International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 3 Issue: 7 4695 - 4698

Automated Test Results Processing and Report Generation in Spacecraft Checkout Systems

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Abstract—An automatic approach is devised to analyze test results and generate test reports of complex and mission critical systems like spacecrafts and other flight missions during various phases of testing. The main idea of proposing this system to minimize the processing time, manual efforts and typographical errors significantly during processing and generation of test results reports.

The proposed system generates test results reports in real-time as well as in off-line for any sub-systems of spacecraft which provides quick and cost effective solutions in spacecraft checkout operations. The paper describes various approaches and algorithms used in automatic test results validation and report generation process. The new system shall be effectively implemented and deployed for any class of satellite.

Keywords *- Automatic Checkout Software system (**ACSS**), Spacecraft Checkout System (**SCS**), Integrated Spacecraft Testing **(IST)**, Checkout Network (**CHECNET**). Automated Test Results Processing and Report Generation* **(ATRGS)**

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I. INTRODUCTION

A spacecraft is a complex mission, consists of various subsystems which undergoes extensive testing from integration to launch phase. The health of the spacecraft is monitored through more than 20,000 telemetry, telecommand and ground systems parameters. In existing system,all parameters are manually observed and compared with bench test results and specifications and then test results reports are generated in off-line mode. All these manual activities are automated in the new system to support automatic checkout activities for spacecraft systems. We have implemented suitable algorithms to accurately process, validate and generate test reports for all subsystems of spacecraft without any typographical errors in real-time.

Background

A typical spacecraft checkout system has two major components. They are spacecraft checkout hardware and software systems.

Further, checkout system shall be classified into mainframe test system, payload test system and associated software systems. There are two major checkout software interfaces

are used between spacecraft and ground hardware systems, called Automatic Checkout Software System (ACSS) and Payload Checkout Software System (PCOS)

Precisely, mainframe and payload test system consists of various hardware systems to support spacecraft testing during all phases of IST. SCS Hardware equipments like Telecommand Encoders, Telemetry Data Acquisition Systems, Battery Simulators, Solar Array Simulators and many other measurement equipments connected

through secured private network, called CHECNET.

All hardware systems are connected to Spacecraft Checkout Computer (SCC) and payload Checkout Computer (PCC) via

CHECNET as shown in figure1and they are controlled and monitored by Automatic Checkout Software System (ACSS) and Payload Checkout Software System (PCOS). The spacecraft data and database accessed by authorized users and ground systems from ACSS database server.

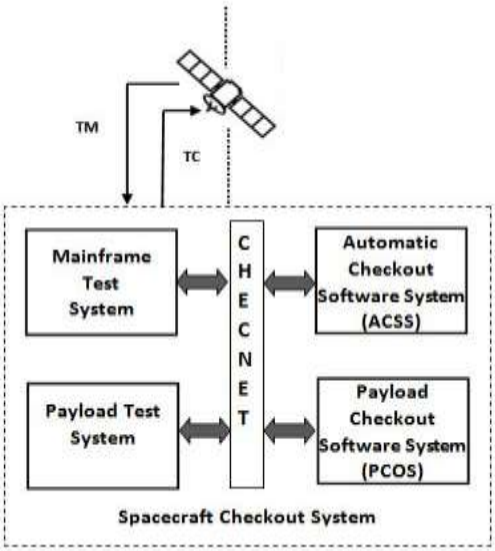


Fig 1: Spacecraft Checkout System

ACSS is a set of software products designed with the prime objective of providing functionality to test spacecraft and to automate the spacecraft checkout operations. It is organized into various real-time, offline, support and special purpose software packages. The proposed system is one of the integral systems of ACSS to automate test results validation and report generation.

ISSN: 2321-8169
4695 - 4698

II. SYSTEM OVERVIEW

The new system comprises various hardware and software interfaces used to test and processes all measurements of sub system parameters for any spacecraft.

Broadly, the system carries out three major operations. They are, test results processing, validation and report generation. The sub modules and their interfaces between them are shown in overall system architecture diagram [2].

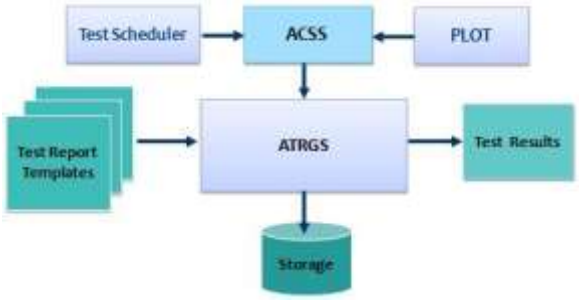


Fig 2: System overview diagram

III. SYSTEM ARCHITECTURE

The proposed system is designed as 3-tier client-server architecture, where server component handles test results acquisition, processing, auto validation and report generation. On the other hand, client component is used for display of real-time test results reports in standard format and also used in off-line data analysis based on user query. The database layer is interfaced to both client and server components to provide required data inputs and storing of test results and reports [3].

