the organization and can lead to leadership roles as subject matter experts who mentor newer members of the estimating team.

Math knowledge. Advanced mathematics allows the senior estimator to efficiently and accurately apply their estimating skill. Algebra, geometry, statistics, probability analysis and calculus all enhance the performance of the senior estimator. In addition to estimating and analysis, these skills can often be used with the application of formulas and macros in spreadsheets to assist estimating development or estimate review and assessment.

Yogi Berra, the Hall of Fame catcher from the New York Yankees, has been quoted as saying that “the game of baseball is 90% mental; the other half is physical.” Given this inventive use of mathematics, it is probably safe to say that Yogi made a good career choice when he chose to tackle curve balls and decided against a career as a senior estimator.



Mentoring and Leadership

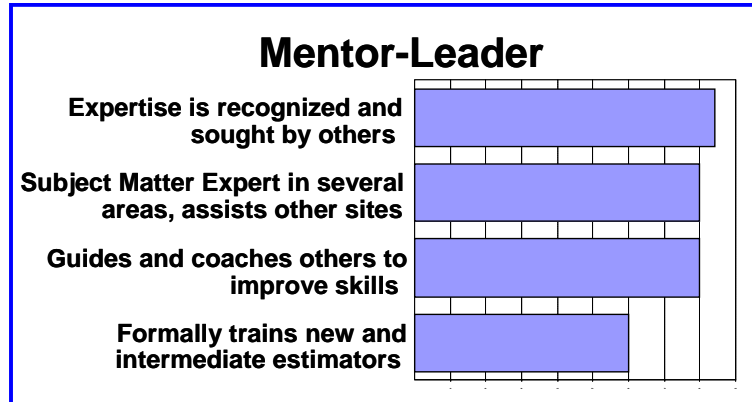
Estimating and management styles are similar in that they continue to evolve and strive for the most effective means to accomplish their goals. In today’s estimating world, the senior estimator would be well advised to remember what ultimately happened to Louis XVI head and avoid his 18th century management style. In other words, don’t be the King. Become an effective mentor / leader by adopting the following important traits as identified by our Chief Estimator survey results.



Expertise is recognized and sought by others. The culmination of experience and skill means that the successful senior estimator has demonstrated the ability to get the job done. But even more so, the prevailing attitude is not to let difficult tasks become insurmountable. Every estimating activity contains numerous complexities that can present significant challenges.

A savvy senior estimator embraces the concept expounded by Steve Chandler in his book *100 Ways to Motivate Yourself*, in which he states that “every solution has a problem”.

M. Scott Peck states: “Problems call forth our wisdom and our courage” (*The Road Less Traveled*). The truly successful senior estimator enjoys such problems, because they present the opportunity for success. This ability to self motivate is a very desirable quality to pass on to the newer estimators.



Subject Matter Expert in several areas, assists other locations. Together with experience and skilled estimating techniques, the senior estimator should be able to pass on this knowledge to the next generation. Successful senior estimators are sought out by others on a regular basis, and these requests for expertise may originate outside the home organization.

Guides and coaches others to improve skills. Our survey recognizes the value of the senior estimator who guides and coaches the next generation of estimators by providing support, monitoring daily work assignments and encouraging new training to improve or enhance their estimating skills. John Kotter, in his book, *A Force for Change*, advocates the importance of establishing direction, aligning people, motivating and inspiring in the process of leadership. A senior estimator can be particularly helpful in the area of motivation by assisting the newer estimators by energizing them to overcome obstacles to achieve their results.

Summary

In summary, our survey of Chief Estimators prioritized 53 important traits that should be exhibited by a senior cost estimator. We have summarized these characteristics into three broad categories: Professional Work Style, Customer Orientation, and Techniques and Tools. Next, we discussed specific attributes within each broad area that should be demonstrated by a senior estimator. These traits cover the entire spectrum from detailed estimating experience to strong ethical behavior to a strong desire for customer satisfaction.

One overarching characteristic that cannot be stressed enough is the importance of ensuring that a senior cost estimator exhibits the highest ethical standards. Living the value that there is only one way to do the job – the right way – the senior estimator becomes a trusted advisor, peer and mentor to all of his customers. Enhancing high ethical standards with experience and skilled estimating techniques allows the senior estimator to be trusted, respected and relied upon for his expert judgment.

Though all 53 traits are deemed important, some have higher priority. The survey results



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encourage the younger estimator to focus their career path and training development on areas of higher importance. He/she should continue with additional training as time and resources permit.



Biographies

Hollis Black has been with Boeing for 26 years, and assumed his current position as Parametric Estimating lead for missile and spaces systems, Huntsville, in 1990. In recent years he led estimating teams for projects such as the Crew Exploration Vehicle, High Energy Upper Stage, missile weapon systems, and launch vehicles. He was recently recognized with the prestigious “Boeing Defense Systems Estimating Best Practice Champion Award” which recognizes his career efforts in advancing the estimating profession and leading implementation of best practice initiatives. He provides subject-matter-expert (SME) advice to colleagues across Boeing, with emphasis on history-based estimates, parametric methods, and cost risk analysis. He has recently presented papers on these subjects to SSCAG, ISPA, SCEA, AIAA, and NCMA; and served as President of the Huntsville SCEA chapter. He earned an BBA from Harding University (1965) and MBA from the University of Texas (1967); and holds CMA (NAA and IMA) and CCEA (SCEA) certifications.



Michael Herrington has over 28 years of broad experience in Aerospace aerospace cost estimating, and has been with Boeing for 24 years.. In recent years he has led estimating teams for projects such as Ares, Missile Defense, and Battlefield Command Systems, and has p. Previously he has led teams for many other programs including missile systems, commercial aircraft, missile systems, space systems and rocket engines. He also has experience with multiple customers including DoD, NASA and foreign governments. He has led numerous process teams for estimating procedures, compliance, basis of estimates, and risk mitigation. He also has a diverse experience with cost and risk models such as PRICE, SEER, ACE-IT, and Crystal Ball He has diverse experience with cost and risk models such as PRICE, SEER, ACE-IT, and Crystal Ball. He earned his a BSIM from Georgia Tech in (1979) and received his MBA from the University of San Diego in (1987).



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