Smart Transportation Alliance

2020 Annual Conference
& Innovation Awards

Electrified L-Category Vehicles Integrated into Transport and Electricity Networks (ELVITEN):

Lessons learned for a post-COVID mobility

José F. Papí
Etelätär Innovation CEO – STA President

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Comparison with other projects

Article	Vehicle type	Number of vehicles	Duration	Number of trips	Number of users	Implementation	Survey
ELVITEN	4 types of ELV-s and EVs	225	1 year	38,866	607	New vehicles	A priori and per trip
Madrid	e-bikes	1,560	1 month	230,238	-	City bike sharing	No
eMotion	Small EVs	357	4 months	65,000	357	EV users	A priori
Netherlands	e-bikes	742	-	17,626	742	e-Bike users	A priori
Shanghai	e-bikes	-	-	-	470	Questionnaires	User data and trips
Milan	e-bikes	1,150	-	500	-	City bike sharing	No
Nagpur	Rickshaws and EV	-	1 year	350,000	350,000	Taxi service	No

- ELVITEN data analysis is unique because it has involved personal mobility for **four different types** of EL-Vs and private electric vehicles ('regular' EVs)
- The project has also analysed a large number of trip data: **38,866 trips** with detailed info about
  - Origin and destination
  - Date and time
  - Distance travelled
  - Trip purpose
  - User age, gender, type of user

Methodology

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General structure

- Black Boxes provided telemetry data (position, speed, state of charge…)
- ICT tools provided booking & trip purpose information
- Questionnaires including background information

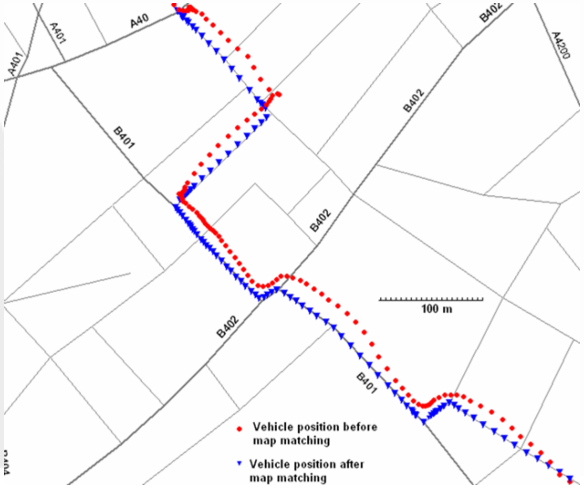
1.5Gb of data collected, with 220 million telemetry values.

Data from different sources had to be:

- Integrated and combined
- Filtered
- Map-matched

Elviten Data Sources
Kyburz / ICCS / Duferco

- Qualitative Data
  - Data Frequency
    - Response categories
- Quantitative Data
  - Data Normalisation
    - IQR/ Z-Scores



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Methodology

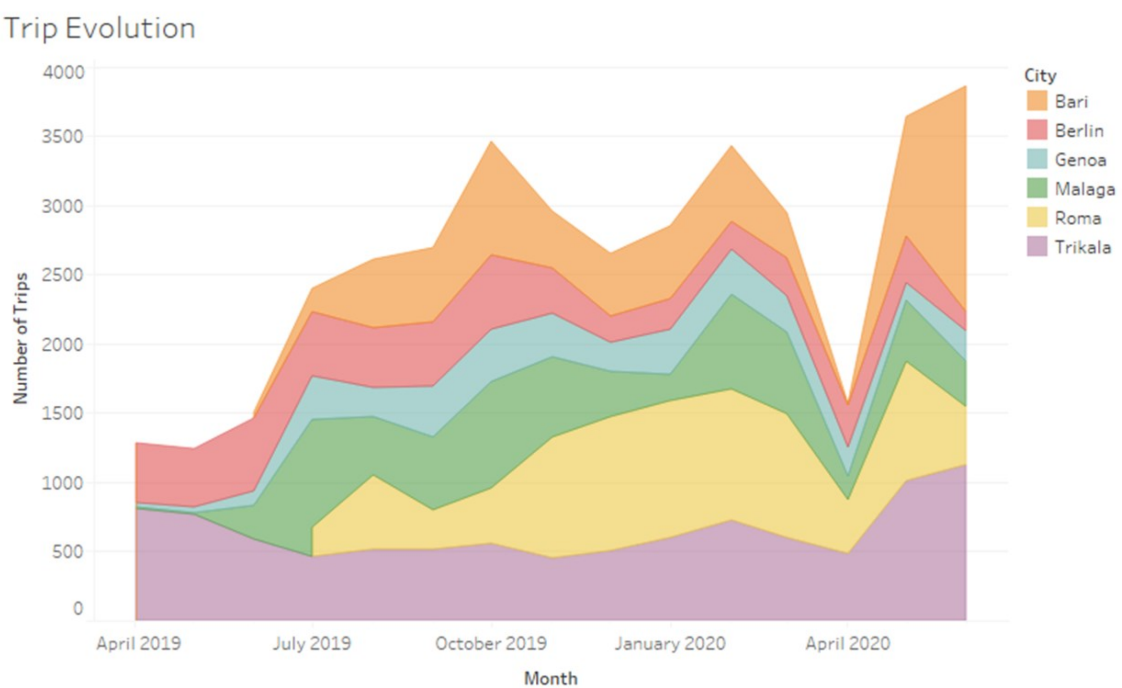
Data analysis tools

The large quantity of data collected during the ELVITEN demonstrations required a potent tool to visualise, filter and analyse the trip information

- The **Tableau** interactive data visualization software was chosen.
- Additionally **Python** was used, to extract additional information from the raw black box data.

