

Smart Inventory Management & Optimization (SIMO)

Review 1
Project S34



SINGAPORE UNIVERSITY OF
TECHNOLOGY AND DESIGN





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1. Background
2. Problem framing
3. Needs and constraints
4. Design direction
5. Project management





Background

Background

Problem
Framing

Needs &
Constraints

Design
Direction

Project
Management



Singapore Airlines Engineering Company (SIAEC)¹



Maintenance, Repair and Overhaul Provider



Extensive services for
>> 60 airlines



Integrated Solutions



Ensuring punctuality for takeoffs



Asset Management Department

- Collate data from various vendors
- Assess orders from various customers
- Provision aircraft parts quantities

Inventory Classes

Annex 1



Repairables



Rotables



Expendables



What are Rotables?

- Aircraft components which can be removed, replaced or inspected at intervals²
- Consists of a significant percentage in a typical commercial aircraft (~80-90%)
- Servicing frequency measured in flight hours and/or flight cycles²
- Defects are sent for repair and will be subsequently re-used²
- Bulky, costly, high level of maintenance



Engine Frame



Engine Turbine



Brake Discs



Operations Overview (Stakeholders)



Customers'
Aircraft Fleet



SIA Engineering
Company



Vendor



SIAEC Warehouse

Operations Overview (Breakdown)



**Customers'
Aircraft Fleet**

Aircraft rotables brought
in for replacement

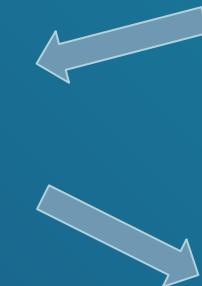


**SIA Engineering
Company**



Operations Overview (Breakdown)

Loaning on short notice
(Optional)



SIAEC Warehouse

Provide supplies and
Conduct Repairs



Vendor



**SIA Engineering
Company**

Background



Operations Overview (Breakdown)

Once completed, the
planes are fit for Flight



SIA Engineering
Company



Customers'
Aircraft Fleet



Problem Framing

Background

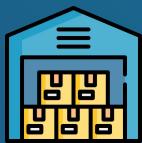
**Problem
Framing**

Customer's
Needs & Constraints

Design
Direction

Project
Management

Focus Area



SIAEC Warehouse



Vendor



SIA Engineering
Company



Customers'
Aircraft Fleet

Current Solutions (Simplified)



Using Microsoft
Excel



Standardized
Formulas



Pre-set Scenarios



Output Result



Problem Framing

The current method of provisioning rotables is **manual** and **prone to human error**, and it impedes SIAEC's ability to expand their business. Moreover, the current formulation used for rotable provisioning is **standardized** for all types of aircraft rotables **regardless of their importance levels**, causing the rotable provisioning to be highly **inaccurate**.



Project Significance



Overprovisioning
of Rotables



Bulky & Housing
Constraints



Expensive &
Costly



3

Needs and Constraints

Background

Problem
Framing

Needs &
Constraints

Design
Direction

Project
Management





Methodology

Needs & Constraints



01
Interview

02
Direct end-users

03
Empathy map

04
Journey map



01: Interview

Who

Senior Manager Team &
Company Mentor

Department

Asset Management



Aim

To empathize with
clients based on their
current work processes

Method

Ask for big overview and
narrow down the
questions

Requirements

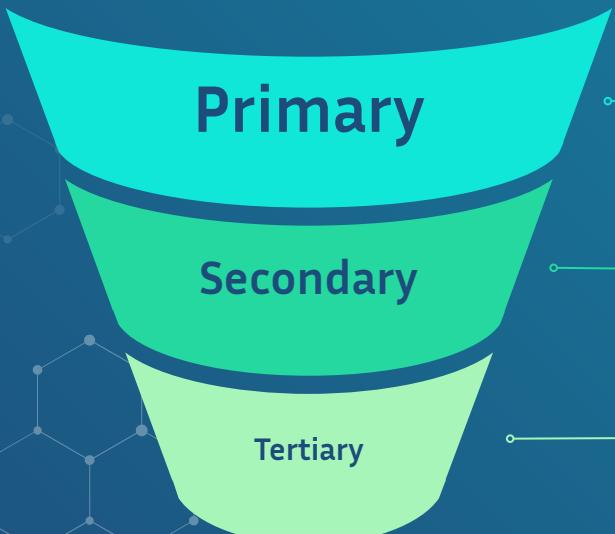
* Priority according to SIAEC

High



- Web-Based Application
- To optimize the current inventory model
- To recommend active assets to hold
- To monitor market pricing of spare parts
- To evaluate performance of vendors

Stakeholders



Asset Management Department

Repair Shop Department, Finance
Department

Passengers, Crews

02: Direct-End Users

Emily Earl



Singapore



Senior Asset Manager

Frustrations

- Not user-friendly
- Slow and laggy
- Prone to errors

John Doe



Singapore



Junior Analyst

Frustrations

- Too manual data input
- Long time to process data

03: Empathy Map (Manager)

Feel

Overwhelmed

Not optimised
& not efficient

Say



Think

What is best for me?

