Bumblebee

Midterm Presentation

10.Oct.2012 | 2pm

SATS

Staff Deployment Simulation Software

The Bees

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Project Manager Statistics SME	**Software Engineer** Data Visualisation SME	**Software Engineer** Database SME	**Software Engineer** Scheduling SME	**Business Analyst** Statistics SME

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1 Problem Statement

2 Project Scope & Demo

3 User Testing

4 Project Management

Contents

1 **Problem Statement**

2 Project Scope & Demo

3 User Testing

4 Project Management

Staff Deployment Simulation Software

What is this?

Why the need?

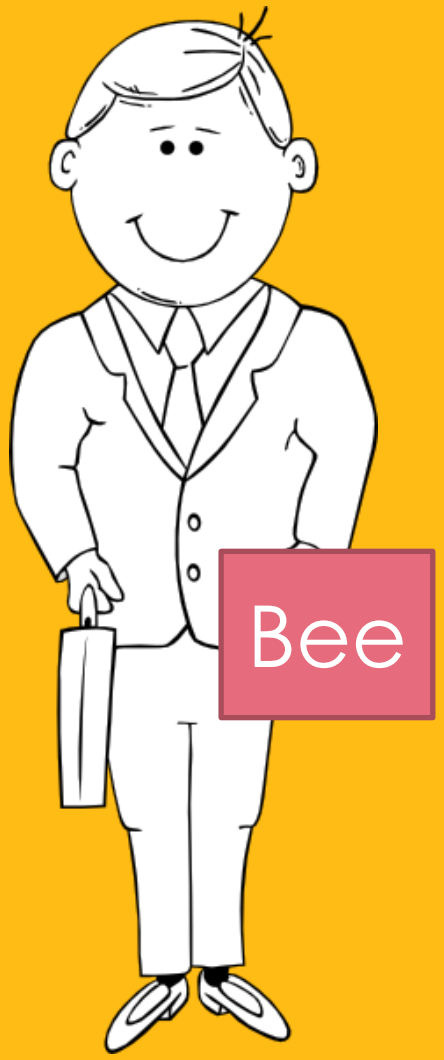
Our Client

- Singapore Airport Terminal Services (SATS)
- The leading provider of the gateway services and food solutions in Singapore

SATS Passenger Services

- Over 800 staffs
- More than 35 airlines
- Partner with airlines
- Goal : to meet all its airlines' requirements

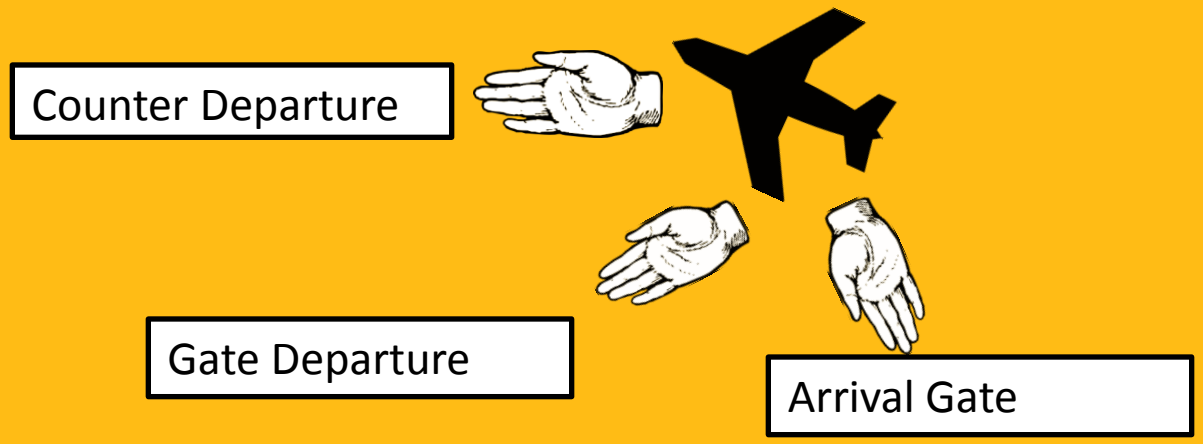
Scenario…

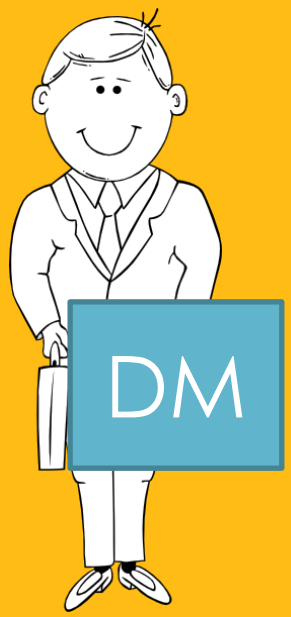


Meet Bee.

SATS Passenger Services

- Airline requirements: Number of required CSA and CSO to serve passengers

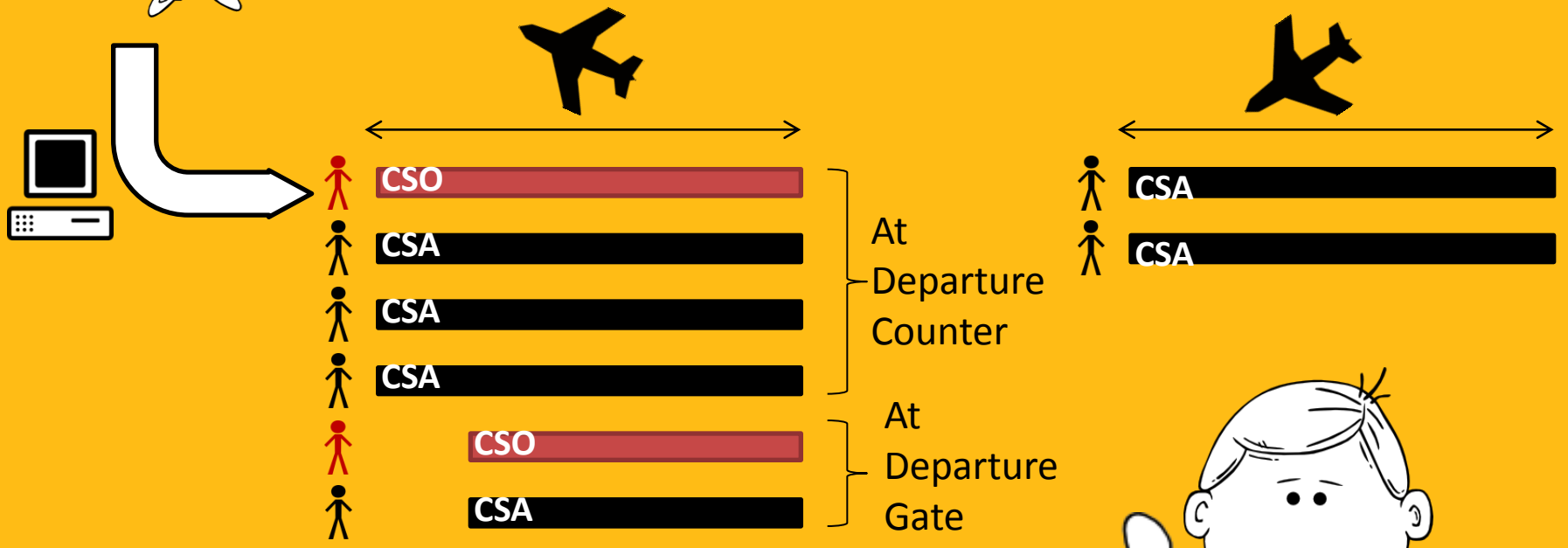




At Counter:
1 CSO + 3 CSA

At Departure Gate:
1 CSO + 1 CSA

At Arrival Gate:
2 CSA



Bee

One ‘fine’ day…

Current Approach

Manual scheduling

→When there is a flight

→Look through the staff list

→Based on experience

→Assign task to a staff

→If there is no staff available

→OT or recall staff

Problem 1

Unexpected events / uncertainties

- Flights delayed
- Medical Certificated (MC)
- Ad Hoc Leave
- Resignation

Problem 2

High cost incurred

- Overtime Cost
  - OT hours : 8,000/month
  - OT Cost : S$96,000

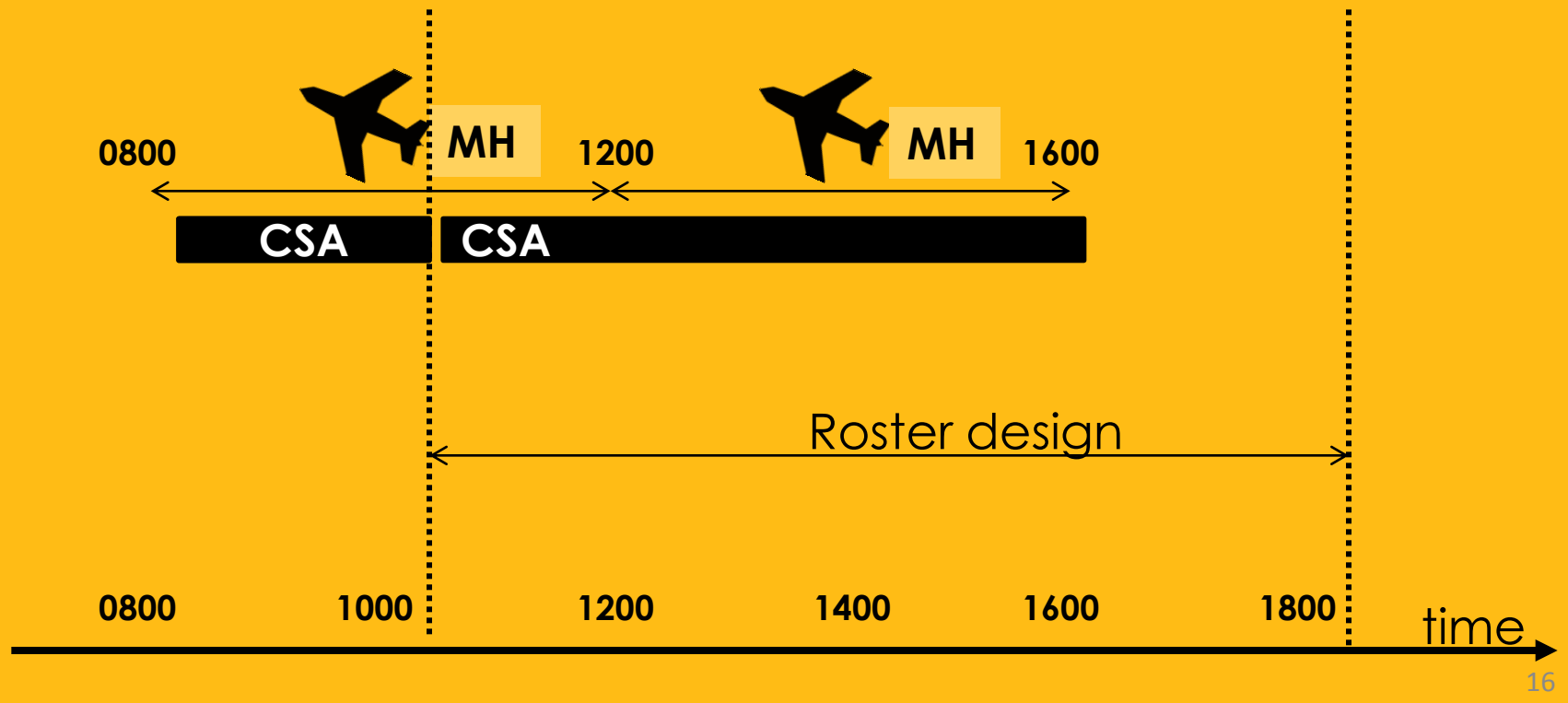
Observation

Possible reasons for high cost:

1. Uncertainties
2. Roster

Problem with Roster

Can there be a better roster design?

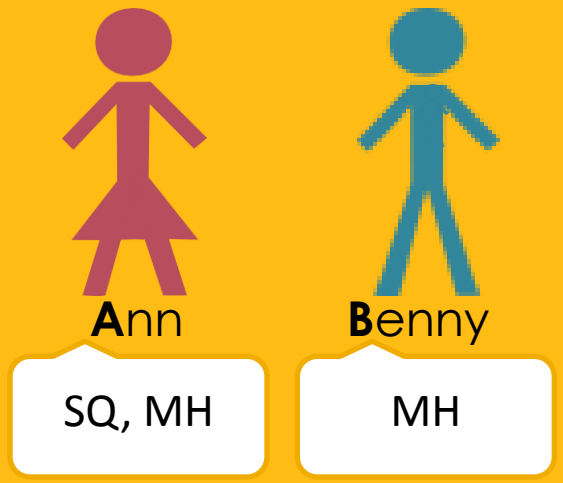


Team's Observation

Possible reasons for high cost:

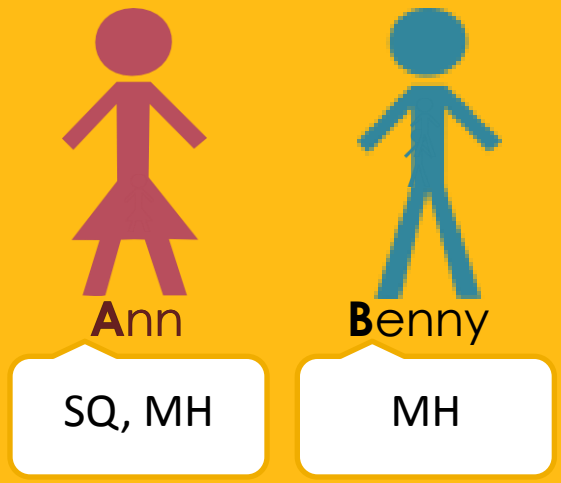
1. Uncertainties
2. Roster
3. Scheduling Approach

Problem with manual scheduling



Manual Scheduling

Problem with manual scheduling



When a better schedule is..

