



# **RDE – Assessment of positive elevation gain**

## **RDE Working group**

**8 July 2015**

**European Commission, Joint Research Centre (JRC), Institute for Energy and Transport**

# Objective



- **Applying the ACEA tool to additional test routes**
- **Conducting a preliminary uncertainty analysis of elevation gain for two selected routes**
- **Assessing elevation gain during city driving**



# Recap: JRC test routes



Route	Distance [km]	95%-ile road grade [%]	Positive elevation gain [m]	Positive elevation gain [m/100 km]
1: Ispra-Milan	141	1.5	502	357
2: Ispra-Varese	63	3.3	450	718
3: Ispra-Sacro Monte	62	8.1	1009	1623
4: Ispra-Motorway	132	2.3	646	490
Arona	114	3.0	725	637
RDE	80	2.8	508	638

# Additional test routes



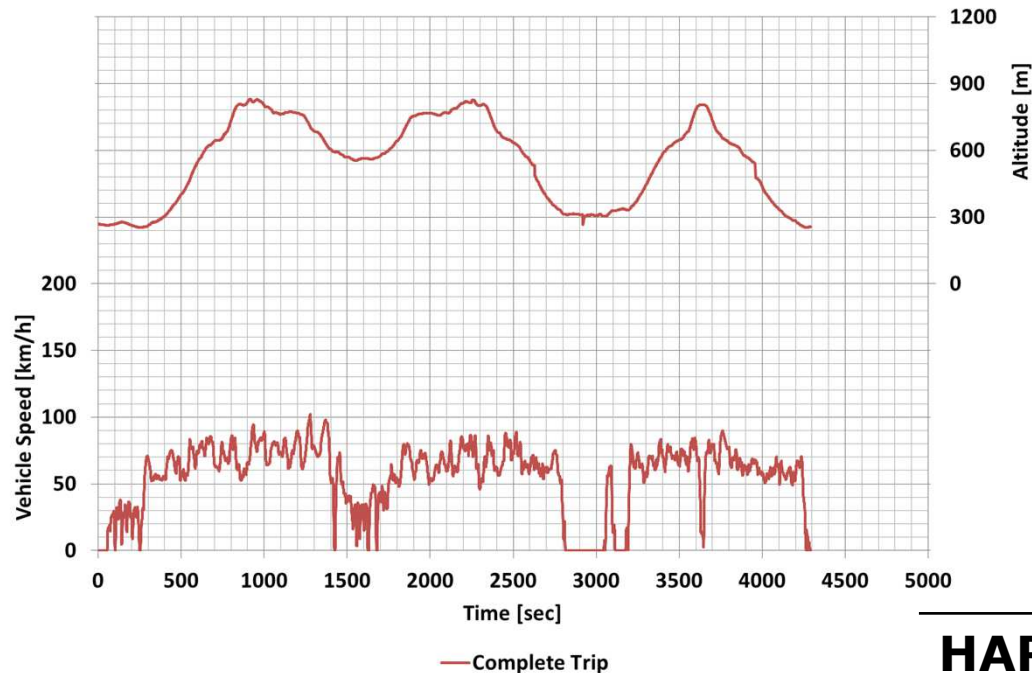
ROUTE ID	Location	distance [km]	95%-ile road grade [%]	Positive elevation gain [m]	Positive elevation gain [m/100km]
LUX-ROUTE1	Urban (Luxemburg)	10.8	4.6	106	981
	<b>Total</b>	<b>102.1</b>	<b>2.6</b>	<b>630</b>	<b>618</b>
LUX-ROUTE2	Urban (Luxemburg)	19.4	2.8	94	482
	<b>Total</b>	<b>150.0</b>	<b>3.3</b>	<b>1072</b>	<b>715</b>
ROMAGNANO	Urban (Ispra-Besozzo)	19.7	2.5	137	692
	<b>Total</b>	<b>118.0</b>	<b>2.7</b>	<b>723</b>	<b>613</b>
MILANO	Urban (Milano)	6.9	2.0	28	407
	<b>Total</b>	<b>139.4</b>	<b>1.6</b>	<b>504</b>	<b>361</b>
BS	Urban (Brunswick)	25.0	1.3	76	305
	<b>Total</b>	<b>87.5</b>	<b>1.5</b>	<b>343</b>	<b>392</b>
DRITTEL	Urban (Wolfsburg)	9.3	1.7	37	400
	<b>Total</b>	<b>101.4</b>	<b>1.9</b>	<b>457</b>	<b>451</b>
HARZ	<b>Total</b>	<b>66.7</b>	<b>8.2</b>	<b>1367</b>	<b>2049</b>



