KYBURZ

Innovation for sustainable last mile delivery

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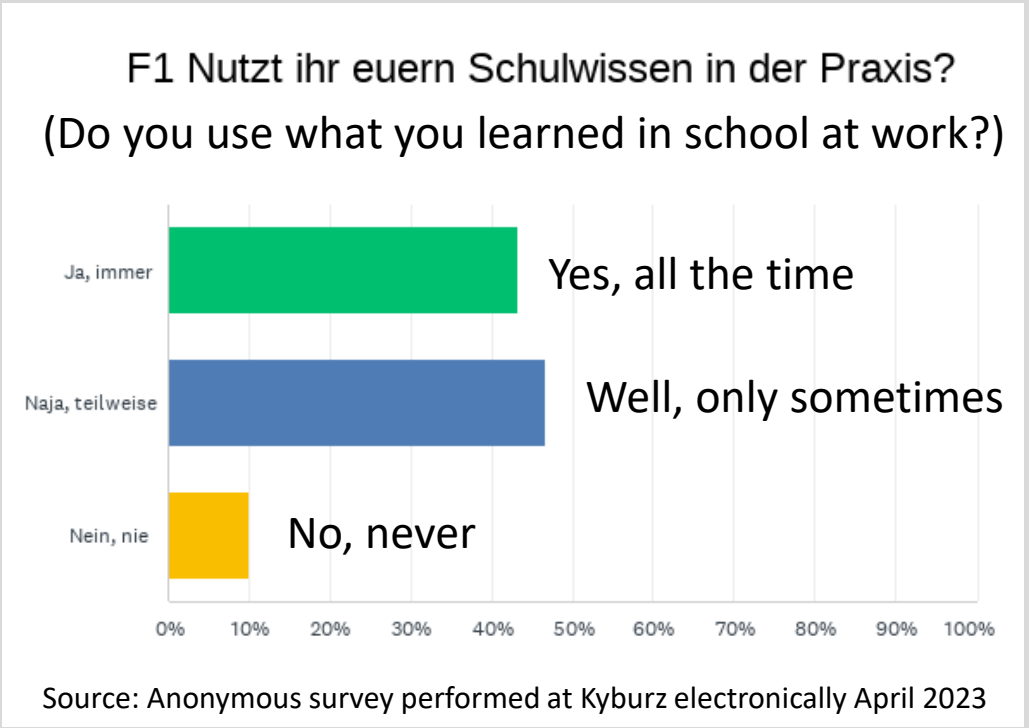
Main theses

1. **Innovation happens when necessary…**
   but there are some ways to encourage it

2. **Collecting and evaluating data helps …**
   but not without a set of strong hypotheses

I don’t use anything I learned in University



Source: Anonymous survey performed at Kyburz electronically April 2023

Physik - Mathe - Schätzungen - Mechanik - Elektronik - Sicher habe ich sehr viel nach meiner schulischen Ausbildung gelernt. Trotzdem sind einige grundlagen hängen geblieben. Am Wichtigsten an der Schule ist es, zu lernen selbständig zu denken und selbständig zu lernen.

Physics - Maths - Estimates - Mechanics – Electronics. I certainly learned a lot after my school education. Nevertheless, some basics stuck. The most important thing at school is to learn to think and learn independently.

What are our mobility innovations?

eTrolley 7+1

ePedelec

Self-stable, electric braking, front box

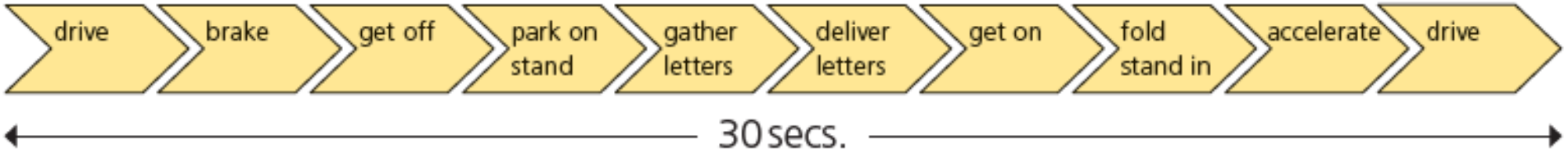
DXP

DXC

Until 2011

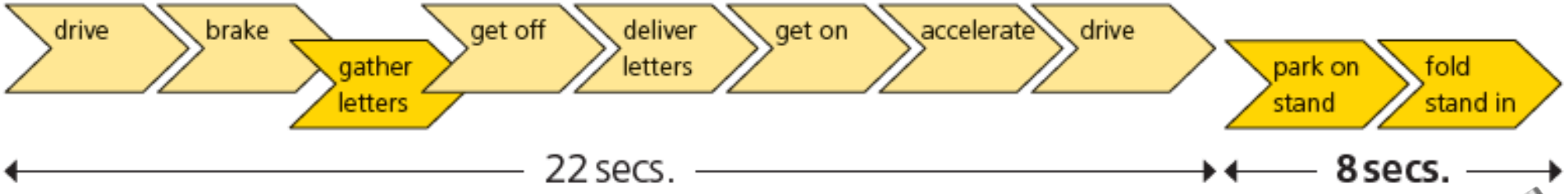
Why were our innovations successful?

