

IN-MOTION CHARGING SOLUTION FOR EBRT IN PRAGUE

DOPRAVNÍ PODNIK HL. M. PRAHY (DPP PRAGUE)

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ŠKODA ELECTRIC A.S.

PETR KASENČÁK, HEAD OF SALES – BUS MOBILITY



Funded by the
European Union

DPP PRAGUE – BASIC DATA

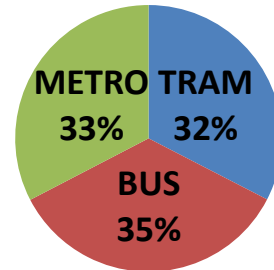


DPP network:

Metro	65 km	3 day lines	730 cars	3 depots
Tram	146 km	26 day + 9 night lines	749 trams	7 depots
Bus(+Tbus)	860 km	134 day + 14 night lines	1259 buses	5 depots

DPP performance:

181 million vehicle km/year



BUS rolling stock:

42% articulated (18m)

50% standard (12m)

8% midi (8-10m)

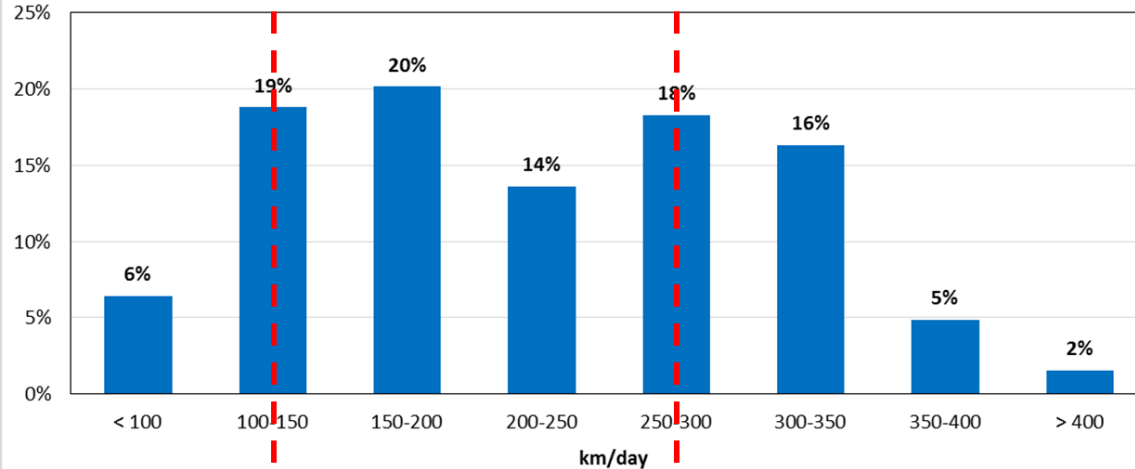
diesel Euro5	363	29%
diesel Euro6	844	67%
e-bus	14	1%
t-bus	37	3%
H-bus	1	0,1%

BUS personnel:

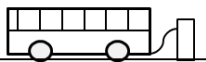
2380 drivers
900 workshop
300 others

- 12/2023 – 15x articulated (18 m) t-bus
- 3/2024 – 20x bi-articulated (24 m) t-bus
- **2035 – ZEV 75% of bus rolling stock**

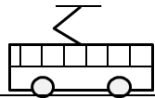
DPP bus operation - daily mileage variation



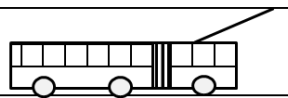
overnight
charging



opportunity
charging



in-motion
charging



Prague strategy – combination of technologies

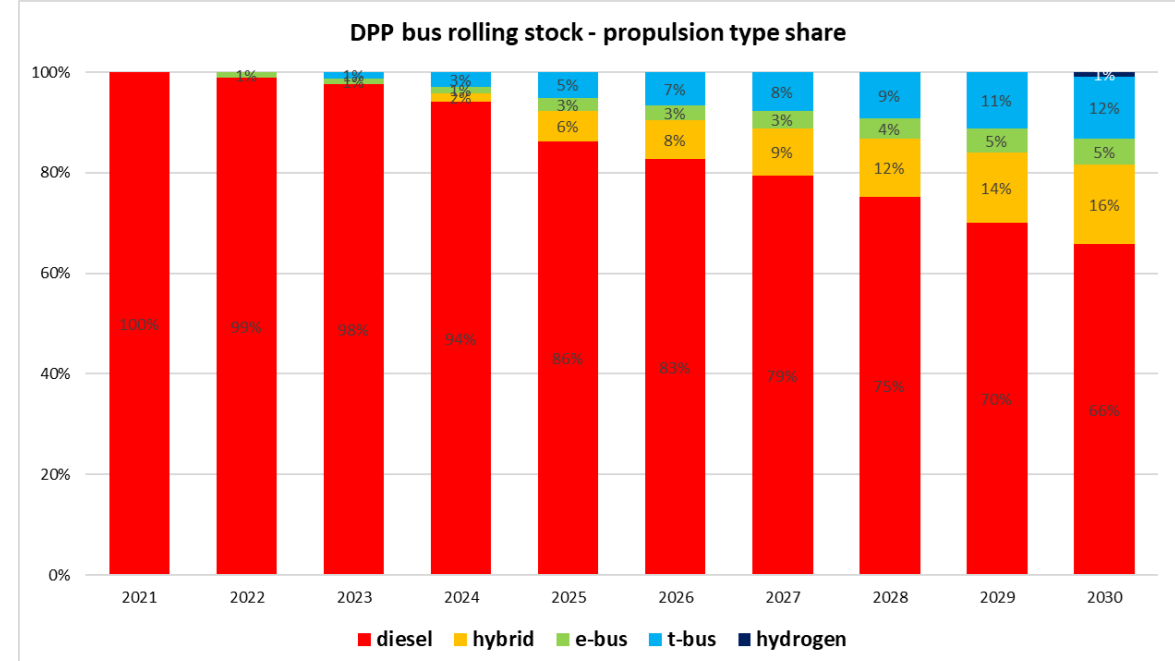
Decarbonisation requirements:

- Clean vehicle directive (2009/33/EU) rev. 2019
- Climatic Plan of Prague (5/2021)

Key limit:

- Infrastructure preparation

Bus fleet renewal plan (2021-2030)



E-bus technical limits

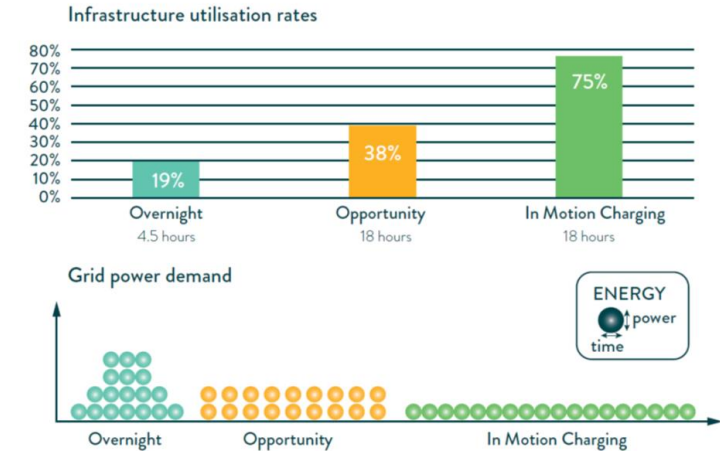
- high energy demand lines – not efficient for e-buses
- e-bus – need more batteries, need longer charging
 - **PT has to carry passengers, not the batteries !**

E-bus power peak demand

- high power charging (depots, terminuses) x less efficient using rate
- trolleybus catenary – flat power demand, full day use

Infrastructure construction

- most complicated part of e-mobility (landscape ownership, permissions), long administrative preparation, construction costs
- in Prague – street lightning poles + trolleybus catenary together
 - **existing trolleybus catenary is big advantage**
 - **do not make same mistakes (Prague 1972, Moscow 2016, ...)**



In-motion charging

- most efficient infrastructure using
- lowest power demand level

28.8.1936	1st trolleybus line in Prague
...	
1959	59,8 km trolleybus network, 179 vehicles
...	
15.10.1972	closing of trolleybuses in Prague
15.10.2017	pilot project In-Motion Charging
...	
10.1.2022	start of construction t-bus line 58 (23 km / 12 km trolley sections)
15.10.2022	open 1st part of line 58 (driver training, 1 vehicle operation)
29.11.2022	start of construction airport t-bus line 59 (18 km / 10 km trolley sections)
1.2.2024	full operation line 58 (14 vehicles)
6.3.2024	start operation line 59 (20 vehicles)



Extremely busy line (>90.000 km/year/bus), 20.000 pax/day + air travel luggage
Temporary solution until rail connection opening (10+ years) – project included further infrastructure and vehicle use

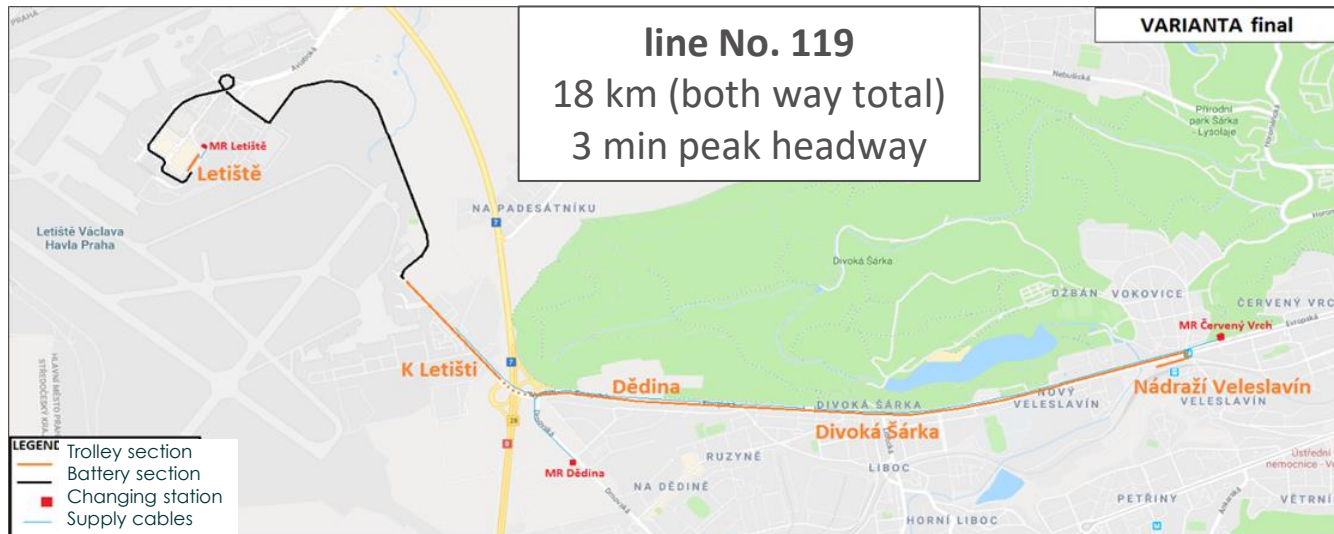
Infrastructure (750 V DC)

