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COST ESTIMATION AND BENEFITS ANALYSIS

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Ed Dean/LaRC
Ernie Fridge/JSC
Joe Hamaker/MSFC

Space Transportation Avionics hardware and software cost has traditionally been estimated in Phase A and B using cost techniques which predict cost as a function of various cost predictive variables such as weight, lines of code, functions to be performed, quantities of test hardware, quantities of flight hardware, design and development heritage, complexity, etc. (Figure 1). The output of such analyses has been life cycle costs, economic benefits and related data. The major objectives of Cost Estimation and Benefits analysis, as an SE&I discipline are twofold: (1) to play a role in the evaluation of potential new space transportation avionics technologies and (2) as a discipline itself, benefit from emerging technological innovations. This paper will discuss both aspects of cost estimation and technology.

First, the role of cost analysis in the evaluation of potential technologies should be one of offering additional quantitative and qualitative information to aid decision-making. Historically life cycle cost analyses, sensitivity studies, risk analysis, and discounted benefits analyses have been utilized to provide comparative economic data to decision-makers on competing technological investment alternatives. Current cost estimating state of the art generally uses parametric estimating approaches in pre-phase A through Phase B for both hardware and software. The design of future launch vehicle avionics will be cost driven. In order to insure that the most cost effective options are identified and accurately compared in total life cycle cost with other options, more accurate cost estimates are needed at all phases of definition.

The cost analyses process needs to be fully integrated into the design process in such a way that cost trades, optimizations and sensitivities are understood. Current hardware cost models tend to primarily use weights, functional specifications, quantities, design heritage and complexity as metrics to predict cost. Software models mostly use functionality, volume of code, heritage and complexity as cost descriptive variables. While these cost metrics have served the aerospace community for over two decades, basic research needs to be initiated to develop metrics more responsive to the trades which are required for future launch vehicle avionics systems. These would include cost estimating capabilities that are sensitive to technological innovations such as improved materials and fabrication processes, computer aided design and manufacturing, self checkout and many others. Such improvements in the cost estimating process must consider DDT&E, Production and Operations in order to adequately address the total life cycle implications of potential new technologies.

In addition to basic cost estimating improvements, the process must be sensitive to the fact that no cost estimate can be quoted without also quoting a confidence associated with the estimate. In order to achieve this, better cost risk evaluation techniques are needed as well as improved usage of risk data by decision-makers. More and better ways to display and communicate cost and cost risk to management are required.

A real time responsiveness in the cost estimating process is needed. This is hampered in current cost estimating by extensive requirement's placed on the analyst's time for data manipulation. More effective cost models can be instrumental in freeing the cost analysts from much of the low value work involved in estimating and allowing the estimator to concentrate his resources on understanding the technologies being estimated and properly modeling those technologies. While the cost analyst will continue to be a required ingredient, new software techniques approaching and borrowing from expert system technologies may have application to the process. The ultimate in real time response would be a wedding of the CAD/CAM/Cost such that as a designer contemplates a material improvement, a tolerance change or an alternate process, the cost implications could be immediately calculated and displayed.

The technology issues associated with these improvements include the requirements for a better data collection and analysis process so that the real cost driving influences in the historical data base are understood (Figure 2). This would lead to improvement, as already discussed, in the development of more accurate hardware and software cost metrics. Finally, the technology of cost modeling needs user friendly, standardized and more capable applications.

There have been notable accomplishments in aerospace cost estimating. First, a data base based on 30 years of missions has been collected. Many first generation cost models have been developed over the years and successfully used. A few second generation models which are more responsive to technological innovation parameters have been developed. Research is ongoing and needs to be continued to improve this evolutionary process. A host of potential future launch vehicle and non-launch vehicle projects are candidates for the type of improvements in cost estimating discussed here. Each of these projects also requires extensive trades between competing technologies in avionics and in other areas as well. These programs are the leading edge avionics applications now being pursued by both NASA and the DOD and

include Shuttle-C, the Advanced Launch System, the Next Manned Transportation System, Shuttle and Expendable Launch Vehicle improvements, Space Station Freedom, the Lunar/Mars New Initiative and others. By proceeding now to both improve the technology of understanding the economics of these systems and to apply the resulting improved techniques to the systems engineering of these projects, the nation can maximize the return on technological innovation.