Process chain: Delivering post on a moped

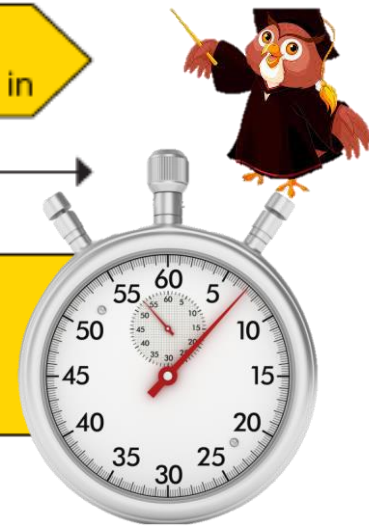


Process chain: Delivering post on a KYBURZ DXP

Time saving

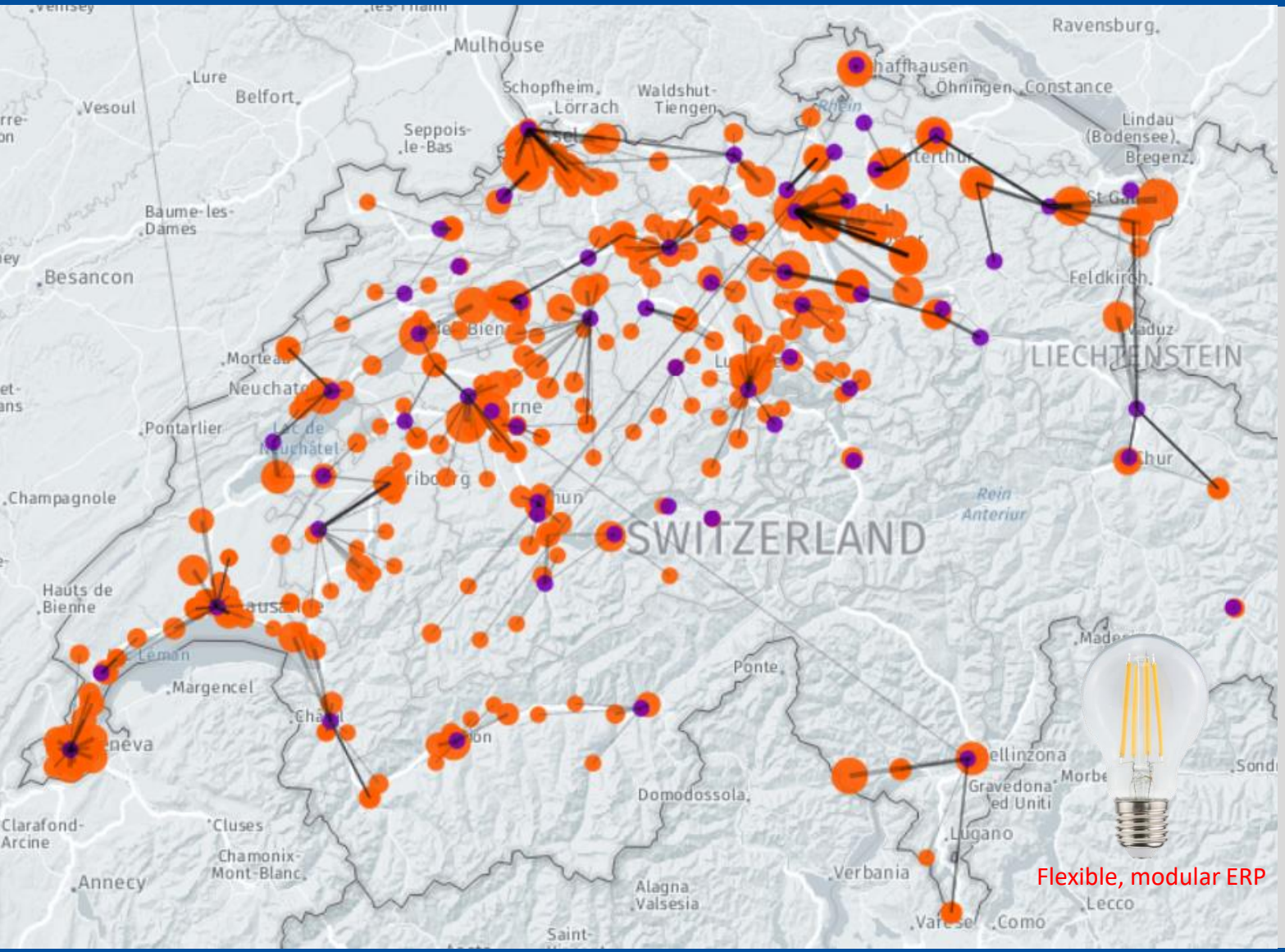


1 postal worker saves on every out-of-town run:	45 min. → 200 hours per year
1 postal worker saves on urban run:	36 min. → 160 hours per year



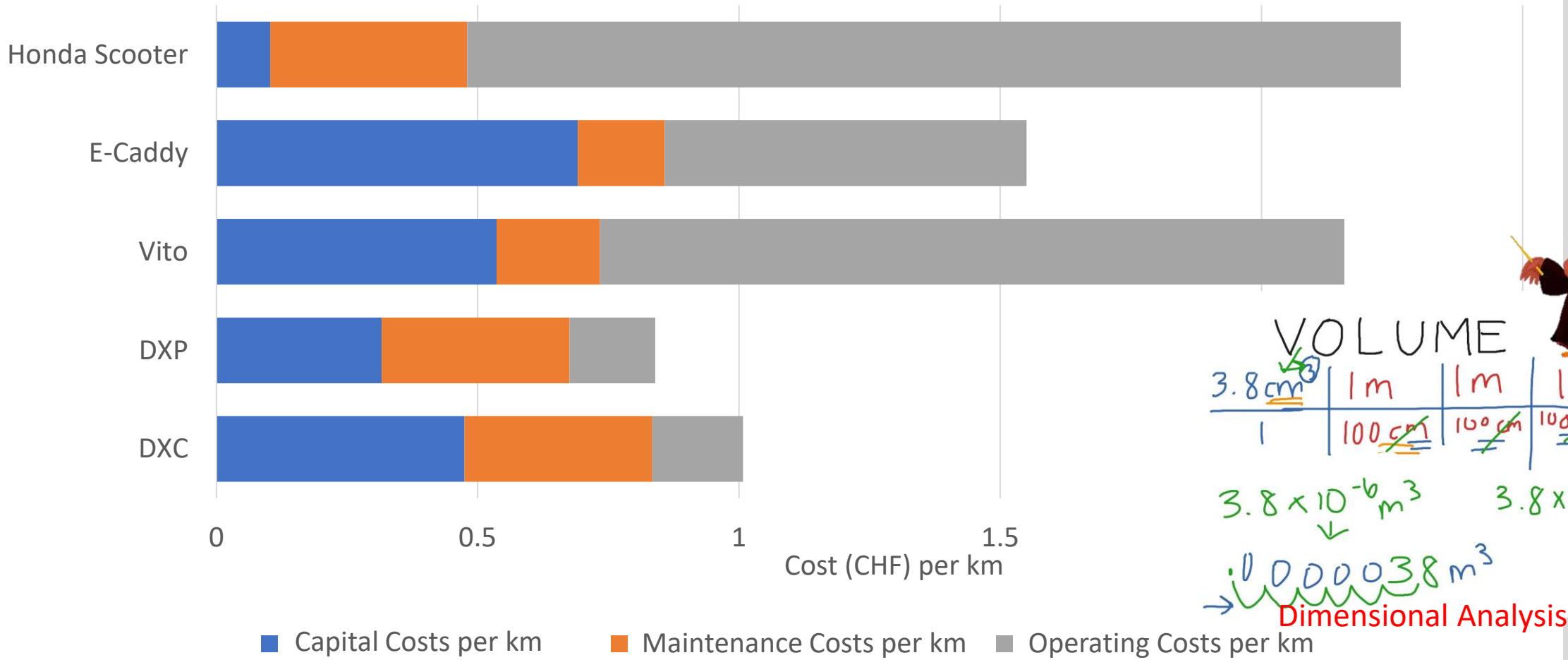
Operations research

Kyburz Switzerland: Datasets



1. Telematics
   1. 500 DXP vehicles CH
   2. 3000 vehicles AUS
   3. 2000 other vehicles worldwide
2. In-house developed ERP / CRM ‘Pachi’
   1. >60,000 CRM entries
   2. >2M Service cases
3. Audio feeds
   1. ~1 year SPL measurements
4. Automated test benches
   1. ~2.5 years of operation
5. Automated vehicles
   1. Too many to name

How does the total cost of ownership compare?

