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Study of Scope of Automation for Post Flight Analysis Activities

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Abstract: *Artificial satellites and their launch vehicles are frontier areas of modern technological arena. Prior to a launch, teams of technical experts are formed by various technical divisions of the organization to monitor the progress of the mission. Such expert bodies concerned with design and integration of missions are multidisciplinary teams functioning from diverse geographical locations of the organization. After the completion of a mission, each team conducts necessary analysis to identify the performance of their subsystems. Their findings are then summarized into a comprehensive report. A consolidated mission PFA report shall also be prepared summarizing the main highlights from individual PFA reports. Quite obviously, in an organization where there are multiple satellite launches every year, such a task, if carried out manually, would make the whole process inefficient, time-consuming and error prone. Effective communication and sharing of analysis results between experts in different work places are very difficult. It is also necessary to extract information from previous missions. All these reasons have necessitated the development of an automation system to support PFA activities. This paper highlights the various activities involved during PFA analysis. A workflow based system that automates the processes associated with post flight analysis is proposed.*

Keywords: *Rocket Technology, Flight Analysis, Post Flight Analysis (PFA), Workflow Automation.*

1. INTRODUCTION

Artificial satellites and rocket technology have applications in diverse fields from cosmological explorations and meteorological studies to telecommunication and defense strategies. They are products of collaborative efforts by diverse technological wings such as aerodynamics, avionics, propulsion, control systems, navigation and guidance systems etc. After a launch, various committees of experts are formed from diverse technical divisions of the organization to monitor the progress of the mission. Each of these committees conducts necessary analyses to identify the performance of subsystems. Analysts review in detail all the measured parameters, plot necessary graphs etc. against their nominal values. Their findings are then summarized into a comprehensive report for future reference. Obviously, such an elaborate manual exercise would be quite time-consuming. Moreover, the teams of experts are from diverse and multidisciplinary fields so they need to communicate and coordinate well. But the work places of these organizations may also be geographically separated. This makes it difficult for them to communicate and integrate the ideas and results of analysis. It is also necessary to store and manage enormous information regarding all flights. All these, and the increased number of missions every year, necessitate the introduction of an automation mechanism for supporting these activities.

For example as shown in figure 1, the post-flight analysis of a mission may be done by different PFA committees like solid propulsion, liquid propulsion, avionics, aerodynamics etc. Each of these committees is responsible for the analysis of the performance of their specific subsystem. The committee members may be assigned different roles. After a launch, the telemetry data is distributed to the committee members for detailed analysis. PFA members are responsible for analyzing the telemetry data and deriving the values of various performance parameters. The members have to note their observations and arrive at conclusions from the available data. They are responsible for reporting the anomalies in flight and reasons thereof.

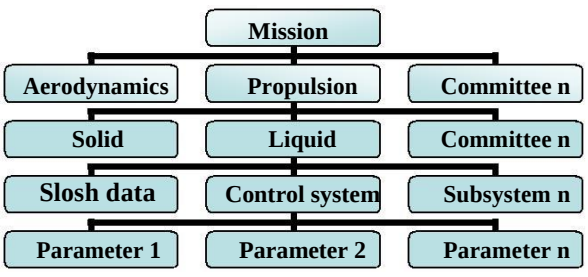

Figure 1: Formation of PFA committees

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The proposed system takes into account all these primary requirements of the post flight analysis process and aims to develop a workflow based application for automation.

2. LITERATURE REVIEW

Johann Eder, Herbert Groiss and Walter Liebhart explored the scope of database based workflow management systems [1]. Xinfeng Ye proposed the possibility of web-based workflow management system [2]. Robert Tolksdorf came up with the implementation of Workspaces, which is the implementation of a popular web-based workflow management system [3]. Miguel Valdes Faura, Christophe Loridan, Anne Geron and Roger Perey introduced the concept of Bonita which is an open source workflow management system [4]. David Hollingsworth put forward the idea of a workflow reference model, which can be considered as the standardization for any workflow model [5]. Followed by this, different types of workflow management systems were introduced in due course [6] - [8]. The list includes market-based, knowledge based, rule-based, groupware and finally a scientific workflow management system by NASA [9] - [14].