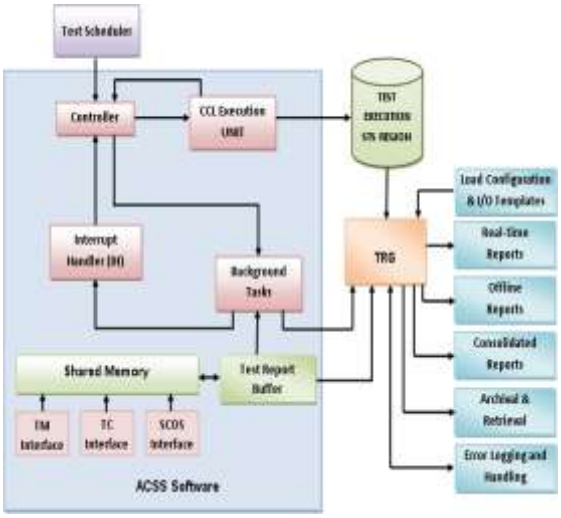


Fig 3: Overall System architecture

The has following components and their interfaces are shown in above figure

- Database system
- Input and output templates
- Test results acquisition and processing
- Test results validation
- Test results report generation
- Archival and retrieval of reports

Database system

It is one of the major layers in system's architecture which can be configured to any class of spacecraft by configuring the relevant parameters in database. DBMS helps the checkout team to define privileges and authenticity to take care of data security and integrity from various users and systems. It performs following operations

- Loading of Spacecraft and ACSS Configuration parameters
- Loading of templates
- Archival of raw and processed test results data and test reports
- Retrieval of test results for customized report generation in off-line
- Test Scheduler and Test file names
- Anomaly data and Reports
- History details

Input and Output Templates

Input template precisely provides specification details and final bench test results of select sub system parameters which are provided by subsystem designer. The output template specifies the structure of final test results report in which list of test procedures executed with their status and all measurements with status (ok/Not-ok) in table format. Finally list of plots and anomaly reports are also be included in output report.

All records of input and output tables are stored in ACSS database associated with subsystem and test name details.

The final test results report is generated using sub system's input and output templates by reading parameter names, final bench results, specifications and other details like sub system's measurements and status which are read from test results processing and validation module. The final test results report formatted and displayed in real-time during execution of test on any sub system.

S.No	Parameter Name	Units	FBT		Spec	
			Min	Max	Min	Max
1	DTG-1 Current	A	1.0	1.5	0.8	2.0
2	DTG-1 sync time	Sec	400	600	380	620
1	DTG-2 Current	A	1.0	2.5	0.9	2.0
3	DTG-2 Sync time	Sec	420	600	380	620

