



Author: Luis E. Serrano
 Advisor: Dr. Héctor J. Cruzado
 Graduate School

Abstract

The project's purpose is to automate the generation of the Functional Readiness Reviews (FRR) presentations for the Pratt & Whitney's modeling group's validation of the State Variable Model for engine control systems. The objectives are to eliminate human error and reduce the time it takes to create the presentation from upwards of 38 hours to 1 hour or less. To achieve these objectives a Value Stream Mapping event that led to the development of two different tools, one to generate plots and one to create the final FRR presentation was completed. The first tool was implemented as a Unigrph script that laid the base for the time reduction in the creation of the FRR presentation by creating separate images for each plot in a standard folder structure with a standard naming convention. The FRR presentation tool was implemented using a combination of Microsoft Excel and Visual Basic for Applications (VBA). This tool automated the generation of the PowerPoint Presentation and reduced the time it takes to create the presentation to 10 minutes once the inputs are provided.

Background

Infotech Aerospace Services, Inc. (IAS) is a company based out of Isabela, Puerto Rico that has been in business since 2003, providing a variety of aerospace solutions to multiple customers. Software Systems and Electronics (SSE) is a department within the IAS that provides software solutions to aid engine software development for Pratt and Whitney (PW) engines. One of the PW groups that SSE supports is the engine modeling group.

The engine modeling group defines the control laws architecture, develops control requirements, and performs design and validation of classical and advanced control techniques. One of the projects SSE supports for the modeling group is the validation of the state variable model (SVM), a linear on-board engine model, for engine control systems.

Every new version of SVM needs to be validated in order to determine compliance with requirements and expectations. To accomplish this a functional readiness review (FRR) presentation is created with every new software version. In this presentation a set of engine parameters is monitored and recorded to analyze overall engine performance.

In the case of this particular set of engine programs, it takes three different processes to complete an FRR presentation:

- Data Generation: the model is run to generate data for the engine parameters to be analyzed in various scenarios.
- Plot Generation: the data obtained from the model is plotted to create a PDF with the different engine parameters in various scenarios.
- FRR Presentation Creation: the PDF is used as input to create the FRR presentation using a PowerPoint template.

An FFR presentation can have anywhere from 11 to 34 different engine parameters. Each of these parameters uses 1 of 6 different slide packages that can have 4, 9, 11, 12 or 21 slides. On average the presentation features 20 different plots per engine parameter.

Even though the task itself is not complex, it is very time consuming, prone to human error and requires multiple inspection points. The simplest presentation consisting of 11 different engine parameters can take upwards of 38 hours to complete.

Methodology

The methodology used for the project consisted on performing a Value Stream Map (VSM) event on the process of generating the plots and the process of generating the presentation. Once these processes were mapped and analyzed for improvements, the software development life cycle was applied to create automated tools to generate the FRR presentation. Finally a timing analysis was performed to validate the time reduction in the creation of the FRR presentations.

Activities Summary

A VSM was performed on the two processes targeted for improvement: Plot Generation and FRR Presentation Creation. The current and future state process maps for the Plot Generation process is shown in Figure 1. The current and future state process maps for the FRR Presentation Creation process is shown in Figure 2.

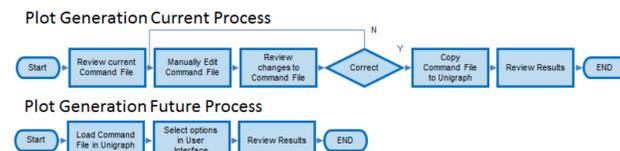


Figure 1
 Plot Generation Process Map Comparison

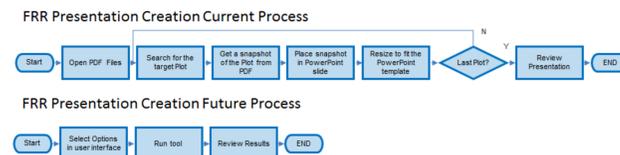


Figure 2
 FRR Presentation Creation Process Map Comparison

The software development lifecycle was applied after the VSM. A set of requirements was created for each process that outlined the automation needs for the implementation of automated tools. A high level design was developed from the requirements to determine implementation options for each tool.

In the case of the Plot Generation process, the implementation consisted on an upgrade to an existing tool in a Unigrph scripting language. Unigrph is a United Technologies Corporation (UTC) proprietary program to plot data. The focus of this implementation was in a user interface and a standardization of a folder structure and naming convention.

In the case of the FRR Presentation Creation process, there was no existing tool, but there was a requirement to have a PowerPoint presentation as the output. The following programming language alternatives were analyzed: Java, .NET and VBA. The analysis performed included interviews with experts on the different options and book. The experts provided a high level outline plan on the implementation required for each programming option, including expected objects, interfaces and completion time to have a final product ready for verification. Based on the information reviewed the VBA option was selected.