Main Functionalities

- Optimised schedule
- Simulation
  - Uncertainties
  - Roster

Key Usage

- Management Tool
- Airline Relations Manager

Benefits

- Optimised schedule

Description	Actual Data	Scheduling Result*	Potential Cost Savings*
OT hours	8,000	2,500	5,500
OT cost	S$96,000	S$30,000	S$66,000

*only scheduling, has not include cost incurred after simulation which includes applying uncertainties.
Assumption: OT Cost = S$12 / hr

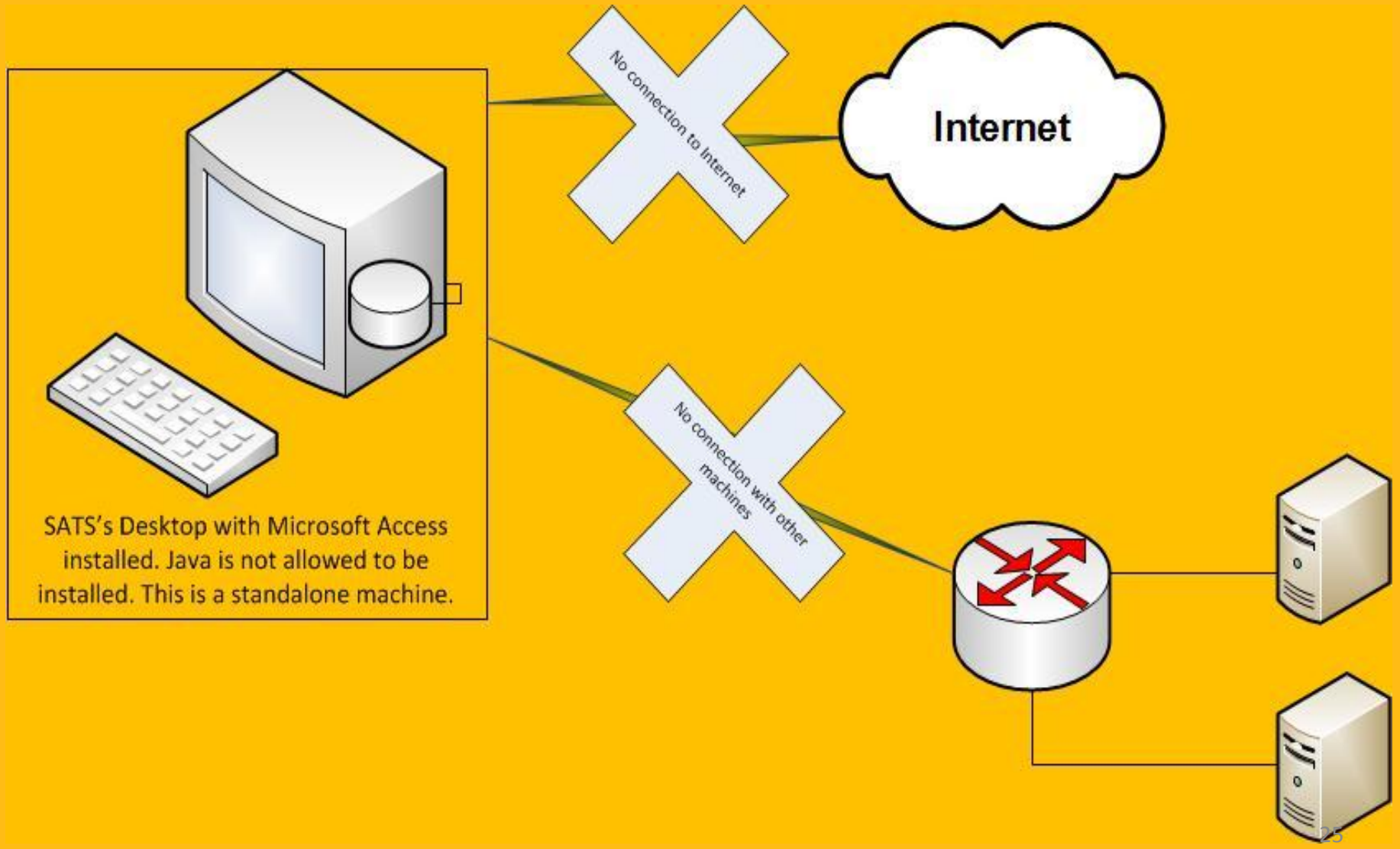
Benefits

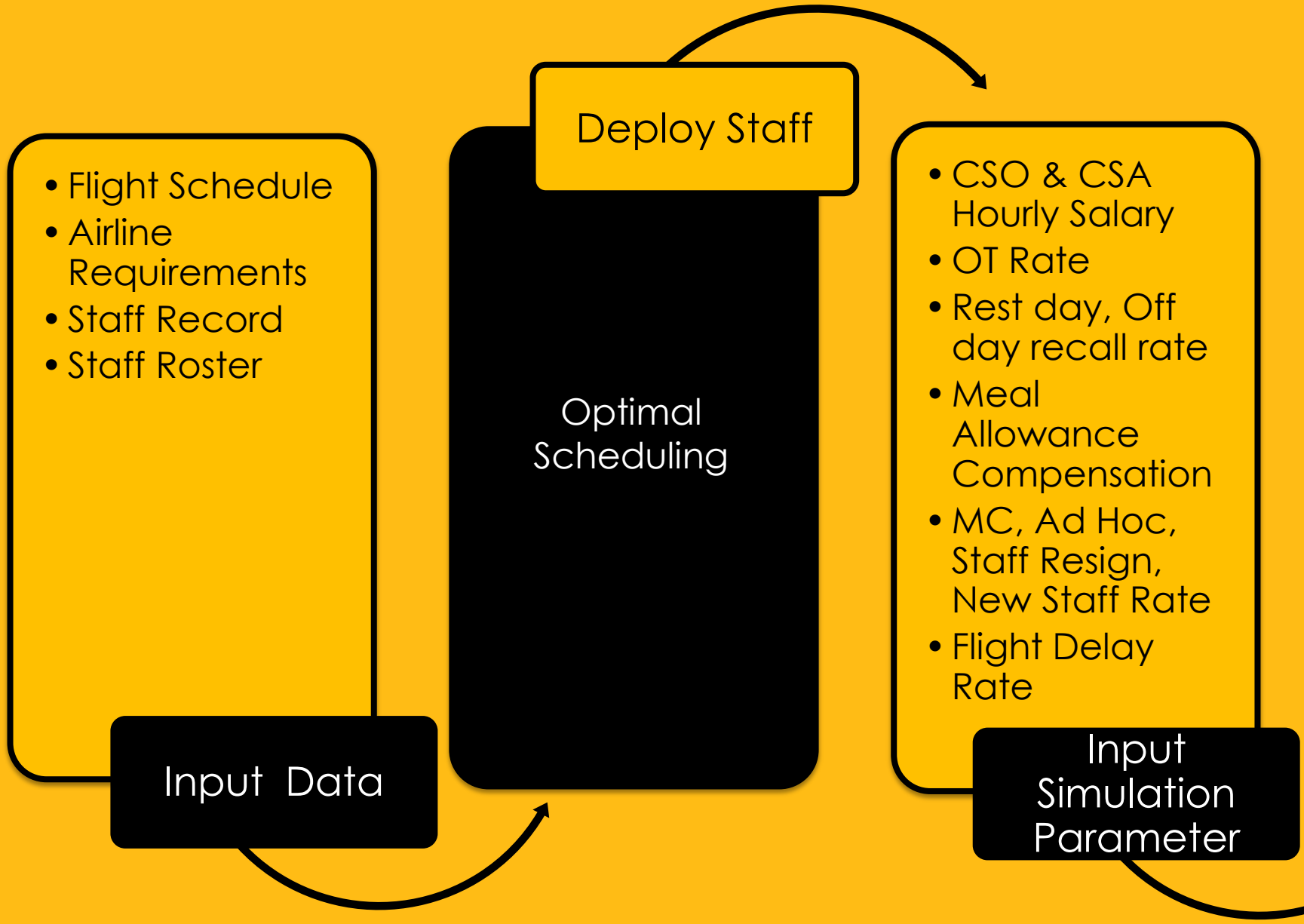
- Simulation
  - Cost breakdown
  - Find out where the problem lies
    - Scheduling problem
    - Roster problem

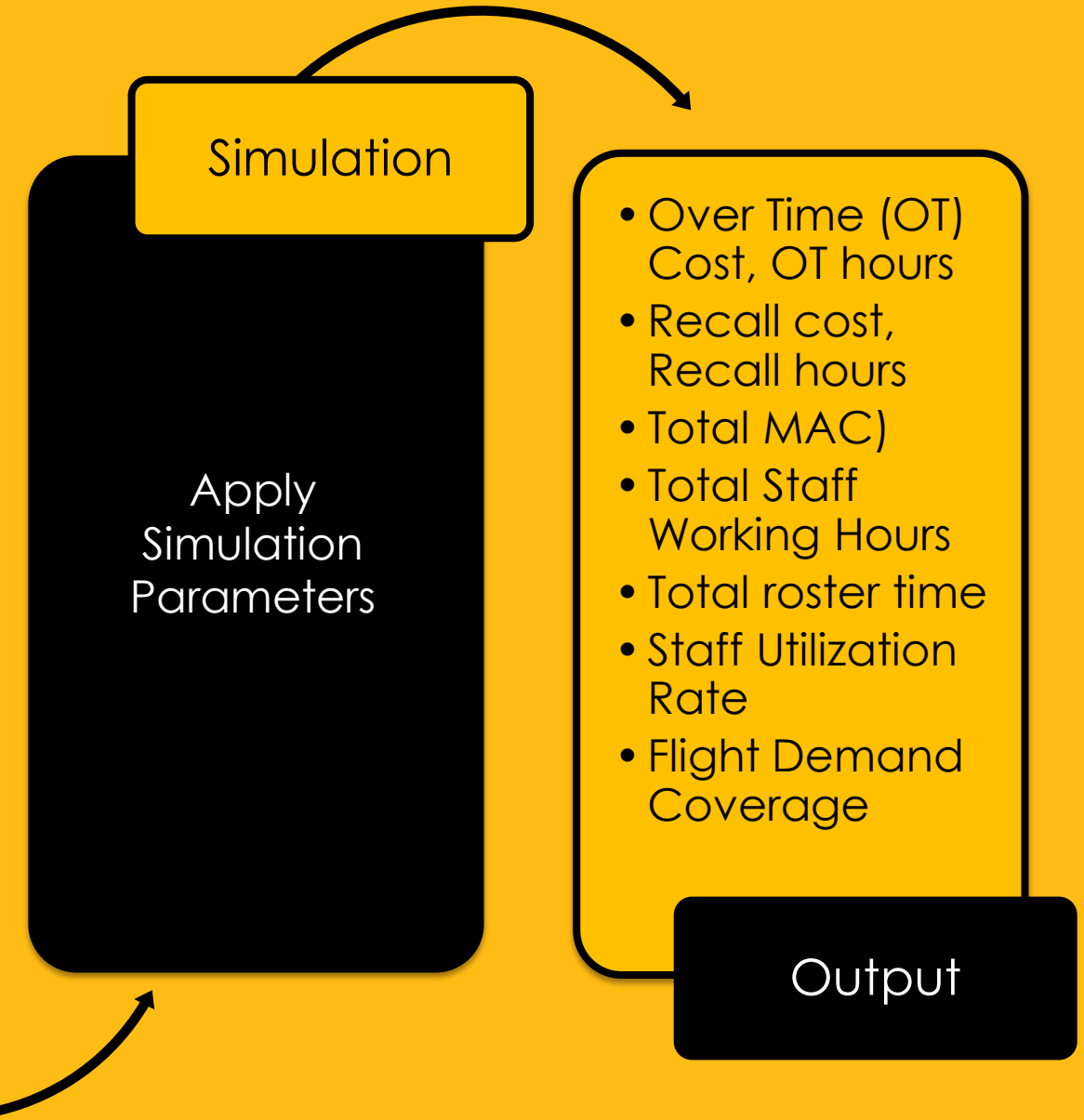
Software Requirement

- Staff Deployment Simulation Software
  - Java Desktop Application
  - Microsoft Access
- Based on client's requirements