# Additional test routes



## HARZ – Complete Trip



## HARZ – Complete Trip

distance [km]	67
95%-ile road grade [%]	8.2
positive elevation gain [m]	1367
positive elevation gain [m/100km]	2049

# Additional test routes



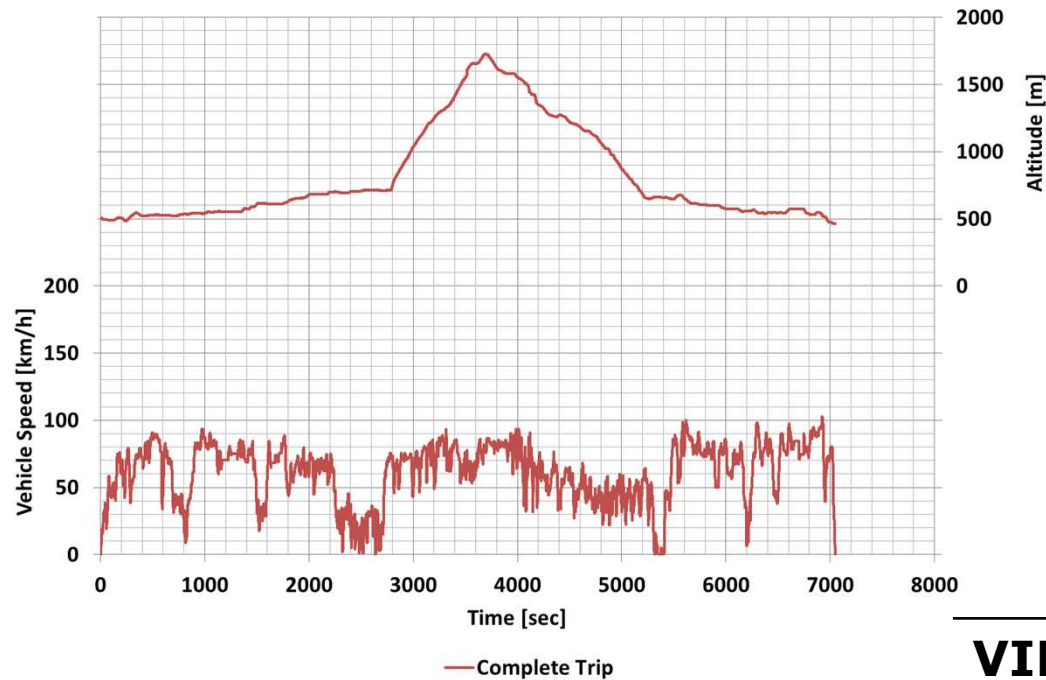
ROUTE ID	Location	distance [km]	95%-ile road grade [%]	Positive elevation gain [m]	Positive elevation gain [m/100km]
UTAC-ROUTE1	Urban (Etampes)	7.3	1.3	16	221
	<b>Total</b>	<b>125.6</b>	<b>2.7</b>	<b>759</b>	<b>605</b>
UTAC-ROUTE2	Urban (Paris)	15.9	5.1	161	1011
	<b>Total</b>	<b>82.2</b>	<b>4.8</b>	<b>778</b>	<b>947</b>
ARONA	Urban (Arona-Sesto Calende)	25.7	2.3	119	461
	<b>Total</b>	<b>106.0</b>	<b>2.9</b>	<b>683</b>	<b>644</b>
VARESE NEW	Urban (Varese)	16.2	4.1	119	735
	<b>Total</b>	<b>69.0</b>	<b>2.7</b>	<b>473</b>	<b>684</b>
IDIADA-ROUTE1	Urban (Vilanova)	17.9	2.5	123	685
	<b>Total</b>	<b>95.8</b>	<b>3.0</b>	<b>767</b>	<b>800</b>
IDIADA-ROUTE2	Urban	trip without a proper urbn driving in a city center			
	<b>Total</b>	<b>120.9</b>	<b>6.6</b>	<b>1436</b>	<b>1188</b>



# Additional routes



## IDIADA-Route2 – Complete Trip



## VIL-Route2 – Complete trip

distance [km]	121
95%-ile road grade [%]	6.6
positive elevation gain [m]	1436
positive elevation gain [m/100km]	1188