Fig 4: Input Template

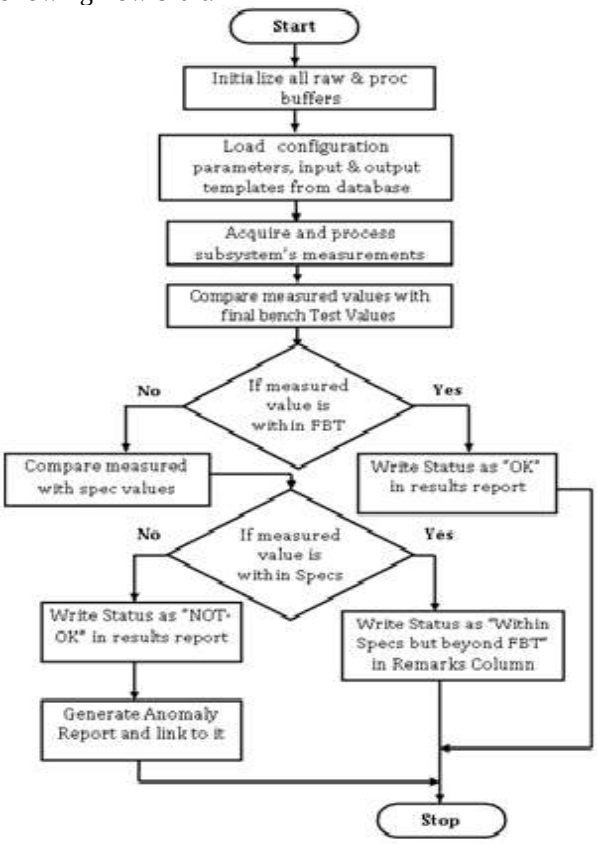
ISSN: 2321-8169
4695 - 4698

Test Results acquisition and processing

During testing on any subsystem, various measurements (test results) are collected and recorded as raw values and same will be processed using predefined equations with satellite specific database and these final processed values are stored in ACSS database. In general, these parameters are acquired from different sources like onboard Telemetry and telecommand data, ground checkout system parameters, computed parameters from background tasks and predefined global parameters.

Auto validation of test results

After processing of test results, validation of test results data is done by comparing processed values with final bench test results and specifications and then test results values are displayed in final report with status message (**OK/NOT-OK**). The detailed auto validation process is represented in following flow chart.



Flowchart 1: Auto validation of Test Results

Test Results Report generation

In real-time report generation, the test results are processed and test reports are generated and displayed on the system console. A standard test report has four standard parts which is standard format for any sub system, as shown in fig 5.

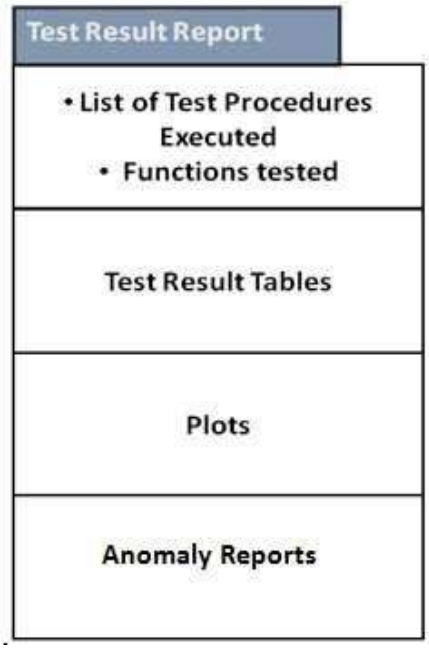


Fig 5: Standard Test Report format

The executed test procedure details with status, processed test results, plots and anomaly reports data will be given to report formatter module and it formats as per output report configuration parameters and settings. The first section displays a list of tests and functions are executed on selected subsystem. Second and third sections represent various test result reports in the form tables and list of plots generated corresponding to sub system. The final section displays various anomaly reports or error reports corresponding failed tests.

Archival and Retrieval of test results

After completion of all tests on any sub system, test results shall be formatted as per standard presentation requirements. Complete data and other details are saved in database in real-time but final test reports are archived in secondary storage. All Reports will be displayed and printed either in portable document format (PDF) and PowerPoint format (PPT) or any standard image format (JPEG, GIF, PNG, BMP) and compatible to any platform (Windows/Linux).

The retrieval operation will be used for generation and display of archived reports in off-line. During archival or retrieval, the following key parameters are logged.

Parameter Names

- Satellite Name
- Subsystem Name
- IST Phase
- Test Name
- Archival Date
- Archival Time
- Test report Title

The above mentioned key parameters shall be used as filters for quick retrieval of stored reports.

IV. FEATURES

This application shall be effectively used in validating test results for complex system and has following features[1]

- Client-Server & Platform Independent application
- Real-time & database driven system
- Subsystem/IST phase wise reports
- Standard test report format for all subsystems
- Trend analysis of test results across test phases
- Easy archival & retrieval of off-line test reports
- Final Test reports available in PDF/PPT format for presentation purpose

V. CONCLUSION AND FUTURE DIRECTIONS

This is one of the major automation activities of the spacecraft checkout system to automate all manual activities. Automation offers many advantages like reduction in test time, repeatability of the tests and avoiding operational and typographical errors during test results validation and report generation process. The system can be further enhanced to automate all activates present in the ground and on-board sub systems to deliver error free and cost effective systems.

ACKNOWLEDGMENT

The author expresses thanks to the entire software development team at Spacecraft Checkout Group of ISRO SATELLITE CENTRE. Author also expresses gratitude to Sri. K B Anantha Rama Sarma**,** **Group** Director and Smt. UshaBhandiwad, Division Head, for their valuable guidance and useful suggestions. I express my heartfelt thanks to Dr. M .Annadurai, Director, ISRO Satellite Centre for his support and providing necessary permissions for generating and submitting this paper for Connect .IEEE Conference.

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