Architecture




• Flight Schedule
• Airline Requirements
• Staff Record
• Staff Roster
Input Data
Optimal Scheduling
Deploy Staff
• CSO & CSA Hourly Salary
• OT Rate
• Rest day, Off day recall rate
• Meal Allowance Compensation
• MC, Ad Hoc, Staff Resign, New Staff Rate
• Flight Delay Rate
Input Simulation Parameter



Input Process Output Diagram

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2 Project Scope & Demo

3 User Testing

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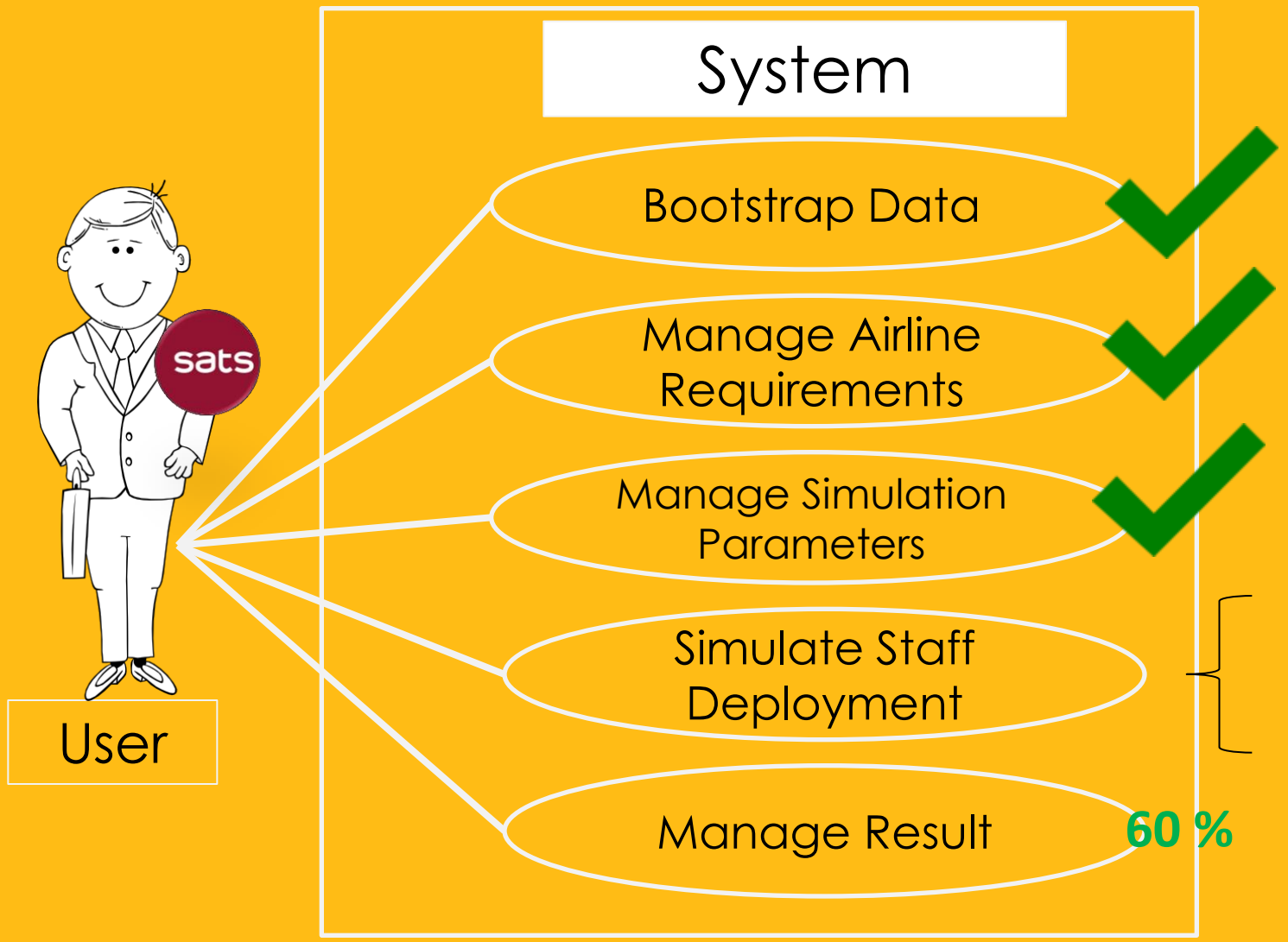
What have we achieved so far?



Bootstrap Data

- Import data:

✓ Flight schedule (Arrival + Departure)

✓ Staff records

✓

Staff roster

✓ Airline requirements

Bootstrap Data

- Data processing and transformation:
  - ✓ Data structure is not "machine-friendly"
  - ✓ Multiple data formats
  - ✓ Complex business logic

Bootstrap Data

- Data processing and transformation:
  - Staff Roster

StaffNo	RosterID	RosterCycle	Mon	Tue
233292	CSA KE	1A	OFF	2100
233296			OFF	700
233287				
233286	CSA KE	2B	2100	2100
			630	630
118347	CSA SPLIT SHIFT ROSTER	1A	OFF	530-0830
			OFF	1500-2100
127362	CSA SPLIT SHIFT ROSTER	2B	530-0830	OFF
			1500-2100	OFF

Bootstrap Data

- Speed of importing:

✓ 6,000+ rows of data

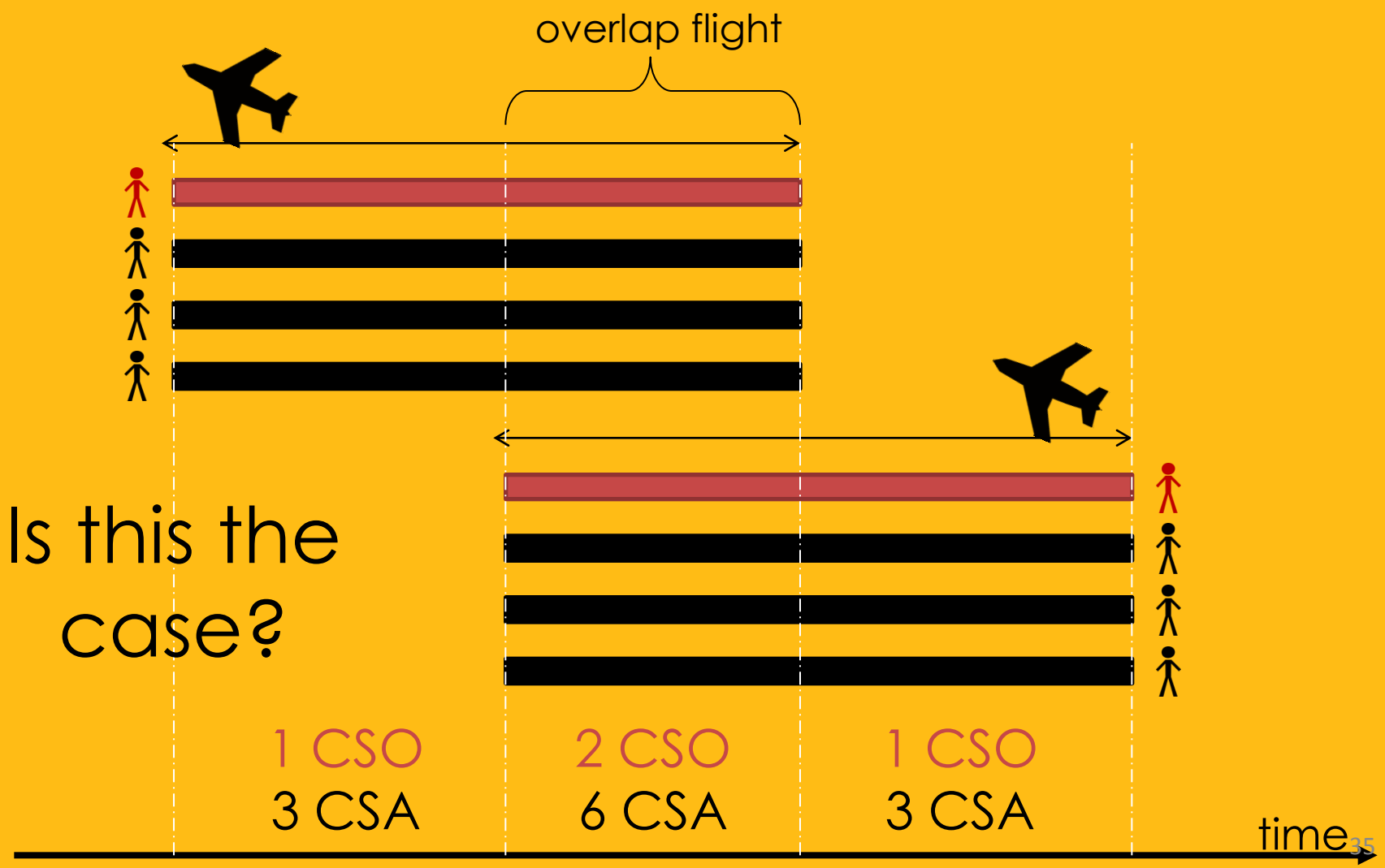
✓ Total number of queries: 21,000+ (not including data processing and transformation)

✓ Total time taken: less than 1 minute

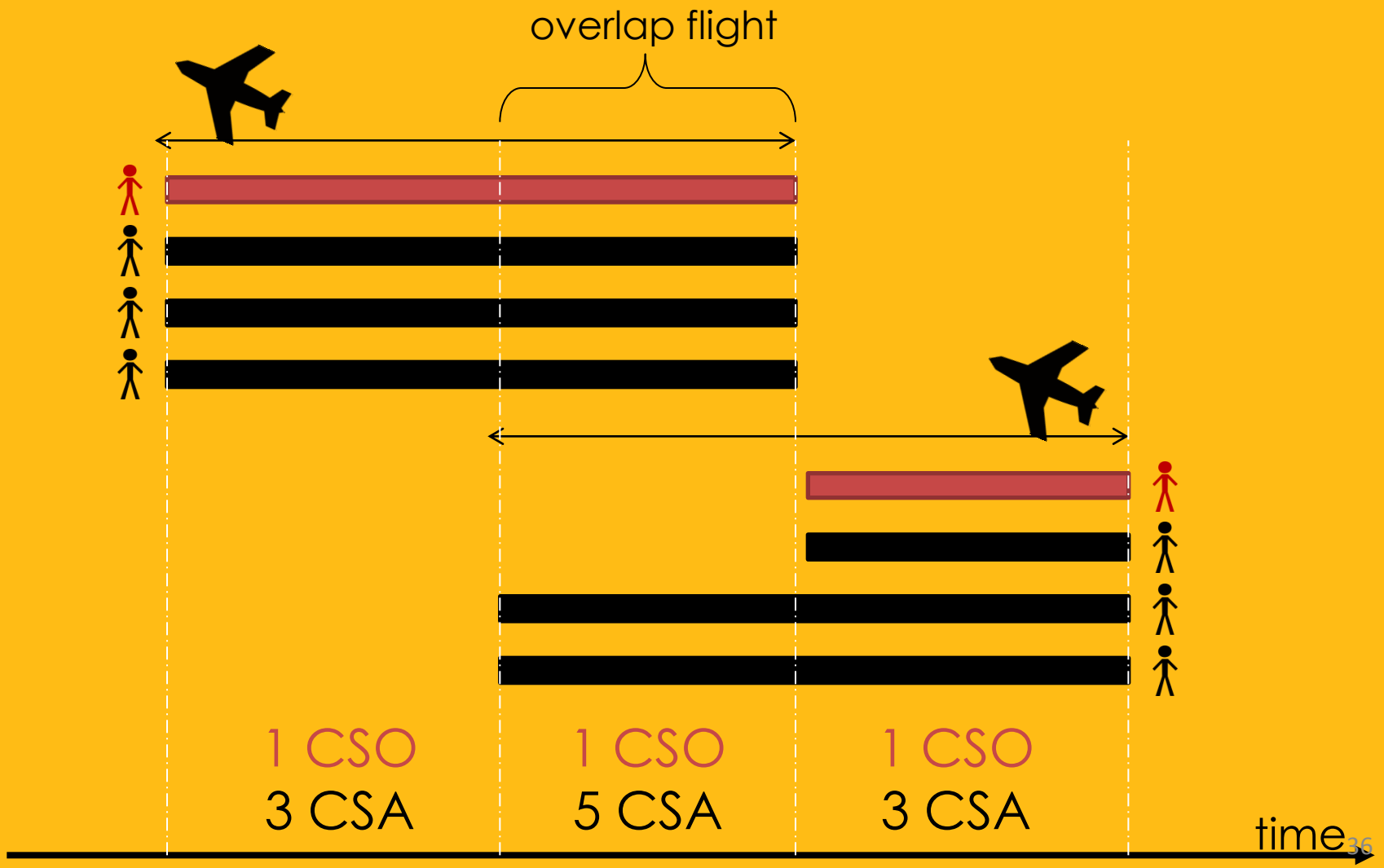
Manage Airline Requirements

- Set special requirement of airlines
  - Counter Departure
    - Counter opens all day
    - Early check in
      - Different counter opening hours
    - Different number of CSA and CSO needed depending on the aircraft size

