Development of a Standard Test Program Set Cost Model

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Abstract - ***The Standard Test Program Set Cost Model (STCM) is an integrated model suite being developed jointly by Naval Air Warfare Center Aircraft Division Lakehurst (NAWCAD LKE), Naval Aviation Depot Jacksonville (NADEP JAX), and Test Automation Incorporated (TAI) to provide government agencies with a tool to perform consistent TPS cost estimating across multiple Automatic Test System (ATS) platforms.***

Through the World Wide Web, STCM will provide the government Test Program Set (TPS) Program Manager (PM) with a comprehensive tool for TPS cost estimating, forecasting, and tracking by capitalizing on the unique capabilities of the following existing software tools for TPS cost estimation and ATS analysis:

- ***NAWCAD LKE System Synthesis Model Plus (SSM+)***
- ***NADEP JAX Should-Cost TPS Cost Estimate Model***
- ***NADEP JAX Auto-ID Merge Model***
- ***TAI Cost Asset Schedule Prediction Evaluation Routine (CASPER)***

INTRODUCTION

Current DoD ATS Acquisition Policy is to minimize the introduction of unique types of ATS into the DoD inventory through the use of designated DoD Family Testers and commercial testers. Use of commercial testers not in the DoD ATS Family requires submittal of a Commercial Tester Acquisition Validation Request (CTAVR) to the DoD ATS Management Board (AMB). Use of testers which are neither commercial nor in the DoD ATS Family requires submittal of a Policy Deviation Request. In both instances, the requesting activity must perform a Life Cycle Cost (LCC) Analysis which demonstrates that the acquisition of a non-DoD ATS Family Tester provides the most economically advantageous alternative to the government.

The most challenging aspect of performing a LCC Analysis has proven to be the derivation of fair and accurate “apples-to-apples” TPS development and production cost estimates across multiple ATS platforms. While the Air Force, Army, and Navy each have their own tools and methodologies for estimating TPS costs for their Automatic Test Equipment (ATE), these estimates reflect the diverse TPS procurement strategies, ATE operational environments and weapons system support philosophies of the three services. A significant difference would be expected between the cost of an organic Air Force effort to develop TPSs to support ten (10) Units-Under-Test (UUTs) on commercial ATE at an Air Force depot and the cost of a competitive Navy contract to develop Consolidated Automated Support System (CASS) TPSs to support the same 10 UUTs at the intermediate maintenance level aboard an aircraft carrier. While the Navy TPSs may be grouped into a single Operational Test Program Set (OTPS) with a single highly complex Interface Device / Interface Test Adapter (ID/ITA) in order to meet of shipboard stowage constraints and to reduce overall production costs, it may be more feasible for the Air Force to develop several less complex IDs. Additionally, the Navy ID must be designed, tested, and manufactured to meet more stringent operational requirements than those IDs developed by the Air Force.

Given that both CASS and the commercial tester provide sufficient capabilities to test the 10 UUTs, the expected deltas in TPS development and production costs are attributed to service peculiar requirements, not to the ATS platforms. While it may be true for the scenario described herein that Navy TPSs are more expensive than Air Force TPSs, it is not necessarily true that CASS TPSs are more expensive than Commercial Tester TPSs. Assuming that CASS possesses more test capabilities than the commercial tester relevant to the support of the UUTs, CASS may have provided a more economical ATS solution to the Air Force.

While identical ATS platforms can be utilized across multiple services, TPS cost estimation methodologies associated with the various ATS platforms can not necessarily be transported across the three DoD services. How the Navy develops and procures CASS TPSs for a set of UUTs may be completely different from how the Air Force would develop and procure TPSs for the same set of UUTs.

By integrating the unique capabilities from a variety of existing TPS Cost Estimation and ATS Analysis software tools, STCM was conceived to provide a level playing field for performing TPS cost estimates across multiple ATS platforms and DoD components.

Although the need for an effective methodology of making "apples-to-apples" TPS cost comparisons has driven the development of STCM, STCM will also provide the government user with a powerful tool for TPS cost estimating, tracking, and forecasting throughout the life of his or her TPS program.

