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SCHOOL OF ENGINEERING AND DIGITAL SCIENCES

Development of a Lifecycle Costing Model for Corrective Maintenance Operations at "*ALSTOM KAZAKHSTAN*"

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Acknowledgements

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Outline

Introduction

Literature Review

Methodology

Results

Recommendations and Conclusions

Company Information

Alstom Kazakhstan is a leading international company in rail transport markets.

800+
employees

2
manufacturing plants

53
freight locomotives in operation

20
passenger locos in operation

Main client: **Kazakhstan Temir Zholy**

Scope of Work and Objectives

This work deals with the development of a LCC model for corrective rolling stock maintenance in railway industry using data analysis tools.

Our main objectives:

- To critically evaluate existing model of Alstom
- To model new improved data model
- To add new functions to the model
- To make model more user-friendly

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Challenges and Expected Results

Main challenges:

- Data confidentiality
- Complexity of the existing model
- Remote teamwork

Expected outcomes:

New and improved LCC model which has the following improvements:

- Improved more functional model using Power BI
- Concepts of financial modeling
- Inventory management application
- Information management functions
- Dashboards and Reports

Why Engineering Management?

Implementation of current project embraces many fields:

- Finance
- Engineering insights
- Business Analytics
- Operations Management
- Supply Chain Management
- Big Data and Information Management

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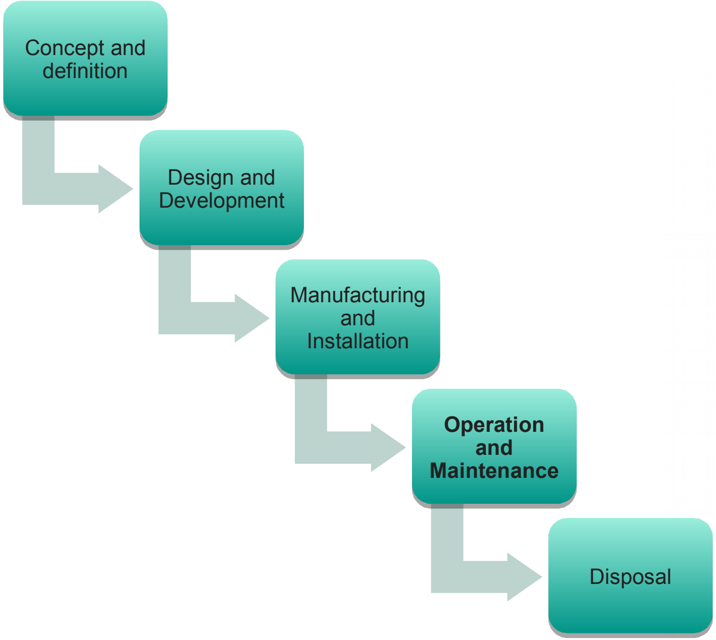
Literature review - Definitions

Lifecycle – follows a product/project from creation to maturity and decline. (Curran, 2008)

Lifecycle costing (LCC) – analysis and integrates cost information from all stages of a product/project, from inception to disposal. (Curran, 2008)

Literature Review – Stages of Lifecycle

Stages of the Product life cycle (Nissen, 2009):



Literature Review – Methods

Analogous cost method is a methodology for estimating the cost of an analogous system or subsystem based on available historical data (Zoeteman A, 2001)

The parametric cost technique is the methodology that develops cost-estimating relationships using different characteristics or other statistical approaches. (Zoeteman A, 2001)

The engineering cost approach generates the total cost estimation by accumulating comprehensive calculations made at lower stages of the cost breakdown structure. (Zoeteman A, 2001)

Literature Review – Outcomes

- Each company creates its own calculation method LCC, no unique model but guidelines

- All future costs should be **reduced to present value** by the use of discounting techniques, and therefore, the economic worth of a project can be assessed (Kato and Maout, 2016)

- LCC analysis provides an understanding of the **main cost drivers** rather than exact number of cost, it also gives understanding the magnitude of the cost (Shang et al., 2019)

- Managers can **make the right choices on alternatives** provided to them by using results gained from LCC. These alternatives may contain comparing possible strategies, evaluation cost-cutting opportunities, procurement options, evaluating potential expenditures and more (Galar et al., 2017)