Manage Airline Requirements



Manage Airline Requirements



Manage Simulation Parameters

- Input cost parameter
- Input uncertainties
- Generate normal distribution for each uncertainties

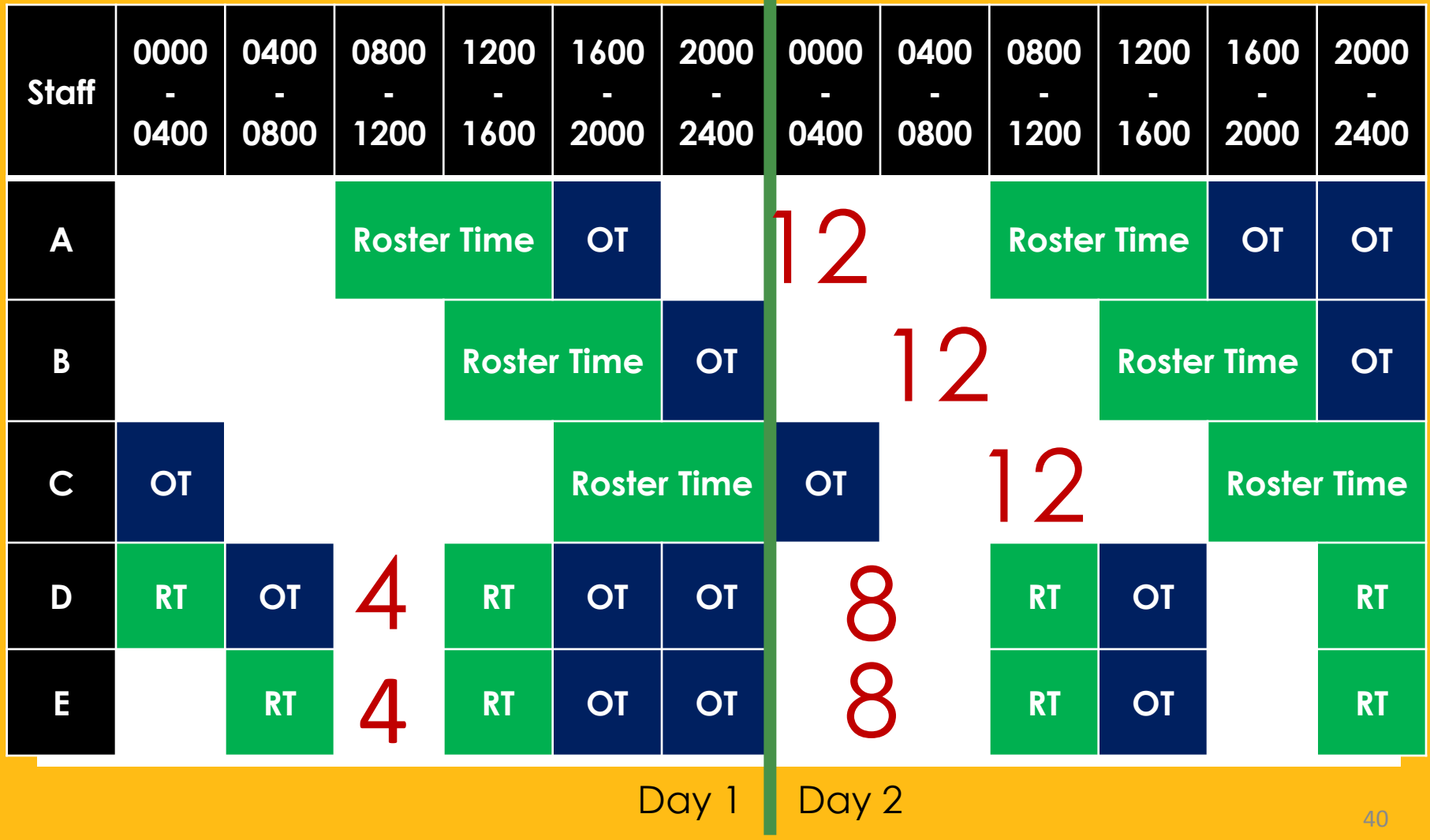
Simulate Staff Deployment

- Optimal scheduling based on staffs' working hours, system qualifications and other factors.
- Rescheduling. With simulation parameters, mimicking Duty Manager's activities such as calling back staff and extending over-time hours.

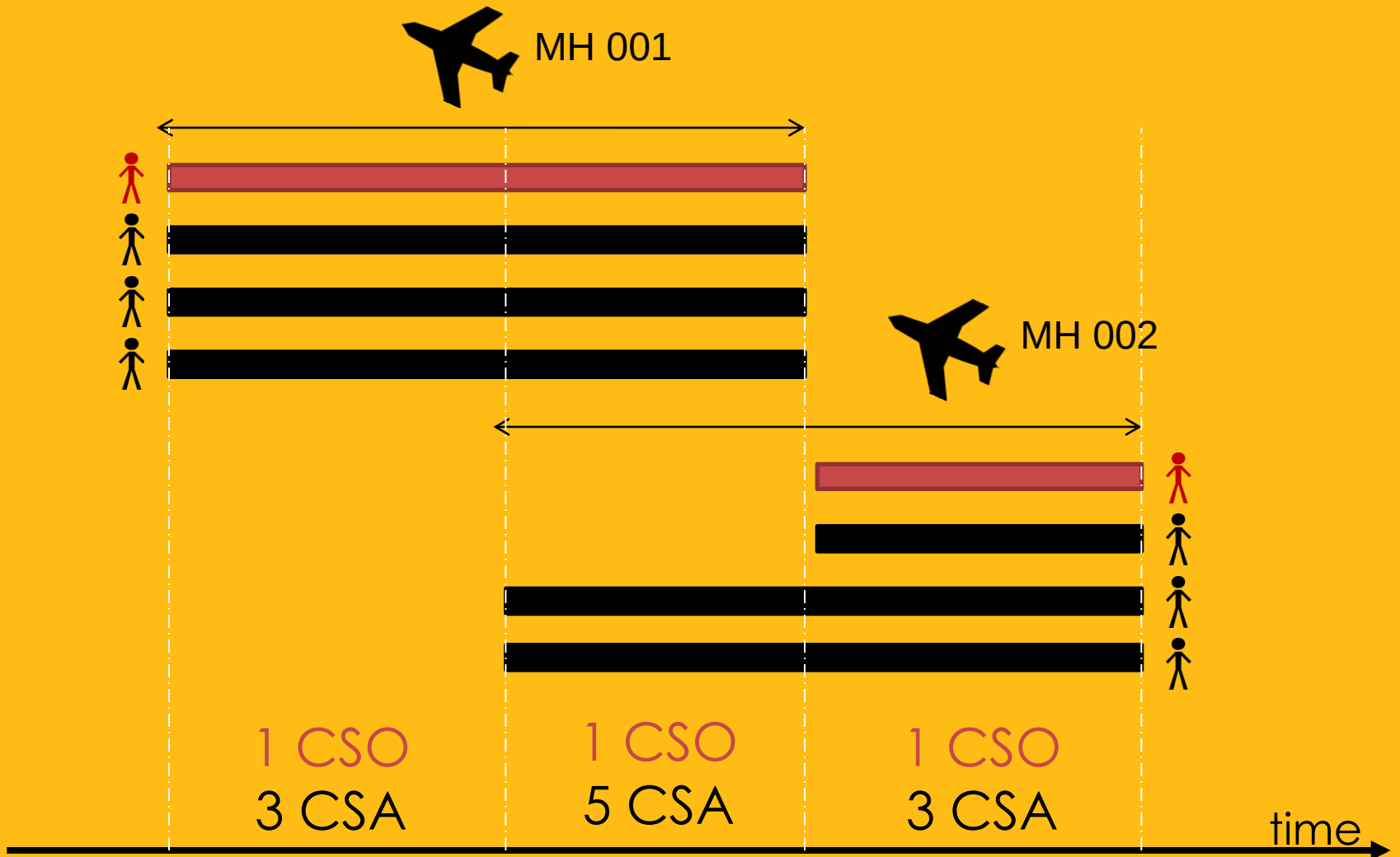
Constraints

- System
- Job Function
- Roster rules
  - Different minimum hours of rest
- Different airline requirements
  - Airline specific
  - Flight size specific
  - Aircraft type specific

Roster Rules



Different Airline Requirements

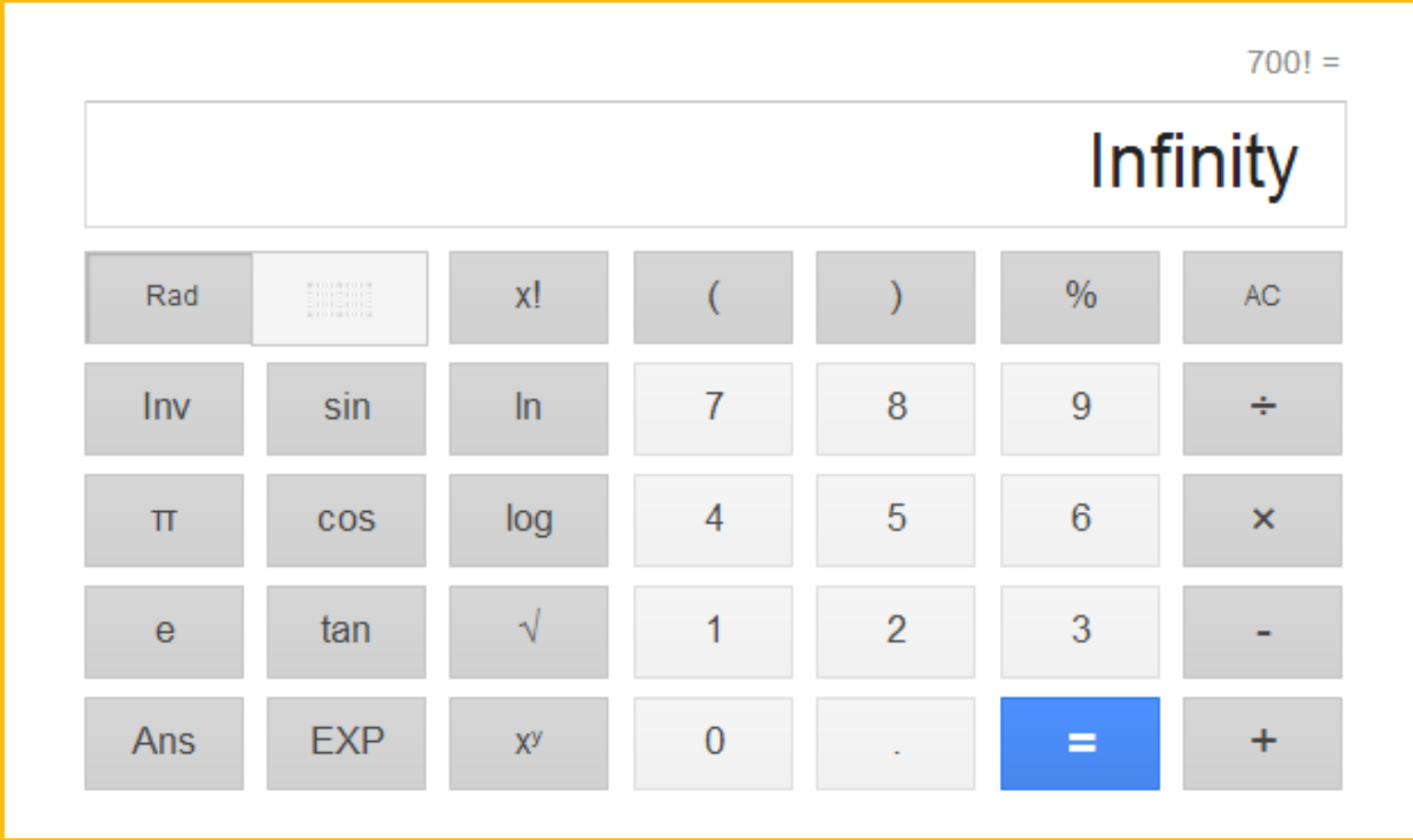


Problem Size

- 200 flights per day
- A flight : approximately 3.5 staff
- 700 tasks a day
- A day : 500 staff (max. 700 staff)
- A staff : 4 slots a day (max. 5 slots if OT)
- Assigning 700 tasks to 2000 staff slots

$$ {}_{2000}C_{700} * 700! = ??? $$

Problem Size



Greedy Algorithm

- Compute problem efficiently and minimise the cost
- Finding locally optimal solution at each stage with the hope of finding a global optimum
- Find "cheapest" available and eligible staff for a task and do it repetitively