Very
Unorganised
See

03: Empathy Map (Junior Analyst)

Feel

Anxious &
Stressed

Think

So tiring to do
manual work



Very painful

Say

Too cluttered

See

Needs & Constraints

04: Journey Map

Data Calculation

01

Data Gathering

02

03

Scenario-Based
Simulation

Result Analysis

04

Data Gathering

Typical Questions

1

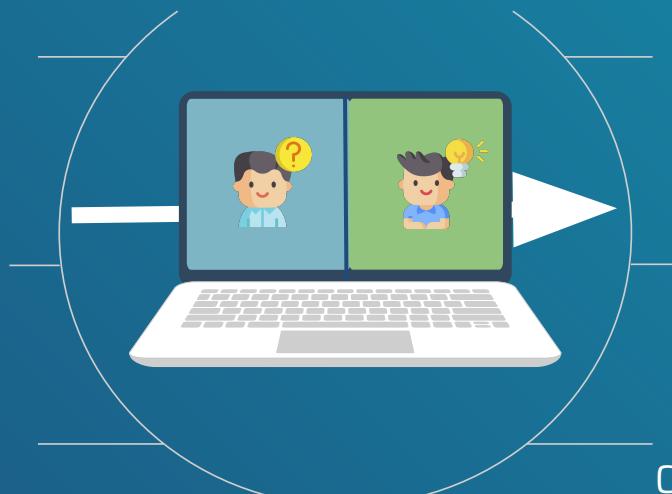
Sources of data
and how to
access?

2

Combine data
files?

3

How do I make
sure the data is
correct?



Opportunities

1

Instruction
Manual

2

Database
Management

3

Error and
Conflict Checking

Data Calculations

Typical Questions

1

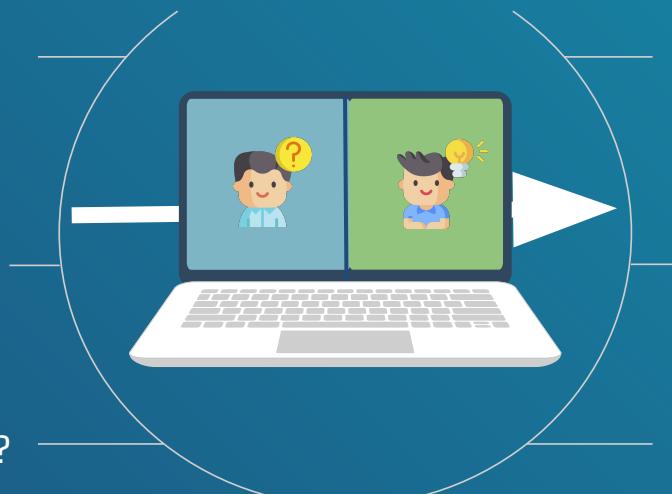
Too many data to calculate?

2

Is the result expected?

3

Optimized further?



Opportunities

1

Parallel Computing

2

Comparison with Historical Result

3

Advanced Tools
(e.g. Machine Learning)



Scenario-Based Simulation

Typical Questions

1

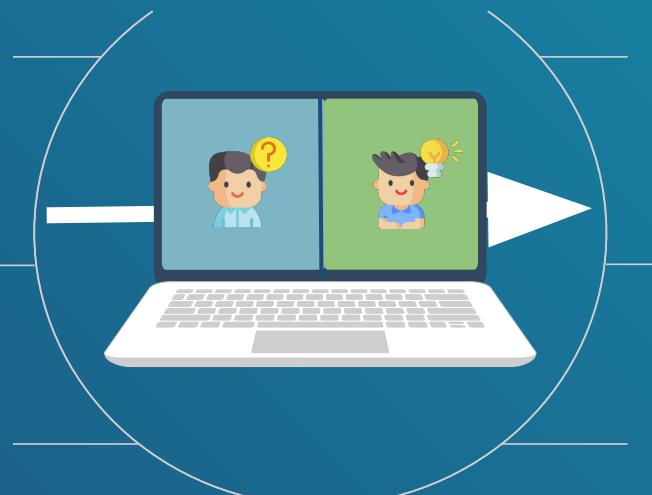
What are the scenarios?

2

Which scenarios are similar to the current one?

3

How do I share the simulations?



Opportunities

Preloaded Scenarios

1

Store and View Past Scenarios

2

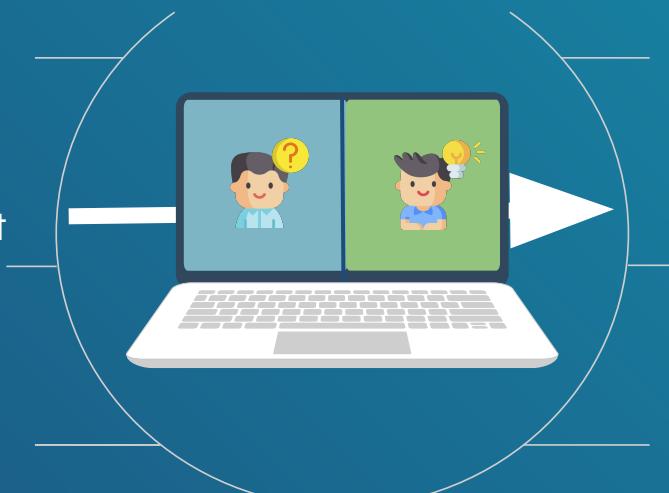
Easy Export and Import of Data

3

Result Analysis

Typical Questions

- 1 What does the clients want to know?
- 2 What is the insight of the result?
- 3 What do I use the result for?