Trip Evolution

Summary of key data analysed



- **607 active users**
- **38,866 trips** analysed
- **54.86 trips/user in average**
- **84.67 trips/day average**
- In total, **117,928 Km** were travelled by the EL-Vs used in the ELVITEN demonstrations
- Main KPIs have remain stable with very little variations along the pilot demonstrations

Trip Evolution

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Trip evolution by city: Pre- and post-COVID

City	Average Trips/Month (Pilot start – Feb 2020)	COVID-19 PERIOD Trips in March 2020	Trips in April 2020	Trips in May 2020	Trips in June 2020
Bari	326	269	10	870	1,628
Berlin	328	277	293	331	136
Genoa	218	260	214	128	224
Malaga	377	578	165	417	320
Rome	571	764	318	834	425
Trikala	511	593	454	980	1,123
Total	**2,229**	**2,741**	**1,454**	**3,560**	**3,856**

Trip Evolution

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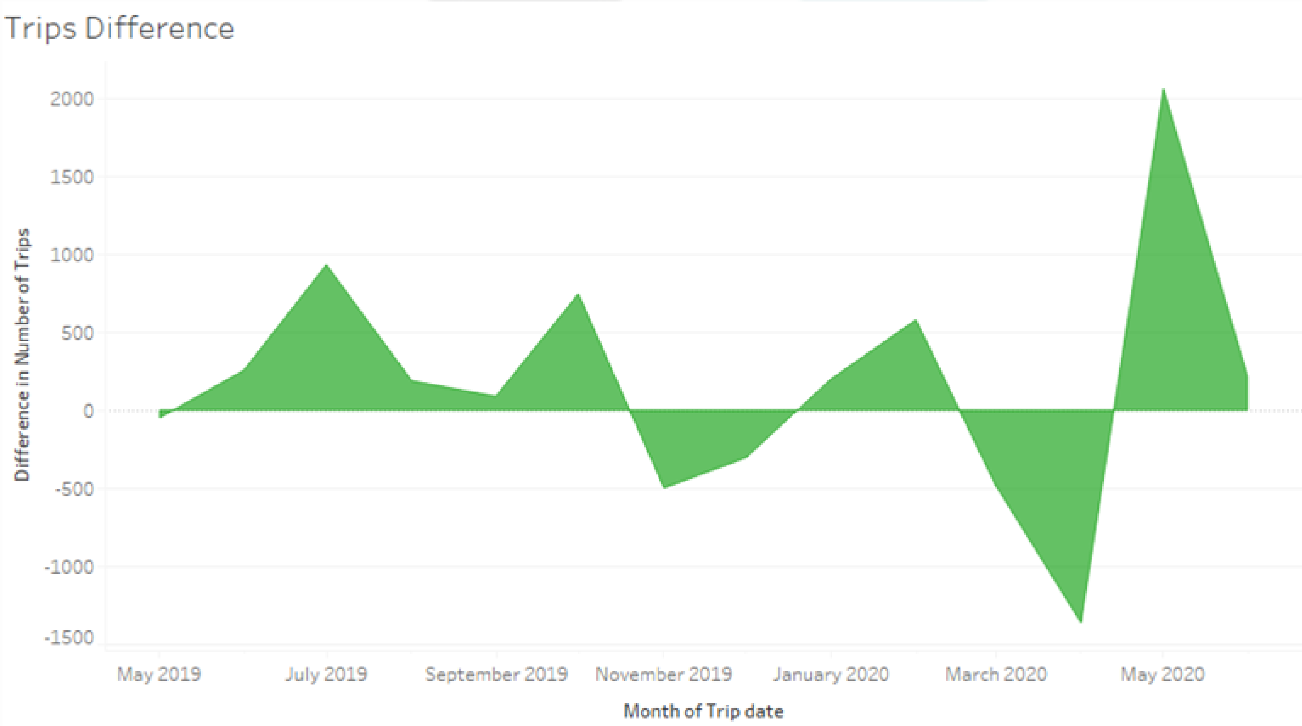
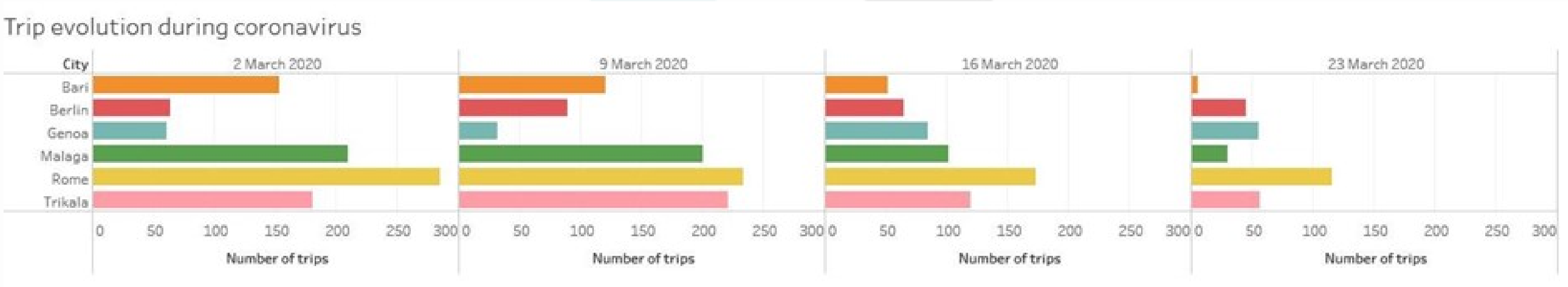
Number of trips of difference compared to previous month