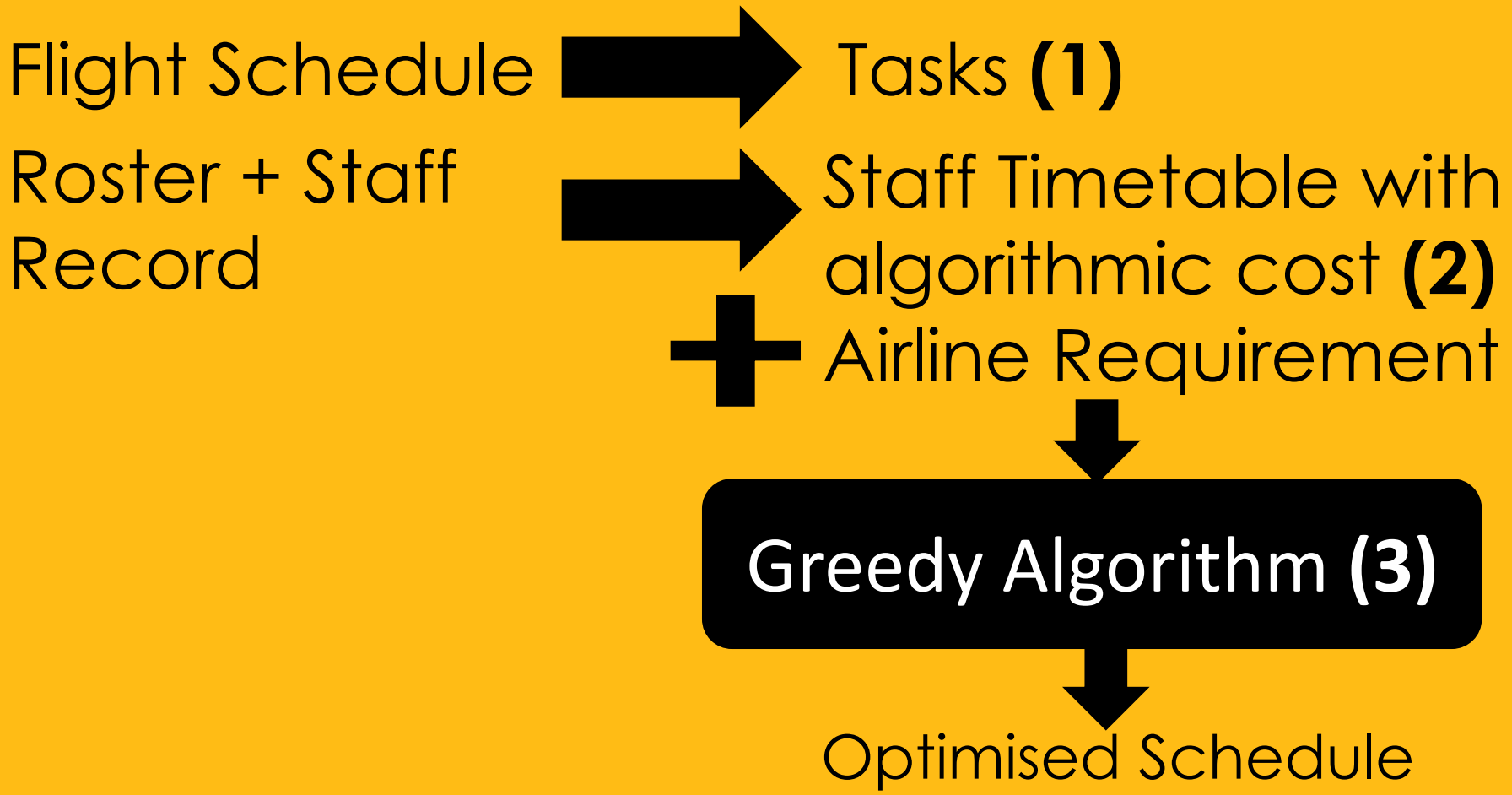
Cost Function

Scenario	Algorithmic Cost	Cost Calculation
Working	0	No of 0 * salary rate
OT	1	No of 1 * OT rate
Rest Day	2	No of 2 * rest day rate
Off Day	3	No of 3 * off day rate
Rest time/ Task assigned	1000	-
System worth	Sum(1/ total no of people trained in the system)	

Cost Function

- Cost function can be **reconfigured** if necessary without affecting the greedy algorithm
- Huge problem scale
  - Caching

Pseudo Code


Flight Schedule
Tasks (1)
Roster + Staff Record
Staff Timetable with algorithmic cost (2)
Airline Requirement
Greedy Algorithm (3)
Optimised Schedule

Demo Time…

Pseudo Code

(1)Create Task

Get the **first week** dates

For each day, get list of **airlines** operating

For each airline, retrieve arrival **schedules** and departure **schedules**

For each arrival flight, **create arrival gate task** (10 mins before STA – 20 mins after STA)

For each departure flight**, create departure gate task** based on airline requirements (check time required from DB)

For each departure flight, **create departure counter task(s)** based on airline requirements (check time required from DB)

Early opening counter

For all dept. counter tasks, process **overlapping tasks** so that there is no overlapping tasks

*Also creating all day counter opening tasks

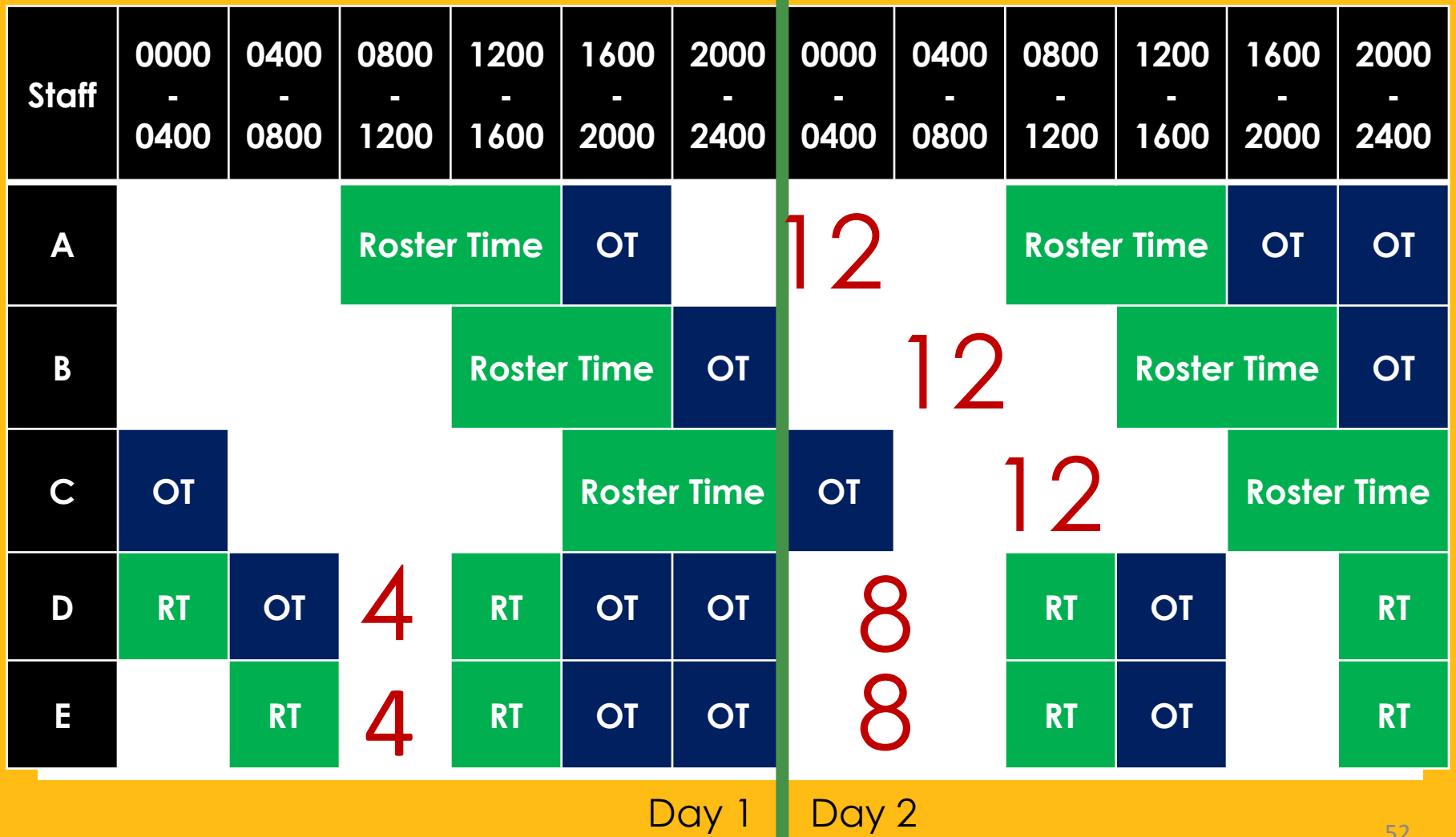
Pseudo Code
(1)Create Task

For each task created, check no of CSA and CSO required (DB)

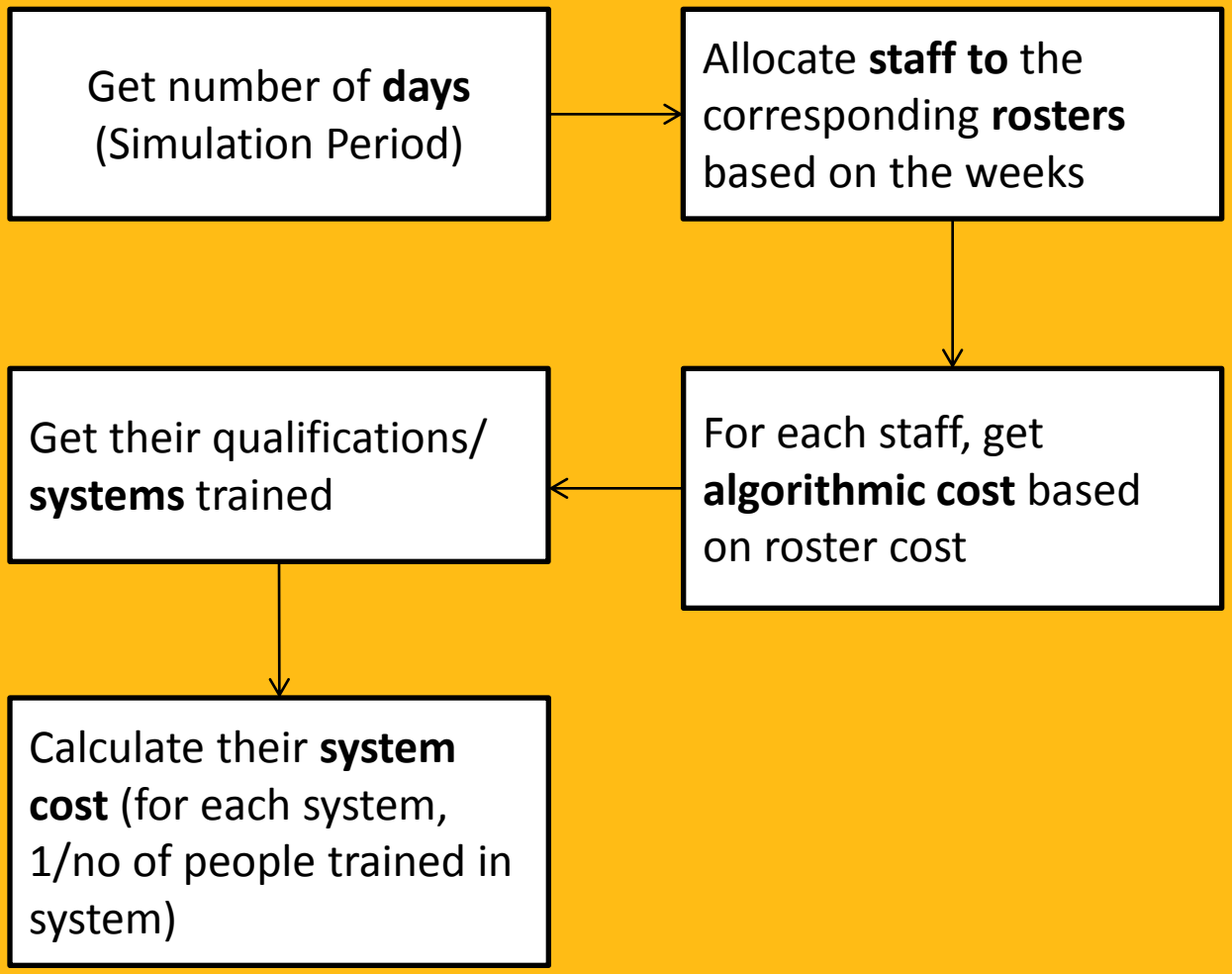
- Be aware of all day counter opening airlines
- For these airlines, reduce no of staff deployed by all day requirement

