



IE3100M System Design Project (SDP)

Decision Support System with Virtual Factory Simulation

SDP GROUP 6:

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Outline

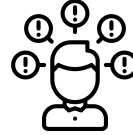
1. Introduction
2. Methodology
 - a. Data Extraction
 - b. Program Application
 - c. Implementation
3. Output Analyses
 - a. Data Visualisation
 - b. Acceptance Testing & System Testing
4. Conclusion and Recommendation

Company Background

- **Infineon Technologies**
 - One of the leading manufacturers of semiconductors
 - Aim to reduce energy consumption and environmental impact
- **Infineon Technologies Asia Pacific Pte. Ltd. (IFAP) - Singapore**
 - Focuses on Testing & Mark, Scan, Pack (MSP)
 - Includes final inspection and shipping



Problem Description



- **Optimise factory production through simulation**
 - Specifically on burn-in process
 - Tests for defects through thermal stress
 - Need for simulation
 - Complex process with tight schedule and expensive materials
 - Allow other engineers to test various scenarios
- **Simulation tools are hard to adopt and use**
 - Complex and hard to understand
 - Data management is time consuming

Project Objectives

- Develop an optimised decision support system using simulation, with the aid of a data extraction tool and a data visualisation tool
- This system can be used to help users determine the optimal batch size and lot sequence for incoming lots of the burn-in process
- Consists of:
 - Automatic data extraction
 - Simple and intuitive program for control of complex simulation-based optimisation
 - Comparison of simulation results

Methodology

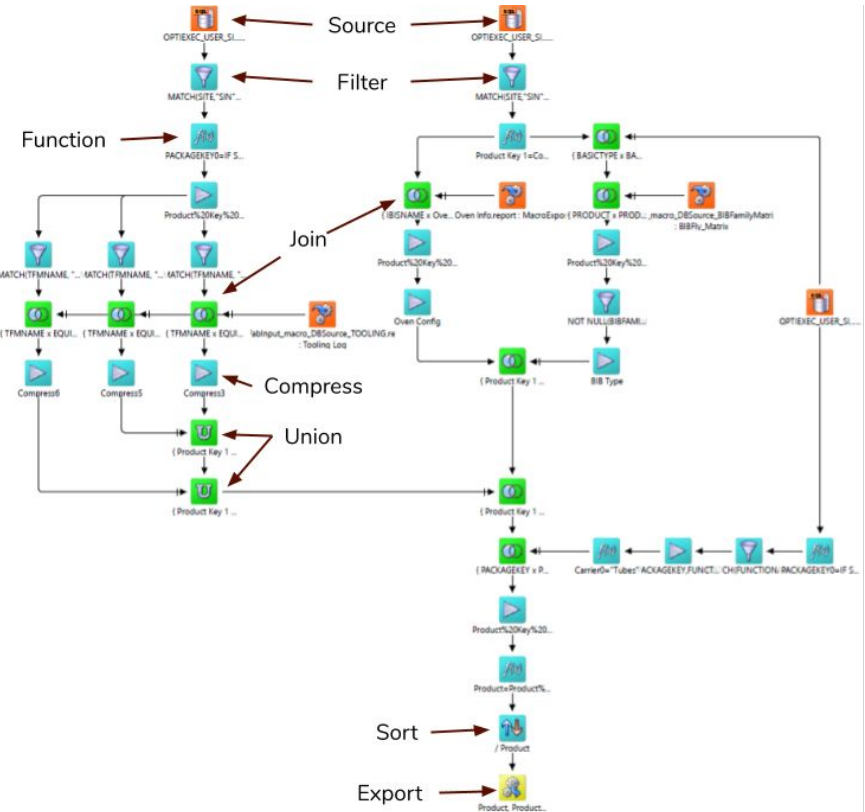


1. Automate the data extraction through APF Formatter to make it easier to create the simulation input file.
2. Develop a program that can interface with Excel and FlexSim to automatically **test different parameters and collect data**.
3. Design a user-friendly GUI.
4. Data visualisation on Tableau for the simulation results.

Data Extraction (APF-RTD)



- Automation of data extraction for simulation input Excel file
- **Extract:** Pulls real-time data from the company raw database
- **Transform:** Formats the required raw data into the data format of the input Excel file
- **Load:** Exports formatted tables instantaneously as an Excel file



Java Application with Graphic User Interface (GUI)



- Object-Oriented Programming (OOP) with Java programming language
- Greater efficiency and productivity
- Allows the user to select the required parameters intuitively
- Presents feedback to the user for greater usability

Program Application

IBIS Simulation

File

Help

Simulation Settings

Run Parameters

File Directories

Lot Dispatch

Choose the lot sequencing rule(s) for the simulation to run. Please select at least one. "First-Come-First-Served" keeps the sequence supplied in Actual Lot Info.

Lot Sequencing Rule(s) to Run: ☒ First-Come-First-Served (Default) ☐ Shortest Processing Time ☐ Most Jobs ☐ Random

BIB Batch Size

Choose the allowable minimum BIB batch size to run. A range can be run incrementally based on the step size. Maximum BIB batch size for every run is fixed at 24.

Lowest Min. Batch Size to Run: Highest Min. Batch Size to Run: Step Size between Runs:

Additional Settings

BIB Load on Lot Criteria: ☐ One lot per BIB ☒ Multi lots per BIB

Resource Select Criteria: ☐ First Available ☐ Shortest Queue ☐ Shortest Distance ☒ Shortest Queue + Shortest Distance

Lot Selection Criteria for Loading: ☐ First-In-First-Out (FIFO) ☐ Lot with same loader kit & BIB type as previous lot processed ☒ Lot with same loader kit & BIB type as previous lot processed + Least changeover time

Trolley Location Select Criteria: ☐ Shortest Distance ☐ Shortest Queue ☒ Original Location

☐ Show model on FlexSim?

Run Simulation

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Simulation SettingsRun ParametersFile Directories

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BIB Batch Size

Choose the allowable minimum BIB batch size to run. A range can be set from 1 to 24.

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☒ Show model on FlexSim?

Run Simulation

Confirm Simulation

Confirm to run simulation?

There will be 12 simulation run(s).

Warning: The more runs there are, the longer it will take until completion. Previously generated files in the Input and Output folders will be overwritten. Please save and close all opened files on Excel before you click OK.

OK

Cancel

IBIS Simulation

FileHelp

Simulation SettingsRun ParametersFile Directories

Lot Dispatch

Choose the lot sequencing rule(s) for the simulation to run. Please select one or more.

Lot Sequencing Rule(s) to Run:

☒ First-Come-First-Served (Default)☐ Shortest Queue☐ Shortest Distance☐ Shortest Queue + Shortest Distance☐ Random

BIB Batch Size

Choose the allowable minimum BIB batch size to run. A range can be specified.

Lowest Min. Batch Size to Run:

18

Highest Min. Batch Size to Run:

24

Step Size between Runs:

2

Additional Settings

BIB Load on Lot Criteria:

☒ One lot per BIB☐ Multi lots per BIB

Resource Select Criteria:

☐ First Available☒ Shortest Queue☐ Shortest Distance☐ Shortest Queue + Shortest Distance

