Collaborative Cost Engineering with ACEIT
Tecolote Research, Inc.
(805) 964-6963
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Beginning in 1994, Tecolote Research, Inc. began to develop a general-purpose framework for integrating cost models with engineering tools. The original effort was initiated by the Naval Undersea Warfare Center (NUWC/NLD). The purpose of this effort was to link a family of cost models to a government-developed design synthesis tool, DESTINATION, for specific complex computer systems requirements.

The DESTINATION system allows the design and system engineers to identify low level hardware, software, and humanware components which comprise the system and ensure various system requirements are met (e.g., power, heat dissipation, reliability, bandwidth, etc.). ACEIT was used to host a family of component-level life cycle cost models for each of the low level components which could be used to define the complex military system (e.g., Power Supply, Display, Processor). A UNIX-based ACE model server (ACE Executive) was developed to allow other applications (DESTINATION) to execute these cost models. As the system is built up from components and the components are specified, appropriate cost models are executed. In this way, ACE and the ACE Executive act as a framework for hosting cost models and linking them to other applications such as engineering tools, performance models, and budgeting tools.

One of the critical lessons learned from this task is that cost models are rarely sensitive to critical engineering design considerations, and engineering systems are rarely concerned with key cost drivers. For example, software lines of code is typically not a major design consideration for software systems, but it is typically the primary cost driver in most software cost estimating models. Furthermore, programmatic data such as system quantities and procurement strategies are not considerations. Because of this natural disconnect between costing and engineering, the value of this integrated capability can be viewed as an IPT support framework, allowing engineers and cost estimators to work effectively together.

During this same time frame, the Naval Surface Warfare Center, Carderock Division, (NSWC/CD) initiated an effort to integrate a ship construction life cycle cost model with a government-developed ship design tool (ASSET). Again, ACEIT was used as the platform for hosting the cost model, and the ACE Executive was used to link the cost model to ASSET. In this project, an Excel client application was developed to drive both ASSET and the cost models in ACE (via the Executive). The Excel client let the analyst extract design scenarios from ASSET, combine these with other required cost model drivers, and develop a life cycle cost estimate. Standard reports and graphs within the Excel client are linked to cost model outputs and engineering data from ASSET. The graphs provide insight into potential program areas where cost savings can be achieved.

In 1996, the Air Force Cost Analysis Agency (AFCAA) initiated an effort to link a commercial aircraft engineering tool with a supersonic fighter cost model hosted in ACE. The DAR Corporation's Advanced Aircraft Analysis (AAA) tool was selected for this effort. It provides modules to perform aircraft weight sizing, analysis of flight dynamics, stability control, as well as mission profiling and links to a CAD system. In this case, a library of aircraft project files was developed in AAA, which could then be used as a starting point for trade studies and analysis of derivative aircraft. For example, the F-22 project file might be used as the starting point for an analysis of a JSF-like system. As with the NSWC application, this Aircraft Cost Engineering Model (ACEM) makes extensive use of ACE and the ACE Executive. In this case, a general-purpose interface template was developed which allows any suitable aircraft cost model hosted in ACE to be linked to AAA. The Excel client combines parameters from AAA with other key cost model inputs to support rapid development of trade studies. This is conceptually shown in Figure 1, below.