Pseudo Code

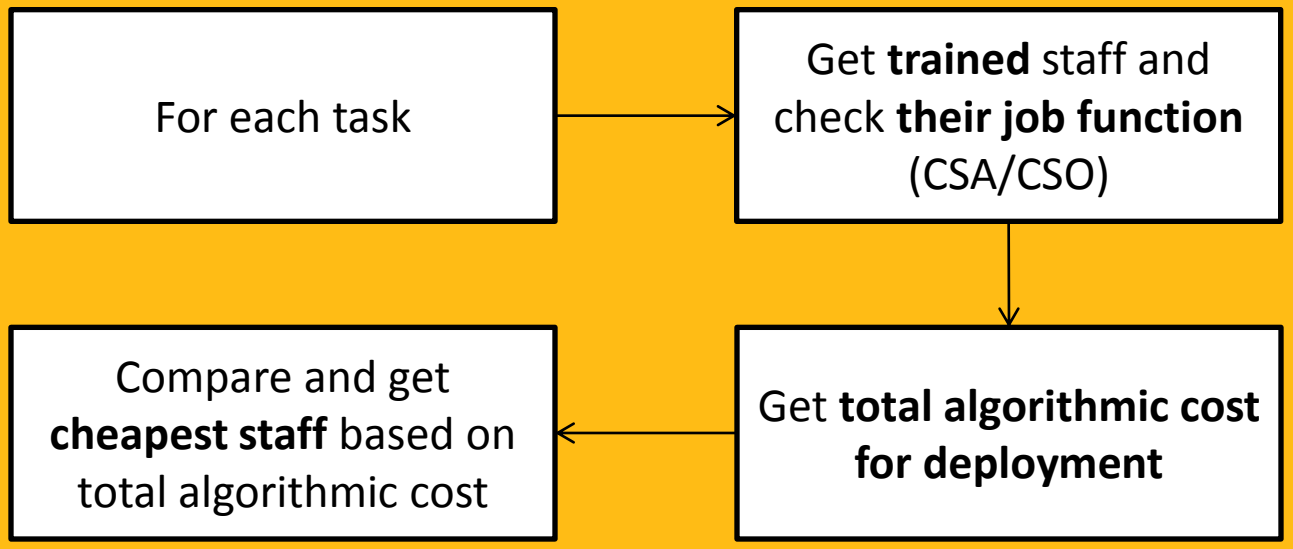
(2)Timetable with Algorithmic Cost



Pseudo Code
(3)Greedy Algorithm



Pseudo Code
(3)Greedy Algorithm



Simulation

- Simulation:
  - Apply simulation parameters (uncertainties)
  - Rescheduling to come out with optimal schedule
- Input: Optimal schedule, simulation parameters
- Output: New optimal schedule, cost breakdown (results)

Manage Results

The main functions are:

- view detailed report (.pdf)
- view optimised staff schedule
- view staff location
- filter results
- delete results

What is the result of simulation?

- Overtime Hours
- Recall Hours
- MAC Hours
- Working Hours
- Roster Hours

- Overtime Cost
- Recall Cost
- MAC Cost

- Utilisation Rate
- Flight Demand Coverage

X-Factor

- ✓ Algorithmic complexity
  - Optimal scheduling
  - Probabilistic simulation
- ✓ Comply with aviation specific business rules
- ✓ Efficiency

```
(total time: 554 minutes 16 seconds)
```

- [28/08/2012] : 554 minutes to create tasks(only 1 airline, 2 days schedules)
- [08/09/2012]: 21 secs to create tasks (3 airlines, 7 days schedules)

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User Testing 1 (17-Sept)

Objectives:

- Identify any potential concerns to address regarding application usability, presentation, and navigation
- Get feedback on the usefulness and accuracy of the functions developed
- To match client expectations on the system developed

User Profiles

Mr Kevin Choy

SATS Airline Relations Manager

→ PIC for this project

→ Testing Venue: SATS Office

Mr Goh Wei Xuan

SATS Airline Relations Manager

→ First time user of the software

User Testing Method

- One Facilitator : One Tester
- Facilitators will record their observations and results

- verbalize their actions
- complete 7 scenarios or "real-life" tasks
- give subjective evaluations

- User Testing 1 Report produced

User Testing Scenarios

1. Bootstrap/import file(s)
2. Add staff costs
3. Add uncertainties
4. **Run simulation**
5. **View staff schedule**
6. Add airline requirements
7. Generate result

UT1 Simulation Results

UT1 Simulation Result	1 day	7 days	30 days	30 days (client data)
Completion Time	2 mins 49 secs	3 mins 10 secs	13 mins	NA
Total Staff Working Hours	1,266.08 hrs	2,478.0 hrs	20,864.0 hrs	NA (729 staff)
Staff Utilization Rate	26.02%	26.12%	5%	NA
Overtime Hours	110.0 hrs	208.33 hrs	2623 hrs	8164.48 hrs
Recall Hours	318.92 hrs	589.08 hrs	NA	TBC
Flight Demand Coverage	83.31%	81.52%	45.76%	Try to meet as far as possible (no data)

UT1 Results: 4. Run Simulation

Run Simulation	Concerns	Recommendation
Critical Errors	- Low Staff Utilization Rate	- Will liaise with client on possible reasons and changes that can be made
Non-Critical Errors	NA	- The "optimize schedule" button run from the homepage does not contain BACK button. (completed)
Scenario Completion Time	13 minutes (run simulation for 30 days) 3 minutes 10 seconds (run simulation for 7 days) 2 minutes 49 seconds (run simulation for 1 day)	

UT1 Results:
5. View Staff Schedule

View Staff Schedule	Concerns	Recommendation
Critical Errors	- More than 1 week scheduling result can be improved	- Will work on improving the result correctness. (completed)
Non-Critical Errors	- Cannot change the week	- Try adding week selection option (completed)
Scenario Completion Time	2 minutes	

UT1
Feedback

- Satisfied with the system
- “Beneficial cost calculation”
- “It could be a good tool”

