TRAIN CAPTAIN DEPLOYMENT at SMRT DEPOTS
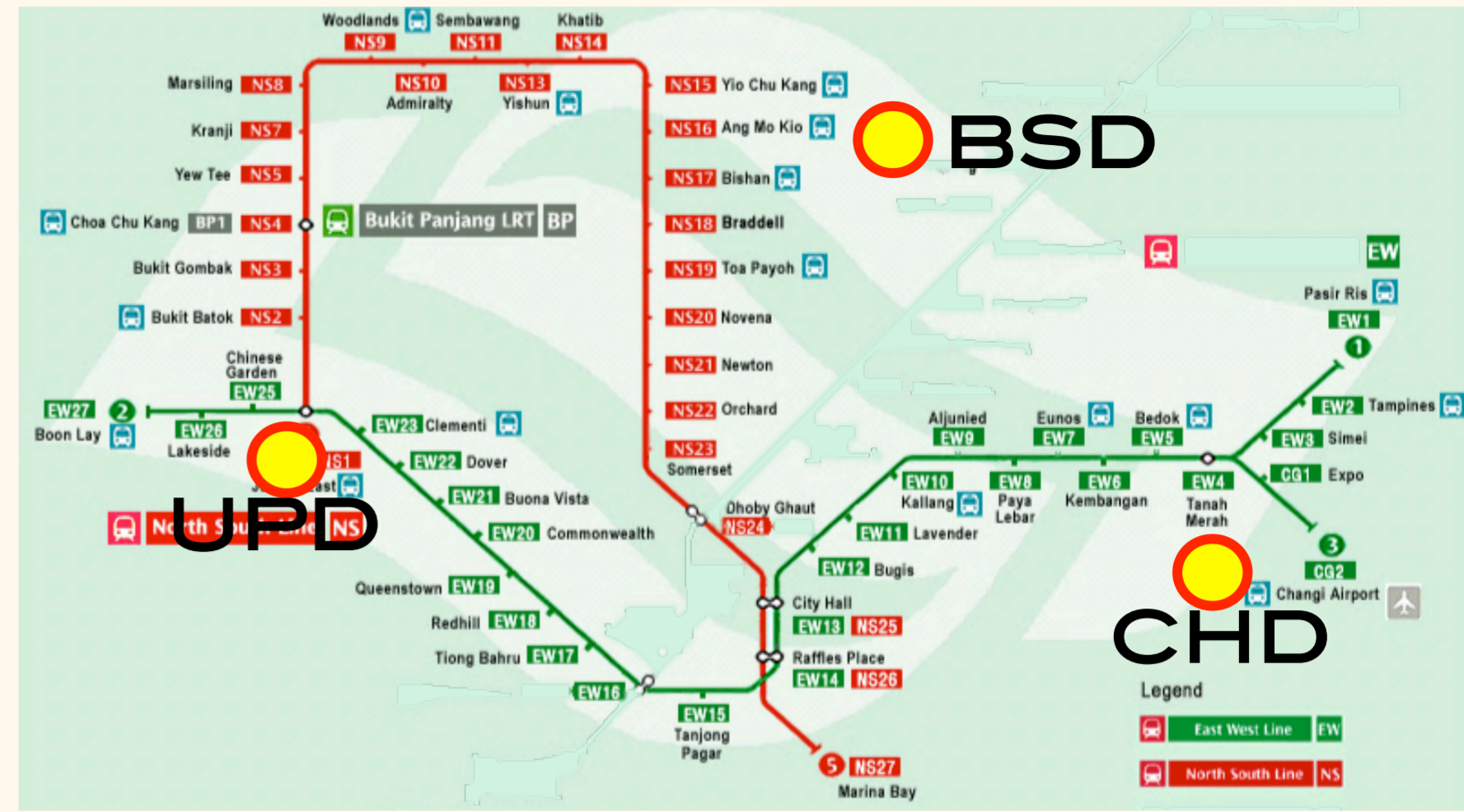
1.0 OVERVIEW
Project Description and Objective

Trains can be launched to the first station of the mainline in driverless operation. Therefore, there will be no Train Captains (TCs) needed to drive trains between depots to the mainline.

