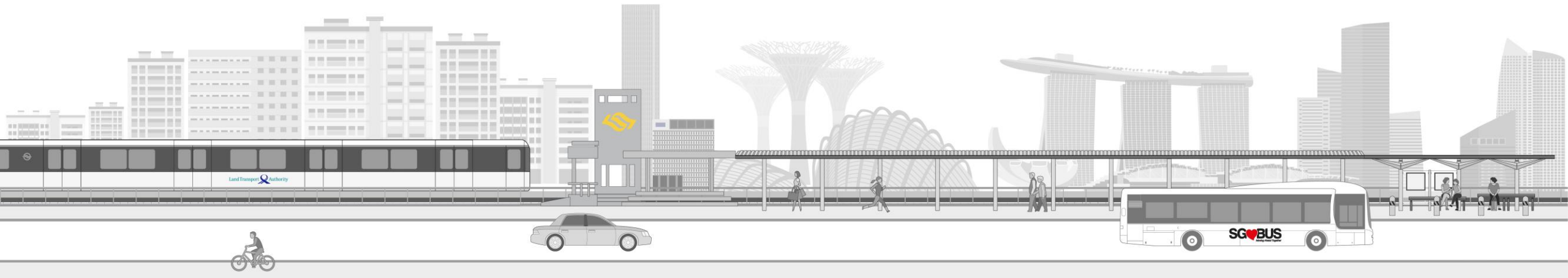


Internship Experience at LTA

Eugene Tan Yan Hao

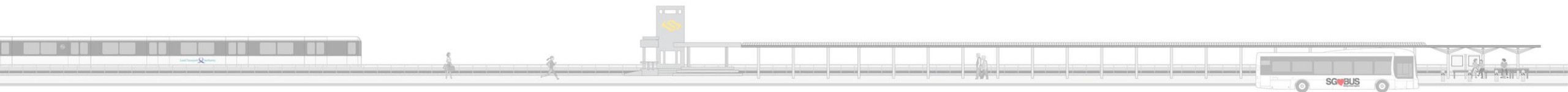
AMSP Intern

2nd June 2022



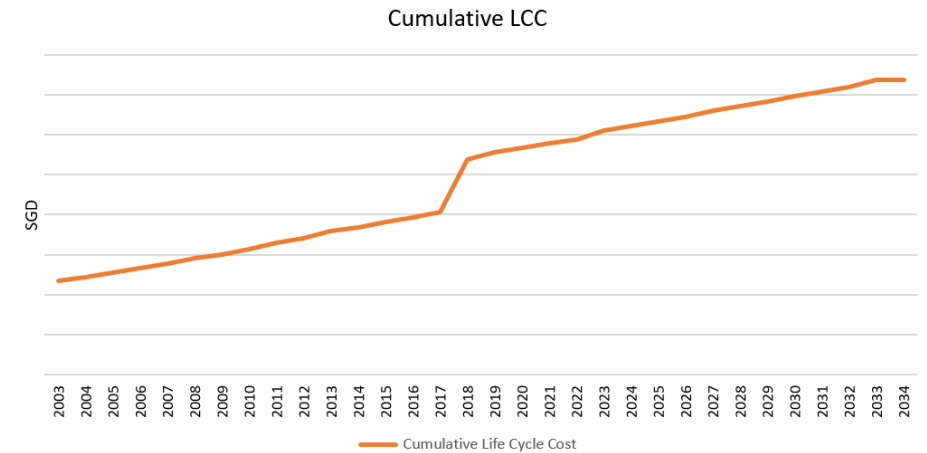
Asset Management Introduction

- Stage 1: Adopt international asset management standards such as ISO 55001.
- Stage 2: Identify what data assets exist and classify them to determine where to focus efforts for more in-depth analysis.
- Stage 3: Focus on asset life cycle data as they are important to understand and manage the conditions, capabilities, and interventions to minimize cost and risk.
- Stage 4: Pool the information collected to form a “predict and prevent” strategy to improve our assets' reliability, availability, and maintainability.