InfoCache, the existing post flight analysis utility enables to manage mission performance details of all flights in a central repository along with PFA reports search engine [15]. This software lacks the required flexibility in configuring different subsystems for different missions based on flight configurations and mission types. The present system proposes to overcome the shortcomings of InfoCache.

3. WORKFLOW AUTOMATION

Workflow Management System is defined by WFMC (Workflow Management Coalition) as a system that defines creates and manages the execution of workflows through the use of software, running on one or more workflow engines, which is able to interpret the process definition, interact with workflow participants and, where required, invoke the use of IT tools and applications.

Workflow Management Systems (also known as Business Process Management Systems) support the execution of business processes through the automated coordination of activities and resources according to a formally defined model of the business process (the workflow model). Workflow technology leverages the value of existing information system infrastructures and helps enterprises in the transition towards process-oriented organization.

Workflow-based systems provide companies with the ability to accurately measure the operational performance of business processes. Combined with data warehousing technology and operational business data, complex evaluations can be performed. These evaluations help enterprises to assess their current situation more precisely than could be done through the sole use of traditional key performance indicators. But workflow-based systems do not replace other enterprise controlling systems, but enhances them significantly.

Workflow management systems rely on database technology to store workflow and organization models, the current states of workflow instances and data relevant to execution of workflow instances. The resulting impact on the design of database management systems has initiated a number of research initiatives that analyze the use of database concepts in workflow applications.

From a functional perspective, the main tasks of a workflow management system can be grouped into planning, implementation, enactment and evaluation of workflows.

- During planning phase the conceptual model of the process to be automated is created, and organizational responsibilities as well as the links to external applications that are invoked during activity execution are specified.
- In the implementation phase the conceptual workflow model is transformed into an executable representation. The interfaces to external systems need to be implemented at this stage in-order to realize the communication between workflow management systems and invoked applications.
- The enactment phase refers to the instantiation and execution of a single workflow instance from a previously defined workflow model.
- As part of evaluation phase, the workflow management system creates an audit trail which contains information about the behavior of the system and the execution of workflow instances.

All these phases of workflow management system are also carried out in the development of the proposed scheme called PFA (Post Flight Analysis) Process Automation.

4. NEW PROPOSED SCHEME

The architecture of PFA Process Automation system can be grouped to four layers as depicted in figure 2 as interfaces, modules, technology and database. The system is also connected to the central file server for data storage as well as the mail server for sending mails.

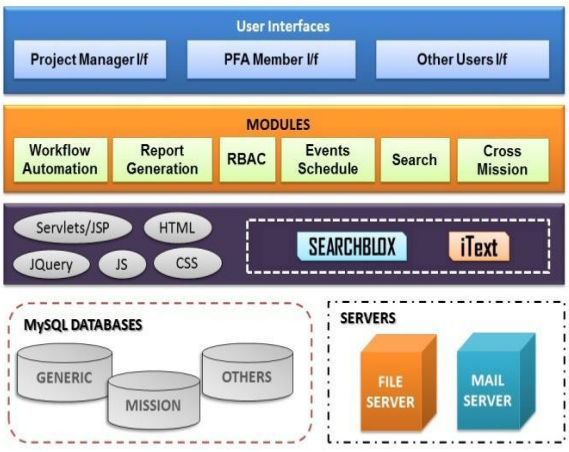

Figure 2: PFA Process Automation Architecture

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4.1 Interfaces

The PFA Process Automation system consists of three user interface options. Each of these interfaces consists of unique set of menus so as to cater the needs of three types of users - project manager, PFA Member, Other users.

4.2 Modules

The system comprises of six modules as shown in the architecture viz. Workflow Automation, Tracking and logging of activities, Report Generation, Events Schedule, Search and Cross Mission Comparison.

