SOLARIS

A CAF GROUP COMPANY

How to design IoT system for buses?

AGH

Łukasz Chełchowski
Michał Pikuła
Michał Sierszyński

HOW TO DESIGN IoT SYSTEM FOR BUSES?

- WHY USE IoT SYSTEM IN BUSES?
- HOW WE DESIGN eSConnect?

- USECASES MANAGED BY eSConnect
- REAL-TIME AUTOMATED ANALYSIS AND PREDICTION
- BUSSINES ANALYTICS SERVICE

- SUMMARY

eSConnect
SOLARIS

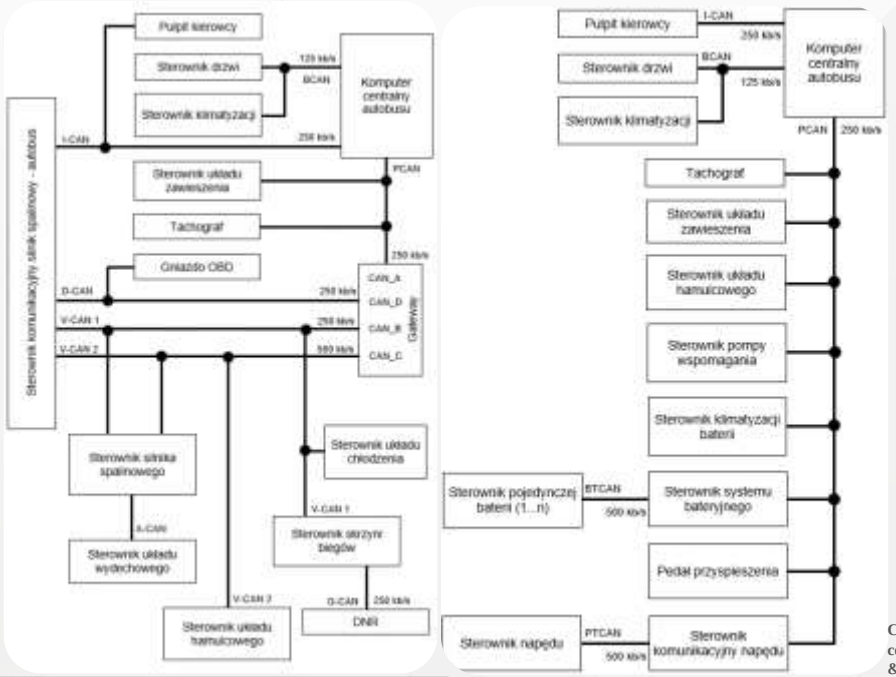
WHY USE IOT SYSTEM IN BUSES?

NEW TECHNOLOGIES AND **CHALLENGES** IN OPERATION

- How **to deal** with sporadical faults?
- When to drive **back** to the depot for charging?
- How to keep **my bus** on the streets?
- How to provide its **highest availability**?
- How to **react** quickly?

WHY USE IOT SYSTEM IN BUSES?

NEW TECHNOLOGIES AND CHALLENGES IN OPERATION



CAN bus architecture of the supervision and control system for conventional and electric buses - own development of Solaris Bus & Coach sp. z o.o.

DATA
AVALIABLE
ON BOARD

WHY **USE IOT** SYSTEM IN BUSES?

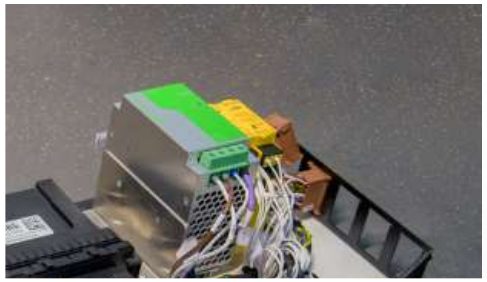
eSConnect **BENEFITS** FOR FLEET OPERATION