The focus of our project is TC deployment within the depots to minimise cost. This can be done in two ways. Thus our project has two objectives:
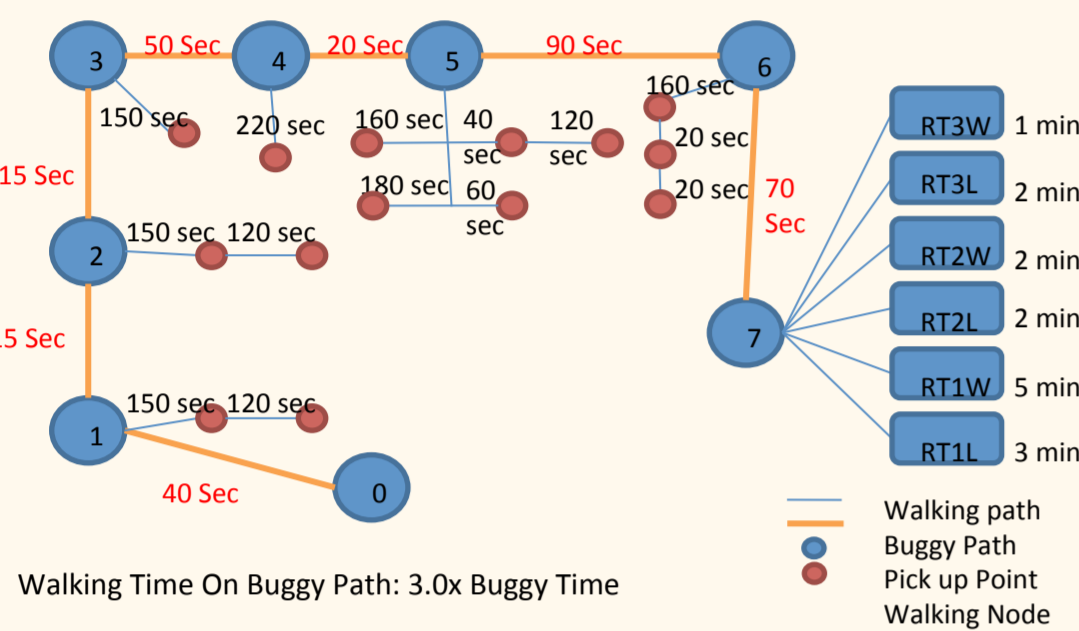
1. Minimising man-hours & **2.** Minimising the total number of TCs

Since only the NS and EW lines are manned by TCs, our study only focuses on depots for these two lines: Ulu Pandan Depot (UPD), Changi Depot (CHD), and Bishan Depot (BSD)

2.0 Ulu Pandan Depot (UPD)
Node Diagram

Walking Time On Buggy Path: 3.0x Buggy Time

Legend:
- Walking path
- Buggy Path
- Pick up Point
- Walking Node

RT3W 1 min
RT3L 2 min
RT2W 2 min
RT2L 2 min
RT1W 5 min
RT1L 3 min

All trains have to be prepared by a TC, then shunted to point 7, before they are launched.

Trains are stabled (parked) at points 1-6, and launched at point 7. TCs will be required to shunt (operate) trains from point 1-6, to point 7 for launching. They would then be "recycled"; required to head to their next duty at any point (1-6) to launch the next train, vice versa for train withdrawals.

Movements within the depot may be facilitated with a buggy.
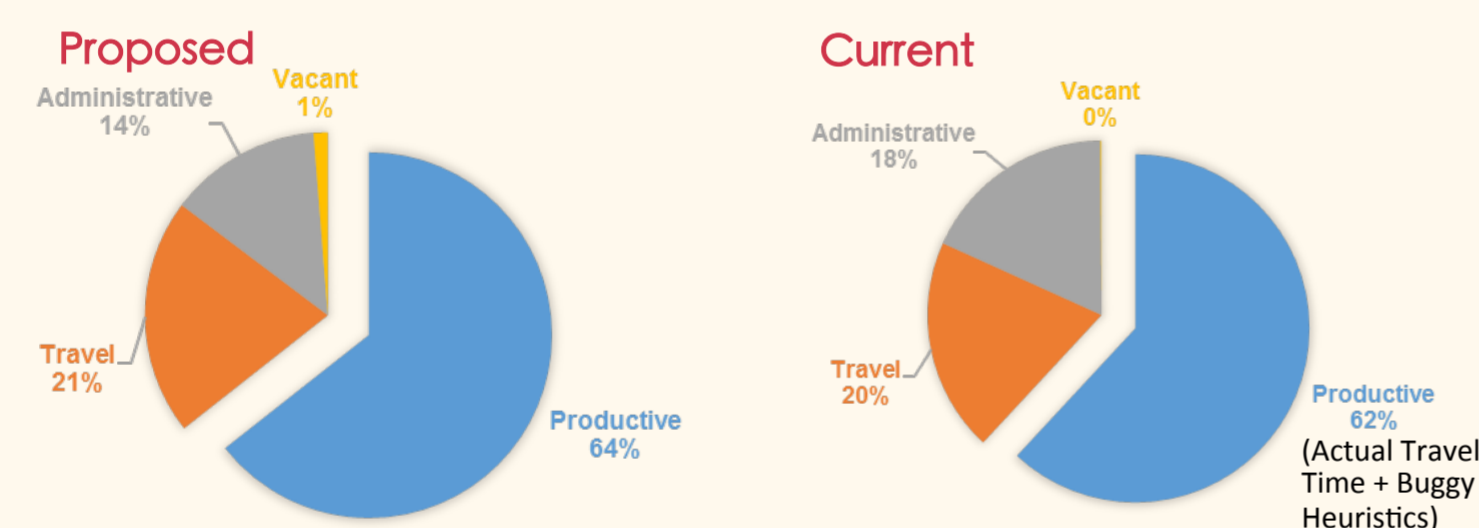
OBJECTIVE 1