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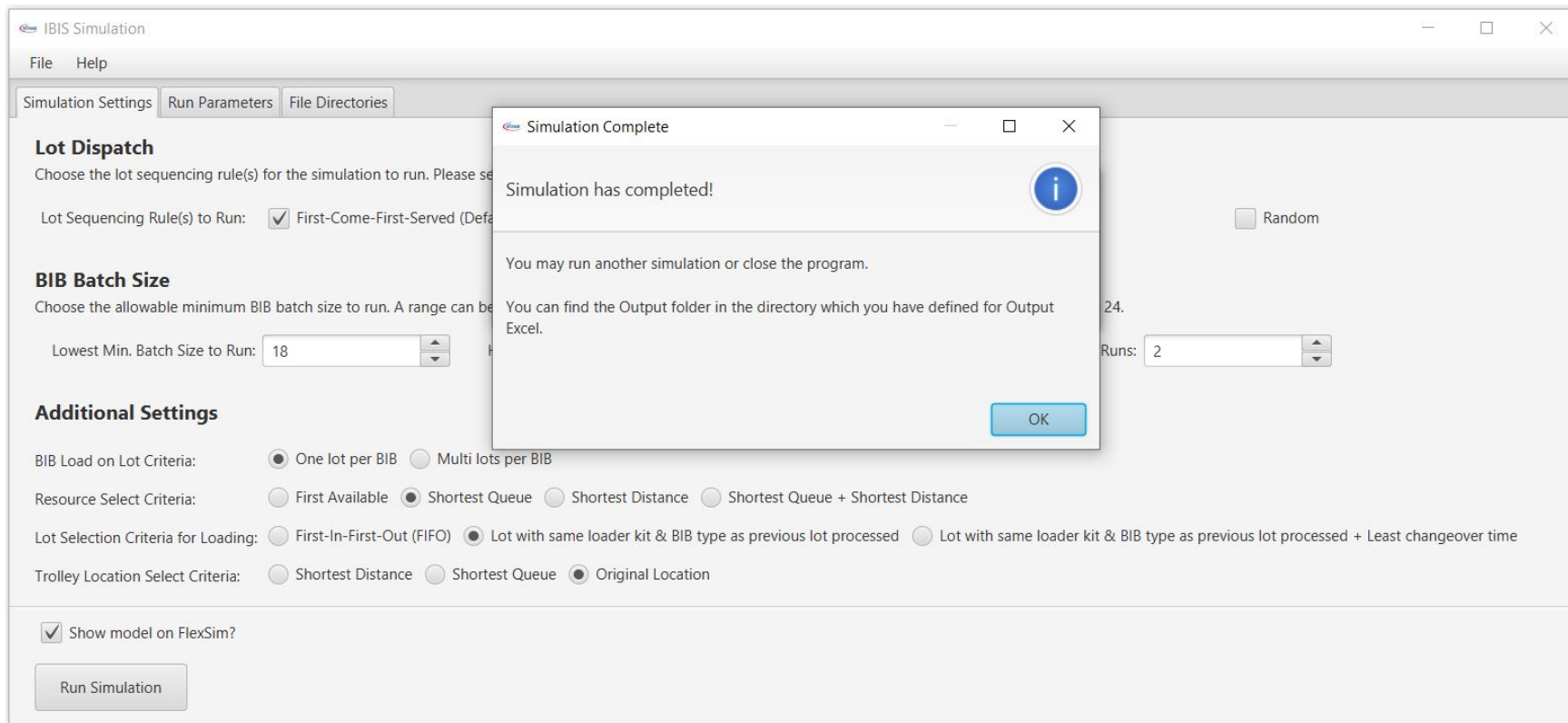
☒ Show model on FlexSim?

Run Simulation

Simulation running... (Please wait...)

Please wait for the simulation to complete...

Please wait for the simulation to complete...



User Interaction Design



- Clean, easy-to-understand interface
 - Only essential information is presented
 - Hover over tooltips if unclear
- Dialog box feedback
 - Provides immediate feedback
 - Allows monitoring of progress
- Input field validation
 - Reduces chance of bugs and errors in run
 - Guides users to make corrections

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☐ Most Jobs

☐ Random

BIB Batch Size

Choose the allowable minimum BIB batch size to run. A range can be run incrementally based on the step size. Maximum BIB batch size for every run is fixed at 24.

Lowest Min. Batch Size to Run:

20

Highest Min. Batch Size to Run:

22

Step Size between Runs:

4

Additional Settings

BIB Load on Lot Criteria:

☒ One lot per BIB

☐ Multi

Resource Select Criteria:

☐ First Available

☒ Shorte

Lot Selection Criteria for Loading:

☐ First-In-First-Out (FIFO)

☒ Shortest Distance

Trolley Location Select Criteria:

☐ Shortest Distance

☐ Sho

☒ Show model on FlexSim?

Run Simulation

Invalid Input

Invalid Input

At least 1 Lot Sequencing Rule must be selected!
Step Size between Runs (BIB Batch Size) cannot exceed 2!

OK

IBIS Simulation

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Help

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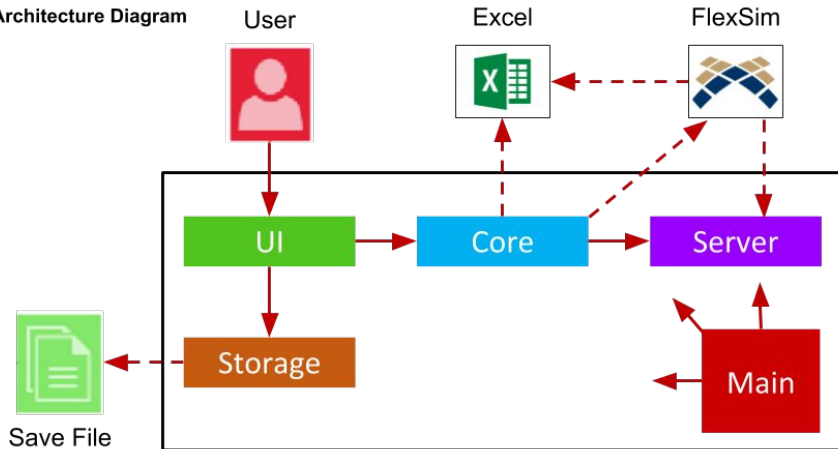
OK

Cancel

Application Implementation

App Implementation (System Architecture)

Architecture Diagram



Main Execution
Sequence Diagram

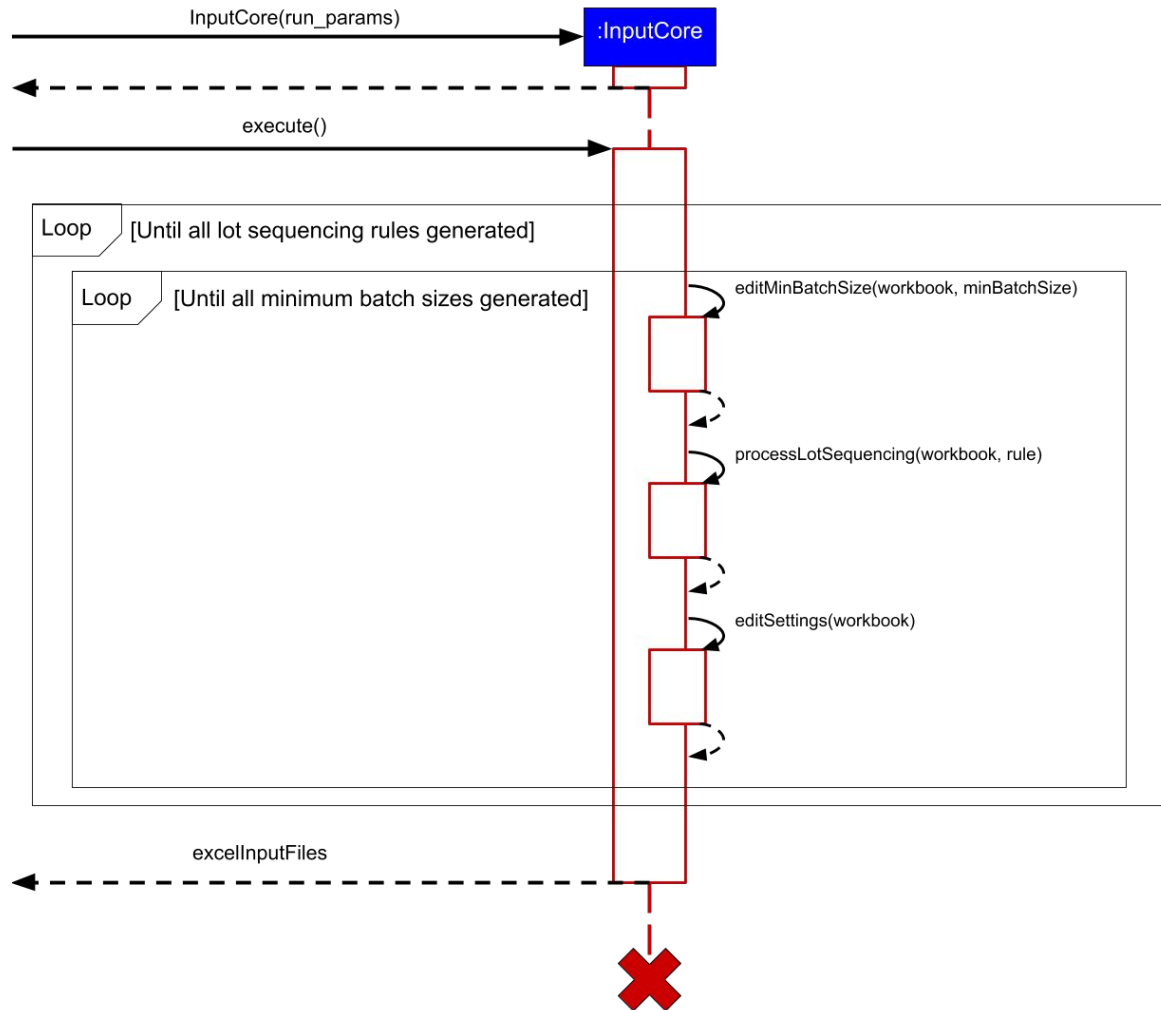


App Implementation (Input Generation)