THE STCM TEAM AND OUR VISION

The STCM Team is currently comprised of over a dozen members from NAWCAD Lakehurst, NADEP JAX, and TAI with experience in TPS development, TPS cost estimation, TPS program management and software development. Established in May 1996, our charter was to optimize the use of existing TPS cost estimation and ATS analysis software tools to develop a Standard TPS Cost Model which can be consistently applied across all DoD Services and ATS platforms.

Through the integration of these existing tools, we soon realized that STCM would also provide the TPS program manager with a valuable tool that could not only be used for TPS budgeting but for managing all aspects of his or her TPS program. Our team's vision was soon defined as follows:

- STCM will be a fully integrated suite of models residing at NAWCAD Lakehurst which can be consistently applied across all DoD Services and ATS platforms.

- STCM will be accessible by all DoD activities through a PC in a Windows-based environment via the World Wide Web.

- NAWCAD Lakehurst will provide a central repository for all user-entered data required to run STCM.

- STCM, a Work Breakdown Structure (WBS) based model, will provide the user the flexibility to tailor the STCM WBS to meet program needs or run STCM against a variety of standard WBSs, such as the Navy WBS which will be kept current with the CASS Red Team Package (RTP).

- Multiple standard output reports will be available to the user while the user shall also have the capability to customize output reports to meet program needs.

- STCM will contain a historical database to provide the user with a quick and efficient methodology to obtain cost data from past TPS development & production efforts on DoD Family Testers for similar programs based on the following:

  ⇒ Contract Type (FFP, CP, etc)
  ⇒ Number of SRAs / WRAs (SRUs/LRUs)
  ⇒ Number of OTPSs
  ⇒ UUT Technology Type (Digital, RF, etc)

- Continuous improvements to STCM will result from on-going TPS Cost Data Collection and Analysis efforts.

STCM COMPONENTS

STCM will be an integrated suite of models comprised of the following existing software tools for TPS cost estimation and ATS analysis:

- NAWCAD Lakehurst's System Synthesis Model Plus (SSM+)
- NADEP Jacksonville's Should-Cost TPS Cost Estimate Model
- NADEP Jacksonville's Auto-ID Merge Model
- Test Automation Incorporated's Cost Asset Schedule Prediction Evaluation Routine (CASPER)

Each of the above tools contributes a unique set of analysis capabilities which are crucial to the development of fair and accurate TPS cost estimates. A brief description of each of these tools and their role in the STCM integrated model suite is provided herein.

SSM+

SSM+ is an integral part of the CASS Implementation Planning (CIP) Process, an on-going effort to assure the timely introduction of CASS to support emerging weapon systems and the coordinated offload of currently fielded TPSs to CASS. SSM+ is the primary instrument in the CIP Process used to determine the quantity and configuration mix of stations needed to support all planned testing at each intermediate or depot level maintenance sites.

SSM+ currently contains twenty-nine (29) test

categories, such as DC Power Stimulus, Waveform Generation, and Digital Test Measurement, for documenting UUT test requirements. These UUT test requirements are stored in an Oracle database at Lakehurst and can be easily mapped to the test capabilities of any ATS modeled in SSM+. Currently, there are over a dozen ATS platforms modeled in SSM+, including the Integrated Family of Test Equipment (IFTE), the F-15 Downsized Tester (F-15 DST) and the Radio Frequency Mobile Electronic Test Set (RF METS).

A variety of mapping reports allow the user to easily perform an analysis of the UUT test requirements versus the ATS test capabilities. Limitations of the target ATS to fully support the UUT without interface device intervention are identified as exceptions. These exceptions can then be utilized by STCM to provide an assessment of the complexity of the ID and to more accurately perform TPS cost estimates. Assuming that two (2) different ATS platforms do not provide equivalent test capability to fully support a weapons system, ID complexity factors would vary across the 2 different ATS platforms and different TPS cost estimates would result.

Should-Cost TPS Cost Estimate Model

The NADEP JAX Should-Cost Model was first developed by NADEP JAX to provide Naval Air Systems Command (NAVAIR) program managers with a consistent, quantitative, and objective method for developing CASS TPS program budgets.

The model is based on a standard Work Breakdown Structure (WBS) table of program tasks derived from the established Red Team acquisition package. Each WBS element has standard man-hour and material cost values based on historical data. Scaling parameters that allow UUT or ID complexity values to adjust these standard cost values are also contained in each WBS element. This approach gives each standard WBS element the capability of having a unique scaling equation.

