

TAKING ADVANTAGE OF GROUND DATA SYSTEMS ATTRIBUTES TO ACHIEVE QUALITY RESULTS IN TESTING SOFTWARE

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ABSTRACT

During the software development life cycle process, basic testing starts with the development team. At the end of the development process, an acceptance test is performed for the user to ensure that the deliverable is acceptable. Ideally, the delivery is an operational product with zero defects. However, the goal of zero defects is normally not achieved but is successful to various degrees. With the emphasis on building low cost ground support systems while maintaining a quality product, a key element in the test process is simulator capability. This paper reviews the Transportable Payload Operations Control Center (TPOCC) Advanced Spacecraft Simulator (TASS) test tool that is used in the acceptance test process for unmanned satellite operations control centers.

The TASS is designed to support the development, test, and operational environments of the Goddard Space Flight Center (GSFC) operations control centers. The TASS uses the same basic architecture as the operations control center. This architecture is characterized by its use of distributed processing, industry standards, commercial off-the-shelf (COTS) hardware and software components, and reusable software.

The TASS uses much of the same TPOCC architecture and reusable software that the operations control center developer uses. The TASS also makes use of reusable simulator software in the mission specific versions of the

TASS. Very little new software needs to be developed, mainly mission specific telemetry commutation and command processing software.

By taking advantage of the ground data system attributes, successful software reuse for operational systems provides the opportunity to extend the reuse concept into the test area. Consistency in test approach is a major step in achieving quality results.

INTRODUCTION

The TASS is a crucial test tool used in the acceptance test process for unmanned satellite operations control centers (Payload Operations Control Centers and Mission Operations Centers) at GSFC. The TASS is used for development, integration, acceptance and regression testing phases of the system development cycle.

For a software delivery to be completely successful, it must meet or exceed all requirements, be delivered on time, within budget, and with minimum defects. Typically, varying degrees of success are achieved, and ideally the software should be delivered to the customer with zero defects.

To help support testing during the system life cycle, the TASS was designed to produce quality results in the testing process at the lowest possible cost. By utilizing proven testing fundamentals, commercial off-the-shelf

products, open industry standards, reusing software and taking advantage of the available infrastructure, the TASS provides a very cost effective way to complete effective software testing for numerous project software deliveries.

TESTING FUNDAMENTALS

The goals of a quality software delivery is to meet all the requirements, with zero defects, on time and within budget. To ensure quality software deliveries during the entire system life cycle, effective testing is necessary for all phases (unit testing, integration testing, acceptance testing, and regression testing). Figure 1 depicts a typical system life cycle.

In order to successfully test all phases of software development, a carefully developed test strategy must be used. First the test process should accurately identify defects in a cost effective manner and perform this process in the shortest possible time. Likewise, availability of the necessary test tools has to be maximized, and the test tool must be easy to use. Finally, the use of automation should be part of the process in order to shorten the testing time and eliminate human error.

OPERATIONS CONTROL CENTER

Next, an understanding of the operations control center infrastructure is necessary. At GSFC, the operations control center is the focal point for the health, safety, command and control of the unmanned satellite. The Flight Operations Team (FOT) commands and controls the spacecraft and monitors its health and safety via the ground data system.

The design of the ground data system is based on the TPOCC architecture and its reusable building blocks. In the operations control center, the ground data system includes a primary and a backup system. See figure 2. The architecture of each system is a distributed processing system consisting of a general purpose workstation, X-terminals, and a real-time front-end processor (FEP) connected by Ethernet. The FEP communicates with NASA

Communications (Nascom), and ultimately the spacecraft, through a matrix switch using proprietary Nascom lines. These systems all utilize generic core TPOCC software, a software reuse library, which is the basis for which the mission software is built upon.

TYPICAL TEST SUPPORT SOLUTION

In the operations control center development environment, a tool to simulate the spacecraft and the status messages of the ground station is necessary to test the operations control center ground data systems. The TASS design concept is to make use of the software reuse library and be able to host its software on existing ground data systems. The TASS was developed with the capability to simulate the Nascom link protocols required to support various satellites, generate simulated spacecraft telemetry streams using the operations control center operational data base, and respond to spacecraft commands.

Unique implementations of spacecraft memory load and dump capabilities are provided. Network Control Center (NCC) communications protocol are simulated for Tracking and Data Relay Satellite System (TDRSS) support. In addition, the TASS validates spacecraft commands and alters the real-time telemetry stream in response to those commands. The user has the capability to alter the telemetry stream either by data base mnemonic or by specifying the individual bits in the telemetry frame or packet. Complexity can also be added by incorporating various dynamic models for the telemetry generating functions.