- In-Motion charging ratio >50 %
- Opportunity (static) charging (2x terminus + depot)

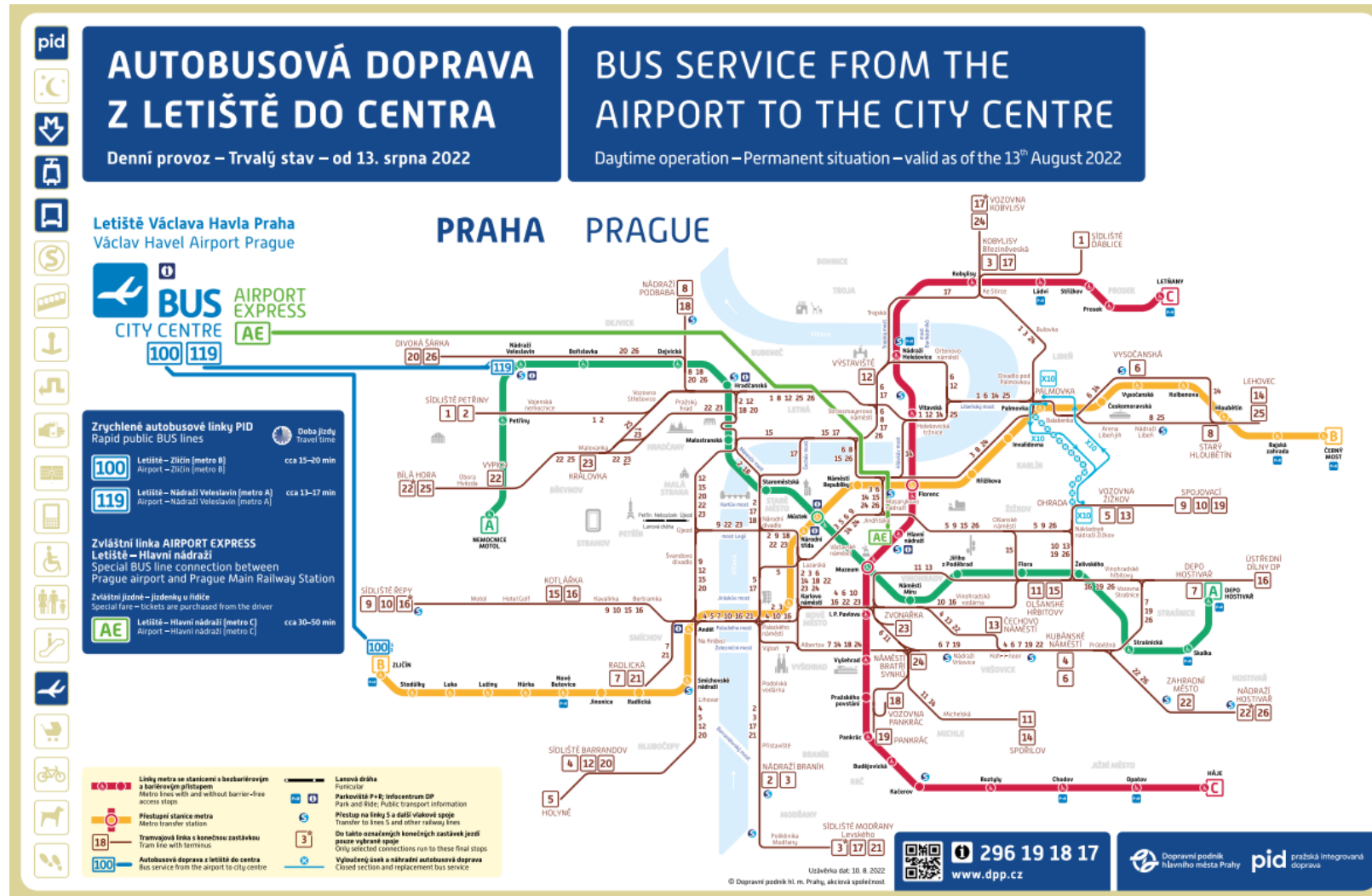
Vehicles

- 20 double-articulated vehicles (23-25 m), apply for EU funds

battery trolleybus Škoda-Solaris 24 M