- Takes in pre-formatted data from the previous step
- Different settings require separate Excel files
- Apache POI - Java API to access Excel
- Automatically generate all Excel files needed for all runs

InputCore Sequence Diagram



App Implementation (FlexSim Interface - Startup)

- Command line startup
 - Allows greater flexibility
 - Enables input of FlexScript
- Executed through Java Runtime class
- User selects mode
- Program automatically generates command

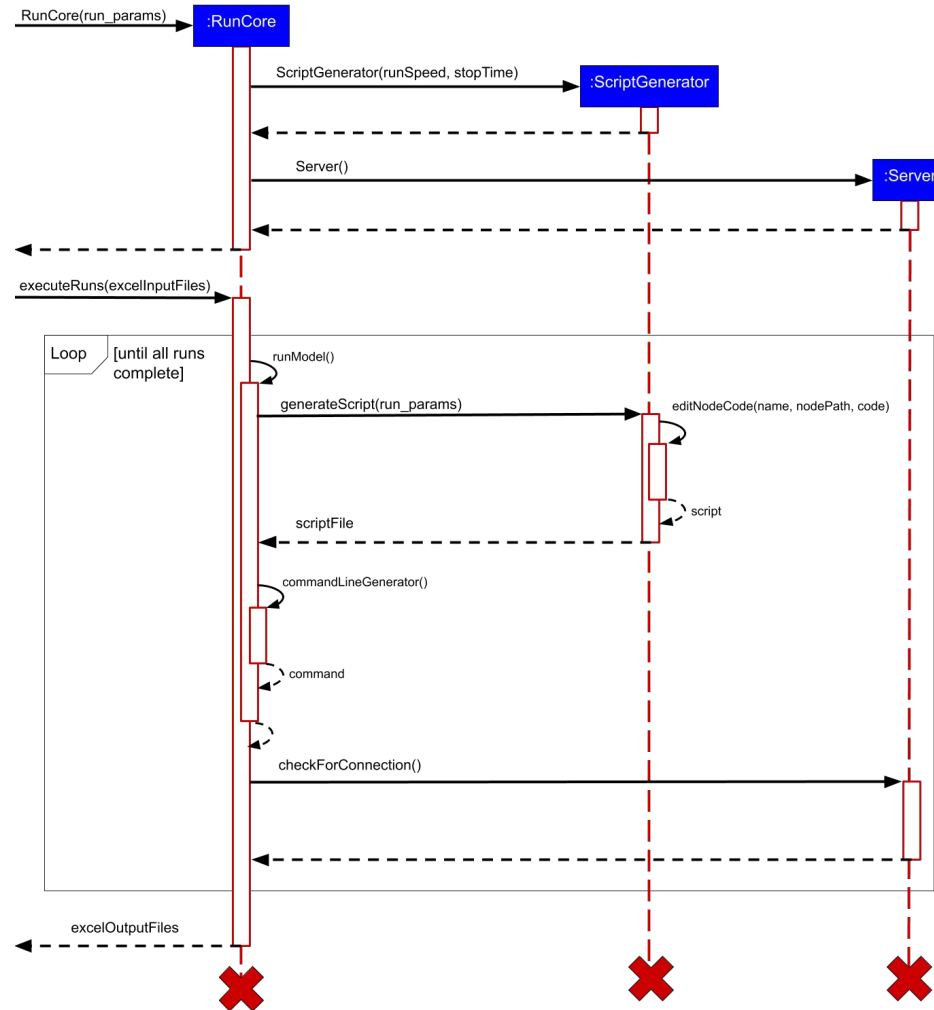
App Implementation (FlexSim Interface - Control)

- Flexscript file run by FlexSim on startup
 - Changes model settings
 - Runs predetermined commands and instructions
 - Replaces code within the model
- Bypasses license restrictions
 - Works for all users free or licensed

App Implementation (FlexSim Control - Communication)

- Communication channel to link application with FlexSim
 - Allows application to monitor FlexSim
 - Informs when to start next run
- Handled through Windows Socket API (WSA)
 - Application creates server, FlexSim creates a client
 - Connected through local network
 - Standardised connection allows easy interfacing

RunCore Sequence Diagram



Design Alternative: Communication

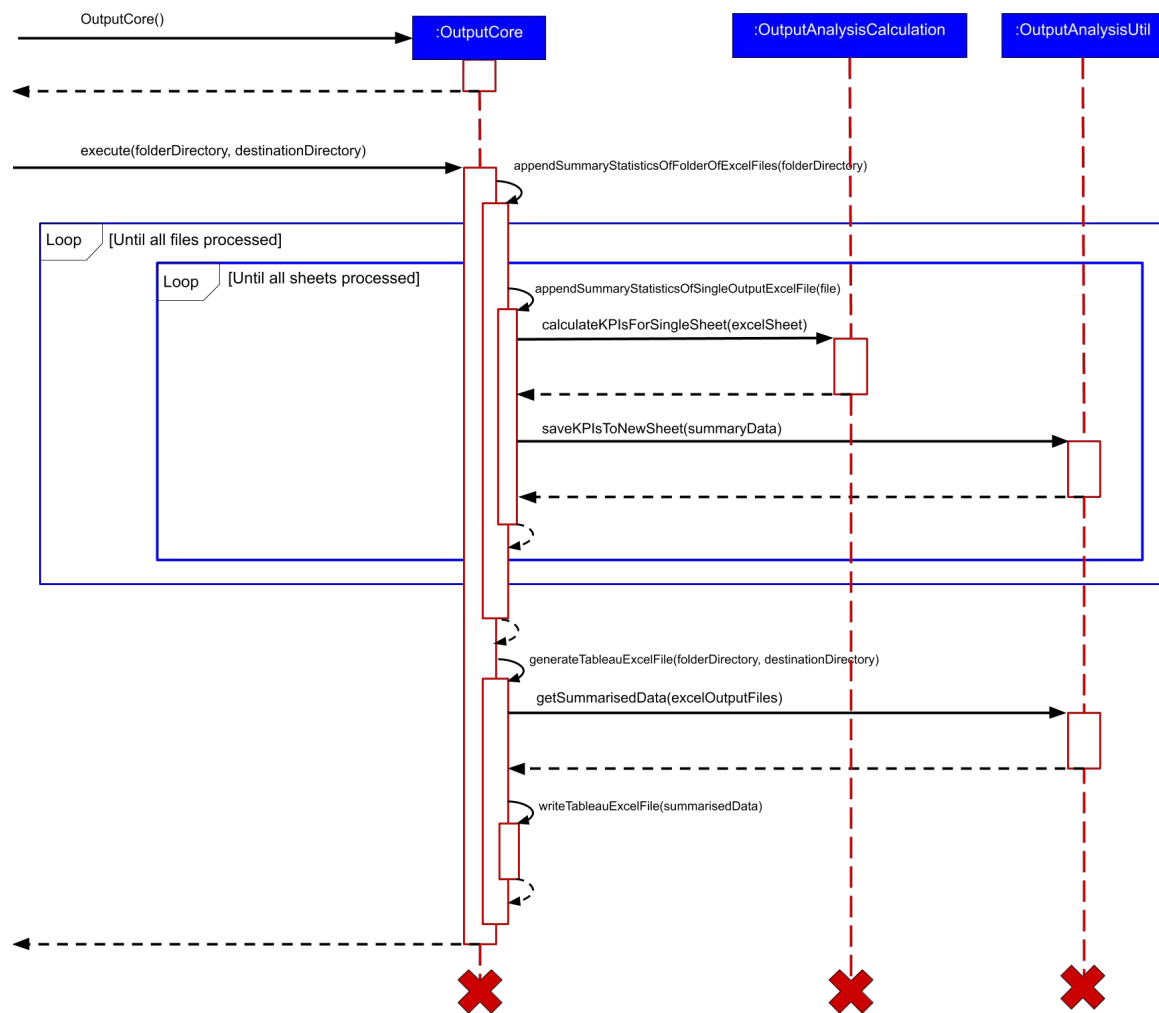
- Three main methods of communication:
 - Microsoft Dynamic Data Exchange (DDE)
 - Microsoft Component Object Model (COM)
 - WSA
- Original plan was to use Microsoft DDE API
 - Communication through an excel sheet intermediary
 - All company computers are guaranteed to have = High compatibility
- High number of crashes and bugs
 - Can be disrupted when a user is actively using Excel
 - Disconnections when too many workbooks are opened
- WSA
 - Most stable connection as it is hidden in background
 - Expected problems with network access, but was discovered to not be an issue