Heuristics
① Same TC to prepare and shunt trains to cut down on travelling time
② No dedicated buggy operator
 • *Savings do no justify extra man-hours for buggy operators*
③ Buggy operation
 • *Parked only at point 0 and point 7*
 • *Buggy rides only can be triggered when a TC needs to travel from one end to another end of the depot, and it enables another TC to be recycled*
④ TC recycling
 • *Savings from clock-in timing and travelling to and from the mainline*

Working Hour Composition

Proposed: Administrative 14%, Vacant 1%, Travel 21%, Productive 64%

Current: Administrative 18%, Vacant 0%, Travel 20%, Productive 62% (Actual Travel Time + Buggy Heuristics)

Sensitivity Analysis for Walking Time

% Change in Walking Time	Proposed	Current Operation	% Reduction (working hour)	% Reduction (headcount)
-10%	24:49:44, 30 TCs	25:54:01,42 TCs	4.14%	28.57%
0	25:00:25, 31 TCs	26:00:04, 42 TCs	3.82%	26.19%
+10%	25:23:32, 33 TCs	26:13:17, 42 TCs	3.16%	21.43%
+20%	25:41:39, 32 TCs	26:23:19, 42 TCs	2.63%	23.81%
+30%	25:58:33, 34 TCs	26:36:19, 42 TCs	2.37%	19.05%

OBJECTIVE 2

Approach
Assign Shunting Jobs → Plug in Tran Preparation into free time windows → Allocate Train Pre-Preparation based on Strategy 1 & 2

Strategies
1 Try having all TCs report at the same time
2 Try balancing TC workloads

Heuristics
① Consider Shunting as the real bottleneck
 • *Focus on the second phase of the launching process: Shunting*
 • *Consider Train Preparation only after Shunting duty is allocated*
② Last available TC → First recycle
③ Do not consider buggy
 • *Only 1-2 TCs reduced, even if we assume infinite buggies*
 • *Planning based on all-walking assumption*
④ Plugging in Train Preparation timings
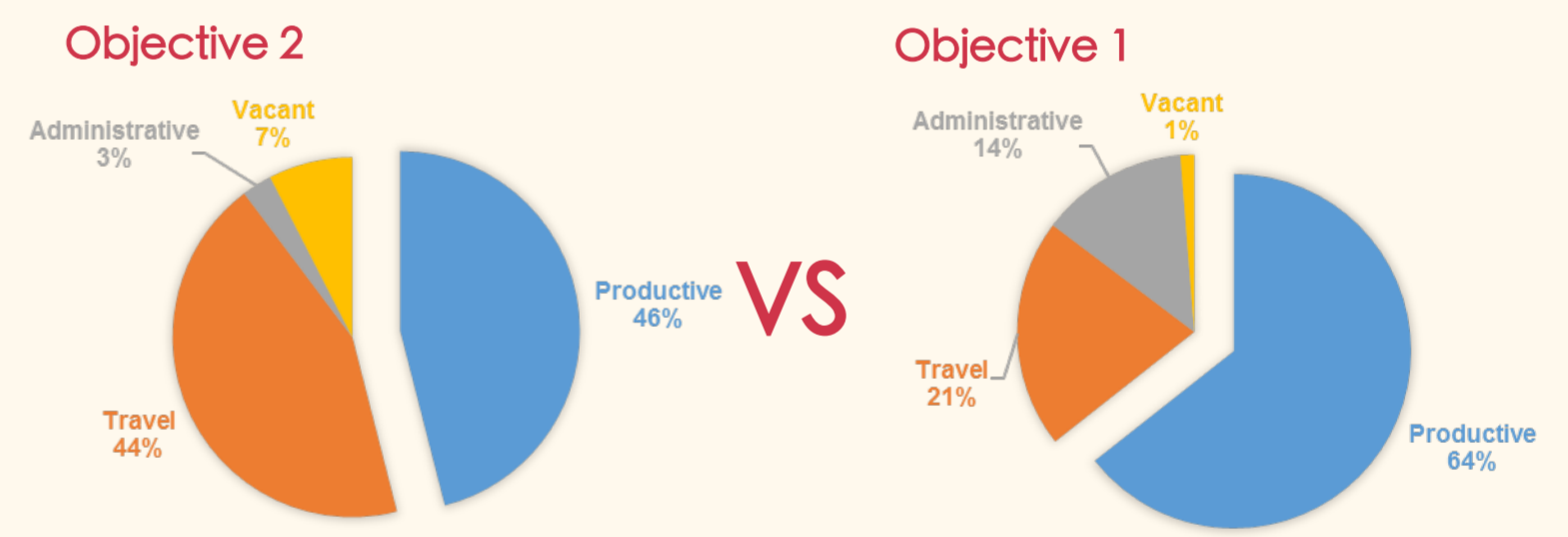 • *Trips taken by TCs are optimised to avoid detour*