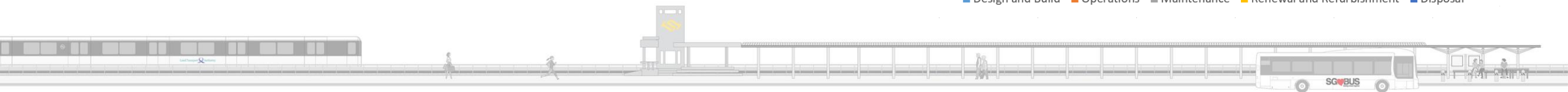
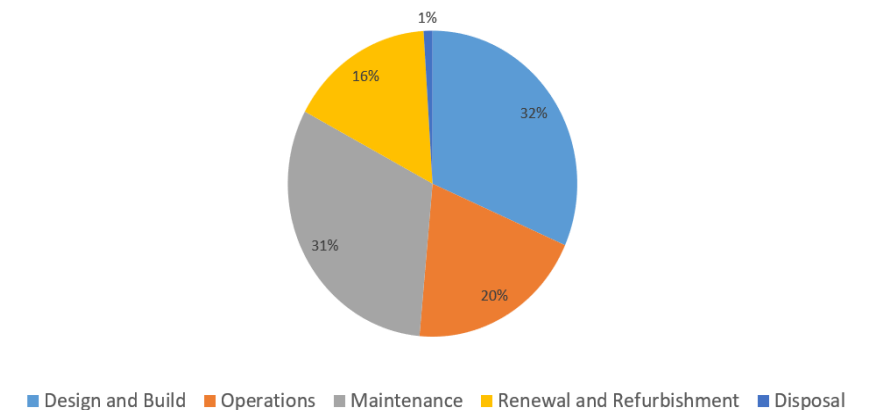


LCC Case Study Background

- C751A case study focused on LCC at the train-level.
- We want to go deeper to investigate cost drivers, preferably at the subsystem level.
- For C830 case study, we explore the use of Work Order (WO) data from the MMS and LCC data from the OEM.



LCC in terms of Life Cycle Activities



Natural Language Processing (NLP)

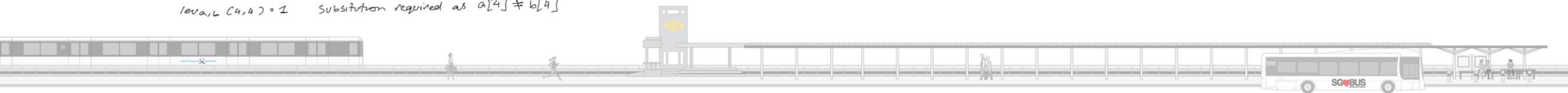
- NLP is used to pool the two data sources together to build a LCC model.
 - Common NLP techniques:
 - Pre-processing: Spell-check, tokenization, lemmatization, stop-words removal.
- Input: 's2 Overhaul for Parking Brake Hose replacement: replaced with brand new hose'
- Output: ['overhaul', 'park', 'brake', 'hose', 'replacement', 'replace', 'brand', 'new', 'hose']
- Feature-recognition: bag-of-words, n-grams, TF-IDF, levenshtein distance.

Index				
	1	2	3	4
a = k	I	I	N	O
b = k	I	I	N	D

$lev_{a,b}(1,1) = 0$ Characters at $a[1] = b[1]$
 $lev_{a,b}(2,2) = 0$ Characters at $a[2] = b[2]$
 $lev_{a,b}(3,5) = 0$ Characters at $a[3] = b[3]$
 $lev_{a,b}(4,4) = 1$ Substitution required as $a[4] \neq b[4]$