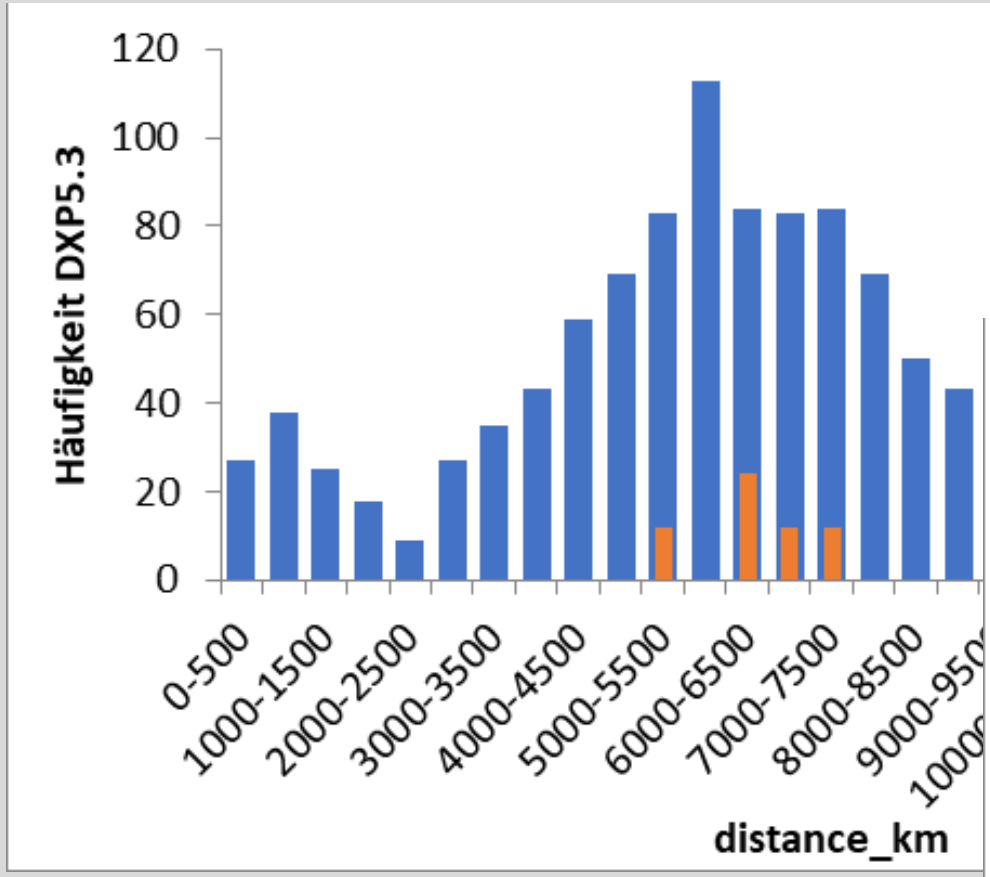


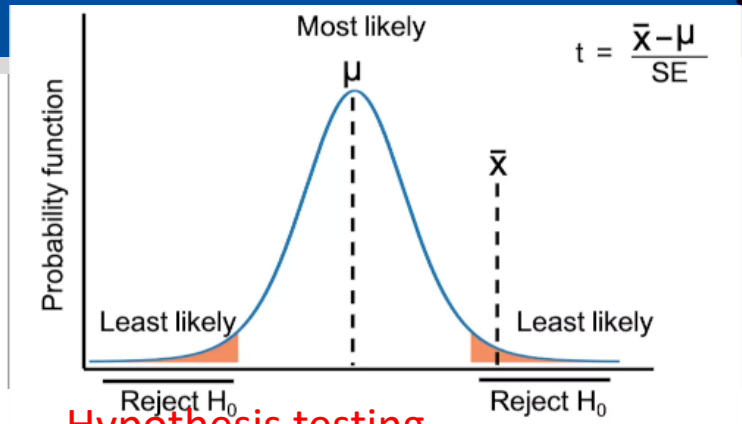
Dimensional Analysis

DXP has the lowest TCO. Combustion vehicles are cheap to buy, but expensive to operate!

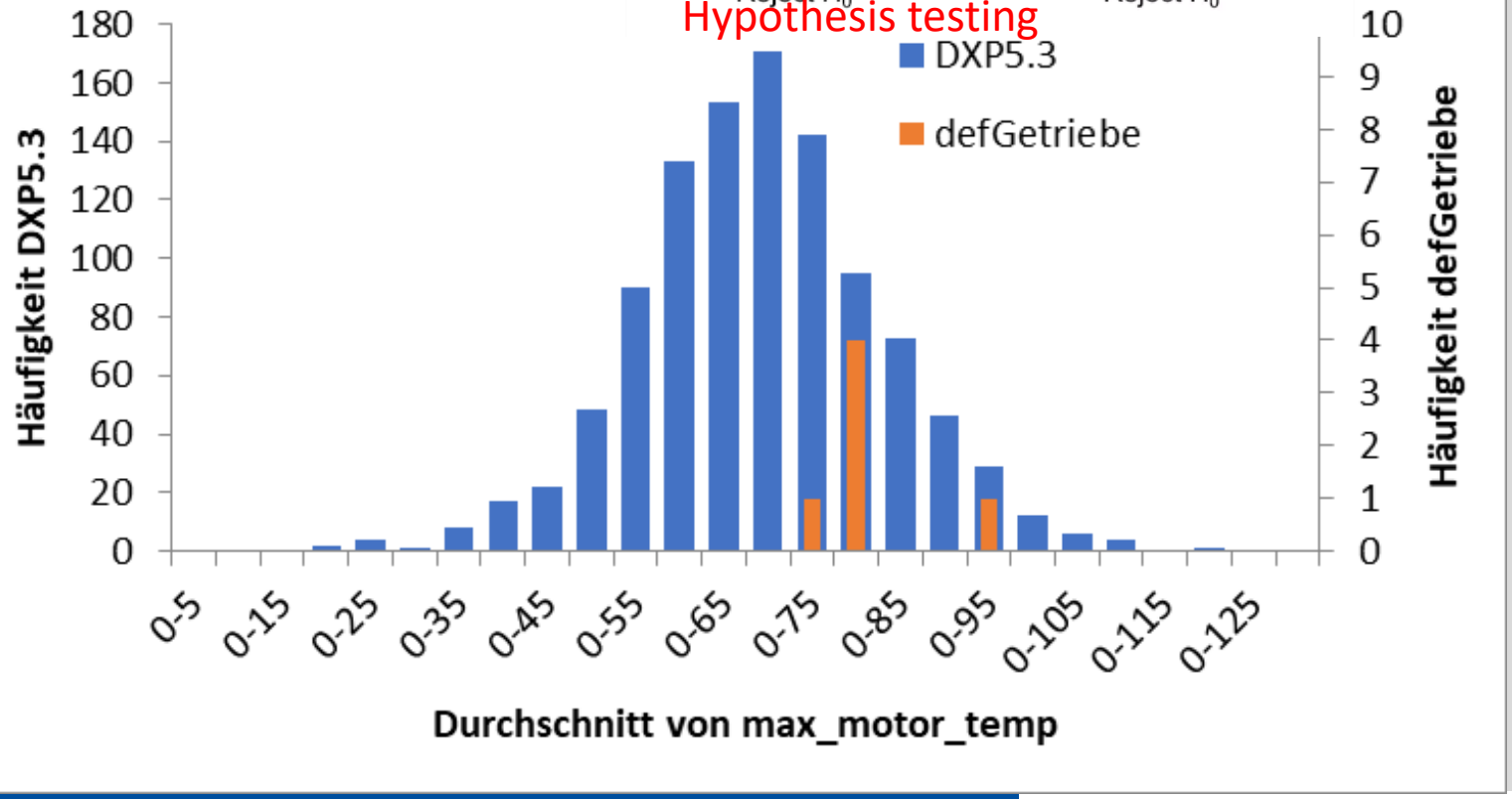
Assumptions: 25 km per day, 236 days of use per year, 5 years of use, petrol price 1.91 CHF, electricity price 0.21 CHF/kWh, no battery replacement

What happened when something breaks?