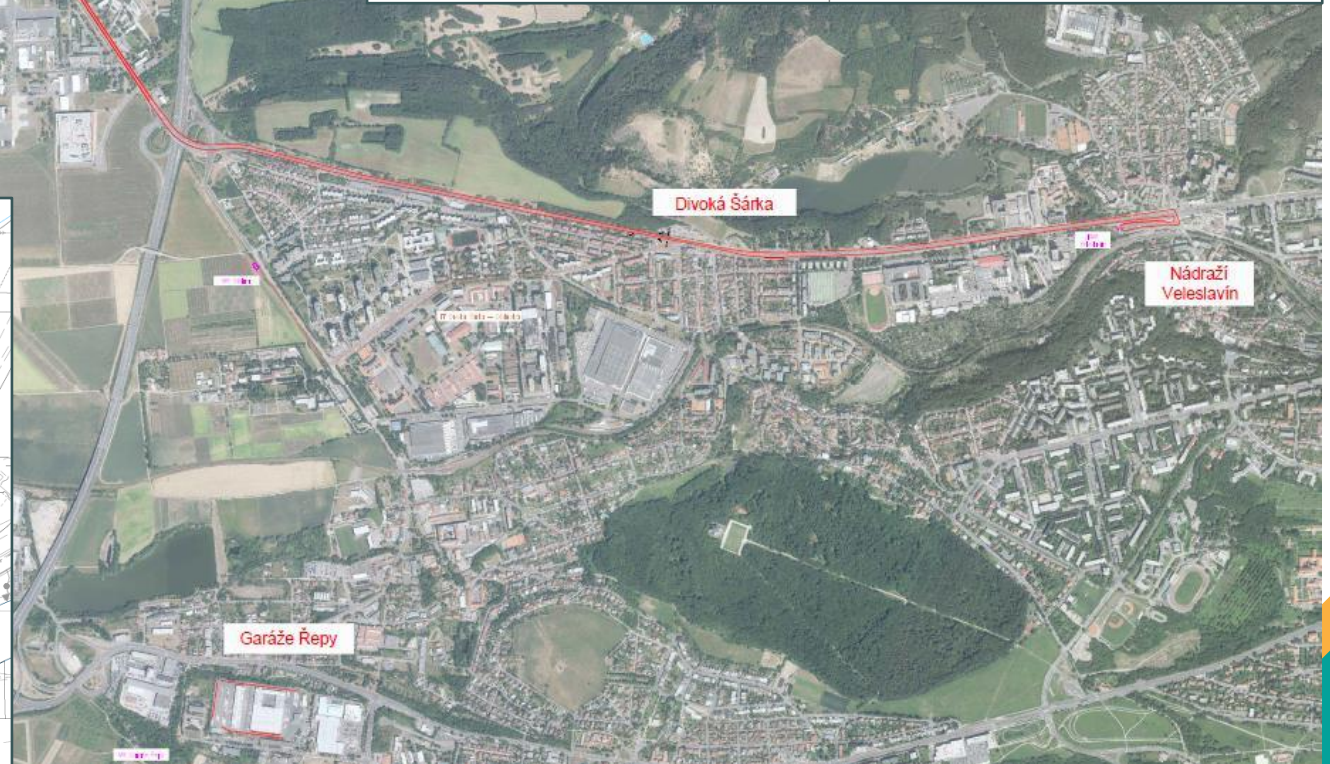
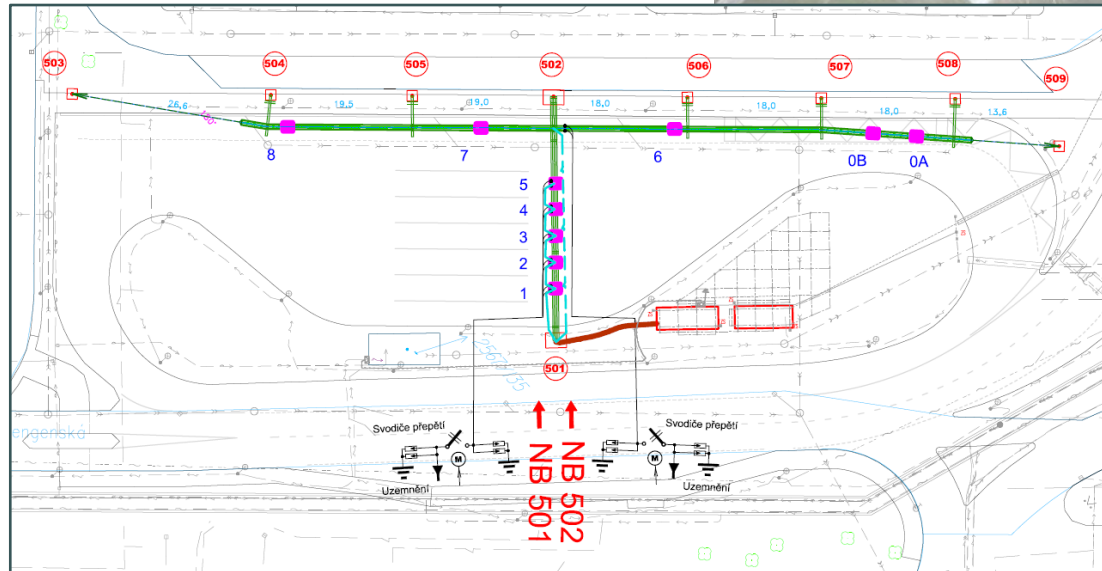
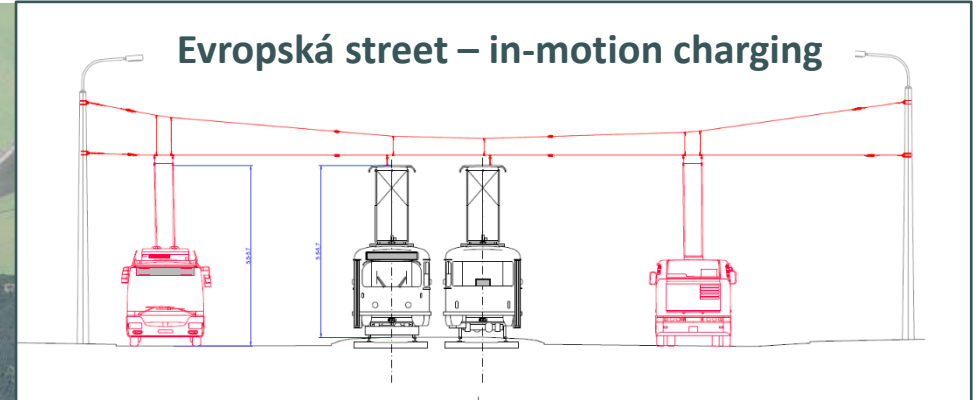
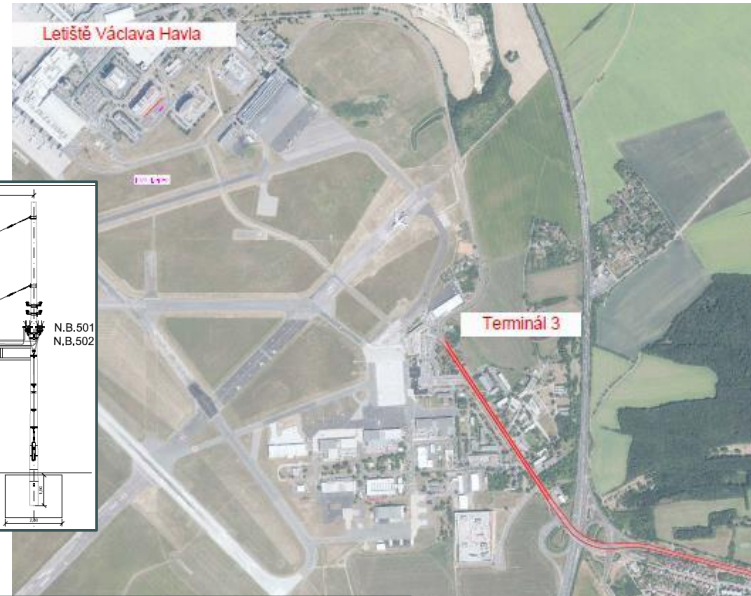
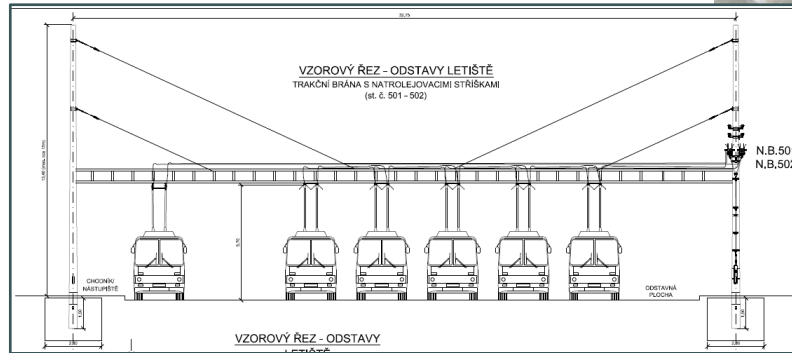