App Implementation (Output Data Processing)



- Excel files with ALL data from the simulation generated at end of a run
 - Extremely complicated
 - Majority is not relevant
- Pre-processing individual runs
 - Key information extracted from each run
- Pre-processing all runs
 - All critical information is collated into a single file
 - Formatted for use in Tableau dashboards

OutputCore Sequence Diagram



Output Analyses

Data Visualisation

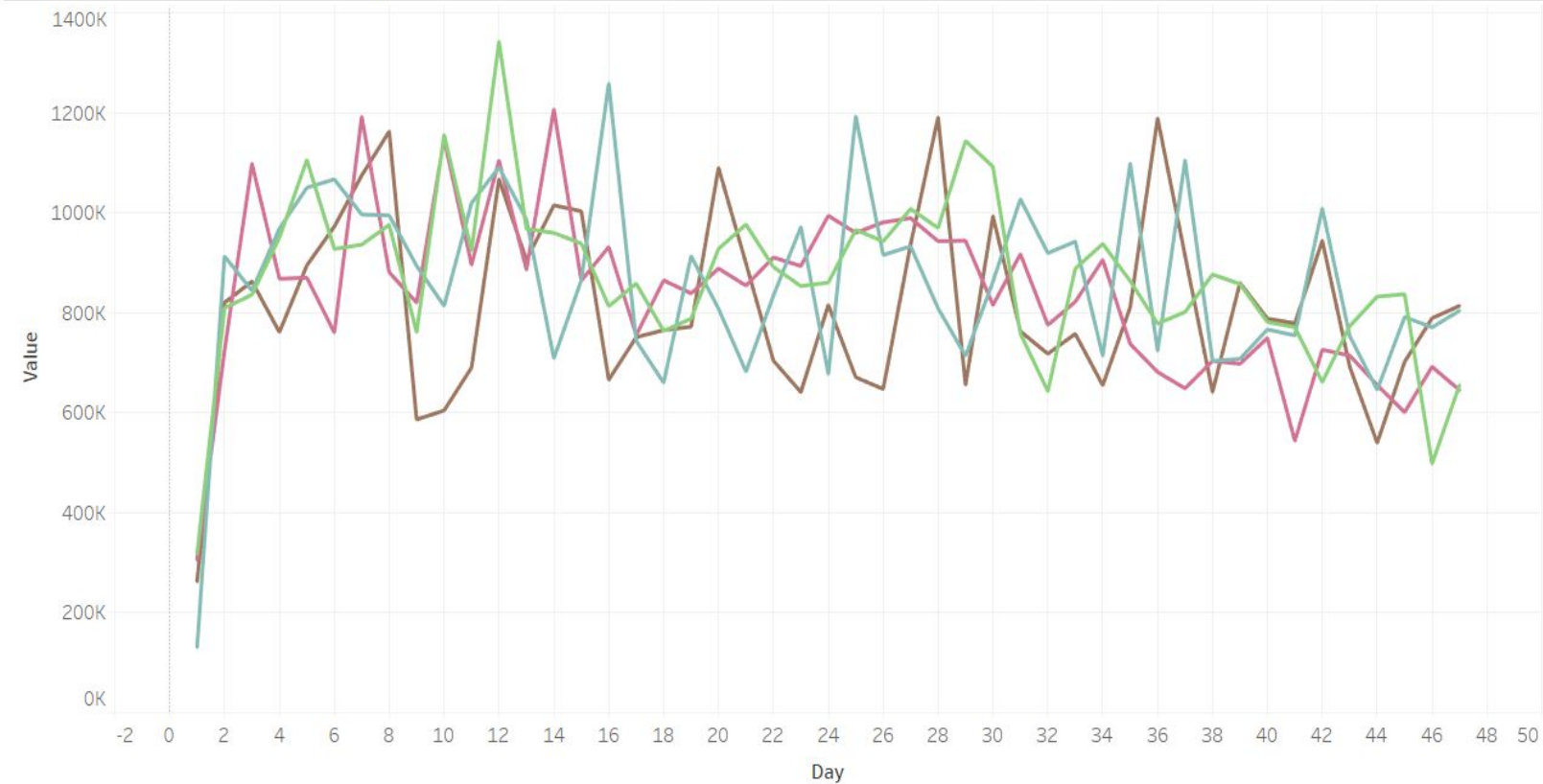


+ a b l e a u[®]

- Using output files of all the simulation runs, a summary Excel file is generated
- Summary Excel file contains the KPI data for all simulation runs
i.e. cycle time, throughput, machine utilisation rate, run worth
- A Tableau dashboard is created, which displays the KPI in a user-friendly format
- Sample data used: 4 runs
 - **Min. Batch Size** \in 24
 - **Lot Sequencing Rules** \in {FIRST-COME FIRST-SERVED, MOST JOBS, RANDOM, SHORTEST PROCESSING TIME}

Data Visualisation

Daily Cumulative Throughput across Run Period



Measure Names

- FCFS_24_min_size_output
- MJ_24_min_size_output
- RAND_24_min_size_output
- SPT_24_min_size_output

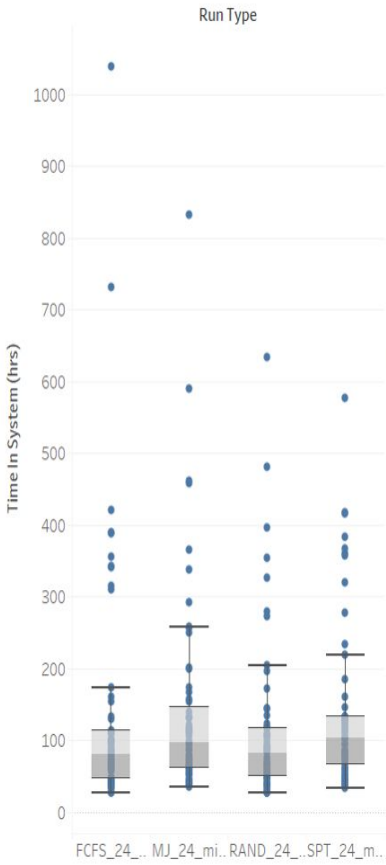
Data Visualisation

Cycle Time

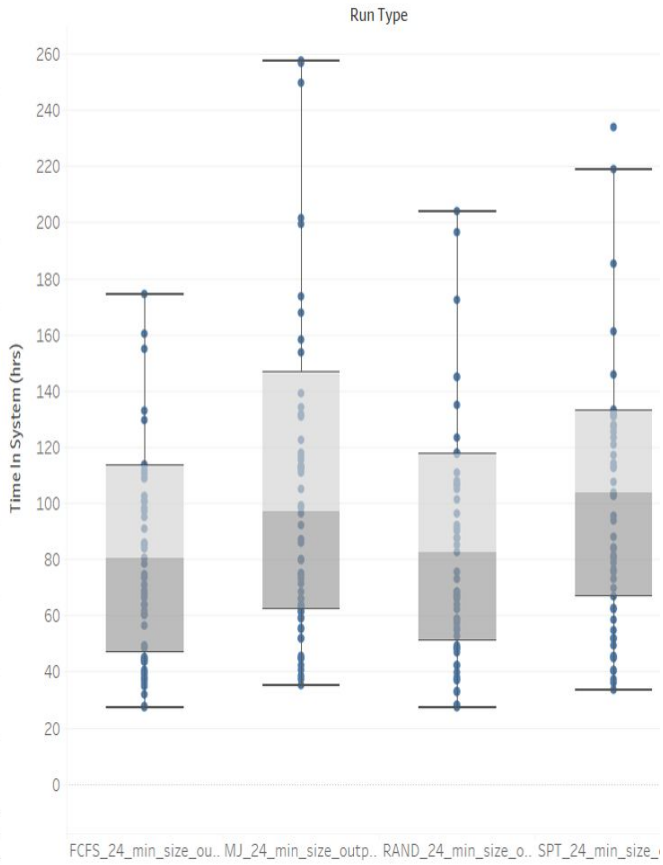
Mean Cycle Time (of All Products)