The TASS records all received Nascom blocks and all received spacecraft commands in history files that can be viewed for detailed analysis through the use of an off-line utility program. All system events, errors, operator input, procedure input recorded in the event log; and spacecraft memory images that are saved can be viewed by using the off-line utility programs. After completing the test, the user generates test reports using the report generation subsystem. These reports can later be used to evaluate the test results during the analysis process.

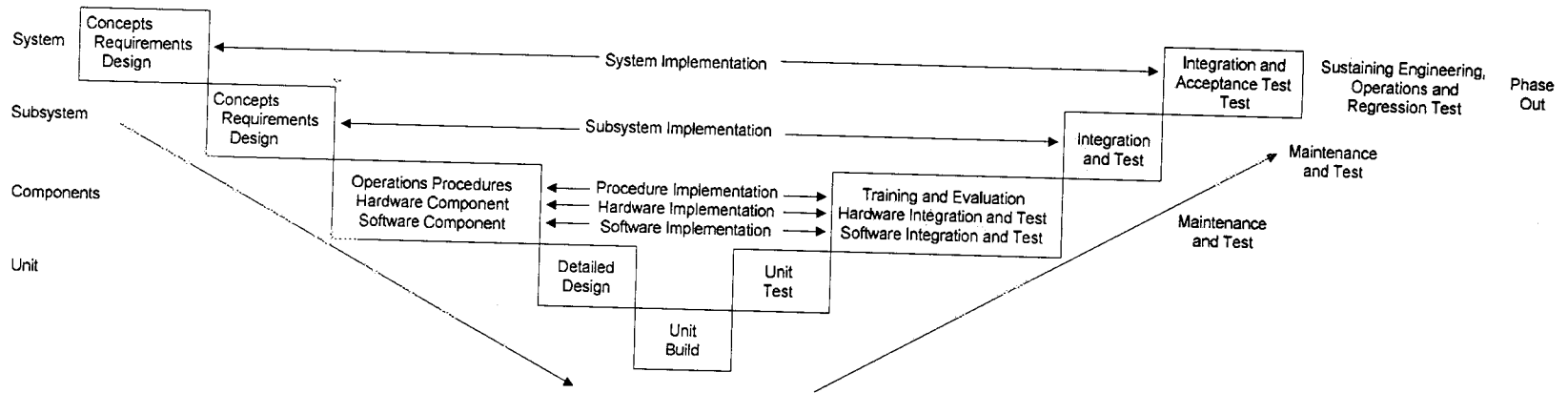


Figure 1. Typical Operations Control Center System Life Cycle

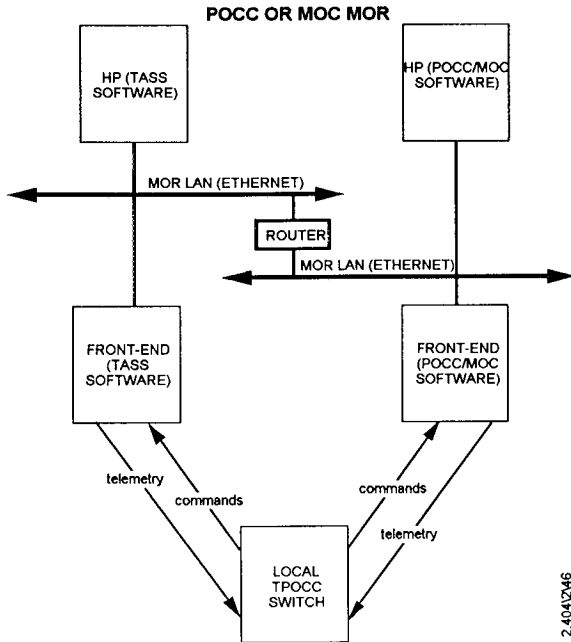


Figure 2. Typical Operations Control Center Ground Data Systems.

Since the test tool is used in all phases of the development cycle, it must be readily available, easy to use, and cost effective. In a typical operations control center, the design provides for a primary and a backup system. The TASS was designed so that it can be hosted on the primary or backup system; thus taking advantage of the control center architecture. Utilizing the backup system eliminates the hardware cost of an additional system, the need for additional floor space, power, cooling, and maintenance. It also eliminates the need to schedule Nascom communication lines and an externally located simulation system during the software development cycle. Likewise, in the development facilities with similar architectural capabilities, the TASS can be hosted on any system string and is essentially available at all times.