Working Hour Composition

Objective 2: Administrative 3%, Vacant 7%, Travel 44%, Productive 46% VS Objective 1: Administrative 14%, Vacant 1%, Travel 21%, Productive 64%
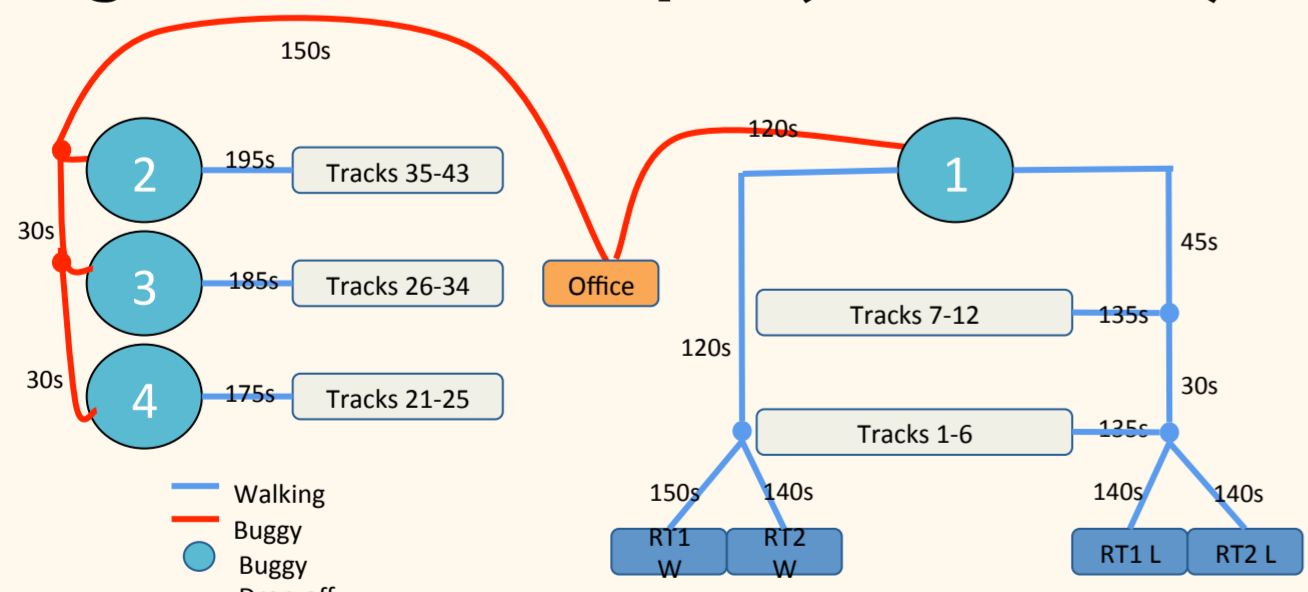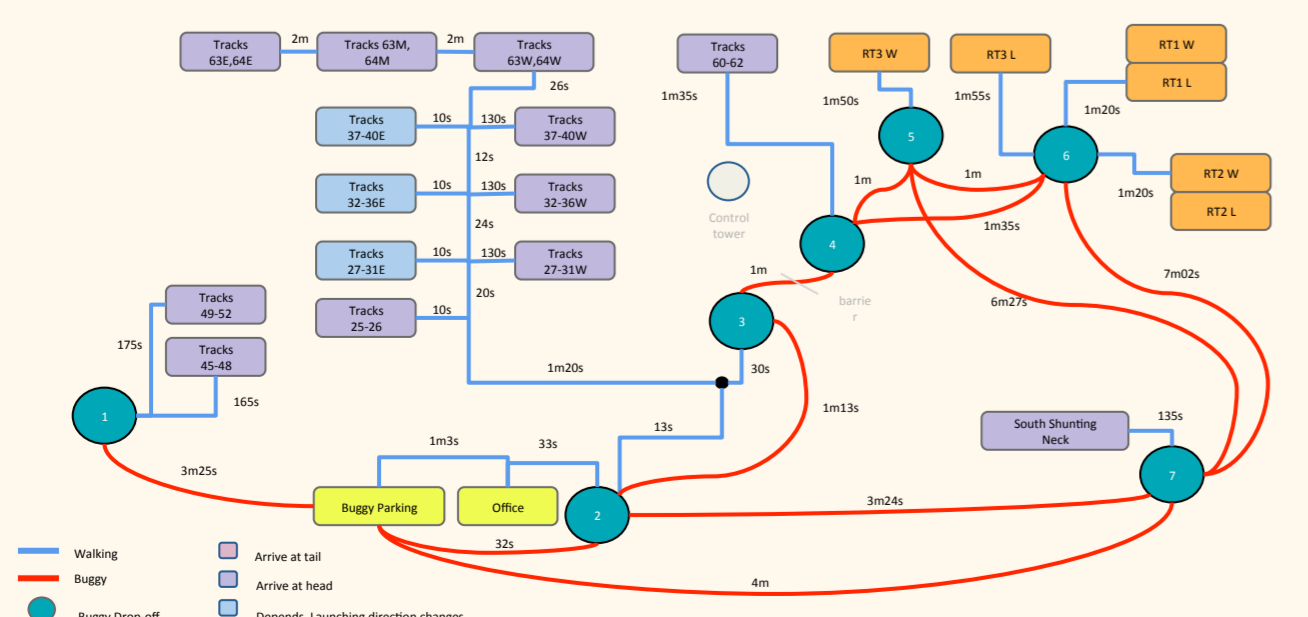
Sensitivity Analysis for Walking Time

