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المؤتمر الدولي الثاني والعشرون لإدارة الأصول والمرافق والصيانة

The 22nd International Asset, Facility & Maintenance Management Conference

Digitization - Excellence - Sustainability

Cost Optimal Asset Replacement Plan – Case Study

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Replacement plan
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ASSIGNMENT

Problem definition:

In a production plant:

- fleet of AGV (Automated Guided Vehicle) is operated, different generations of technology and ages between 3 and 12 years
- availability of spare parts for older generations is not further guaranteed by suppliers
- missing decision-making bases for fleet renewal with optimal cost balance between maintenance cost and investment for renewal of a unit

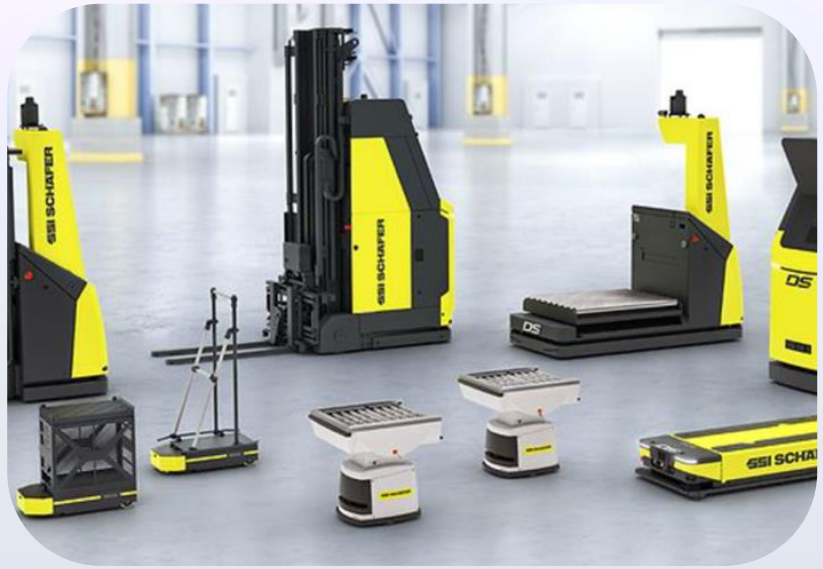


Illustration of AGV handling equipment (source: SSI SCHAFER)

Solution:

Systematic approach - Plan for conceptual fleet renewal, comparison of scenarios for asset replacement in terms of minimal costs

ASSIGNMENT

Project purpose - "Why": Ensuring stable operation of driverless handling equipment meeting needs of logistics and production processes and Optimization of costs of driverless handling equipment.

Number of AGV unites:	418 pcs
Types of AGV:	12
Planning horizon:	10 years
Interest rate:	9%
Considered costs:	Renewal costs (AGV unit price)
	Flat rate maintenance service (prev. + correct. maintenance, operation)
	Overhauls
	Spare parts
	Re-certification and upgrades of current AGV types
	Purchase of batteries

DATA INPUTS

Illustration of AGV maintenance (source: conger.com)

List of AGV units with Unique Identifier, including information for each unit:

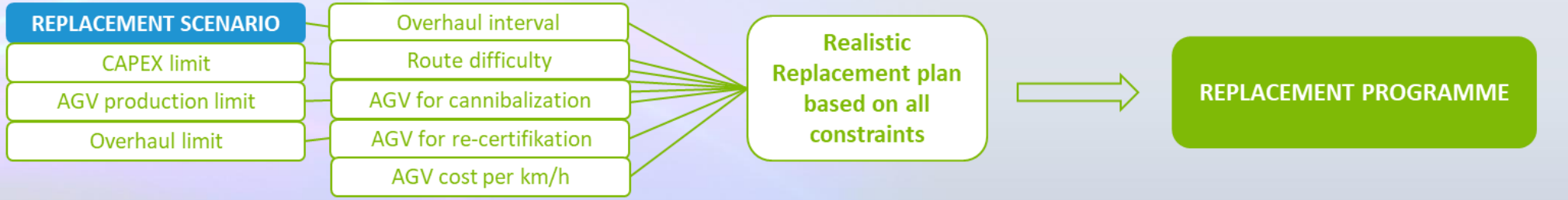
- Place of operation (hall/route)
- Date of entry into service, shift regime
- Type of ownership (own, leasing with maintenance, full-service, etc.)
- Mileage km and moto-hours from commissioning
- History of maintenance - labour consumption, materials and maintenance costs from the time of commissioning to the present
- Charging stations with the assignment of AGV operating groups
- Consumption of energy, oils/other media
- Critical parts for which the support ends and BOMs
- Offered used / retrofitted AGV from partners incl. price and technical condition
- Electricity costs at individual charging stations
- CAPEX + price indexation and residual value (costs of acquisition and commissioning, disposal of old equipment, administration, etc.)
- OPEX costs + cost development
- Other relevant costs (if any)
- Discount rate for calculating the NPV of the future cash flow