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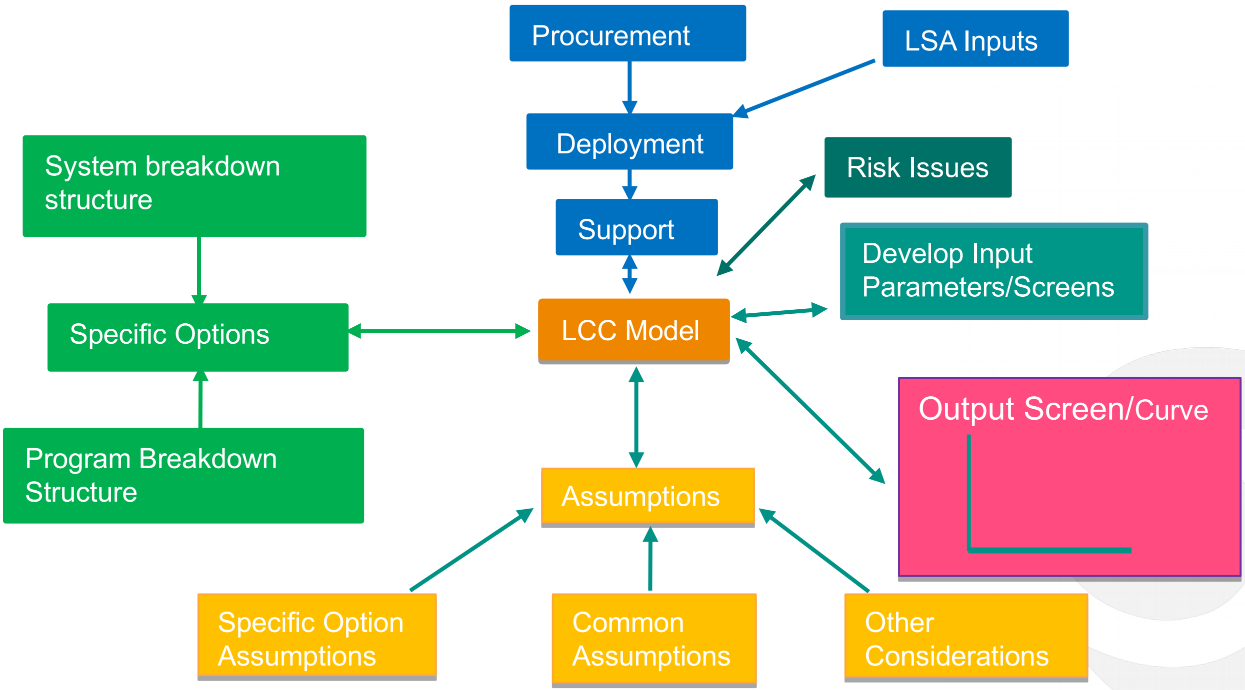
Methodology For Developing LCC

- General approach for development of life cycle costing model concept (NATO, 2007) :
  - Determine the objectives and goals of the product
  - Set the content of the system, the boundary of costing and hypothesis for the product
    - Determination of the elements of costing
    - Determine of the timescale facets
    - Things to embed within the framework of product
  - Elaborate the structure of the life cycle cost framework
  - Set the data and populate the life cycle cost framework