Trip Evolution

Trip decrease by week during March 2020

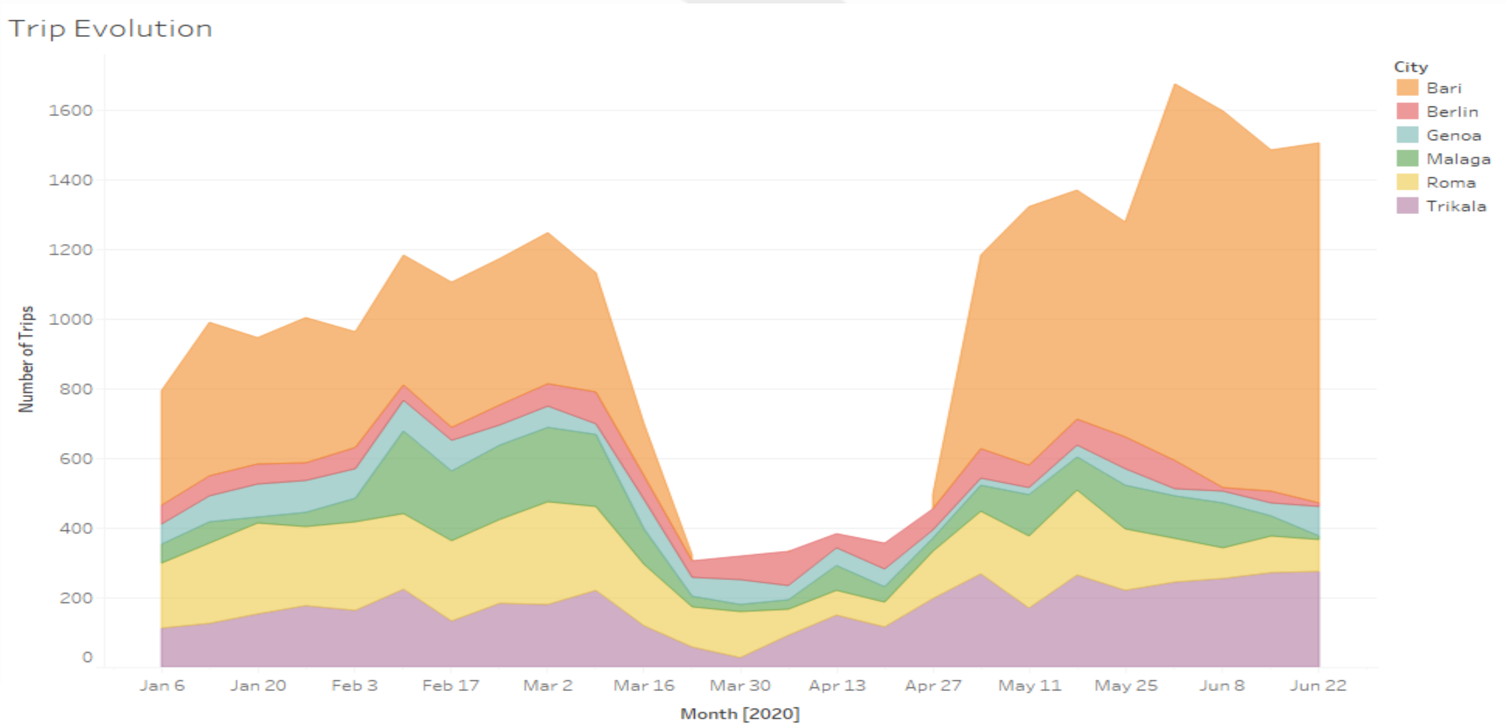
During March 2020, the decrease in the number of trips was closely observed. In the table and figure below, it is shown the number of trips recorded in every week in the demonstration cities



Trip Evolution

Number of trips per week

Number of trips decreased during March, However, once restrictions began to lift in May, demand increased to surpass the average pre-COVID-19 scenario in more than 800 trips per month. This number even increased in June



