NUS National University of Singapore
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Abbott

IE3100R SYSTEMS DESIGN PROJECT AY2025/2026

Optimization of Canning Lines Through Data-Driven Simulation Modelling

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Project Description

Abbott Singapore is a key manufacturing hub supplying nutritional products, such as Similac *(infant formula)* and Ensure *(adult nutrition shakes)*, to the Asia-Pacific region. To support future demand, Abbott needs a reliable way to **assess their canning line capacity** in five-year horizons.

Hence, a **robust and flexible simulation-based approach** is needed to represent end-to-end line operations accurately, incorporate real-world variability, and support experimentation with different operational and design scenarios.

Objectives

The project aimed to develop a **discrete-event simulation model of the canning lines** using FlexSim software, providing Abbott with a validated analytical tool to **identify throughput constraints** and **assess system sensitivity to key parameters**.

This **strengthens** Abbott's existing modelling approach by improving the reliability of simulation outputs for **scenario analysis, bottleneck evaluation**, and **line sensitivity studies.** It provides a **stronger basis for capacity planning** and **more informed operational and investment decisions.**

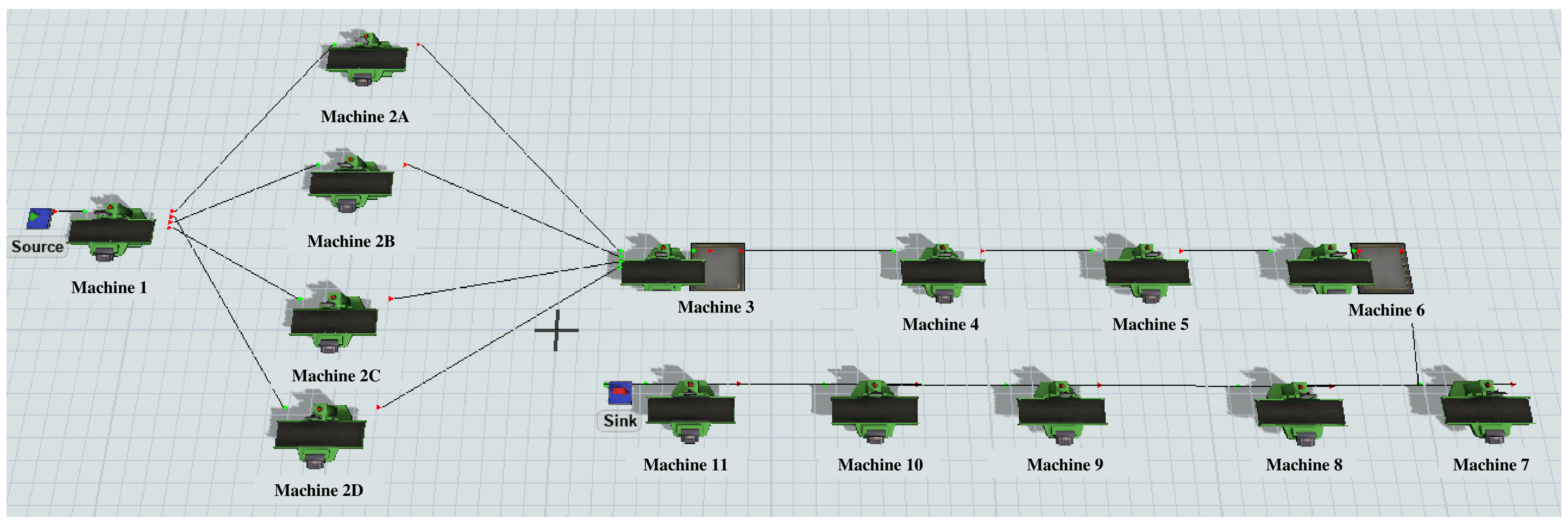
Methodology

The project was carried out in **two phases:**

Phase 1 - Model Building and Verification

Data Wrangling and Automation
Data selection was performed and henceforth cleaned and converted into the appropriate units. An Excel template was also linked to the FlexSim model so that parameter updates were automatically synced to the model.