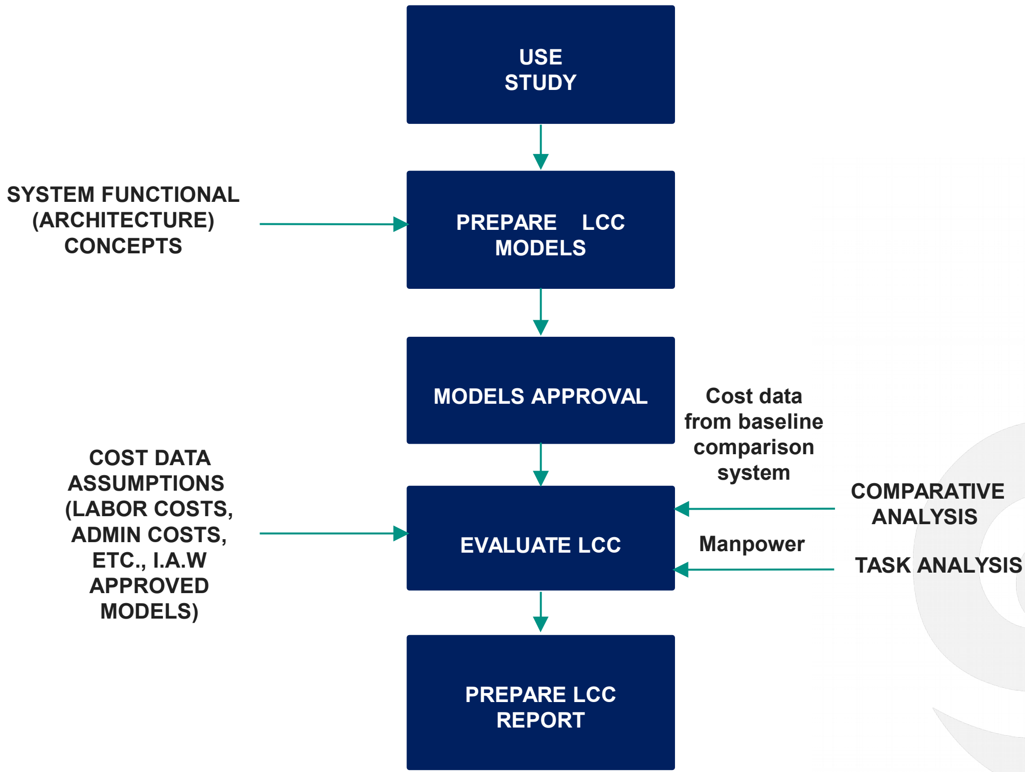
Methodology For Developing LCC

Elaboration of the structure of the life cycle cost framework (NATO, 2007)



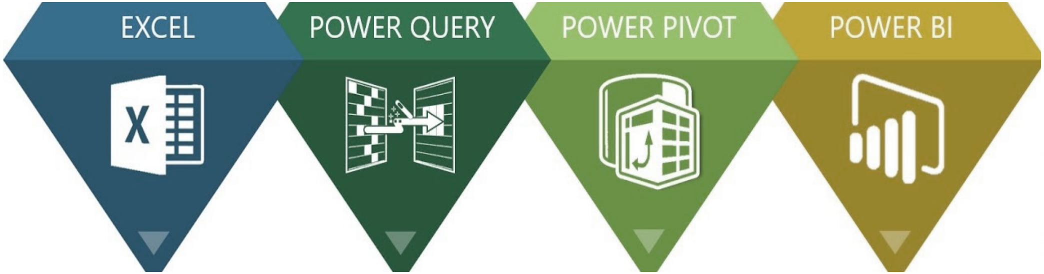
Methodology For Developing LCC

Setting the data and populating the life cycle cost framework (NATO, 2007)



Tools and Software Used

- MS Excel and VBA
- Power Suite (Power Query, Power Pivot, Power View)
- Power BI



Outline

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Existing model

AB1 =IFERROR(IF(OR($S4="KZT";$S4="RUB");0;(SUM(OFFSET(KM!$A$4;-3;MATCH(Z$3;KM!$B$4:$RT$4;0);1;-13))-OFFSET(KM!$A$4;-3;MATCH(Z$3;KM!$B$4:$RT$4;0);1;1))/$L4*($R4+IF(