The model's core algorithm replicates each standard WBS element for each OTPS and for each UUT of the target program. During replication, the standard costs in each WBS element are also scaled using the appropriate OTPS or UUT complexity value. The resulting expanded and scaled WBS is a project-specific Contract WBS (CWBS) that establishes and quantifies each unique program task. Figure 1 illustrates the entire process.

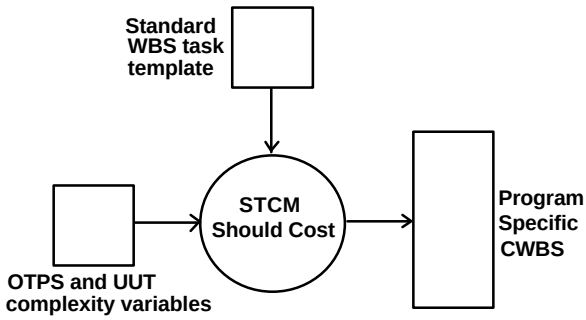

Figure 1. NADEP JAX TPS Should-Cost Model

When all CWBS tasks are multiplied by labor rates and scheduled in time, a program scheduled baseline is established. This baseline can be viewed or analyzed in multiple ways using the flexible reporting utilities of the host relational database management system.

Auto-ID Merge Model

The NADEP JAX Auto-ID Merge Model was first developed in 1991 to support CASS OTPS estimates by providing an objective and repeatable method for the quantitative grouping of UUTs to common IDs/ITAs. Historically, the number of IDs required to support a given number of UUTs typically plays a major role in overall program costs. This software model was developed to provide a consistent, objective, exhaustive, and visible method of estimating the number of deployed IDs required to support a weapon system.

The objectives of merging (or allocating) UUTs to a common ID are as follows:

- To accommodate as many UUTs as theoretically possible onto a single ID for the target ATE.
- To do this without compromising practical limits or creating unnecessary risk.

The Auto-ID Merge Model supports both these objectives using an established UUT merging process. During this merging process, the following four primary finite resource areas (local to the ATS interface) of an ID are considered:

- ID volume
- Digital channels
- Analog (relay paths) signals
- ID front panel (to UUT) input/output count

The relationship of these 4 basic resources are illustrated in Figure 2.

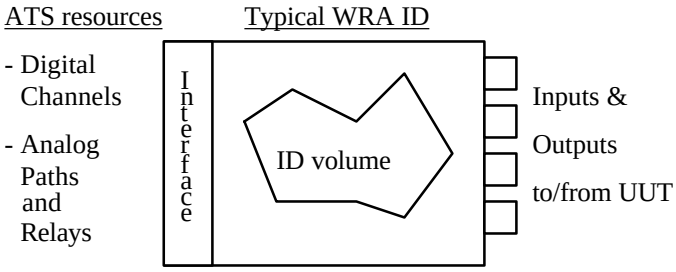

Figure 2. ID Resource Relationships

Although the merge sequence is totally automated, the user has the ability to further analyze the OTPS groupings and manually manipulate them to reflect conditions not addressed by the model. The observed effect of human assistance during the auto-merging of IDs is illustrated in Figure 3.

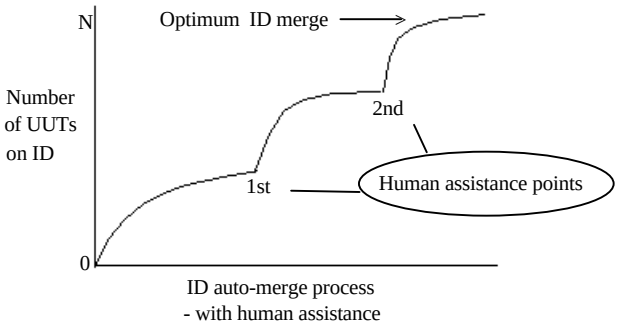

Figure 3. Human Intervention During Auto-ID Merge

The Auto-ID Merge model also calculates the electrical and mechanical complexities of each ID. These ID complexities are used to support the quantitative and objective estimation of ID Development and Production costs. The complexities are derived from ID requirements needed to support each UUT. These ID requirements are intended to overcome UUT to ATS exceptions identified by SSM+.