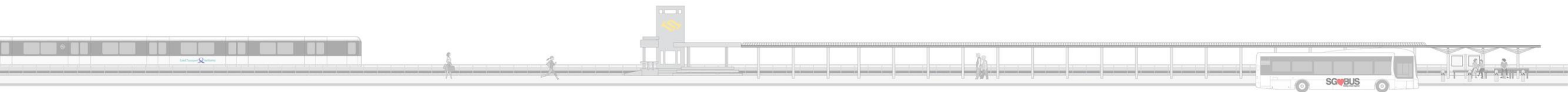
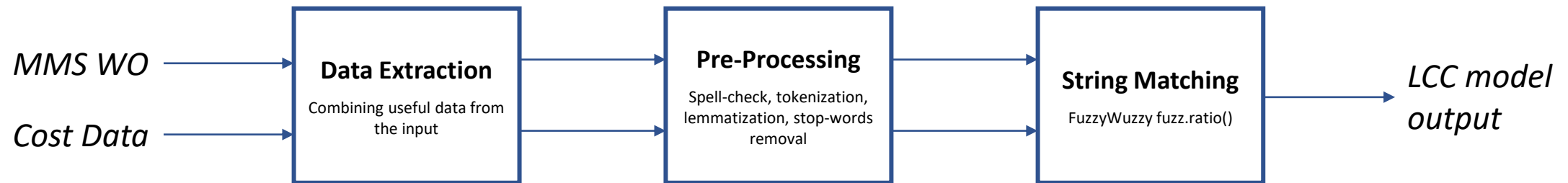
Order Number	Order Type	Actual Finish Date Time	Functional Location	Category	Sub Category	WO Text	Operation Text	Man Hour
1836911	PM02	01/01/2019 01:30:00	8520RSC/TRN	TRN	NH	3-Weekly Inspection Checklist 01C	- PM DONE BY KCD 4	1:00:00
1836911	PM02	01/01/2019 01:30:00	8520RSC/TRN	TRN	NH	3-Weekly Inspection Checklist 01C	- PM DONE BY KCD 4	0:15:00
1836911	PM02	01/01/2019 01:30:00	8520RSC/TRN	TRN	NH	3-Weekly Inspection Checklist 01C	- PM DONE BY KCD 4	1:00:00
1836869	PM02	01/01/2019 02:30:00	8230RSC/TRN	TRN	NH	3-Weekly Inspection Checklist 01	- PM DONE BY KCD 5 & 2	0:00:00
1836869	PM02	01/01/2019 02:30:00	8230RSC/TRN	TRN	NH	3-Weekly Inspection Checklist 01	- PM DONE BY KCD 5 & 2	0:00:00
1836869	PM02	01/01/2019 02:30:00	8230RSC/TRN	TRN	NH	3-Weekly Inspection Checklist 01	- PM DONE BY KCD 5 & 2	0:00:00
1837030	PM02	01/01/2019 02:30:00	8560RSC/TRN	TRN	NH	6-Weekly Inspection Checklist 01C	- PM DONE BY KCD 3	0:00:00
1837030	PM02	01/01/2019 02:30:00	8560RSC/TRN	TRN	NH	6-Weekly Inspection Checklist 01C	- PM DONE BY KCD 3	0:00:00
1837030	PM02	01/01/2019 02:30:00	8560RSC/TRN	TRN	NH	6-Weekly Inspection Checklist 01C	- PM DONE BY KCD 3	0:00:00
1837027	PM02	01/01/2019 06:00:00	8560RSC/TRN	TRN	NH	3-Weekly Inspection Checklist 01C	- PM DONE BY KCD 3	0:00:00
1837027	PM02	01/01/2019 06:00:00	8560RSC/TRN	TRN	NH	3-Weekly Inspection Checklist 01C	- PM DONE BY KCD 3	0:00:00
1837027	PM02	01/01/2019 06:00:00	8560RSC/TRN	TRN	NH	3-Weekly Inspection Checklist 01C	- PM DONE BY KCD 3	0:00:00
1835676	PM02	01/01/2019 08:36:38	8000RSC/TRN	TRN	NH	Train Wash - Exterior Side Wash	- PM DONE BY KCD 3	0:00:00
1835809	PM02	01/01/2019 09:06:11	8270RSC/TRN	TRN	NH	Train Wash - Exterior Side Wash	- PM DONE BY KCD 3	0:00:00
1836050	PM02	01/01/2019 10:01:04	8530RSC/TRN	TRN	NH	Train Wash - Exterior Side Wash	- PM DONE BY KCD 3	0:00:00
1836877	PM02	01/01/2019 11:00:00	8040RSC/TRN	TRN	NH	CCL/W/RSO/W01	- PM DONE BY KCD 1 & 8	0:00:00
1836877	PM02	01/01/2019 11:00:00	8040RSC/TRN	TRN	NH	CCL/W/RSO/W01	- PM DONE BY KCD 1 & 8	0:00:00
1836877	PM02	01/01/2019 11:00:00	8040RSC/TRN	TRN	NH	CCL/W/RSO/W01	- PM DONE BY KCD 1 & 8	0:00:00
1836877	PM02	01/01/2019 11:00:00	8040RSC/TRN	TRN	NH	CCL/W/RSO/W01	- PM DONE BY KCD 1 & 8	0:00:00
1836877	PM02	01/01/2019 11:00:00	8040RSC/TRN	TRN	NH	CCL/W/RSO/W01	- PM DONE BY KCD 1 & 8	0:00:00