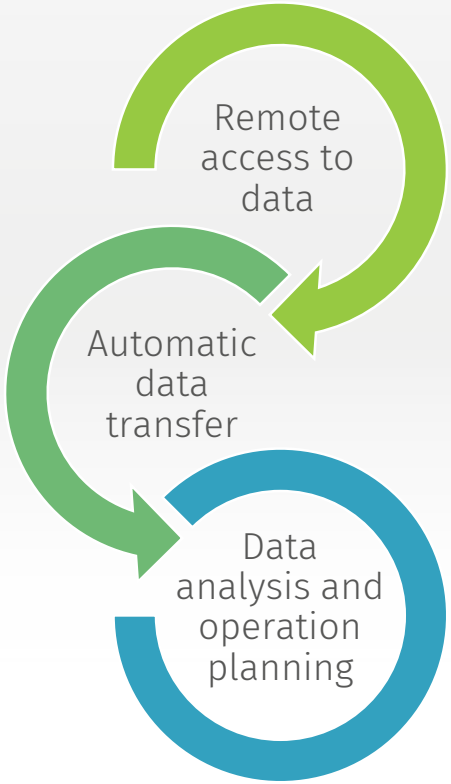
- **Limit unnecessary** downtime thanks to immediate breakdown information
- Time to **prepare your workshop** for repair
- Historic data analysis for **higher operational efficiency**
- Avoid **unnecessary visits** to the depot
- **Optimum** fleet capacity
- Higher **availability**
- **Reduced** operation cost

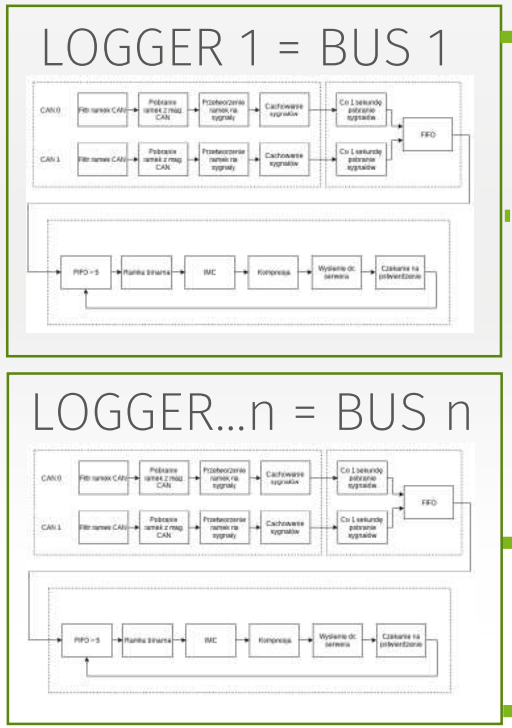
HOW WE DESIGN eSConnect?

STEPS OF DEVELOPMENT

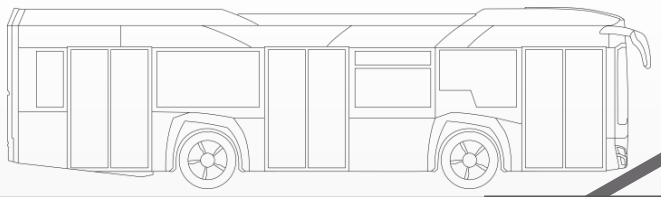
Creating the base platform







DATA DELIVERY SYSTEM IN DETAIL



PROCESSING

AGGREGATION

THREE DATABASES

WEB APPLICATION

SERVER eSconnect

LOGGER 1

ACTOR 1

UPLOAD TO SERVER

Postgres

InfluxDB

Redis
(Cache)

ACTOR...n

Worker 1 ..

ZMQ

SEVERAL FIFO QUEUES

LOGGER...n

SERVER VPN

FIFO: loggers	Worker 1	W 2	W 3	W 4	W 5
FIFO: wykresy	Worker 1	W 2	W 3		
FIFO: raporty	Worker 1	W 2			