REPLACEMENT PLAN

Step 1 – REPLACEMENT MODEL: Cost-based mathematical determination of the replacement interval

Step 2 – REPLACEMENT SCENARIO: Distribution of replacement in years based on technical constraints

Step 3 – REPLACEMENT PROGRAMME: Realistic replacement plan based on business constraints and lifetime maximization



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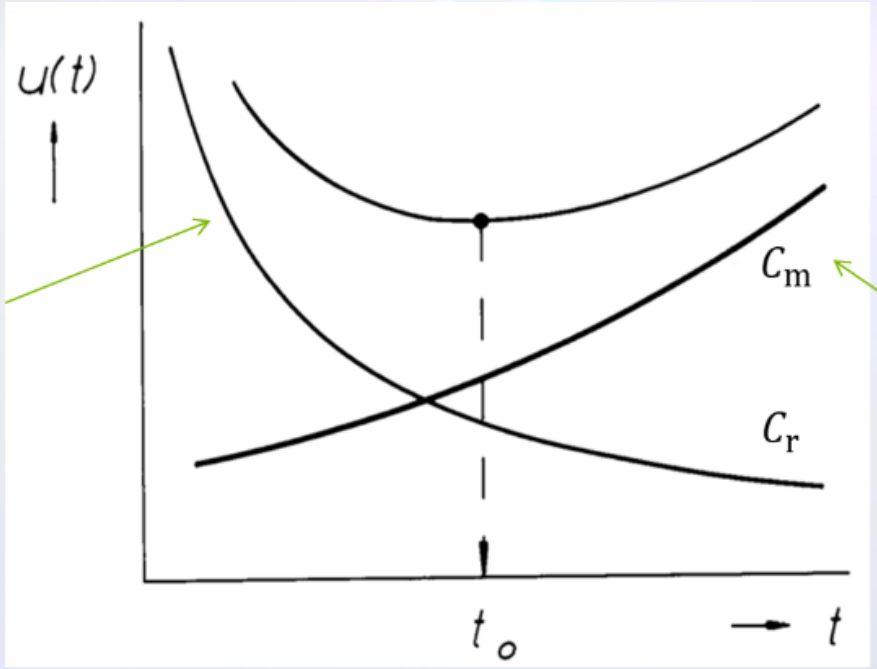
REPLACEMENT MODEL

Renewal costs
New machine price
–Residual value
+Disposal costs
CAPEX

Years



Operating costs
Maintenance and SP
Energy consumption
Overhaul
Service
Other OPEX