Valid building permission 1/2022
Vehicle tender finished 2/2022
Infrastructure construction since 12/2022
Operation start 6.3.2024



Double articulated vehicle test operation on bus line 119 (diesel version)

Airport – opportunity charging





vehicle – test operation in Pilsen

terminus
Nádraží
Veleslavín



Airport terminus – static charging



shared stop TRAM + BUS Divoká Šárka



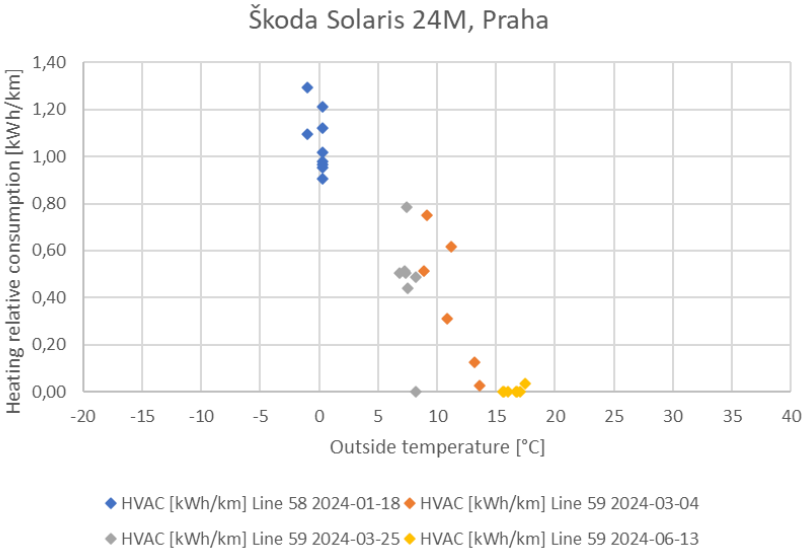
Evropská street – IMC





	A	B	C	D	E	F	G	H	I	J	K
1	RealTime	res1UinAv_V_	res2UinAv_V_	res1IinAv_A_	res2IinAv_A_	res1PwrInAv	res2PwrInAv	ac3_UdcAv_V_	KmHod100_km_hod_	UtReal_V_	It_A_
2	13.06.2024 09:58:27.000	1300,246575	1300,246575	1,081339132	1,242613324	1424,242125	1633,997605	16,05224609	0	6,8	1,031939394
3	13.06.2024 09:58:27.100	1300,186523	1300,186523	1,084049093	1,236207962	1427,04163	1634,484513	15,8536044	0	6,743933884	1,18368595
4	13.06.2024 09:58:27.200	1299,772717	1299,772717	1,188054109	1,381190872	1531,880131	1769,335559	15,84676107	0	6,895393939	1,171333333
5	13.06.2024 09:58:27.300	1299,973236	1299,973236	1,254653452	1,463228781	1596,76871	1872,370732	15,72376598	0	6,9	1,216666667
6	13.06.2024 09:58:27.400	1299,964953	1299,964953	1,379804375	1,582959782	1783,624028	2058,262857	15,67937678	0	6,9	1,21630303
7	13.06.2024 09:58:27.500	1300,105764	1300,105764	1,331394618	1,524572442	1726,962873	1987,005415	15,87246982	0	6,864429752	1,259702479
8	13.06.2024 09:58:27.600	1300,101622	1300,101622	1,242704988	1,430955609	1615,689076	1847,308072	15,94016335	0	6,9	1,3
9	13.06.2024 09:58:27.700	1300,0005	1300,0005	1,227800202	1,420936966	1594,723889	1841,699573	15,89152018	0	6,9	1,212
10	13.06.2024 09:58:27.800	1299,830353	1299,830353	1,196142931	1,406442781	1594,75016	1854,578729	15,86914063	0	6,824727273	1,102181818
11	13.06.2024 09:58:27.900	1300,053995	1300,053995	1,202055573	1,412355423	1562,851705	1833,77801	15,63831676	0	6,913454545	0,441818182
12	13.06.2024 09:58:28.000	1299,904901	1299,904901	1,241473187	1,415558104	1592,938286	1846,900837	15,79034979	0	7	0,932727273
13	13.06.2024 09:58:28.100	1299,892476	1299,892476	1,226322042	1,430462889	1581,214109	1876,424811	15,63054865	0	6,948727273	1,034545455