4.2.1 Workflow Automation

Workflow automation is done using database based workflow automation mechanism. The PFA workflow automation module consists of three types of participants' viz. Project Manager, PFA Convener and PFA Members as shown in figure 3.

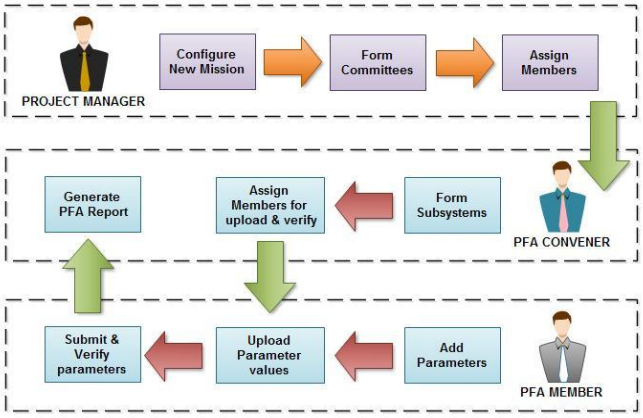

Figure 3: PFA Workflow Automation

Project manager is the person responsible for controlling the entire activities of the mission. He is assigned with the duty of PFA task initiation. Task initiation consists of three major phases viz.

- *Configuring a new mission*: This involves the process of initiating the PFA process automation by adding a new mission to the existing list of missions along with the details of the mission like launch date, project, and mission id and mission name. The mission id is auto-generated.
- *Forming PFA Committees*: This is another vital responsibility vested with the project manager. The project manager forms several post flight analysis committees consisting of engineers from various divisions as analysts. The various teams formed in this regard are related to Mission and vehicle performance, Solid propulsion system, Liquid propulsion system, Control power plants, Structural performance and environmental data, Telemetry and tele-command network, Hardware and onboard system etc.
- *Assigning members to the committees*: This is also a responsibility of the project manager. The project manager can copy the committees and members from previous missions. He can also add new members. These members assigned by the project manager forms the group of analysts who are responsible for post flight analysis. Each team of analysts assigned by the project manager consists of Chairman, Convener, Co-convener, Members, and Invitees.
- *Data upload:* Convener has the main role in the PFA committee. The convener subdivides the committee into several subsystems and chooses those members who are authorized to *upload* and *verify* the data. Once the PFA workflow is defined, the telemetry parameters for each subsystem can be uploaded by respective committee members. The responsibility of data integration and generation of PFA reports after data verification is handled by the PFA convener.

4.2.2 Tracking and Logging of Activities

The PFA automation system maintains an upload log to update the status of uploading activities along with other details like date and time of action, employee id of the action etc. There are currently four actions defined for subsystems viz.*saved*, *submit*, *verified*, *rejected*. These status updates are based on the upload of parameters of the subsystem. When the member responsible for uploading parameters has initiated the upload, the status is set to *save*. After uploading all these parameters associated with a subsystem, the member submits the subsystem for verification and the status is changed from *saved* to *submit*. The person responsible for verification verifies the parameters submitted. He may either verify or reject the set of parameters. The rejected parameters are subject to re-submission by the uploading authority.

Also, in the case of PFA activities for each committee there are three statuses viz: *Not Initiated*, *Initiated* and *Complete*. The status of a newly added committee is *Not Initiated*. When the PFA members starts uploading parameters to the subsystems associated with a particular committee its' status changes to *Initiated*. After successful verification of all the parameters of all the subsystems of a particular committee the upload status of that committee is changed to *complete*. Each newly added mission hold the status *active* by default. When the activities of all committees under this mission are *completed*, the status of the mission is changed to *close*.

4.2.3 Report Generation

PFA Report Generation module deals with automatic generation of PFA report (figure 4). The subsystems and parameters which are finally approved are utilized for the generation of the PFA Report for PFA committee.