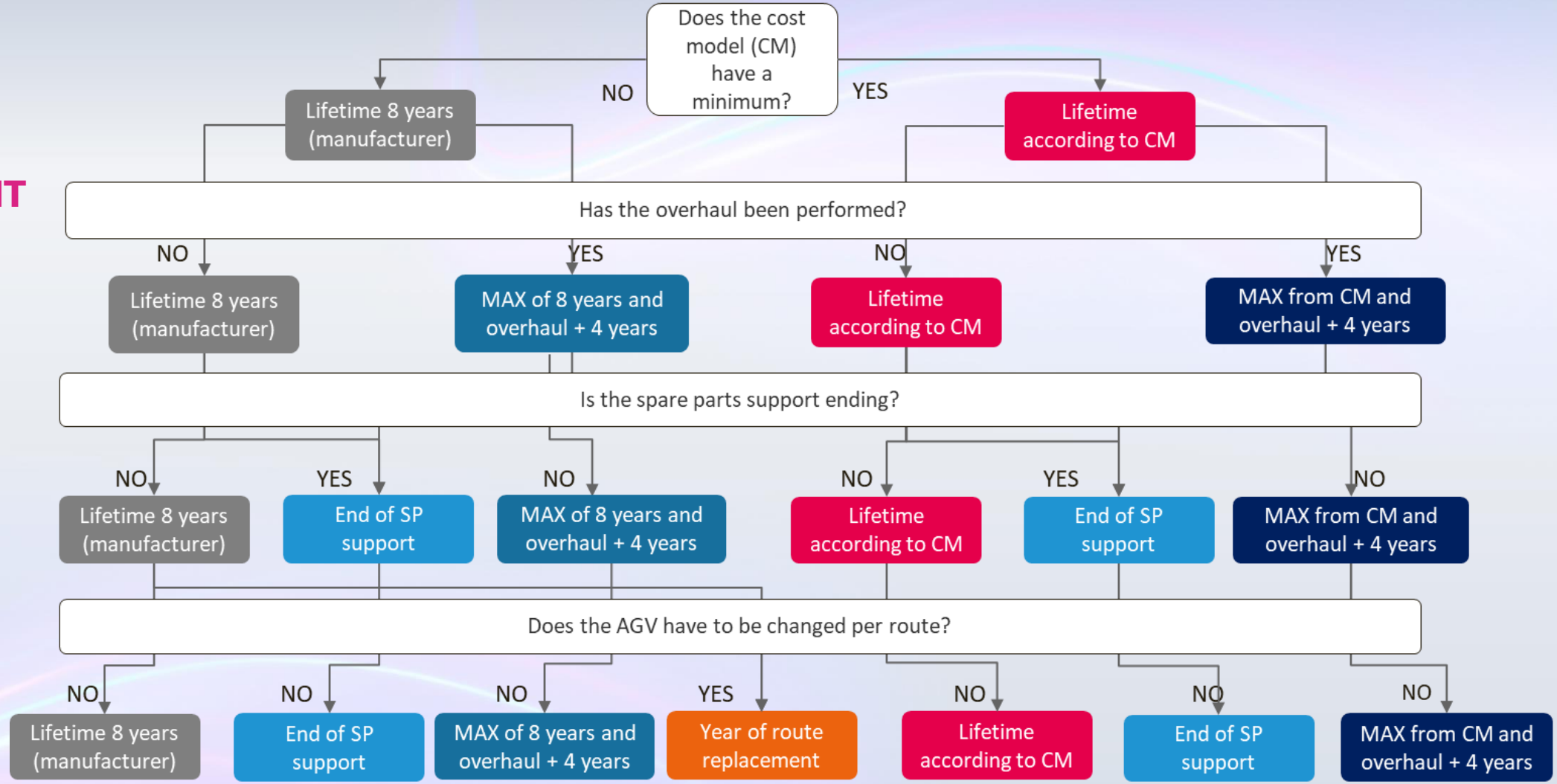
Years

$$u(t) = \frac{C_r(t) + C_m(t)}{t} = \frac{C_r(t)}{t} + \frac{C_m(t)}{t}$$

REPLACEMENT CRITERIA

No.	Criterion
1	Replacement Model
2	End of Spare parts support
3	AGV Cannibalization
4	AGV Re-certification (upgrade)
5	Overhauls
6	Routes
7	Cost of AGV per km/hour of operation
8	Technology update strategy
9	CAPEX limit and distribution
10	Limit for Overhauls
11	Capacity of manufacturer