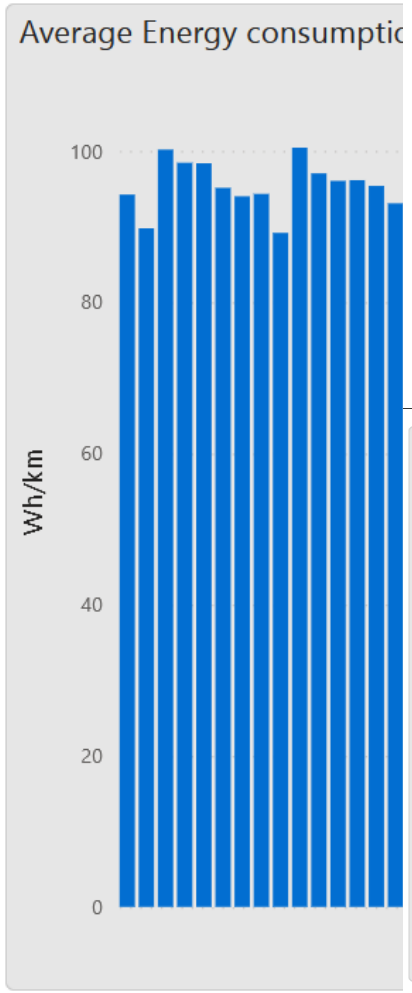


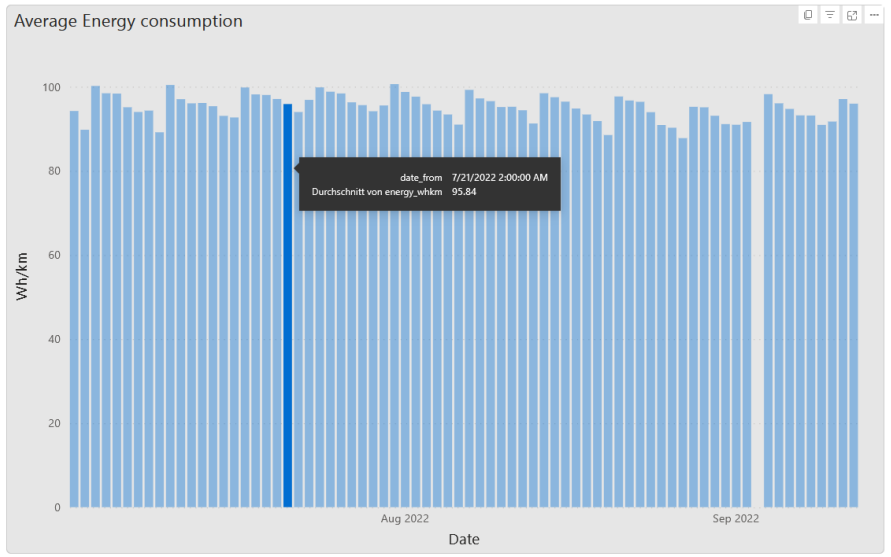
Hypothesis testing



How efficient are our vehicles?

KYBURZ FLEET MANAGEMENT | DXP Dai





Ø Energy Wh/km
40.00 200.00

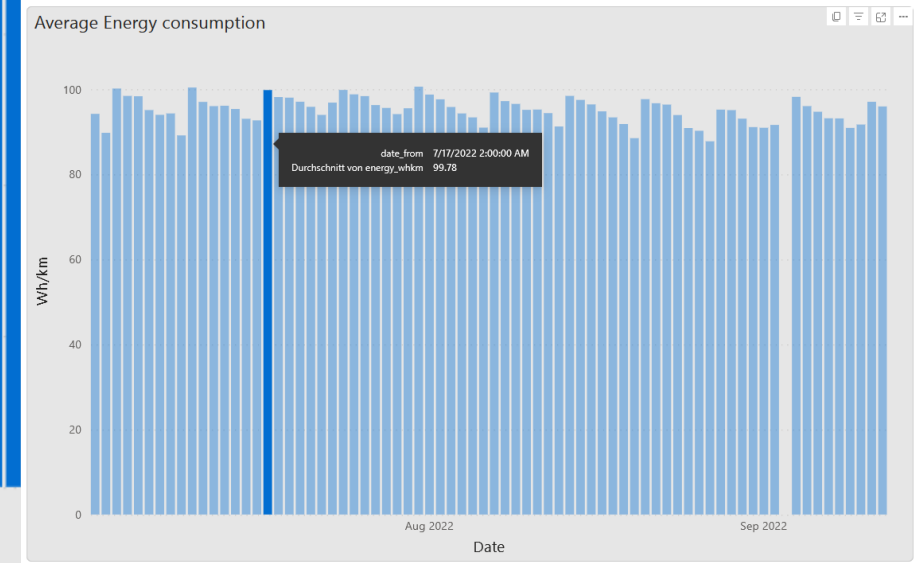
Kilometers driven by all selected Vehicles
70,154 km