Opportunities

Report Generation

Result Summary
(e.g. Five-number summary)

Data Visualization

1

2

3

Priority of Needs - Criteria Definition



Cost Saving

Able to make use of free open source tools?



Usefulness

Able to improve user experience?



Urgency

A prioritized need according to SIAEC?



Feasibility

Able to be done considering the time limit and our ability based on research?

Priority of Needs

	Instruction Manual	Database Management	Report Generation	Error & Conflict Checking	Pre-loaded Scenarios	Store and View Past Scenarios
Cost Saving						
Usefulness						
Urgency						
Feasibility						
Priority			1st			2nd

Priority of Needs

	Result Summary	Easy Export and Import of Data	Data Visualization	Comparison with Historical Data	Parallel Computing	Support Advanced Tool
Cost Saving						
Usefulness						
Urgency						
Feasibility						
Priority			2nd			3rd

More considerations...

- Scalability
- Duration of project
- To handle concurrent accessing
- To integrate with company's data source platforms (SAP, excel, etc)
- To ensure data is constantly up to date

Constraints



Safety

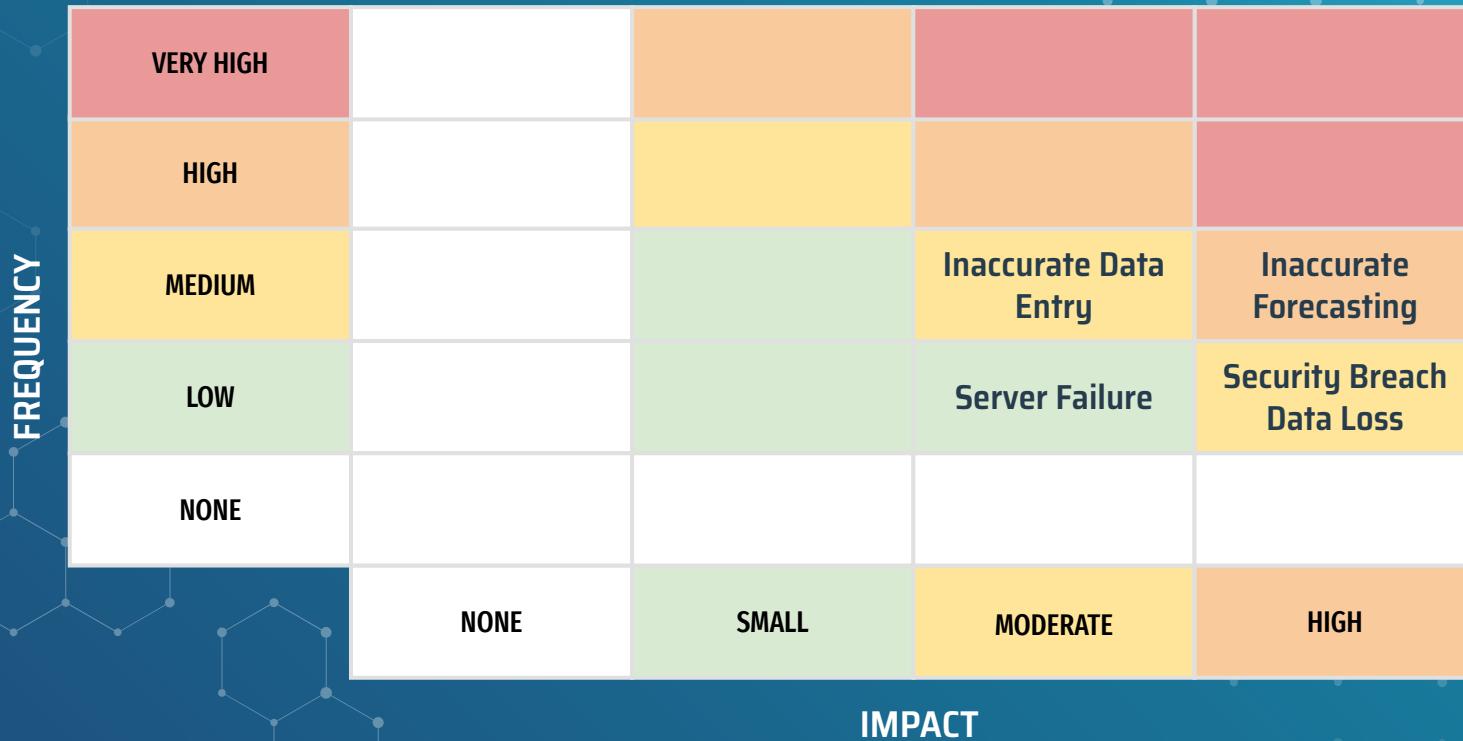
- Security of database
- Availability of service
- Confidentiality of user info