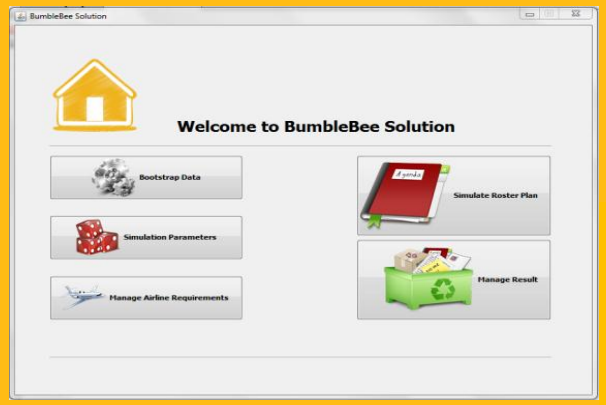
Main changes after UT1

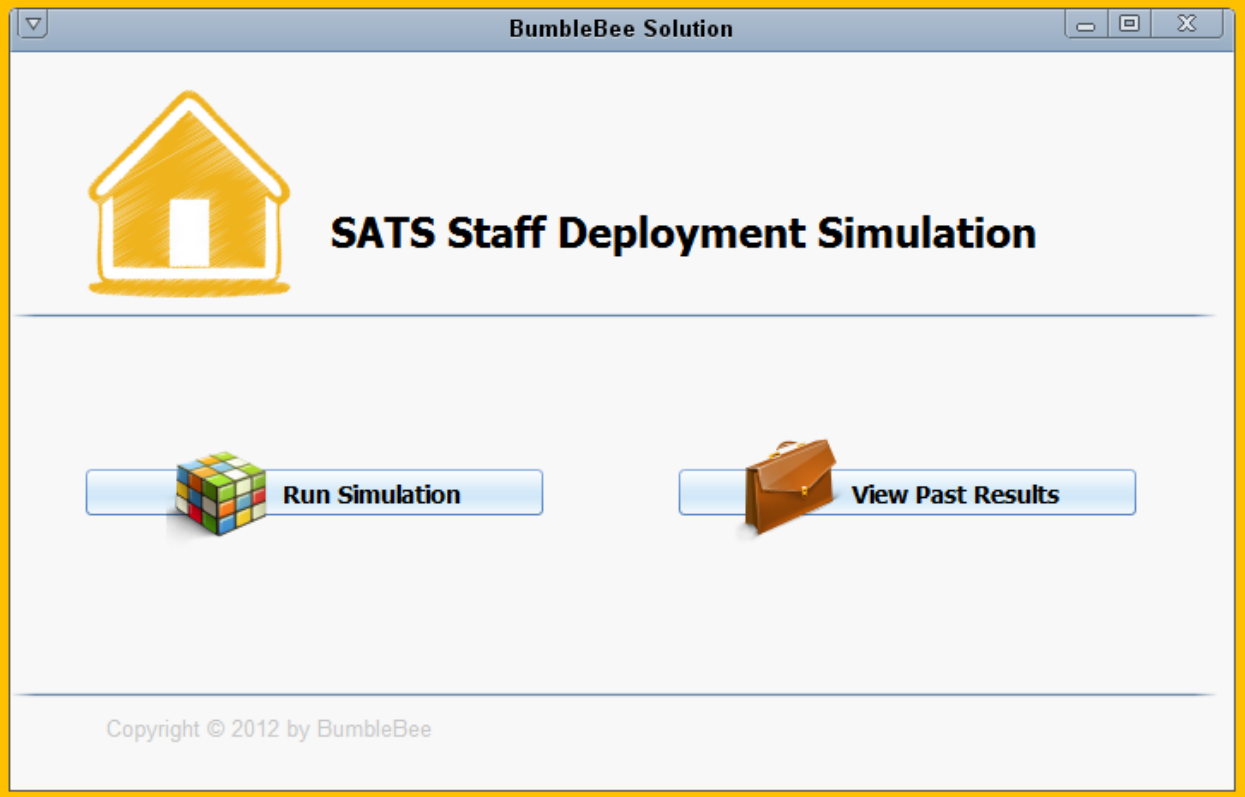
- User Interface
- Scheduling Algorithm

Main changes after UT1

- User Interface

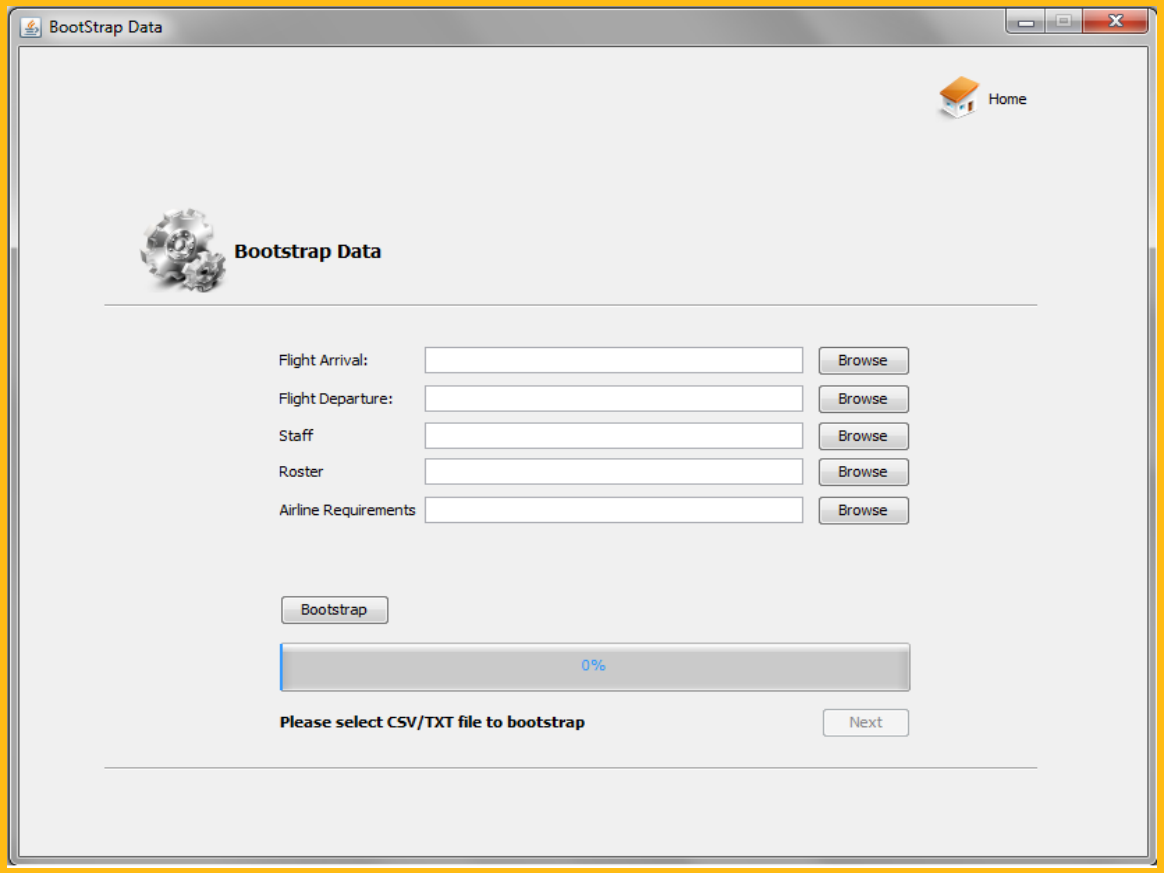
Main changes after UT1



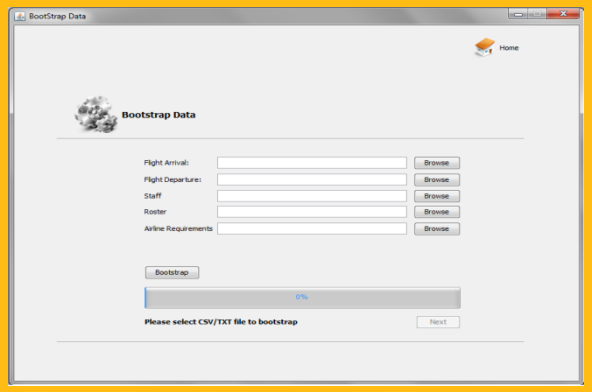


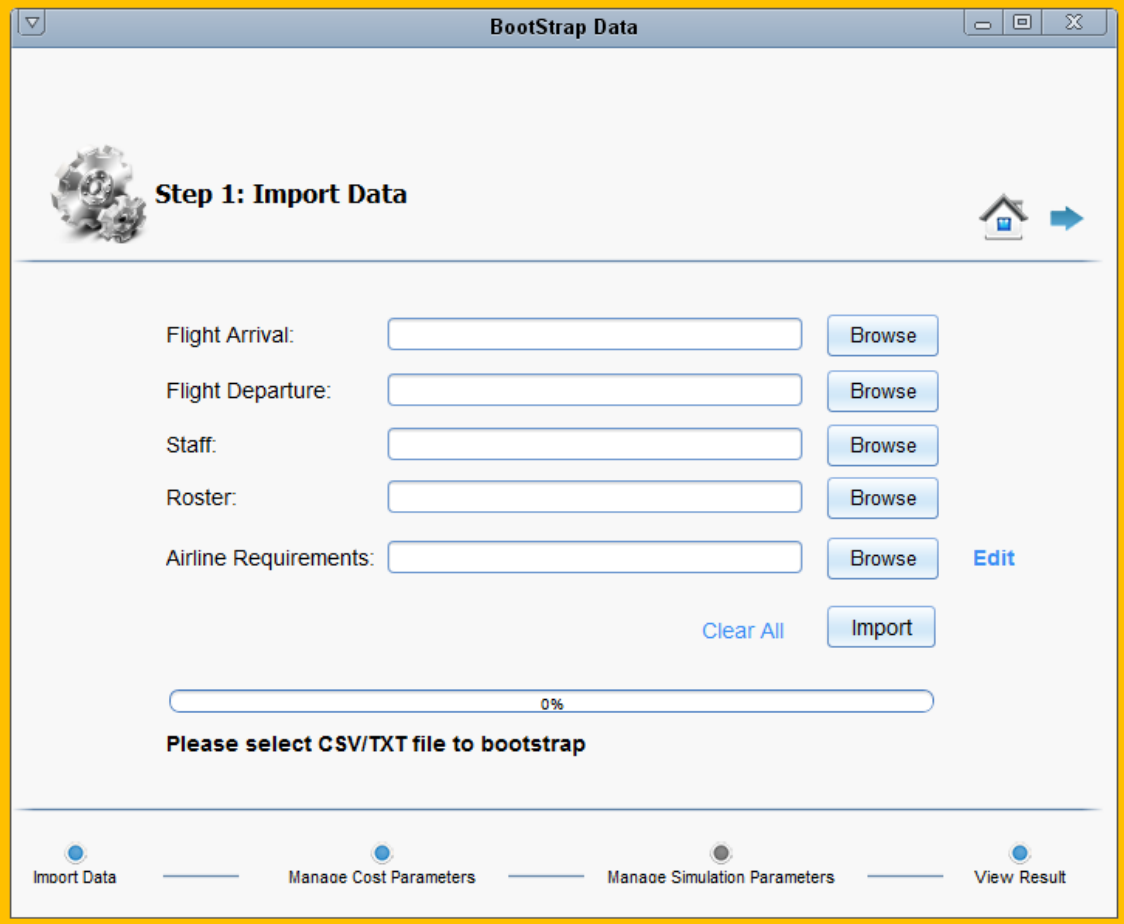
Main changes after UT1

- User Interface



Main changes after UT1





Main changes after UT1

- Scheduling algorithm

UT1 Simulation Result	1 day	7 days	30 days	30 days (client data)
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Recall Hours	318.92 hrs	589.08 hrs	NA	TBC
Flight Demand Coverage	83.31%	81.52%	45.76%	Try to meet as far as possible (no data)

Main changes after UT1

Current Simulation Result	1 day	7 days	30 days
Completion Time	2 mins 48 secs	3 mins 10 secs	4 mins 55 secs
Total Staff Working Hours	1,129 hrs	7,954 hrs	30,742 hrs
Staff Utilization Rate	38.48%	38.71%	38.98%
Overtime Hours	87 hrs	565 hrs	2467 hrs
Recall Hours	136 hrs	810 hrs	3751 hrs
Flight Demand Coverage	93.56%	92.17%	85.20%

UT1 Reporting Conclusion

- Successful deployment of software
- Satisfied client
- Working system for self trial
- Testers gained more understanding on the system functions
- Improvement needed for navigation and logic

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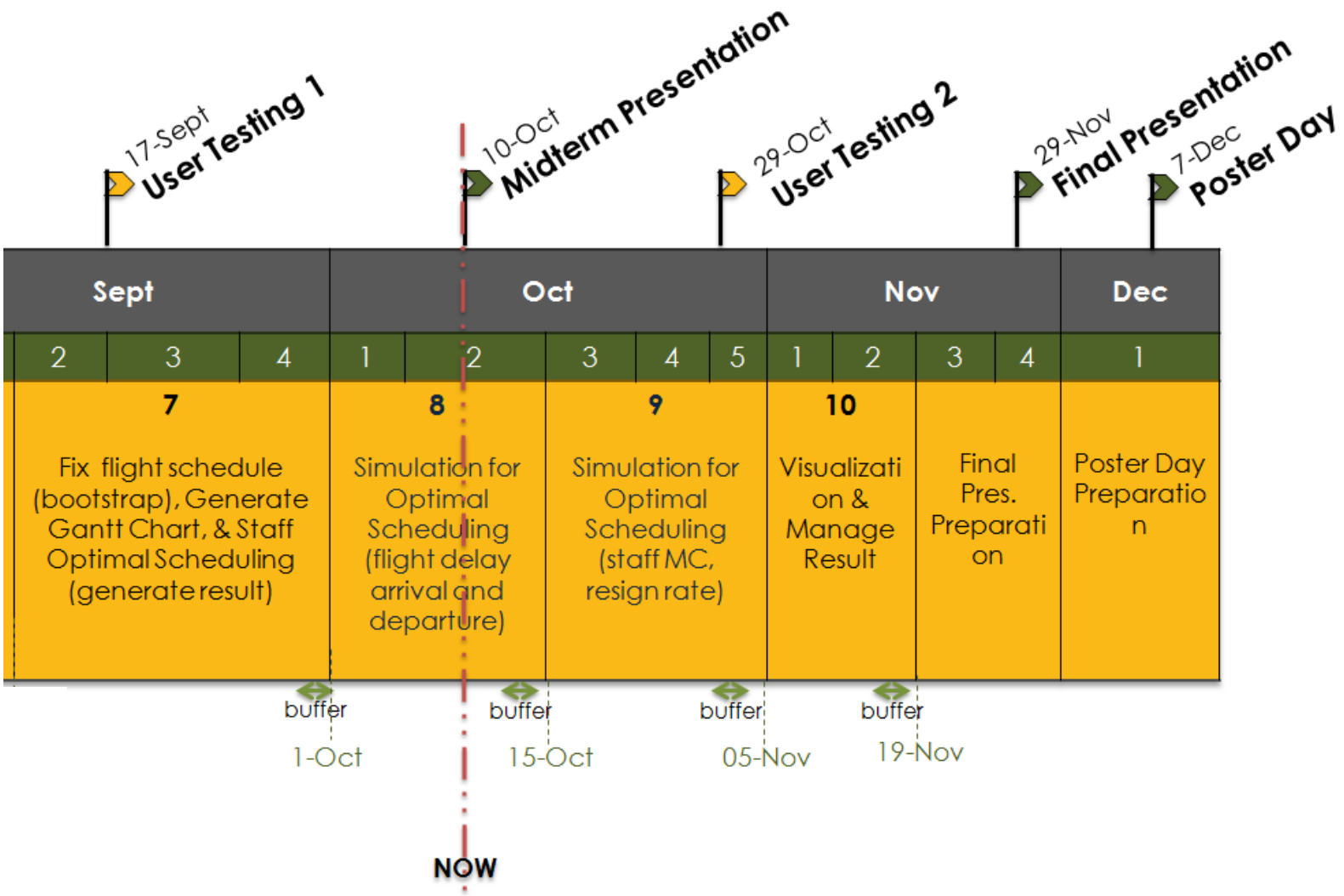
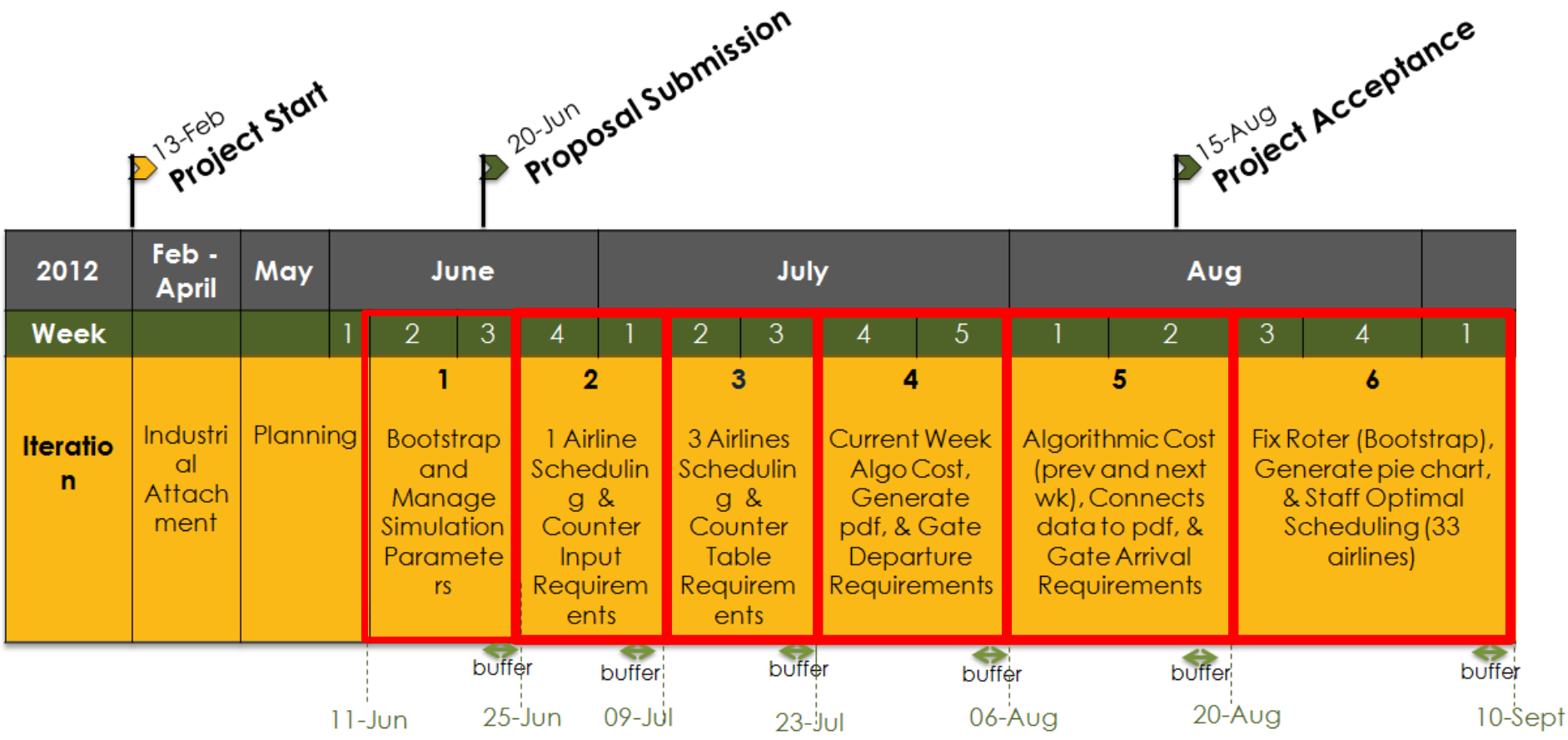
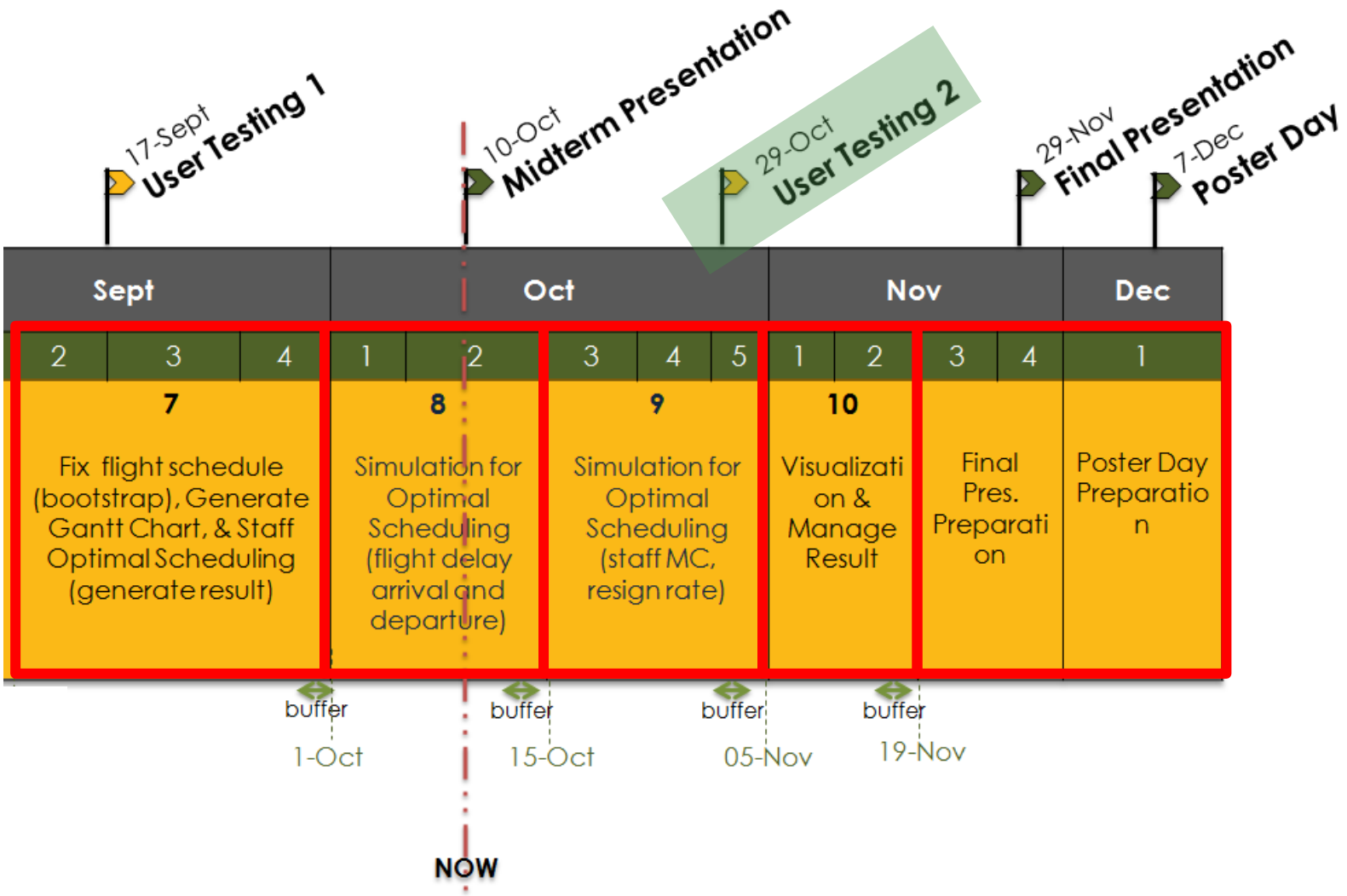
Timeline