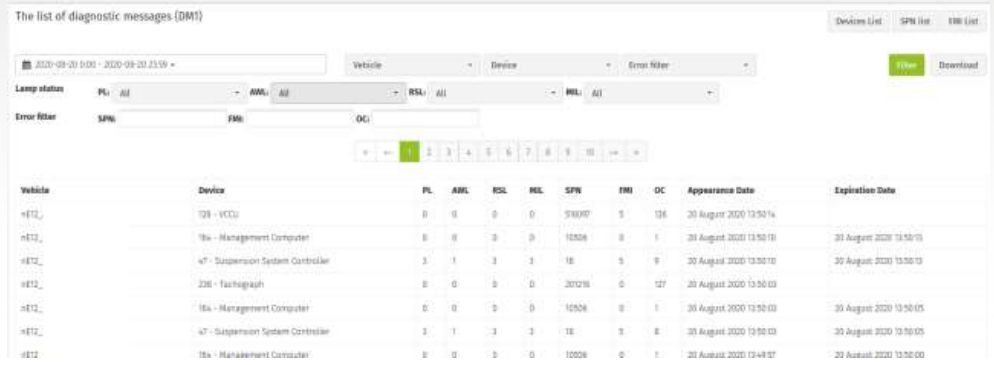
HOW WE DESIGN eSConnect?

STEPS OF DEVELOPMENT

Customisation

- Ergonomic layout
- Website features (strong password, password reminder)
- Fleet view (dashboard)

eSConnect
SOLARIS



HOW WE DESIGN eSConnect?

STEPS OF DEVELOPMENT

Service needs

- GSM transfer monitoring
- Fault codes with description in different languages
- Vehicle ECUs soft version monitoring
- Automatic download of logs from the vehicle
- API function

eSConnect
SOLARIS

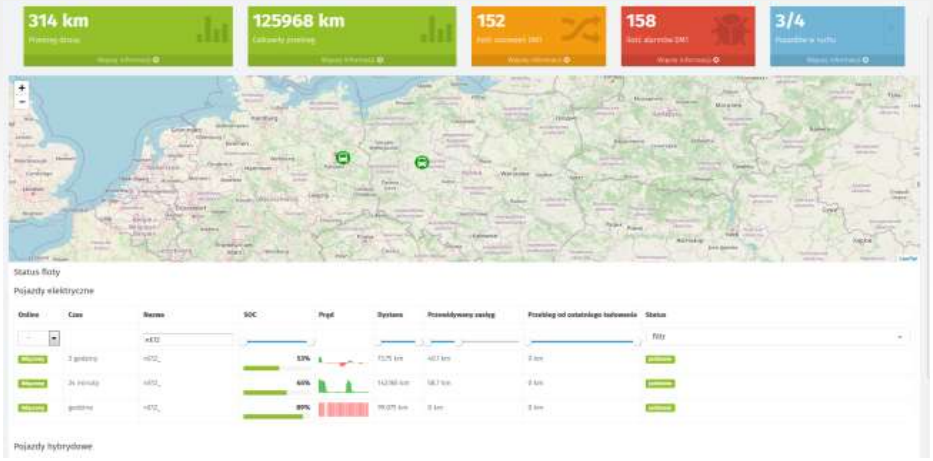
HOW WE DESIGN eSConnect?

STEPS OF DEVELOPMENT

Customer needs

- All types of buses (diesel, CNG, troleybus, electric, hydrogen, hybrid) + flexibility in adding new monitored signals
- Chargers in eSConnect
- New, advanced map view (topography and route statistics)
- Inspection monitoring
- Activation of preconditioning function
- Passenger counting system - Assured project

