# SMART INVENTORY MANAGEMENT & OPTIMIZATION (SIMO)

Project S34 Review 2

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

SIA ENGINEERING COMPANY

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# Company Background[1]

- Singapore Airlines Engineering Company (SIAEC) is Asia's foremost maintenance, repair and overhaul (MRO) provider
- Delivers integrated solutions to large client bases consisting of both international airline and aerospace companies.
- Provides frontline maintenance services to more than 60 airlines* that fly through Singapore whilst ensuring a high level of punctuality for their customers' flight takeoffs.

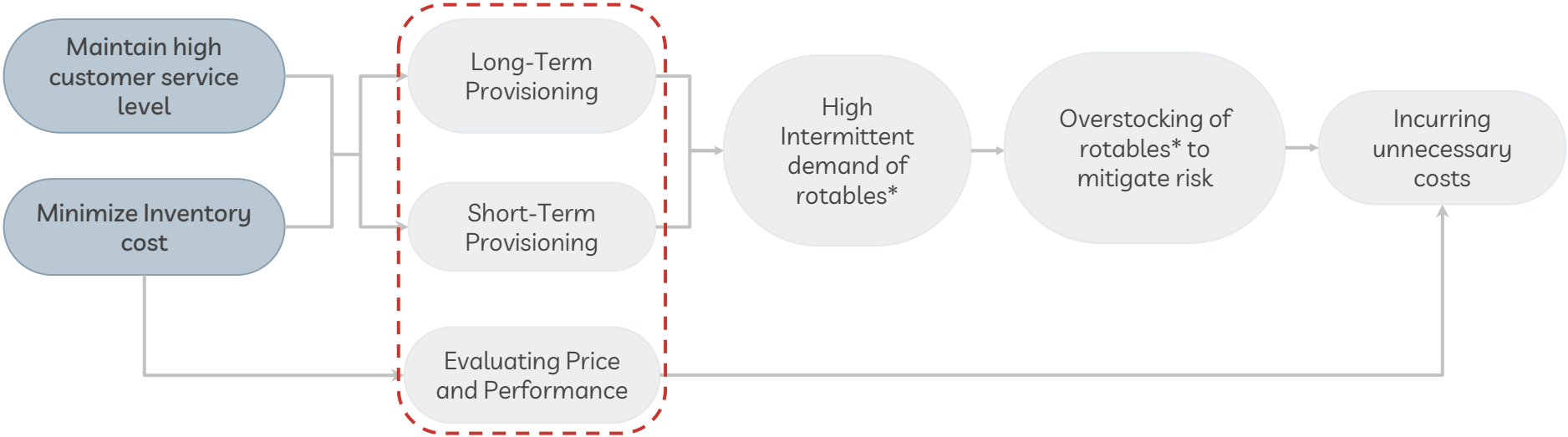
*Some companies include Singapore Airlines, SilkAir and TigerAir

# Problem Framing

Despite efforts by SIAEC in deploying inventory management practices, the company ***still overprovision rotables***, incurring ***unnecessary capital***. The underlying causes of this overprovisioning include ***inefficient inventory management practices***, ***forecasting techniques***, and ***inflexible interface for managing inventory***.

# Problem Analysis

## Goals for SIAEC

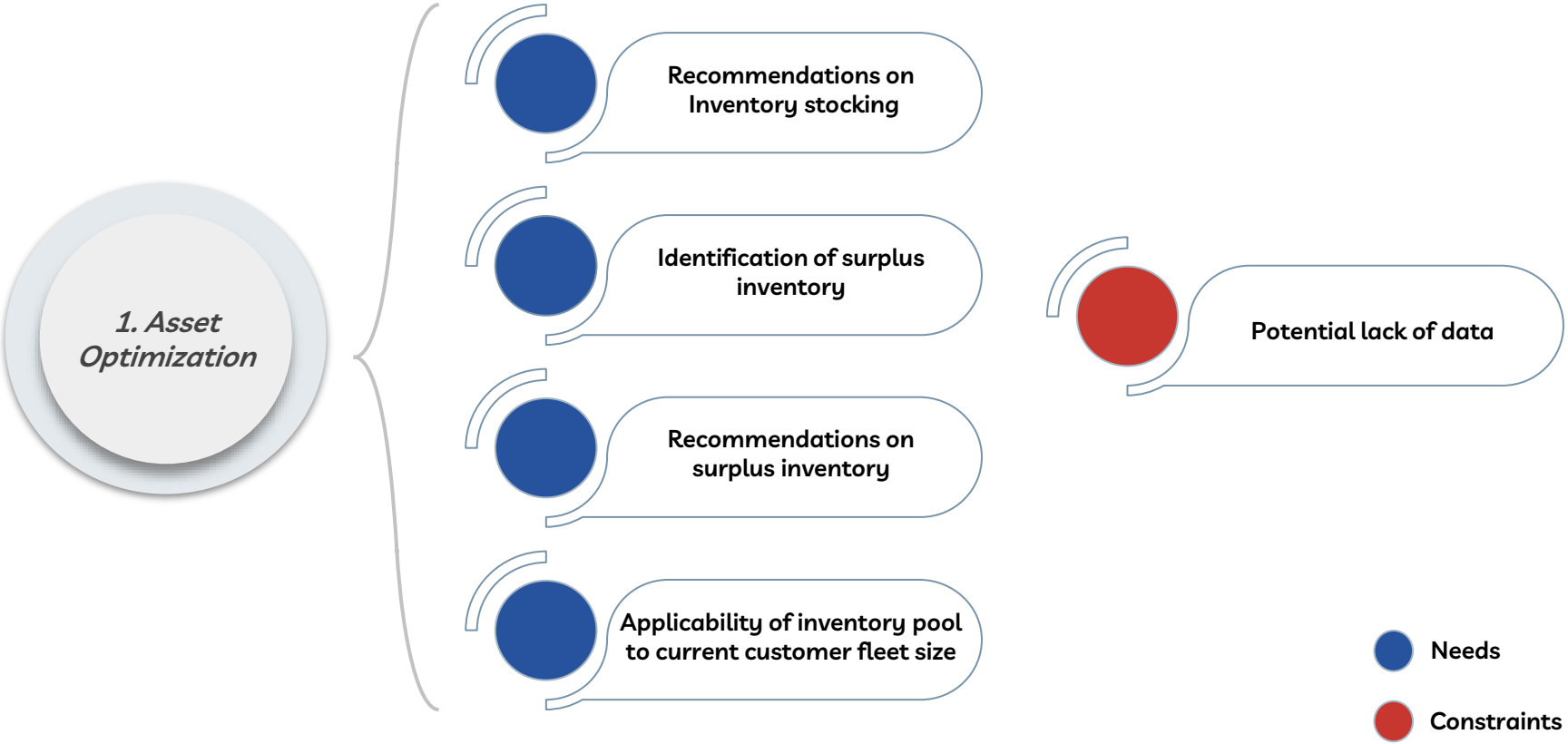



*Rotables are aircraft components which are removed, replace or inspected at intervals and they consist a significant percentage in a typical commercial aircraft.

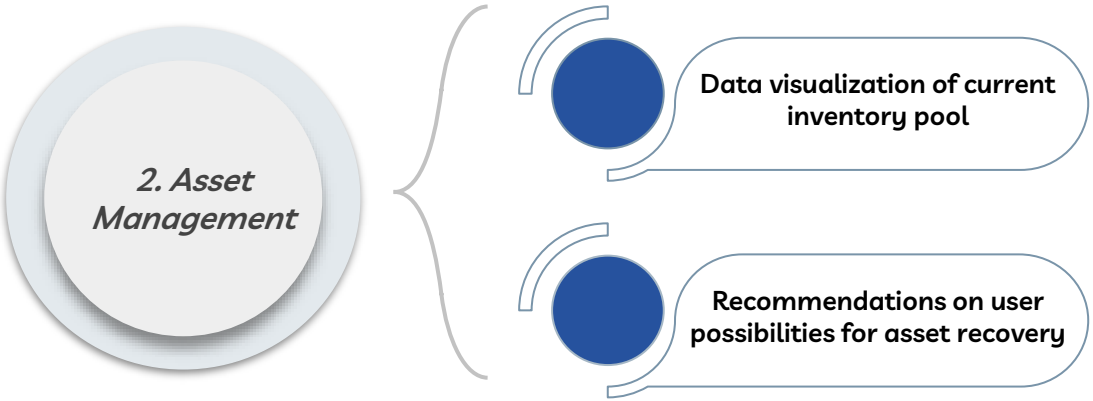
# Milestone


1. Asset Optimization
2. Asset Management
3. Just In Time Provisioning
4. Price Monitoring with Performance Measure

# User Needs & Constraints



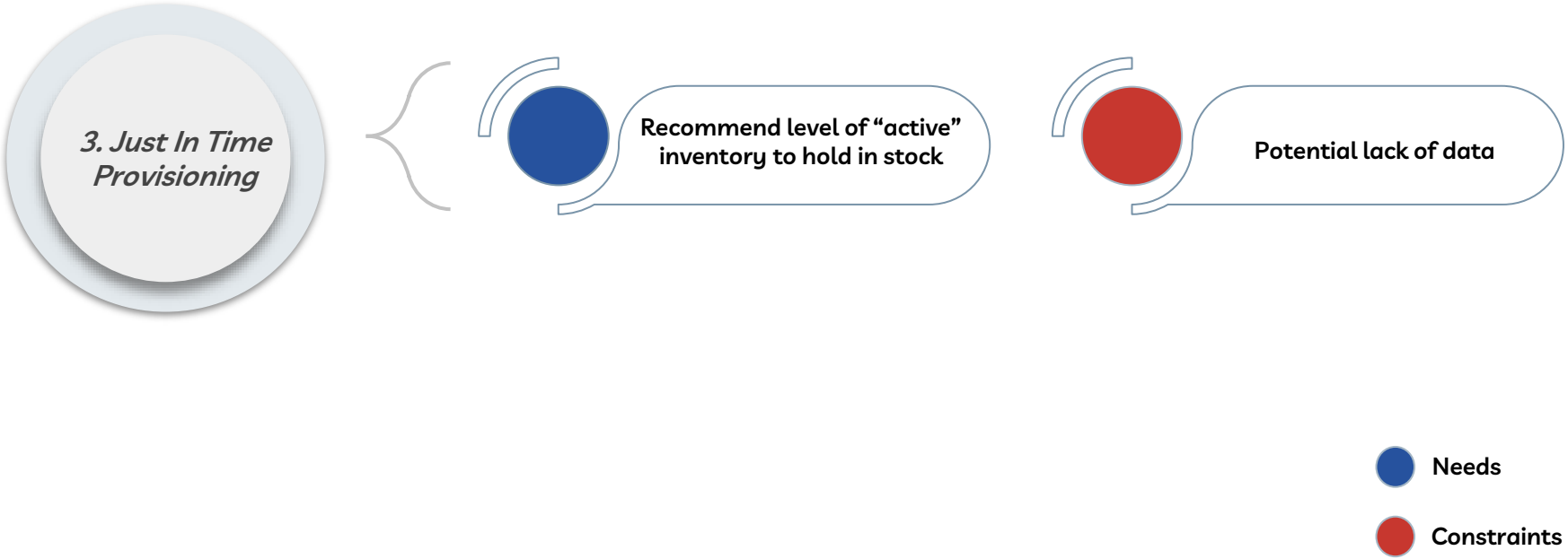
# User Needs & Constraints




Needs

Constraints

# User Needs & Constraints



# User Needs & Constraints


Needs

Constraints

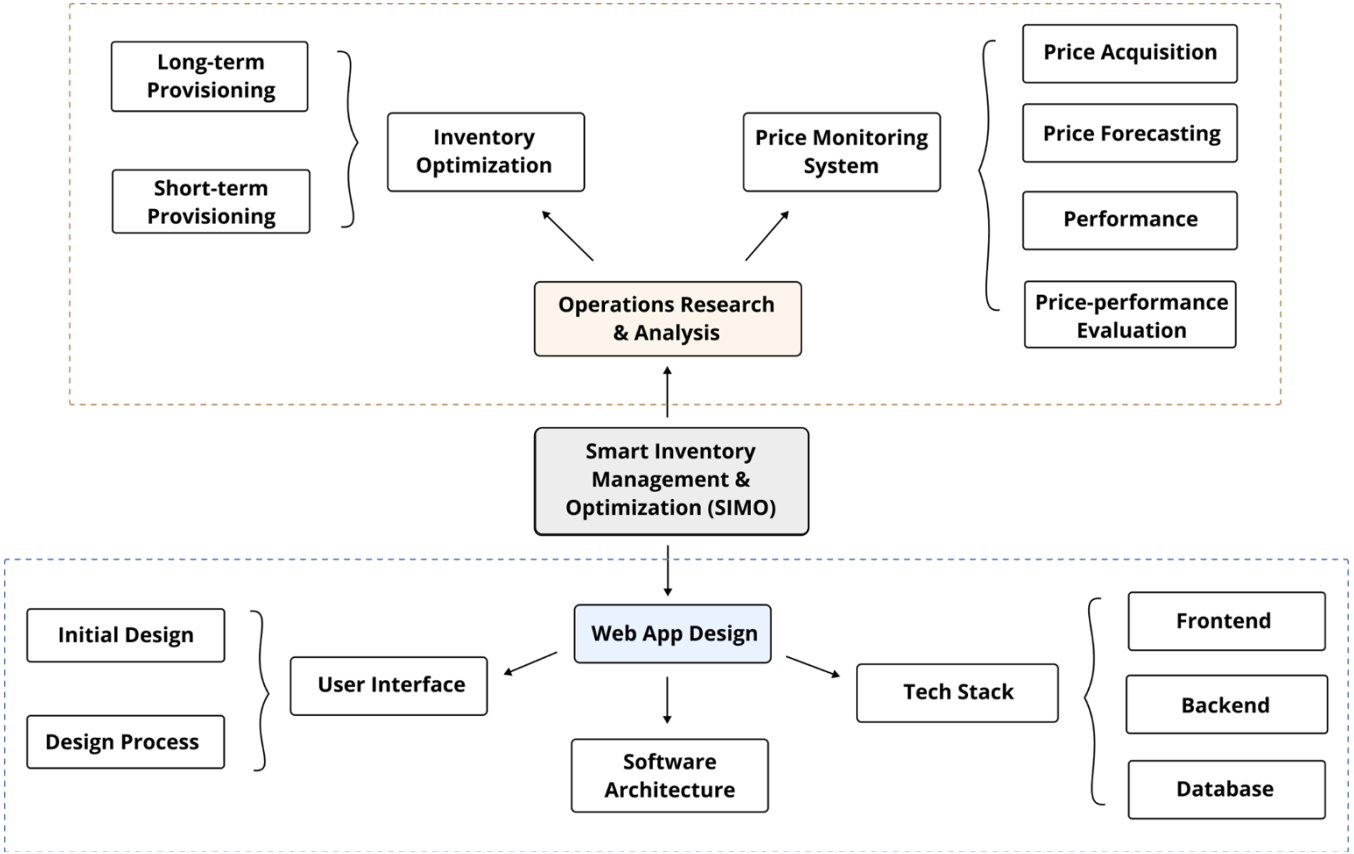
# Refined Problem Statement

This project aims to **create a web-based application** with dynamic features such as having **variable inputs**, **scenario-based optimization** and **data visualization** to help manage and optimize rotables in hopes of a more **user-friendly and cost-saving alternative** for the company to fit into their current workflow.

# Design Direction

**Concept Generation**
**Optimizations Research & Analysis**
**Web Application Design**

# Concept Generation

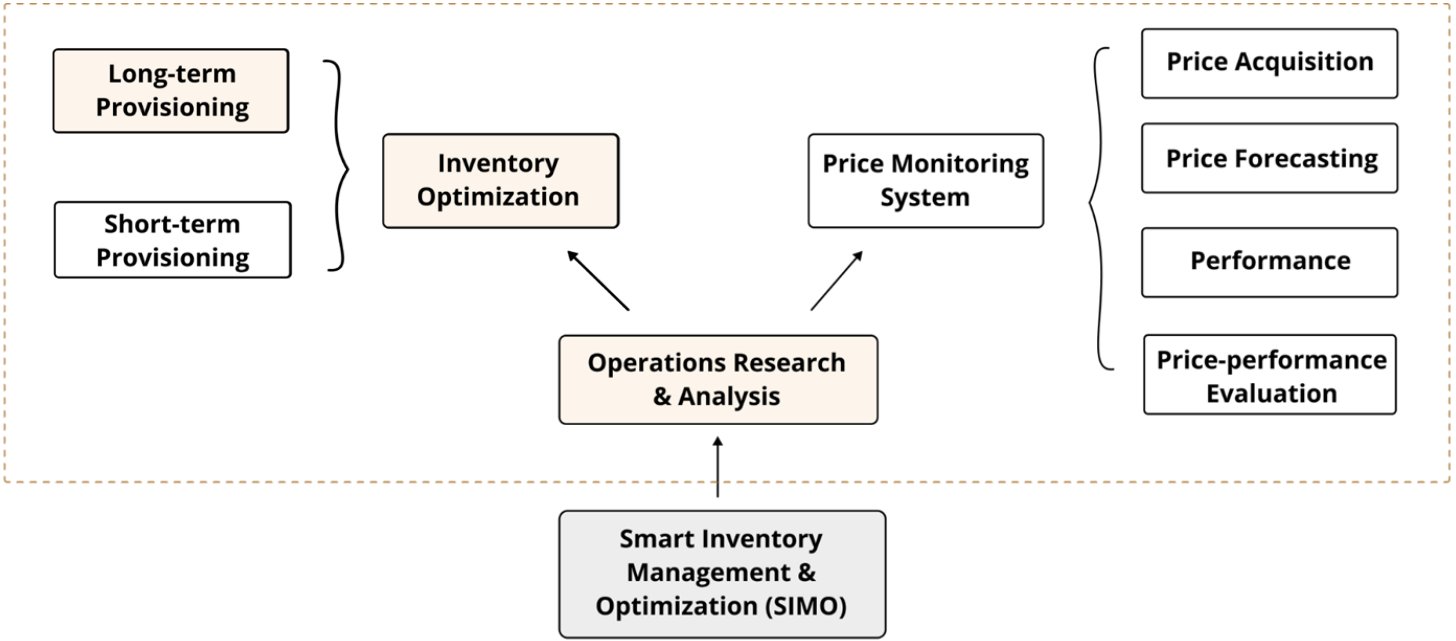


# Operations Research & Analysis

**Inventory Optimization**
Long-term Provisioning
Short-term Provisioning

**Price Monitoring System**
Price Acquisition
Performance
Price-performance Evaluation

# Long-term Provisioning



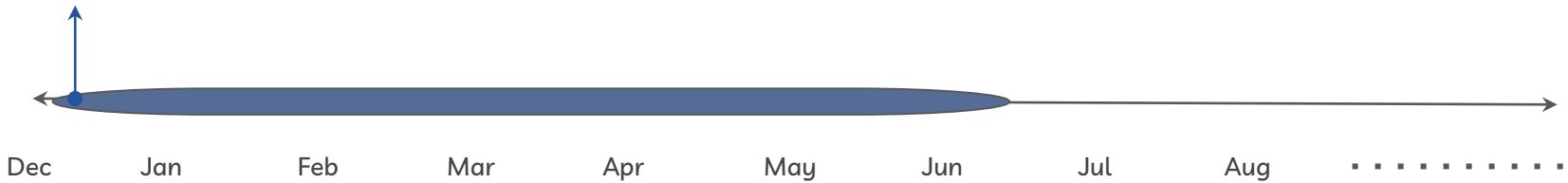
# Milestone


1. Asset Optimization
2. Asset Management
3. Just In Time Provisioning
4. Price Monitoring and Vendors Performance Measure

# Milestone (Long-term Provisioning)

# Long-Term Provisioning

**Determine Number of Quantity to be topped up 6 months in advance for each type of rotable**

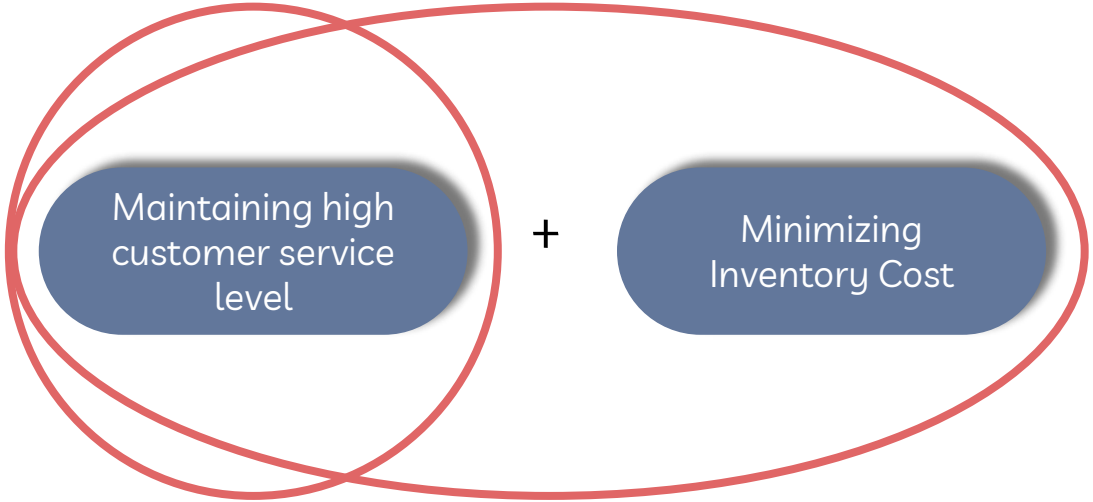


# Long-Term Provisioning

SIAEC current focus!