	D	L	M	N	O	P	Q	R	Y	Z	AA	AB	AC	AD	AE
1		454,79	#DIV/0!						'Labour hours	50,00	Material EUR	0,95	Material KZT	-	Material RUB
2			100%		Yearly update		50%	35%	FORECAST	€ 401,46	€ 393,04	€ 393,04	€ 393,04	€ 393,04	€ 393,04
3	Unit name of Affected equipment	MKBF REX, km	Man Hours	Labour cost	Labour rate	Unit price (EUR)	Repair cost, EUR	Replacement cost, EUR	Averg. Yearly QTY (GAP)	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20
4	Part1	473 626 664,00	50,0	€ 902,29	€ 18,05	€ 80,00	€ 970,29	€ 930,29	-1,0	1,94	1,94	1,94	1,94	1,94	1,94
5	Part2	473 626 664,00	50,0	€ 902,29	€ 18,05	€ 1 099,42	€ 1 836,80	€ 1 287,09	0,0	3,19	3,19	3,19	3,19	3,19	3,19
6	Part3	473 626 664,00	44,0	€ 794,02	€ 18,05	€ 2,86	€ 796,45	€ 795,02	0,0	1,63	1,63	1,63	1,63	1,63	1,63
7	Part4	157 875 554,67	26,5	€ 478,22	€ 18,05	€ 21,99	€ 496,91	€ 485,91	-12,0	1,56	1,56	1,56	1,56	1,56	1,56
8	Part5	378 901 331,20	26,5	€ 478,22	€ 18,05	€ 80,00	€ 40,00	€ -	-5,0	0,10	0,10	0,10	0,10	0,10	0,10
9	Part6	15 787 555,47	20,0	€ 360,92	€ 18,05	€ 4,79	€ 2,39	€ -	-29,7	0,07	0,07	0,07	0,07	0,07	0,07
10	Part7	67 660 952,00	20,0	€ 360,92	€ 18,05	€ 2,55	€ 1,27	€ -	-6,9	0,01	0,01	0,01	0,01	0,01	0,01
11	Part8	663 342,67	12,0	€ 216,55	€ 18,05	€ 73,00	€ 36,50	€ -	-707,9	26,64	26,64	26,64	26,64	26,64	26,64
12	Part9	78 937 777,33	12,0	€ 216,55	€ 18,05	€ 1 034,43	€ 517,21	€ -	-5,9	3,17	3,17	3,17	3,17	3,17	3,17
13	Part10	157 875 554,67	12,0	€ 216,55	€ 18,05	€ 19,94	€ 233,50	€ 223,53	-3,0	1,40	1,40	1,40	1,40	1,40	1,40
14	Part11	47 362 666,40	12,0	€ 216,55	€ 18,05	€ 325,00	€ 162,50	€ -	-9,9	1,66	1,66	1,66	1,66	1,66	1,66
15	Part12	236 813 332,00	12,0	€ 216,55	€ 18,05	€ 3 603,18	€ 1 801,59	€ -	-2,0	3,68	3,68	3,68	3,68	3,68	3,68
16	Part13	473 626 664,00	12,0	€ 216,55	€ 18,05	€ 445,00	€ 594,80	€ 372,30	-1,0	0,99	0,99	0,99	0,99	0,99	0,99
17	Part14	473 626 664,00	12,0	€ 216,55	€ 18,05	€ 4,79	€ 2,39	€ -	-1,0	0,00	0,00	0,00	0,00	0,00	0,00
18	Part15	2 853 172,67	6,0	€ 108,28	€ 18,05	€ 2,55	€ 1,27	€ -	-164,6	0,43	0,43	0,43	0,43	0,43	0,43
19	Part16	20 592 463,65	6,0	€ 108,28	€ 18,05	€ 10 991,00	€ 9 450,63	€ 3 955,13	-22,8	351,37	351,37	351,37	351,37	351,37	351,37
20	Part17	6 766 095,20	5,0	€ 90,23	€ 18,05	€ 267,60	€ 133,80	€ -	-34,4	-	-	-	-	-	-