Line	Date	Time	Outside temp. (°C)	Trolley provided average power (kW)	Trolley recuperated average power (kW)	Trolley provided energy (kWh)	Trolley recuperated energy (kWh)	Heating/air conditioning average power (kW)	Heating/air conditioning energy (kWh)	Heating/air conditioning relative energy (kWh/km)
58	2024 01 18	11:45 12:07	0,3	147	5	30	0	23,4	8,5	1,2
59	2024 03 25	10:10 10:29	7,4	113	76	15	1	13	4	0,5
59	2024 03 25	11:53 12:14	8,2	100	48	17	1	12	4	0,5



Vehicle energy management

ONGOING

- Optimize vehicle battery charging (in-motion, opportunity at terminus)
- Optimize HVAC (incl. preheating at trolley section / terminuses)
- Operational management (delays, irregularities)
- Decrease energy consumption, decrease peak charging power

Depot energy management

PLANNED

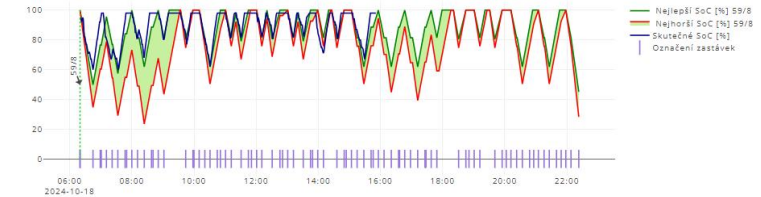
- Optimize fleet battery charging and balancing (incl. vehicle preheating)
- Decrease energy consumption, decrease peak charging power

Current collector connection and disconnection

DONE

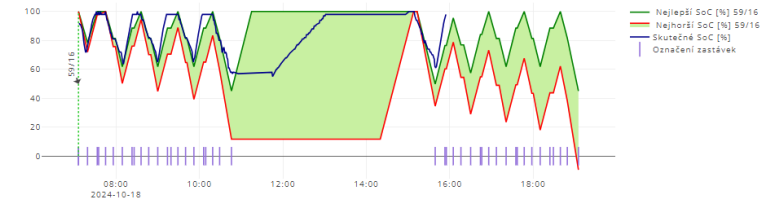
- Automatic disconnection at the end of the catenary section
- Connection remind to driver at the beginning of the catenary section
- Radio communication between infrastructure and vehicle

ENERGY MANAGEMENT - PLÁN VS. REALITA



(Linka 59, pořadí 8)

