

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	N	C	
$b = k$	I	N	D	

$$\text{lev}_{a,b}(1,1) = 0$$

Characters at $a[1] = b[1]$

$$\text{lev}_{a,b}(2,2) = 0$$

Characters at $2[2] = 6[2]$

$$\text{lev}_{a,b}(3,5) = 0$$

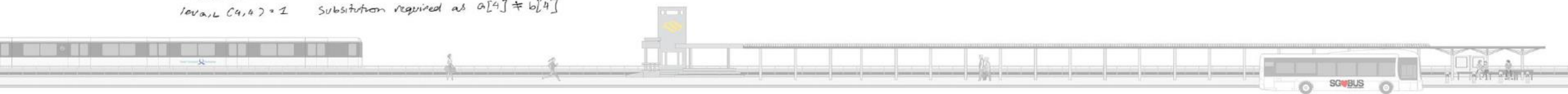
Characters at $a[3] = b[3]$

$$\text{lev}_{a, L}(4, 4) = 1$$

Substitution required as $a[4] \neq b[4]$

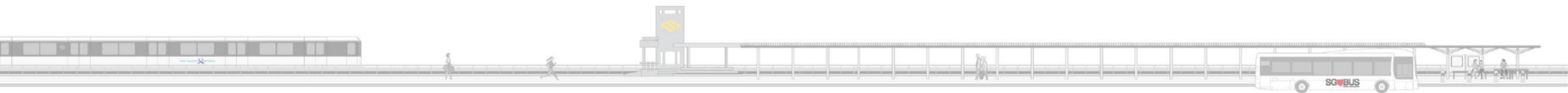
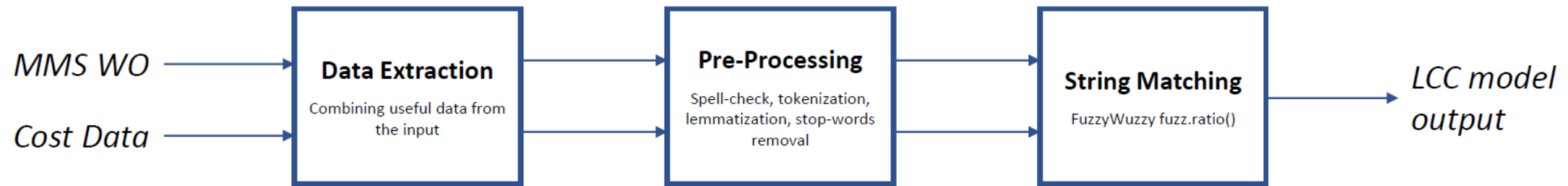
[illegible]