eSConnect
SOLARIS



USECASES MANAGED BY eSConnect

BUS PRECONDITIONING

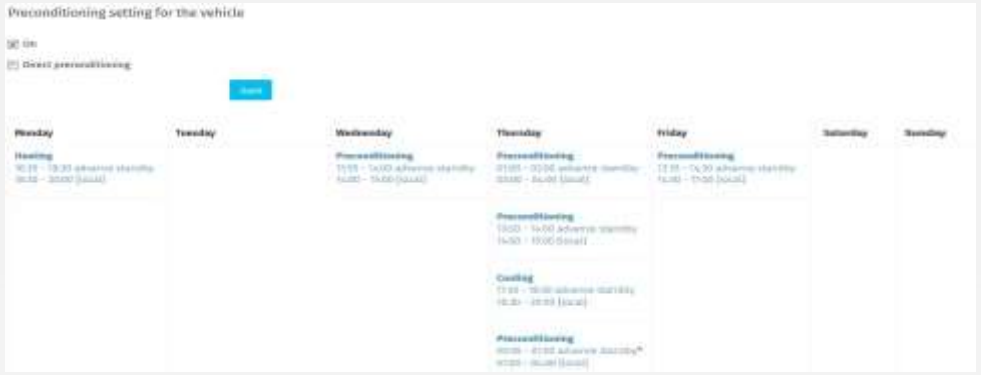
eSConnect
SOLARIS

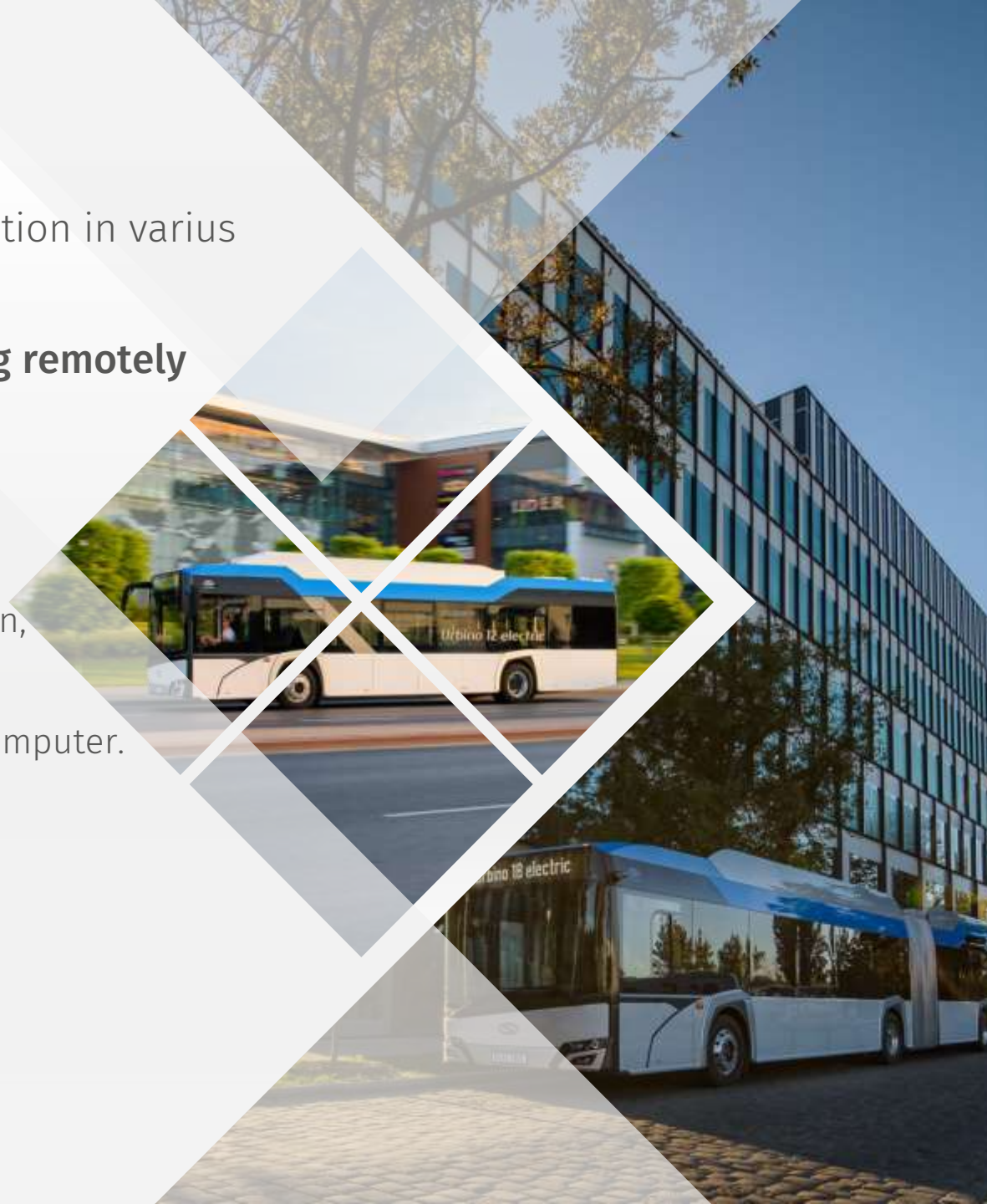
HOW DATA FROM THE EXTERNAL SYSTEM CONTROL THE INTERNAL BUS FUNCTIONS

- **Bus preconditioning** allows to reduce energy consumption in varius weather conditions
- eSConnect allows you to **schedule** bus **preconditioning remotely**
- Solution already used in buses
- **Cybersecurity aspects** already implemented

in the function:

- bus eSConnect ECU request the status of function activation,
- bus gateway filter only that function signal,
- remote preconditioning function activation in bus' main computer.