Sustainability

- Ease of maintenance and update
- Vulnerability of open source library
- Flexibility to respond to future changes

Risk Assessment



Problem Statement

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



Design Direction

Background

Problem
Framing

Needs &
Constraints

**Design
Direction**

Project
Management

Design Direction: Research Findings

Research Findings



1. Inventory model³



- Simple application of **inventory model** in excel
- Example: Stationary Poisson Process
- **Cheap** to implement
- Only suitable for **small businesses**

2. Virtual warehouse simulation⁴



- Simulates **spare part failures**
- **Long hours** to run, but **highly accurate**
- **50% reduction** in inventory stored, while meeting all demands

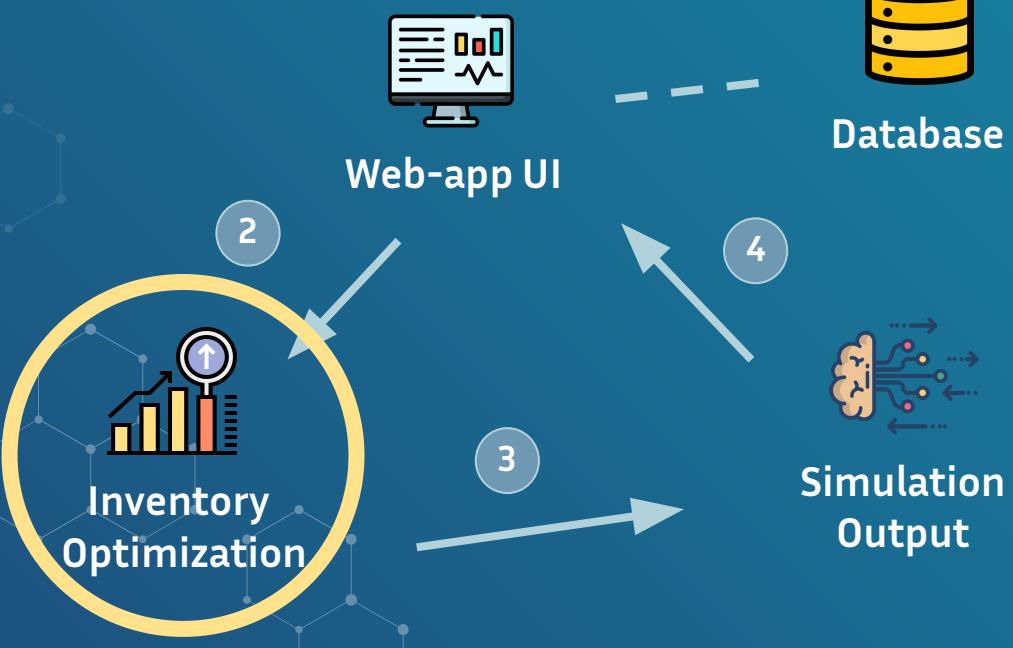
3. Lokad (Supply Chain Optimization App)⁵



- Integration of **analytics, machine learning & supply chain expertise**
- Surpasses many of the **traditional** software companies

Design Direction: Ideation

Design Direction: Overview



Database



Excel data

**Inventory
Optimization**



Simulation

**Machine
Learning**

**Inventory
Modelling**



Inventory modelling



"All models are wrong but some are useful"
-George E.P. Box

1

Process of describing an ***inventory system*** in ***mathematical terms***⁶
(Outputs: when, & how many to order?)

2

Goal of ***minimizing cost while***
achieving ***high satisfactory*** levels of
customer service⁶

3

Existing Inventory models:
E.g. (Q,r) model, Economic Order
Quantity (EOQ) model, Base-stock
model⁷

Inventory modelling



Identifying Inventory Type

Understanding Inventory Type

Understanding inventory flow + Data availability

Identifying + Extending useful models

Generate Output: Optimal stock

Inventory modelling: Limitations

1

Might be **challenging** to build an inventory model that accounts for **all** complexities of project

2

Difficult to account for real-life **uncertainties**, requires simplification

3

Accuracy of outputs **highly dependent** on the accuracy of inputs -> more **advanced** approach should be used to produce **more accurate inputs** for inventory model

Inventory Optimization

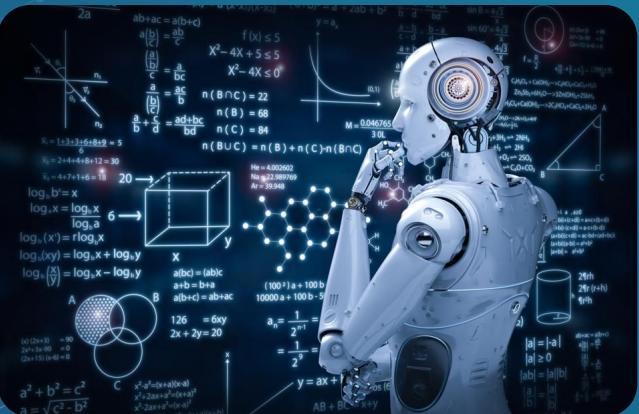


Inventory
Modelling

Machine
Learning

Simulation

Machine Learning⁸



"Data is a new science. Big data holds the answers"