Average Energy consumption for all selected Vehicles
96 wh/km

Average max. Range for all sected Vehicles
60.1 km

Minimum accepted SOC value
20 %

Average max. range up to min. SOC for all selected vehicles
48.1 km



Ø Energy Wh/km
40.00 200.00

Kilometers driven by all selected Vehicles
5,965 km

Average Energy consumption for all selected Vehicles
100 wh/km

Average max. Range for all sected Vehicles
57.7 km

Minimum accepted SOC value
20 %

Average max. range up to min. SOC for all selected vehicles
46.2 km

VCL Version
Alle

Mean calculation

Kilometers driven by all selected Vehicles
3.578.096 km

Average Energy consumption for all selected Vehicles
95 wh/km

Average max. Range for all sected Vehicles
60.4 km

Minimum accepted SOC value
20 %

Average max. range up to min. SOC for all selected vehicles
48.3 km

Direct recycling with no
Pyrometallurgical processes

1stLife

2ndLife

3rdLife

4thLife

1stLife

2ndLife

3rdLife

4thLife

1stLife 2ndLife 3rdLife 4thLife

1stLife 2ndLife 3rdLife 4thLife

1stLife

2ndLife

3rdLife

4thLife

4thLife

Rebuilt cells using recycled materials

400 g separator

8 cells per vehicle

4'640 g plastic

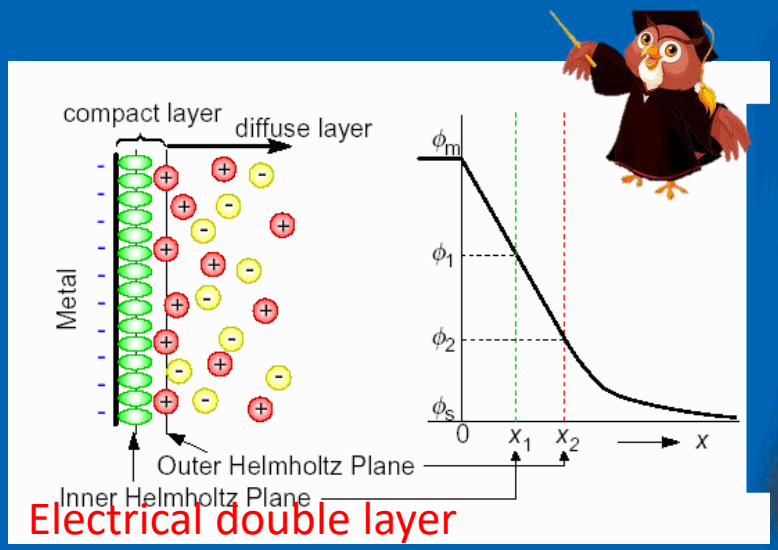
4'752 g graphite

8'184 g Li-iron phosphate

3’168 g copper

2’112 g aluminium

4thLife



Electrical double layer

8 cells per vehicle

23'256 g raw material

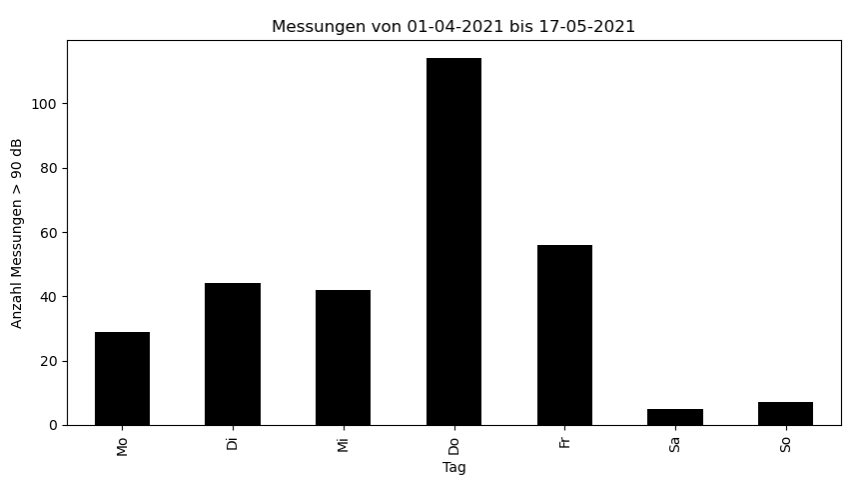
3'168 g copper
2'112 g aluminium
4'752 g graphite
8'184 g Li-ironphosphate
400 g separator
4'640 g plastic

91 % recovery rate

How can we get even better?

- In 2022 2.5% sales were 2ndLife (almost break-even)
- Grey energy 50% saved, through 21t material re-use
- Batteries:
  - 30% back in vehicles (2ndLife)
  - 65% into home energy storage (3rdLife)
  - 5% recycled (4thLife)
- Constantly finding new 2nd and 3rd life applications
- Expanding 4thLife with new processes

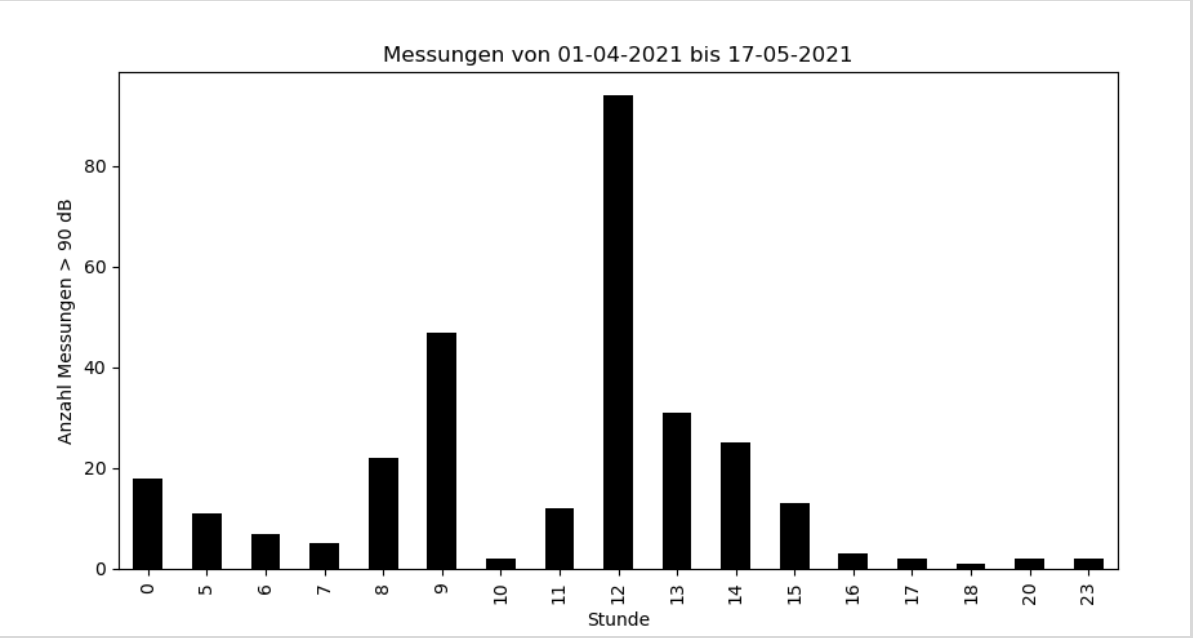
How loud are we in our neighbourhood?