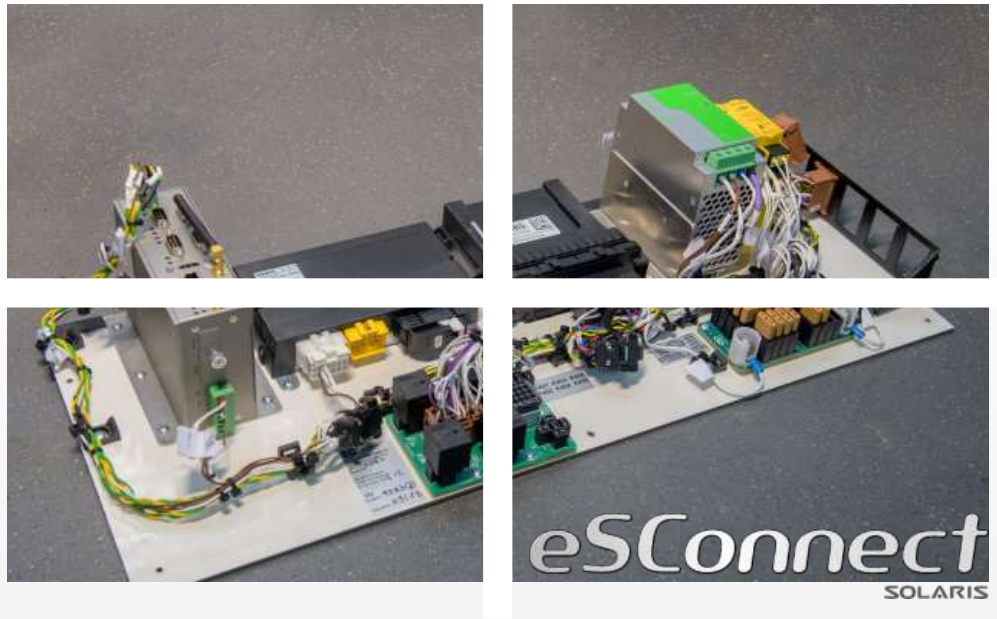




AUTOMATED ANALYSIS AND PREDICTION

AUTOMATED ANALYSIS AND PREDICTION

REAL-TIME AUTOMATED ANALYSIS



Automated analysis

- Faults
- Event generator
- Reports

Faults

System will recognize anomalies and will notify the operator. DM1 messages (fault codes and lamp status):
Red / Amber lamp status of ECU

SPN – Suspect Parameter Number of ECU

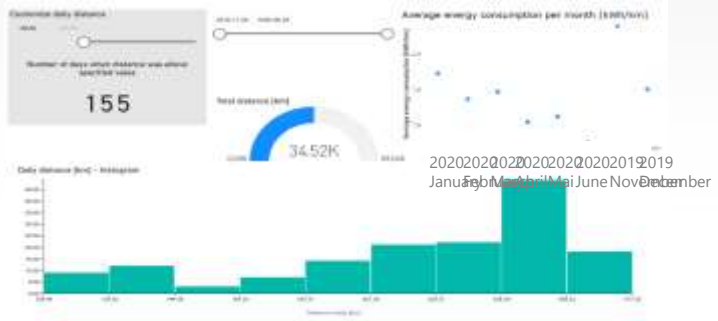
FMI – Failure Mode Identifier of ECU

Event generator

Devices' state monitoring in real-time.
Various options for parameters analysis by creating queries. The queries are analysed constantly by data logger. If conditions defined in query are fulfilled event is added to list of events

