SAIC Inc.
Case Study

Optimizing Manufacturing Process Design for NASA Test Flight Article

"We chose SIMUL8 as part of the study because it provides rapid model development, a high degree of control over entities within the simulation and superior graphical execution of the model that helps with troubleshooting and customer buy-in."

George Culver
Sr. Operations Research Engineer
SAIC

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The purpose of the study was to model the manufacture of a test flight article, the Ares 1-X Upper Stage Simulator (USS), for the future Ares 1 launch vehicle as part of NASA's program to return to the moon.

Background to the Project

SAIC used SIMUL8 to develop an integrative and interactive approach to optimize the manufacturing process design for the test flight article.

The manufacturing concept is to divide the entire upper stage of the vehicle into a series of cylindrical segments (called tuna cans) that stack together. The tuna cans are produced by rolling sheet metal into halves of the tuna can, welding the sheets together to create a skin, then welding a circular flange to the top and bottom of each tuna can. The flange will be used to secure the tuna cans to adjacent segments.

Many tuna cans have a similar design; however, each tuna can has unique aspects. Details such as the location and number of sensors can result in small changes in the complete manufacturing process.

The main reason for dividing the USS into these tuna cans is that there are no heavy manufacturing facilities at NASA Glenn Research Center (GRC) that could accommodate manufacturing the entire USS in one piece. Primarily two facilities are being used

in manufacturing the USS at GRC. Historic Building 50 is being used to receive the raw materials and to fabricate and check out the tuna cans. The tuna cans will be transferred to Building 333 for segment assembly and preparation and finally to segment staging in Building 4, for long-haul transportation to the NASA Kennedy Space Center (KSC) in Florida.

Of critical interest is the attainment of the individual segment departures from the two manufacturing facilities and the GRC.

The project is highly complex as the study is required to take into account various complications; fabrication and material handling floor space is limited; fabrication equipment and techniques that need to be created during the production of some segments must be integrated into the IPT plan; the pool of skilled labor available to expand the fabrication work force is limited; and the engineering development tasks are being executed in a highly complex team structure, with the work spread across multiple design teams and contractors.

Project Objectives

Given the different budgetary and schedule constraints (objectives), what is the best plan to achieve the Ares I–X USS IPT goals? Specifically, the study had to:

1 Optimize the design, fabrication, and test approach(es) to ensure that all of the USS segments for flight test article 1 are manifested in Building 4 for transport to KSC no later than 9/3/08

2 Optimize the utilization of USS team resources (civil service and support service contractor staff, and facilities and equipment) to achieve the targeted segment departure dates within the baseline resource budget for the USS IPT.

The Approach

The approach combined discrete event simulation technology by SIMUL8 with an agent-based simulation to model manufacturing and organizational effects of NASA's build team.

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SIMUL8 was used to focus specifically on the challenging process of manufacturing and mating the tuna cans in Building 50 to provide more detail on this part of the overall USS IPT.

The model focused only on characterizing the overall process duration and identifying major process and resource sensitivities to the tuna can manufacturing steps required in Building 50, where the USS skins and flanges are fabricated, assembled and test-fit prior to transfer to Building 333.

The most significant part to understand about the model was how the work items flowed between these major portions of the overall process. Flange segment work items were routed using SIMUL8's 'Cycle Matrix' feature, where specific transfer and processing steps can be directed. This allowed for a fine degree of control for each work item to follow the scripted manufacturing process as provided by the NASA process managers.

For example, each build stand requires enough flange segments to construct a top flange and a bottom flange for each tuna can. It was imperative that the model properly route enough flange segments to produce both flanges or the work item processing will cause a bottleneck while waiting for the correct resources. The Cycle Matrix ensured that each stand received the correct materials in the correct order.

Collecting Process Information

In the SIMUL8 model, process details were obtained from the process managers over repeated question-and-answer sessions as well as through weekly feedback sessions. This process helped mature the model, ignite process discussions among the process owners and gain confidence in results provided.

Analyzing the Existing Manufacturing Process

The following cases were analyzed with the SIMUL8 model:

- Characterize the baseline process—provide metrics describing the baseline process that NASA can expect
- Skin weld strategy—assess variations in skin welding strategy, to include mechanical welders versus manual welding, and weld on stand versus weld on roller
- Sensitivity to nondestructive evaluation (NDE) parameters—the NDE process has significant unknowns, such as defect rate frequency, repair duration for each defect, and inspection duration
- Improve clock and mate procedure with additional facilities—the clock and mate portion of the manufacturing process was identified as a significant bottleneck; the analysis investigated a potential alternative to reduce the bottleneck.

The Results

Results from the SIMUL8 model were used to improve the resolution and focus of the companion agent-based simulation.

The resultant recommendations were considered to be highly effective by the USS IPT team and as a result, the IPT has adopted the following changes:

- Adopt a mechanized welding approach to minimize weld defects and subsequent rework
- Shift design resources to finish the common segment design as quickly as possible
- Adopt a crew-based approach to maximize crew skill level
- Implement a schedule “dashboard” to increase visibility of segment manufacturing flow to the team and to the labor on the floor
- Implement flange storage recommendations
- Study moving the clock, mate and match drill and the secondary structure to Building 333.

While the results obtained were directly beneficial, the study also helped the build team to consider aspects of their manufacturing problem and address fundamentals solely as part of collecting data to build the model.

In effect, the model outputs were useful, as was the process of coordinating with the team to build the model.

The Benefits

SIMUL8 was cited by the Program Manager as providing the concrete results to justify altering the manufacture process to allow the team to deliver on schedule, contribute to the timely flight test of the new launch vehicle and subsequently allow the continuation of manned spaceflight.

Future Projects

As the NASA process managers gain a better understanding of the process, the SIMUL8 model can be updated to investigate more dynamic routing for the order of tuna cans and the assignment of which tuna can is assembled on which stand.

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