Probabilistic Modelling
Machine failures and repair times were modelled using TBF *(Time Before Failure)* and TTR *(Time to Repair)* from historical data to obtain empirical distributions to replicate real-world scenarios more accurately.



Model Validation
40 one-month replications of the model were run to verify whether the same bottlenecks were observed when TBF and TTR were included. Machine reliability was also compared against empirical data.

Phase 2 - Experimental Analysis

This phase tested how different modelling assumptions and line changes influence **throughput** and **reliability performances to identify** the most reliable and practical modelling approach.

Fitted vs. Empirical Distributions
Empirical data are often limited or incomplete. Hence, there is a need to evaluate whether fitted statistical distributions can replicate system behaviour as accurately as empirical data.

Data Bucketing
Large datasets may increase model complexity. Hence, data bucketing was performed to determine the appropriate data resolution required to preserve system behaviour.

Data Size Sensitivity
Maintaining a large dataset may not always be practical. Hence, there is a need to evaluate whether smaller datasets are sufficient for reliable simulation results.

Speed Sensitivity
According to the Theory of Constraints, bottleneck machines limit production line throughput due to block and idle. Hence, increasing it's speed may improve throughput.
Bottleneck machine is the lowest Effective Capacity (Speed * Reliability)

Accumulator Size Modification
Accumulators act as temporary storage for cans before they move to the next machine. Hence, different storage capacities of the accumulators were evaluated to observe their impact and diminishing results.

Outcomes & Impacts

Empirical vs. Fitted Distributions
Empirical distributions gave the closest match to actual system behaviour, as they are based directly on observed data. Nevertheless, fitted distributions may become more representative as data availability improves. The **Weibull distribution** was found to best capture system variability in terms of both reliability and throughput among the fitted distributions.

Data Bucketing
Results showed a trade-off between reliability and throughput, with **20 buckets providing a closer reliability** match and **50 buckets providing a closer throughput** match.

Data Size Sensitivity
Comparing the 1-month and 2-month datasets against the full dataset, 99mm worsened in both reliability and throughput measures, 127mm improved in both, while 153mm showed better reliability fit but worse throughput fit. This suggests that each can size is affected by **different bottleneck losses and line interactions**, so more study with a **larger dataset** is needed before drawing stronger conclusions.

Speed Sensitivity
Increasing Bottleneck machine's speed by 10%, 20%, and 30% caused it to have increased Downtime. As a result, the upstream machines got blocked more often. Consequently, overall **throughput dropped**, **blocked time increased**, **idle time decreased** across the line.

Accumulator Size Modification
Increasing accumulator size improved throughput across **all** can sizes, with +100% configuration giving the **highest gain** but only **limited improvement over +50%**. Hence, a **+50% increase** is more beneficial with lower risk of over-investing.

Overall, the findings show that reliable canning line modelling **depends on detailed empirical data**, while **bottlenecks can shift under different scenarios** as machine speed, reliability, and buffer space all **affect one another**. Hence, decisions based on **one machine alone may not reflect actual line behaviour**. In addition, throughput is better improved through practical line adjustments such as **moderate** buffer increases. This provides Abbott with a stronger basis for capacity planning and investment decisions.

Future Direction

Immediate Actions

Adopt System-Based Experimentation
Move from machine-based testing to combined scenario analysis across speed, reliability, and buffering settings.

Longer-Term Developments

Analyze Dependencies
Investigate correlations between TBF and TTR, and across machines to improve system-level accuracy.

Optimise Speed Balancing
Use algorithms to balance machine speeds, cost, and maximize throughput.

Integrate Cost Modelling
Link throughput, downtime, and maintenance to operating costs for direct capital investment evaluation.

Acquired Skills

- Modelling Simulation
- Data Analytics and Statistical Modelling
- Operations and Systems Engineering