REPLACEMENT CRITERIA



Cascading decision tree

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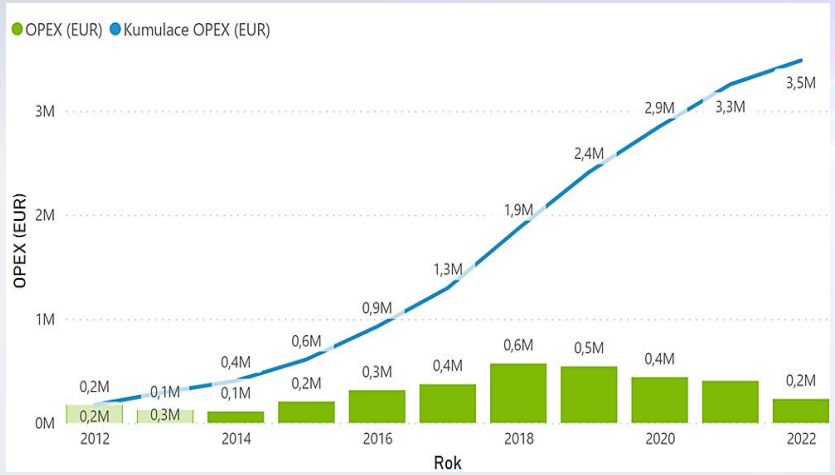
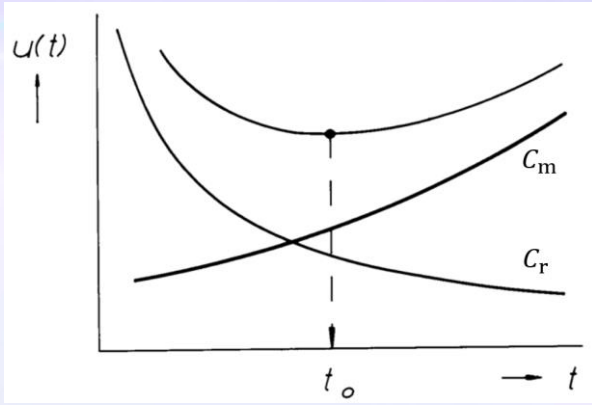
REPLACEMENT PLAN SUMMARY