Type	Code	L2 Item Description	L3 Item Description	L4 Item Description	L5 Item Description	L6 Item Description	Task	Task Description	Labour Cost [Hrs]	Material Cost [Hrs] (incl. consumables)	Space Part Cost (for new Replacement Task) [Hrs]
PM	1	Carbody and Car Interior	Car Interior	Seats	Fixed Passenger seat		Inspection	Visual inspection	10	0	0
PM	2	Carbody and Car Interior	Car Interior	Seats	Fixed Passenger seat		Cleaning	Clean with water. Wash with detergent for heavy stains	20	2.50	0
PM	3	Carbody and Car Interior	Car Interior	Seats	Rotation Passenger seat		Cleaning	Clean with water. Wash with detergent for heavy stains	10	2.50	0
PM	4	Carbody and Car Interior	Car Interior	Seats	Rotation Passenger seat		Inspection	Visual and function inspection	10	0	0
PM	5	Carbody and Car Interior	Car Interior	Seats	Gas spring		Replacement	Replace gas spring	40	0	11.80
PM	6	Carbody and Car Interior	Lighting	Exterior Lighting	Head Light / Tail Light (Left & Right)		Inspection	Visual check	5.00	0	0
PM	7	Carbody and Car Interior	Lighting	Exterior Lighting	Head Light / Tail Light (Left & Right)		Inspection	Check whether bulbs are loosened or not	5.00	0	0
PM	8	Carbody and Car Interior	Lighting	Exterior Lighting	Head Light / Tail Light (Left & Right)		Cleaning	Wipe off foreign substance on the lens	5.00	0	0
PM	9	Carbody and Car Interior	Lighting	Exterior Lighting	Head Light / Tail Light (Left & Right)		Inspection	Check the lighting status and if it is defective, replace the LED module	5.00	0	0
PM	10	Carbody and Car Interior	Lighting	Exterior Lighting	Head Light / Tail Light (Left & Right)		Inspection	Check the lighting status and if it is defective, replace the Power module	5.00	0	0
PM	11	Carbody and Car Interior	Lighting	Exterior Lighting	Head Light / Tail Light (Left & Right)		Inspection	Check the lighting status and if it is defective, replace the LED module	5.00	0	0
PM	12	Carbody and Car Interior	Lighting	Exterior Lighting	Head Light / Tail Light (Left & Right)		Inspection	Check the lighting status and if it is defective, replace the Power module	5.00	0	0
PM	13	Carbody and Car Interior	Lighting	Exterior Lighting	ATC Marker Light		Inspection	Visual check	5.00	0	0
PM	14	Carbody and Car Interior	Lighting	Exterior Lighting	ATC Marker Light		Inspection	Check whether bulbs are loosened or not	5.00	0	0
PM	15	Carbody and Car Interior	Lighting	Exterior Lighting	ATC Marker Light		Cleaning	Wipe off foreign substance on the lens	5.00	0	0
PM	16	Carbody and Car Interior	Lighting	Exterior Lighting	ATC Marker Light	LED module	Inspection	Check the lighting status and if it is defective, replace the LED module	5.00	0	0
PM	17	Carbody and Car Interior	Lighting	Exterior Lighting	ATC Marker Light	Power module	Inspection	Check the lighting status and if it is defective, replace the Power module	5.00	0	0
PM	18	Carbody and Car Interior	Lighting	Exterior Lighting	Flood Light		Inspection	Visual check	5.00	0	0
PM	19	Carbody and Car Interior	Lighting	Exterior Lighting	Flood Light		Inspection	Check whether bulbs are loosened or not	5.00	0	0
PM	20	Carbody and Car Interior	Lighting	Exterior Lighting	Flood Light		Cleaning	Wipe off foreign substance on the lens	5.00	0	0
PM	21	Carbody and Car Interior	Lighting	Exterior Lighting	Flood Light	LED module	Inspection	Check the lighting status and if it is defective, replace the LED module	5.00	0	0
PM	22	Carbody and Car Interior	Lighting	Exterior Lighting	Flood Light	Power module	Inspection	Check the lighting status and if it is defective, replace the Power module	5.00	0	0
PM	23	Carbody and Car Interior	Lighting	Exterior Lighting	Exterior Door Indicator Lamp		Inspection	Visual check	5.00	0	0
PM	24	Carbody and Car Interior	Lighting	Exterior Lighting	Exterior Door Indicator Lamp		Inspection	Check whether bulbs are loosened or not	5.00	0	0
PM	25	Carbody and Car Interior	Lighting	Exterior Lighting	Exterior Door Indicator Lamp		Cleaning	Wipe off foreign substance on the lens	5.00	0	0



