

Linkker

Intelligent eMobility

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Helsinki 28-29 May

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Mission – Quality of Life in Cities With Intelligent eMobility



Environment

Economy

Experience

City bus routes ideal for electrification – high consumption, high mileage, fixed route, energy supply available, emission reductions important, passenger attractiveness wanted, multimodal potential (rail & bus), green city image

Our background



Sami Ruotsalainen
CEO



Tom Granvik
CFO



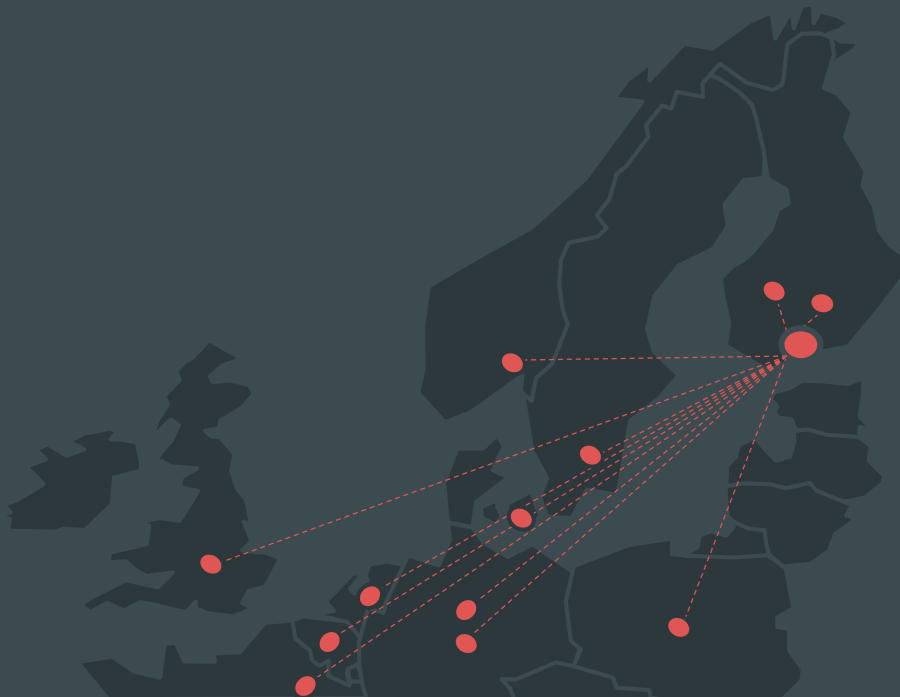
Kimmo Erkkilä
Strategy, BD



Tommi Mutanen
Bus Constructions



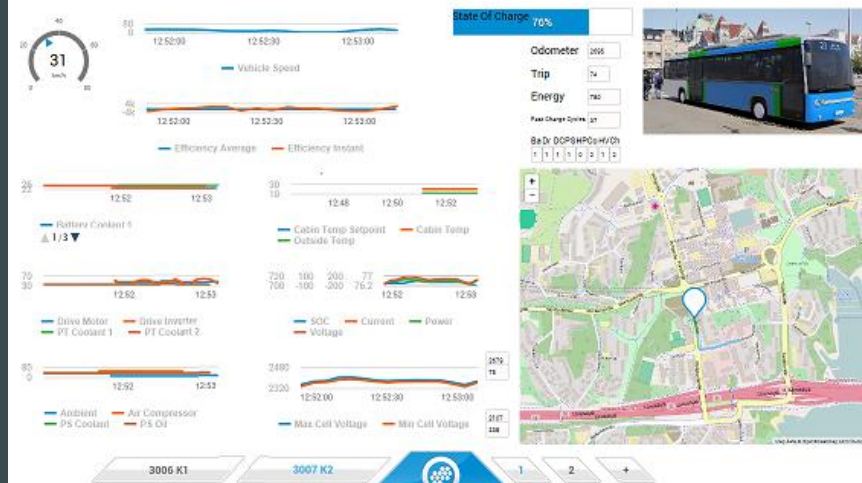
Otto Pietikäinen
Prototypes, Pilots



- | HQ in Finland
- | +10 years of eBus R&D
- | Ecosystem of best partners
- | Engineering & Production in Finland
- | European standards (R100/R107)