-Pat Gelsinger (Intel CEO)

1

Supervised Learning
Random forest, Regression, KNN, etc

2

Unsupervised Learning
PCA, K-means clustering, etc

3

Reinforced Learning
Markov Decision Tree



7 Steps in Machine Learning⁹



Machine Learning

PROS

Precise & Accurate

Keep Improving

CONS

Complex

Time-Consuming



The algorithm is only as good as the data being used.

Inventory Optimization



Simulation

**Inventory
Modelling**

**Machine
Learning**



Simulation and Modelling



Safe



Efficient

Simulation and Modelling



Easily Verified



Easily Communicated



Easily Understood

Simulation and Modelling



1

Shows the **behavior** of a supply chain network **over time**

2

The **rules of operation** of a supply chain are **represented** in a simulation model

3

Common use for simulation¹⁰:

- Determine optimal stocking quantities
- Evaluate inventory policies
- Identify bottlenecks in a system

4

Modelling techniques¹¹:

Eg. System Dynamics, Discrete Event Simulation, Agent-based Simulation



Simulation Softwares



Simulation¹¹

PROS

Observation of time

Real world Variability

Dynamic Interactions

Actual Behaviour



CONS

Expensive
(Commercial Softwares)

Tedious & Tricky
(Open-source)

Design Direction: Web-application



Web-application



Frontend



Backend



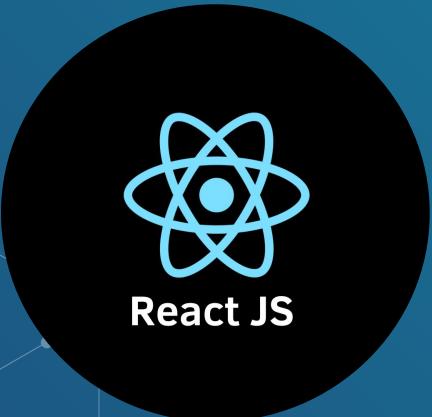
Database



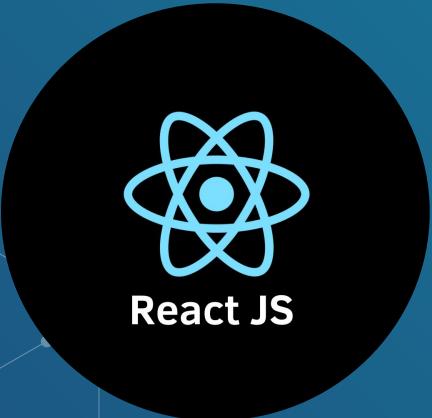
Other Tech Supports



Frontend



Frontend - React JS¹²



Pros

- Fast to develop
- Reusable Components
- Highly supported
- Experience

Cons

- Constant changes
→ resources get outdated



Frontend - Vue JS¹²



Pros

- Detailed documentation
- Simple syntax
- Dynamic and flexible

Cons

- Smaller community
- Language barrier
(Community in Chinese)

Frontend - Angular¹²



Pros

- Real-time synchronization
- Reusable components
- Highly supported

Cons

- Complex and steep learning curve

Web-application



Frontend



Backend



Database



Other Tech Supports



Backend



Backend - Golang Gin¹³



Pros

- Fast execution
- Built to handle concurrent tasks

Cons

- Codes are less reusable
- Harder to upscale/maintain

Backend - Express JS¹⁴



Pros

- Easy to learn
- Fast to develop
- Highly scalable for low processing tasks

Cons

- Reduced performance for computationally-heavy tasks

Backend - Ruby On Rails¹⁵



Pros

- Easy to learn
- Great support with many libraries

Cons

- Not flexible enough
- Long boot time
- Constant changes

Web-application



Frontend



Backend



Database



Other Tech Supports



Database



Database - AWS RDS¹⁶



Pros

- Instant scalability
- Automatic backup and recovery
- Robust security

Cons

- Queries complex to write
- Steep learning curve

Database - MongoDB¹⁷



Pros

- High speed
- Highly available data
- Flexible schema

Cons

- Limited document size
- Limited nesting of documents
- High memory usage

Database - Firebase¹⁸



Pros

- Easy to Integrate
- More database options
- Community support

Cons

- Reduced performance for computationally-heavy tasks
- Limited querying capabilities