17-Sept
User Testing 1
10-Oct
Midterm Presentation
29-Oct
User Testing 2
29-Nov
Final Presentation
7-Dec
Poster Day
Sept
Oct
Nov
Dec
2 3 4 1 2 3 4 5 1 2 3 4 1
7
8
9
10
Fix flight schedule (bootstrap), Generate Gantt Chart, & Staff Optimal Scheduling (generate result)
Simulation for Optimal Scheduling (flight delay arrival and departure)
Simulation for Optimal Scheduling (staff MC, resign rate)
Visualization & Manage Result
Final Pres. Preparation
Poster Day Preparation
buffer
buffer
buffer
buffer
1-Oct
15-Oct
05-Nov
19-Nov
NOW

Timeline


13-Feb
Project Start
20-Jun
Proposal Submission
15-Aug
Project Acceptance
2012
Feb - April
May
June
July
Aug
Week
1 2 3 4 1 2 3 4 5 1 2 3 4 1
Iteration
Industrial Attachment
Planning
1
Bootstrap and Manage Simulation Parameters
2
1 Airline Scheduling & Counter Input Requirements
3
3 Airlines Scheduling & Counter Table Requirements
4
Current Week Algo Cost, Generate pdf, & Gate Departure Requirements
5
Algorithmic Cost (prev and next wk), Connects data to pdf, & Gate Arrival Requirements
6
Fix Roter (Bootstrap), Generate pie chart, & Staff Optimal Scheduling (33 airlines)
buffer
buffer
buffer
buffer
buffer
buffer
11-Jun
25-Jun
09-Jul
23-Jul
06-Aug
20-Aug
10-Sept

Timeline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2 3 4 1 2 3 4 5 1 2 3 4 1
7
Fix flight schedule (bootstrap), Generate Gantt Chart, & Staff Optimal Scheduling (generate result)
8
Simulation for Optimal Scheduling (flight delay arrival and departure)
9
Simulation for Optimal Scheduling (staff MC, resign rate)
10
Visualization & Manage Result
Final Pres. Preparation
Poster Day Preparation
buffer
buffer
buffer
buffer
1-Oct
15-Oct
05-Nov
19-Nov
NOW

*	Acceptance Presentation	
6	Optimal Scheduling	
7	Simulation for Optimal Scheduling, Visualisation, Manage Result	
8	Simulation for Optimal Scheduling, Visualisation, Manage Result	
*	Midterm Presentation, UT Final Presentation, Poster Day	UT

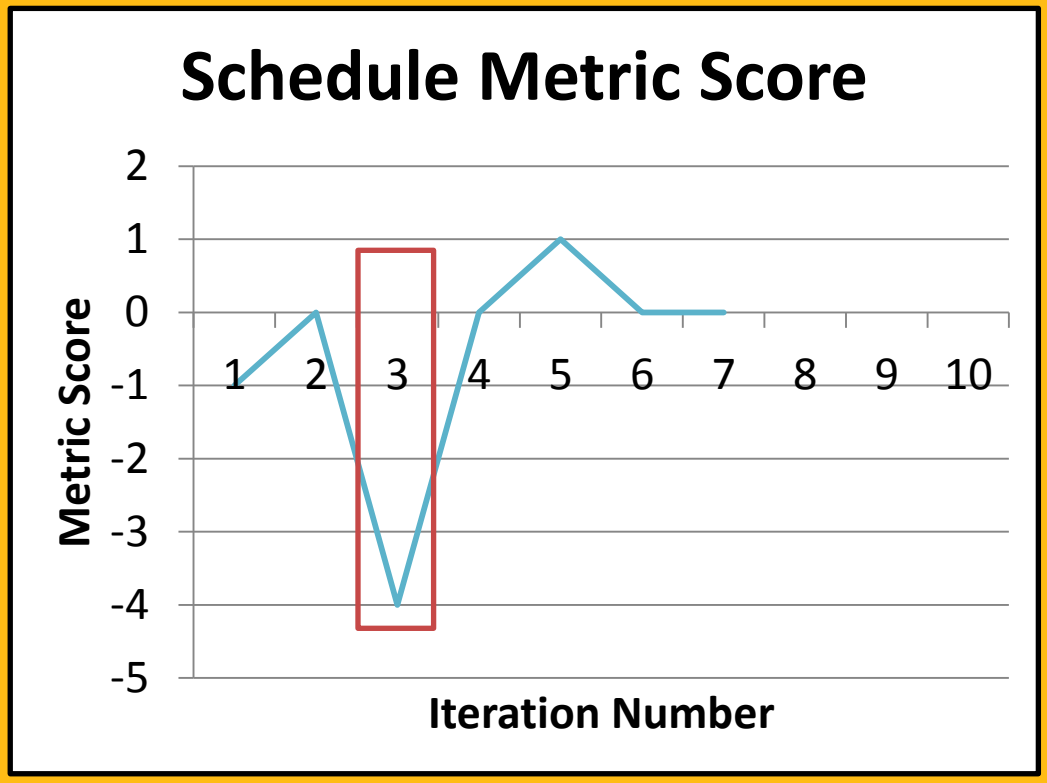
Before Acceptance

After Acceptance

*	Acceptance Presentation	
6	Bootstrap, Visualisation, Optimal Scheduling	
7	Bootstrap, Visualisation, Optimal Scheduling	UT1
8	Simulation for Optimal Scheduling	
*	Midterm Presentation	
8	Simulation for Optimal Scheduling	
9	Simulation for Optimal Scheduling	UT2
10	Visualisation, Manage Result	
*	Final Presentation, Poster Day	

Schedule Metric

X > 2	• Re-plan schedule to bring forward tasks
0< X ≤ 2	• Do nothing. Take a short break
-2< X ≤ 0	• Use buffer time to catch up
-4< X ≤ -2	• Utilize administrative time
X ≤ -4	• PM to re-schedule the project

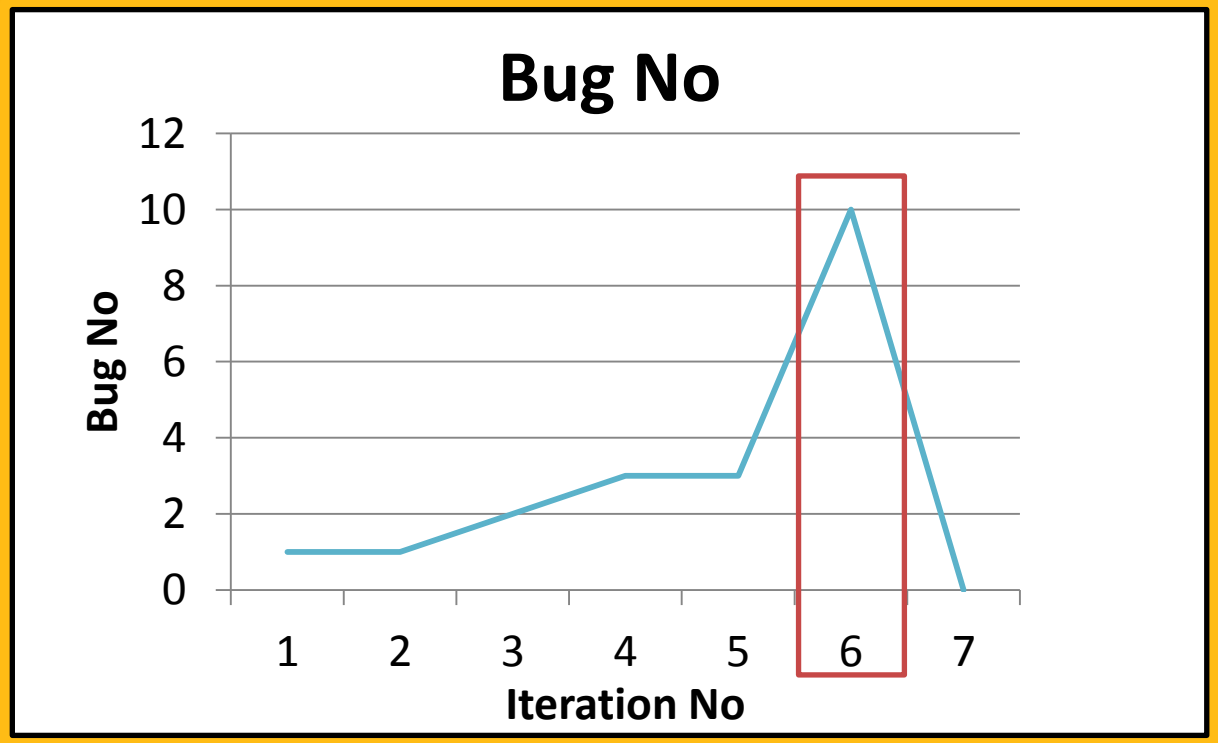


Risk Metric

S/N	Risk Statement	Likelihood (H/M/L)	Impact (H/M/L)	Lvl	Mitigation Strategy &/or Contingency Plan
1	**Managing expectation of new person in charge**	H	H	**A**	-Prepare software introduction to client and other potential users. -Earlier UT2 with client
2	**Limited real data to work with**	H	H	**A**	Consistent and thorough demonstration of system to client
3	**Long simulation duration taken**	H	H	**A**	Explore ways to increase the efficiency of code (e.g. caching)

Bug Metric

pts < 5	• Task programmer(s) to privately solve the bug. Fix during buffer time
5 ≤ pts < 10	• Raise the issue during a meeting to discuss cause and corresponding solution. Programmer(s) to solve the bug privately. Fix during iteration
pts ≥10	• Halt development. Call for a meeting to address the high-bug point level . Team solves the bug before proceeding. Project Manager to re-schedule the project



Reflection

- Proactive communication with stakeholders
  - To clarify doubts as soon as possible
  - To actively update all stakeholders on any changes and progress
- Conflict mitigation skills
  - Logical reasoning

Learning Outcome

- Familiarity with aviation industry
- Knowledge in :
  - Greedy algorithm
  - Algorithmic cost
  - Algorithm efficiency
  - Statistic and probability
  - Scheduling
  - Data visualisation
- Proficiency in Java Desktop application

Bumblebee

Midterm Presentation

10.Oct.2012 | 2pm

SATS

Staff Deployment Simulation Software