Sum-up | LBS | Price update | Operation BOM | KM | MKBF | LOG

Inputs

Part prices

Labour hours

Reliability rates

Expected mileage

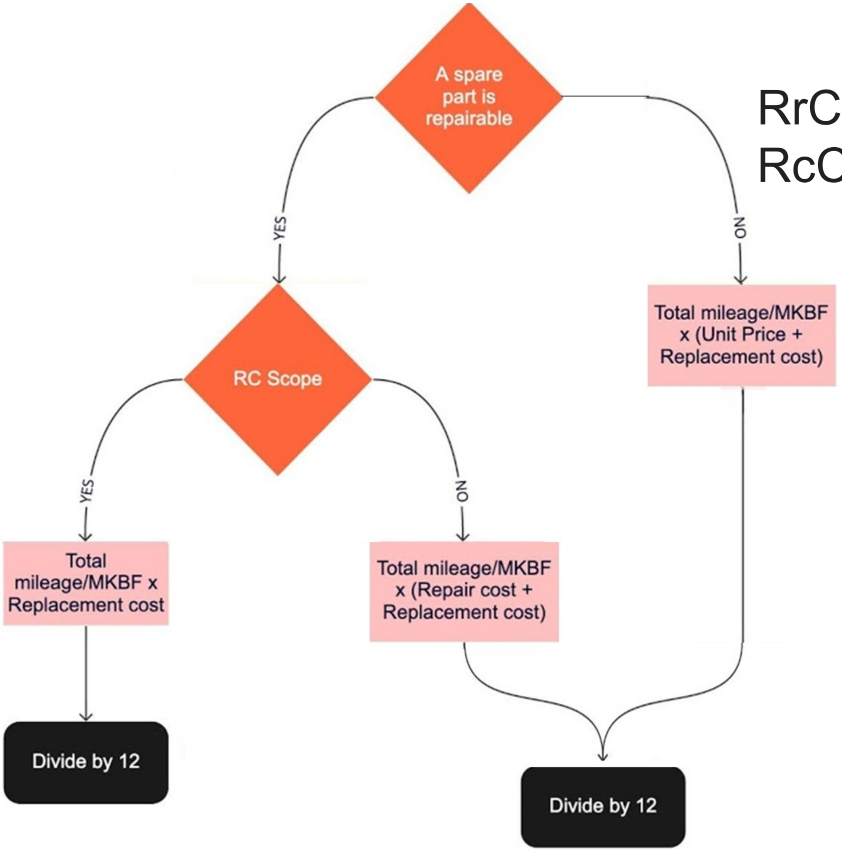
Outputs

Maintenance cost

Expected quantity

Expected labour hours

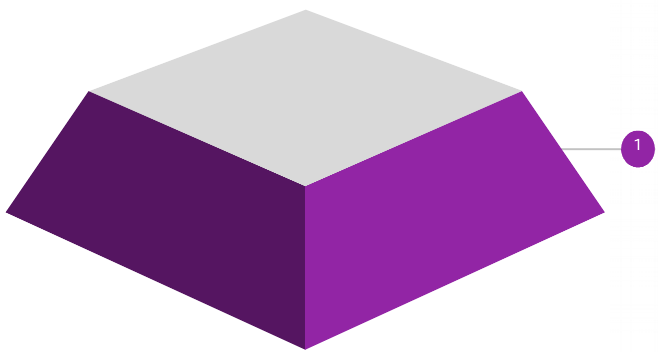
Part of the cost calculation algorithm



RrC= Unit price * 0,5 + LC

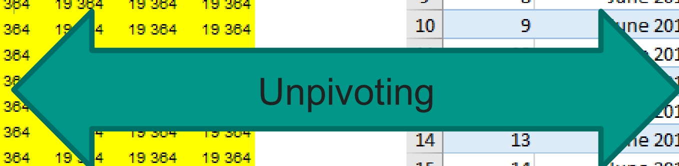
RcC = Unit cost*0,35 + LC

The stages of new model development



Data Modeling
Power Query
Data import
Relationships

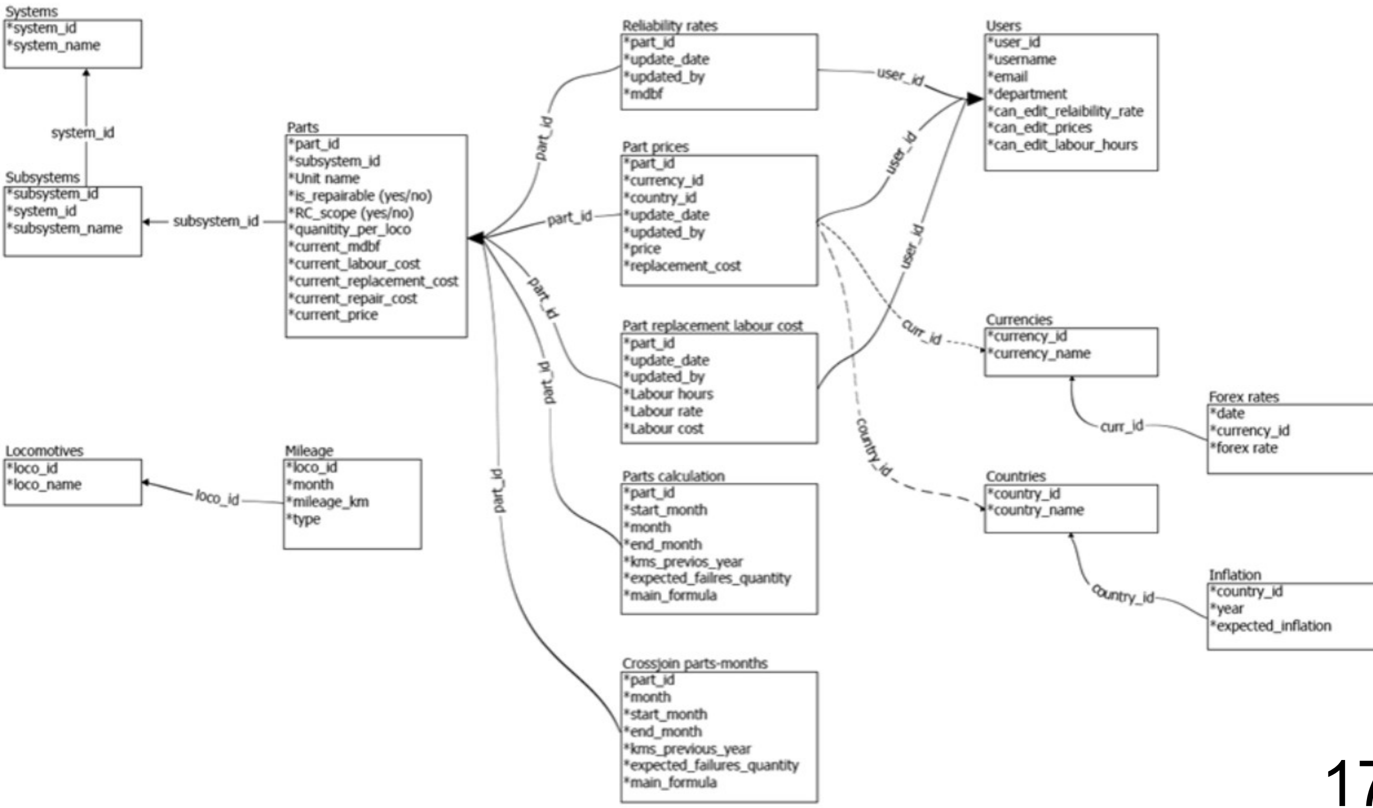
Data Import
Power Query



	A	B	C	D	E	F
1	Total mileage	484110	[illegible]	484110	484110	484110
2						
3	Loco QTY	25,00	25,00	25,00	25,00	25,00
4	Locomotives	июн.19	июл.19	авг.19	сен.19	окт.19
5	Loco 1	19 364	19 364	19 364	19 364	19 364
6	Loco 2	19 364	19 364	19 364	19 364	19 364
7	Loco 3	19 364	19 364	19 364	19 364	19 364