NLP Process

- Actual levenshtein distance algorithm is quite technical. We use a python package FuzzyWuzzy to take care of that.
- FuzzyWuzzy matches each WO from the MMS to a maintenance task specified by the OEM. We then extract the cost data from that matched maintenance task.



NLP Output

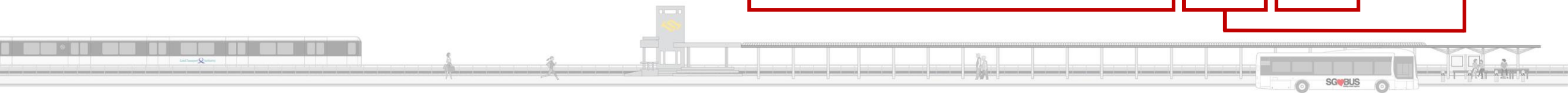
List of keywords
from the MMS WO

Task the WO
is matched to

How good
the match is

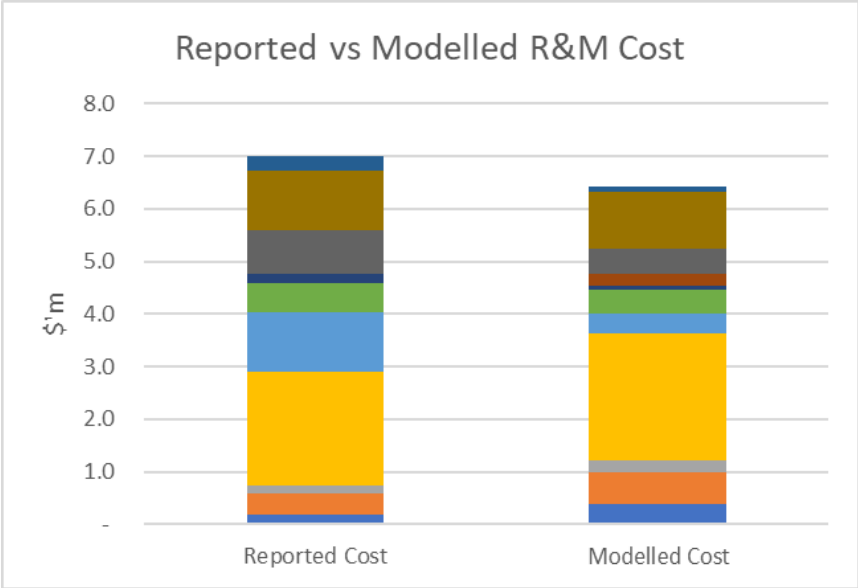
	Order Number	Order Type	Actual Finish Date Time	Functional Location	Category	Sub Category	Man Hour	Combined Info	Matched Task	Matched Score
0	1872288	PM01	01/04/2019 12:00:00	8352/RSC/AUX	AUX	Nil	00:00:00	['pv35', 'tip', 'show', 'cool', 'fail', 'du', 'show', 'ai', '2', 'green', 'check', 'air', 'fault', 'code', 'ok', 'normal', 'replace', 'air', 'fip', 'card', 'precautionary', 'measure', 'replacement', 'fip', 'card', 'du', 'show', 'ai', '2', 'ok']	1671	50
1	1872288	PM01	01/04/2019 12:00:00	8352/RSC/AUX	AUX	Nil	00:00:00	['pv35', 'tip', 'show', 'cool', 'fail', 'du', 'show', 'ai', '2', 'green', 'check', 'air', 'fault', 'code', 'ok', 'normal', 'replace', 'air', 'fip', 'card', 'precautionary', 'measure', 'replacement', 'fip', 'card', 'du', 'show', 'ai', '2', 'ok']	1671	50
2	1913738	PM01	01/09/2019 12:15:00	8372/RSC/AUX	AUX	Nil	00:00:00	['pa', '37', '8372', 'auxiliary', 'equipment', '1', 'failure', 'du', 'show', '8372', 'air', 'fail', 'code', 'air', 'caf', 'check', 'find', 'ke', 'faulty', 'replace', 'ke', 'air', 'replace', 'power', 'test', 'ok', 'du', 'show', 'air', 'green', 'old', '14', 'new']	1733	51
3	1913738	PM01	01/09/2019 12:15:00	8372/RSC/AUX	AUX	Nil	00:00:00	['pa', '37', '8372', 'auxiliary', 'equipment', '1', 'failure', 'du', 'show', '8372', 'air', 'fail', 'code', 'air', 'caf', 'check', 'find', 'ke', 'faulty', 'replace', 'ke', 'air', 'replace', 'power', 'test', 'ok', 'du', 'show', 'air', 'green', 'old', '14', 'new']	1733	51
4	1863689	PM01	02/03/2019 13:30:00	8352/RSC/AUX	AUX	Nil	03:45:00	['pv35', 'ats', 'alarm', 'show', 'high', 'voltage', 'able', 'du', 'show', 'ai', '2', 'fail', 'car', '3', 'battery', 'charger', 'inhibit', 'care', 'air', 'compressor', 'fail', 'check', 'air', 'code', 'caf', 'fail', 'replace', 'air', 'ke', 'ke', 'replace', 'test', 'power', 'air', 'ok']	1733	49