The hardware configuration that is used to host the TASS consists of two distributed computers connected by Ethernet and their associated peripherals as shown in Figure 3. One of the computer systems is a real-time VMEbus based front-end processor. It is used to receive and process spacecraft commands and to build and transmit the telemetry streams utilizing the Nascom link protocols. The other computer is a general purpose workstation

used to configure, control, and monitor the FEP from one or more user terminal.

To minimize simulator development cost, the TASS utilizes a proven software reuse library. A major component of the software reuse library is the generic TPOCC software. Seventy-eight percent of the TASS software consists of these TPOCC building blocks. This reuse library is also the same core software building block for the operations control center. For the TASS, it is used mainly for the user interface (display and TPOCC Systems Test and Operations Language (TSTOL)) and the Nascom interface. Another component of the library used by the TASS is the TASS generic software that is shared across different missions. These components account for seventeen percent of the TASS software. Finally, only five percent of the software is specific to simulating each spacecraft. Figure 4 shows a breakout of the TASS software reuse for a typical mission. To further increase reuse, the TASS utilizes many industry standards, including C, TCP/IP, sockets, XDR, Motif, X11 and RPC.

Another major consideration in the design of the TASS is the user interface. First, to maximize usability, the TASS makes use of a graphical user interface (GUI) which is based on X Windows and fully adheres to the industry-standard OSF/Motif principles. Since a major portion of the software is common between the operations control center and the TASS, they maintain a consistent look and feel between both systems. Finally, an open dialog with the TASS users is maintained in order to provide continued improvement in the test process.

To help automate testing, user inputs from both the command line and the GUI are processed by the TSTOL, the control center script language. By utilizing TSTOL, it is possible to log user inputs into a text procedure file. This text procedure file can be edited and is used to execute an automated test or repeat a previous test under user control. The TASS provides a means for saving and restoring predefined test scenarios and results, telemetry stream contents, and data structures. This allows the user to repeat specific tests, retest