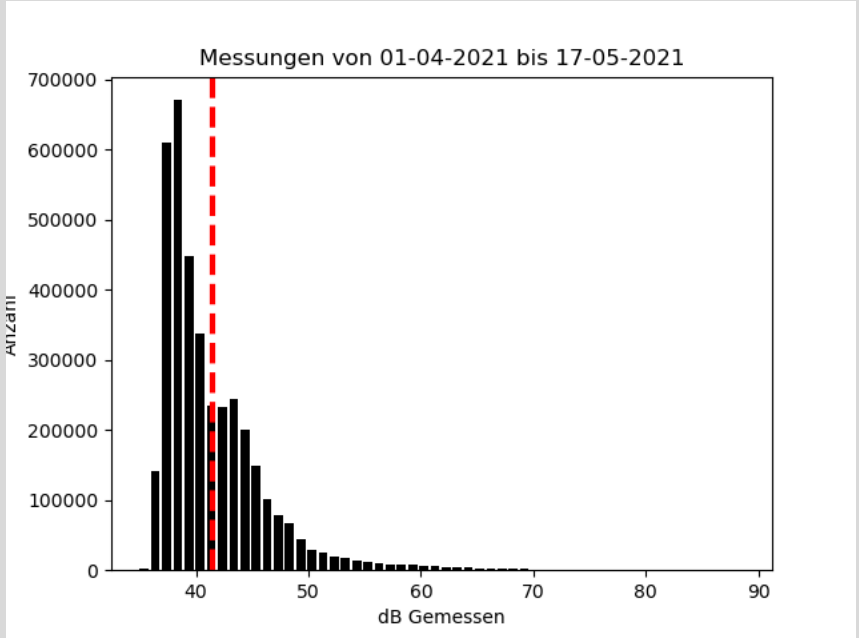


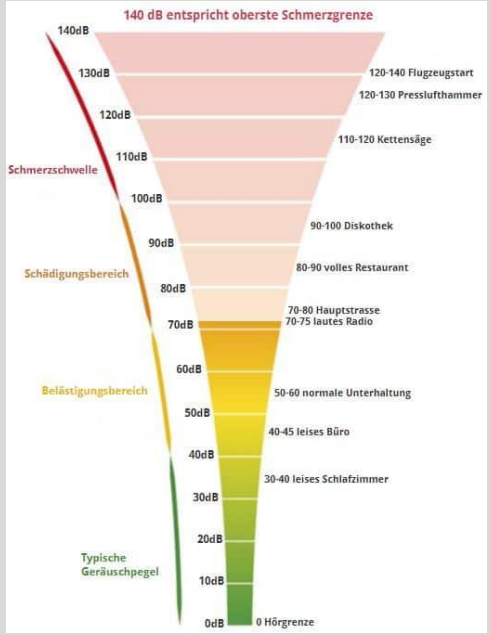
From 01.04.2021 until 17.05.2021
Measurements taken: 3,757,796
Measurements > 90 db: 299 (0.0079 %)
Average SPL: 41 dB

Use data for constructive disagreement resolution

Quelle: https://www.messwerttechnik.de/rat-und-tat/dezibel-tabelle/







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What can we learn about our products?

$$v_f = v_i + at \qquad \text{no } \Delta x$$

$$\Delta x = v_i t + \tfrac{1}{2} a t^2 \qquad \text{no } v_f$$

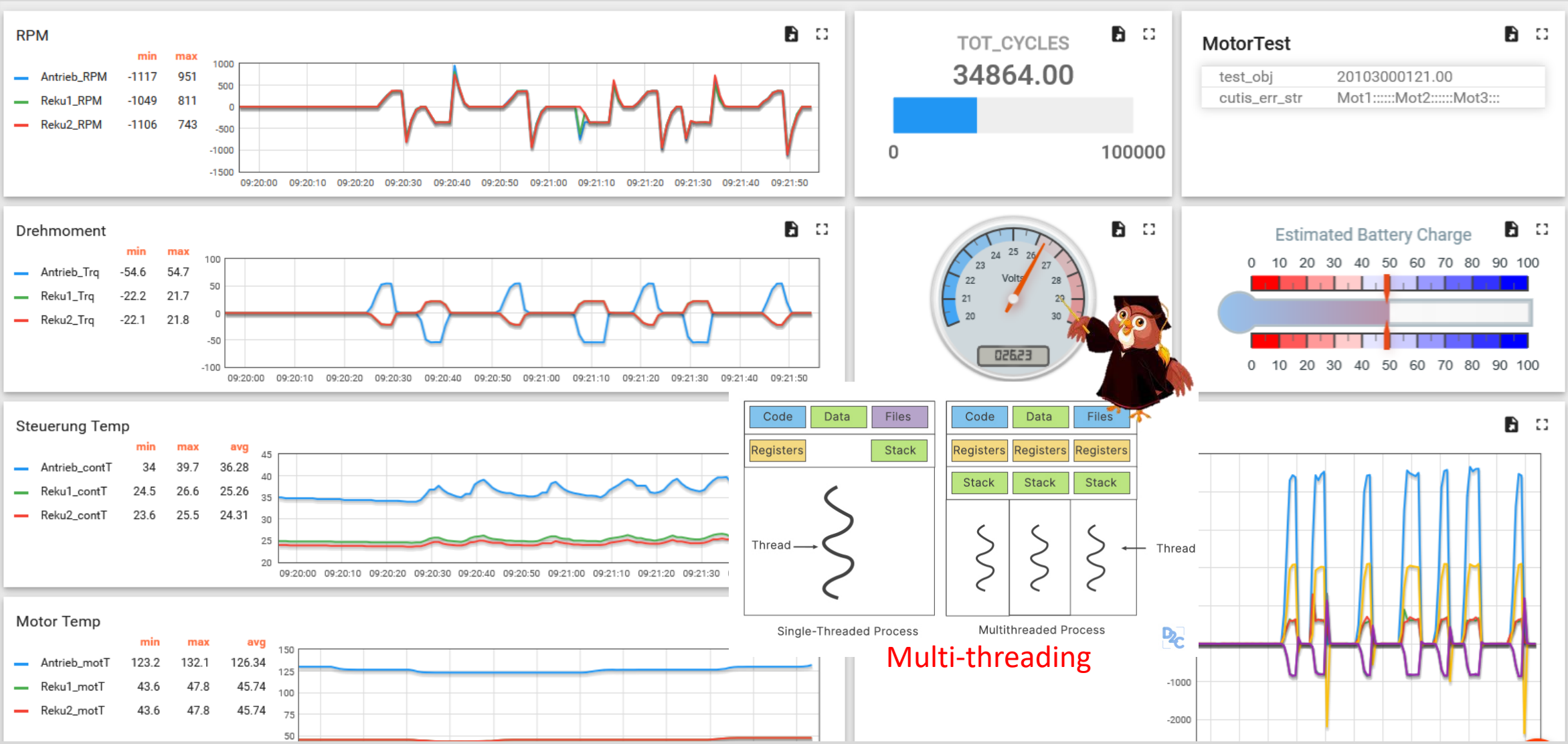
$$v_f^2 = v_i^2 + 2a\Delta x \qquad \text{no } t$$

$$\Delta x = \bar{v}t = \tfrac{1}{2}\left(v_i + v_f\right)t \qquad \text{no } a$$

$$\Delta x = v_f t - \tfrac{1}{2} a t^2 \qquad \text{no } v_i$$

Kinematics equations

What can we learn about our products?