% Change in Walking Time	Number of TCs Needed	Pre-Prep Needed	Total Man-hour (assume 20min pre-prep)	% Reduction (headcount)
-10%	11	17	31:54:27	73.81%
0	11	17	32:45:30	73.81%
+10%	12	15	33:18:38	71.43%
+20%	12	16	34:24:21	71.43%
+30%	12	18	35:25:09	71.43%

3.0 Changi and Bishan Depot (CHD & BSD)

CHD

Legend:
- Walking
- Buggy
- Buggy Drop-off

BSD

Legend:
- Walking
- Buggy
- Buggy Drop off
- Arrive at tail
- Arrive at head
- Depends, Launching direction changes

ANALYSIS

Under objective 1, there are potential savings that can be achieved
• However, savings do not justify the extra risk of running a more complicated TC deployment plan

Under objective 2, separation of duties can be achieved as we only need around 11 TCs for the busiest morning launch
• However, unless depot TC's hourly wage is significantly lower than mainline TC, such separation does not seem to produce favorable economic outcome

FINAL CHOICE

Savings from Objective 1 do not justify the additional operational risks

We have chosen to work on Objective 2 for the other 2 SMRT depots, Changi (CHD) and Bishan (BSD) depots. We used the same methodology to approach the problem from CHD and BSD..

4.0 Future Direction

This project only focuses on TC deployment. Currently, time taken for Shunting is estimated to be a constant value. In the future, SMRT could look at optimising Shunting and TC deployment concurrently. This was not done in our project because it would result in complicated TC deployment schedule. In every socio-technical system like SMRT, it is important to consider the interactions between human operators and the technical aspect of the system. Introducing too much changes at once may result in high risks of human error. Thus, changes should be carried out in a step-by-step process.

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