Trip Evolution

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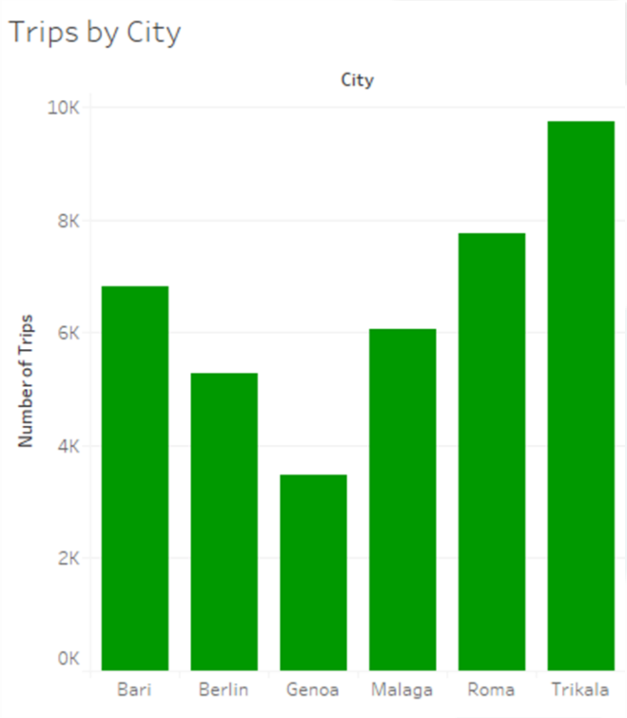
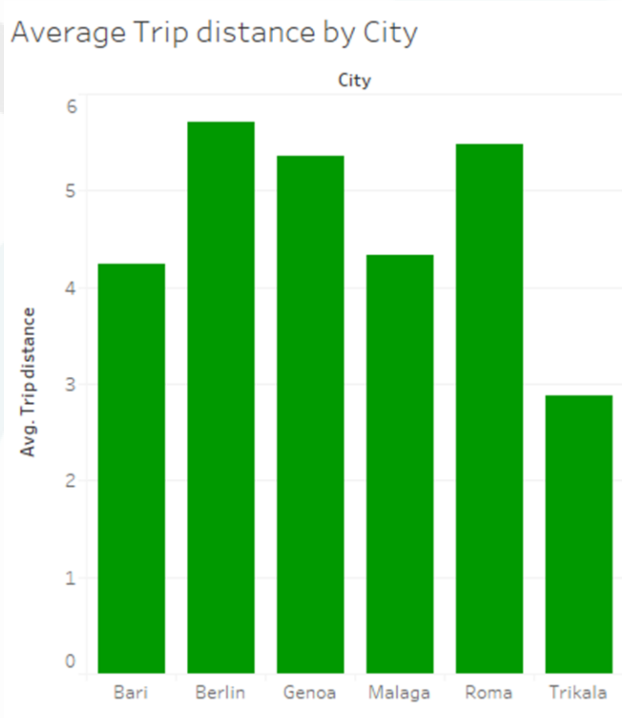
Trip evolution by city: Average trips distance





- Average trip distance is above **4 km**
- The number of trips recorded, and the average distance each city is different, due to:

i) different use cases and

ii) type and total number of vehicles

Data Evolution in relation to number of trips

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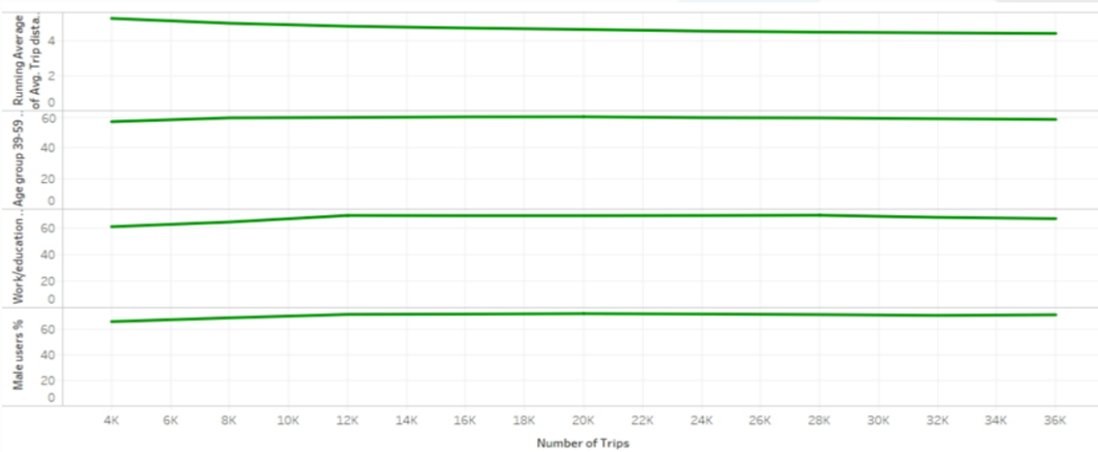
KPI monitoring

Period	Number of trips	Number of users	Average distance	Work/ education trips %	Male users %	Age group 30-59 %
Start Project – February 2020	26,798	532	4.49	67.04	80.87	72
March – April 2020	4,435	161	3.75	50.18	87.57	69