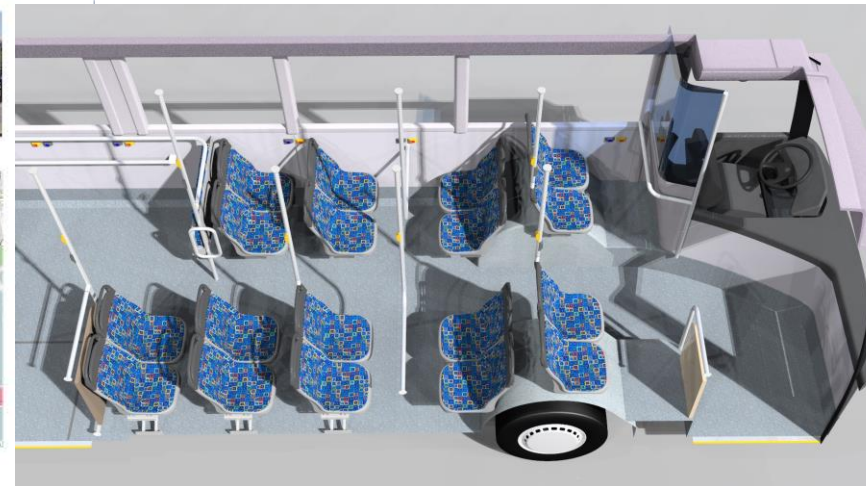
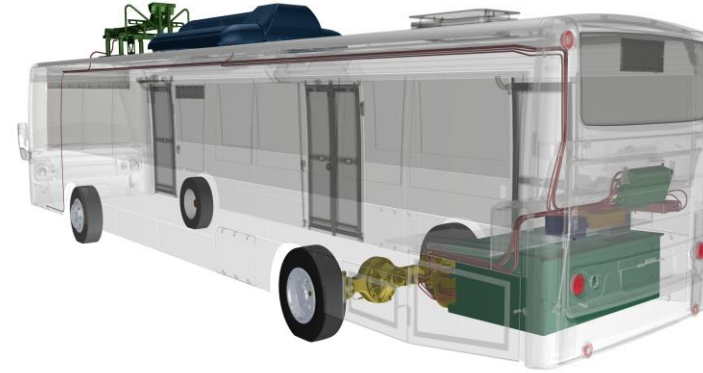
Linkker Products

Linkker electric buses



LinkView operational SW

LinkDrive drive line & ultra fast charging



LinkLight chassis and body

Milestones – Developing Competence



Key Challenges for Electric Bus Operation

Planning impact

- Infrastructure
- Network coverage
- Operations
- Financial
- Technology
- Construction
- Transition

Re-charging concepts

- Depot vs Opportunity
- Charging location
- Charging power
- Charging time vs time table
- Connectivity
- Grid connection & power supply