8	Loco 4	19 364	19 364	19 364	19 364	19 364
9	Loco 5	19 364	19 364	19 364	19 364	19 364
10	Loco 6	19 364	19 364	19 364	19 364	19 364
11	Loco 7	19 364	19 364	[illegible]	19 364	19 364
12	Loco 8	19 364	19 364	[illegible]	[illegible]	[illegible]
13	Loco 9	19 364	[illegible]	[illegible]	[illegible]	[illegible]
14	Loco 10	19 364	[illegible]	[illegible]	[illegible]	[illegible]
15	Loco 11	19 364	19 364	[illegible]	[illegible]	[illegible]
16	Loco 12	19 364	19 364	[illegible]	19 364	19 364
17	Loco 13	19 364	19 364	19 364	19 364	19 364
18	Loco 14	19 364	19 364	19 364	19 364	19 364
19	Loco 15	19 364	19 364	19 364	19 364	19 364
20	Loco 16	19 364	19 364	19 364	19 364	19 364
21	Loco 17	19 364	19 364	19 364	19 364	19 364
22	Loco 18	19 364	19 364	19 364	19 364	19 364
23	Loco 19	19 364	19 364	19 364	19 364	19 364
24	Loco 20	19 364	19 364	19 364	19 364	19 364
25	Loco 21	19 364	19 364	19 364	19 364	19 364