5 key KPIs were monitored during the project:

- Number of trips
- Number of users
- Percentage of Work/Education in total trips
- Percentage of Male users in total trips
- Percentage of Age group 30-59 in total trips

Increase in the number of trips did not bring any major change to KPIs or the key conclusions of the analysis

EL-V Category Analysis

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Daily trips and distance

A relatively high number of daily trips per user was observed (4.75 trips per user and day)

Vehicle type / Vehicle code-name				
EL-V				Electric Car
L1e-A	L1e-B	L5e-A	L6e-B	E-V
5.04	2.76	8.22	3.25	3.72

The average daily trip distance per vehicle is 18.87 Km. By EL-V type, differences can be observed.

Vehicle type / Vehicle code-name	EL-V				Electric Car
	L1e-A	L1e-B	L5e-A	L6e-B	E-V
Daily distance travelled (Km)	20.37	16.37	16.5	17.42	15.67

EL-V Category Analysis

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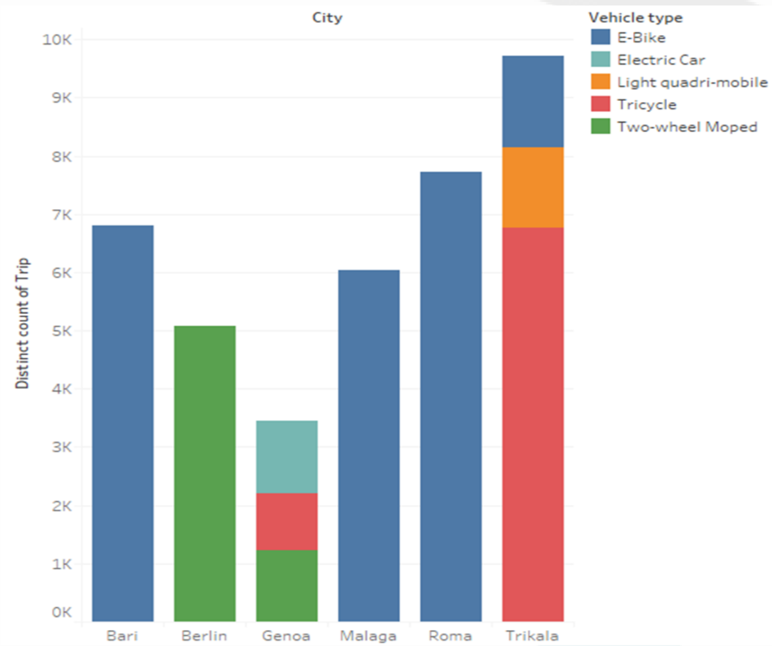
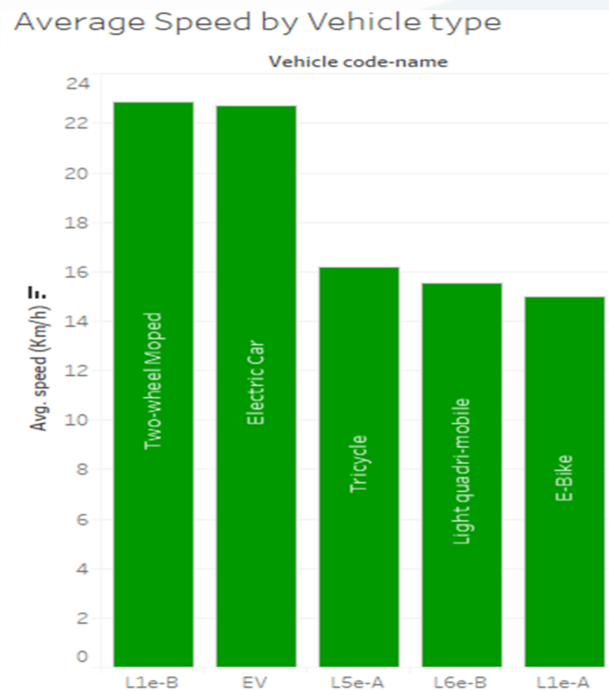
Type of EL-Vs – Trips and average speed





The average daily trip speed per vehicle was **18.87 km/h**, which is relatively high for light vehicles

Real Mobility Needs

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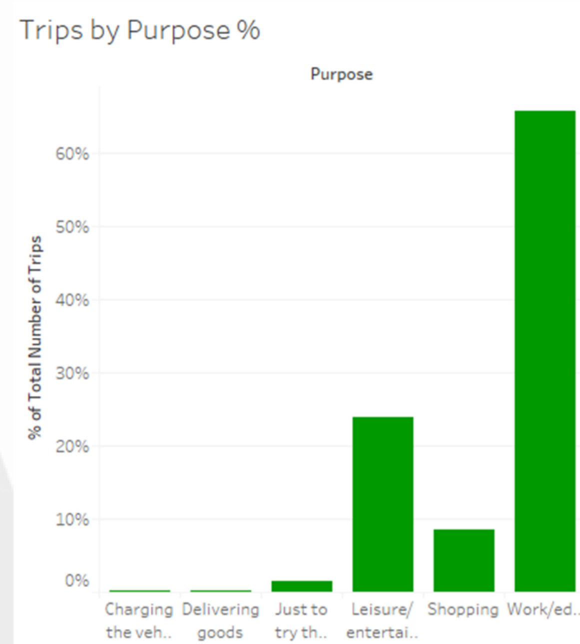
Trips by purpose