Operational impact

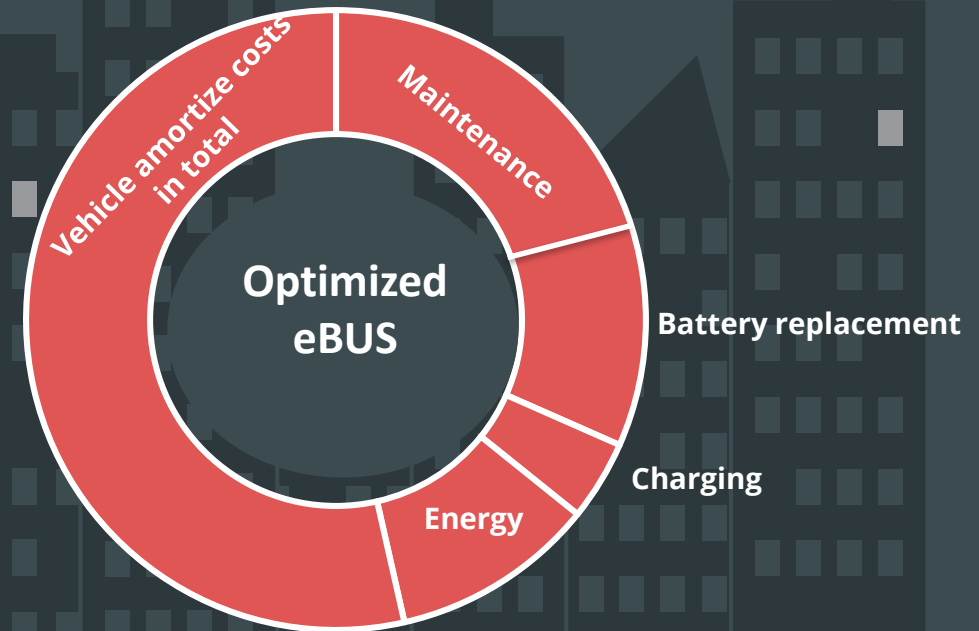
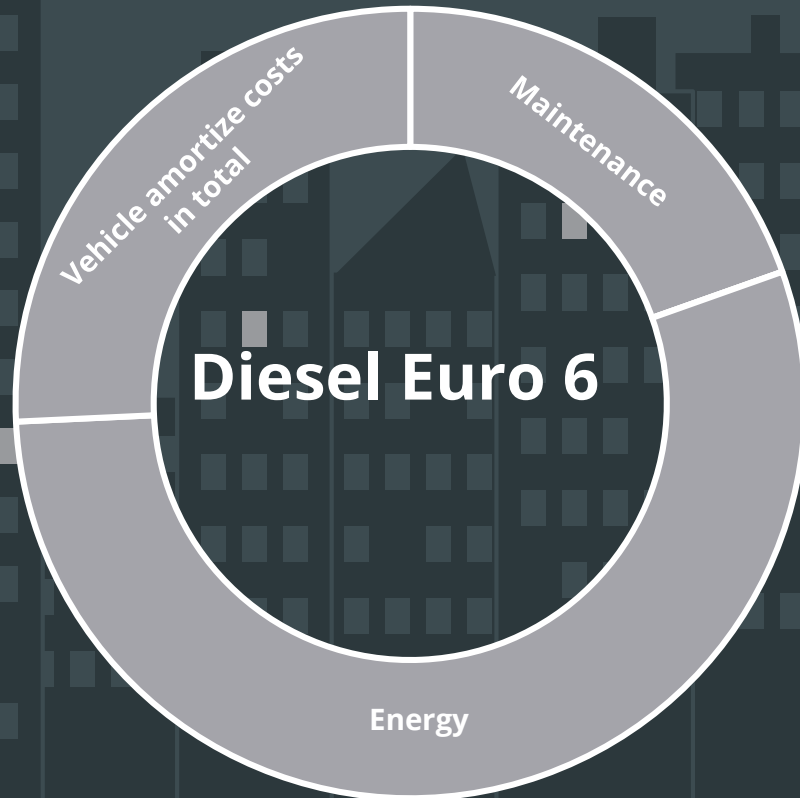
- Line length
- Energy consumption
- Continuous operation
- Daily mileage
- Time table
- Depot operation

Total Cost of Ownership

- Battery cost
- CAPEX – bus – drive line – infrastructure
- OPEX – energy – battery replacement – maintenance
- Asset management (bus – battery – depot – infrastructure)
- Technology development
- Standardization

Business Case – CAPEX & OPEX

RoI comes with mileage driven and timetable performance!