Cycle Time by Product (Full)



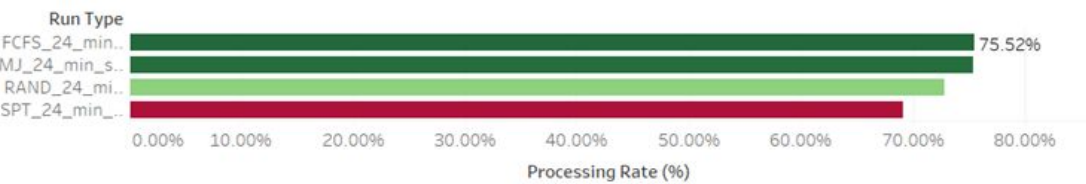
Cycle Time by Product (Focused)



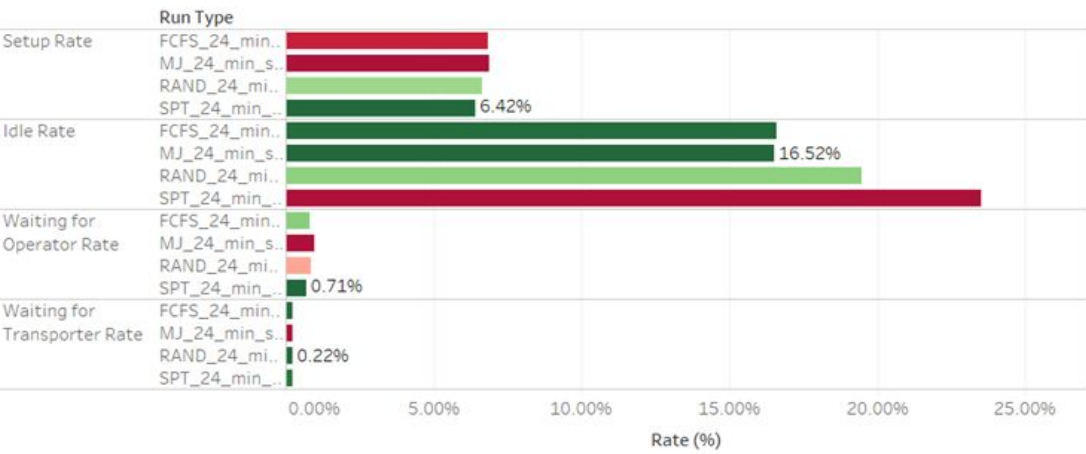
Data Visualisation

OEE

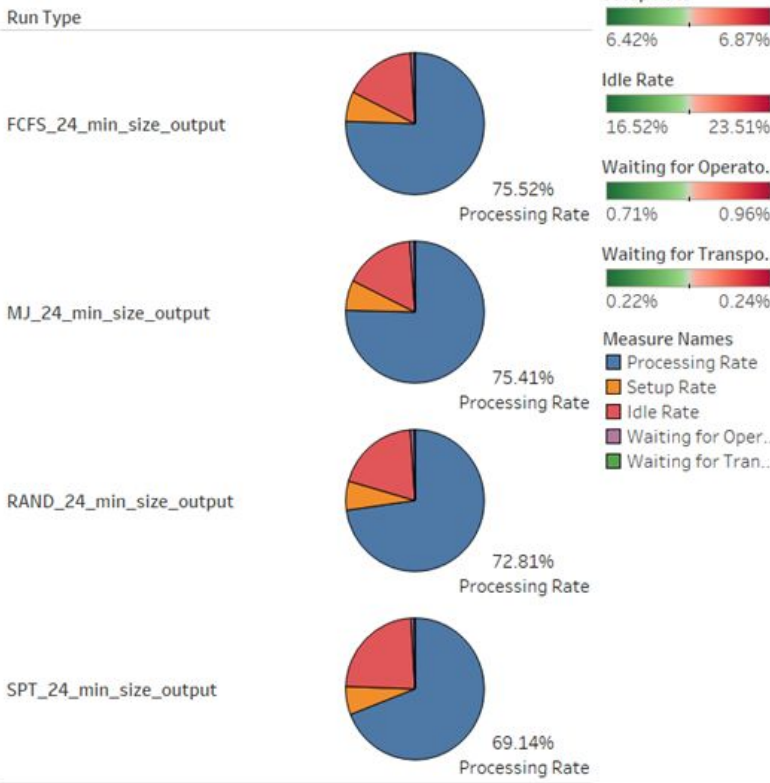
IBIS Oven OEE (Utilisation Rate)



IBIS Oven OEE (Other Rates)



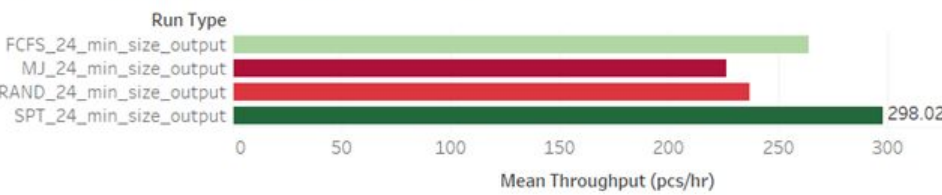
IBIS Oven OEE



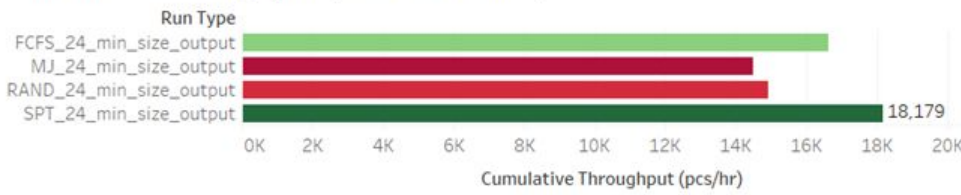
Data Visualisation

Throughput

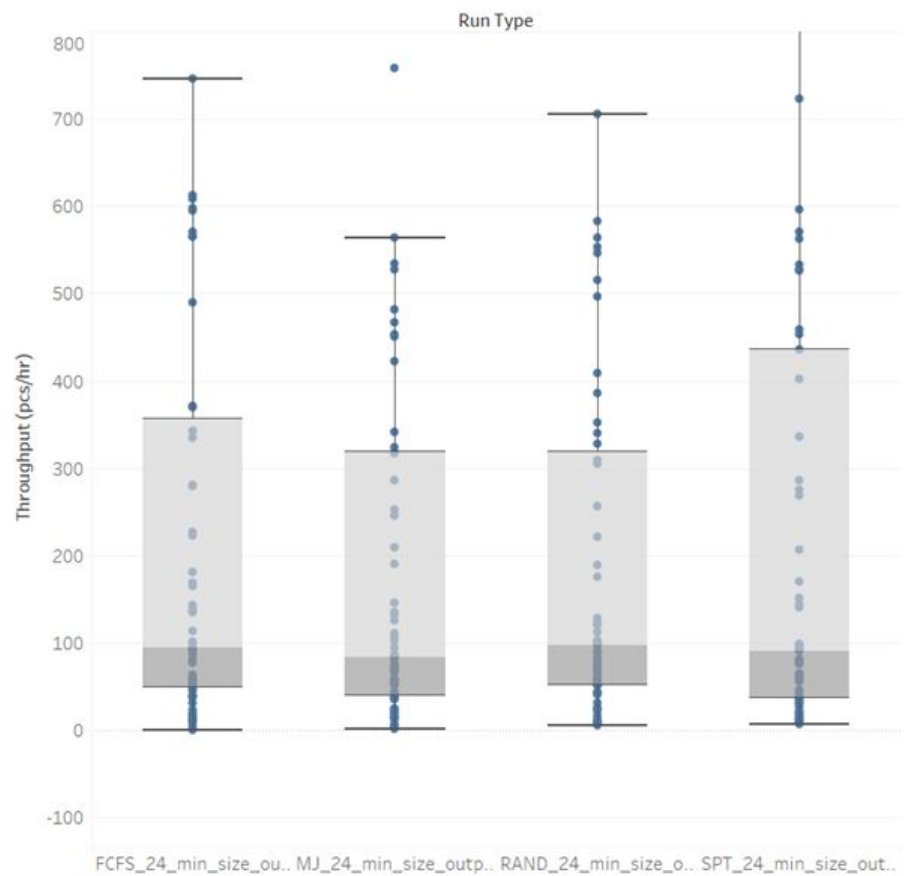
Mean Throughput (of All Products)