Our solution aims to . .

**GOALS:**



# Long-term Provisioning

## Approach A

Optimization model

## Approach B

Improving Accuracy & Quality of Input Data


## Approach C

Statistical Distribution of Demand

# Long-term Provisioning

## Approach A

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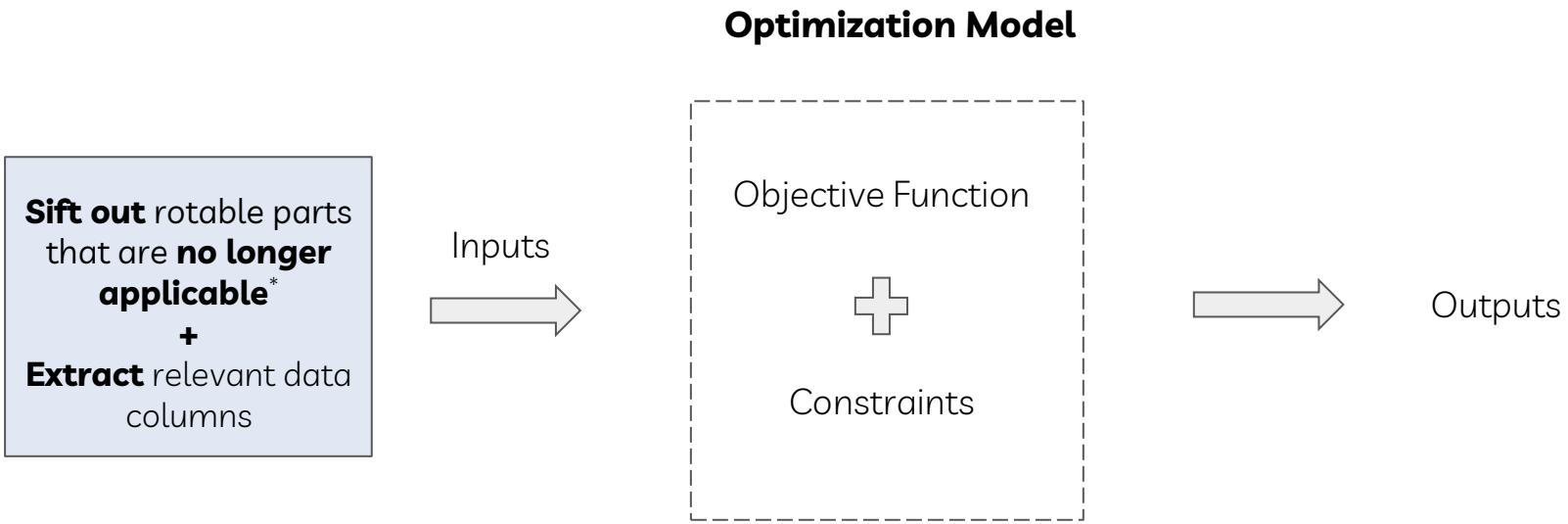
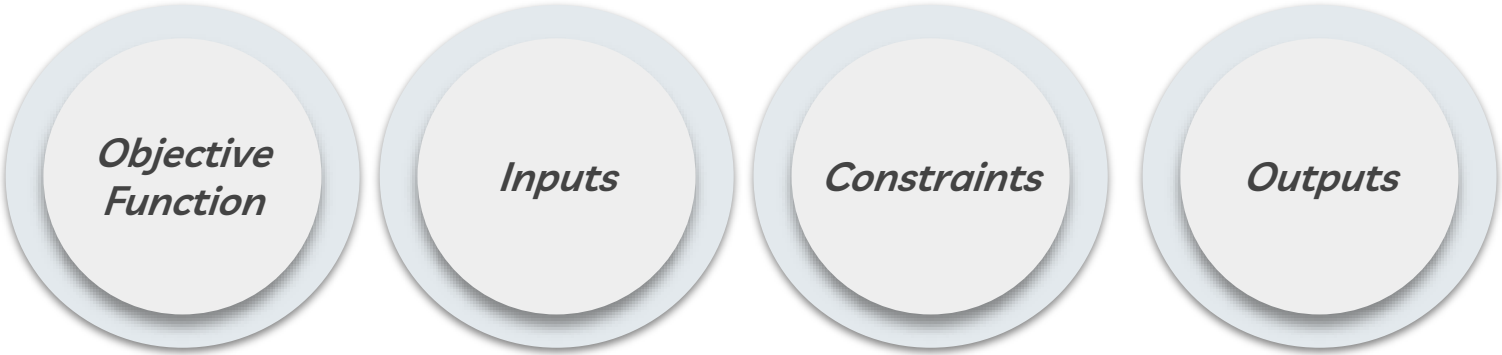
# Long-term Provisioning




* Applicable: Non-applicable rotable parts are parts that are no longer part of the contractual agreement between SIAEC and their customers hence, SIAEC will not need to provide for these parts to customer

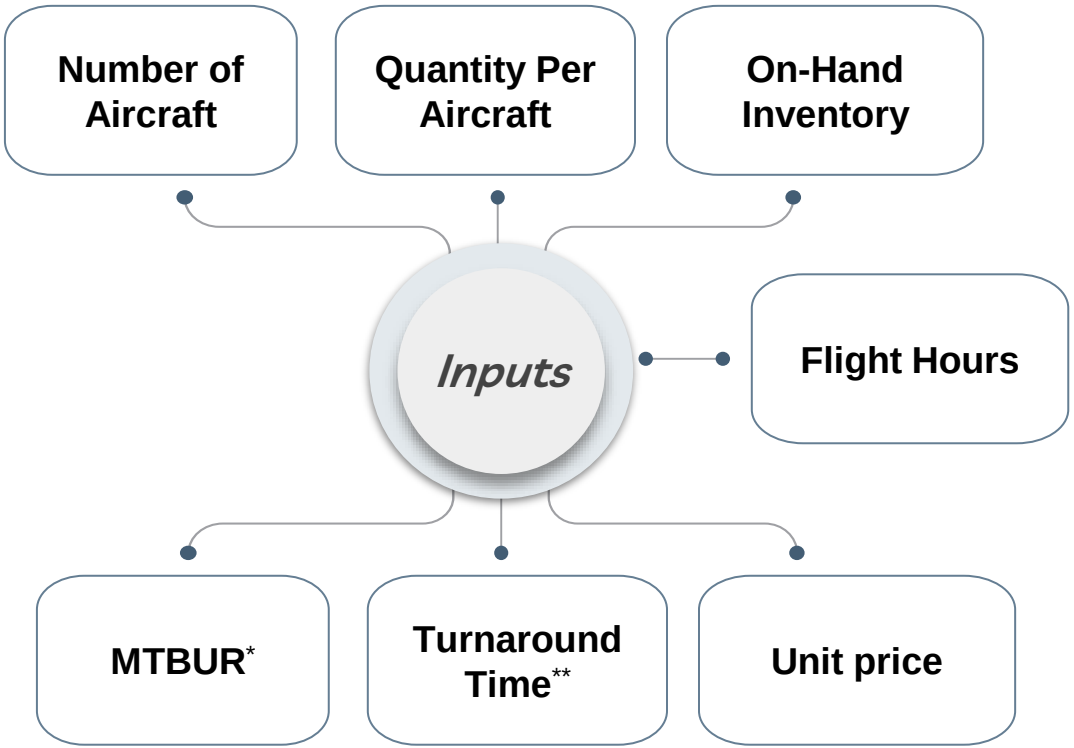
# Optimization Model (Formulation)



# Optimization Model (Objective Function)

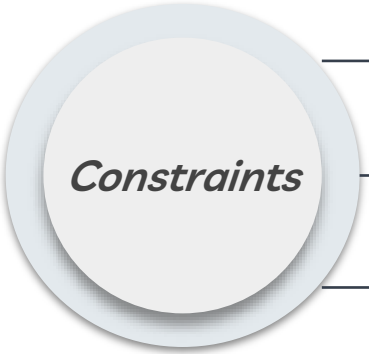

**Minimize** the **total cost** to purchase the required rotables

# Optimization Model (Inputs)




*MTBUR: Mean Time Before Unscheduled Removal;
**Turnaround Time includes the repair time and logistics/transportation time

# Optimization Model (Constraints)



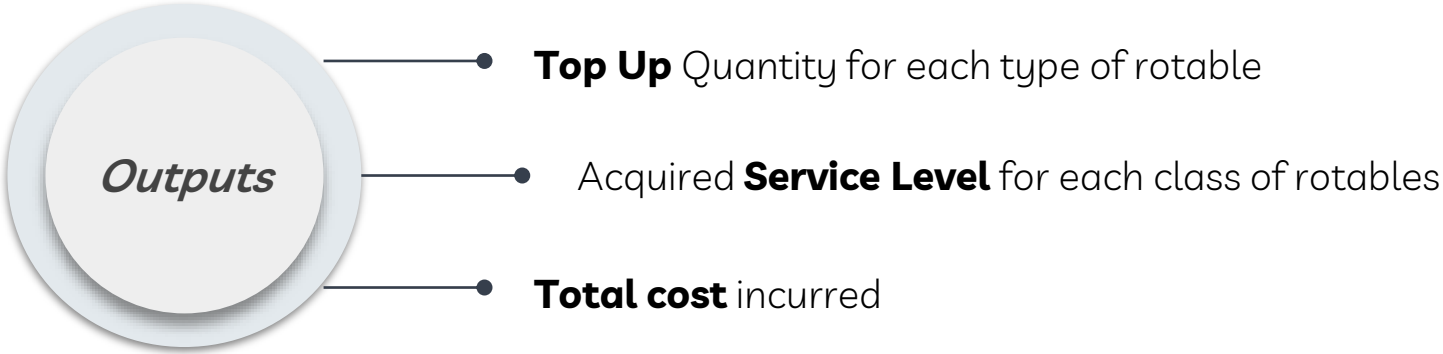

**Service level** for each class* of rotables are **to be met**

**Total cost** Incurred should **not exceed** SIAEC budget

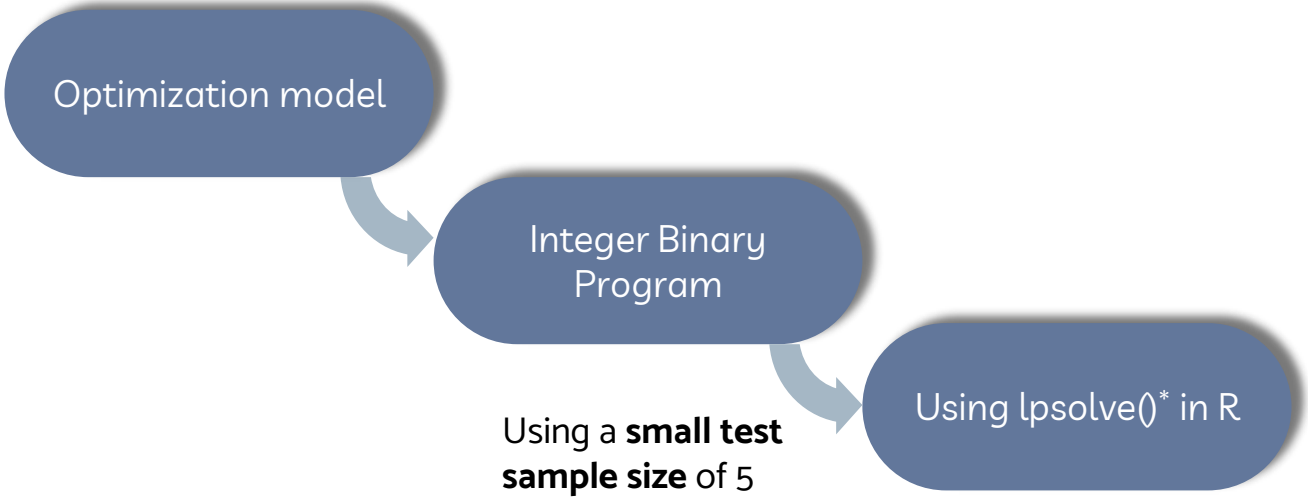
A certain number of specific types of rotables are **always to be available** in the warehouse

*Class: Rotables are classified into 3 classes, 1,2,3 based on their importance level, with class 1 being the most important. The average service level to be met for class 1,2,3 are 98%, 95% and 88% respectively

# Optimization Model (Outputs)



# Optimization Model (Experiment)




Using a **small test sample size** of 5 rotables + Assume **zero** on-hand inventories

* lpsolve() is a package from R for solving linear, integer and mixed integer programs

# Optimization Model (Experiment* result)

| Class** | Part Number | Unit Price ($) | Quantity to hold (SIAEC's method) | Quantity to hold (Our optimization model) |
|---|---|---|---|---|
| 2 | 12-34 | 17,712 | 1 | 1 |
| 2 | 12-35 | 17,712 | 0 | 0 |
| 2 | 12-36 | 9501 | 1 | 0 |
| 2 | 12-37 | 4678 | 1 | 1 |
| 2 | 12-38 | 83,971 | 2 | 1 |

SIAEC's current method

**Average Service Level:** 98.22% (>95%)

**Total Investment:** USD 199,836

**~50% reduction**

Our Optimization model

**Average Service Level:** 95.82% (>95%)

**Total Investment:** USD 106,363

*Experiment: To simplify our model, we have assumed on-hand inventory to be zero for this experiment
**Class: Class 2 rotables need to achieve on average a service level of 95%

# Long-term Provisioning

## Approach A

Optimization model

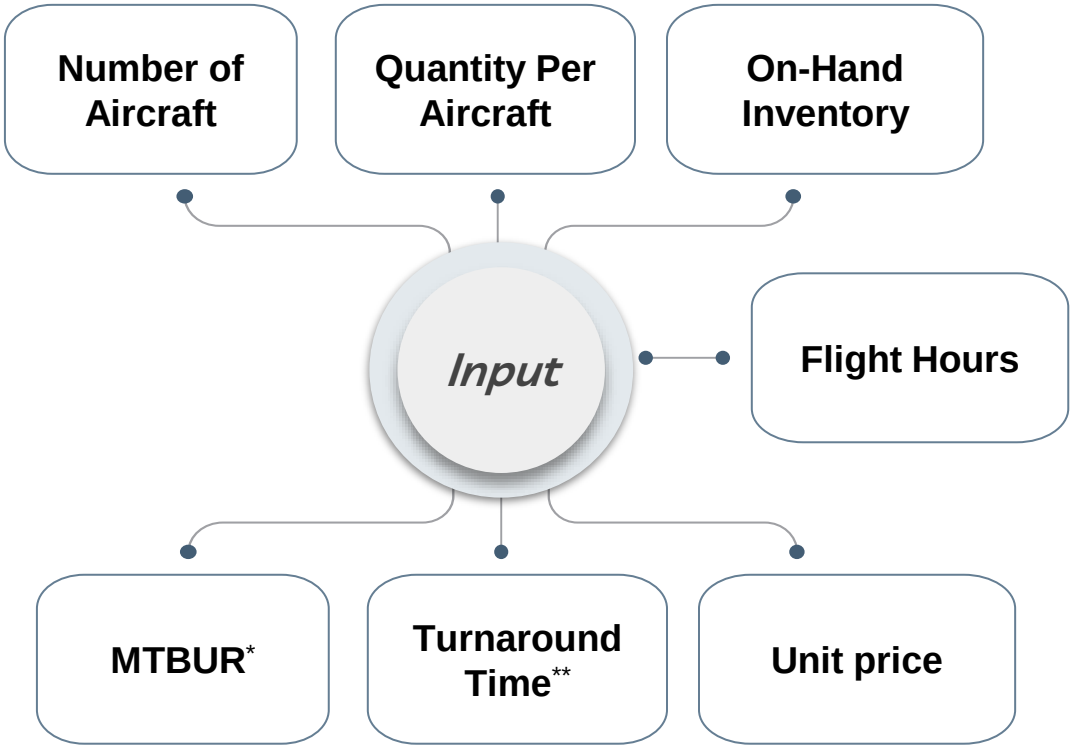
## Approach B

Improving Accuracy & Quality of Input Data


## Approach C

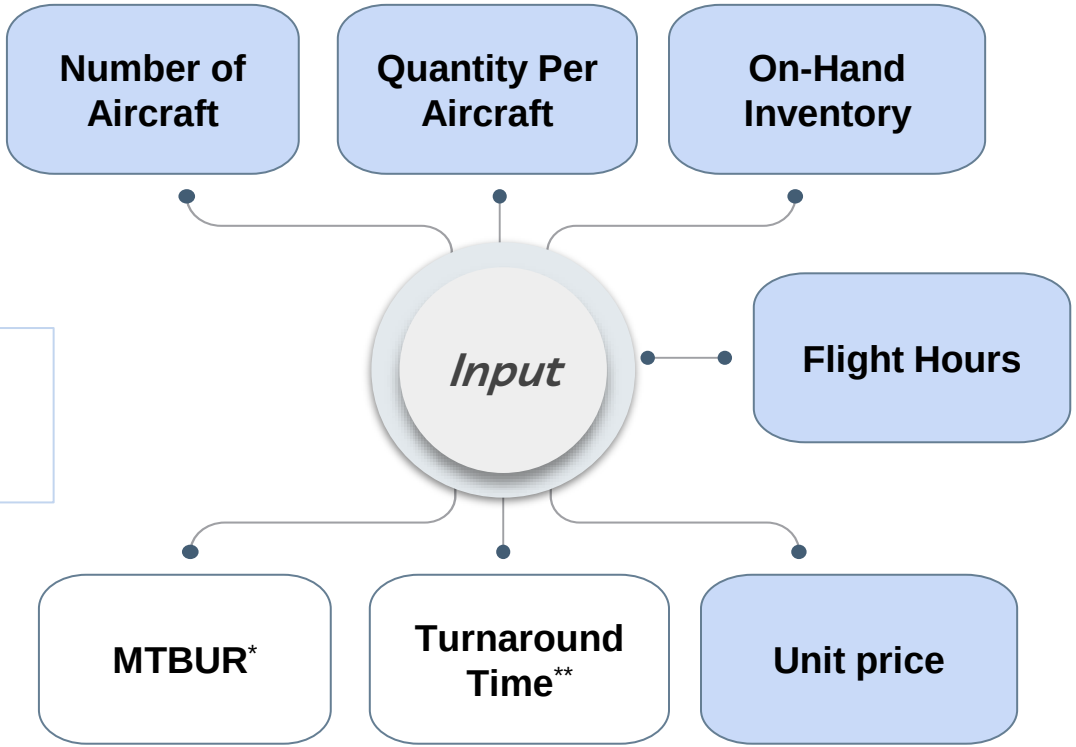
Statistical Distribution of Demand

# Improving Quality of Input Data




*MTBUR: Mean Time Before Unscheduled Removal;
**Turnaround Time includes the repair time and logistics/transportation time