Trip Purpose	Total trips %	Av. distance (Km)	Trips Count
Charging the vehicle	0.18%	9.039	13
Delivering goods	0.25%	4.818	20
Just to try the shared EL-V curiosity	1.39%	3.508	107
Leisure/entertainment or visit (family/friends)	24.07%	6.244	1,770
Shopping	8.58%	3.688	634
Work/education	65.54%	4.998	4,891



Real Mobility Needs

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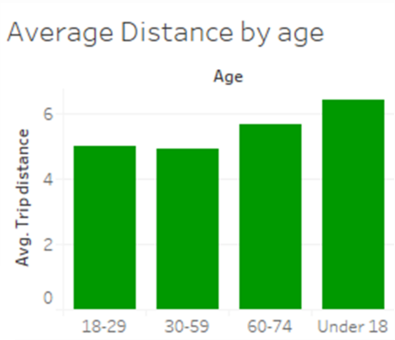
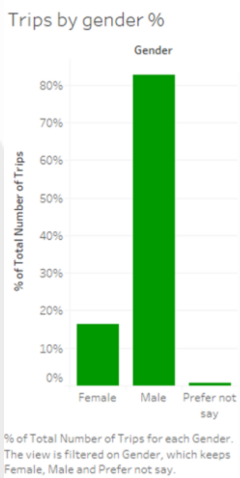
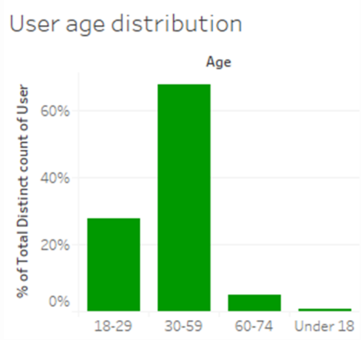
Trips by age, gender and type of user

Age	Trips Distribution	AV. Distance	Count (users)	Count (trips)	Average
Age 18-29	23.58%	4.84	141	6,012	42.6
Age 30-59	71.26%	4.54	347	18,173	52.4
Age 60+	4.96%	4.89	25	1,265	50.6
Under 18	0.20%	2.26	3	51	17.0

User type/Gender	Total trips %	AV. Distance (Km)	User Count	Trips Count	Average
Type User Regular	93.83%	4.93	267	37,312	89.6
Type User Occasional	5.60%	4.95	135	1,739	10.6
Type User Tester	0.57%	9.07	110	175	1.3
Female	16.37%	4.87	165	4,174	25.3
Male	82.78%	4.98	347	21,110	60.8
Prefer not to say	0.85%	3.86	5	219	43.4







- *Regular users*: 20+ trips recorded *and* at least 10 trips in one single month
- *Tester users*: 3 or less trips recorded
- *Occasional users*: those not matching the criteria above

Real Mobility Needs

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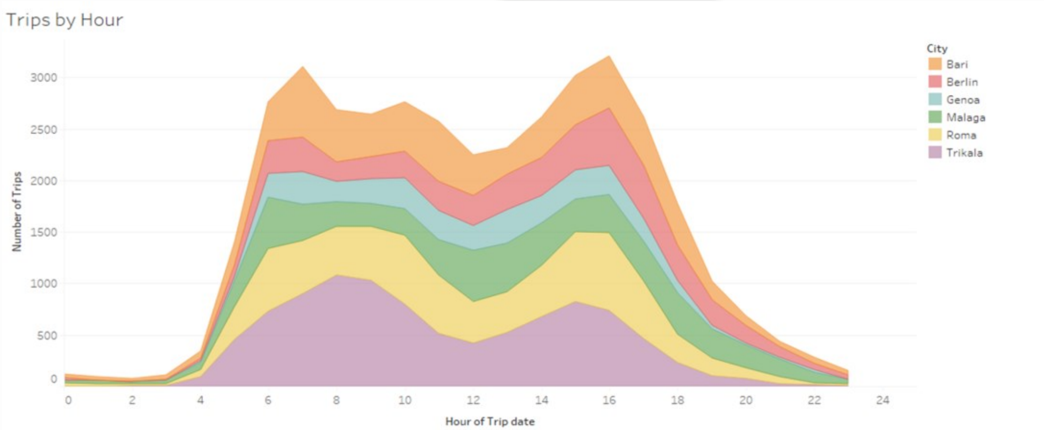
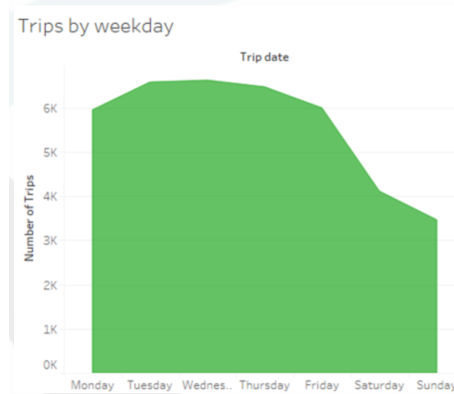
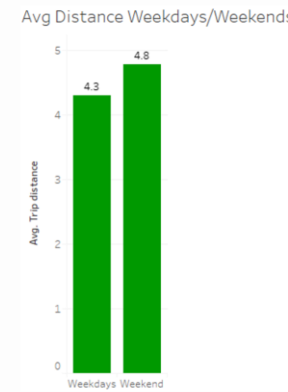
Trips by hour, weekday and average distance