CASPER

Test Automation's CASPER is an expert system designed to provide the TPS Program Manager with a sounding board for project estimating and planning. CASPER consists of a UUT Complexity Module, Schedule and Assets Module, and Cost Module which work together to generate "should-cost" estimates for a TPS development contract. Although CASPER does not account for bid strategy, a significant factor in any cost proposal, it provides a detailed WBS based assessment of expected costs and schedule. CASPER also incorporates a Task Update editor which can be used by the TPS cost estimator to account for the use of new TPS development tools and techniques when performing a TPS cost estimate.

CASPER's UUT Complexity Module utilizes a wide range of UUT input parameters, such as component count by component type and input/output pin count, to derive the UUT complexity factor. This complexity factor is not a best guess based on the gut feeling of how complex the user views the UUT but rather a repeatable number based on documented UUT design data. Although UUT complexity does not vary across ATS platforms, UUT complexity significantly affects any TPS cost estimate. Consequently, CASPER's UUT Complexity Module is an integral part of the STCM integrated model suite.

CASPER's Schedule and Assets Module and Cost Module work hand-in-hand to generate detailed TPS development cost estimates based on a wide variety of inputs, including UUT and ID complexity factors and OTPS Groupings. While the CASPER Complexity Module generates the UUT complexity factors, ID complexity factors and OTPS groupings are assigned by the user who makes his "best guess". In STCM, however, automated ID complexity factors and OTPS groupings are fed to the CASPER Cost Module from SSM+ and Auto-ID Merge, providing defensible inputs which can be consistently applied across any ATS platform. CASPER's Schedule and Assets Module and Cost Module provide the basis for TPS development cost estimates in STCM.

The CASPER Task Update Editor provides the user with a vehicle to adjust the impact of a particular task on the overall TPS development cost estimate. Assuming a new Automatic Tester Program Generator (ATPG) could cut anticipated TPS code and compile time in half, the TPS program manager could easily assess anticipated cost savings with the use of the new ATPG. The CASPER Contract Data Requirements List (CDRL) Editor allows the user to turn CDRL Items "off" and "on" as specified in a contract. As part of STCM, the CASPER Task Update and CDRL Editors will be applied not only to TPS development costs but to TPS production and government oversight costs as well.

STCM INTEGRATION

While the STCM components addressed above represent fully operational, stand-alone models which successfully satisfy their individual target applications, their integration into a single suite of models will provide a powerful TPS cost estimating and management tool that can easily be accessed and utilized by all government TPS program managers for use with any ATS platform. Figure 4 provides a block diagram illustrating the integration of the four (4) models into STCM.

Because the various STCM components were developed using a variety of different software platforms, optimizing the use of existing software to produce a seamless model suite has been quite challenging. Although we hoped to use existing "as-is" software to the maximum extent practical, the investigation of numerous alternatives indicated that a slow, cumbersome system would result, discouraging potential STCM users.

Of greater importance to the STCM Team, was the development of a fast, efficient, user-friendly model suite which will frequently be utilized by the government TPS program manager. Consequently, all STCM components will be converted to Oracle, an industry accepted standard software package, which can operate in a multi-user Windows NT environment. STCM will be accessible by all DoD activities via the World Wide Web with minimum personal computer requirements. The Oracle database resident at NAWCAD Lakehurst will provide a central repository for all user-entered data required to run STCM.

Figure 4. Block Diagram of Standard TPS Cost Model Integration

Although each STCM component has proven to be successful as stand-alone applications, the STCM Team recognizes that there is always room for improvement. The integration period provides the opportune time to enhance existing capabilities. With the user always in mind, additional features being designed into STCM include the following:

- The user will have the flexibility to turn most WBS elements "off" and "on", although some mandatory WBS elements must remain "on" at all times. It would be difficult, for example, to develop a TPS without generating any code. Canned WBS subsets that map to the latest CASS Red Team and IFTE TPS acquisition packages will also be available to the user. Of course, with any STCM WBS, the CASPER Task Update Editor will still provide the ability to edit individual TPS Task contributions to the overall WBS and apply these edited values to a contract scenario.