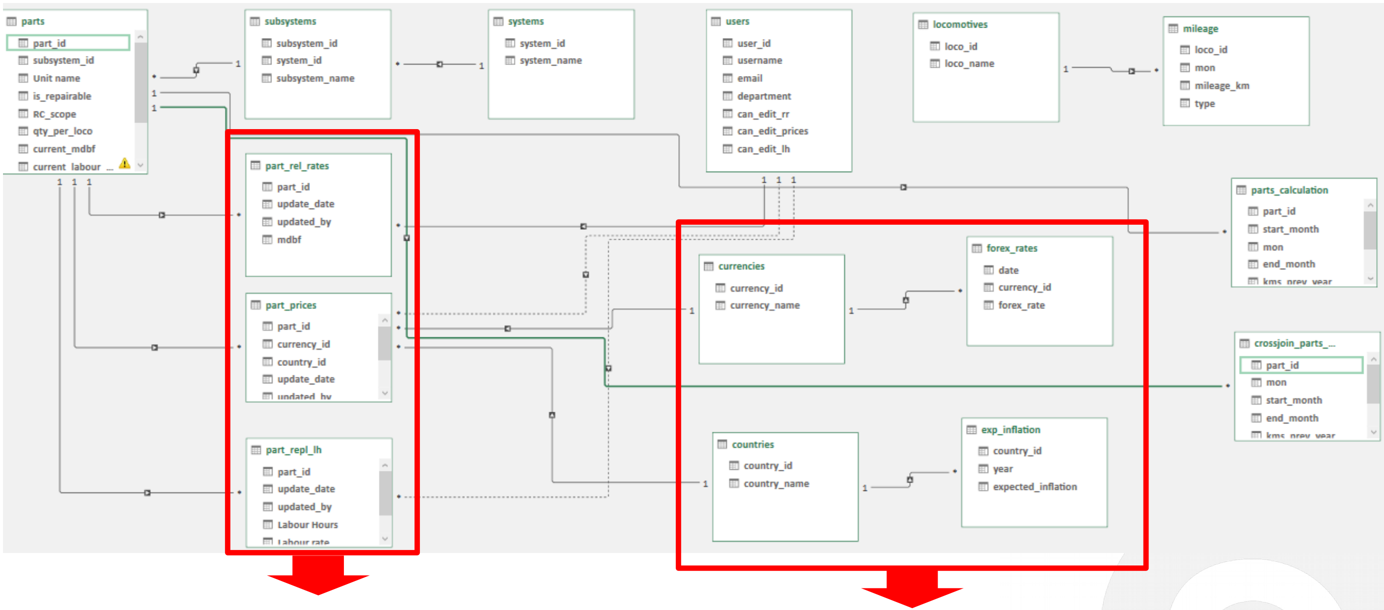
	A	B	C	D
1	loco_id	mon	mileage_km	type
2	1	June 2019	19 364,38	
3	2	June 2019	19 364,38	
4	3	June 2019	19 364,38	
5	4	June 2019	19 364,38	
6	5	June 2019	19 364,38	
7	6	June 2019	19 364,38	
8	7	June 2019	19 364,38	
9	8	June 2019	19 364,38	
10	9	[illegible]	19 364,38	
[illegible]	[illegible]	[illegible]	19 364,38	
[illegible]	[illegible]	[illegible]	19 364,38	
[illegible]	[illegible]	[illegible]	19 364,38	
14	13	[illegible]	19 364,38	
15	14	June 2019	19 364,38	
16	15	June 2019	19 364,38	
17	16	June 2019	19 364,38	
18	17	June 2019	19 364,38	
19	18	June 2019	19 364,38	
20	19	June 2019	19 364,38	
21	20	June 2019	19 364,38	
22	21	June 2019	19 364,38	
23	22	June 2019	19 364,38	