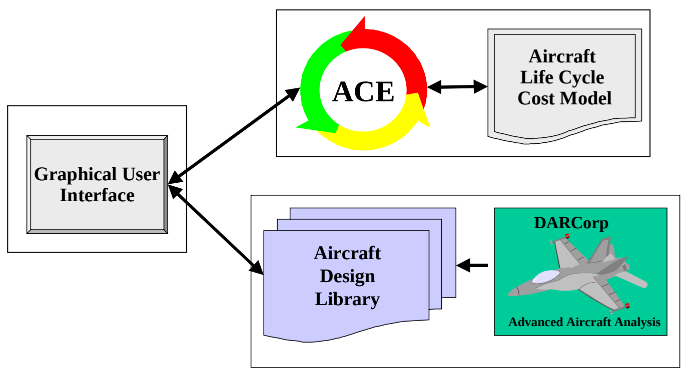

Figure 1:
Aircraft Cost Engineering Model Design Concept

This process of using ACE and the ACE Executive to link cost models with engineering systems provides a powerful, general purpose framework for implementing Cost As an Independent Variable (CAIV) analysis. For life cycle cost to be a consideration early in the life of a system, cost models must be sensitive to design issues. The engineering design applications define the parameters, which become critical to the technical trade studies. Furthermore, the engineering systems provide a potential link between costing and system performance. In this way, budget considerations can be filtered back through the design to identify a system technical solution, which yields the best performance given the available funding. By driving the cost model backwards, target technical system descriptors (e.g., weight, power, speed, range, etc.) can be set. These technical targets become inputs into the engineering process, which then ensures design feasibility and provides an assessment of result system performance. A hypothetical process is shown with a DAR Corporation AAA screen, an ACE screen, and an ACE Executive screen in Figure 2.