- On-line help will not only serve to navigate the user through STCM, but will also provide guidance to the TPS program manager. Detailed definitions of all WBS elements will be available and risk assessments will be supplied when critical WBS elements are turned "off".

- Enhancements to the Auto-ID Merge Model will provide an iterative mode that allows the user to "fine-tune" OTPS groupings based on user knowledge. If several UUTs have high known failure rates, for example, it may not make sense to group them on a single, complex ID only to require multiple copies of the ID to support a given maintenance activity's workload. The user will also be allowed to "tag" UUTs that should be merged to a single ID based on user knowledge such as common ancillary requirements. At any time, the user will be able to specify all OTPS groupings. Once a TPS contract is awarded, the TPS PM may modify his or her STCM data to reflect the actual OTPS grouping strategy being employed by the successful bidder and re-run the STCM Schedule and Cost Modules.

- The extensive repository of UUT test requirement and design data at NAWCAD Lakehurst will afford the user an opportunity to perform rough TPS cost estimates on emerging systems with little or no data. By searching the NAWCAD Lakehurst Oracle database for functionally similar UUTs, the user may obtain sample test requirement and design data that can be used to model his or her TPS contract until actual UUT data is available. Additionally, a historical database of actual TPS contract prices will allow the user to search past TPS development and production costs on DoD family Testers based on UUT type and quantity and procurement strategy. While this would not be the preferred method of TPS cost estimating, it would provide the program manager with a quick and simple vehicle to generate Rough-Order-of-magnitude budget wedges for future TPS development and production efforts.

STCM APPLICATIONS

In support of its intended mission, STCM will perform a vital role in the DoD ATS Selection Process by providing "Apples to Apples" TPS cost estimating across all ATS platforms and DoD services. STCM TPS cost estimating will account for the test capability limitations of one ATS versus another to fully support a weapons system through SSM+ exceptions. The Task Update Editor will allow the user to identify any additional anticipated TPS cost differences from one ATS to another that may result from any advantages that the use of one ATS platform may have over another. Such advantages may include an ATE peculiar software development tool or the ability to re-use existing TPS hardware or software on a particular ATS platform. The ability to "fine-tune" the Auto-ID Merge process will allow the various services to model the OTPS grouping strategy which best meets their mission requirements.

STCM's capability to generate detailed TPS cost estimating reports down to the fifth WBS level will not only allow the government program manager to prepare budgets to fund TPS development and production contracts as well as associated government oversight efforts, but more importantly will provide him or her with the ammunition necessary to defend these budgets. Additionally, these detailed reports will provide a baseline that can be compared to any contractor Cost/Schedule Status Reports that might be available to the program manager and used to help track the health of his or her TPS program.

The ability to play "What-If" games will provide an invaluable service to the program manager during all phases of a TPS contract. During the preparation of a Request for Proposal (RFP), for example, the program manager could trade off the costs of including

various CDRL items or technical/management reviews in the contract. As previously discussed, risk assessments will also be provided when critical items are deleted from the contract scenario. The program manager can also quickly make various cost and schedule trade-offs during the RFP phase by changing only a few simple parameters. As an example, STCM could be used to determine the optimum quantity of ATE stations or UUTs that should be provided to the contractor for TPS integration.

Once a TPS contract is awarded, STCM could be used to assess the cost and schedule impact of any unforeseen events, such as the late delivery of ATE or UUT government furnished equipment. With an original and revised cost report down to the fifth WBS element in-hand, the program manager will be better prepared to negotiate any claims received against his or her program.

SUMMARY

STCM provides a WBS based TPS cost estimating and management tool with applications far beyond initial ATE selection and TPS budget estimates. While STCM was conceived to facilitate the DoD ATS Selection Process by providing consistent TPS cost estimates across multiple ATS platforms, it is also intended to provide an invaluable program management tool which can be used throughout the life of a TPS Development and Production Program.

STCM will be available to all DoD components via the World Wide Web in a Windows-based point-and-click environment. Initial release of STCM to service ATS Program Offices for validation is scheduled for May 1998.

ACKNOWLEDGMENTS

The authors of this paper wish to acknowledge all members of the STCM Team whose expertise, dedication, and hard work are making the development of STCM possible.

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