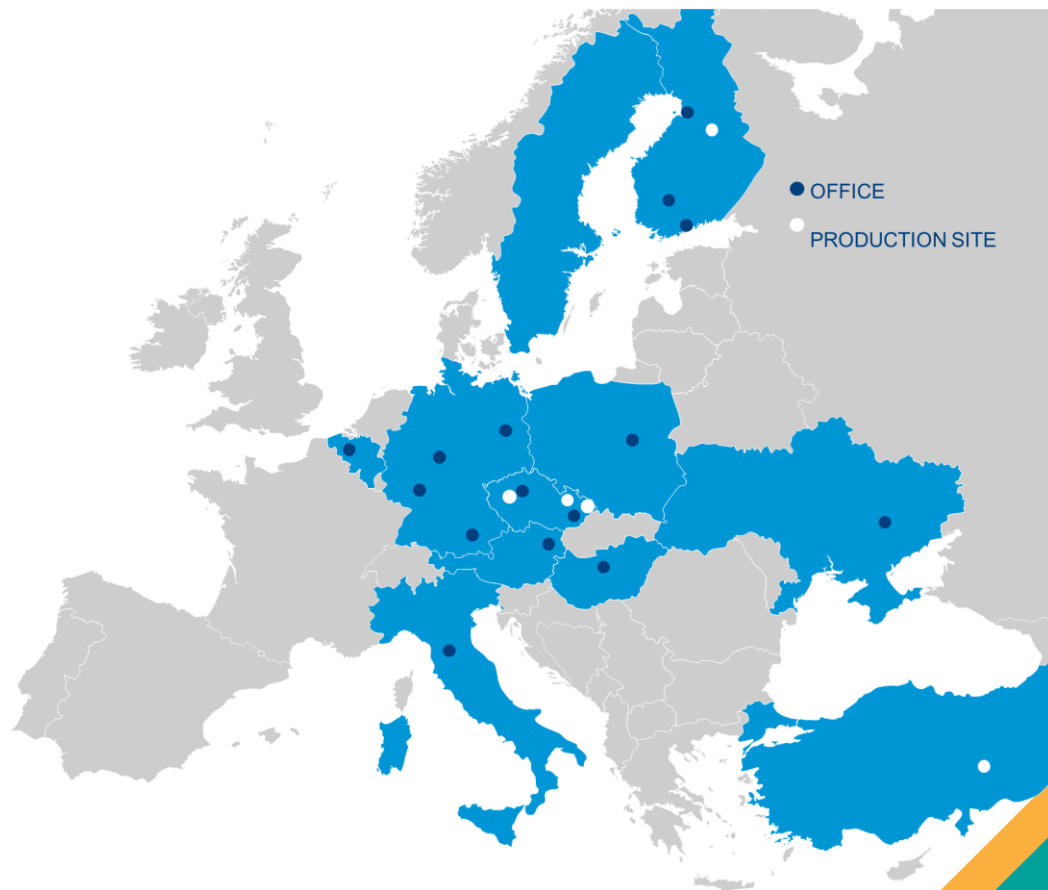
ENERGY MANAGEMENT - PLÁN VS. REALITA



(Linka 59, pořadí 16)



Demo Leader	
Dopravní podnik hl. m. Prahy, akciová společnost (Prague Public Transit Co., Inc.)	PT operator
Demo Partners	
Škoda Electric a.s.	Vehicle producer (electric parts)
Elektroline a.s.	Infrastructure
University of Pardubice, Faculty of Transport Engineering	University
Demo Support	
ROPID	PT authority
Letiště Praha a.s. (Prague Airport Inc.)	Airport operator
Solaris Bus and Coach sp. z o.o.	Vehicle body producer