Kyburz Autonomous Delivery vehicles

Mobile depot box (eT1 / eT2)

Next big thing…

Autonomous delivery agent (eT3)

Actuated castor wheel carriers for hill climbing

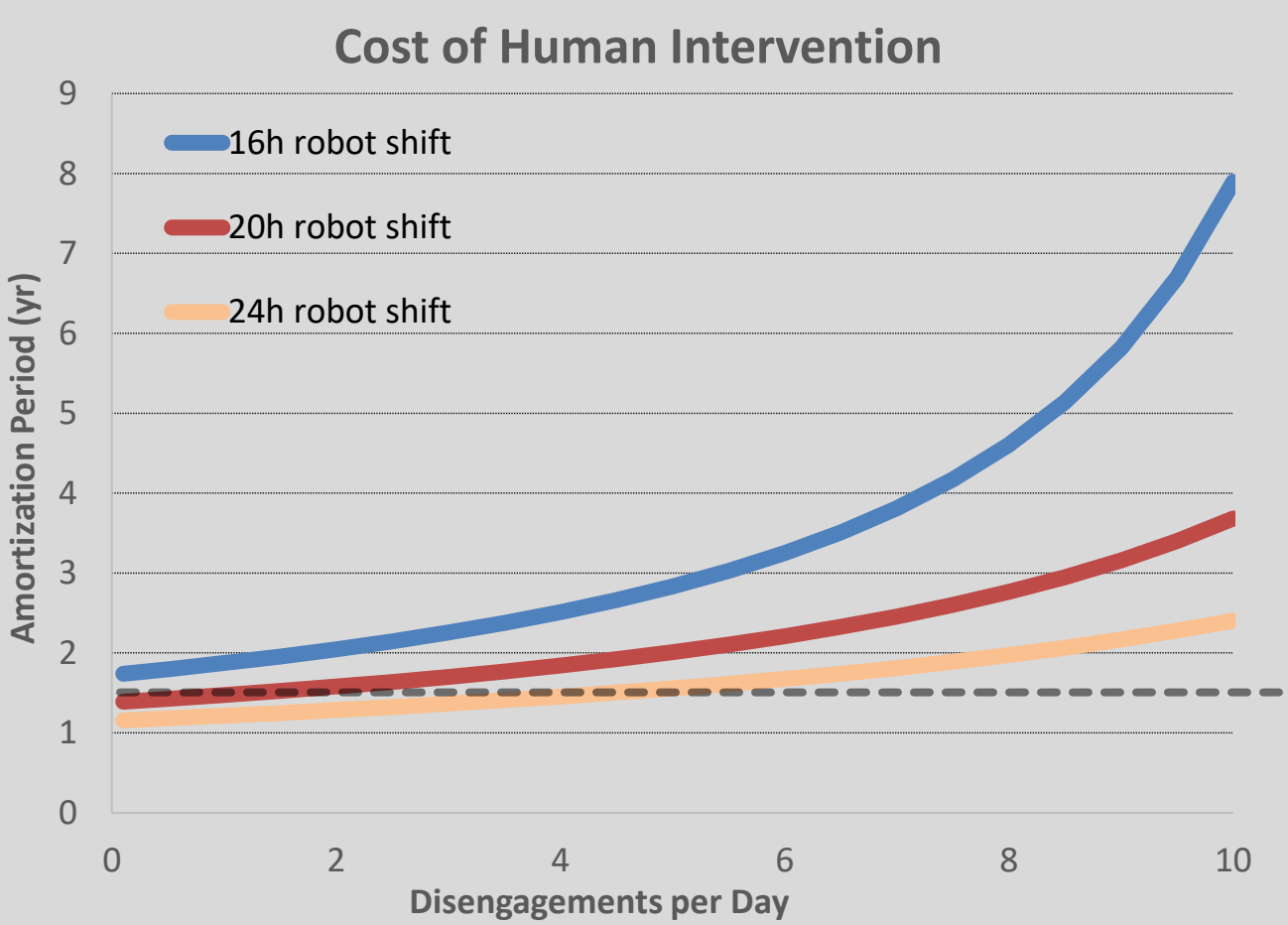
Flexible delivery system (eT4)

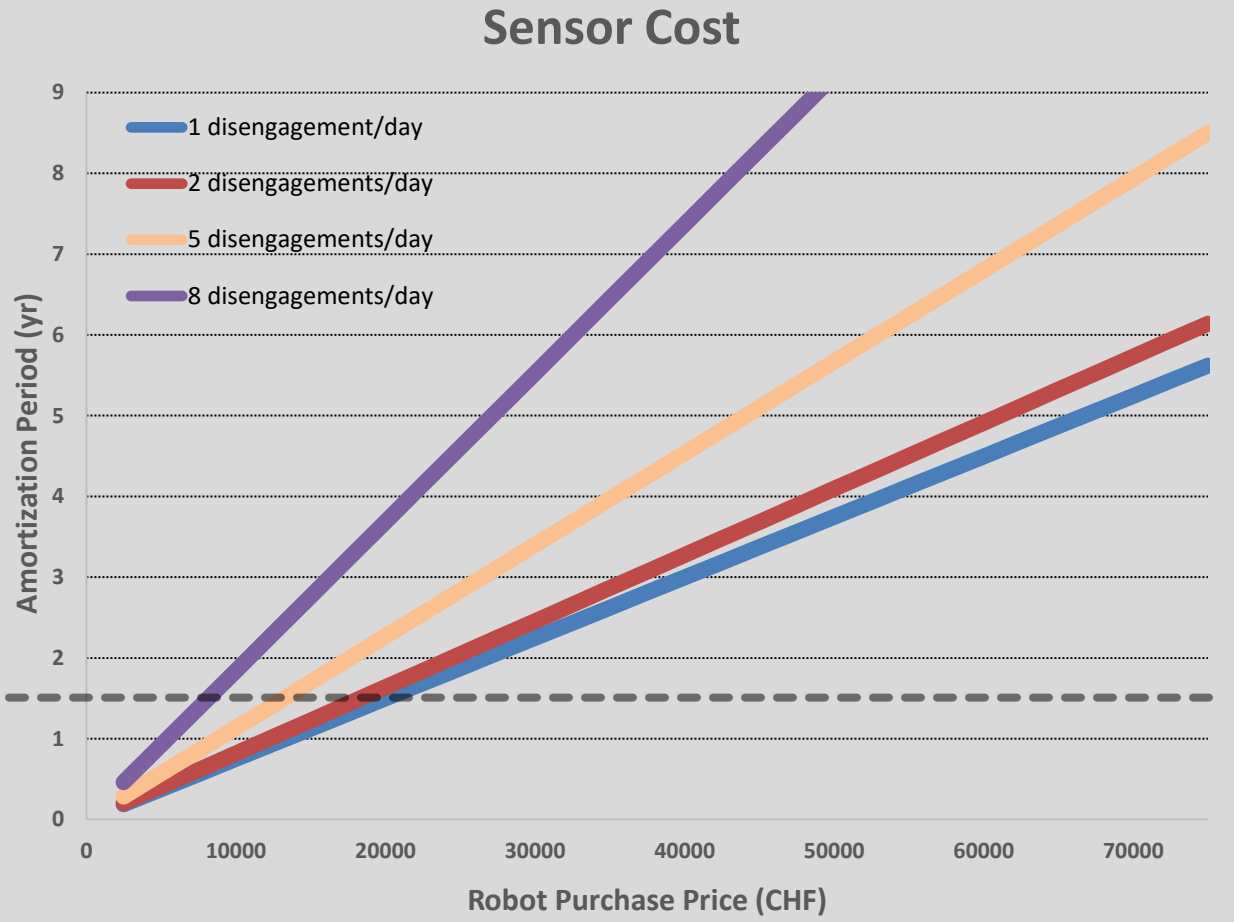
Driver assistance (Plus2)

How do we spare people from boring tasks?