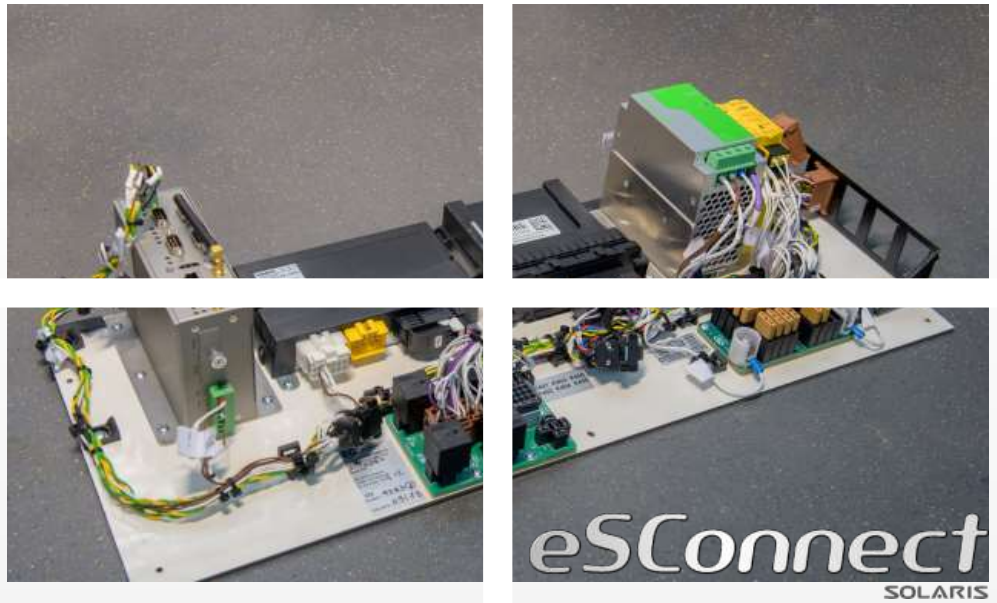
Reports

More customizability regarding report generating.
You can access the data in the required form.



AUTOMATED ANALYSIS AND PREDICTION

REAL-TIME AUTOMATED ANALYSIS



Predictive maintanance

- based on historical data, system will predict faults and will warn operator before the fault occurrence

Automated analysis
(faults, events, reports)

Experts knowledge & machine learning

Prediction

BUSSINES ANALYTICS SERVICE

eSConnect
SOLARIS

BUSSINES ANALYTICS SERVICE

ANALYTICS AND DATA VISUALIZATION USING POWER BI

- **Power BI** is service provided by Microsoft
- Service for analysing **large volume of data**
- **Ready solution** to analyse various types of databases (technical and business databases)
- **Safe and simple distribution** of reports inside the company (email, website, spreadsheet)
- Distribution of reports **to customers** – under verification
- Reports used for datasets viewing