Remark – driver hours and cost assumed the same

Vision – Intelligent eMobility

Increasing revenue



**Improved efficiency
30% lower consumption**



**Modular energy storage
& life time management**



**24 x 7 operation
+350km mileage**

Decreasing life cycle cost



**high power charging
2-4min typ.**



**High time table
performance**



Predictive & lower maintenance



Passenger Experience

Intelligent eMobility Architecture

Increasing revenue

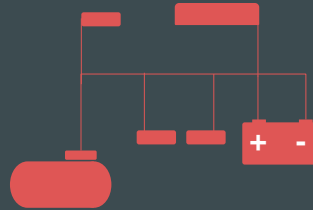


LinkLight



- Full aluminium body and chassis
- Long life time proven technology (70 million km driven)
- 3tn lighter than comparable steel buses
- Easy assembly construction

LinkDrive



- Drive line and vehicle control SW
- Energy efficient and optimized power train
- Lightweight energy efficient components
- High efficiency permanent magnet motor
- LinkControl intelligent vehicle control system

LinkView

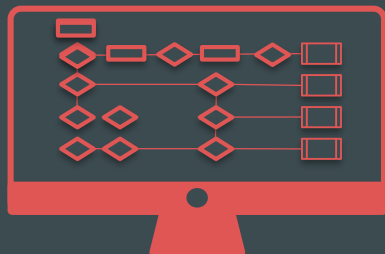


- Performance & fault monitoring (of battery, driveline and auxiliary)
- Components monitored for performance degradation to allow fast proactive response
- eFleet management data, reporting & analytics
- eFleet management applications Battery life time management, charge cycle optimization, energy efficient driving

Decreasing life cycle cost



LinkControl & LinkAuto



- Vehicle Control Unit
- Drive by wire system
- Acceleration & Torque control
- Hill stand, anti jolt, anti vibration, wheel slip
- SelfDrive applications
- Sensoring system
- Platooning
- Automated depot
- Automated drive

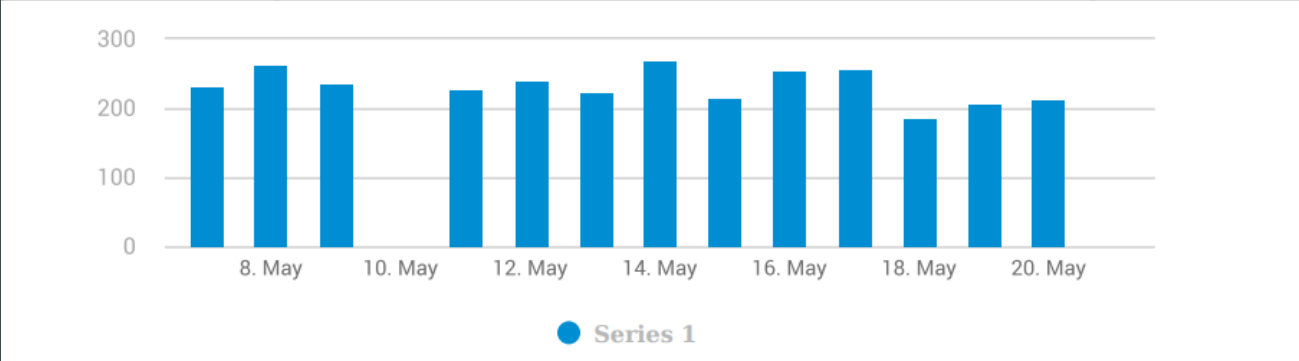
Business Case - Performance & TCO



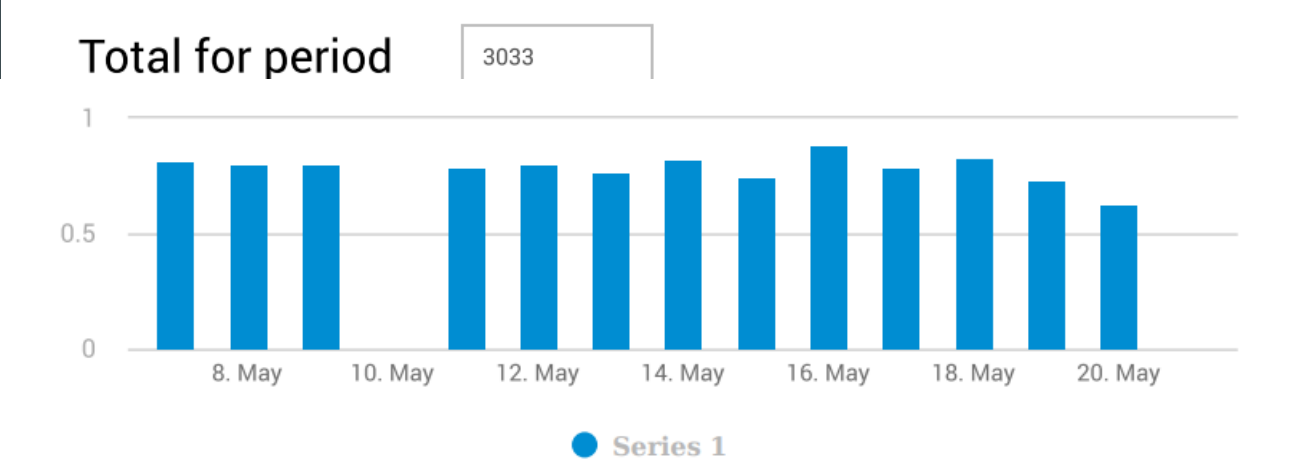
- Typical route:
- Inner city routes
 - 10-20km
 - 1-2 charging events
 - 16-20h operation