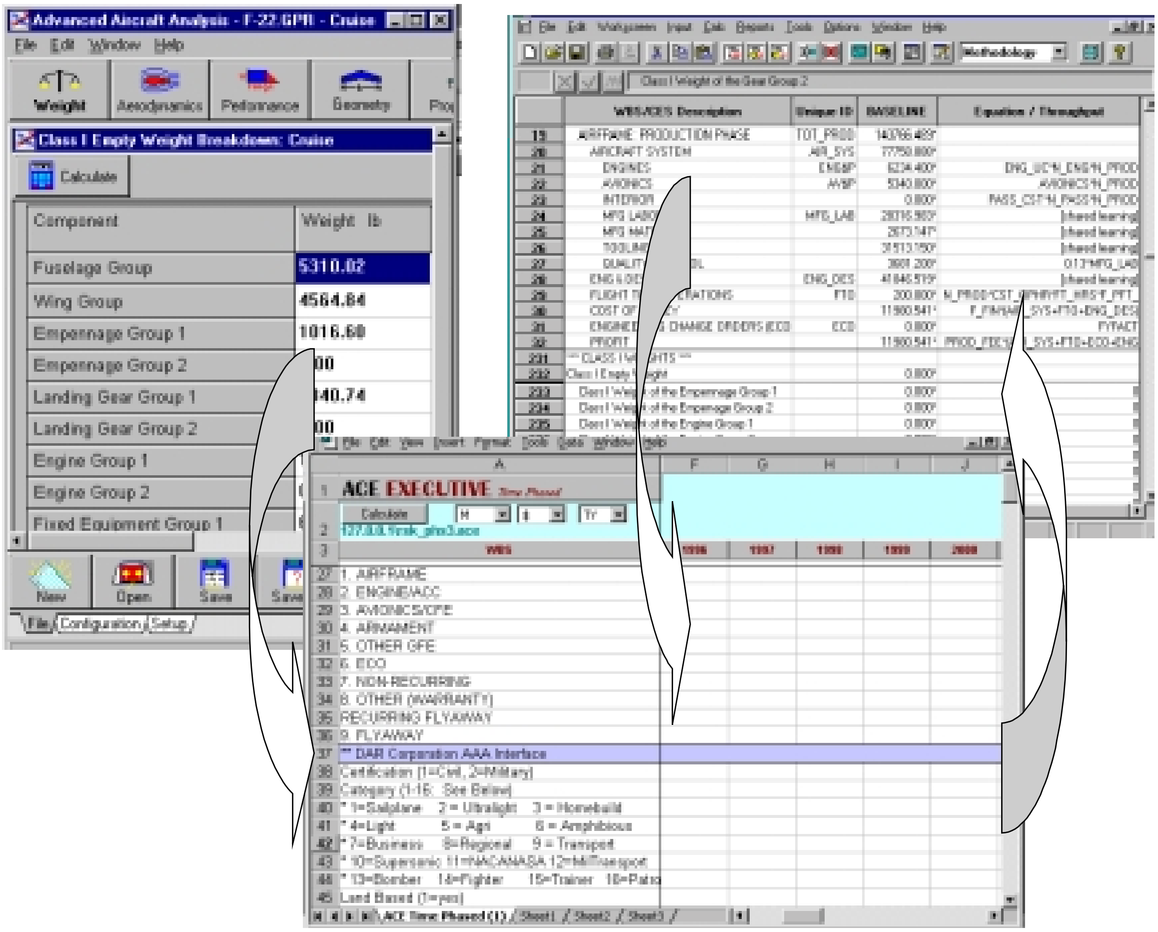

Figure 2
Aircraft Cost Engineering Model Interfaces and Data Flow

The recent Performance Affordability Assessment Model (PAAM) project initiated by the US Army Tank and Automotive Command (TACOM) and the Force Analysis Decision Support System (FADSS) project initiated by the AFCAA will use this process as the basis for a force cost analysis framework. The purpose of these efforts is to allow an analyst to study the cost impacts associated with different force mixes. This will involve looking at different platforms and mixes of technologies hosted on each. In the case of the TACOM project, platform (vehicle) cost models will be developed, together with cost models for specific technologies, which might be integrated on each vehicle. The user would then define a force in terms of numbers of types of vehicles together with installed technologies. Cost models hosted in ACE would be executed via the Executive to determine various cost metrics (unit production cost, yearly operating cost, etc). FADSS is designed to support force level budget trade studies. It provides a summary budget view across multiple weapon systems comprising a force. It then lets the analyst allocate budget to specific weapon systems and measure the impact on force makeup. This could then be linked to force effectiveness models such as CASTFOREM. A conceptual design for the ACE Executive interface to FADSS is shown in Figure 3.

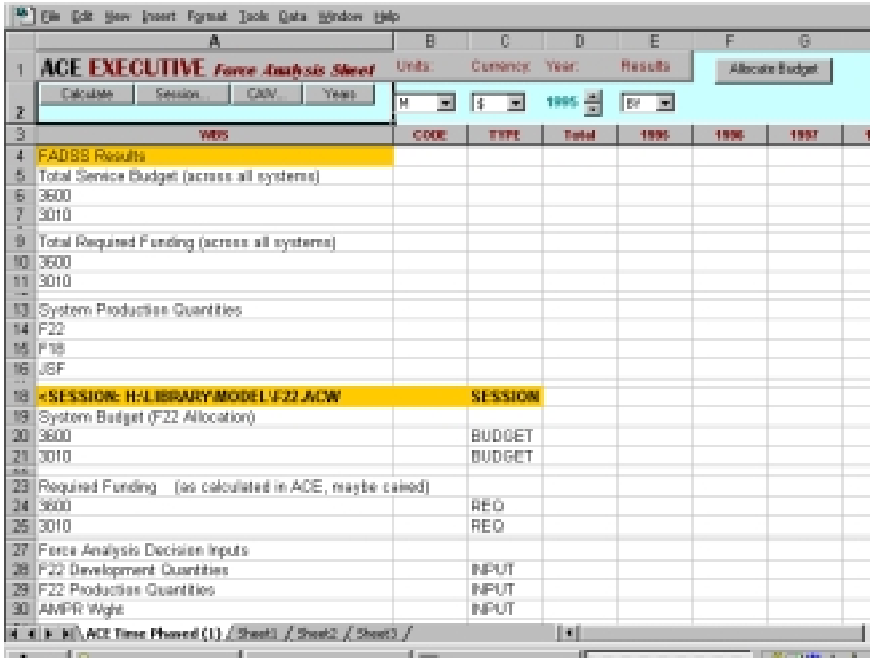

Figure 3
FADSS User Interface Design Concept

Even more recent efforts sponsored by the Air Force Research Laboratories (AFRL) involve using the ACEIT Executive to host and run ACE-based models on web servers. Client applications based on web browsers, Excel, or other web-based engineering tools can access these ACE-based models, perform trade studies, and review cost results. One example prototype, called RADEVAL, is available at HTTP://WWW.TECOLOTE.COM/RADEVAL/. In this case, a radar performance simulation tool, the AIRADE (Airborne Radar Detection) program, developed by Technology Service Corporation (TSC), allows the user to generate radar range performance data for varying radar antenna mainbeam gain and transmitter peak power. This performance data is passed into a radar life cycle cost model, REACT (Radar Engineering and Cost Tool), developed by Tecolote. For this demonstration, REACT responds to values from AIRADE such as center frequency; beamwidth; transmitter type, peak power, and duty cycle; antenna steering; and number of receiver channels. Simulation results are displayed on an HTML page. Associated plots have been temporarily disabled. The RADEVAL web-based interface is shown in Figure 4.