1) DATA ANALYSIS

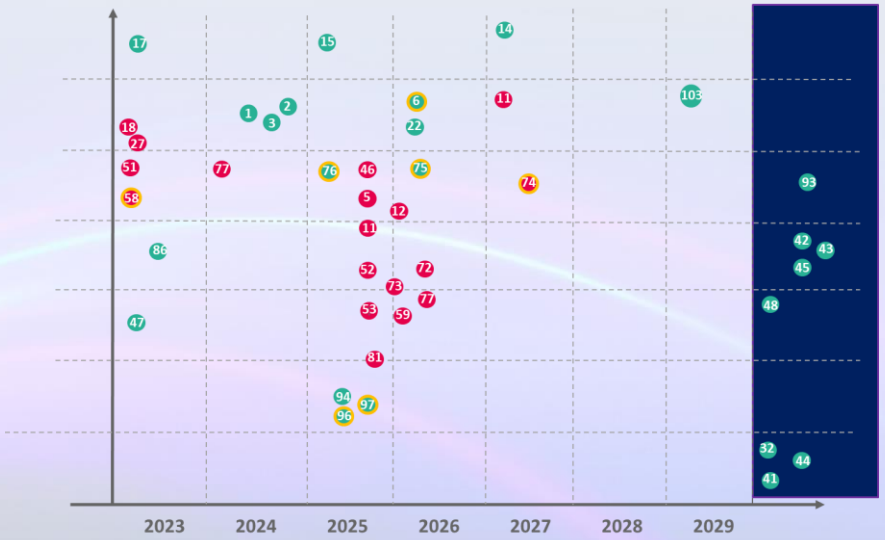


2) REPLACEMENT MODEL

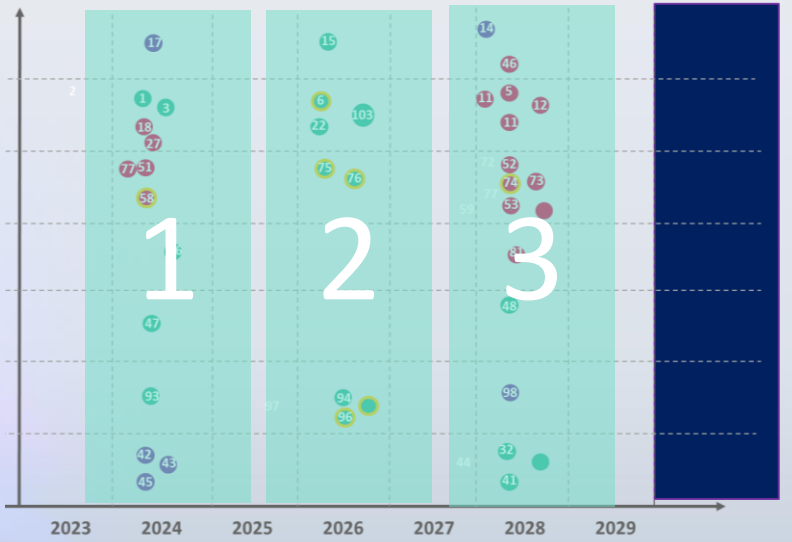


$$u(t) = \frac{C_r(t) + C_m(t)}{t} = \frac{C_r(t)}{t} + \frac{C_m(t)}{t}$$

3) REPLACEMENT SCENARIO



4) REPLACEMENT PROGRAMME



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DATA ANALYSIS

FTS description

ID AGV	B-36
AGV type	B
Hall	XX
Route	XX
Commissioning	01.12.2016
Purchase price	XXX EUR
Next model and price	B AF (XXX EUR)

Cost statistics

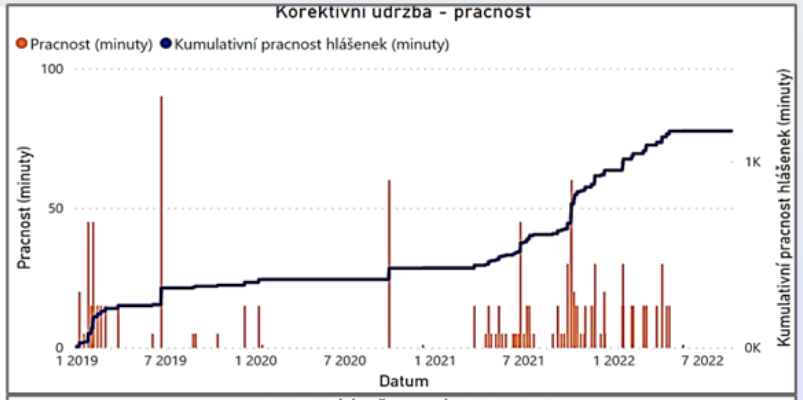
Náklady na km / hodinu na úrovni typu

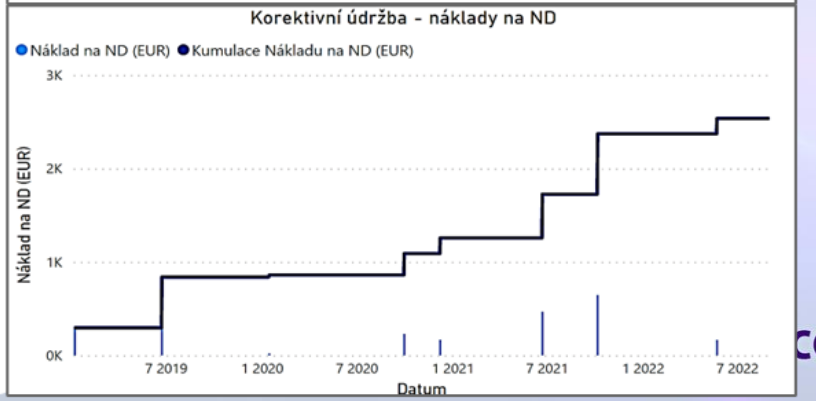
Typ FTS	Počet FTS	Počet směn 2019-2022	Náklad na ND korektivní údržby 2019-2022	Korektivní náklady ND na hodinu 2019-2022	Korektivní náklady ND na 1 km (2019-2022)	Počet směn celkem	Počet GRO	Suma nákladů GRO	Generální opravy náklady ND na 1 km	Generální o náklady ND
FTS 1300A	54	108 582	191 197,72	0,220	0,307	268 264	32	158 995,71	0,095	
FTS 500	28	45 352	61 298,57	0,169	0,307	187 768	9	90 452,89	0,113	
FTS 1300	55	102 418	130 549,51	0,159	0,255	374 424	52	655 939,16	0,306	
FTS 500ii	16	17 696	19 956,45	0,141	0,933	83 696	6	58 088,70	0,574	
FTS 6000A	28	50 996	52 130,62	0,128	0,172	51 600				
FTS 1000L-A	32	65 114	60 394,07	0,116	0,188	89 824	3	18 803,58	0,042	
FTS 3000A	25	51 061	46 318,82	0,113	0,182	88 102	2	12 338,88	0,026	
FTS 2000A	78	158 574	138 133,53	0,109	0,164	343 343	28	132 987,07	0,071	
FTS 800AF	43	83 303	44 173,23	0,066	0,140	179 821	18	96 403,16	0,136	
FTS 1300AF	5	10 337	3 737,66	0,045	0,075	18 449	3	18 548,52		
FTS 3000AP	1	2 083	164,80	0,010	0,019	2 137				
FTS 800L	5	5 530	0,00	0,000	0,000	26 155				