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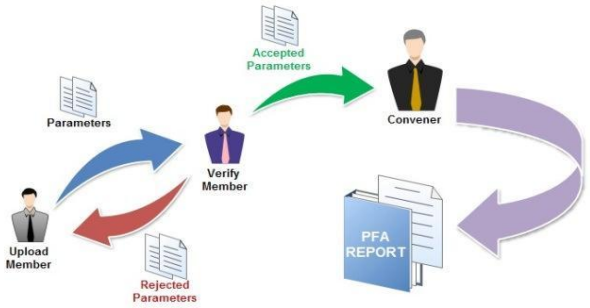

Figure 4: PFA Report Generation Process

The PFA Report is generated using iText library which is a free and open source PDF library in Java.

4.2.4 Events Schedule

PFA events schedule module is an interface provided to PFA teams to schedule PFA committee meetings. Post flight analysis teams consist of several members from different technical departments. For effective communication between them, an automated system for convening meeting and sharing review minutes is essential. The proposed system facilitates PFA conveners to schedule the meetings, intimate members and other invitees, upload and share the minutes and other presentations of the meeting.

4.2.5 Search

Advanced PFA Search Engine is a search facility for full text search of PFA reports in PFA reports repositiry. This search engine is implemented using an open source component viz. SearchBlox. SearchBlox is a J2EE search component that is deployed as a web application. It is controlled and customized via a web browser interface. The search engine can index and search HTML, PDF, Word, Excel and PowerPoint documents.

4.2.6 Cross Mission

Cross mission analysis facilitates the comparison of uploaded parameter values across several missions. This module helps the PFA teams in analyzing the flaws and other performance related details of a particular mission with reference to prior missions. Graphs can be plotted using series of values obtained as a result of comparison across missions so as to identify and isolate the flaws associated with a particular mission.

4.3 Case Study

As per requirements of the organization, PFA Process Automation software was implemented as a web based application, in Java platform using Netbeans IDE and MySQL as the RDBMS. A mission was taken as the pilot project and initiated formation of PFA committees and assign roles such as Chairman, conveners and members. Subsystems were added under each committee using corresponding convener role.

Three GUIs were designed based on the 3 role types: project manager, PFA members and others and functions were appropriately enabled based on user roles. The project manager role includes adding a new mission, forming new committees and assigning members to each of these committees. The interface for PFA members facilitates PFA convener to form subsystems, authorize PFA members to upload and verify parameters of each subsystem, generating PFA reports and scheduling meetings.

The different members in each committee authorized for uploading the parameters added the details of parameters associated with each subsystem. The authorized members reviewed these uploaded parameters and marked them as verified or rejected them for resubmission. After all the parameters of all the subsystems of a particular committee are verified, PFA report for that committee was generated by the convener.

The third group of interfaces is intended to aid the activities related to access of PFA data by authorized users. These were used to view mission details, PFA committees, compare parameter values across missions, and view mission PFA reports with advanced search using open source Searchblox.
The prime aim of this system was to improve the flexibility and usability. This was achieved by promoting the addition of new PFA committees and subsystems based on the requirements of the mission. To minimize manual entry of data, features are enabled to select and copy PFA committees, subsystems and parameters from previous missions. This improvised the system and also increased the user friendliness of the system.

5. CONCLUSIONS AND FUTURE WORK

The software for Automation of Post Flight Analysis Activities is a workflow management solution with improved functional and security features for automating the post flight analysis (PFA) activities in connection with launching of satellites. A detailed study of application of various workflow management systems was carried out. This system has all the necessary features to improve and accelerate the post flight analysis activities. It facilitates the automation of all the workflow stages associated with post flight analysis, including the auto-generation and secure storage of PFA reports.
The present database design ensures flexibility and expandability of the system. The proposed system also provides a simple and user friendly GUI to users. The features of the proposed system can be enhanced by incorporating facilities to support analysis activities like plotting graphs, automatic computation of dependent parameters etc. There is also further scope to facilitate the automatic analysis of telemetry data and update of parameter values to ensure more accuracy and faster completion of PFA activities.

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