# Additional test routes



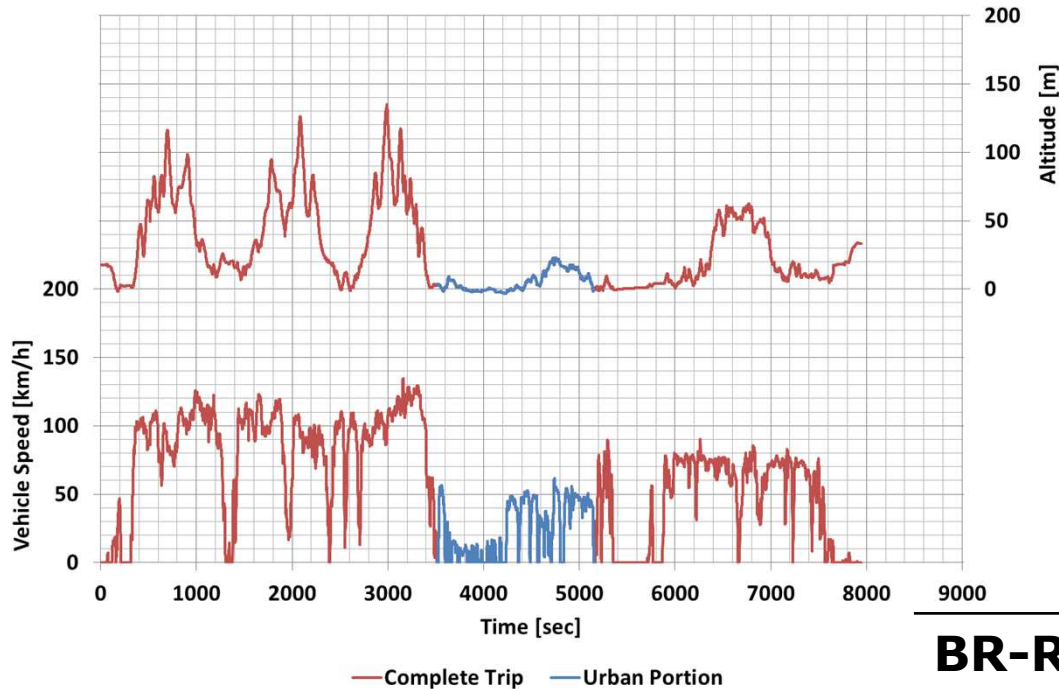
ROUTE ID	Location	distance [km]	95%-ile road grade [%]	Positive elevation gain [m]	Positive elevation gain [m/100km]
TUV-NORD-ROUTE1	Urban (Essen)	13.1	3.2	98	744
	<b>Total</b>	<b>46.2</b>	<b>4.7</b>	<b>410</b>	<b>887</b>
TUV-NORD-ROUTE2	Urban	trip without a proper urbn driving in a city center			
	<b>Total</b>	<b>52.0</b>	<b>4.5</b>	<b>453</b>	<b>871</b>
Ricardo-ROUTE C	Urban (Brighton)	11.4	1.6	36	314
	<b>Total</b>	<b>125.4</b>	<b>3.4</b>	<b>899</b>	<b>717</b>
Ricardo-ROUTE D	Urban (Brighton)	29.1	2.3	175	603
	<b>Total</b>	<b>97.6</b>	<b>4.2</b>	<b>790</b>	<b>810</b>
ENEA-ROUTE1	Urban (Rome)	16.8	1.8	70	415
	<b>Total</b>	<b>16.8</b>	<b>1.8</b>	<b>70</b>	<b>415</b>
ENEA-ROUTE2	Urban (Rome)	3.7	1.8	21	548
	<b>Total</b>	<b>31.8</b>	<b>2.6</b>	<b>207</b>	<b>652</b>