298	2018-05-05 00:00:00	G A016 014
317	2018-05-05 00:00:00	G A016 013
311	2018-05-05 00:00:00	G A016 016
296	2018-05-05 00:00:00	G A016 015
310	2018-05-05 00:00:00	G A016 011
286	2018-05-05 00:00:00	G A016 012

Fleet mileage



Energy consumption per day



Energy consumption per km



Linkker – References

Linkker is already proven and market tested

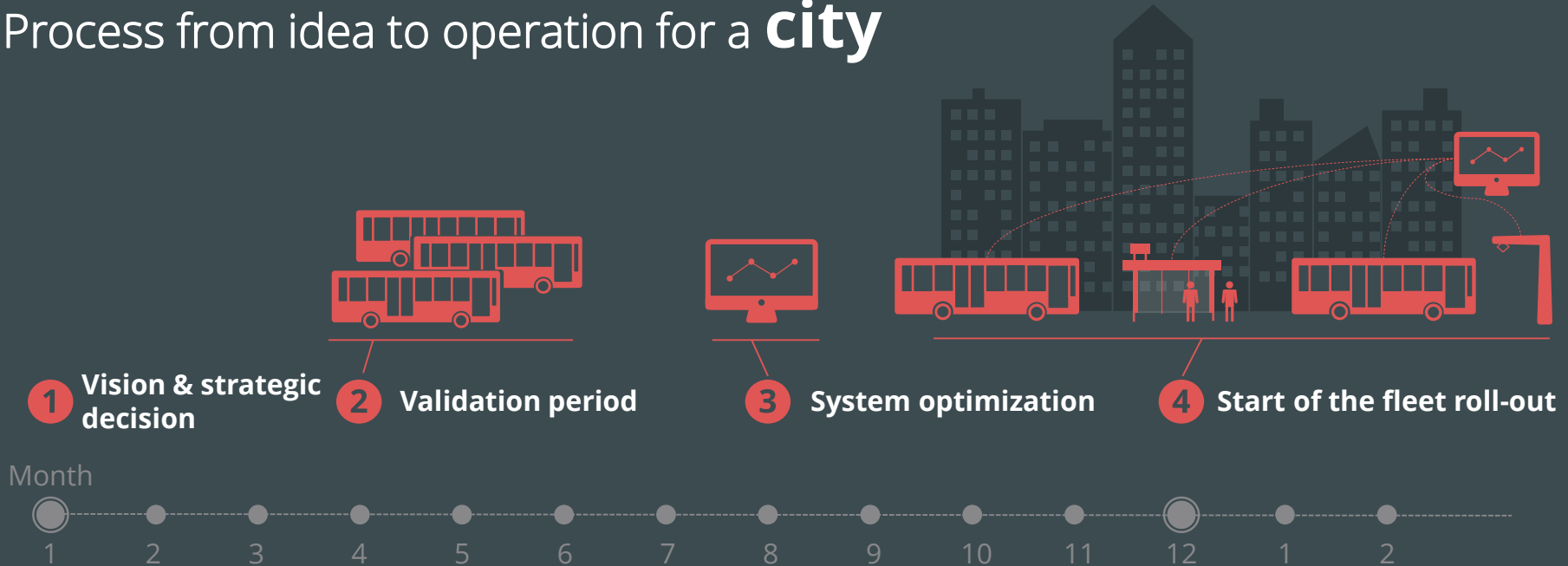


Buses in operation/ ordered by customers

We will partner you all the way