BUSSINES ANALYTICS SERVICE

ANALYTICS AND DATA VISUALIZATION USING POWER BI

Figure 1. Magic Quadrant for Analytics and Business Intelligence Platforms

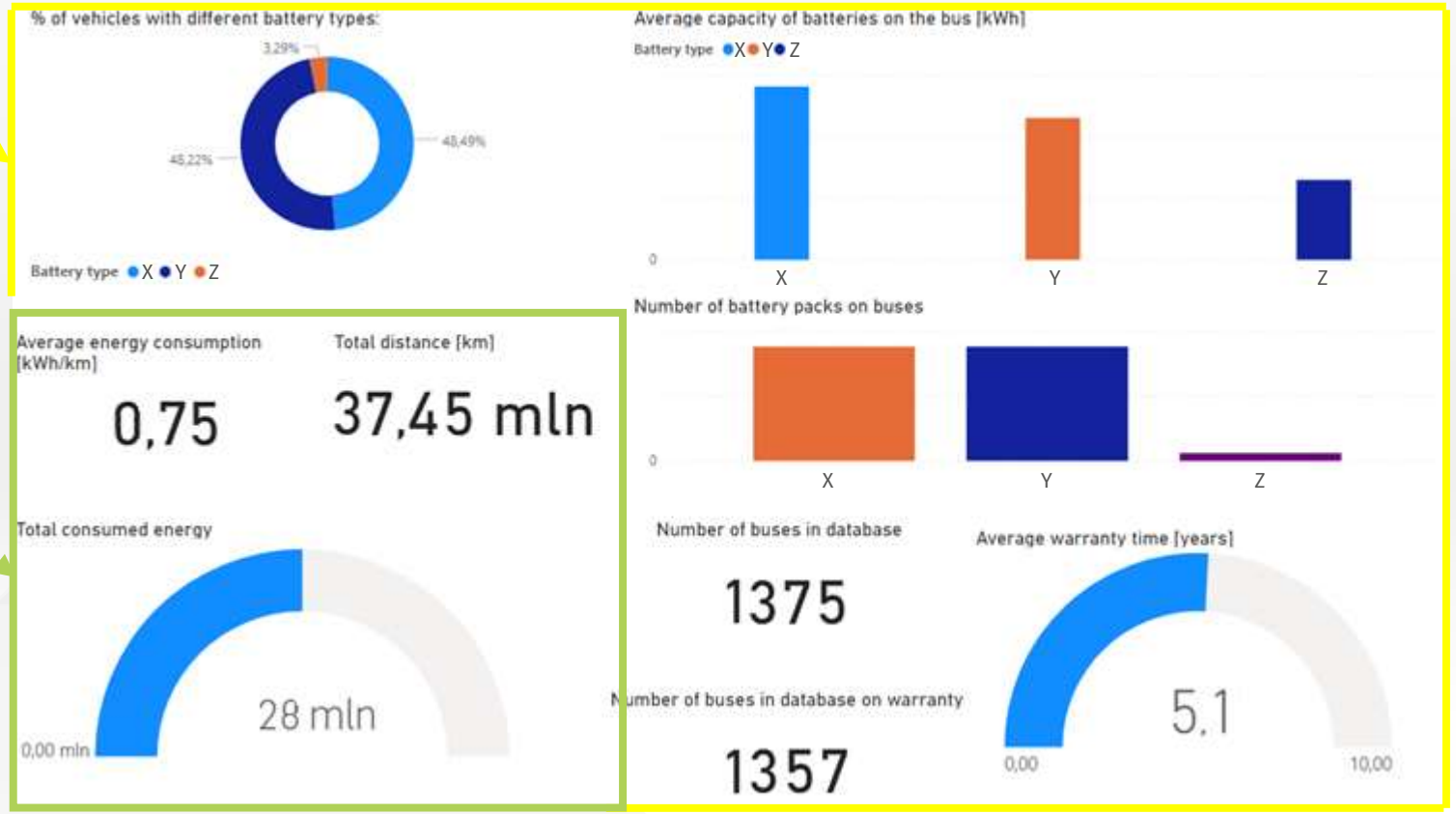
Source: Gartner (February 2020)

BUSSINES ANALYTICS SERVICE

ANALYTICS AND DATA VISUALIZATION USING POWER BI – BUSINESS – TECHNICAL SUMMARY - EXAMPLE

Warranty summary (xlsx)

eSConnect (CSV + API)



SUMMARY

WHY USE IOT SYSTEM IN BUSES?

- **Reliable data** – eSConnect is created by the bus manufacturer
- **Quick service support** – Solaris service has remote access to diagnostic data
- **Access to historical data** – ability of creating summaries
- **Comprehensive service** – transfer, data storage and system service within a single subscription fee
- **Implementation of new functionalities** – access to periodic updates
- **API** – the possibility of integration with the 3rd party systems

SOLARIS
A CAF GROUP COMPANY

Thank you!