# Additional test routes



## Brighton-RouteC – Complete Trip



### BR-Route1 – Complete trip

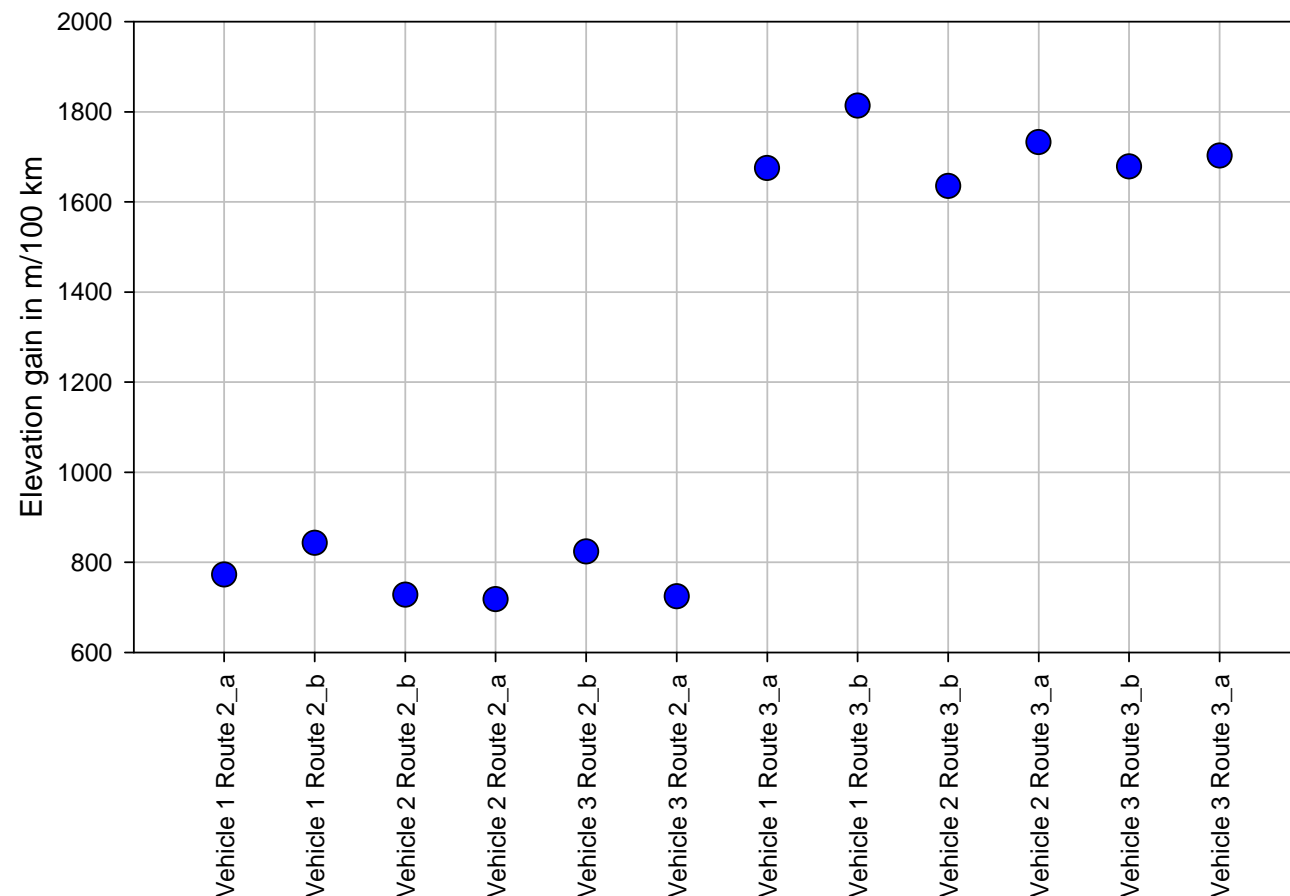
distance [km]	125
95%-ile road grade [%]	3.4
positive elevation gain [m]	899
positive elevation gain [m/100km]	717

# Elevation gain – Uncertainty analysis



**Average deviation  $\pm$  95% confidence interval**

- **Route 2 (Ispra-Varese):  $768 \pm 109$  m/100 km (14% deviation)**
- **Route 3 (Ispra-Sacro Monte):  $1706 \pm 123$  m/100 km (7% deviation)**