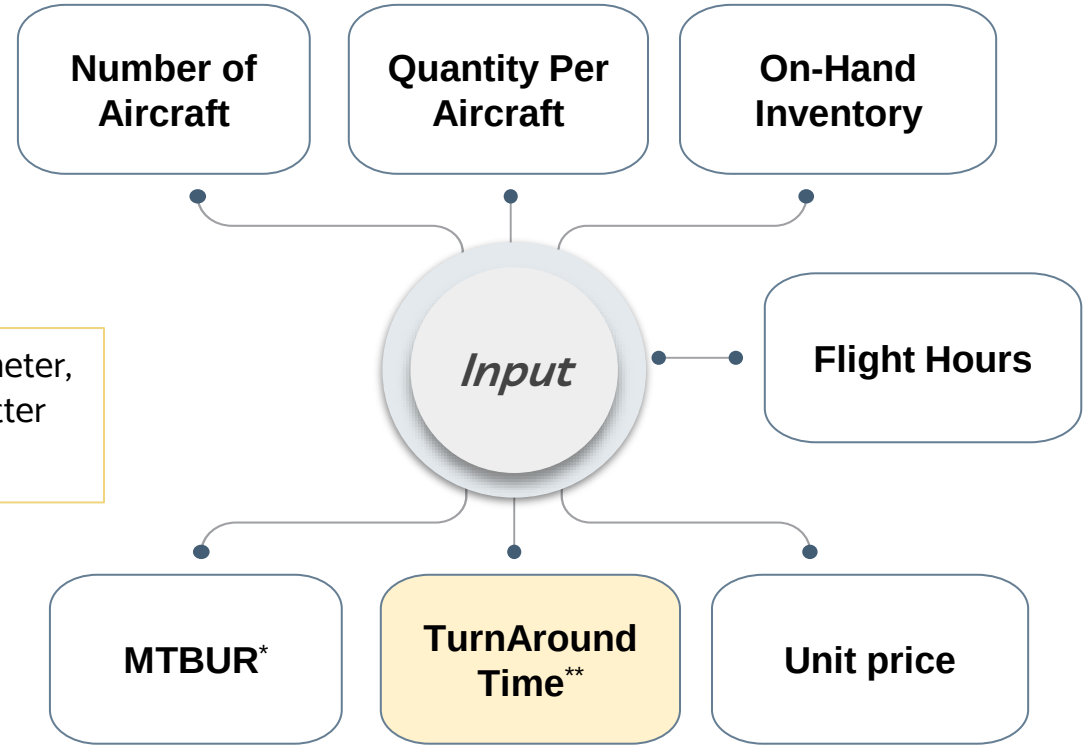
# Improving Quality of Input Data




Fixed Parameters, cannot be better predicted

*MTBUR: Mean Time Before Unscheduled Removal;
**Turnaround Time includes the repair time and logistics/transportation time

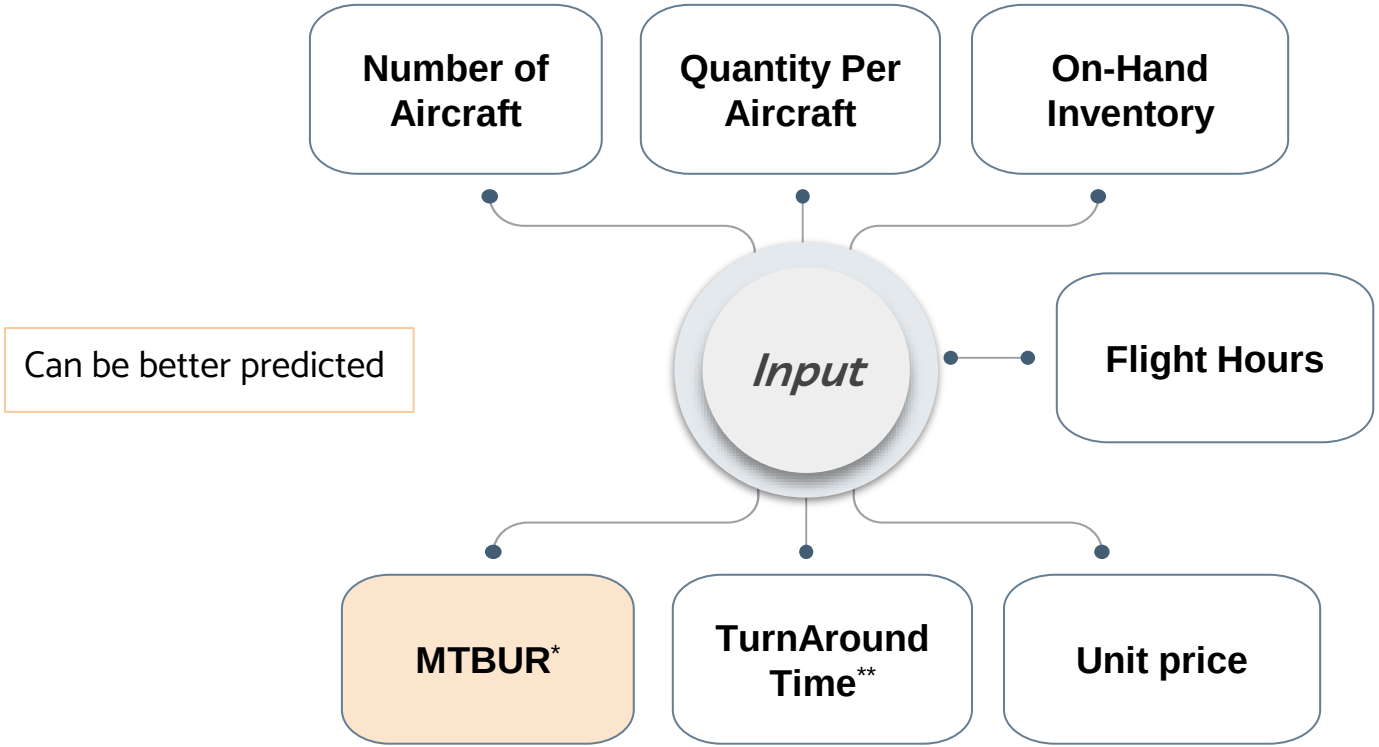
# Improving Quality of Input Data




User-Input parameter, no need to be better predicted

*MTBUR: Mean Time Before Unscheduled Removal;
**Turnaround Time includes the repair time and logistics/transportation time

# Improving Quality of Input Data

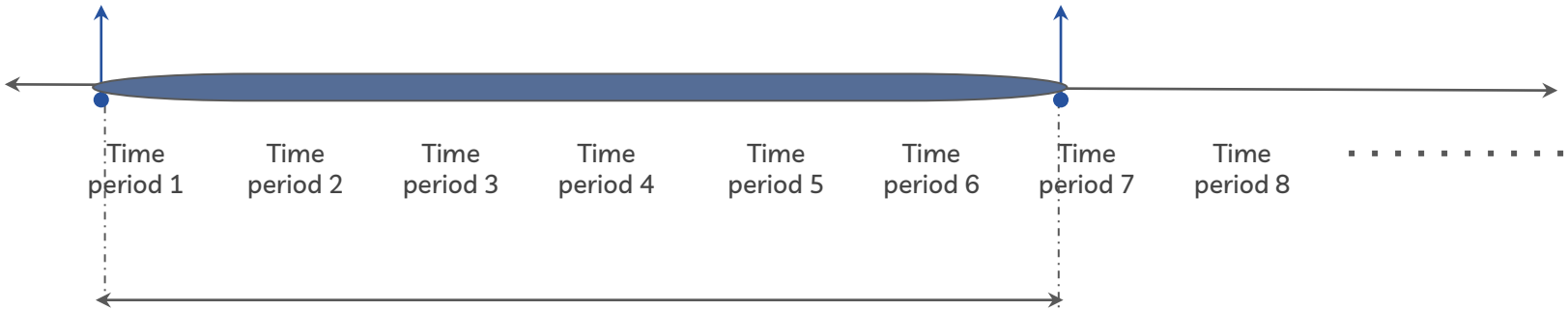



*MTBUR: Mean Time Before Unscheduled Removal;
**Turnaround Time includes the repair time and logistics/transportation time

# Predicting MTBUR

**Rotable $i^{th}$ fitted onto an aircraft**

**Rotable $i^{th}$ removed from the same aircraft**




**Mean Time Between Unscheduled Removal (MTBUR)**

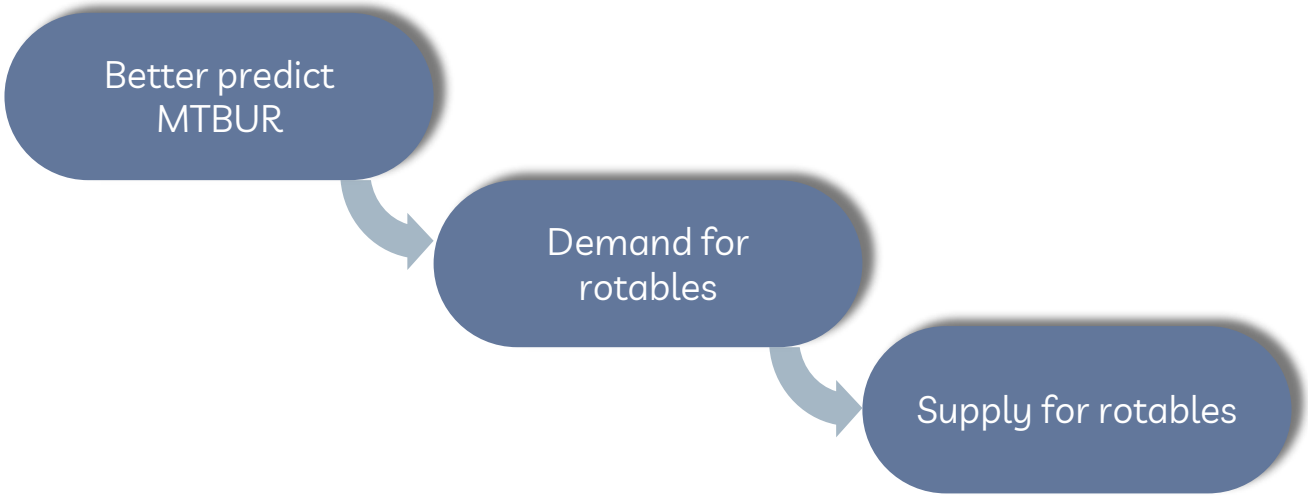
Each rotable type will have a MTBUR value of its own

# Predicting MTBUR

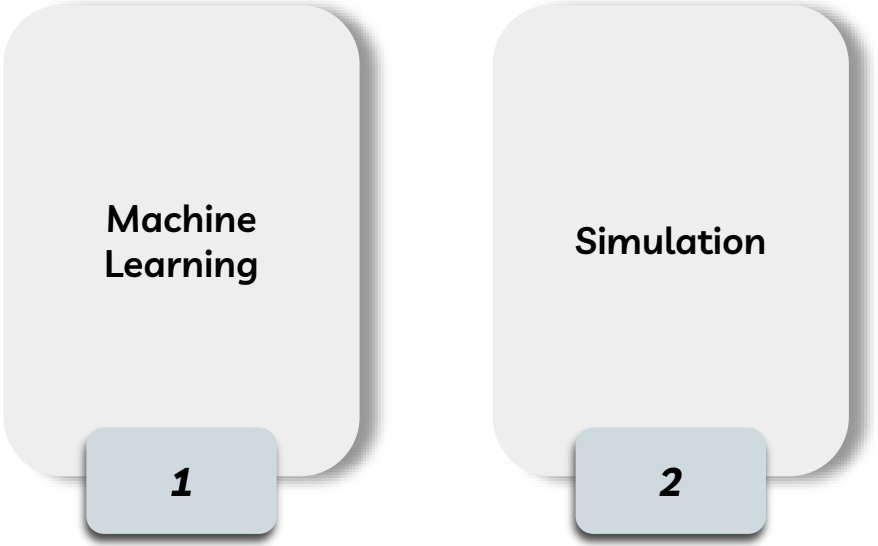

**Majority** of MTBUR used by SIAEC is provided by the original manufacturer which is **very generalized**[1] and **is skewed**, only a **minority** of rotable parts have **historical MTBUR** available

[1] Generalized: For example, airplanes that frequently fly to more warm areas might corrode faster (hence lower MTBUR) as compared to cold climates, but these factors affecting the mTBUR are not captured in the aggregated MTBUR that is provided by the original rotable manufacturer

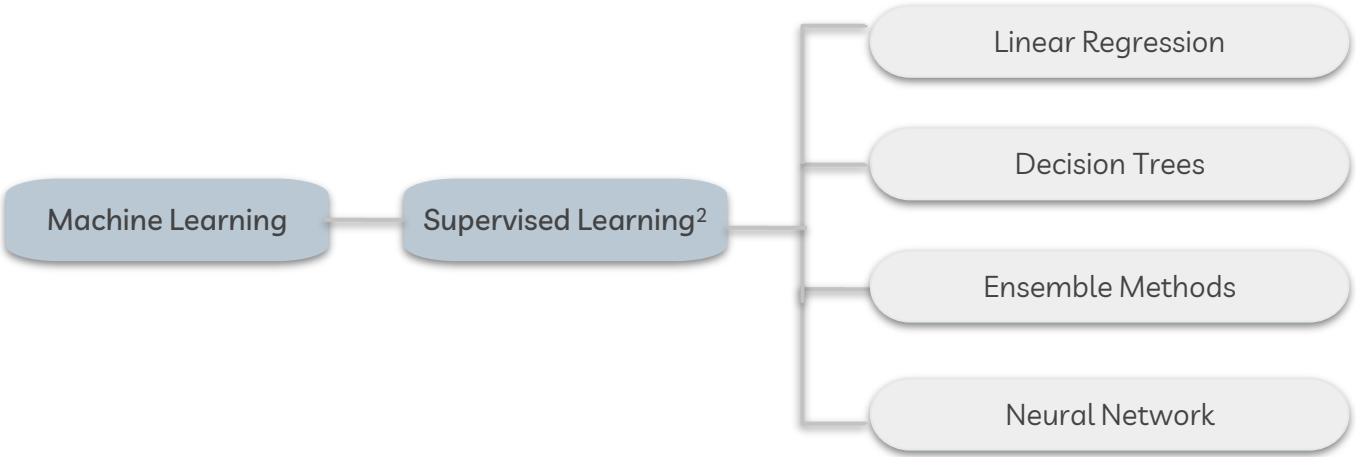
# Predicting MTBUR



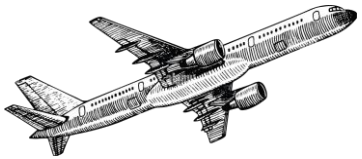
# Predicting MTBUR



# Machine Learning



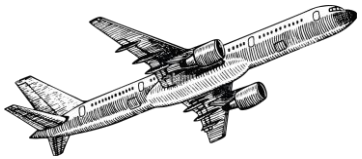
# Machine Learning



Factors affecting MTBUR[3]

- Running Life
- Machine usage
- History of past failures
- Number of past failures
- Operating Conditions

# Machine Learning

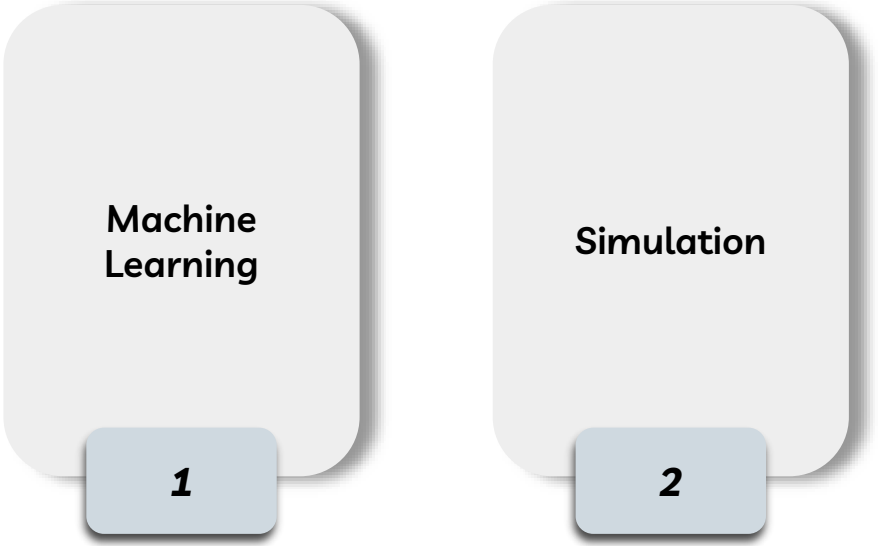


Factors affecting MTBUR

- Running Life
- Machine usage
- History of past failures
- Number of past failures
- Operating Conditions

Lack of these data

# Predicting MTBUR



# Simulation[4]

- **Lack** of data on the **feature** variables
- Lack of good understanding of the **dynamics** of the **system**
- **Not feasible** to predict MTBUR using simulation

# Long-term Provisioning

## Approach A

Optimization model

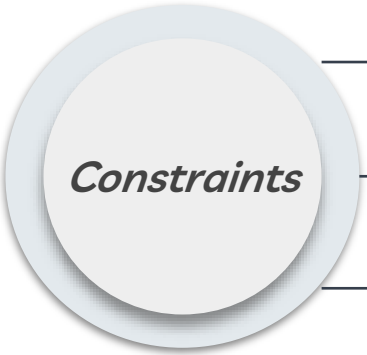
## Approach B

Improving Accuracy & Quality of Input Data


## Approach C

Statistical Distribution of Demand

# Statistical Distribution of Demand




**Service level** for each class of rotables are **to be met**

**Total cost** Incurred should **not exceed** SIAEC budget

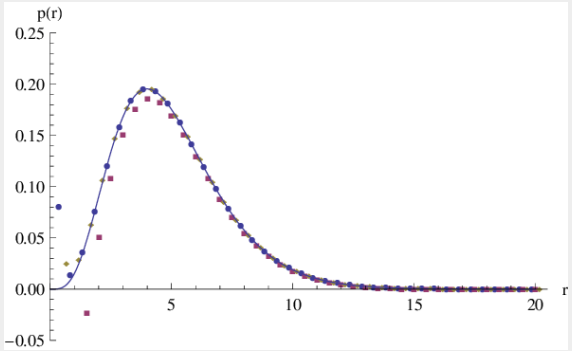
A certain number of specific types of rotables are **always to be available** in the warehouse

# Statistical Distribution of Demand

***Constraints***

**Service level** for each class of rotables are **to be met**

SIAEC assumes Poisson Distribution



# Statistical Distribution of Demand

***Alternative***

**Compound**

- Stuttering Poisson
- Negative Binomial

**Non-Compound**

- Normal
- Gamma

# Statistical Distribution of Demand

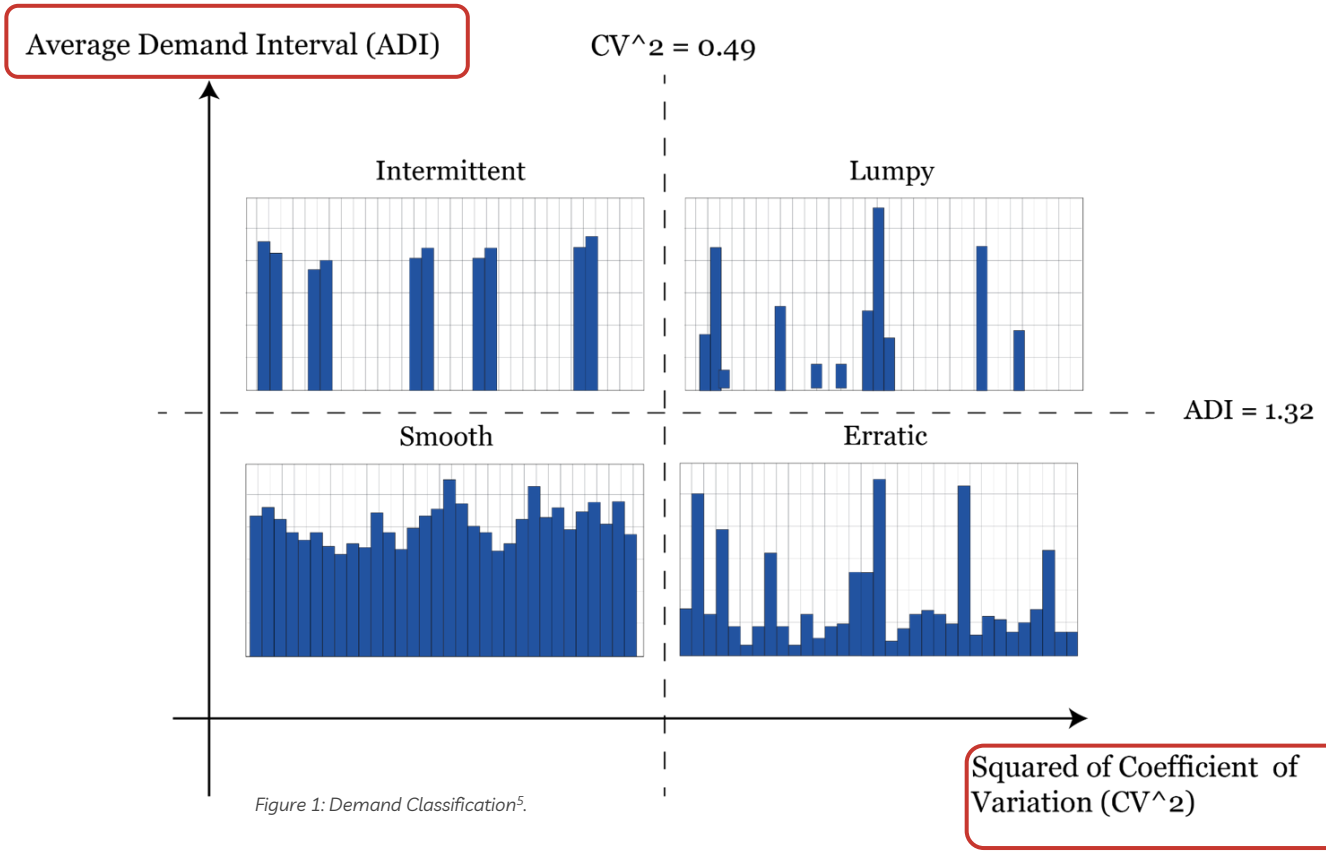
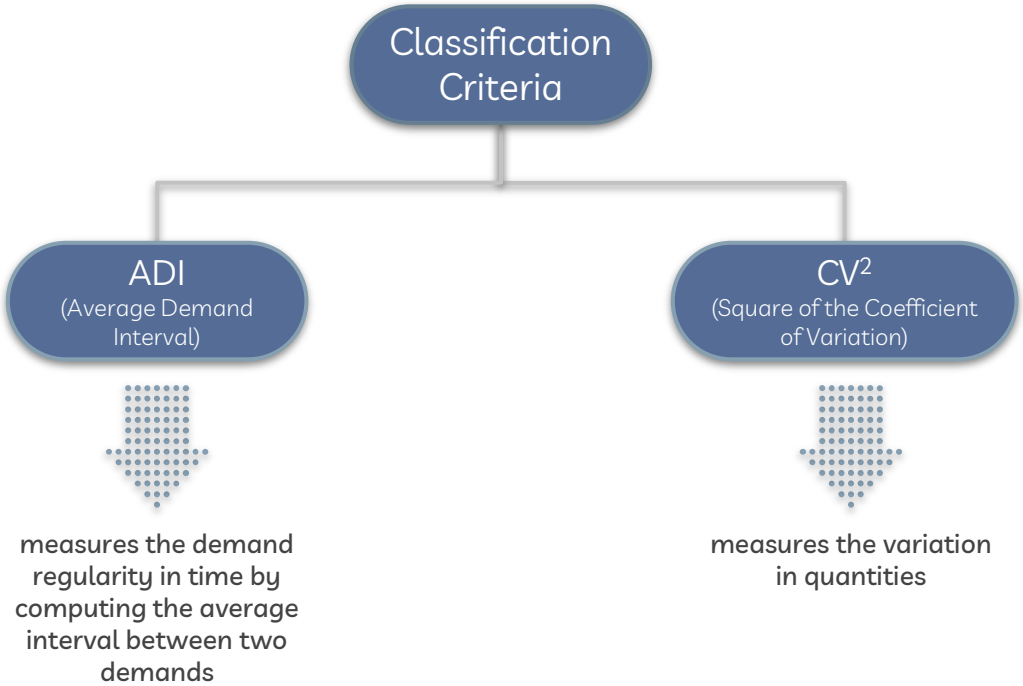