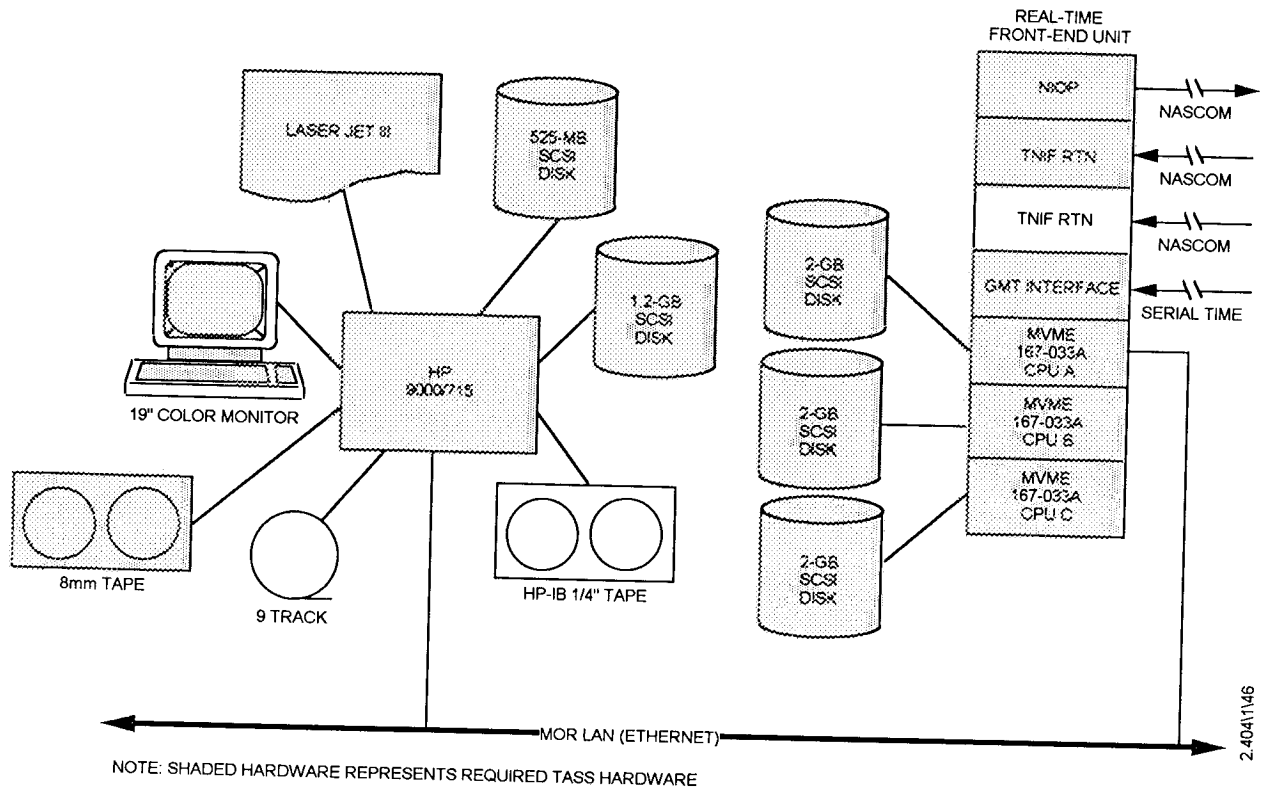


Figure 3. TASS Hardware Configuration

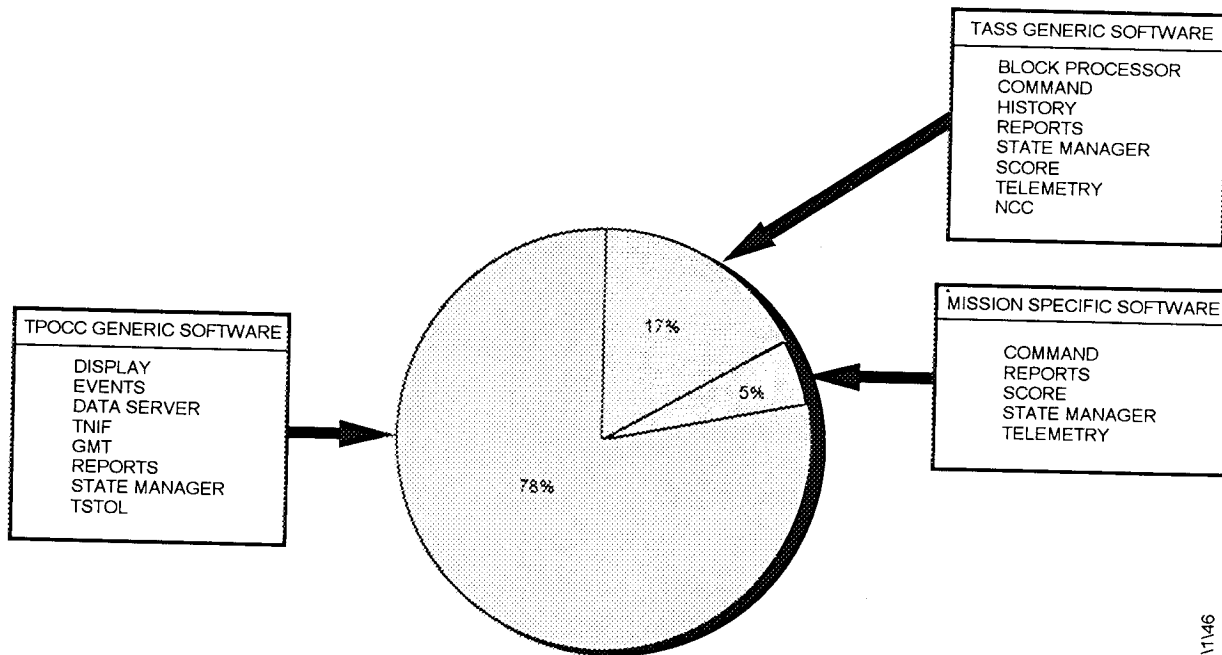


Figure 4. TASS Software Reuse

with known data, or continue testing from a given point in the test scenario.

Another planned feature that is being developed to automate testing is called Test/Score/Report. This function automates testing of the operations control center software in three areas: telemetry decommutation, spacecraft command processing, and spacecraft memory load and dump processing. The TASS system "tests" the operations control center software and provides a "score" based on the test results. Finally, the TASS system provides formatted "reports" that document each step performed during the test and the results of each step. These features help to test new deliveries and perform regression testing in the shortest time possible.

CONCLUSION

By taking advantage of the ground data system attributes, it is possible to achieve cost effective quality results in testing operations control center software. By using proven testing fundamentals, industry standards, reusing available hardware and software, maximizing usability and automation, it is possible to minimize the time and cost to perform quality software testing.

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Acknowledgments -- We wish to extend special thanks to the following personnel for their inspirational ideas used to formulate and implement the TASS: Carroll Dudley (National Aeronautic and Space Administration, Goddard Space Flight Center), Darlene Riddle (Integral Systems, Inc.), Luan Luu (Integral Systems, Inc.), and Nancy McCluer (Integral Systems, Inc.).