| 87 YEARS OF TROLLEYBUS
PRODUCTION

| OVER 15,000 TROLLEYBUSES
DELIVERED

| FIRST HYDROGEN BUS IN 2009;
NEW GENERATION 2023

| HYDROGEN BUS WITH 350 KM RANGE

| TROLLEYBUSES WITH BATTERY
FOR UP TO 24 KM
30,000 KM PER YEAR

IN OPERATION

CZECH REPUBLIC

SLOVAKIA

HUNGARY

ITALY

FRANCE

NORWAY

SWEDEN

ROMANIA

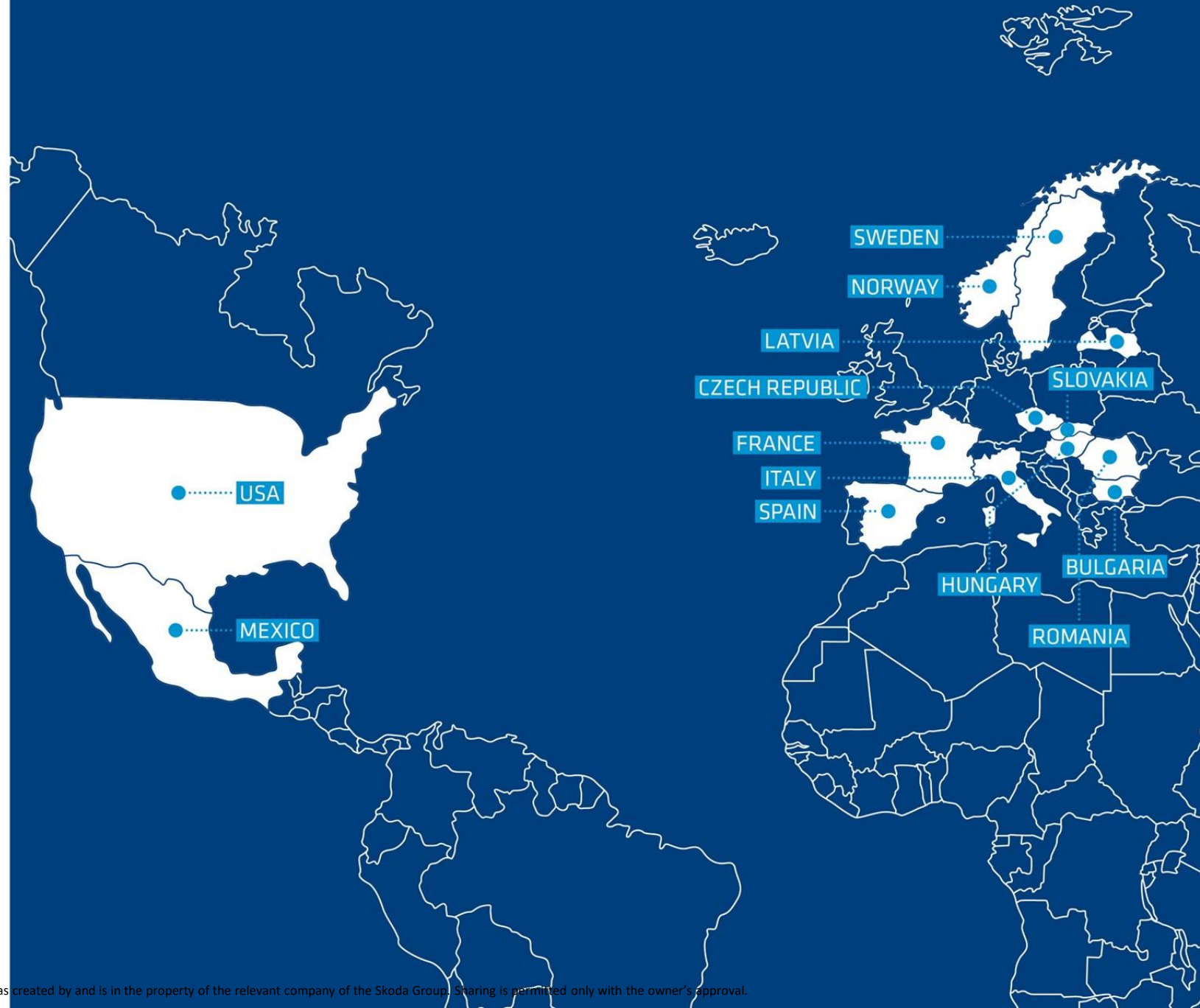
BULGARIA

LATVIA

SPAIN

MEXICO

USA



BUS MOBILITY

ELECTRIC BUSES / TROLLEYBUSES / HYDROGEN BUSES



electric bus E'City Prague



trolleybus 27Tr Sofia



hydrogen bus H'City



trolleybus 32Tr Opava



trolleybus 27Tr Pilsen



trolleybus 35Tr Limoges

Škoda 24-metre long trolleybus



VEHICLE PARAMETERS



Double articulated, fully low floor, 4-axle trolleybus

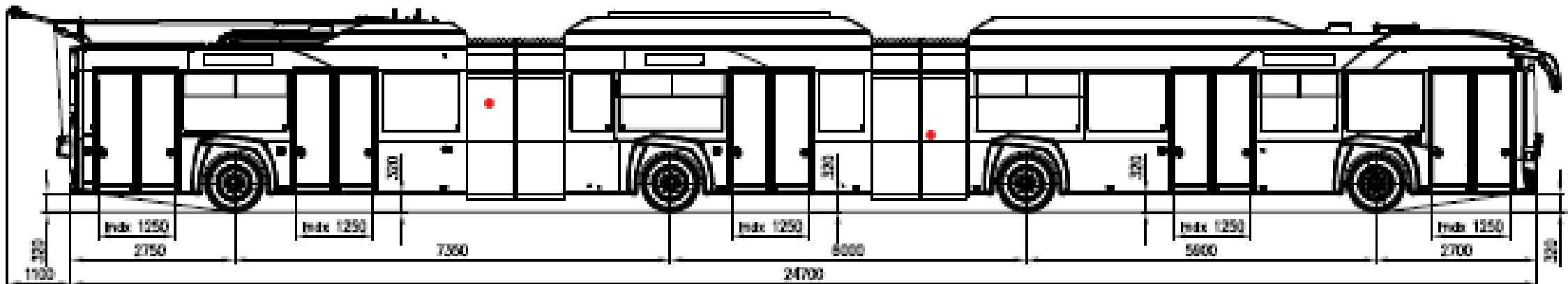
5 entrance doors

Total length 24,70 m

Turning radius 11,71 m

Total passenger capacity 195

Number of seats 52



Traction motor 2 x 160 kW (driven axle: 2nd and 3rd)

Maximal speed 65 km/h

Climbing ability 15%

Traction batteries (LTO) for autonomous motion, capacity 60 kWh

Remote diagnostic, telemetry and statistics (ASTRID system)



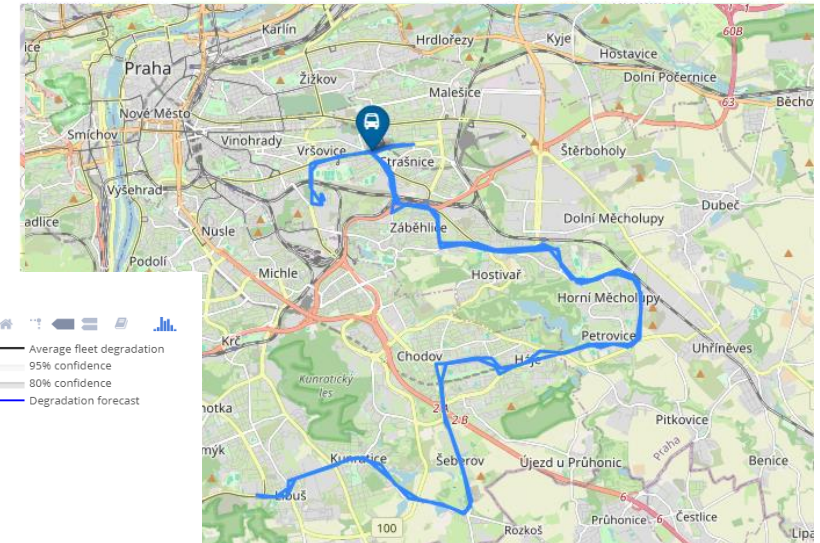
ASTRID: Telemetry & Statistics System

- Developed & maintained in-house by Skoda Electric
- Used for vehicles in several European countries
- Collects telemetry data from vehicles
- Provides vehicles status information
- Generates statistical reports, predictions, anomaly alerts
- Localized to several languages, new languages can be added easily

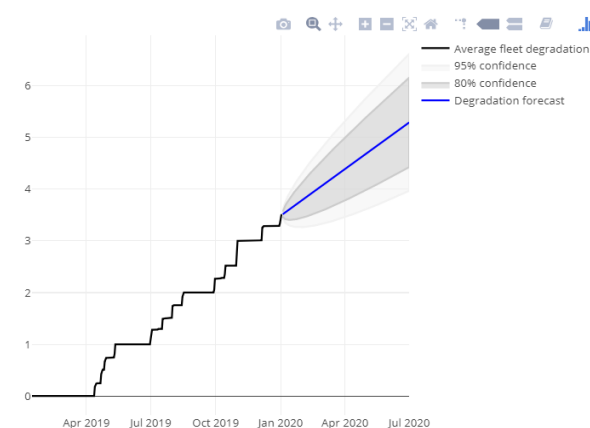
VEHICLE MOVEMENT

Today

SHOW



ARIMA forecast



THANK YOU!

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