# Elevation gain – 10 largest EU cities



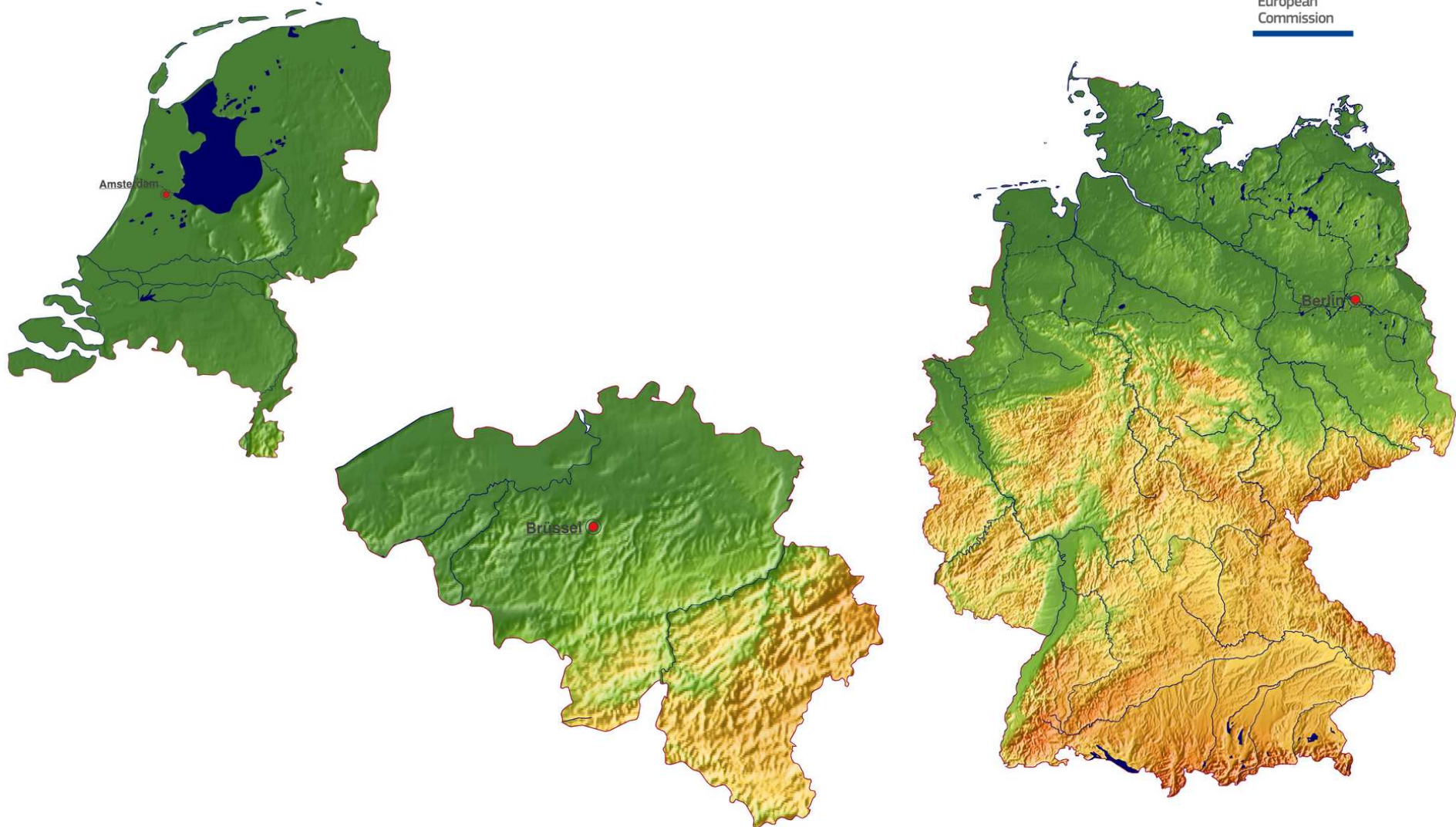
- **London (flat)**
- **Berlin (flat)**
- **Madrid (no google bike map)**
- **Rome (no google bike map)**
- **Paris (flat-hilly)**
- **Vienna (flat)**
- **Bucharest (no google bike map)**
- **Hamburg (flat-hilly)**
- **Budapest (no google bike map)**
- **Warsaw (flat)**
- **Milan (flat; no google bike map)**