- Built to perform BAD missions:
  - **B**oring: *no one wants to drive the routes*
  - **A**like: *missions are highly similar and repetitive*
  - **D**eterministic: *few dynamic elements in the scenario*
- With characteristics which make them:
  - Available: *few human interactions, quick charging*
  - Safe: *absent of unacceptable risk, foreseeable misuse*
  - Secure: *free of preventable defects and vulnerabilities*

Economics of Autonomous Transportation





Robots should be operated for long shifts without disengagement, quick charging, with cheap sensors

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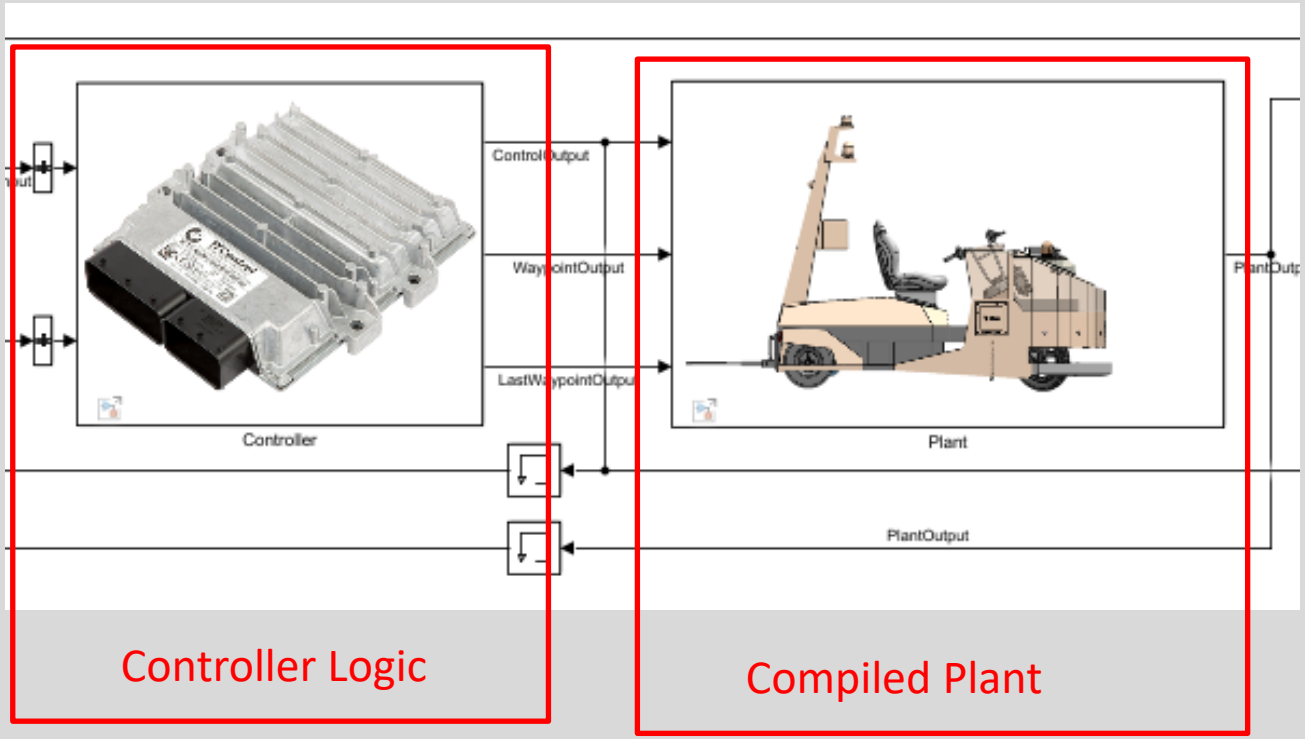
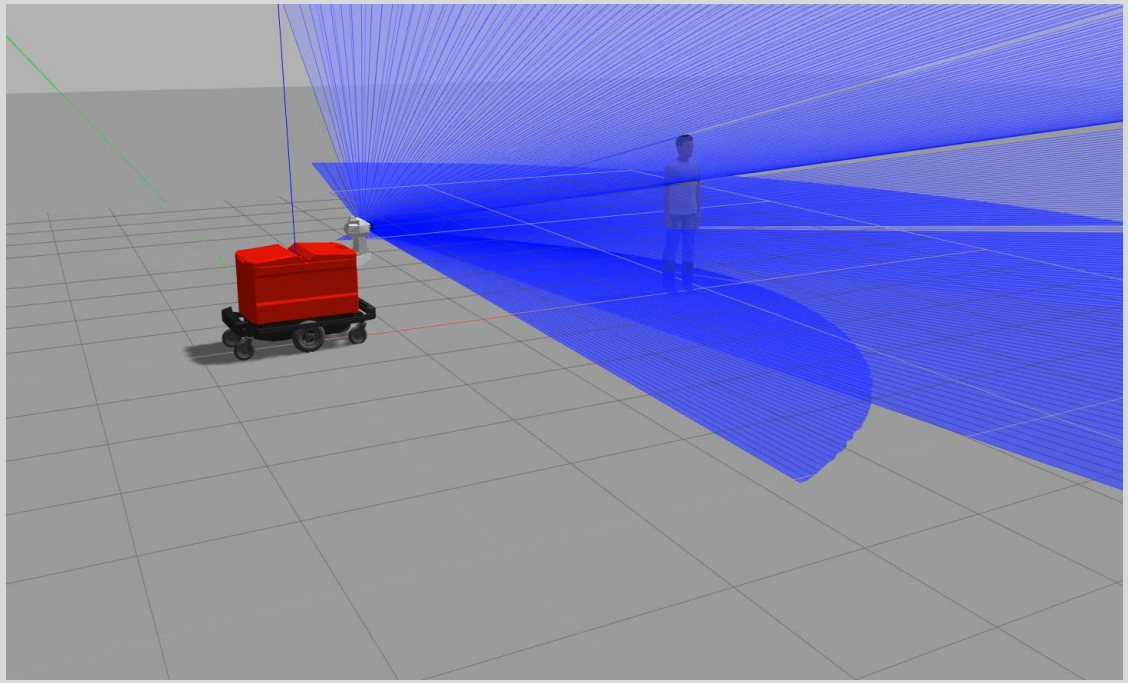
Redundancy of sensor systems

Localization	Day	Night	Precipitation	Fog	Tall structures	Tranparent obstacles	Diffuse obstacles
INS (GPS)	✓	✓	✓	✓	!		
Optical	✓	✗	✗	!	✓		
Pointcloud	✓	✓	!	✗	✓	-	-
Obstacle Avoidance							
LiDAR	✓	✓	!	✗	-	✗	!
Optical	✓	✗	✗	!	-	✓	✓
Radar	✓	✓	!	✓	-	✓	✓
Ultrasonic	✓	✓	✓	✓	-	✓	!
Time-of-Flight	!	✓	!	✗	-	!	✗
Infrared	✗	✓	!	✗	-	✗	✗
Bump Stop	✓	✓	✓	✓	-	✓	✓

Simulation and Model-based Design





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What did we cover in the last 20 min?

- Kyburz applies what we have learned in University
- We try to innovate where necessary, apply what exists where possible
- Our innovations in a niche positively impact our society and environment
- We have fun at work!


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