*Figure 1: Demand Classification[5].*

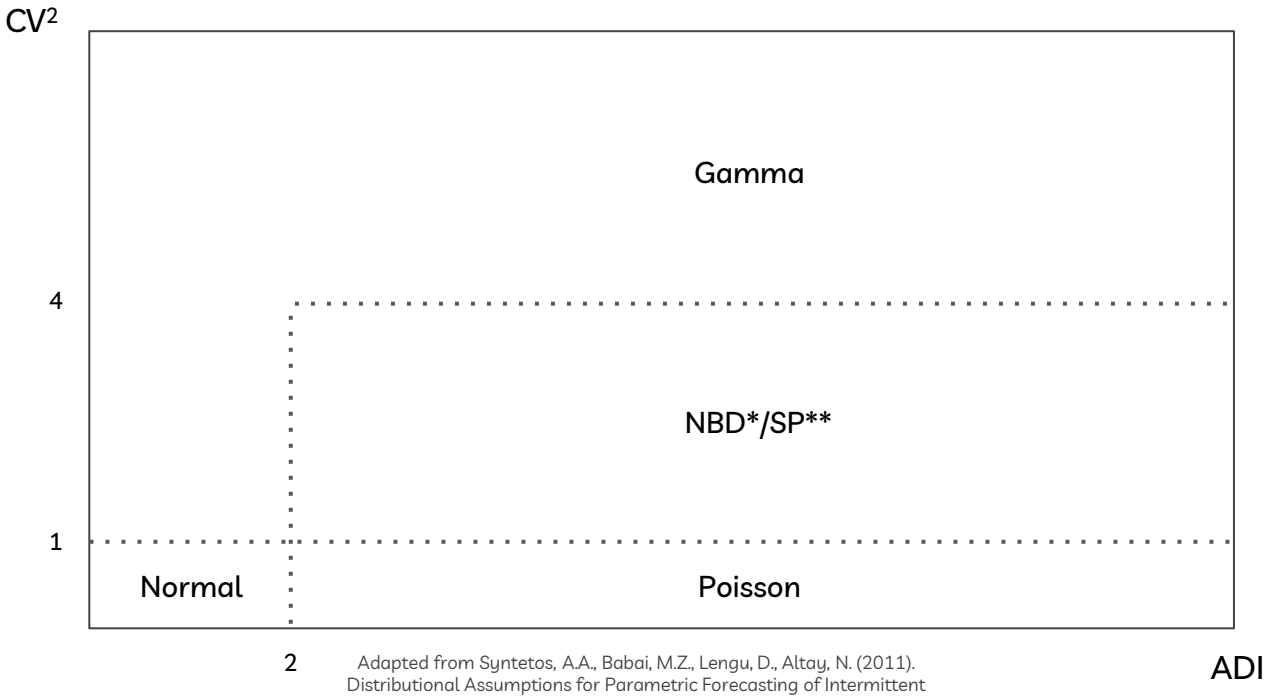
# Statistical Distribution of Demand[6]



# Statistical Distribution of Demand[6]

| | | |
|---|---|---|
| Smooth | if | ADI<1.32 and $CV^2$<0.49 |
| Intermittent | if | ADI>=1.32 and $CV^2$<0.49 |
| Erratic | if | ADI<1.32 and $CV^2$>=0.49 |
| Lumpy | if | ADI>=1.32 and $CV^2$>=0.49 |

# Statistical Distribution of Demand



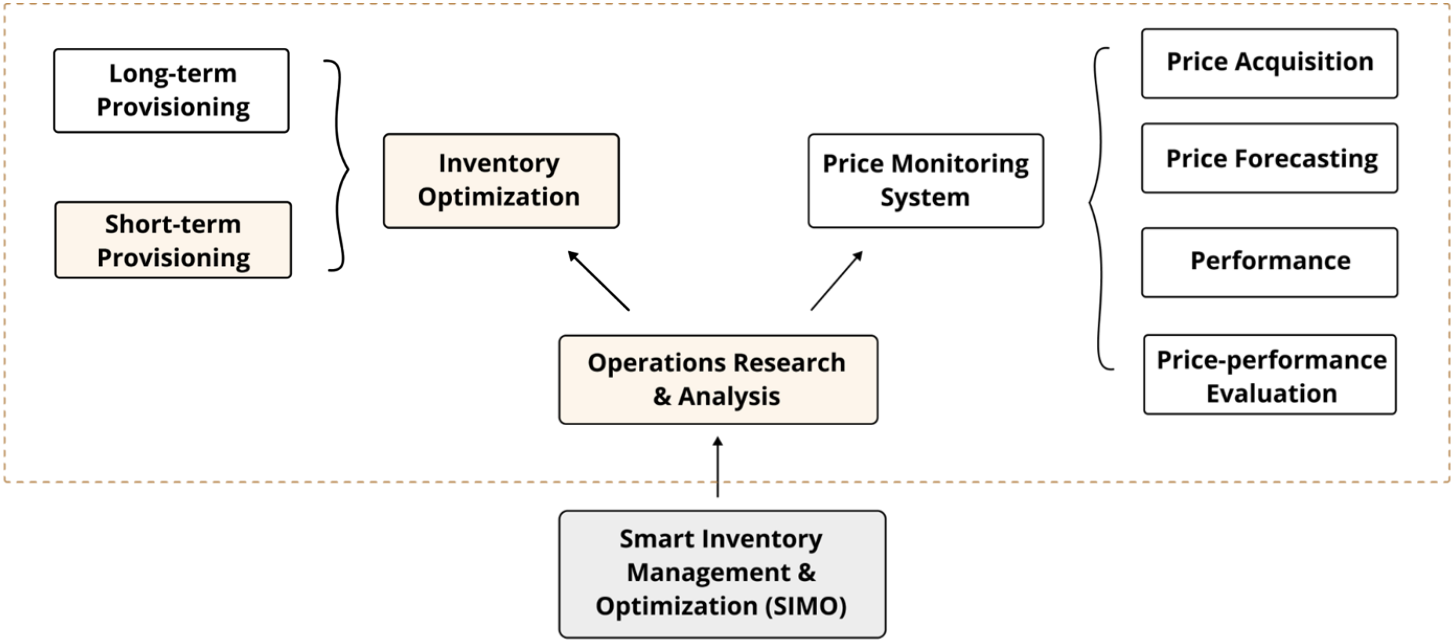

Adapted from Syntetos, A.A., Babai, M.Z., Lengu, D., Altay, N. (2011). Distributional Assumptions for Parametric Forecasting of Intermittent Demand. In: Altay, N., Litteral, L. (eds) Service Parts Management. Springer, London. Distributional Assumptions for Parametric Forecasting of Intermittent Demand | SpringerLink

* Negative Binomial Distribution
** Stuttering Poisson

# Milestone

# Milestone

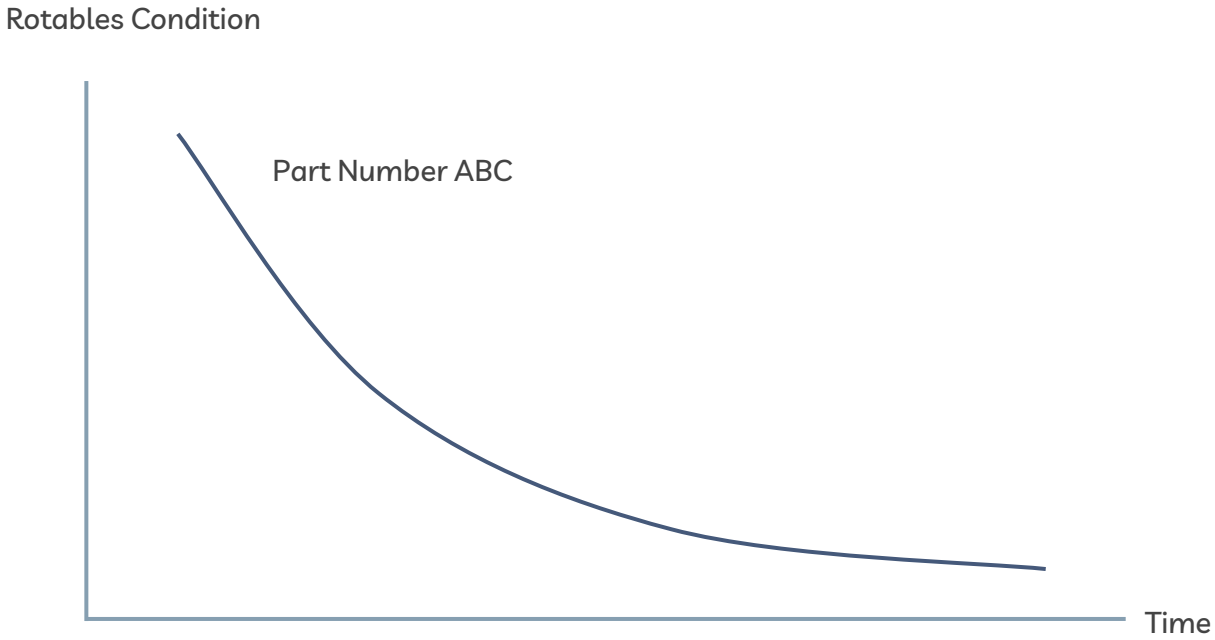
# Short-term Provisioning



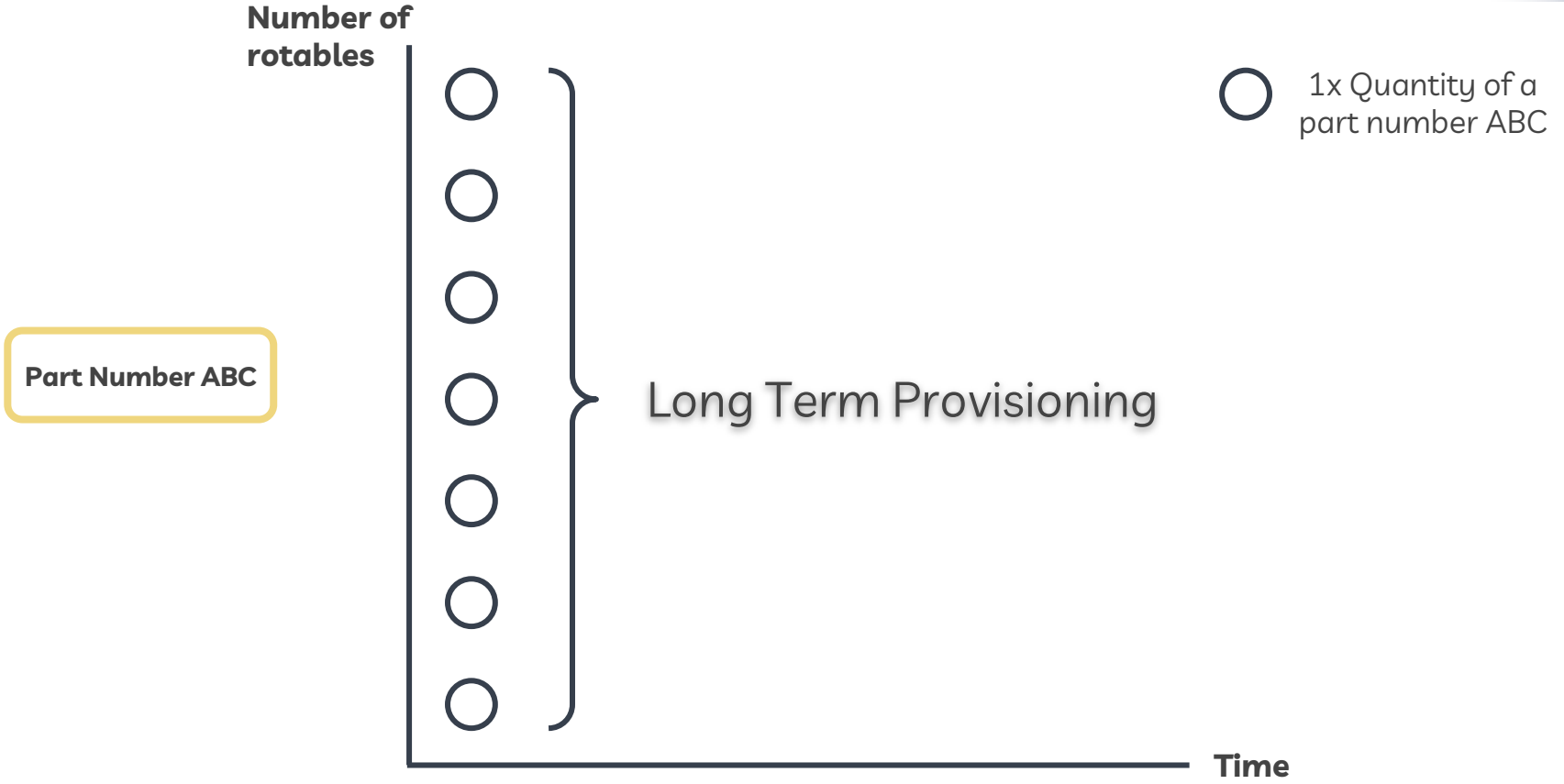
# Milestone


1. Asset Optimization
2. Asset Management
3. Just In Time Provisioning

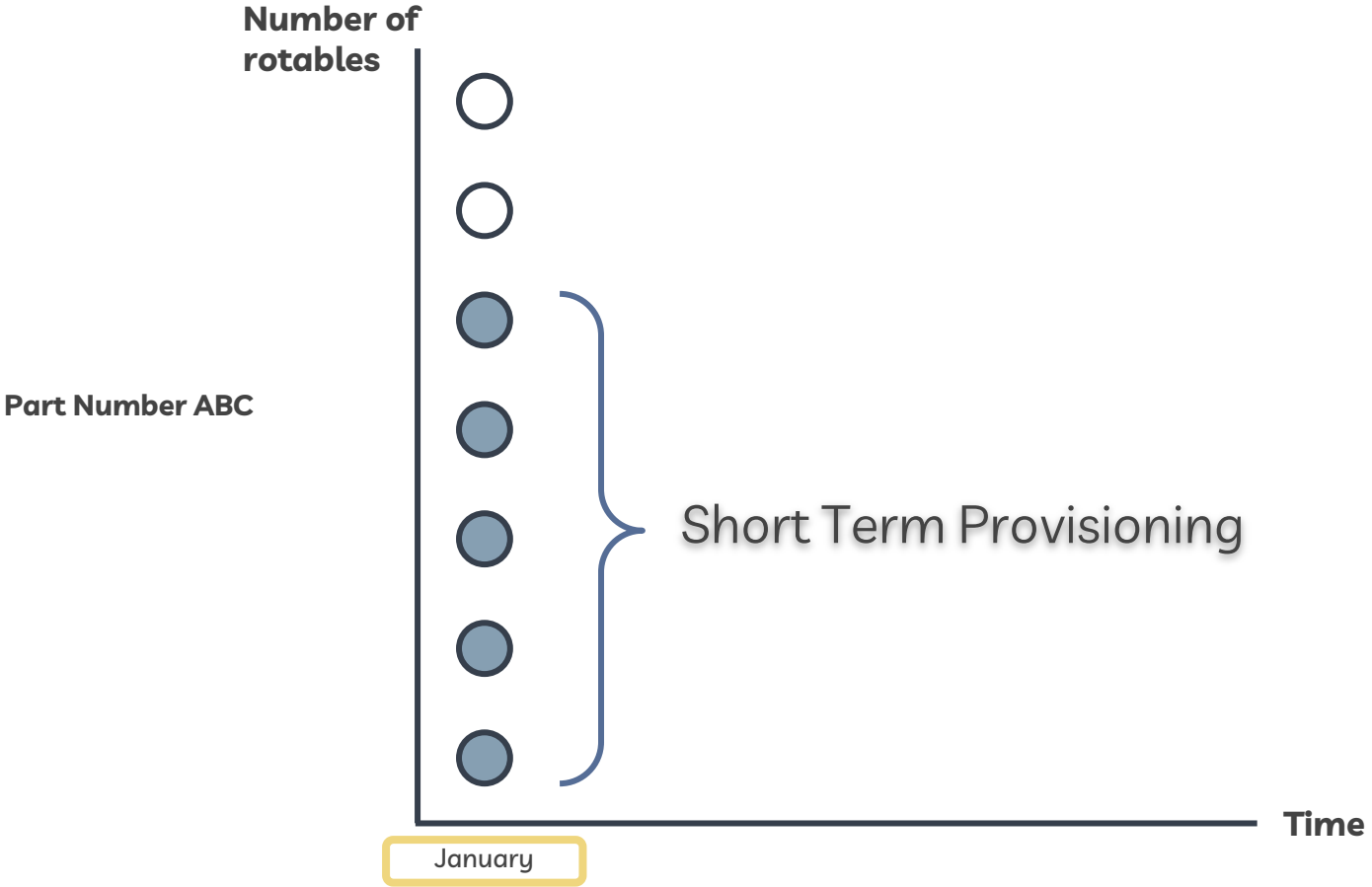
# Short-term Provisioning



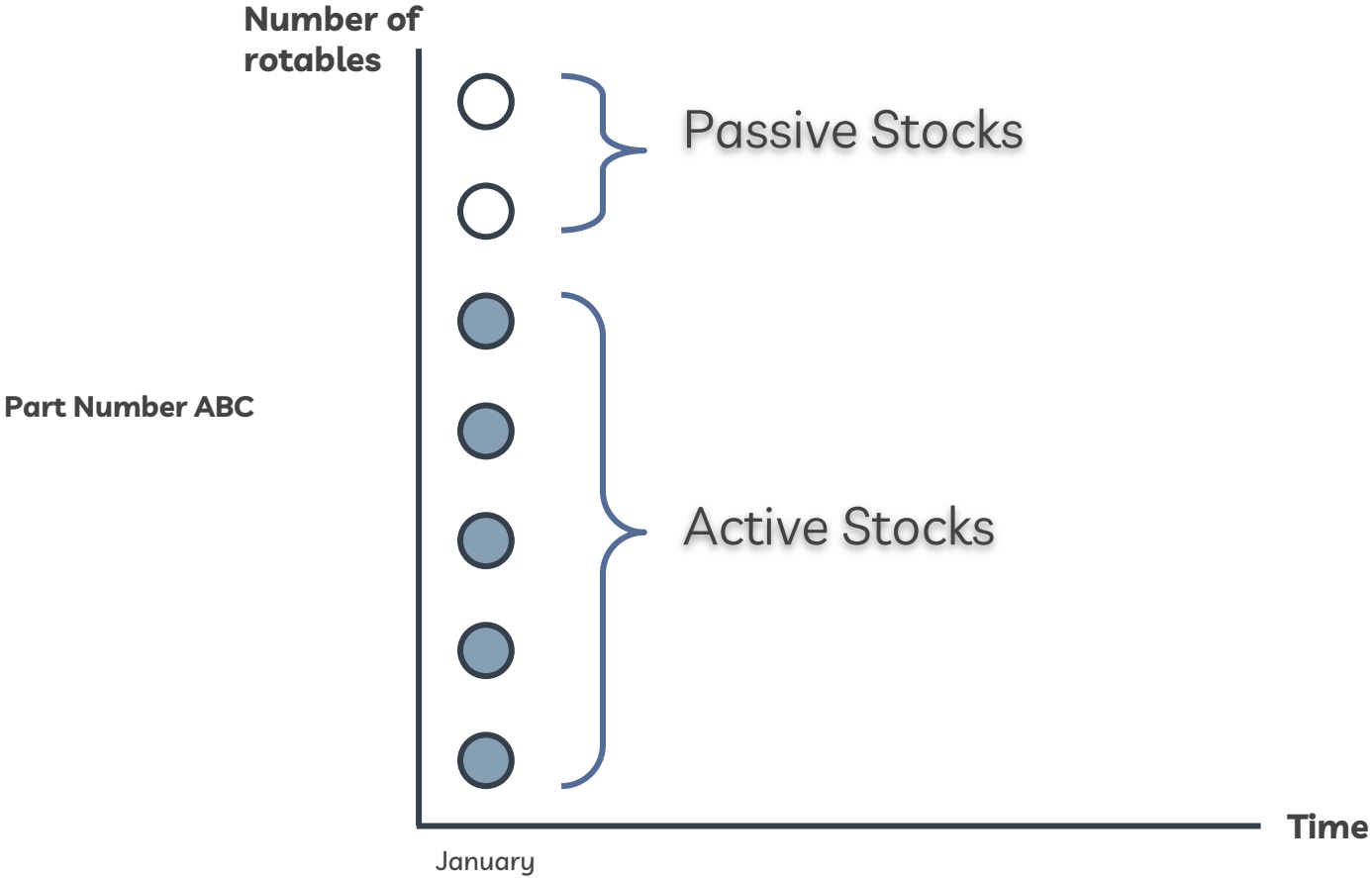
# Short-term Provisioning



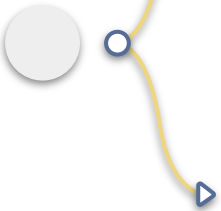
# Short-term Provisioning



# Short-term Provisioning



# Short-term Provisioning



Active

- Freshly Repaired
- Optimal Condition (Tip-top condition)

Passive

- To preserve rotables
- Slow down the deterioration rate

# Short-term Provisioning

So what are our approaches to forecasting for active rotables?