Cost data
extracted
from
matched task



LCC Model

- We check the output by comparing it against the reported C830 costs in the LCC report.



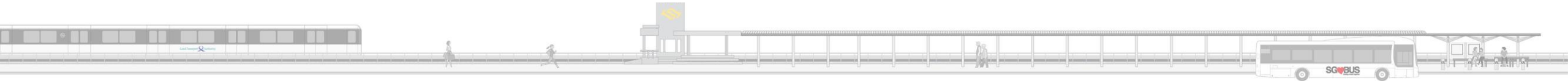
S/N	Subsystem	Reported Cost		Results	
		R&M ¹	Labour ²	R&M	Labour ³
1	Air Conditioning and Ventilation	\$ ██████████	\$ ██████████	\$ ██████████	██████████
2	Air Supply and Braking System	\$ ██████████		\$ ██████████	██████████
3	Auxiliary Electrical System & Vehicle	\$ ██████████		\$ ██████████	██████████
4	Bogie	\$ ██████████		\$ ██████████	██████████
5	Carbody & Interior	██████████		\$ ██████████	██████████
6	Gangway & Coupler	██████████		\$ ██████████	██████████
7	EDD	██████████		\$ ██████████	██████████
8	Passenger Access Door	██████████		\$ ██████████	██████████
9	Traction System	██████████		██████████	██████████
	████████████████████	██████████		██████████	██████████
11	Train-borne Communication System	██████████		\$ ██████████	██████████
Subtotal		\$ ██████████	██████████	██████████	██████████
Percentage Accuracy				91.86%	43.80%

