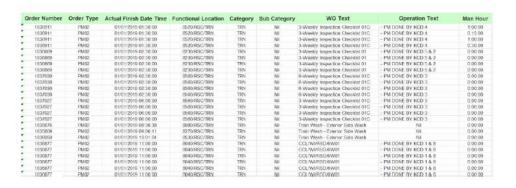
Natural Language Processing (NLP)

- 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, <u>levenshtein distance</u>.

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7 2 3 4	
azkINO	
1 2 3 4 a z k I N O y z k I N D	
leva,6 (1,1) = 0	Characters at a[1] = b[1]
leva, 6(2,2) 2 0	Characters at alz7 o 6127
leva, 6 (3, 5) 2 0	Characters at also 2 623]
leva, L (4,4) = 1	substitution required as a [4] = 6[4]



Type	Code	LZ fore Description	C ton Oncrytes	L4 ten Description	LS Nove Description	Lá Rem Description	Test	Fosh Unscription	Caboo Cost (SGR)	Masocial Cust (incl. consumation) (for mea deprocesses Task) (SGU)	Square Post Con- plac Replacement Total [5000]
PM		Cartaidy and Car tetwice:	Carleteior	Seats	Flowd Passwager seek	1		Visual impector	- 11		-
PM	2	Carbody and Car leteror	Car Printer	Seats	Fixed Passeage seat		Civaneig	Clean with water. Wash with donesgore for heavy stains.	- 21		
PW	- 3	Carbody and Cal linterior	Carintelol	Seats	Robition Passenger seat.		Ceaning	Clean with water. Week with detergent for heavy stalks.	- 1		
PW	- 4	Cartooly and Car Interior	Car Interior	Seats	Roberon Pessenger seat		Impection	Visual and fanction inspection	- 10		
PM	- 6	Carbody and Car Interior	Cartiteiri	Geets	Ger spring		Replaceme	Professor year against	- 41		11.8
PM	- 6	Casbody and Car leterar	Lighting	Exterior Lighting	Head Light / Trail Eight (Loft &		repection	-Visual check	6.00		
PW:	7	Carbody and Car Interior	Lighting	Extensy Lighting	Hood Light / Toll Light (Lott &		Vispection	Check whether beto are trocered prinot	6.00		
PU	- 1	Carbody and Car interest	Lighting	Entwir Lighting	Heart Light Tail Light (Lint &		Deaning	Wipe of timign quickfance on the less	6,00		
PV	. 9	Carbody and Car Interior	Lighting	Entwice Lighting	Hood Light / Tiel Dight (Lot &	LED moths (Heat)	Impaction.	Check the lighting status and this is refective, replace the LEO module	5.00		
PM -	90	Cathody and Car Interior	Lighting	Distance Lighting	Read Light This bight (Light &	Power medica (meat)	Vegetties	Check the lighting status and fit is reflective, explace the Power module	6:00		
M	71	Cartody and Car Interior	Lighting	Entwice Lighting	Head Light / Tiel Eight (Left &		Tripertion.	-Check the lighting status and if it is reflective, replace the LED module	5.00		
PV	- 2	Carbody and Car interior	Lightleg	Extract Lighting	Hood Light / Tail Light (Left &	Peyer module (Tail)	Fispection	- Check the lighting status and fit is defective, replace the Power module	5.00		
PV .	10	Castody and Car Interior	Lighting.	Exterior Lighting	ATC Marker Light		Impection.	- Visual check	5.00		
PW.	54	Carbody and Gar Interior	Lighting	Exterior Lighting	ATC Marker Light		Irapection	Check whether belts are basered or not	5.00	- 0	
PV	- 15	Corbody and Gar Interior	Lighting	Extrir Lighting	ATC Marker Light		Geasing	Wise of breign substance on the less	6.00		
PW.	16	Carbody and Car Interior	Lighting	Exterior Lighting	ATC Marker Light	LED models .	Inspection	Check the lighting status and first a defective, replace the LED module	5.00		
PM	17	Carbody and Car letoner -	Lighting	Exterior Lighting	ATC Marker Light	Payer Medicia	Pepuries.	Check the lighting states and fit is ratective, applace the Power module	6.00		
PW.	10	Carbody and Car Interior	Lighting	Enterior Lighting	Fleed Light		inspection.	Visual check	5.00		
PM -	79	Carbody and Car Interes	Lighting	Extens Lighting	Provd Light		Impaction.	Check whether belo are bosoned or roll	6,00		
PM	20	Cartady and Car interior	Lighting	Exterior Lighting	Fixed Light	distriction.	Calasing	Wipe of breign substance in the less	6.00		
MV	21	Cattody and Car leteror	Lightime	Extens Lighting	Plead Light	LED markée	Properties	- Check the botton status and fill is delective, replace the LED medule	5.00		
PM	- 72	Carcody and Car leteror	Lighting	Exterior Lighting	Fleed Light	Power wedsite	Vispection	Check the lighting status and fin is defective, replace the Power module	5.00		
PV.	23	Castody and Car Interior	Lighting	Exterior Lighting	Exterior Decrindicator Larry	C-0. VA. 157	Yapectics	- Visual check	5.00		
PW	24	Carbody and Car leteror	Lighting	Extrior Lighting	Exterior Deor Indicator Larry		Trape clice	Chrok whether bots are leasured princt	5.00	- 3	
PV	26	Cashedy and Car leteriar	Lighting	Foderic Lighting	Exterior Dear Indicator Lawy	-	Cleaning	Wige of lavige substance in the leas	6.00	- 1	

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

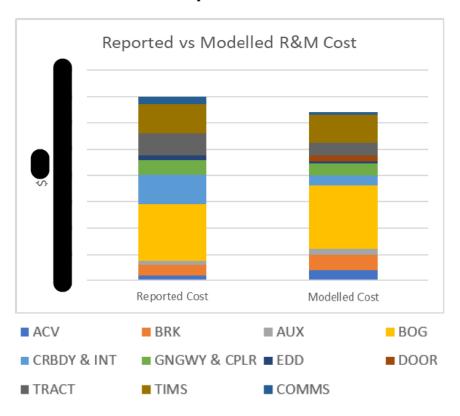
How good the match is

	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	m

Cost data extracted from natched task

LCC Model

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



S/N	Cultinueta en	Report	ted Cost	Results			
	Subsystem	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	\$					
		Per	centage Accuracy	91.86%	43.80%		

<u>Remarks</u>

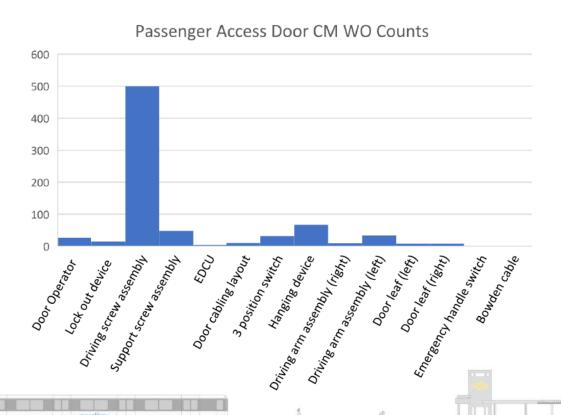
¹ Prorated according to FY21 R&M subsystems breakdown

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.