Web-application



Frontend



Backend



Database



Other Tech Supports



Tech Stack Tools/Services

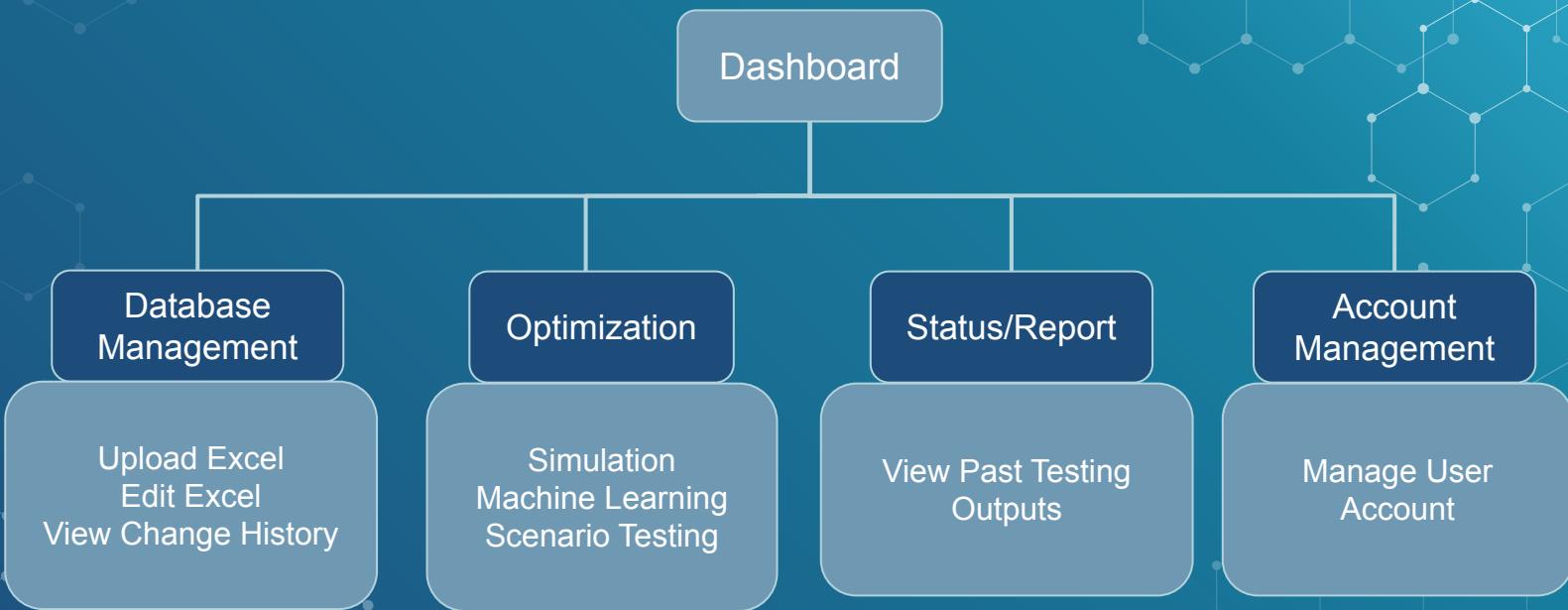
Hosting Service

Cloud Computing
Service

Reverse Proxy

SSL Certificate

Initial Design Idea





5

Project Management

Background

Problem
Framing

Needs &
Constraints

Design
Direction

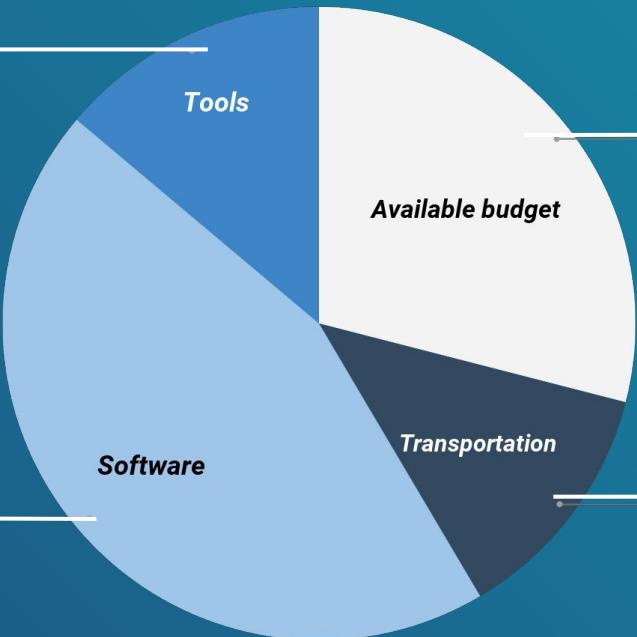
Project
Management

Project Management: Budget Allocation

Budget Allocation

Tools
13.9% (\$555)

Software
44.6% (\$1,785)



Available budget
(\$1,160) 29.0%

Transportation
(\$500) 12.5%

Detailed Breakdown Annex 3

	Review 1	Review 2	Review 3	Review 4	Total
Tools <i>Miro</i> <i>Jira</i>	-	80 105	80 105	80 105	240 315
Software <i>RDS</i> <i>EC2</i> <i>Cloudfront</i> <i>SSL cert</i>	-	-	400 475	400 475 10 25	800 950 10 25
Transportation	-	100	200	200	500
Budget (\$)	-	285	1,260	1,295	2,840