Cumulative Throughput (of All Products)



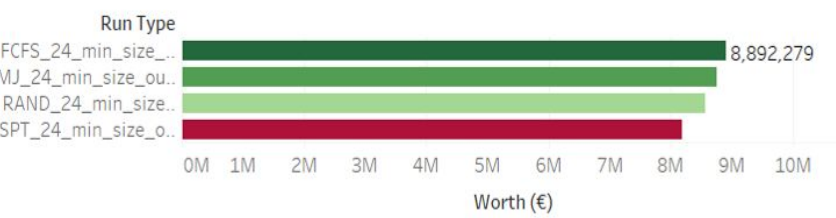
Throughput by Product (Focused)



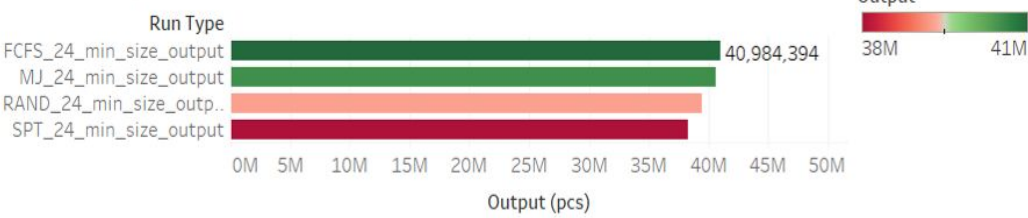
Data Visualisation

Output Worth

Total Worth



Total Output



Acceptance Testing & System Testing

User Acceptance Testing



Infineon Notebook Specifications

- CPU: Intel Core i5-5300U
- RAM: 8GB
- GPU: Intel HD Graphics 5500

Simulation Configuration

- No. of Runs: 2
- Run Speed: 4 hrs/real sec
- Stop Time: 1140 hrs

Testing Outcome

- Application ran smoothly
- Each simulation run took ~ 90 - 100 mins

System Testing & Stress Testing



Desktop Specifications

- CPU: Intel Core i7-4770K
- RAM: 8GB
- GPU: NVIDIA Geforce GTX 1050

Testing Outcome

No. of Runs	Total Time Taken
16	~ 10 hours
28	~ 19 hours

On average, each run took 0.6 hours (36 mins)

Simulation Results from System Testing

Simulation Parameters

Min. Batch Size $\in [18, 24]$

- $n_{\text{Min. Batch Sizes}} = 7$

Lot Sequencing Rules $\in \{\text{FIRST-COME FIRST-SERVED, MOST JOBS, RANDOM, SHORTEST PROCESSING TIME}\}$

- $n_{\text{Lot Sequencing Rules}} = 4$

Total Runs $= 7 \times 4 = 28$

Simulation Results from Varying Batch Size with Lot Sequencing

KPIs	OEE	Cycle Time	Throughput	Worth
Batch Size				
18	RAND	MJ	SPT	RAND
19	MJ	RAND	SPT	SPT
20	FCFS	FCFS	SPT	FCFS
21	RAND	MJ	SPT	FCFS
22	MJ	RAND	SPT	MJ
23	RAND / FCFS	MJ	SPT	FCFS
24	FCFS / MJ	RAND	SPT	FCFS

- For fixed batch size, no rule will dominate every scenario
- Must consider how close the next-best performing run is
- Further analysis must be done

Legend: FCFS: First-Come First-Served
SPT: Shortest Processing Time

RAND: Random
MJ: Most Jobs

Challenges Encountered & Solutions

- Communication problems
 - Originally used DDE and had a lot of crashes
 - Switched to sockets
- Model cannot be controlled easily due to license restrictions
 - FlexScript system

Conclusion



To tackle Infineon's problem of optimising the burn-in process, we designed a three-part decision support system that is centered around their simulation model.

The purpose of the system is to determine the best lot sequence and batch size of incoming lots, making the burn-in process more efficient.

The system also comes with a simple and user-friendly interface that allows anyone to use as well.

Using this system, Infineon is able to reduce cost of the burn-in process and increase their profits.

Recommendations



- Integrate APF with the GUI
- Acquire FlexSim license
- Improve the lot sequencing algorithms
- Include more parameters to be varied
- Adapt the model for other processes

Technology Used



1. **APF Formatter & Activity Manager**
 - ETL Tools
2. **GitHub**
 - Version Control
3. **IntelliJ**
 - Java Integrated Development Environment (IDE)
4. **Apache POI**
 - Java API library to interface with Excel
5. **Windows Socket API**
 - Interface between Java and FlexSim
6. **Microsoft Excel**
 - Data Input and Output
7. **Tableau**
 - Data Visualisation

Skill Sets Acquired



1. Manufacturing Logistics

- a. Experience real world data and scale - complex data sets and highly detailed information
- b. Application of ISE optimisation knowledge - lot sequencing , batch sizes, OEE

2. Data Analysis

- a. Sensitivity Analysis
- b. Data Visualisation

3. Data Management

- a. Extract, Transform, Load (ETL)