# Map-based urban routes



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Source: Ginkgo Maps



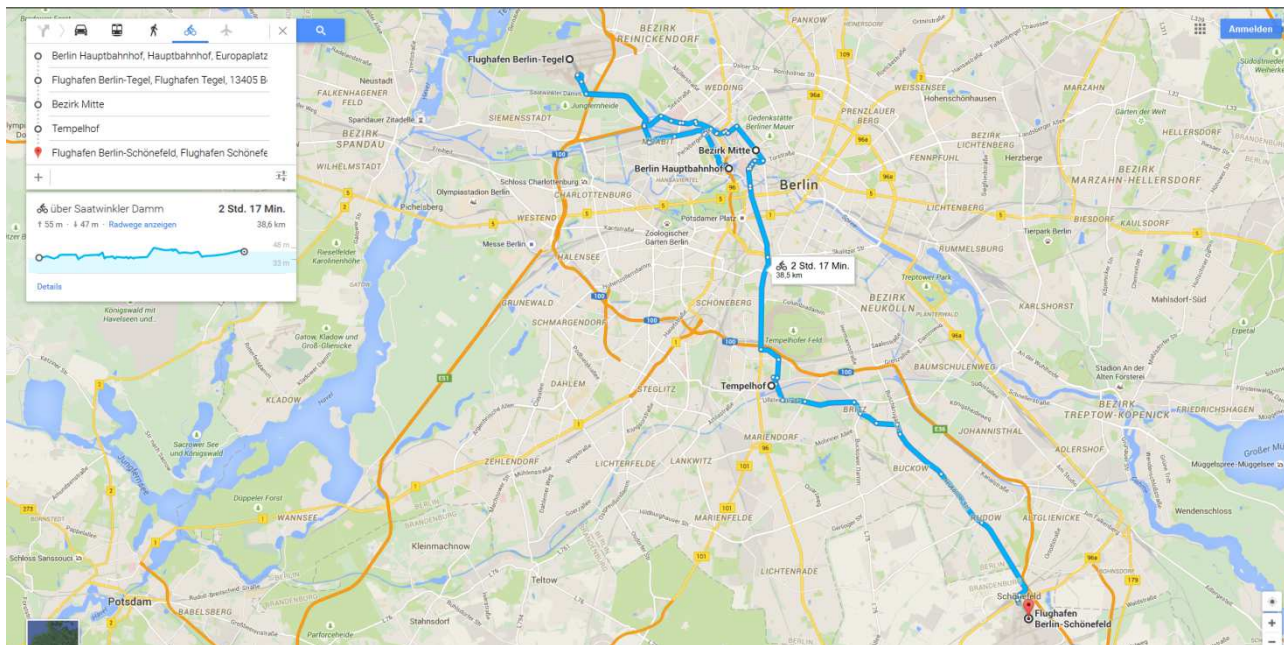
# Map-based urban routes



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**Flat terrain: Minimum elevation gain displayed at Google bike maps  $\approx 40$  m**

- **City trips: Amsterdam, Antwerp, Berlin, London ( $<40$  m)**



**Berlin**

(City – Airport  
Schoenfeld)

**55 m/38.6 km**

(142 m/100 km)