Project Management: Project Schedule

Project Scheduling Review 1

Problem framing

JAN 24th - JAN 31st

Needs and Constraints

JAN 31st - FEB 7th

Design Direction

JAN 31st - FEB 14th

Project Management

JAN 31st - FEB 28th

User-flow planning

JAN 31st - FEB 28th

Week

1

2

3

4

5

6

Project Scheduling Review 2

Concept and Application selection

MAR 7th – MAR 21th

Database Planning

MAR 14th - APR 18th

Wireframe for UI

MAR 21st - APR 18th

Basis of Simulation

MAR 21st - APR 11th

Evaluation of choices

APR 11th - APR 18th

Week

7

8

9

10

11

12



Project Scheduling Review 3

Website development

MAY 9th - JUN 20th

Refining simulation parameters

MAY 9th - MAY 30th

Machine Learning

MAY 30th - JUN 20th

Live and historical tracking

JUN 6th - JUN 20th

Week

1

2

3

4

5

6



Project Scheduling Review 4

Host Web App

JUN 20th - JUL 11th

Security of App

JUN 28th - JUL 18th

User Testing

JUL 4th - AUG 1st

Unit tests

JUL 18th - AUG 1st

Summary of analysis result

AUG 1st - AUG 14th

Week

7

8

9

10

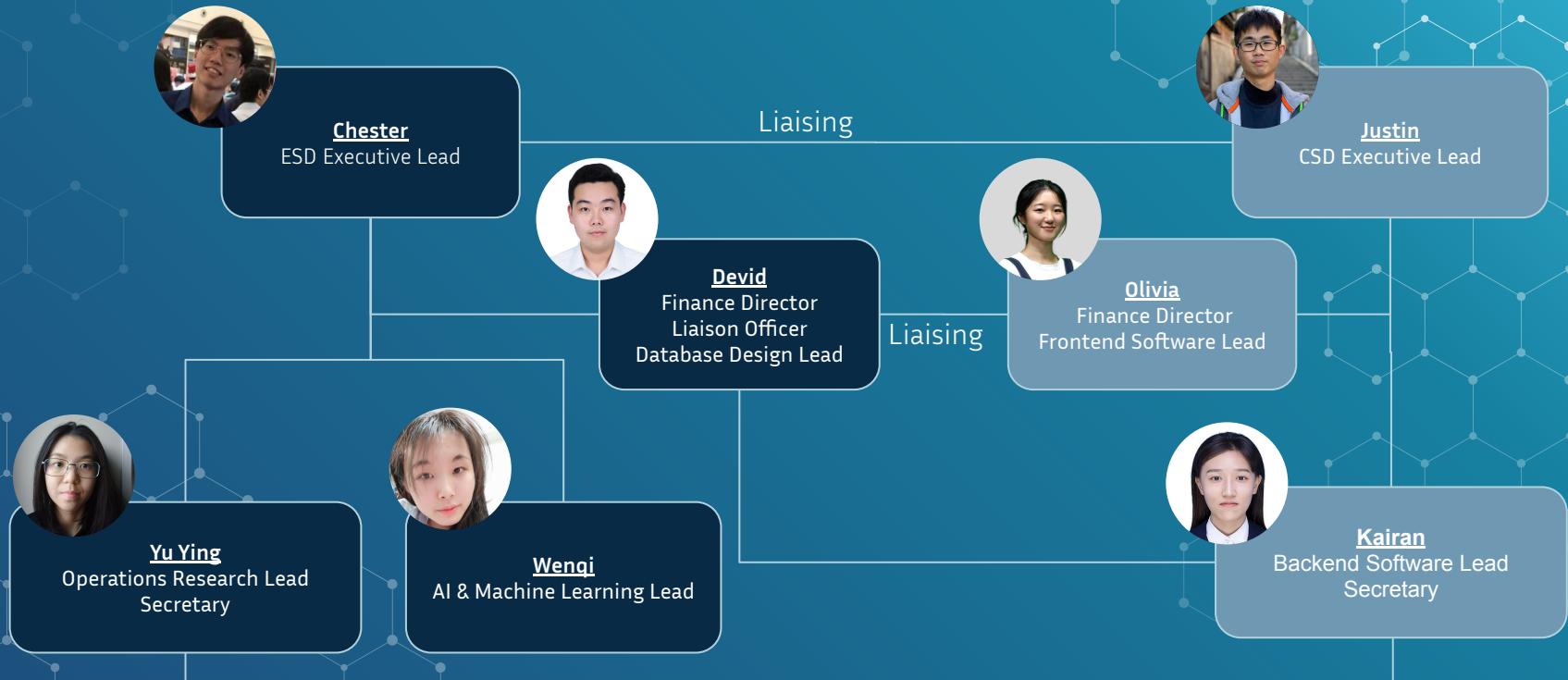
11

12

Project Management: Team Structure & Work Allocation



Organisational Breakdown Structure Annex 2





Task Allocation

Chester

Justin

Olivia

Devid

Wenqi

Yu Ying

Kairan

Simulation



Database



Machine Learning



User Interface



Q & A





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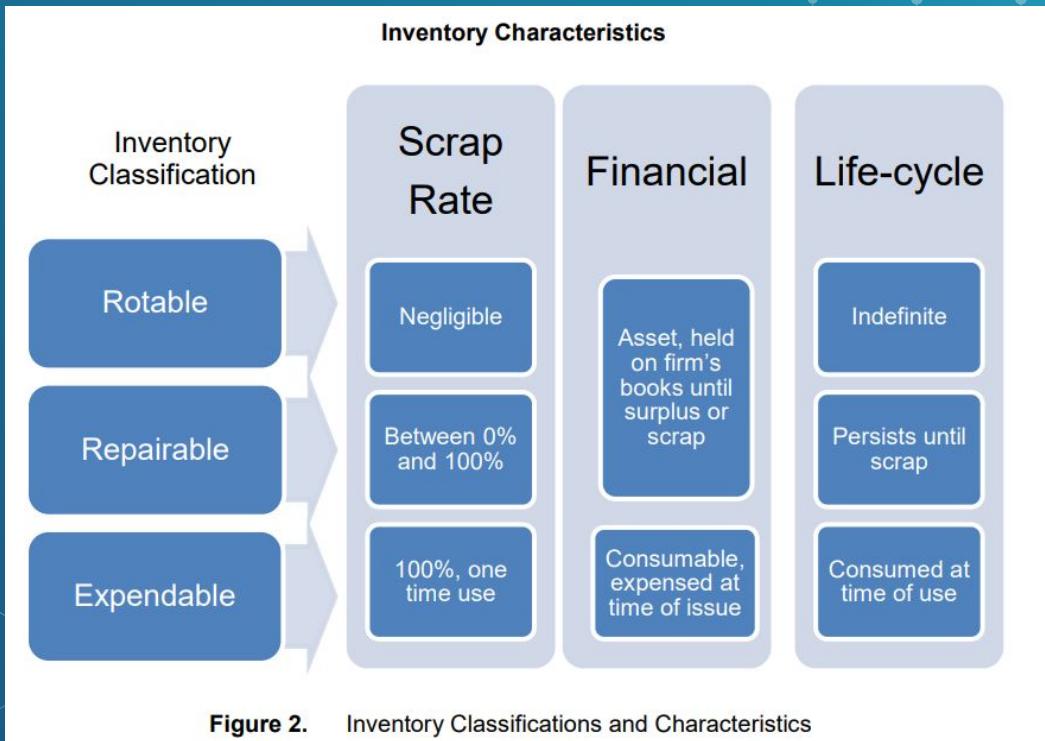
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Annex 1



Annex 2 - Roles



Chester
ESD Executive Lead



Justin
CSD Executive Lead

Executive Lead

- **In charge of project direction within each pillar**
- Liaise with other pillar
- Address problems within and between pillars
- Collate questions for Liaison Officer

Annex 2 - Roles



Devid
Finance Director
Liaison Officer
Database Analyst



Olivia