Process from idea to operation for a **city**

Increasing revenue



Decreasing life cycle cost



PERFORMANCE

- Line profiling
- Time table analysis
- Charging cycle simulation
- Daily mileage and 24 x 7 analysis

AVAILABILITY

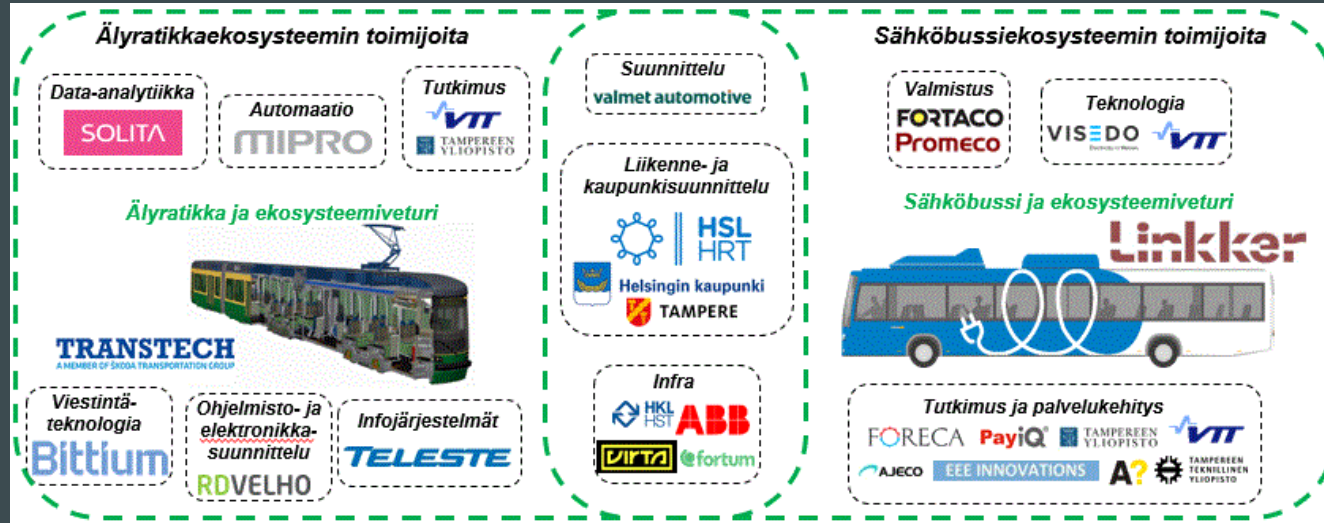
- Infrastructure & storage configuration
- Fleet management solutions
- Maintenance strategy

TCO

- Cost driver analysis
- Business driver analysis
- Risk management
- Optimization