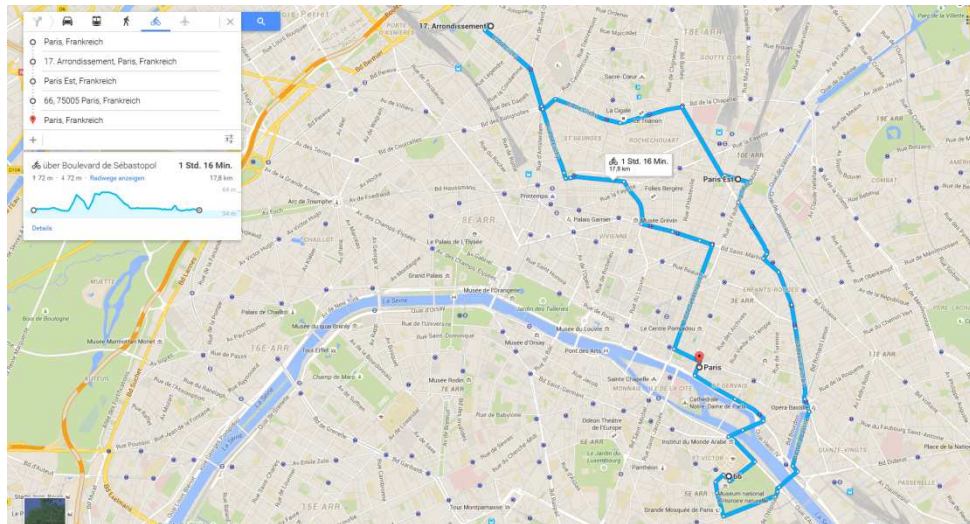


# Map-based urban routes



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## Flat-hilly terrain

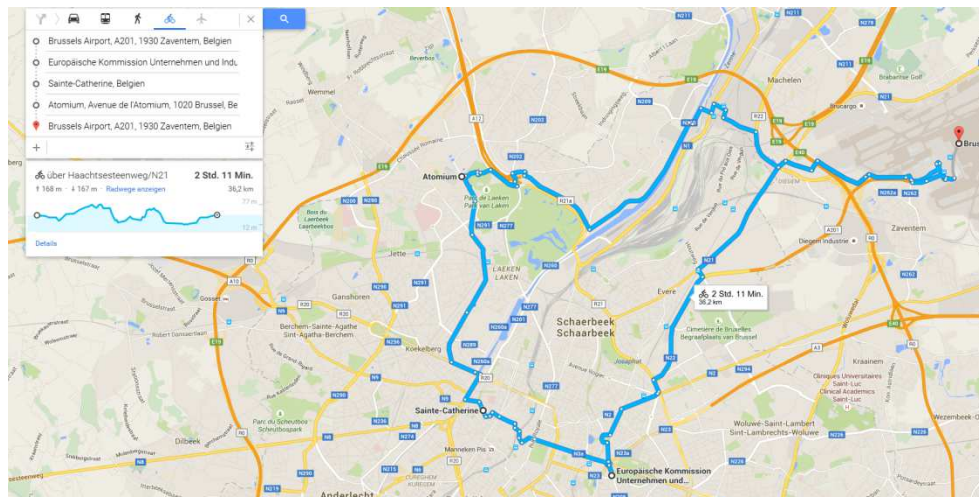


### Paris

(City trip)

**72 m/17.8 km**

(404 m/100 km)



### Brussels

(Airport-DG-GROW – St.  
Catherine – Atomium – airport)

**168 m/36.2 km**

(464 m/100 km)

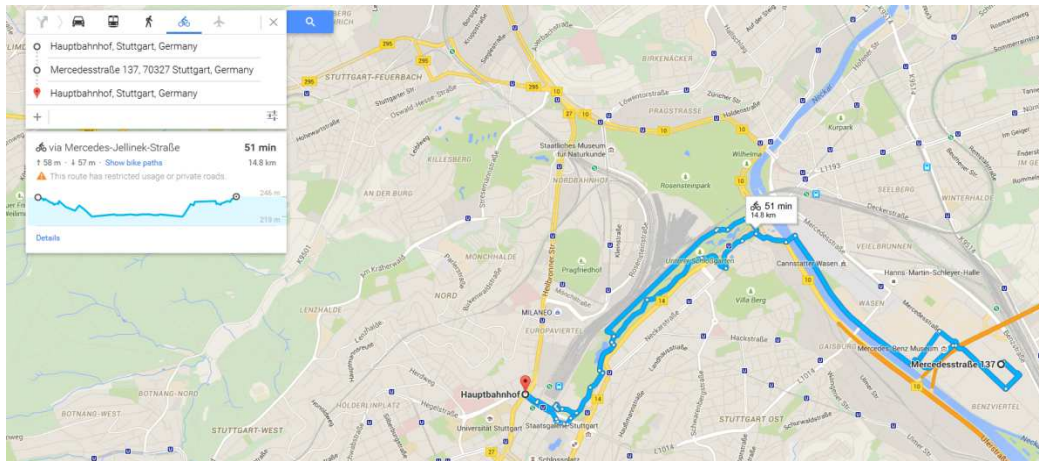


# Map-based urban routes

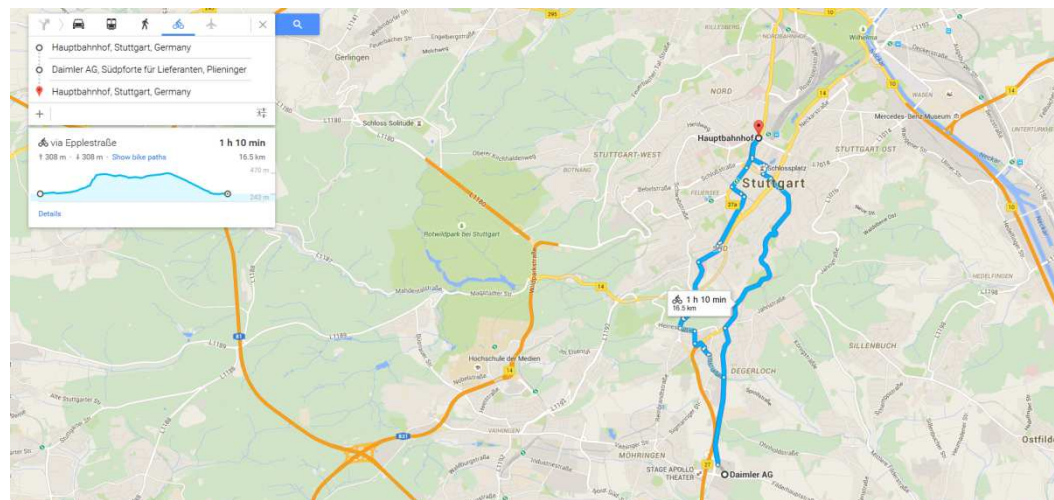


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## Hilly-mountainous terrain