Náklady na km / hodinu na úrovni routy

Routa	Hala	Počet FTS	Počet směn 2019-2022	Náklad na ND korektivní údržby 2019-2022	Korektivní náklady ND na hodinu 2019-2022	Korektivní náklady ND na 1 km (2019-2022)	Počet směn celkem	Počet GRO	Suma nákladů GRO	Generální opravy náklady ND na 1 km
Pístrosy	H8	8	16 040	15 075,49	0,117	0,228	46 067	6	32 138,82	0,169
R20	H4a	5	10 025	9 034,20	0,113	0,222	25 589			
Pístrosy Rezerva	H8	1	2 005	1 460,66	0,091	0,176	3 953	1	5 353,81	0,328
Predna naprava	H3a	7	14 581	8 993,56	0,077	0,161	19 133			
Rezerva	H4a	2	4 010	2 236,55	0,070	0,067	13 546			
Prevodovky SUV	H8	6	12 030	4 318,52	0,045	0,097	23 718	3	16 061,43	0,182
Bentley predná	H8	1	2 005	450,00	0,028	0,239	5 833	1	5 353,81	0,976

Corrective maintenance in time

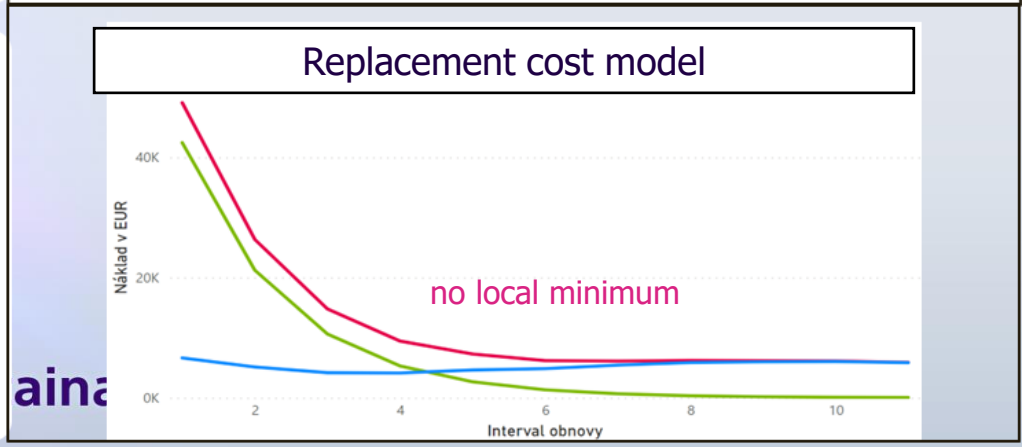




Critical parts consumption

Typ FTS	Kritické díly	Počet dílů na FTS	2019 Spotřeba Krit. ND	2019 Počet FTS	2020 Spotřeba Krit. ND	2020 Počet FTS	2021 Spotřeba Krit. ND	2021 Počet FTS	2022 Spotřeba Krit. ND	2022 Počet FTS	Spotřeba dílů na kus za rok	AVG Roční spotřeba KND
TS 1300	SNÍMAČ PÁSKY	1	10	55	6	55	5	55	3	55	0,11	6
TS 1300	FREKVENČNÝ MENIČ TRAKČNÝ FTS1300 GEN.2010	2	6	55	1	55	6	55	4	55	0,08	4
TS 1300	MAINBOARD	1	3	55	2	55	10	55	1	55	0,07	4
TS 2000A	POČÍTAČ IPC227D	1	2	78	2	78	3	78		78	0,02	2
TS 1300A	POČÍTAČ IPC227D	1	4	54	1	54	1	54		54	0,03	2
TS 500	SNÍMAČ PÁSKY	1	2	28	2	28	1	28	1	28	0,05	2
TS 500	MAINBOARD	1	1	28	3	28	1	28		28	0,04	1
TS 500ii	FREKVENČNÝ MENIČ TRAKČNÝ FTS1300 GEN.2010	2	1	16	1	16	1	16		16	0,05	1
TS 500ii	MAINBOARD	1	1	16	2	16		16		16	0,05	1
TS 500ii	SNÍMAČ PÁSKY	1	1	16		16		16		16	0,02	0
TS 800AF	POČÍTAČ IPC227D	1	1	41		41		41		43	0,01	0
otal											0,04	22

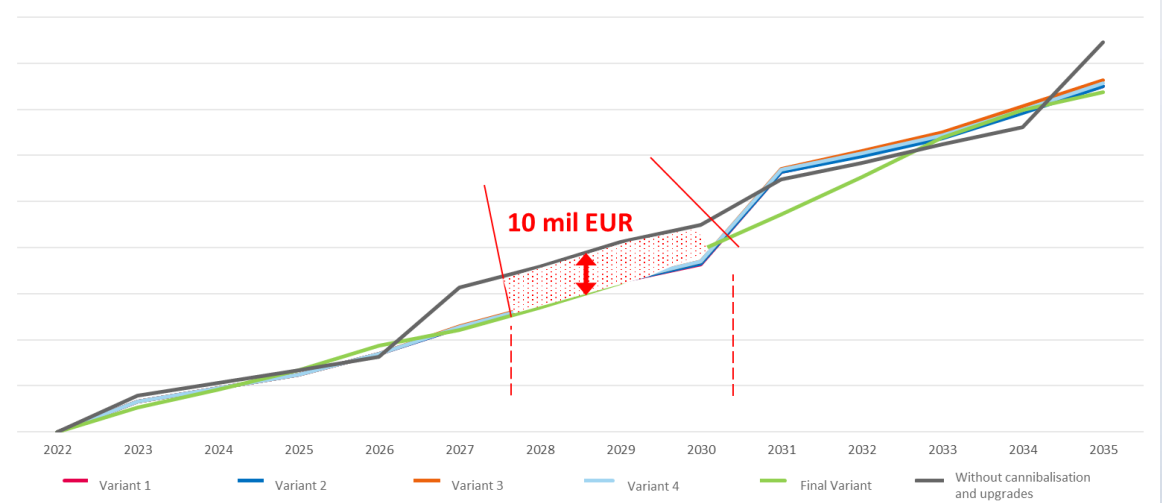
Replacement model construction



RESULTS - REPLACEMENT PROGRAMME

AGV Type	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	Total
A						36						36
B	44			18								62
C									51			51
D									10			10
E								61				61
F									6			6
G									19	60	9	88
H											28	28
I						1						1
J	7			25								32
K	10			8								18
L							32					32
M											49	49
N								6				6
	61	0	0	51	0	37	32	67	86	60	86	479

Total number of AGV replaced in particular year



Distribution of cumulative CAPEX + OPEX in years

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CONCLUSION

Project carry outs:

- For large number of assets, an optimal solution for replacement requires a strategy and data-based solution.
- However, poor data quality can be critically misleading – missing cost history or links to individual asset units, group payments and flat rates under framework contracts, missing work orders, duplicates.
- Assumptions are made by data provider, not dana receiver
- Methodology of creating a Replacement Plan has proven its robustness
- Cost replacement model is appropriate base to get understanding of asset replacement cycle. The final realistic Replacement plan is then completed by sequence of applying replacement criteria with given prioritization.

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