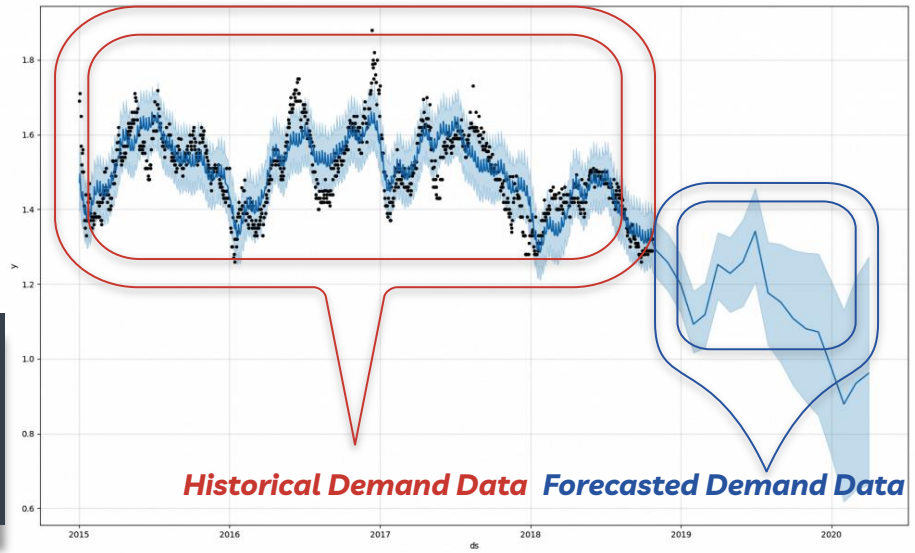
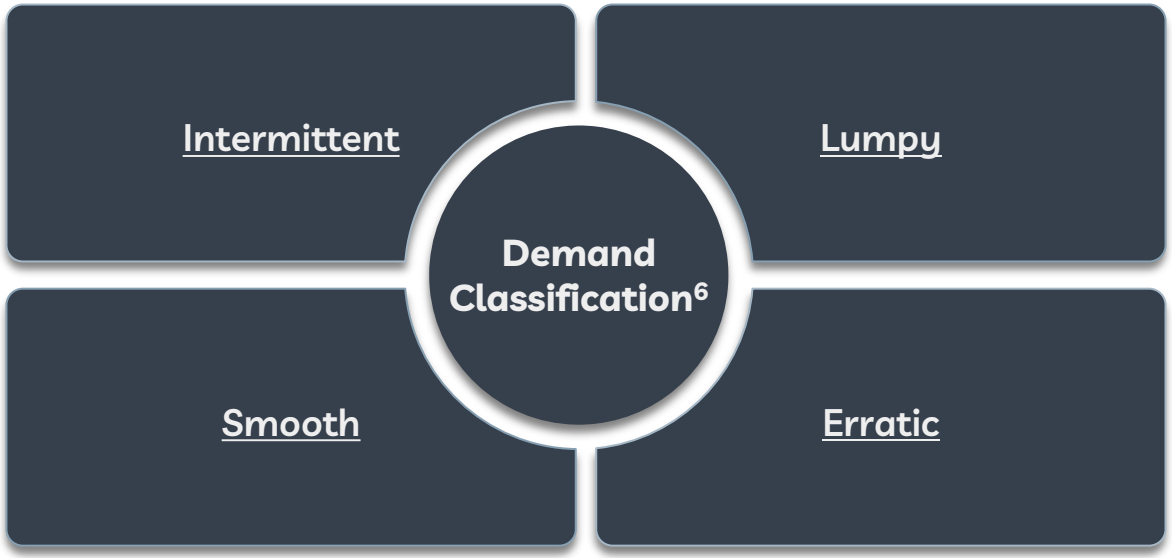
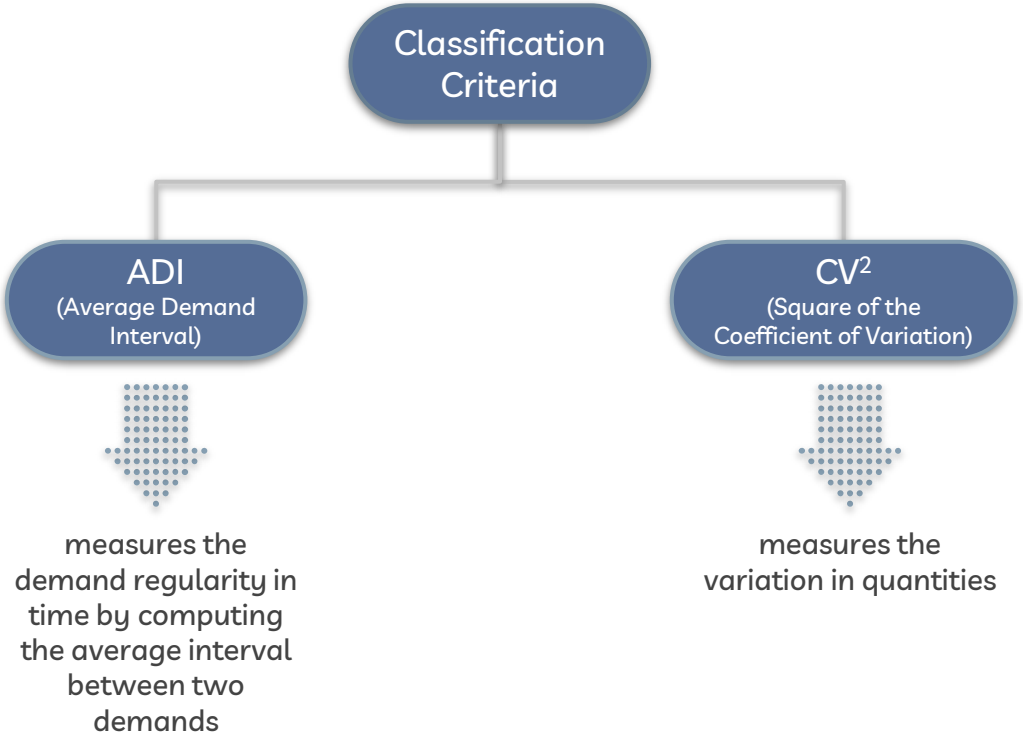



Figure 2: Time Series Forecasting. Adapted from Colin.catlin. (n.d.). Syllepsis. Retrieved April 12, 2022, from https://syllepsis.live/2019/10/08/time-series-forecasting-a-quick-reference/

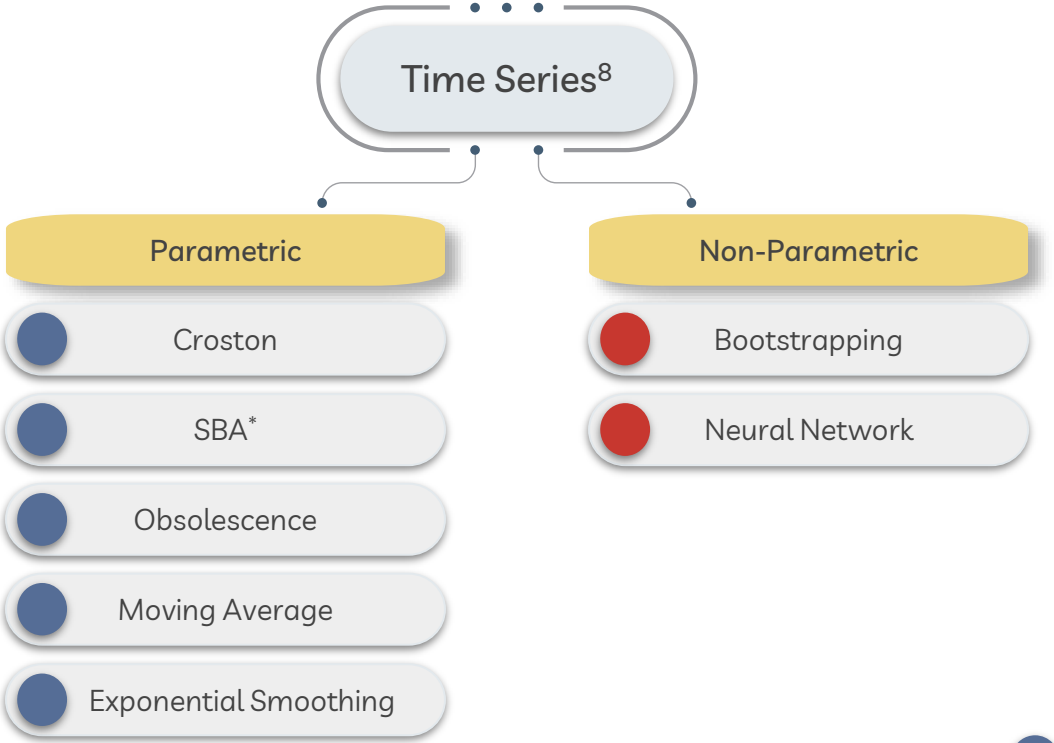
# Short-term Provisioning



# Short-term Provisioning



# Short-term Provisioning




*. SBA: Syntetos–Boylan approximation

# Short-term Provisioning

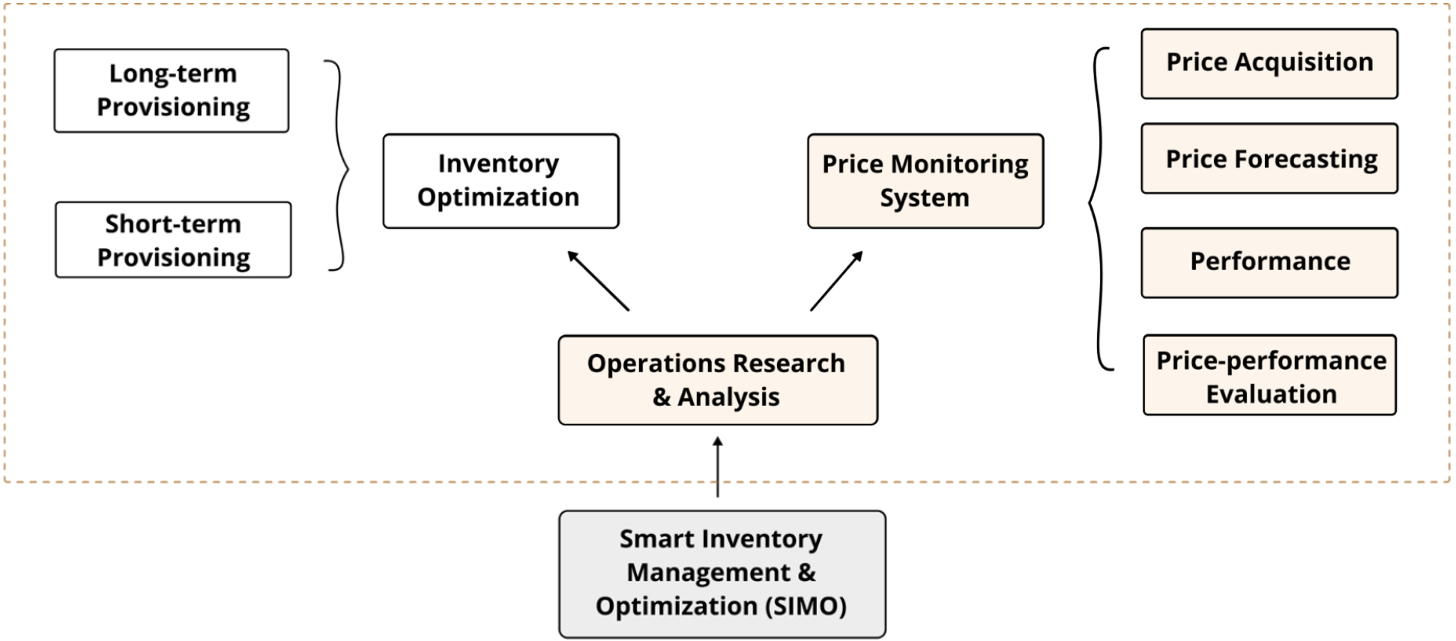
| Design Criteria | Alternative Design Concepts | |
|---|---|---|
| | Parametric | Non-Parametric |
| Data Requirement | + | 0 |
| Accuracy | 0 | + |
| Time | + | 0 |
| Ease of implementation | + | 0 |
| Totals | +++ | + |

** Further explanation of the Criteria used and assessment Rubrics can be find in Annex 1.1*

# Short-term Provisioning

# Short-term Provisioning

# Price Monitoring System (Price Acquisition)



# Price Monitoring System

- Price monitoring or price intelligence refers to the awareness of pricing in the market and the response to these changes in pricing.

- Metasearch engine[9] → Sending queries through multiple search engines and aggregating these results
  - Ranking
  - Combine

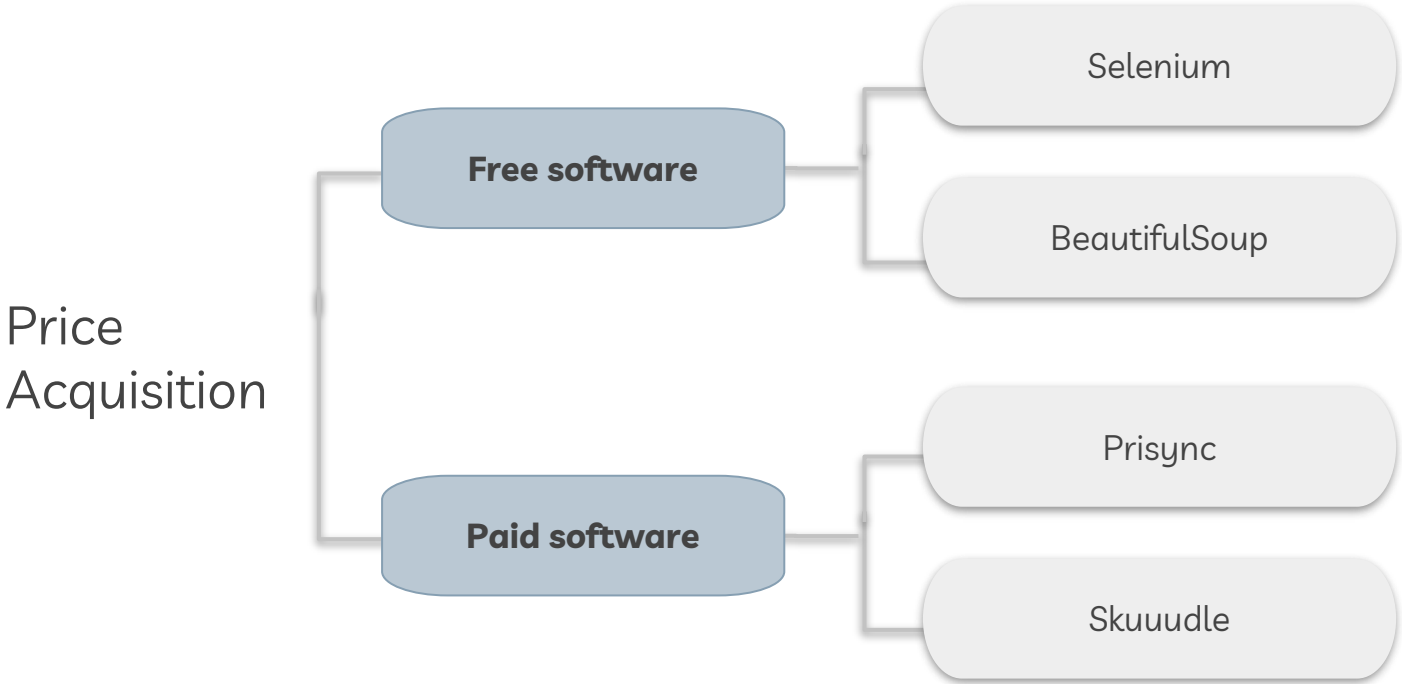

# Price Monitoring System

- Price Acquisition
- Price Forecasting
- Performance Evaluation

# Price Monitoring System

- Price Acquisition
- Price Forecasting
- Performance Evaluation

# Price Monitoring System



# Price Monitoring System (Price Acquisition)

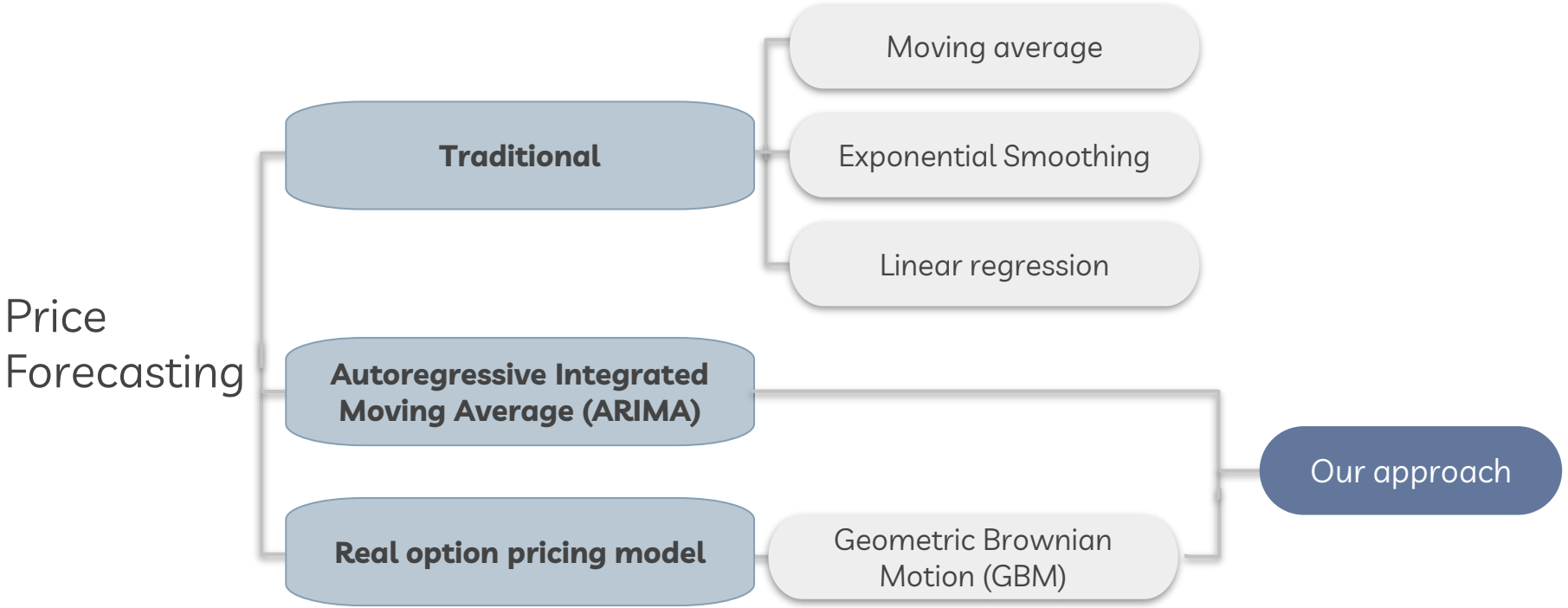
| Design Criteria | Alternative Design Concepts | | | |
|---|---|---|---|---|
| | Skuuudle | Priscync | BeautifulSoup | Selenium |
| Affordability | - | 0 | + | + |
| Ease of Integration | - | 0 | + | + |
| Adaptability | + | + | - | 0 |
| **Total** | **-** | **+** | **+** | **++** |