Linkker - Ecosystems

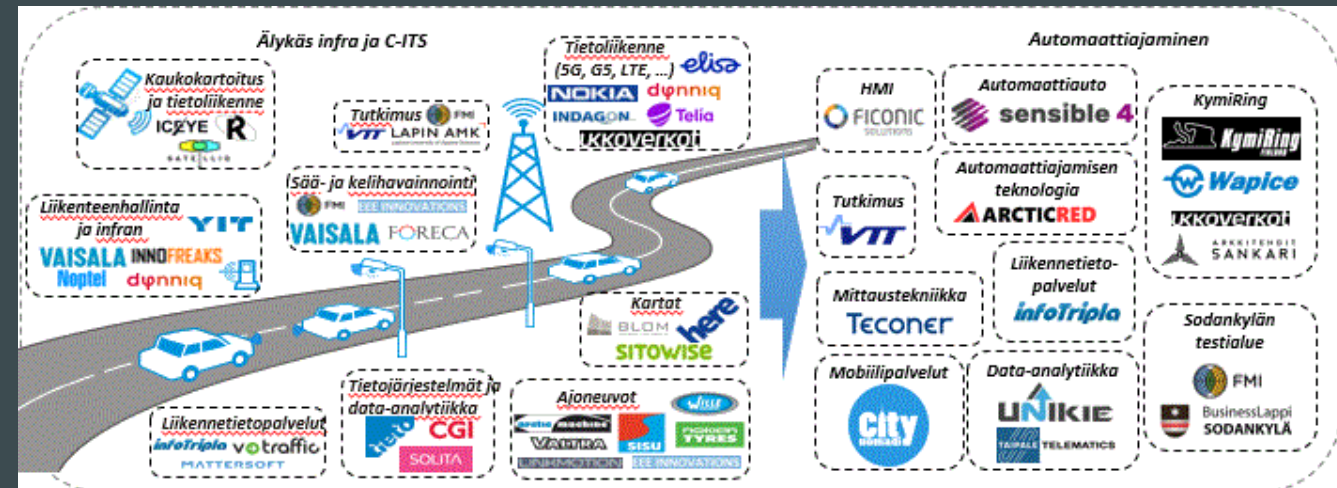
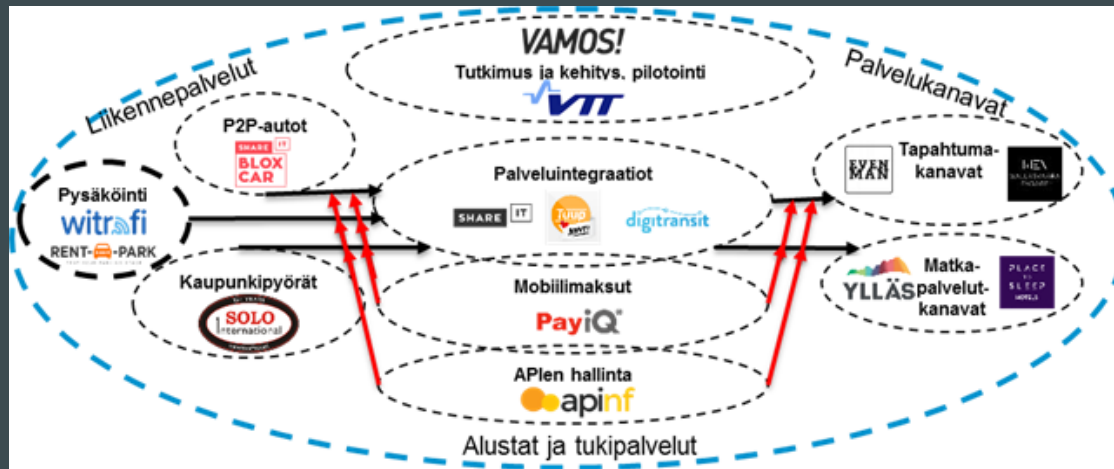
Sustainable Transport Systems