Type	Code	1.4 Item Description	2.4 Item Description	3.4 Item Description	4.4 Item Description	5.4 Item Description	Task	Task Description	Labour Cost (\$/hr)	Material Cost (\$/hr) (excludes the cost of replacement task)	Notes that can be replaced by the replacement task (N/A)
PM	1	Catwalk and Car Interior	Car Interior	Seats	Front Passenger seat		Inspection	Visual inspection	10	0	
PM	2	Catwalk and Car Interior	Car Interior	Seats	Front Passenger seat		Cleaning	Seat with water. Wipe-dry thoroughly for heavy stains.	20	2.50	
PM	3	Catwalk and Car Interior	Car Interior	Seats	Front Passenger seat		Cleaning	Seat with water. Wipe-dry thoroughly for heavy stains.	10	2.50	
PM	4	Catwalk and Car Interior	Car Interior	Seats	Front Passenger seat		Inspection	Visual inspection	10	0	
PM	5	Catwalk and Car Interior	Car Interior	Seats	Car spring		Inspection	Check upper and lower springs	40	0	11.00
PM	6	Catwalk and Car Interior	Lighting	Interior Lighting	Head Light 1 Left Light Lock & Release		Inspection	Visual check	5.00	0	
PM	7	Catwalk and Car Interior	Lighting	Interior Lighting	Head Light 1 Left Light Lock & Release		Inspection	Check whether bulbs are burned out	5.00	0	
PM	8	Catwalk and Car Interior	Lighting	Interior Lighting	Head Light 1 Left Light Lock & Release	LED module (2nd)	Cleaning	Wipe off foreign substances on the lens	6.00	0	
PM	9	Catwalk and Car Interior	Lighting	Interior Lighting	Head Light 1 Left Light Lock & Release	Power module (2nd)	Inspection	Check the lighting status and fit it to machine, replace the Power module	6.00	0	
PM	10	Catwalk and Car Interior	Lighting	Interior Lighting	Head Light 1 Left Light Lock & Release	LED module (2nd)	Inspection	Check the lighting status and fit it to machine, replace the LED module	6.00	0	
PM	11	Catwalk and Car Interior	Lighting	Interior Lighting	Head Light 1 Left Light Lock & Release	Power module (2nd)	Inspection	Check the lighting status and fit it to machine, replace the Power module	6.00	0	
PM	12	Catwalk and Car Interior	Lighting	Interior Lighting	ATC Mark Light		Inspection	Visual check	5.00	0	
PM	13	Catwalk and Car Interior	Lighting	Interior Lighting	ATC Mark Light		Inspection	Check whether bulbs are burned out	5.00	0	
PM	14	Catwalk and Car Interior	Lighting	Interior Lighting	ATC Mark Light		Cleaning	Wipe off foreign substances on the lens	5.00	0	
PM	15	Catwalk and Car Interior	Lighting	Interior Lighting	ATC Mark Light	LED module	Inspection	Check the lighting status and fit it to machine, replace the LED module	5.00	0	
PM	16	Catwalk and Car Interior	Lighting	Interior Lighting	ATC Mark Light	Power module	Inspection	Check the lighting status and fit it to machine, replace the Power module	5.00	0	
PM	17	Catwalk and Car Interior	Lighting	Interior Lighting	ATC Mark Light		Inspection	Visual check	5.00	0	
PM	18	Catwalk and Car Interior	Lighting	Interior Lighting	ATC Mark Light		Inspection	Check whether bulbs are burned out	5.00	0	
PM	19	Catwalk and Car Interior	Lighting	Interior Lighting	ATC Mark Light		Cleaning	Wipe off foreign substances on the lens	5.00	0	
PM	20	Catwalk and Car Interior	Lighting	Interior Lighting	ATC Mark Light	LED module	Inspection	Check the lighting status and fit it to machine, replace the LED module	5.00	0	
PM	21	Catwalk and Car Interior	Lighting	Interior Lighting	ATC Mark Light	Power module	Inspection	Check the lighting status and fit it to machine, replace the Power module	5.00	0	
PM	22	Catwalk and Car Interior	Lighting	Interior Lighting	Exterior Chassis Indicator Lamp		Inspection	Visual check	5.00	0	
PM	23	Catwalk and Car Interior	Lighting	Interior Lighting	Exterior Chassis Indicator Lamp		Cleaning	Wipe off foreign substances on the lens	5.00	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

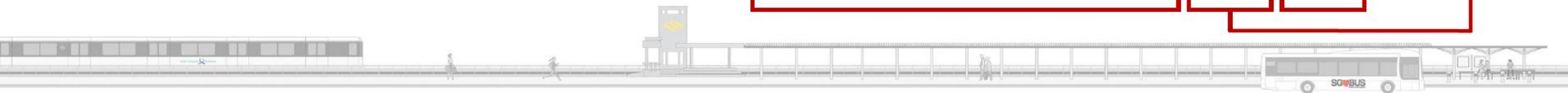
List of keywords
from the MMS WO

Task the WO
is matched to

How good
the match is

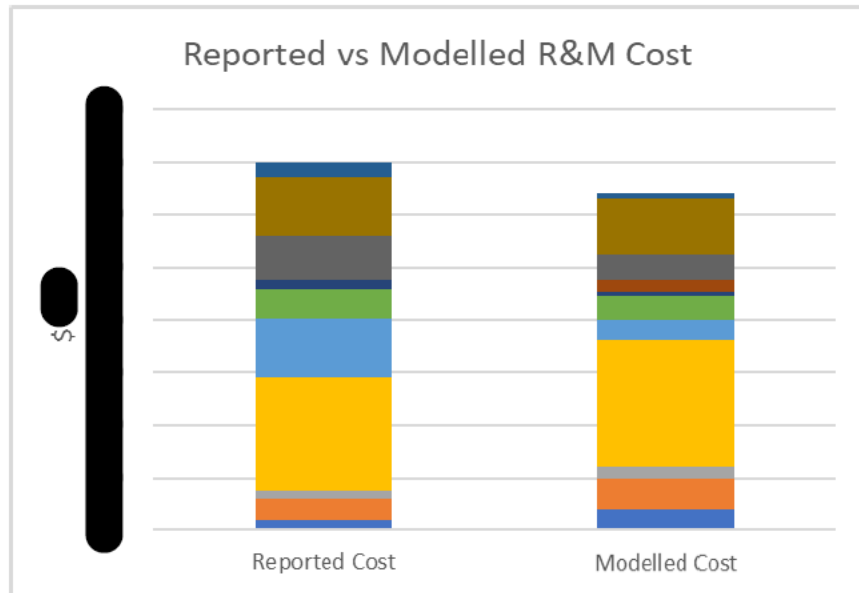
	Order Number	Order Type	Actual Finish Date Time	Functional Location	Category	Sub Category	Man Hour	Combined Info	Matched Task	Matched Score
0	1872288	PM01	01/04/2019 12:00:00	8352/RSC/AUX	AUX	Nil	00:00:00	['pv35', 'tip', 'show', 'cool', 'fail', 'du', 'show', 'ai', '2', 'green', 'check', 'air', 'fault', '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.