Remarks

¹ Prorated according to FY21 R&M subsystems breakdown

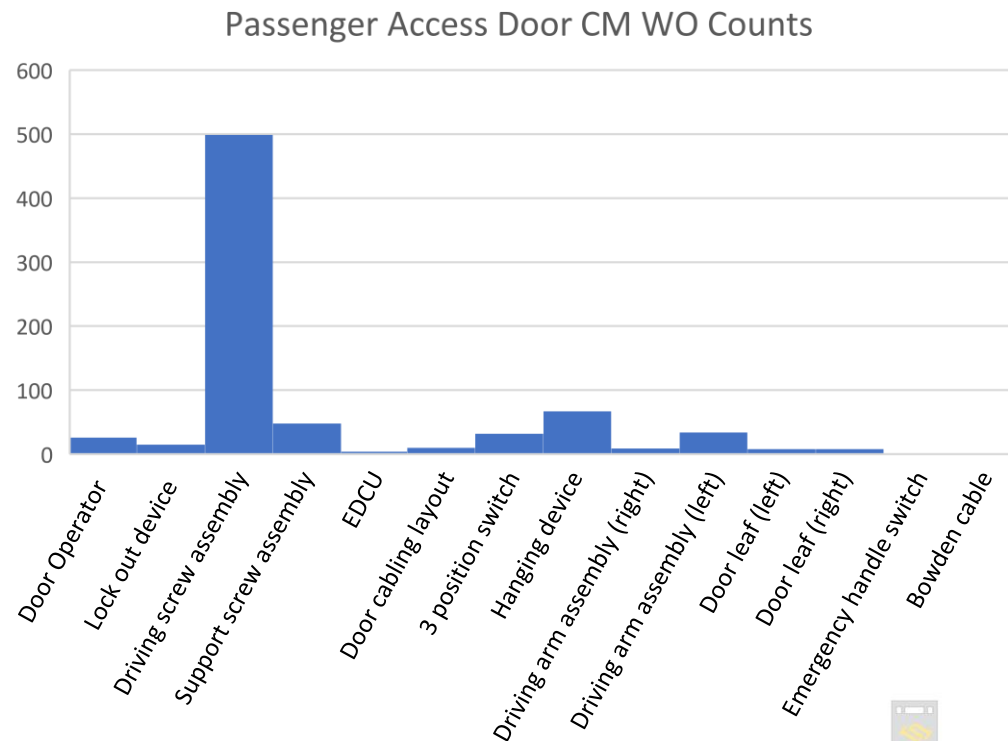
² Prorated according to FY21 R&M fleet breakdown

³ Labour cost is expected to be lower to account for depot technicians staff cost

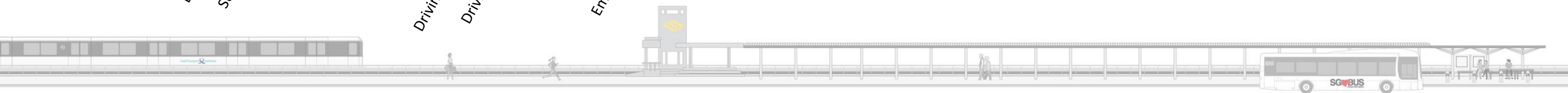


Advantage of NLP Approach

- This approach gives us greater visibility into the specific elements that are causing more frequent failures.

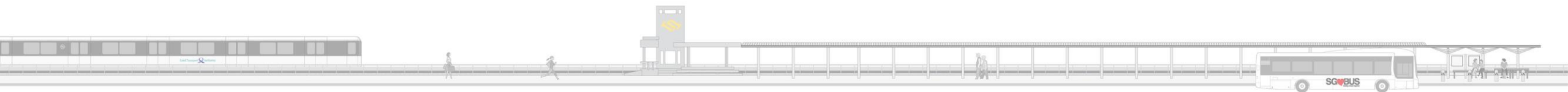


- Able to correlate this data with asset condition data (tied to subsystems) to do projections on LCC.
- Able to correlate this data with RAMS parameters to investigate their impact on the LCC.
- Able to apply this method to historical MMS data to obtain past breakdown of maintenance cost.
- Easy to replicate this approach to other systems.



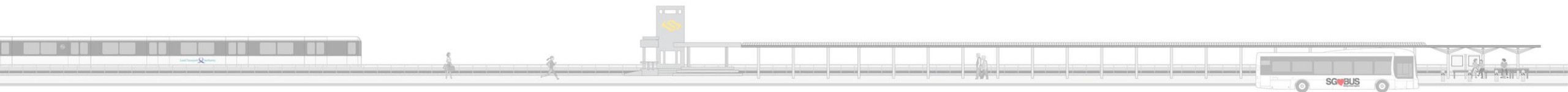
Concluding Remarks

- Limitations of LCC modelling with NLP:
 - Unable to determine exactly how accurate the matched tasks is.
 - Unable to factor in obsolescence, which can be quite a wildcard to the LCC.
- Next steps for case study:
 - Integrate other LCC elements: CAPEX, operations cost, energy costs, depot equipment costs.
 - Apply same financial projection approach as C751A to estimate LCC, but with greater insight into the subsystems characteristics and cost drivers.



Internship Thoughts

- Good experience in using skills learnt in school to be applied in the railway industry datasets
- Looking forward to how the Digital Lab can help clean data more efficiently in the future
- Improvement would be python installed in WOG laptops in the future
- Many thanks to Ning Xuan for his guidance!



Q&A