Mobility as a Service



Digitalization & Service Integration



Intelligent infrastructures & Automation

Linkker eFleet Management

Energy reduction

Charge cycle optimization

Battery life time management

Time table performance

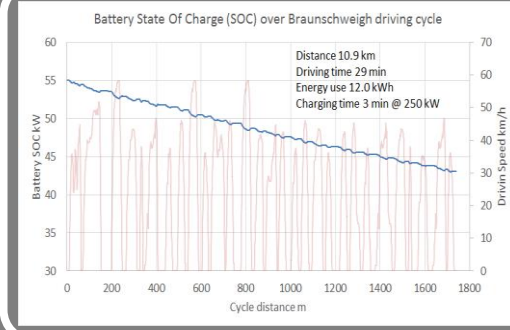
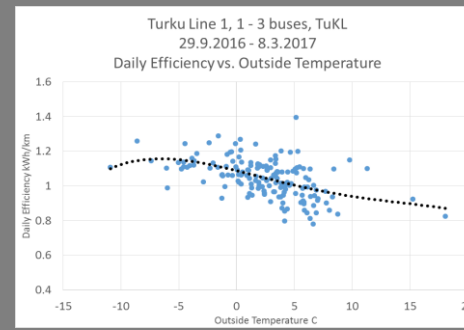
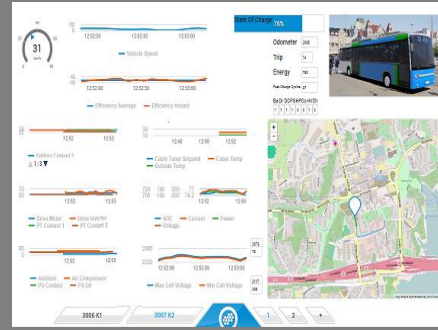
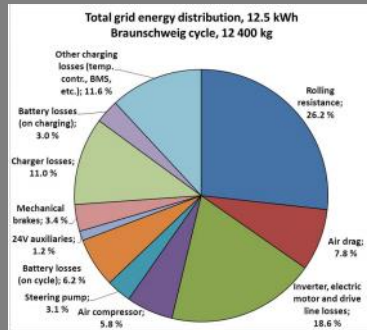


Performance monitoring

Performance management

Analytics & optimization

Active Driver Assistance



LinkView IoT platform

LinkControl

CAN

I/O GW

DataLink

Security

Autom.Vehi.

Standardization and Certification

- Engineering done by using only high quality components and adoption of industry standards.
- Integration on component level to have high flexibility in selection of best components.
- Certified according to EU-type approval as per 2007/46/EC (M3, Class I), ECE R107 (general construction of the bus, it determines e.g. seating, gangways, handrails, emergency exits), ECE R100 (electrical safety), ECE R10 (EMC), ECE R13 (braking), ECE R51 (drive-by noise), ECE R79 (steering)
- Performance tests have been done by VTT, accredited vehicle test laboratory and by collecting real time data from operation.
- Linkker supports and commits to standardization of charging infrastructure by CEN/CENELEC and ISO/IEC in order to establish a common European standard for electric bus systems together with major electric bus OEMs and charging system suppliers.

VTT CUSTOMER REPORT VTT-CA-0207-18 1 (17)

Report title Simulation of Linkker Battery Electric Bus Energy Consumption	
Customer contact person, address Linkker Oy Salmi, Rautatiekatu 00100 Helsinki Puhelin: 09 2500 0000	
Project name Simulation of bus energy consumption	Project number/Client name 154004-BusSim
In this work energy consumption of Linkker battery electric bus has been defined using computer simulation. Energy consumption is defined for Braunschweig and JCMT 2 driving cycles. Total vehicle mass in the simulation is 12400 kg. Simulated energy consumption from battery in Braunschweig cycle is 152 kWh/km and in JCMT 2 cycle 152 kWh/km.	
Reported by Esposito 21.3.2017	Reviewed by Ar-Pekka Pellikka
Author Pekka Pellikka, Senior Expert	Approved by Mika Rittman, Research Team Leader
VTT Technical Research Centre of Finland, P.O. Box 1000, FI-02044 VTT, Finland	
Distribution (customer and VTT) Sigge Rautavaara, Linkker Oy, 1 copy	
VTT, 1 copy	

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VTT VTT EXPERT SERVICES LTD

MANAGEMENT SYSTEM
CERTIFICATE

Certificate no.
VTT-C-12886-00-17

ISO 9001:2015

Linkker Ltd
Kortte 2, 15540 Vihti, Finland

VTT Expert Services Ltd has assessed the company's management system and found that it meets the requirements of ISO 9001:2015.
This certificate covers the following functions/services:
Management, Development, Manufacturing, Life-cycle Management, Sales, Marketing and Aftermarket of electric buses.

Issued:
13th June 2017
Valid until:
14th June 2020
First issued:
12th June 2017

Mika Rittman
Certifier
VTT Expert Services Ltd

Jani Rautavaara
Lead Auditor
VTT Expert Services Ltd

FINAS
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This certificate is translation of original Finnish certificate.
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ISO 14001:2015

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