** Further explanation of the Criteria used and assessment Rubrics can be find in Annex 1.2*

# Price Monitoring System

- Price Acquisition
- Price Forecasting
- Performance Evaluation

# Price Monitoring System (Price Forecasting)[10]



# Price Monitoring System (Price Forecasting)[10]

| Design Criteria | Alternative Design Concepts | |
|---|---|---|
| | Geometric Brownian Motion | ARIMA |
| Data Requirement | + | + |
| Accuracy | + | 0 |
| Time | 0 | 0 |
| Ease of implementation | + | + |
| Totals | +++ | ++ |

** Further explanation of the Criteria used and assessment Rubrics can be find in Annex 1.3*

# Price Monitoring System

- Price Acquisition
- Price Forecasting
- Performance Evaluation

# Price Monitoring System (Performance)

*Variables*

Time Lasted on Wing (TSI) across each vendor

Original Equipment Manufacturer (OEM) MTBUR

$$\frac{TSI}{MTBUR}$$

# Price Monitoring System (Price to Performance)

*Variables*

MTBUR v.s Time Lasted on Wing (TSI)

Price given by OEMs v.s. Prices quoted

$$\frac{MTBUR}{Price\ given\ by\ OEMs}$$

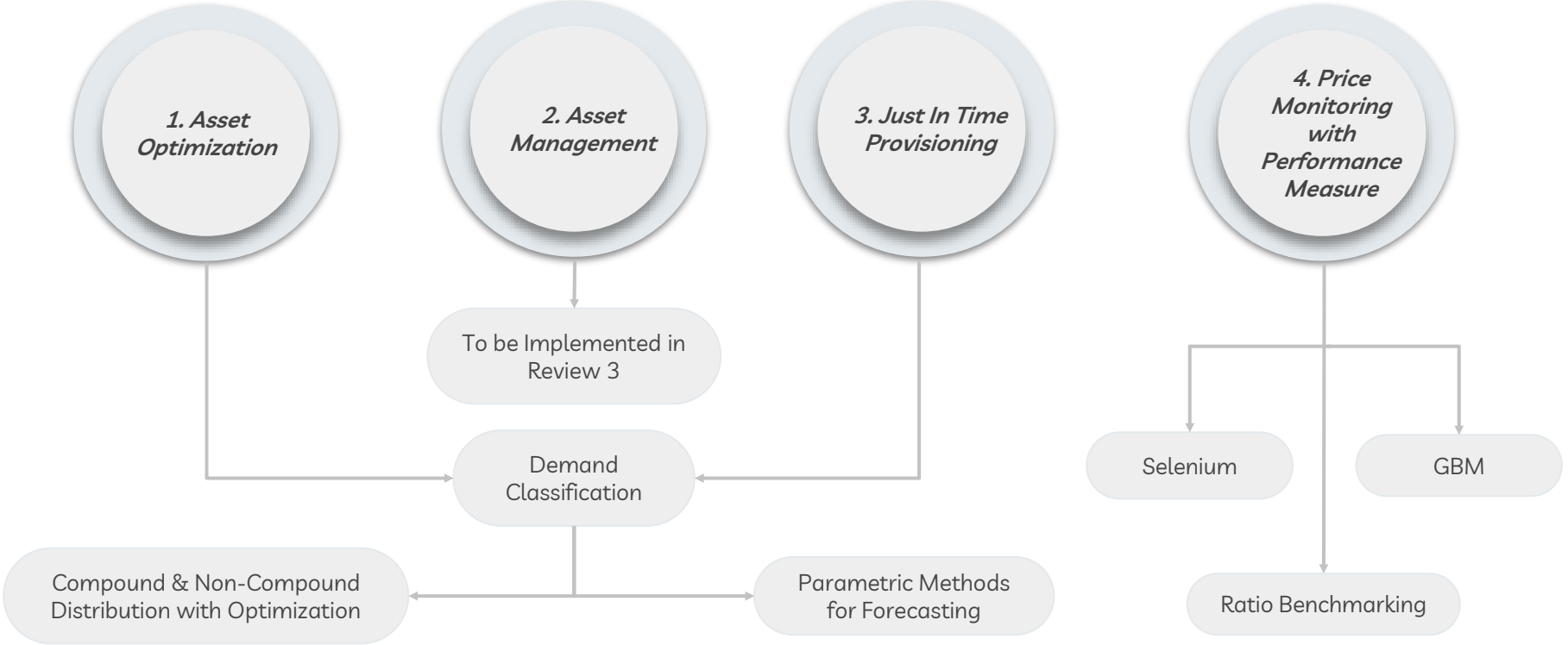
**Benchmark**

$$\frac{TSI}{Price\ quoted}$$

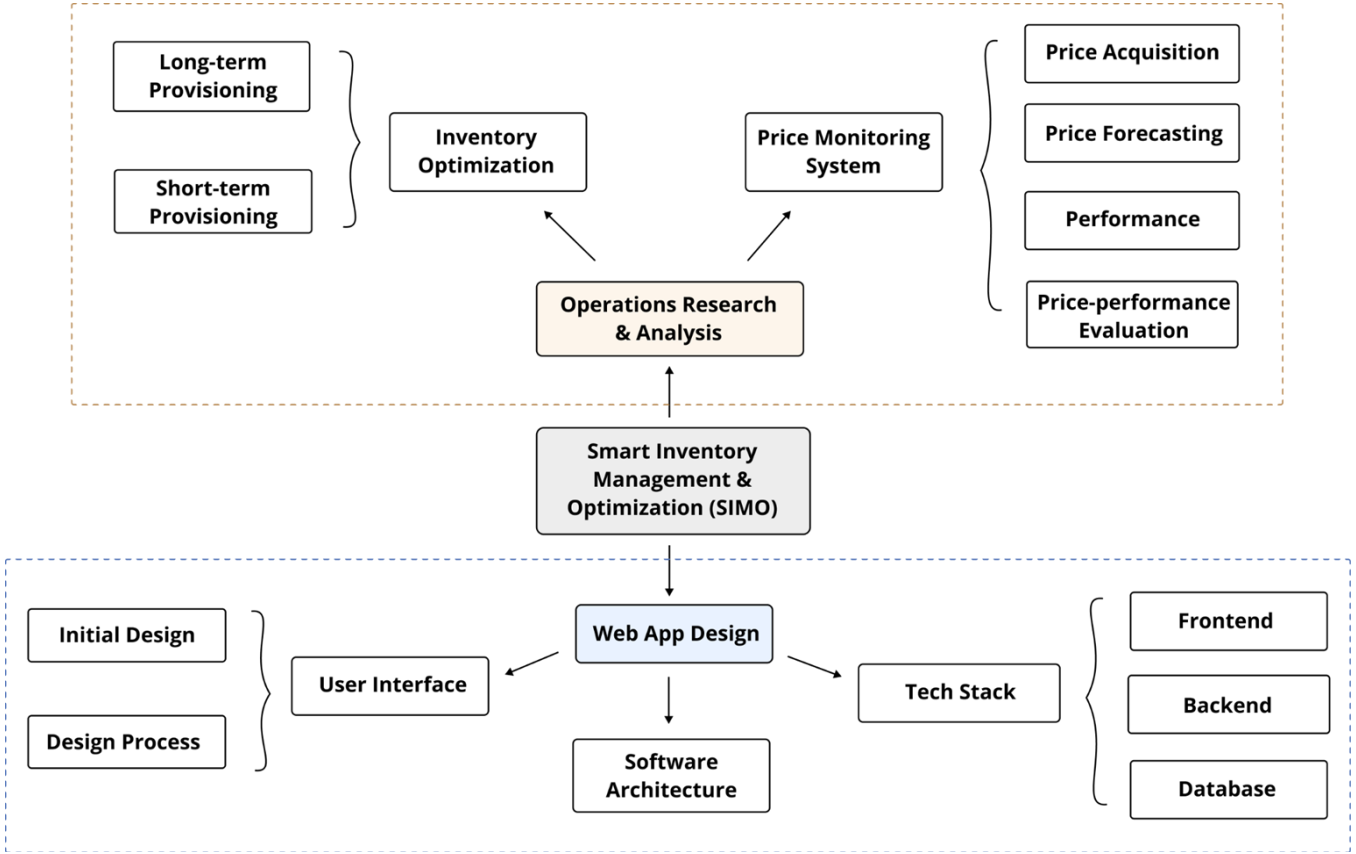
# Price Monitoring System

- Price Acquisition
- Price Forecasting
- Performance Evaluation

# Summary


1. Asset Optimization
2. Asset Management
3. Just In Time Provisioning
4. Price Monitoring with Performance Measure
To be Implemented in Review 3
Demand Classification
Compound & Non-Compound Distribution with Optimization
Parametric Methods for Forecasting
Selenium
GBM
Ratio Benchmarking

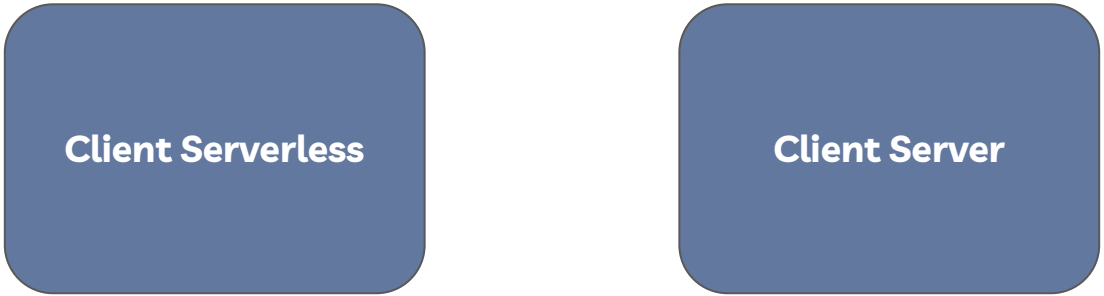
# Concept Generation



# Web Application Design

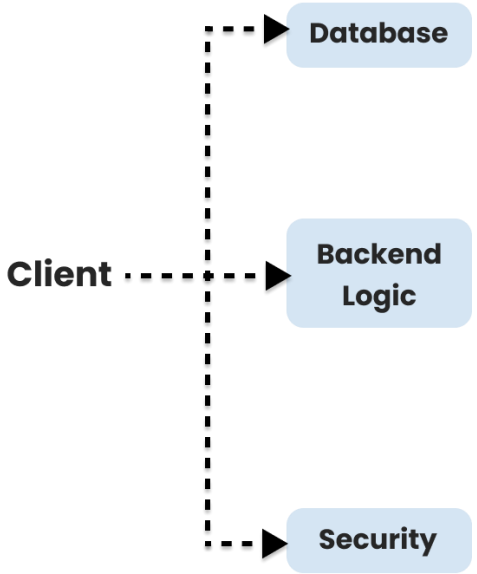
Software Architecture
User Interface
Tech stack

# Software Architecture



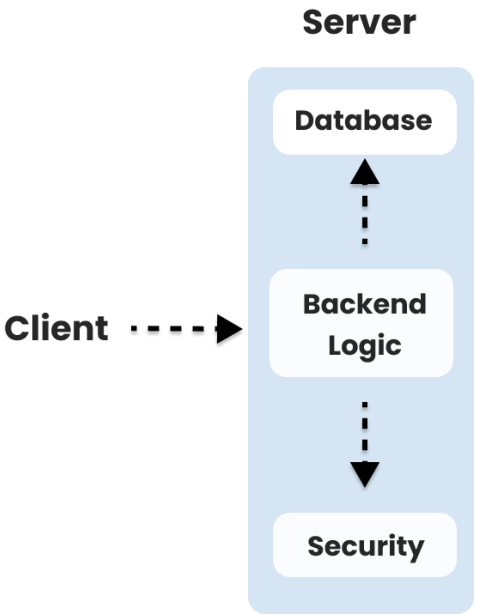
# Software Architecture

| | Pros | Cons |
|---|---|---|
| **Client Serverless[11]** | Server management not required | Difficult to debug |
| | Pay per usage | Security issues |
| | Easily Scalable | Not cost-efficient for long data-intensive processes |

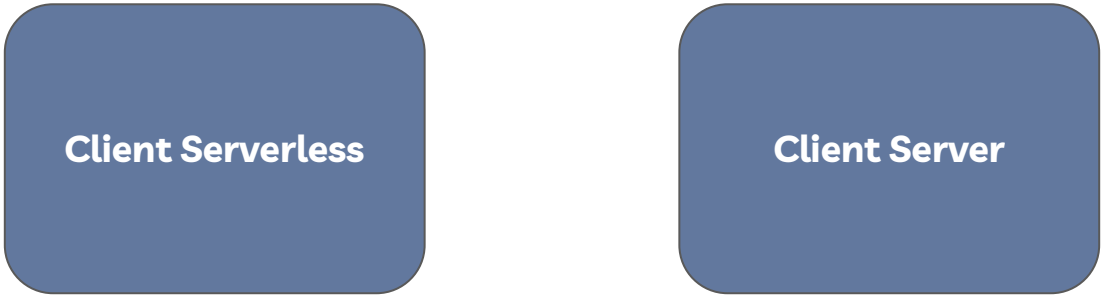


# Software Architecture

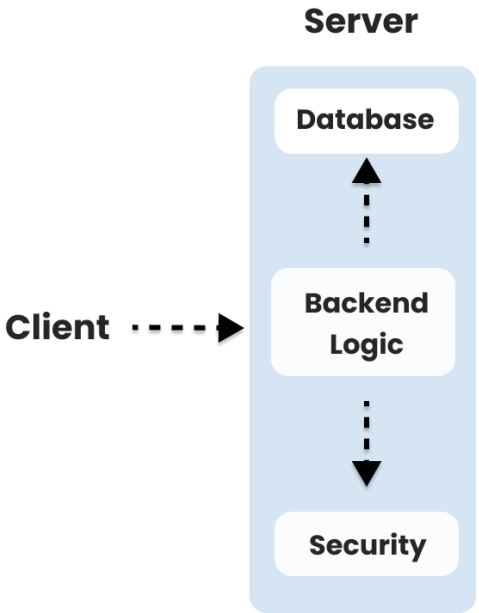
| | Pros | Cons |
|---|---|---|
| Client Server[12] | Cheaper compared to physical hardware | |
| | Easy set up | Lock in with vendor |
| | Security by cloud provider | Expensive to scale |
| | Easy network configuration | |

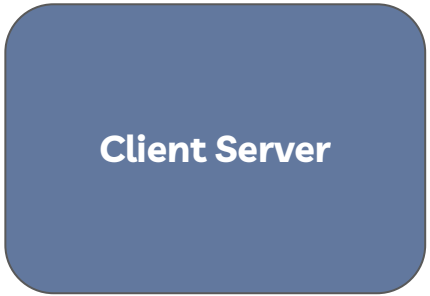


# Software Architecture



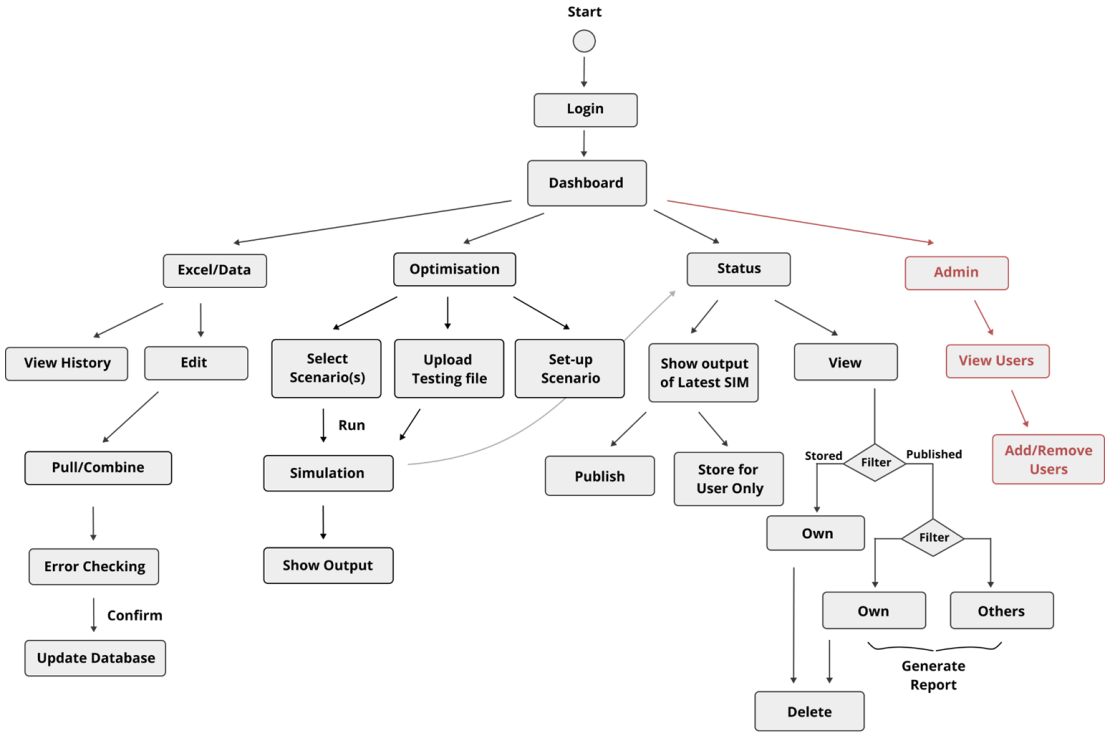
# Software Architecture



# User Interface

# User Interface



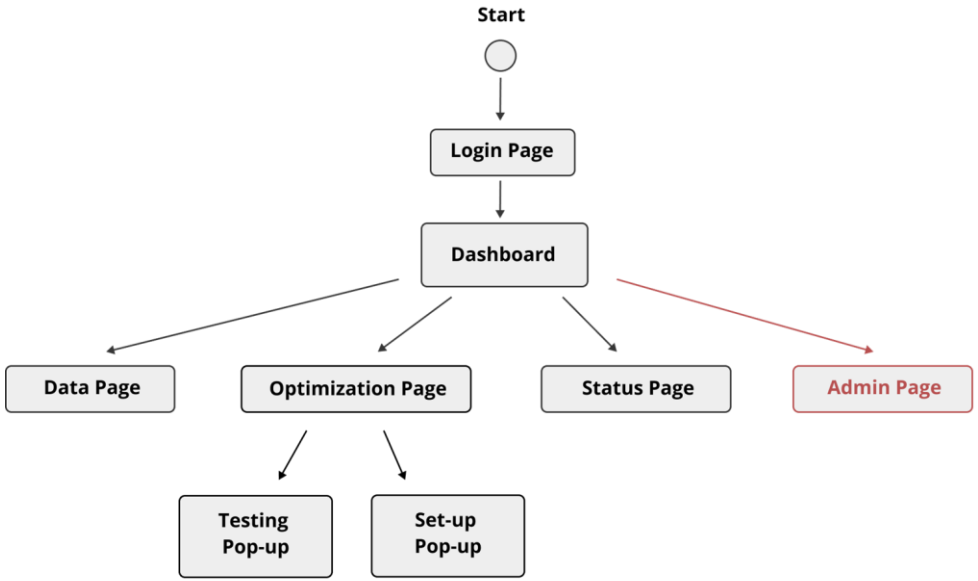

## Action Flow Diagram

Contextualise user's needs

Understand user's workflow

Visualise functionalities

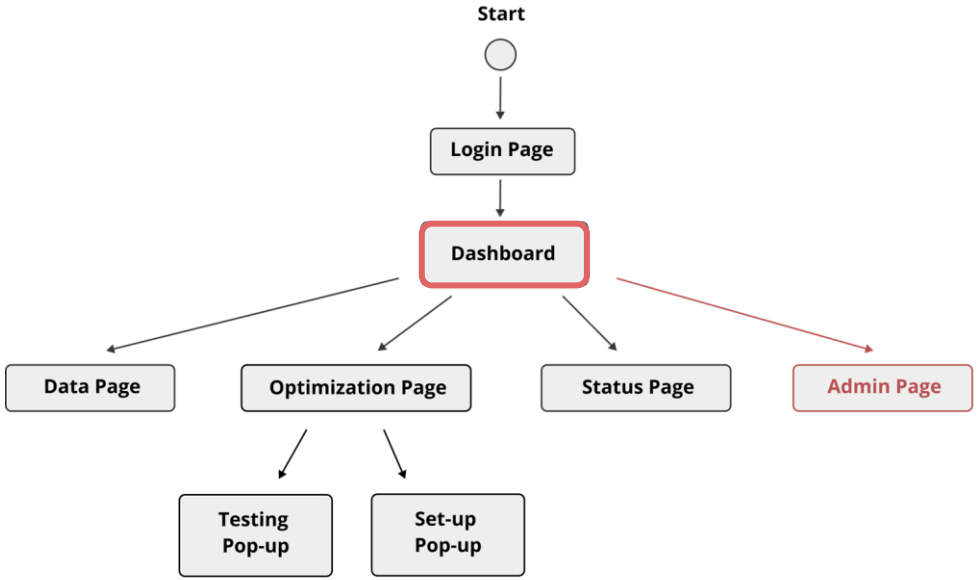
# User Interface




## Page Flow

Dashboard page
Data page
Optimization Page
Status Page
Admin Page (for admin user only)