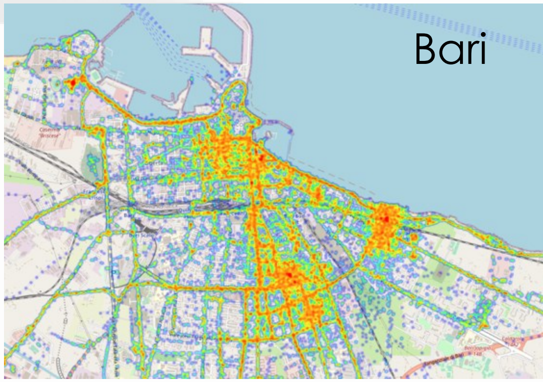


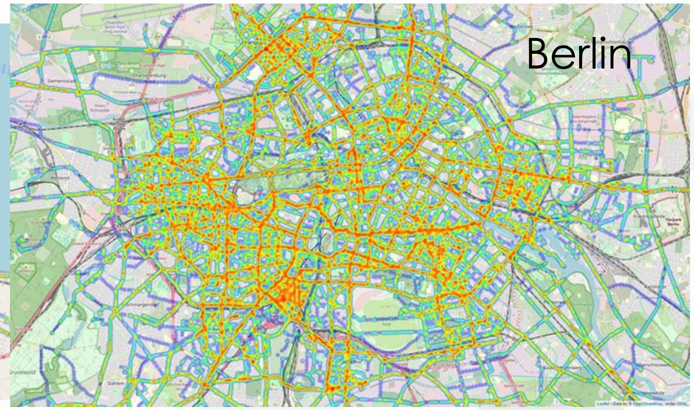


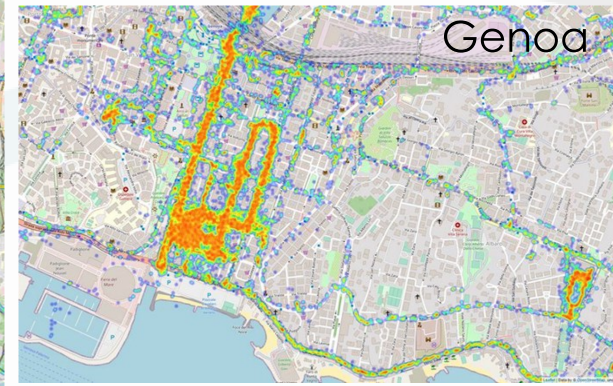
- ✓We can observe that most trips (87.90%) are recorded **between 6 AM and 6 PM**
- ✓In general, the busiest time (28.66%) is in the morning between 6-9 AM (trip start time)
- ✓This information is consistent with the results of the trip purpose questionnaires, since most trips are related to work & education
- ✓Very few trips are recorded in the evenings and during the night. This is also a direct consequence of the use cases chosen for the demonstrations
- ✓Average distance is very similar between weekdays and different hours, being 6% longer in weekends

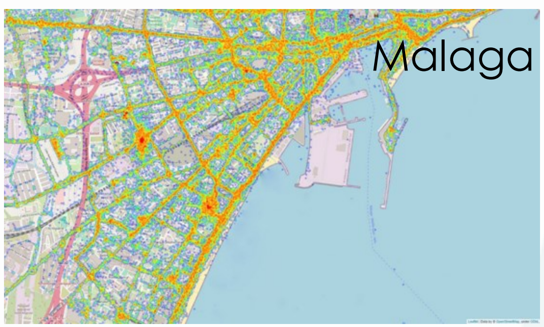
Density Maps

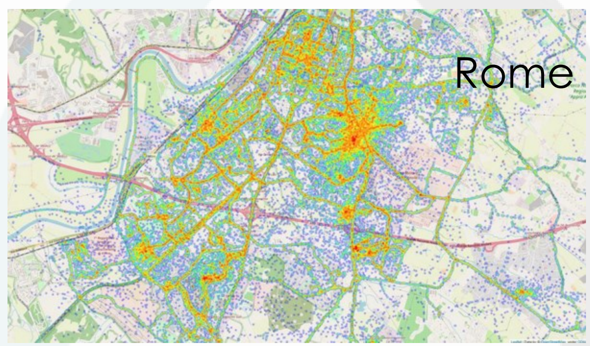
Trip density and patterns











The trip density maps show differences in the driving patters in all city demonstrations. These differences are caused by the different use cases of each demonstration, the types of vehicles used, and the characteristics of each city (topology, climate, traffic conditions). Yet we can observe common patterns for all EL-Vs**. In general, EL-V users prefer main streets, avenues and roads to move around their cities**. This behaviour is different to that observed for cyclists, who tend to prefer less congested secondary streets.