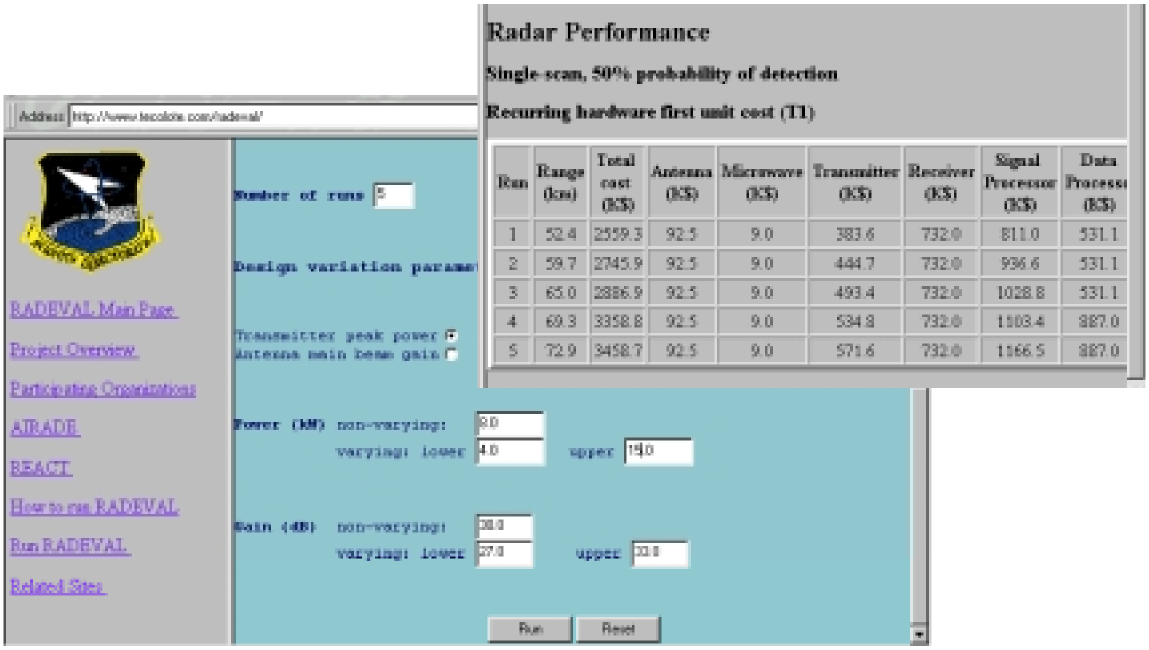

Figure 4
RADEVAL Interface

Several other applications, which interface cost modeling functions with engineering tools, have been developed using techniques based on ACE and the ACE Executive. One national intelligence agency has hosted the ACE Executive on a Sun UNIX system to enable ACE-built models to interface with engineering workstations and tools. A major defense aircraft manufacturer has hosted the ACE Executive on an HP UNIX system to link its engineering design synthesis tools to interface with ACE-based aircraft cost models. In this case, the engineer can make design changes to a system and see the impact on cost in real time without leaving the design tool. This process has also been used by a government agency to develop an installation physical security model which combines basic CAD functionality for defining physical security components with activity based cost (ABC) models hosted in ACE to support cost/effectiveness trade-off studies.

ACEIT has an open architecture and an increasingly rich application programming interface (API) to enable any third-party software developer to interface its software applications with ACEIT. The interface specification for ACEIT is available, and it provides a straightforward method for other tools to communicate with ACEIT.

See the ACEIT web site at HTTP://WWW.ACEIT.COM for additional information.