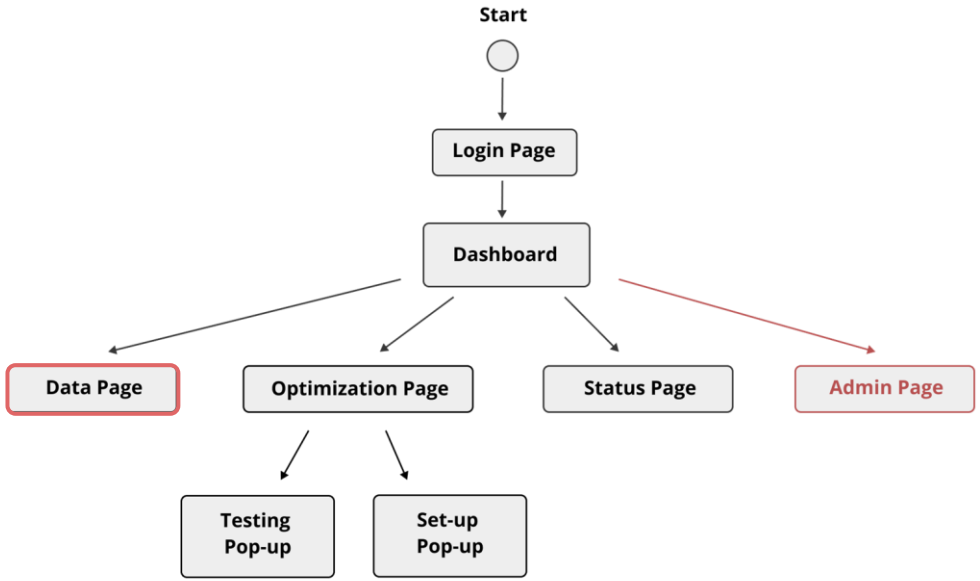
# User Interface




## Dashboard

**Inventory Management**
Asset Management
Live Price Monitoring
Report and recommendation

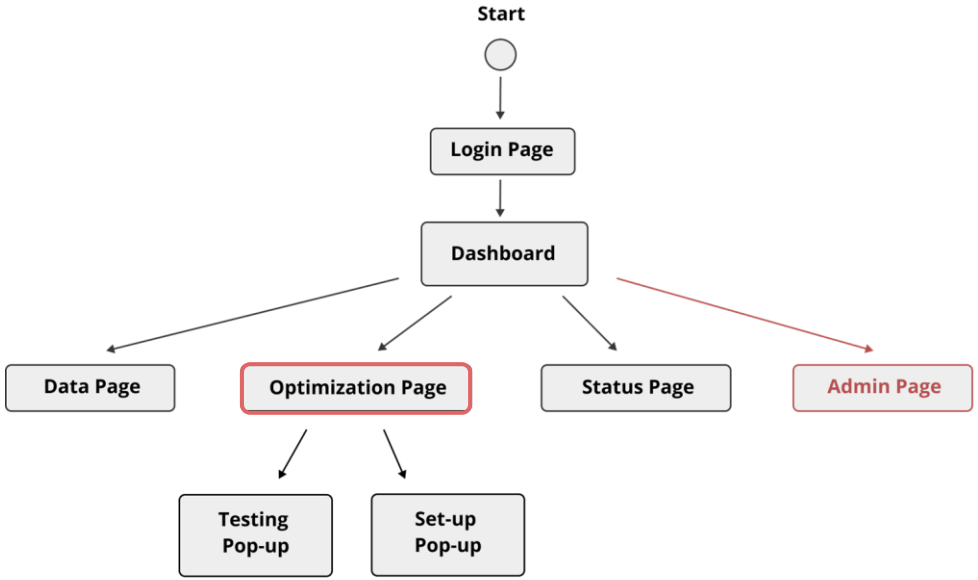
# User Interface




## Data Page

**Data Management**
Update data file
View/Edit data file
Export data file

# User Interface

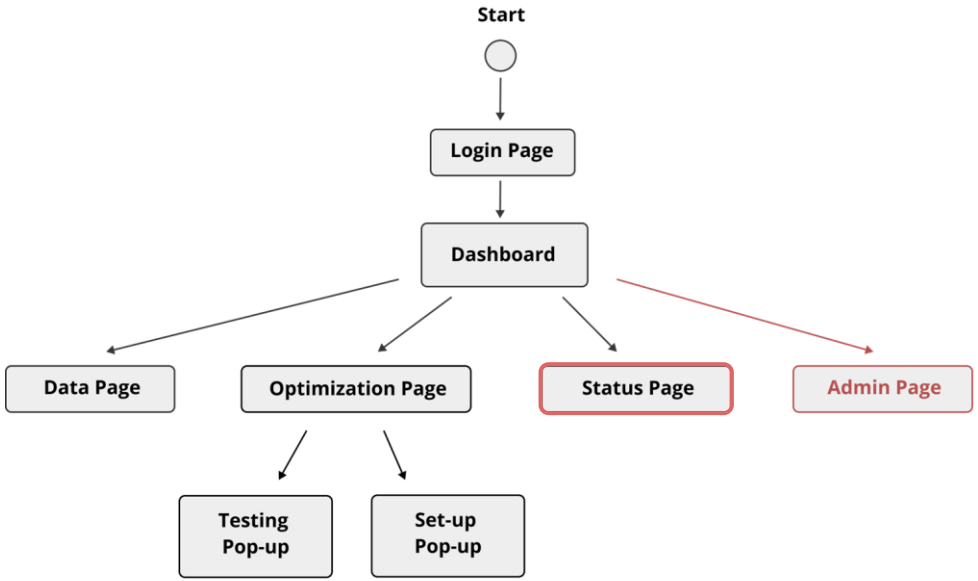



## Optimization Page

**Simulation Model**
Select Scenario
Set Constraints
Save Simulation output
Testing on temporary file

**Supporting Features**
Set new Scenarios
Adjust parameter values

# User Interface



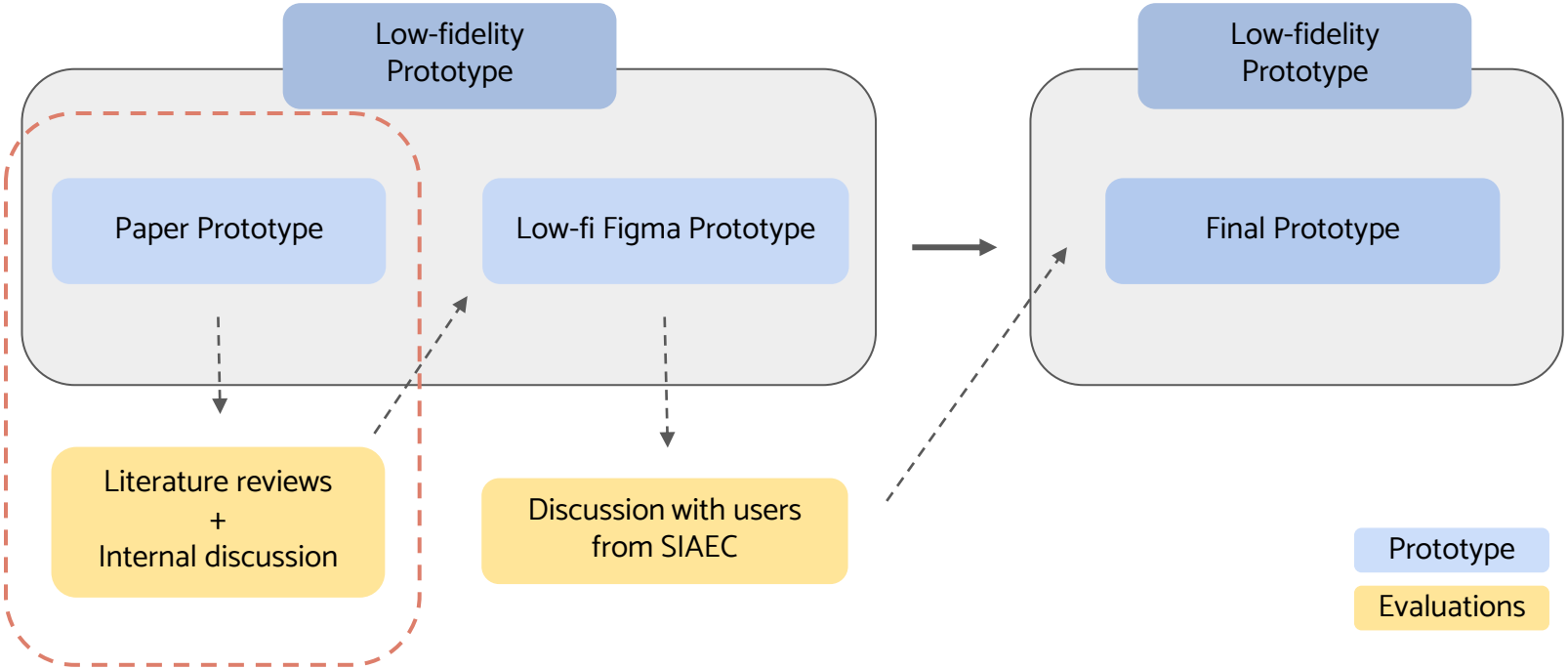

## Status Page

**Managing Reports**
View/delete/publish report
Export report files

**Sharing of Results**
Export published report files
View published reports by other users

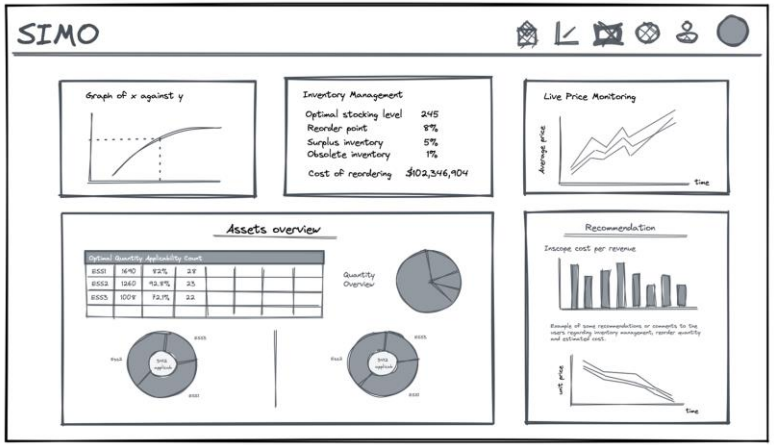
# User Interface

## Prototypes Iterations

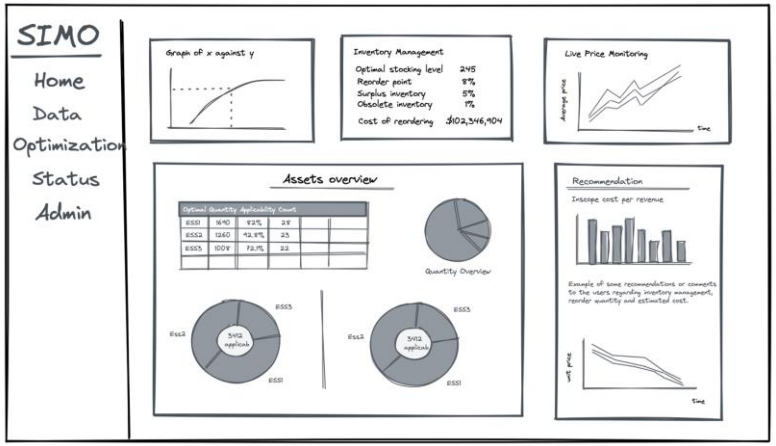


# User Interface

## Navigation Bar[13]




Top Navigation Bar

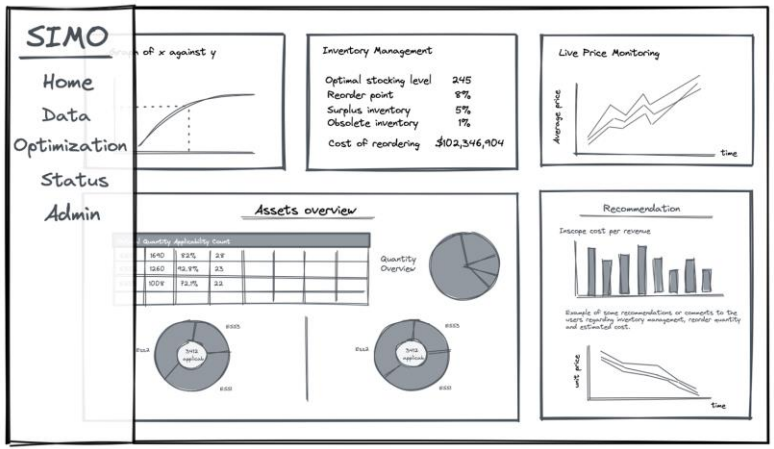



Left Navigation Bar

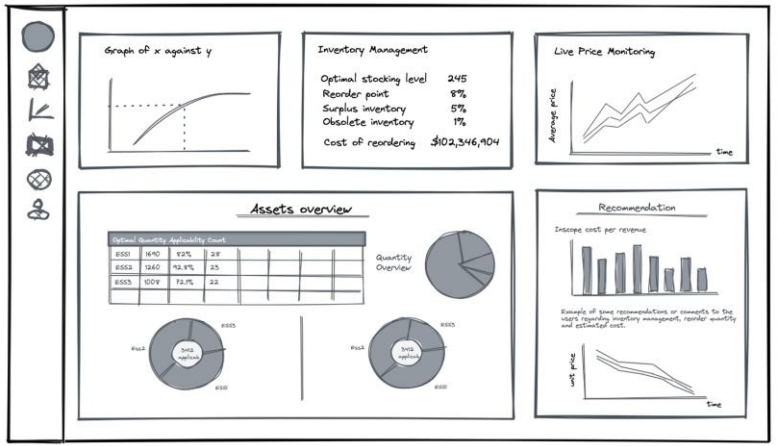
# User Interface

## Navigation Bar

### Open



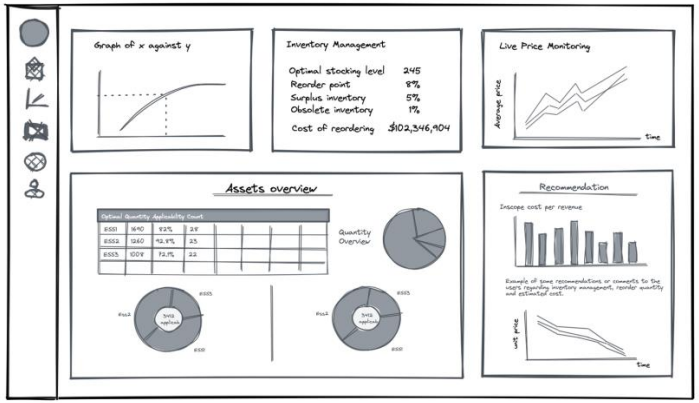

### Collapsed




## Collapsible Left Bar

# User Interface

## Improved Dashboard



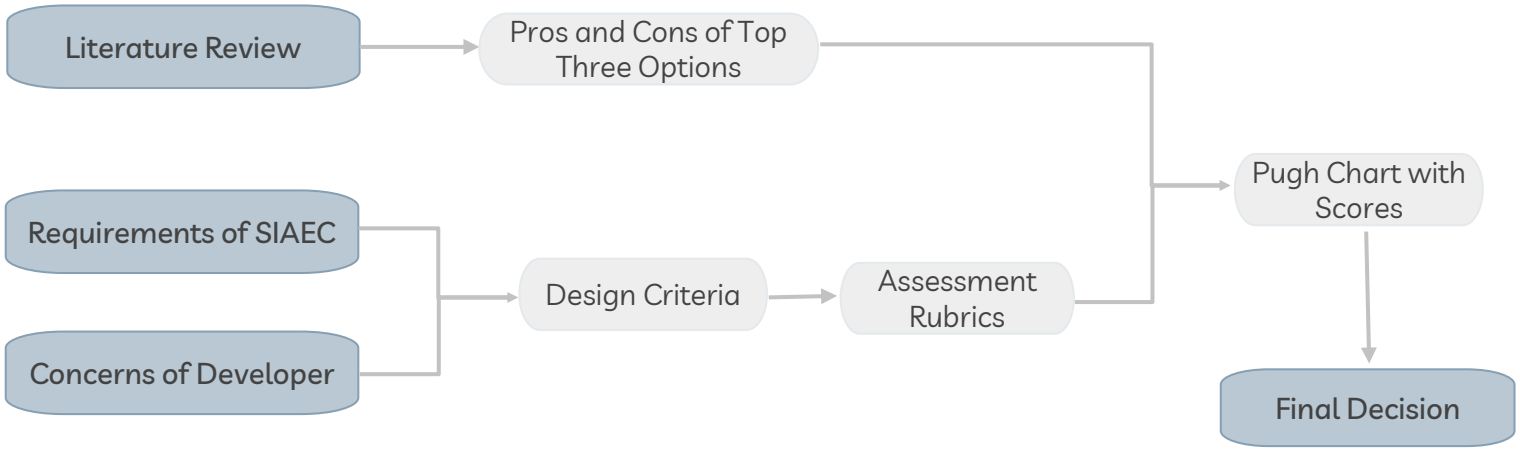

- Conceptual Model
- Explore Various Alternative
- Consolidate Screen Contents
- Functionality
- Navigation & Task flow
- Terminology

# Tech Stack

Frontend
Backend
Database Service

# General Approach

For frontend, backend, and database exploration



# Frontend Framework

| Design Criteria | Alternative Design Concepts | | |
|---|---|---|---|
| | React | Angular | Vue |
| Ease of Learning | + | - | - |
| Performance | + | - | + |
| Applicability of Features | + | + | 0 |
| **Total** | **+++** | **-** | **0** |

** Further explanation of the Criteria used and assessment Rubrics can be find in Annex 1.4*

# Frontend Framework

| | React | Angular | Vue |
|---|---|---|---|
| **Ease of Learning** | + | - | - |

- Familiarity to framework

| React | Angular | Vue |
|---|---|---|
| Some team members have prior experience | No team members has experience | No team members has experience |

Pros

Cons

# Frontend Framework

| | React | Angular | Vue |
|---|---|---|---|
| **Performance[14]** | + | - | + |
| • Rendering speed<br>• Response speed | Only re-render when needed | MVC structure* allows separation of tasks | Bundle size and Tree-shaking |
| | Support server-side rendering | Slower response due to the number of features | Code splitting |
| | Virtual DOM* increases performance | | |

Pros

Cons

*Virtual DOM: Virtual Document Object Model;
*MVC structure: Model-View-Controller Structure

# Frontend Framework

| | React | Angular | Vue |
|---|---|---|---|
| **Applicability of Features[14]** | + | + | 0 |
| • Number of relevant features | Reusable components | Modular development | Template Syntax |
| | Unidirectional data flow | Code conventions | Track dependencies |
| | Changeable state | Real-time synchronization | |

Pros

Cons

# Frontend Framework

| Design Criteria | Alternative Design Concepts | | |
|---|---|---|---|
| | React | Angular | Vue |
| Ease of Learning | + | - | - |
| Performance | + | - | + |
| Applicability of Features | + | + | 0 |
| **Total** | **+++** | **-** | **0** |