4. Software Engineering and Design

- a. Object-Oriented Programming
- b. Multi-Layered Architecture
- c. UX Design

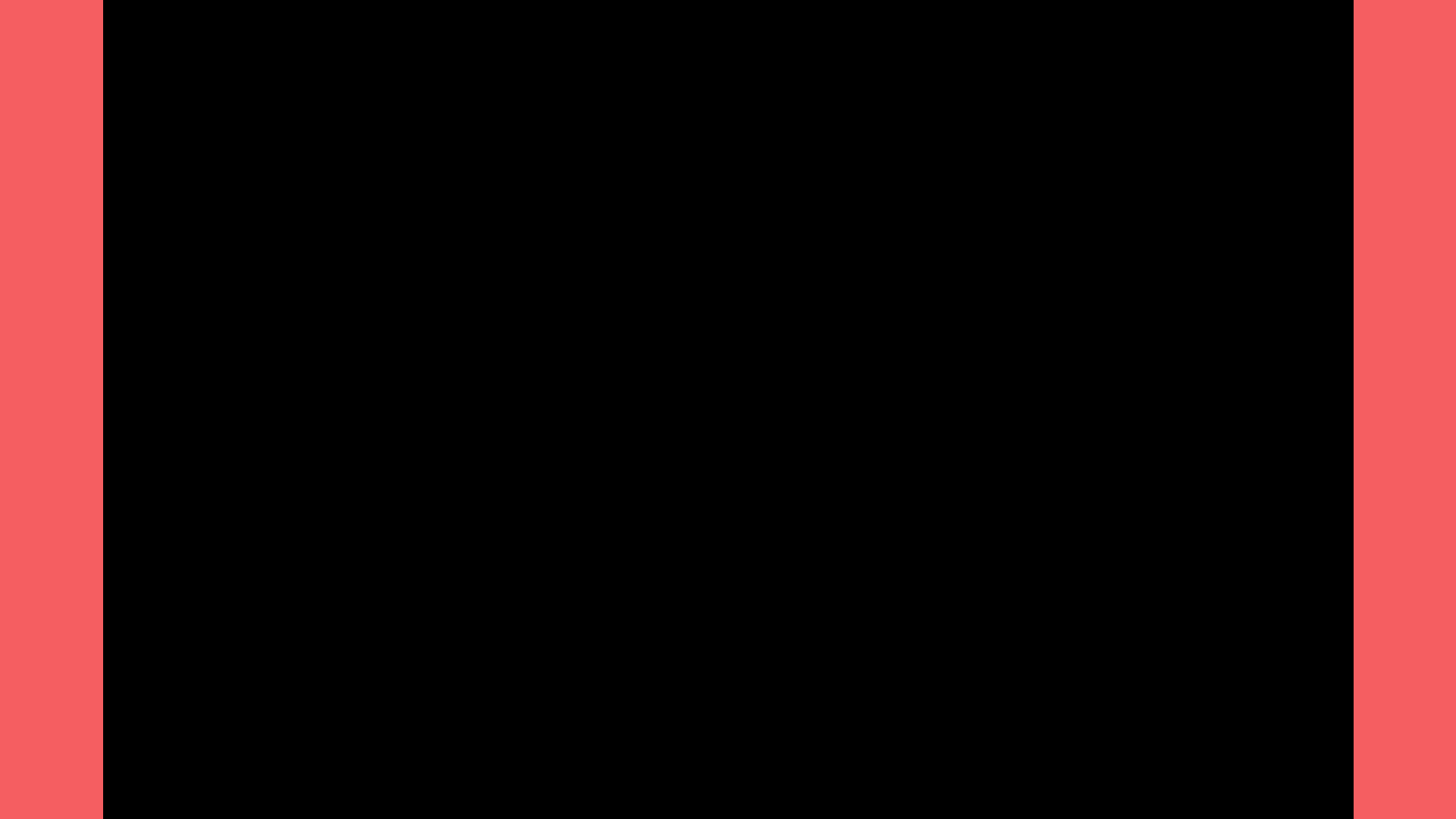
5. Discrete Event Simulation (DES)

- a. Simulation-based Optimisation

Thank you!

Q&A

References



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Trolley Location Select Criteria: ☐ Shortest Distance ☐ Shortest Queue ☒ Original Location

☒ Show model on FlexSim?

Run Simulation

higher the stop time, the greater the time frame for simulation. Note that total real time required is dependent on system performance.

IBIS Simulation

File

Help

Simulation Settings

Run Parameters

File Directories

File Directories

File locations are required for the simulation model to run. For Output Excel, simply create a new empty Excel file in the desired location

File Locations:

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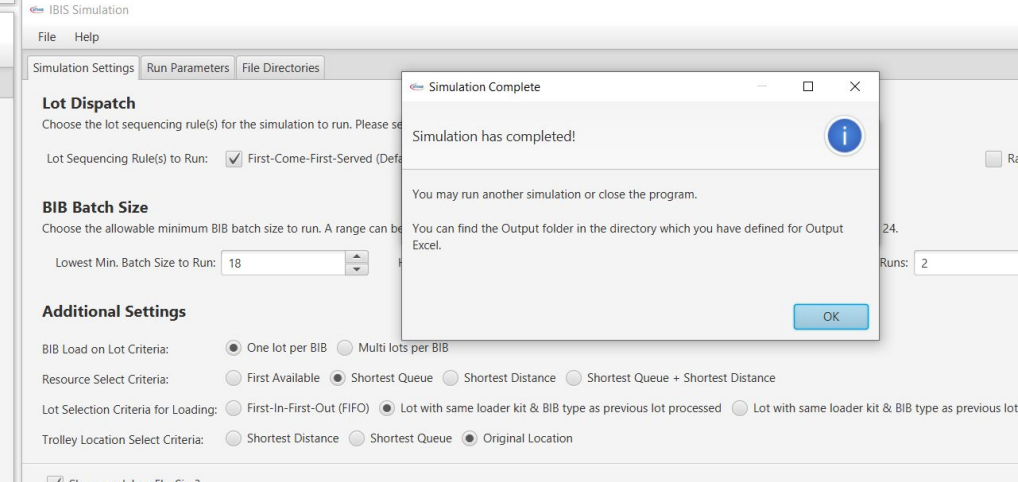
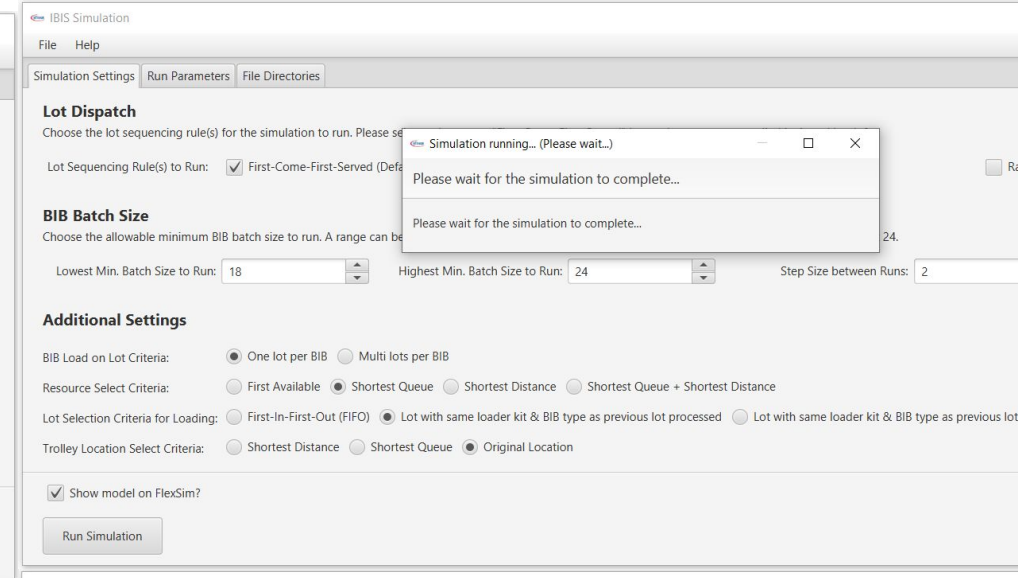
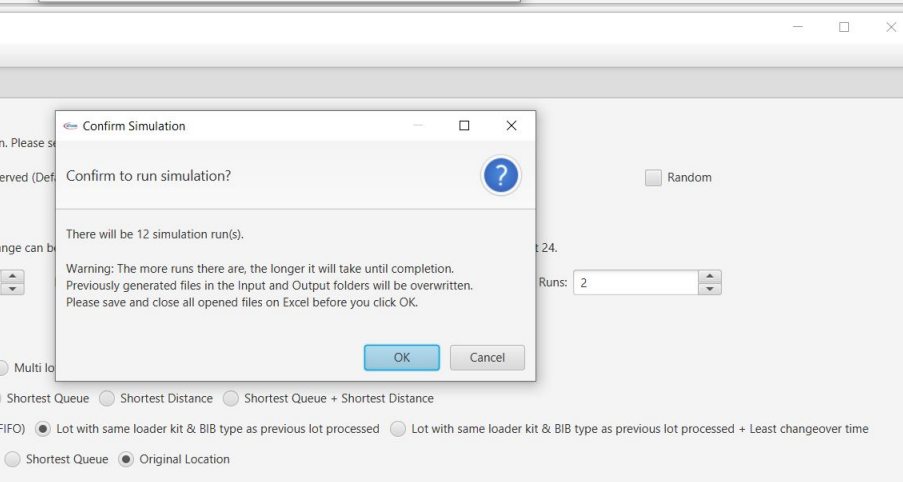
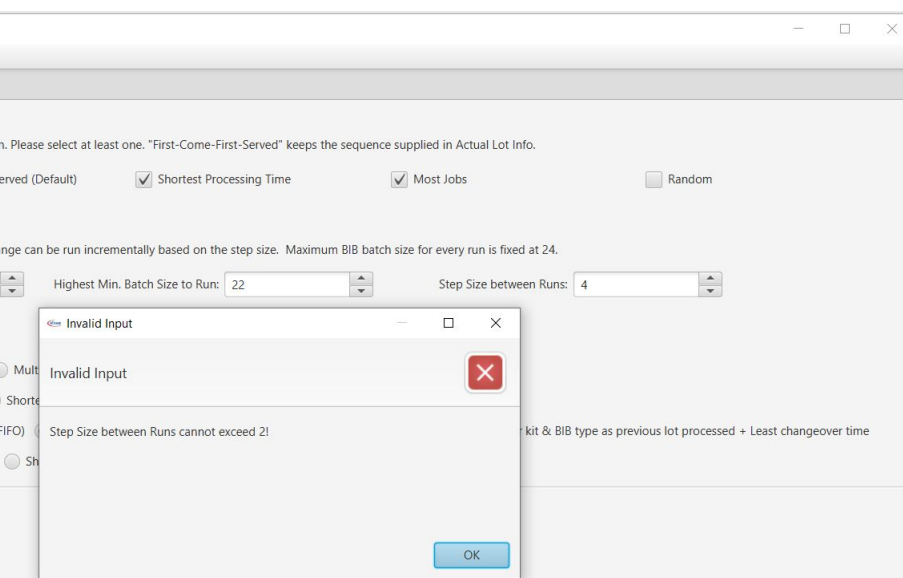
Run Simulation

File Directories

File locations are required for the simulation model to run. For Output Excel, simply create a new empty Excel file in the desired location for the simulation.