**Stuttgart**  
(Train station – Mercedes  
Strasse – Train station)  
**58 m/14.8 km**  
(391 m/100 km)



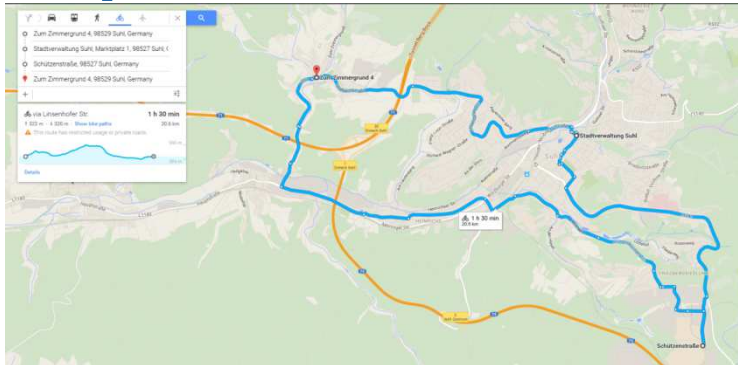
**Stuttgart**  
(Train station – Plieninger  
Strasse – Train station)  
**299 m/16.5 km**  
(1812 m/100 km)

# Map-based urban routes



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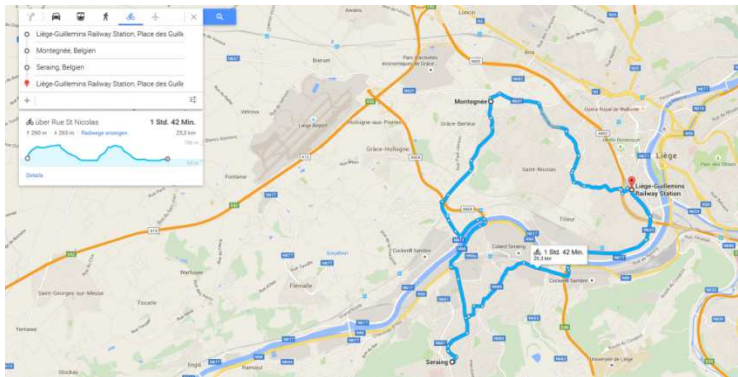
## Hilly-mountainous terrain



### Suhl

(Home – Municipality –  
Work place – Home)

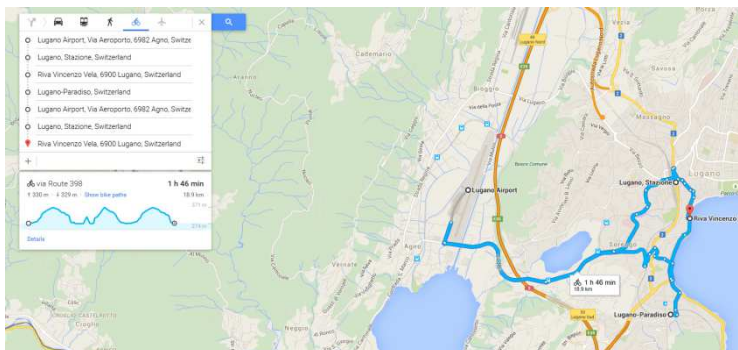
**322 m/20.6 km**  
(1563 m/100 km)



### Liege

(City trip)

**260 m/25.3 km**  
(1028 m/100 km)



### Lugano

(City trip)

**330 m/18.9 km**  
(1746 m/ 100 km)



# Conclusions



- **Between-trip variability in elevation gain  $\approx 15\%$  (spatial resolution; measurement uncertainty)**
- **Urban driving in the largest EU cities appears to be unproblematic with respect to elevation gain**
- **Urban driving in mountainous cities feasible ( $<1000\text{m}$ /urban part) but compensation by flat R/M parts may be necessary**
- **Large cities in alpine environment are usually located in river valleys with limited variability in altitude**
- **Critical are cities in hilly/sub-mountainous terrain**
- **Tool does not accept zero altitude and requires zero vehicle speed at test start**