** Further explanation of the Criteria used and assessment Rubrics can be find in Annex 1.4*

# Backend Framework

| Design Criteria | Alternative Design Concepts | | |
|---|---|---|---|
| | Golang Gin | Express.js | Django |
| Ease of Learning | - | + | 0 |
| Ease of Implementation | 0 | - | + |
| Performance | 0 | - | + |
| **Total** | **-** | **-** | **++** |

** Further explanation of the Criteria used and assessment Rubrics can be find in Annex 1.5*


Express JS

django

# Backend Framework

| | Golang Gin | Express.js | Django |
|---|---|---|---|
| **Ease of Learning** | - | + | 0 |

- Familiarity to framework
- Available learning resources

| | | |
|---|---|---|
| Relative small community | Available learning resources | Available learning resources |
| Relative bad documentation | Some team members have experience | No team members has experience |

Pros

Cons

# Backend Framework

| | Golang Gin[15] | Express.js[16] | Django[17] |
|---|---|---|---|
| **Ease of Implementation** | 0 | - | + |
| • Code size<br>• Flexibility | Syntax is relatively easy to learn | Same language for both frontend and backend | Readymade packages |
| | Easy to create middlewares | Heavy code changes due to unstable API | Model View Template |
| | Low reusability of code due to no OOP* | Callback functions are hard to read but needed | Lack of code conventions |

Pros

Cons

*OOP: Object-Oriented Programming

# Backend Framework

| | Golang Gin[18] | Express.js[16] | Django[19] |
|---|---|---|---|
| **Performance** | 0 | - | + |
| • Response time<br>• Processing speed | Radix tree | Event-driven | MTV Architecture |
| | Built to handle concurrent tasks | Unable to handle CPU intensive task | Same language as our optimization model |
| | Hard to integrate with optimization model (Python) | | |

Pros

Cons

# Backend Framework

| Design Criteria | Alternative Design Concepts | | |
|---|---|---|---|
| | Golang Gin | Express.js | Django |
| Ease of Learning | - | + | 0 |
| Ease of Implementation | 0 | - | + |
| Performance | 0 | - | + |
| **Total** | **-** | **-** | **++** |

** Further explanation of the Criteria used and assessment Rubrics can be find in Annex 1.5*


Express JS

django

# Database Service

| Design Criteria | Alternative Design Concepts | | |
|---|---|---|---|
| | Firebase | AWS RDS (Relational Database Service) | MongoDB Atlas |
| **Performance** | - | + | + |
| **Applicability of Features** | - | + | 0 |
| **Cost-Efficiency** | - | 0 | 0 |
| **Total** | **---** | **++** | **+** |

** Further explanation of the Criteria used and assessment Rubrics can be find in Annex 1.6*

# Database Service

| | Firebase | AWS RDS (Relational Database Service) | MongoDB Atlas |
|---|---|---|---|
| **Performance**[20] | - | + | + |
| • Query speed<br>• Concurrency capabilities | Inefficient for complex queries | Instant provisioning and auto scaling with EC2* | Sharding for cloud-base storage |

Pros

Cons

* EC2: Elastic Compute Cloud

# Database Service

| | Firebase | AWS RDS (Relational Database Service) | MongoDB Atlas |
|---|---|---|---|
| **Applicability of Features[21]** | - | + | 0 |
| Pros | Non-Relational | Data Replication (High Availability) | Data Replication (High Availability) |
| | | Robust Security Support | Dynamic Schemas |
| | | Convenient integration with AWS Redshift | Limited document size |
| Cons | | Only vertical scaling which is costly | Non-Relational |

- Number of relevant features

# Database Service

| | Firebase | AWS RDS (Relational Database Service) | MongoDB Atlas |
|---|---|---|---|
| **Cost-Efficiency** | - | 0 | 0 |
| • Monthly expenditure | > SGD 300 | Between SGD 100 -300 | Between SGD 300 - 100 |

Pros

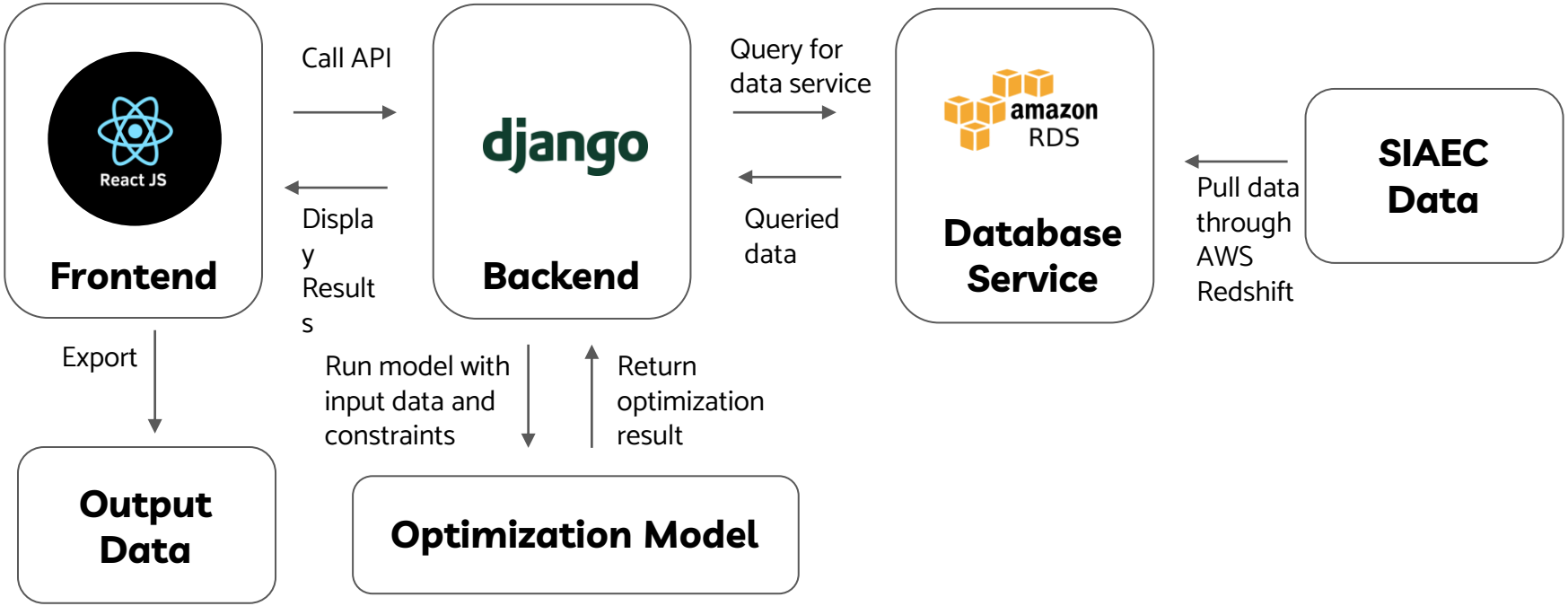
Cons

# Database Service

| Design Criteria | Alternative Design Concepts | | |
|---|---|---|---|
| | Firebase | AWS RDS (Relational Database Service) | MongoDB Atlas |
| **Performance** | - | + | + |
| **Applicability of Features** | - | + | 0 |
| **Cost-Efficiency** | - | 0 | 0 |
| **Total** | **---** | **++** | **+** |

** Further explanation of the Criteria used and assessment Rubrics can be find in Annex 1.6*

# Web Application Architecture Summary



# Risk Assessment

**Consequence Frequency Matrix**
**Potential Risk & Precautions**
**EHS**

# Consequence-frequency Matrix[22]

| | | Impact | | |
|---|---|---|---|---|
| | | Small | Moderate | High |
| Frequency | Very High | | | |
| | High | | | |
| | Medium | | Inaccurate Data Entry | Inaccurate Forecasting |
| | Low | | Server Failure | Data Loss<br>Security Breach |

# Potential Risk and Precautions

| Event | Consequences | Mitigations |
|---|---|---|
| **Inaccurate Forecasting** | Potential increase in investment costs for SIAEC, leading to over provisioning | Writing test cases for algorithms |
| **Inaccurate Data Entry** | Inaccurate data displayed<br>Decisions made based on incorrect data | Input validation |
| **Security Breach** | Stolen data<br>Web application down | Follow the latest established security practices |
| **Data Loss** | Loss of valuable company data<br>Web application unable to function | Data loss is hence mitigated by measures implemented by the cloud provider such as data replication |
| **Server Failure** | Web application would be down. | Will be using cloud service. Only physical disasters or virus attacks can result in a server failure |

Low Risk
Moderate Risk
Moderate High Risk
High Risk

** More details can be found in Annex 1.7*

# Environment, Health & Safety

| Safety | Sustainability |
| --- | --- |
| Security of Database | Ease of maintenance and update |
| Availability of service | Vulnerability of open source library |
| Confidentiality of user info | Flexibility to respond to future changes |

# Project Management

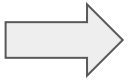
**Limitations due to Covid-19**
**Project Task Allocation**
**Project Schedule**
**Budget Allocation**

# Limitations due to COVID-19

**Limitations**

- Easy to fall ill

- Shortened working hours



**Solution**

- Clear Objectives

- Delegation of tasks

# Project Task Allocation

| Responsibility Matrix (Exploration and Design Phase for Prototype) | | | | | | | R - Responsible | S - Supporting |
|---|---|---|---|---|---|---|---|---|
| | Task | Justin | Olivia | Kairan | Chester | YuYing | Devid | Wenqi |
| 1 | UI/UX design | S | R | | | | | |
| 2 | Database Schema | R | | R | S | | S | R |
| 3 | Data Cleaning | R | | R | | | | R |
| 4 | Data Integration | R | | R | | | | |
| 5 | Operations Research | | | | S | R | S | |
| 6 | Risk Management | R | | | R | | | |
| 7 | Project Management | R | | | R | | | |
| 8 | Updating of schedule | S | | | R | | | |
| 9 | Updates to budget | | R | | | | R | |
| 10 | Report | S | S | S | S | R | R | S |
| 11 | Slides | S | R | S | S | S | S | S |
| 12 | Exploration for frontend | S | R | | | | | |
| 13 | Exploration for database | R | | S | | | | |
| 14 | Exploration for backend | S | | R | | | | |
| 15 | Exploration for system architecture | S | | R | | | | |

# Project Schedule

| March | | | | | April | | | | May | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Concept and application selection | | | | | | | | | | | | |
| | Wireframe for UI | | | | | | | | | | | |
| | Research theory and application | | | | | | | | | | | |
| | Formulation and completion of Just In Time Provisioning | | | | | | | | | | | |
| | | Database Planning | | | | | | | | | | |
| | | Frontend and Backend Exploration | | | | | | | | | | |
| | | | Review 2 Report and Slides | | | | | | | | | |
| | | | Just in Time Provisioning | | | | | | | | | |
| | | | | | Asset Management | | | | | | | |
| | | | | | | | | | Frontend and Backend Implementation, Testing | | | |
| | | | | | | | | | Price Monitoring System | | | |

# Project Schedule

| June | | | | July | | | | August |
|---|---|---|---|---|---|---|---|---|
| Frontend and Backend Implementation Testing | | | | | | | | |
| Price Monitoring System | | | | | | | | |
| Review 3 slides | | | | | | | | |
| Model Fine Tuning | | | | | | | | |
| | | | | Deploy Frontend and Backend | | | | |
| | | | | | User Testing | | | |
| | | | | Final Report and software documentation | | | | |
| | | | | | | Poster and summary of analysis result | | |
| | | | | | | | | Exhibition and Final Presentation |

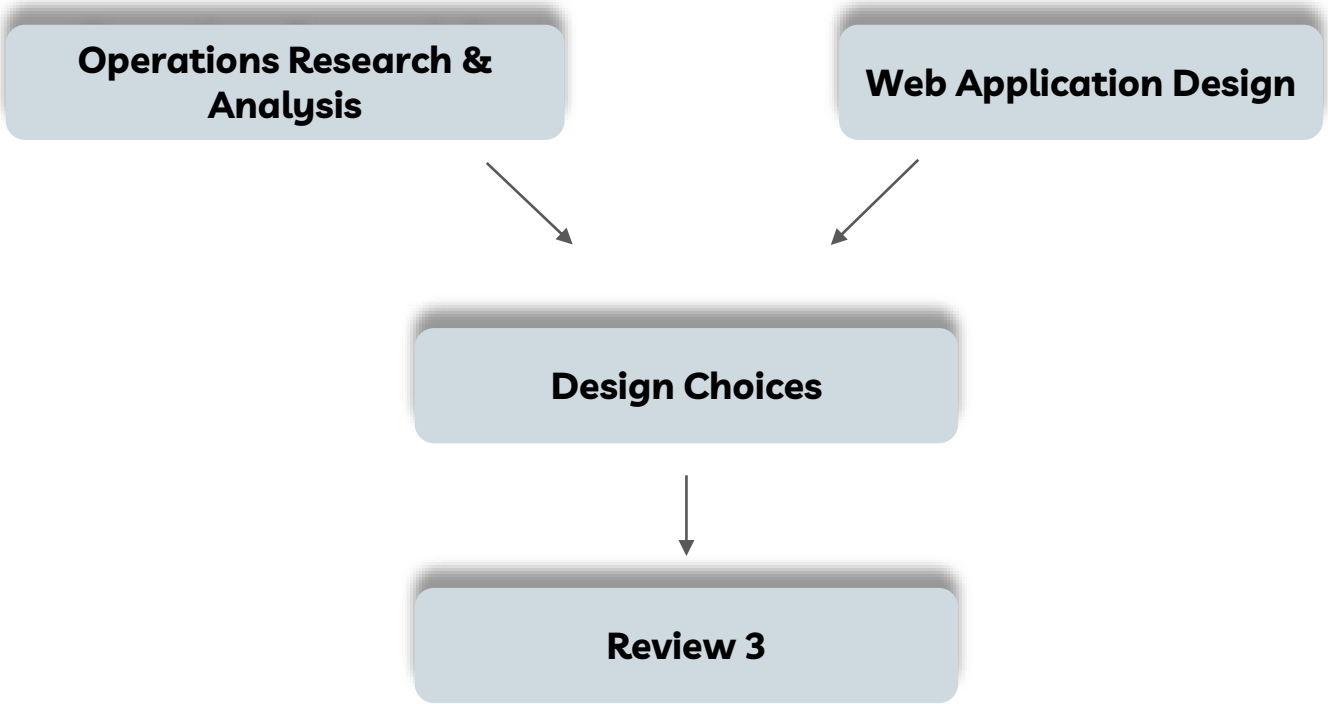
# Budget Allocation

| Expected Expenditure (SGD) | May | Jun | Jul | Aug |
|---|---|---|---|---|
| Tools | | | | |
| Jira | 52.50 | 52.50 | 52.50 | 52.50 |
| Softwares | | | | |
| RDS | 200 | 200 | 200 | 200 |
| EC2 | 287.50 | 287.50 | 287.50 | 287.50 |
| Cloudfront | 0 | 0 | 0 | 10 |
| SSL Cert | 0 | 0 | 0 | 25 |
| Transportation | | | | |
| Taxi | 100 | 100 | 100 | 100 |
| **Total Expenditure** | **590** | **590** | **590** | **625** |

| | May | Jun | Jul | Aug |
|---|---|---|---|---|
| Total Fund Available (SGD) | 4,000 | 3,410 | 2,820 | 2,230 |
| Total Expenditure (SGD) | 590 | 590 | 590 | 625 |
| **Total Fund Remaining (SGD)** | **3,410** | **2,820** | **2,230** | **1,605** |

# Conclusion

# Conclusion


Operations Research & Analysis
Web Application Design
Design Choices
Review 3

# Q&A

# Reference

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## Design Credit

**Presentation template by Slidesgo**

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https://www.123rf.com/photo_36638346_modern-notebook-computer-with-future-technology-media-symbols.html

# Annex

# Annex 1.1

## Short-term Provisioning

| Criteria\Score | - | 0 | + |
|---|---|---|---|
| **Data Requirement** | The method requires a few years of historical data | The method requires a few months a historical data | The method requires a month worth of historical data |
| **Accuracy** | The method produces poor accuracy result | The method produces acceptable accuracy result | The method produces exceptional accuracy result |
| **Time** | The method requires a lot of time to implement | The method uses moderate amount of time to implement | The method requires very little time to implement |
| **Ease of implementation** | The method is computationally intensive with many mathematical equations and concepts | The method is moderately easy to implement with fair amount of mathematical equations and concepts | The method is easy to implement with little mathematical equations and concepts |

# Annex 1.2

## Price Monitoring System (Price Acquisition)

| Criteria\Score | - | 0 | + |
|---|---|---|---|
| **Affordability** | Software costs more than SGD 100 | Software costs less than SGD 100 | This software is free to use |
| **Ease of Integration** | Software is difficult to integrate relative to the other alternatives | Software is reasonably difficult to integrate relative to the other alternatives | Software is easy to integrate relative to the other alternatives |
| **Adaptability** | Requires major tuning whenever website is changed relative to the other alternatives | Requires moderate tuning whenever website is changed relative to the other alternatives | Requires little to no tuning whenever website is changed relative to the other alternatives |

# Annex 1.3

## Price Monitoring System (Price Forecasting)

| Criteria\Score | - | 0 | + |
|---|---|---|---|
| **Data Requirement** | The method requires a few years of historical data | The method requires a few months a historical data | The method requires a month worth of historical data |
| **Accuracy** | The method produces poor accuracy result | The method produces acceptable accuracy result | The method produces exceptional accuracy result |
| **Time** | The method requires a lot of time to implement | The method uses moderate amount of time to implement | The method requires very little time to implement |
| **Ease of implementation** | The method is computationally intensive with many mathematical equations and concepts | The method is moderately easy to implement with fair amount of mathematical equations and concepts | The method is easy to implement with little mathematical equations and concepts |

# Annex 1.4

## Frontend Framework

| Criteria\Score | - | 0 | + |
|---|---|---|---|
| **Ease of Learning** | All team members have no prior knowledge with the framework | Some team members have some prior knowledge with the framework | Every members have prior experience with the framework |
| **Performance** | Has slow rendering speed, slower response speed with increased number of features relative to the other alternatives | Has a moderate rendering speed, no significant reduction in response speed with increased number of features relative to the other alternatives | Has fast rendering speed, no significant reduction in response speed with increased number of features relative to the other alternatives |
| **Applicability of Features** | Offers few relevant features fulfilling the needs and constraint of the project relative to the other alternatives | Offers some relevant features fulfilling the needs and constraint of the project relative to the other alternatives | Offers many relevant and useful features fulfilling the needs and constraint of the project relative to the other alternatives |

# Annex 1.5

## Backend Framework

| Criteria\Score | - | 0 | + |
|---|---|---|---|
| **Ease of Learning** | All team members have no experience with the framework, few learning resources available | All team members have no experience with the framework, some learning resources available | Some team members have experience with the framework, some learning resources available |
| **Ease of Implementation** | Framework requires a lot of code, rigid in implementation | Framework requires a moderate amount of code, relatively flexible in implementation | Framework requires a moderate amount of code, flexible in implementation |
| **Performance** | Slow response time relative to the other alternatives | Moderate response time relative to the other alternatives | Fast response time relative to the other alternatives |

# Annex 1.6

## Database Service

| Criteria\Score | - | 0 | + |
|---|---|---|---|
| **Performance** | Slow reads and writes with poor concurrency capabilities relative to the other alternatives | Fast reads and writes with moderate concurrency capabilities relative to the other alternatives | Fast reads and writes with good concurrency capabilities relative to the other alternatives |
| **Applicability of Features** | Has few relevant features offered by service provider relative to the other alternatives | Has some relevant features offered by service provider relative to the other alternatives | Has many relevant and useful features offered by service provider relative to the other alternatives |
| **Cost-Efficiency** | Monthly expenditure is above SGD 300 | Monthly expenditure is between SGD 300 and SGD 100 | Monthly expenditure is below SGD 100 |

# Annex 1.7

## Potential Risk and Precautions

| Event | Description | Consequences | Mitigations |
|---|---|---|---|
| **Inaccurate Forecasting** | Caused by the algorithm's inaccuracy to forecast out the optimal number of parts for SIAEC to provision or to keep as active stock | Potential increase in investment costs for SIAEC, leading to over provisioning | Writing test cases for algorithms |
| **Inaccurate Data Entry** | Data input into the database is wrong | Inaccurate data displayed<br>Decisions made based on incorrect data | Input validation |
| **Security Breach** | Caused by human error and loopholes in software. | Stolen data<br>Web application down | Follow the latest established security practices |
| **Data Loss** | Caused by human error, viruses, natural disasters, power failure | Loss of valuable company data<br>Web application unable to function | Data loss is hence mitigated by measures implemented by the cloud provider such as data replication |
| **Server Failure** | Caused by disk failure, virus attack, failed updates and physical disasters | Web application would be down. | Will be using cloud service. Only physical disasters or virus attacks can result in a server failure |