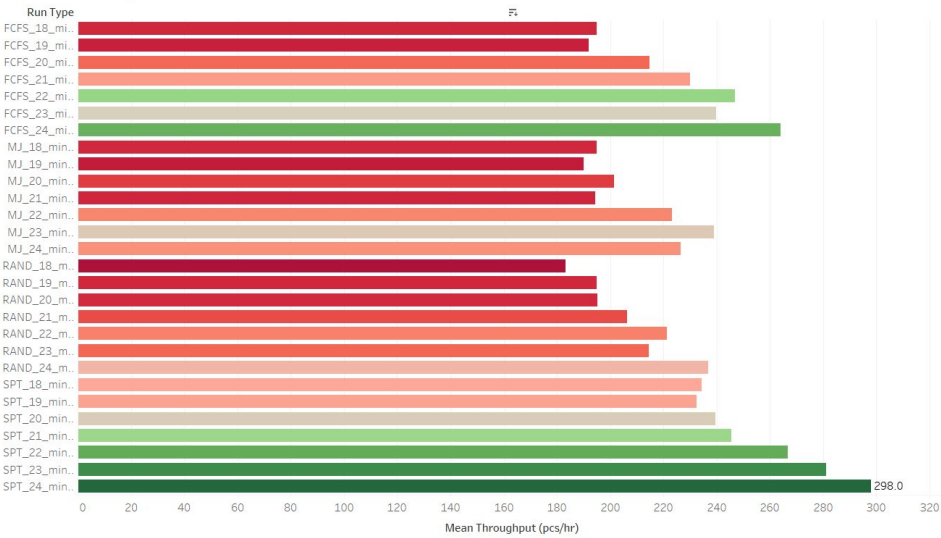
FlexSim (.exe):

Drag here or type in the file address, e.g. C:\Program Files (x86)\FlexSim7.3\program\flexsim.exe

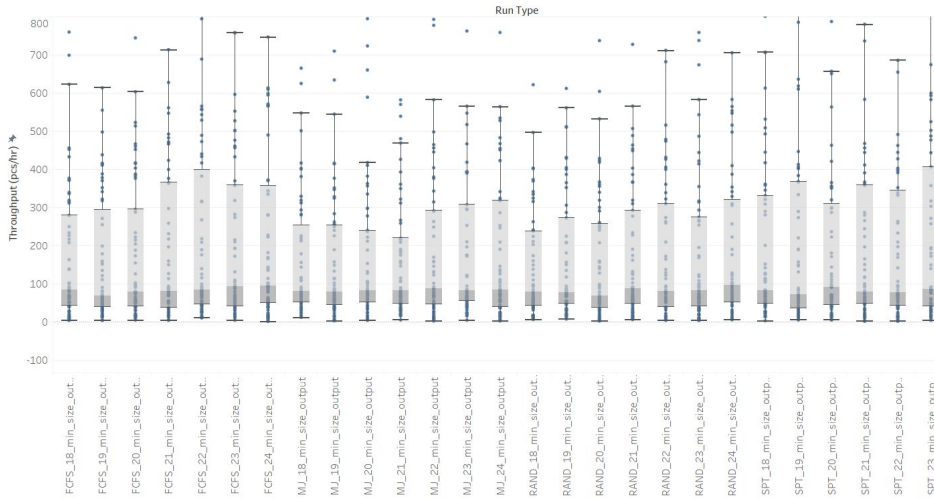


Data Visualisation

Mean Throughput (of All Products)

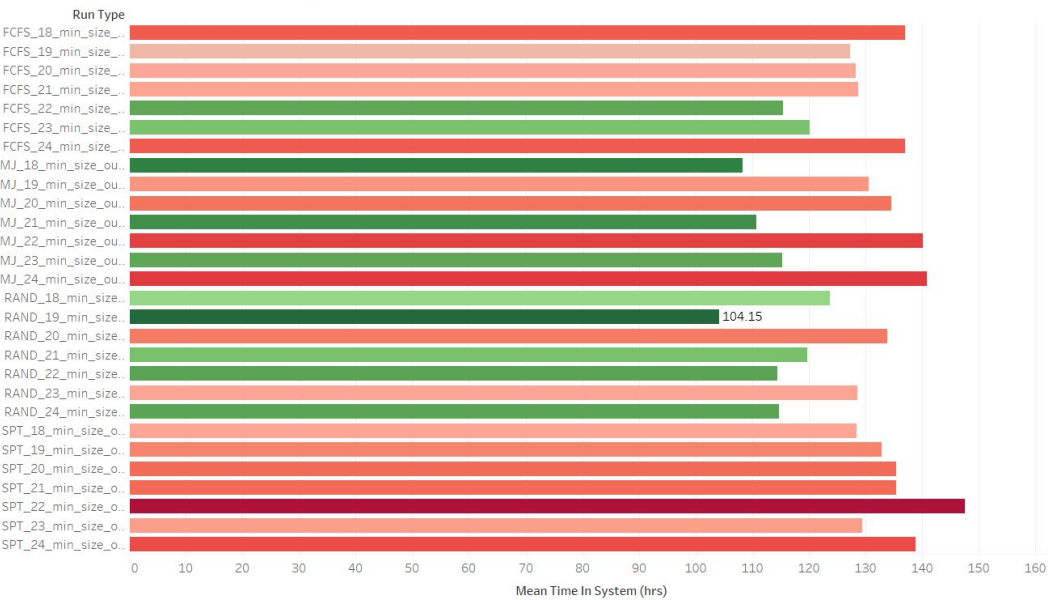


Throughput by Product (Focused)

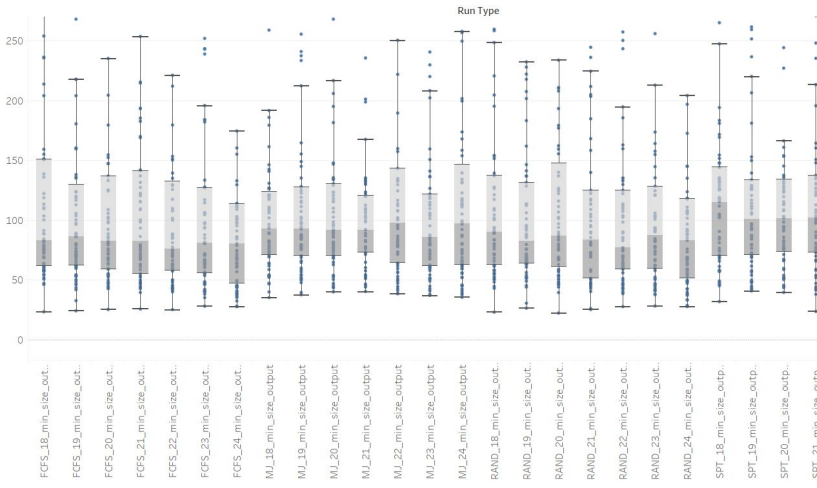


Data Visualisation

Mean Cycle Time (of All Products)



Mean Cycle Time by Product (Focused)



Data Visualisation

IBIS Oven OEE (Utilisation Rate)