■ ACV ■ BRK ■ AUX ■ BOG
 ■ CRBDY & INT ■ GNGWY & CPLR ■ EDD ■ DOOR
 ■ TRACT ■ TIMS ■ COMMS

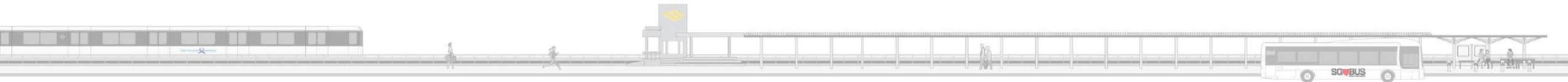
S/N	Subsystem	Reported Cost		Results	
		R&M ¹	Labour ²	R&M	Labour ³
1	Air Conditioning and Ventilation	\$ [REDACTED]	\$ [REDACTED]	\$ [REDACTED]	[REDACTED]
2	Air Supply and Braking System	\$ [REDACTED]		\$ [REDACTED]	[REDACTED]
3	Auxiliary Electrical System & Vehicle	\$ [REDACTED]		\$ [REDACTED]	[REDACTED]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

Remarks

¹ Prorated according to FY21 R&M subsystems breakdown

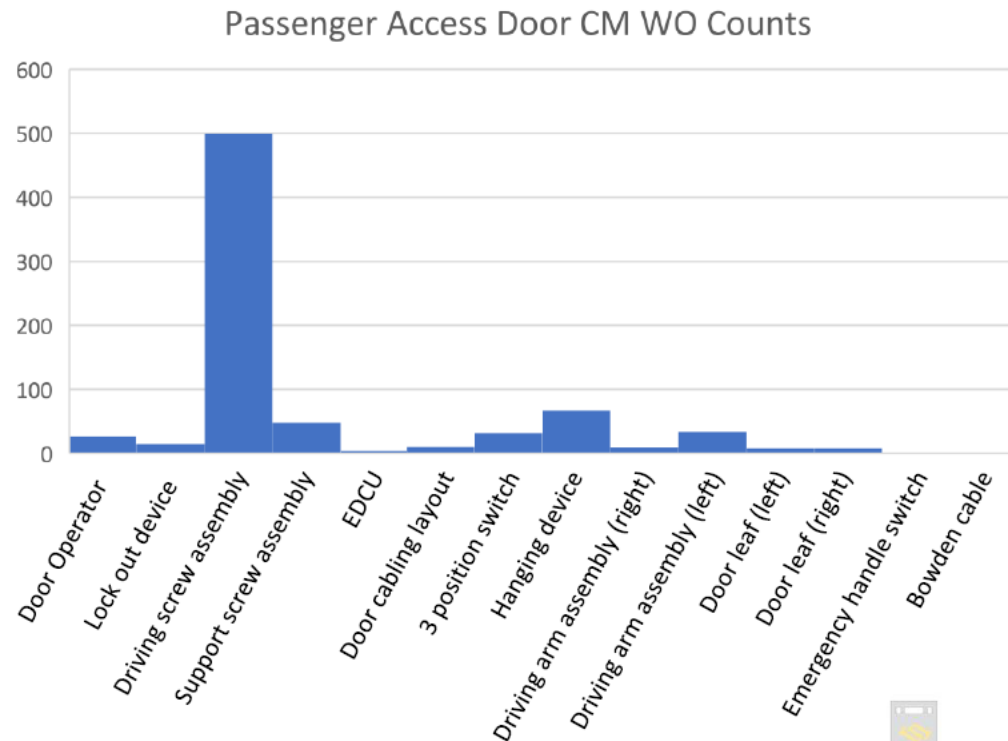
² Prorated according to FY21 R&M fleet breakdown

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.