Once the implementation was selected, the tools were implemented and tested.

Results

The process to create FRR presentations was listed and validated at 38 hours for a standard 11 parameter presentation. With the implementation of the tools, the process was validated at taking 30 minutes for a 34 parameter presentation and 22 minutes for the same standard 11 parameter presentations. This represents a reduction of 99% of the time and cost.

Table 1
 Time Reduction Analysis

Process	Current Process	Updated Process	Reduction
Plot Generation	0.8 hrs	0.2 hrs	75%
FRR Presentation Creation	35.2 hrs	0.17 hrs	99.5%

The tools provide the opportunity to create multiple presentations using different scenarios and more parameters than were feasible before in a shorter time frame and for a fraction of the cost.

Plot Generation tool

The plot generation tool is a script for Unigrph. It has a simple user interface in command line format. It takes the information from the user or the user can select the default values for each input, except engine variant, which is required. Once the user completes the required fields, the tool proceeds to create all the plots. If the option for FRR presentation is selected, the tool creates a folder structure and places the separate image files for each plot using a standard naming convention and location. The tool includes data validation to the inputs to make sure they are feasible. The tool takes approximately 12 minutes to plot every parameter and create the files.

The inputs for the plot generation tool are:

- Data location
- Tools location
- Input Name
- Output name
- Decision if the tool run will be used for FRR Presentations
- Engine Variant

The outputs for the plot generation tool are:

- PDF with plots
- Separate image files for each plot in a folder structure if the tool is run to create FRR Presentations.

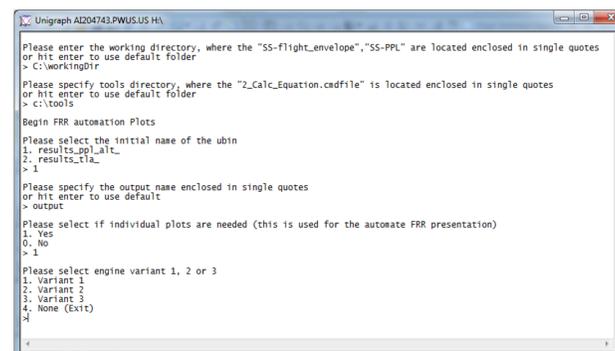


Figure 3
 Plot Generation Tool User Interface

FRR Presentation Creation Tool

The FRR presentation tool is an Excel spreadsheet with a Macro that connects to PowerPoint and creates a presentation. The tool consists of a set of worksheets that provide the basic architecture for the user interface and for the PowerPoint slides and a macro that finds the information and assembles the PowerPoint presentation. This tool automatically finds the plots in the folder structure and formats them to the required slide template. The tool includes data validation for inputs and the output presentation. If an image is missing it provides the link and name of the missing file so it can be recreated if needed. The tool takes approximately 10 minutes create an 11 parameter presentation.

The inputs for the FRR presentation tool are:

- Engine Variant
- Location of the folder structure
- Parameters to include in the FRR presentation

The output for the FRR presentation tool is:

- PowerPoint presentation with the plots for the parameters selected in the user interface.

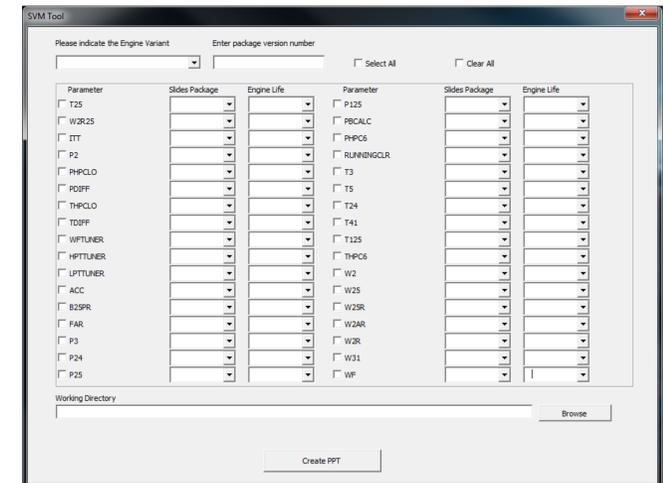


Figure 4
 FRR Presentation Creation Tool User Interface

Conclusions

The implementation of the tools was completed ahead of schedule and under budget. The objective to eliminate human error in the creation of the images used as input for the FRR presentation and in the creation of the presentation was achieved by creating user interfaces that eliminated the interaction of the user with the Unigrph script code and the need to manually place the plots into the PowerPoint presentation. The objective to reduce the time required to create the presentation from upwards of 38 hours to 1 hour was achieved with the tools performance. The overall process takes less than 1 hour for every presentation size.

The tools created a productivity improvement in the SVM validation and provided the opportunity to create multiple presentations using different scenarios and more parameters than what was feasible before. The customer approved the improvement and awarded a productivity improvement savings of \$37,560.00.