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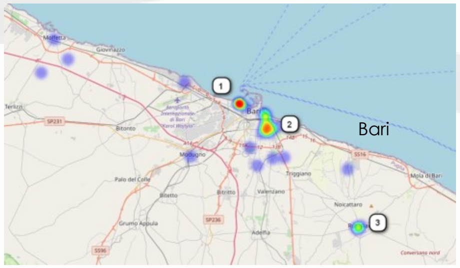
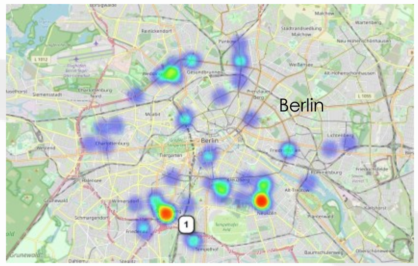
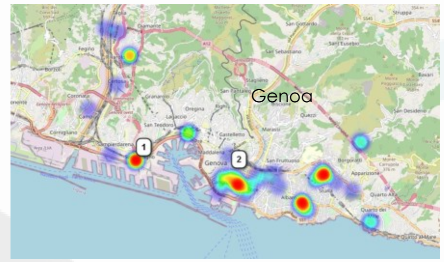
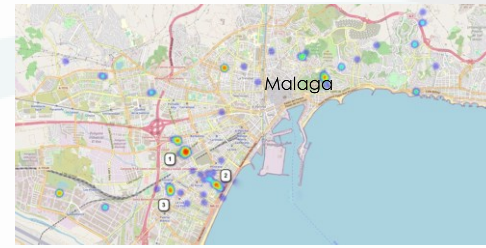
Density Maps

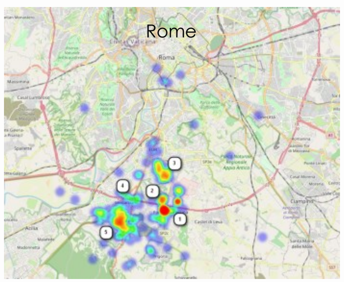
Charging Heat Maps and Charging Behavior

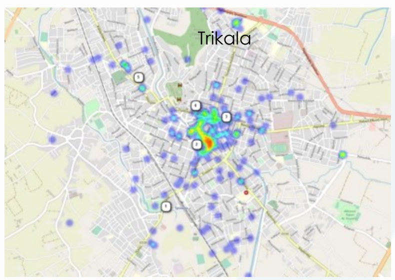






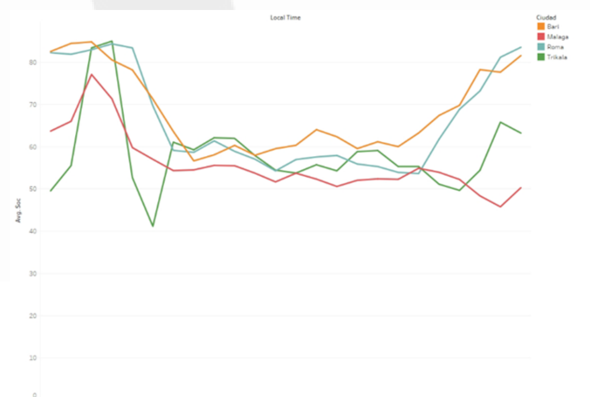






- We observe that many vehicles were charged at **user's home at night**.
- Nevertheless, in all cities we also observe a high charging activity at the location of **companies, institutions and public bodies** that participated in the demonstrations. This means that the employees that were using the vehicles usually charged them at their working place during the business hours.

For all 6 demonstration cities, we observe similar patterns.
In general, *most* vehicles are charged during the **evening and night hours**, with *some* recharge periods during **business hours**.



SoC/hour

COVID-19 Conclusions

Impact of COVID-19 on e-mobility

After a drastic decrease on demand due to lockdown and telework, a higher demand on e-bikes and EL-Vs is observed once restrictions began to lift, even surpassing the previous demand. The possible reasons are:

- Easier to maintain social distance than public transport
- Individual vehicles offer easy cleaning in case of sharing services
- E-bikes and EL-Vs as an desirable alternative to public transport during the pandemic

Other key Conclusions

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Average trip distance, *speed* and *number of trips* demonstrate that EL-Vs perform very well in urban traffic, being a **suitable alternative complementing traditional means of urban transport**

Long-range autonomy and *easiness to charge* at home or workplace **reduces the need for EL-Vs to rely on a wide charging infrastructure**

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THANK YOU FOR YOUR ATTENTION

Tribes European Quarter
Avenue Marnix 17
1000 Brussels (Belgium)
Tel: + 32 2 808 60 50

Email: info@smart-transportation.org

www.smart-transportation.org