Data Modeling
Model breakdown structure



Data Modeling

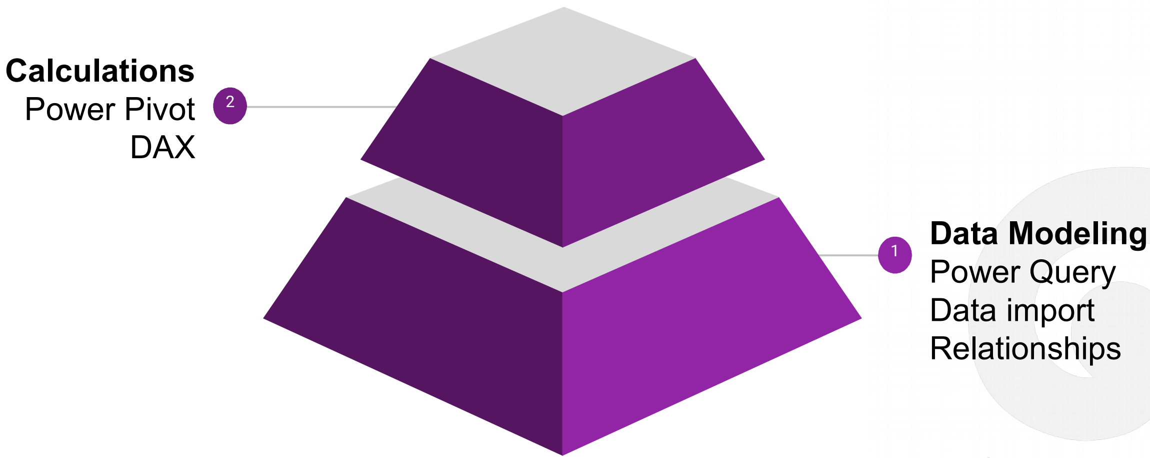
Developed Data model



Part reliability rates
Part Prices
Labour hours

Supportive tables

The stages of new model development



Calculations

DAX stands for Data Analysis Expressions; it is simple and easy to learn language developed by Microsoft to interact with data in their certain platforms.

Excel functions

```
=IFERROR(IF($I4="YES";
(SUM(OFFSET(KM!$A$4;-
3;MATCH(Z$3;KM!$B$4:$RT$4;0);1;-13))-
OFFSET(KM!$A$4; 3;MATCH(Z$3;KM!
$B$4:$RT$4;0);1;1))/
$L4*($R4);IF($K4="YES";
(SUM(OFFSET(KM!$A$4;-
3;MATCH(Z$3;KM!$B$4:$RT$4;0);1;-13))-
OFFSET(KM!$A$4;-3;MATCH(Z$3;KM!
$B$4:$RT$4;0);1;1))/$L4*($Q4+$R4);
(SUM(OFFSET(KM!$A$4;-
3;MATCH(Z$3;KM!$B$4:$RT$4;0);1;-13))-
OFFSET(KM!$A$4;-3;MATCH(Z$3;KM!
$B$4:$RT$4;0);1;1))/$L4*($R4+$P4)));0)/12
```

DAX functions

```
Total Cost (KZT) =
if(RELATED(q_parts[is_outsourced]),
[Expected failures QTY]*[Replacement Cost
Per Unit],
if(RELATED(q_parts[is_repairable]),
[Expected failures QTY]*([Repair Cost Per
Unit]+[Replacement Cost Per Unit]),
[Expected failures QTY]*([Replacement Cost
Per Unit]+[Latest Price Per Unit]))
) / ( ( 1 + [discount_rate] ) ^ ( [n_per]/12 ) )
```

The stages of new model development

Dashboards
Power BI
Reports
Interactive visualizations

Calculations
Power Pivot
DAX

Data Modeling
Power Query
Data import
Relationships

Dashboards

Demonstration in Power BI Desktop

Improvements of the Model

- It has better data structure, because it uses relational data model
- It is more maintainable, because it is more structured
- It is more understandable for the users
- It is more modern
- It has better computational performance

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Our contribution:

- Scrutinized the existing LCC model in Excel
- Identified key factors
- Implemented the LCC model from scratch
- Suggested and implemented several model improvements
- Developed dashboards suitable for the end users
- Several recommendations for the future development of the model

Recommendations

- Further integration of the LCC model with other business functions
- Incorporation of additional business data into the model
- Integration of data exchange with Company’s IT platforms
- Model migration and deployment into the cloud

Further research

- Predictive maintenance for the Alstom's locomotives maintenance project
- Similar methodology with using Power BI can be applied to other business modeling areas, such as:
  - Sales analysis and forecasting
  - Inventory management applications
  - General financial modeling
  - Business prediction and forecasting

Conclusions

- Combined several areas of the MEM program for a real-world business case
- Reverse-engineered existing LCC model and recreated it using Power BI
- Suggested and implemented several model improvements
- All team members obtained hands-on experience with business modeling and modern data analysis software

References

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Thank you!