Finance Director
Frontend Software Lead

Database Design Lead

- **Assisting Backend Development on database creation**
- In charge of schema mapping to be implemented into database

Liaison Officer

- **In charge of communication between team and client**
- In charge of collation of issues that needs to be addressed

Finance Director

- **Management of all claims and team funding**

Frontend Software Lead

- **In charge of creation of wireframes for web-design**
- UI/UX development and functionalities

Annex 2 - Roles



Yu Ying
Operations Research Lead
Secretary



Kairan
Backend Software Lead
Secretary



Wengi
AI & Machine Learning Lead

Operations Research Lead

- **Spearhead Simulation building**
- Theoretical Backbone Modelling

Secretary

- **Collation of error logs in meetings**
- Collation of questions for internal meeting

Backend Developer Lead

- **In charge of creating database structure and security**
- Assisting in schema mapping to be implemented into database

AI & Machine Learning Lead

- **In charge of software, algorithmic building**



Annex 3 - Detailed Breakdown

Category	Detailed Breakdown	Review 1	Review 2	Review 3	Review 4	Total	Remark		
							Unit price in SGD	Quantity	Total
General	Transportation		100	200	200	500	25 per trip/car	2 car, round trip	$25 \times 2 \times 2 = 100$
						500			
Software	AWS RDS			400	400	800	0.276 per hr	4 month (2880 hr)	$0.276 \times 2880 \approx 800$
	AWS EC2			475	475	950	0.328 per hr	4 month (2880 hr)	$0.328 \times 2880 \approx 950$
	AWS Cloudfront				10	10	10 per usage		
	SSL certificate				25	25	25 per certificate		
						1785			
Tools	Miro			80	80	240	10 per pax/month	2 month, 4 pax	$10 \times 2 \times 4 = 80$
	Jira			105	105	315	7.5 per pax/month	2 months, 7 pax	$7.5 \times 2 \times 7 = 105$
						555			
Sum		0	285	1260	1295	2840			
					Tally	2840			