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S-FLOW: METHODOLOGY OF APPLYING DISCRETE-EVENT SIMULATION

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ABSTRACT

S-Flow, or Simulation-Flow, is the name of the methodology for utilizing discrete-event simulation (DES) that has evolved from over 20 years of use in automotive manufacturing. This process has been refined to address typical pitfalls of applying DES and to ensure acceptance by non-experts. The methodology walks the simulation engineer through stages of project planning, model planning, data analysis, model development, model verification and validation, scenario testing, results analysis, and project reflections. Each stage is explored in depth to show the potential pitfalls that can be avoided. Complete and consistent usage of the methodology promotes awareness and approval of DES analysis as well as the opportunity to further improve the S-Flow methodology.

1 INTRODUCTION

DES has been used for over 20 years to analyze the manufacturing operations and capital investments for automotive production. A refined methodology, known as S-Flow, has evolved to establish a standardized approach to applying DES to a diverse array of opportunities to optimize solutions in the automotive manufacturing environment. The methodology breaks down phases of planning, analyzing, developing, testing, and reporting to provide recommended deliverables and touch-points to review progress. A sign-off sheet is used for documenting project milestones and acceptance of deliverables by the requesting customer. Adherence to S-Flow allows for greater buy-in to DES results by all parties involved and the opportunity to improve the methodology even further.

2 PLANNING

DES activity is initiated by submitting a support request form. The information on this form is transformed into a theme sheet by the DES expert to confirm that the results deadline is achievable and outline specific study items, scenarios, and/or concepts. At this time, it is also determined if DES is the appropriate analysis tool for the study or if there are other, easier alternative methods to solve the problem statement. Before building a conceptual model begins, the theme sheet is agreed to by the requestor. The goal of the conceptual model is to use the problem statement to identify characteristics of the model that are needed to answer the problem statement. The characteristics of the model then drive the required data or assumptions for inputs. The problem statement should also drive the model scope and key performance indicators (KPI) to be measured in the system. The conceptual model activity then dives deeper into the material flow of the system and even further down into specific process characteristics and level of detail required to achieve model accuracy. These items are reviewed with the study requestor and recorded on the sign-off sheet.

In parallel to the development of the theme sheet and conceptual model, a specific action plan (SAP) is created to reflect the required time for each task to be achieved in order to fulfill the results deadline. By starting with the end in mind, beginning at the deadline and working backwards allows the simulation engineer to consider model details and scope relative to the available time. This schedule is maintained throughout the study and used to track project progress. A high-level schedule is included in the theme sheet and denotes milestone reviews for the requesting customer.

3 ANALYZING DATA AND DEVELOPING THE MODEL

The conceptual model activity provides a list of required input data. This data is collected and analyzed to consider the variance to be used in the DES model. Data should be collected over a period that provides enough data samples for statistical testing. The period for data collection should also strive to be in steady state. Where data is not available or unknown, consultation with process or equipment experts is completed to set an assumption with a tolerance range to be used in sensitivity testing later on in S-Flow.

Once the data and assumptions are confirmed, the model development begins. An agile approach is taken to model development. As each component is added to the system, it is verified visually and via reported metrics by the DES software. Sources of variation to the systems are tested individually to confirm the intended impact to the system. A deterministic run is completed for each verification item. Once all items are verified, baseline system parameters are set and sources of variation are enabled. The KPI of the DES model is compared to the KPI of the actual system during the same period as the data collection. Statistical tests for mean and standard deviation, and measurements taken from comparing histograms of the KPI are used to judge model validation. This milestone is another touch-point for review and signed by the requesting customer on the sign-off document.

4 MODEL TESTING AND RESULTS REPORTING

The model testing can begin after the model validation is achieved. Concepts and scenarios outlined in the theme sheet can be run and compared to the KPI of a baseline run or the validation run. Sensitivity testing of inputs for sources of variation can be tested to indicate areas of interest for optimization of the KPI.

Results of model testing are then compiled and visualized to explain model dynamics and show comparative KPI measurements. The S-Flow also provides a framework for which the results can be presented back to the study requestors in a comprehensive storyline. If new audience members become part of the evaluation process, the S-Flow provides a logical way to walk them through the steps of the study to ensure understanding and build trust of the DES model, and therefore the results. This is the final touch-point for the requestor to sign-off and take ownership of the study results and DES model for future use.

5 REFLECTION AND IMPROVEMENT OPPORTUNITY

At the conclusion of the S-Flow, a questionnaire allows the DES engineer to reflect on the overall project. The SAP is used to determine where scheduled tasks achieved their deadlines and what activities may have exceeded the allotted time and why. Model validation can be reviewed to understand where accuracy may have been lost and whether it was caused by modeling simplifications or input assumptions. Finally, the reflection process allows the DES engineer to identify potential opportunities from improvement or new needs for additional tools and resources to improve overall efficiency of the S-Flow process.

6 CONTINGENCIES

At any point in the project timeline, there can be minor or even major changes to the overall project direction. As a simulation engineer, it is important to remain flexible in the scheduling and modeling of a project to deal with these inevitable occurrences. Planning for any type of change can be very difficult and the impact can be very time consuming. Utilizing variables for data inputs from the beginning of model development is a quick and easy way to address many minor changes and make scenario testing more efficient as well. Modular coding and/or proper selection of simulation software package are other ways to plan for changes with minimal effects to deadlines. Thoughtfulness in the planning phase is the key to foreseeing possible change-points and determining how to best position the project for success.