PTV GROUP

the mind of movement

ITS CATALUNYA 2017

MaaS meets Travel Demand Modeling

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MOBILITY IS CHANGING

CONNECTIVITY

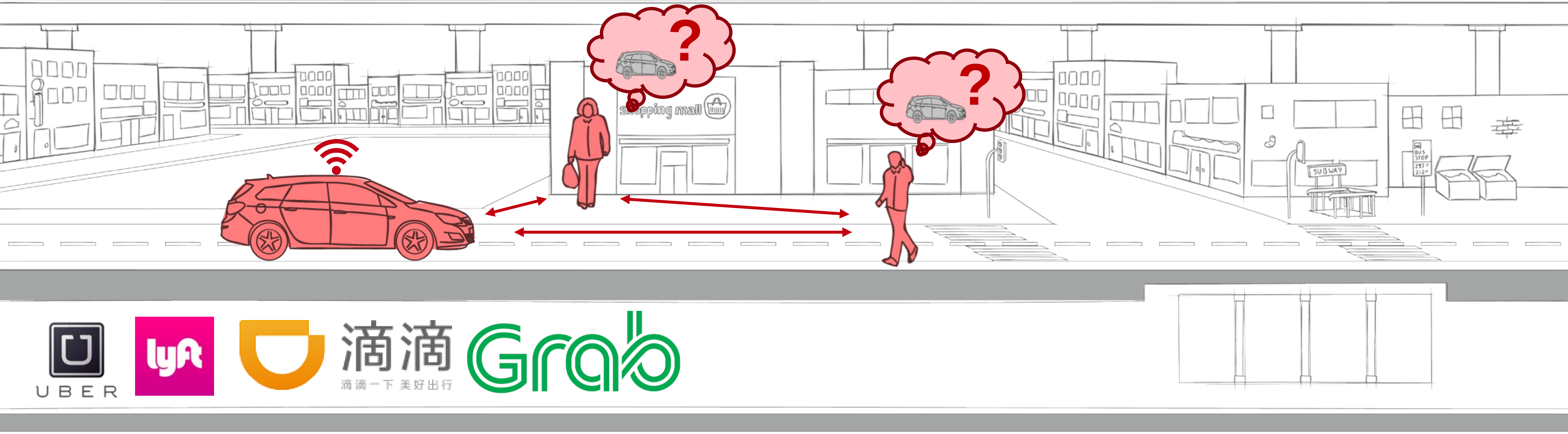
Real-time communication between people, vehicles and the physical environment.

NEW FORMS OF MOBILITY

With e-hailing, vehicle and ride sharing, new forms of mobility are emerging. Self-driving vehicles are on the way.

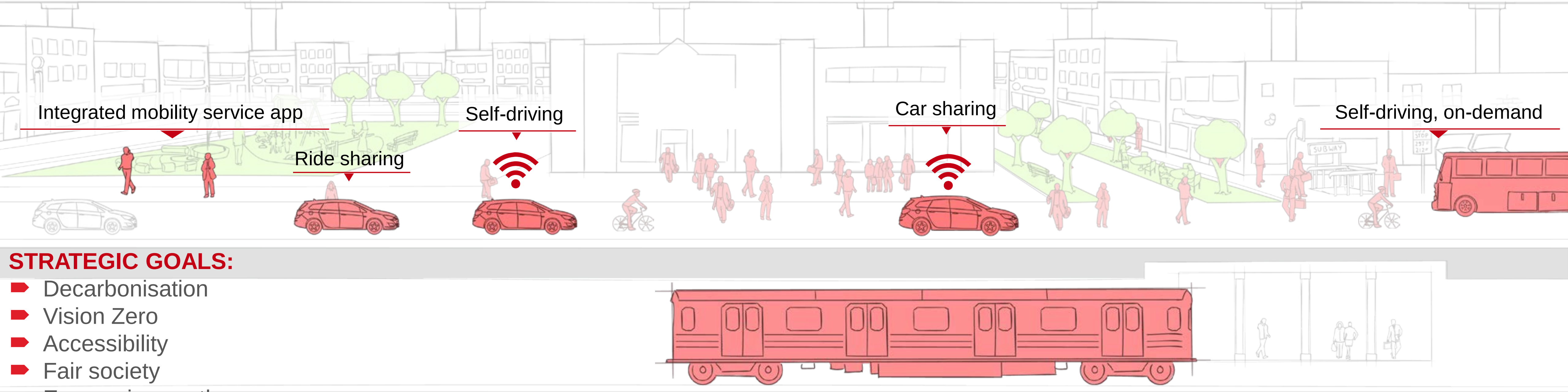
CHANGE OF VALUES

People overthink their relationship to the car. Using resources in an efficient and sustainable manner is the desired goal.



ARE YOU ABLE TO PLAN FOR THE FUTURE?

- How will this affect our strategic goals and long term plans?
- How much parking will freed up and how to utilise the space?
- What additional infrastructure is needed to facilitate pick-up/drop/off?
- How to co-ordinate mobility services for the good of the city?
- What will be the impact of phased autonomy / mixed traffic?
- Will congestion improve or intensify and over what time period?
- How will this impact on our current committed and planned schemes?
- How best to regulate ride-sharing companies such as Uber?
- Can the city profitably run its own mobility service?



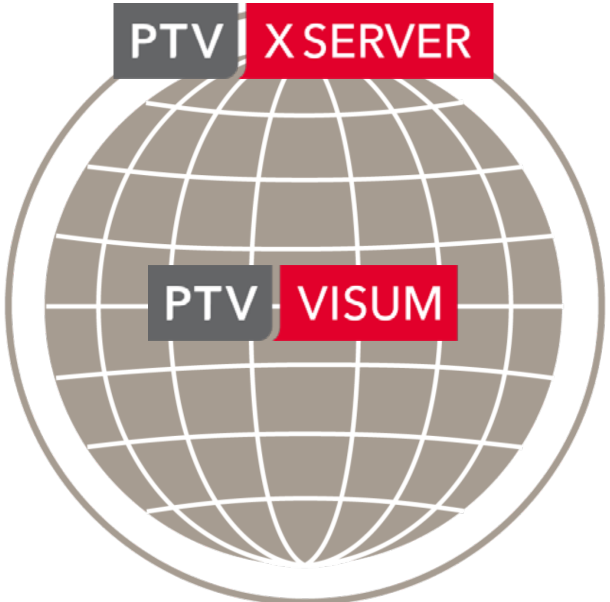
STRATEGIC GOALS:

- Decarbonisation
- Vision Zero
- Accessibility
- Fair society
- Economic growth

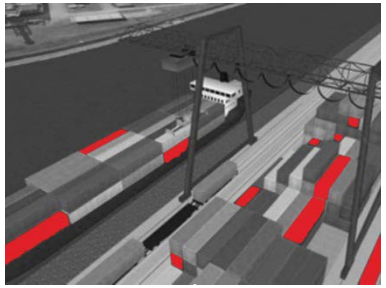
PTV MAAS R&D PROGRAMME – TWO WORLDS COMBINE

TRAFFIC

PLANNING AND OPTIMISING THE FLOW OF PEOPLE



LOGISTICS



PLANNING AND OPTIMISING THE FLOW OF GOODS

NEW SOLUTION FOR PLANNING FUTURE MOBILITY:

- PTV Visum for the digital replica of cities and people
- Logistics algorithms to replicate MaaS dispatchers
- The only company with combined expertise
- Only solution for cities and operators to plan for the future

FLAVORS OF SHARED MOBILITY SYSTEMS

General principle

- Alternative forms of mobility that do not require exclusive access (or exclusive ownership) of a means of transport

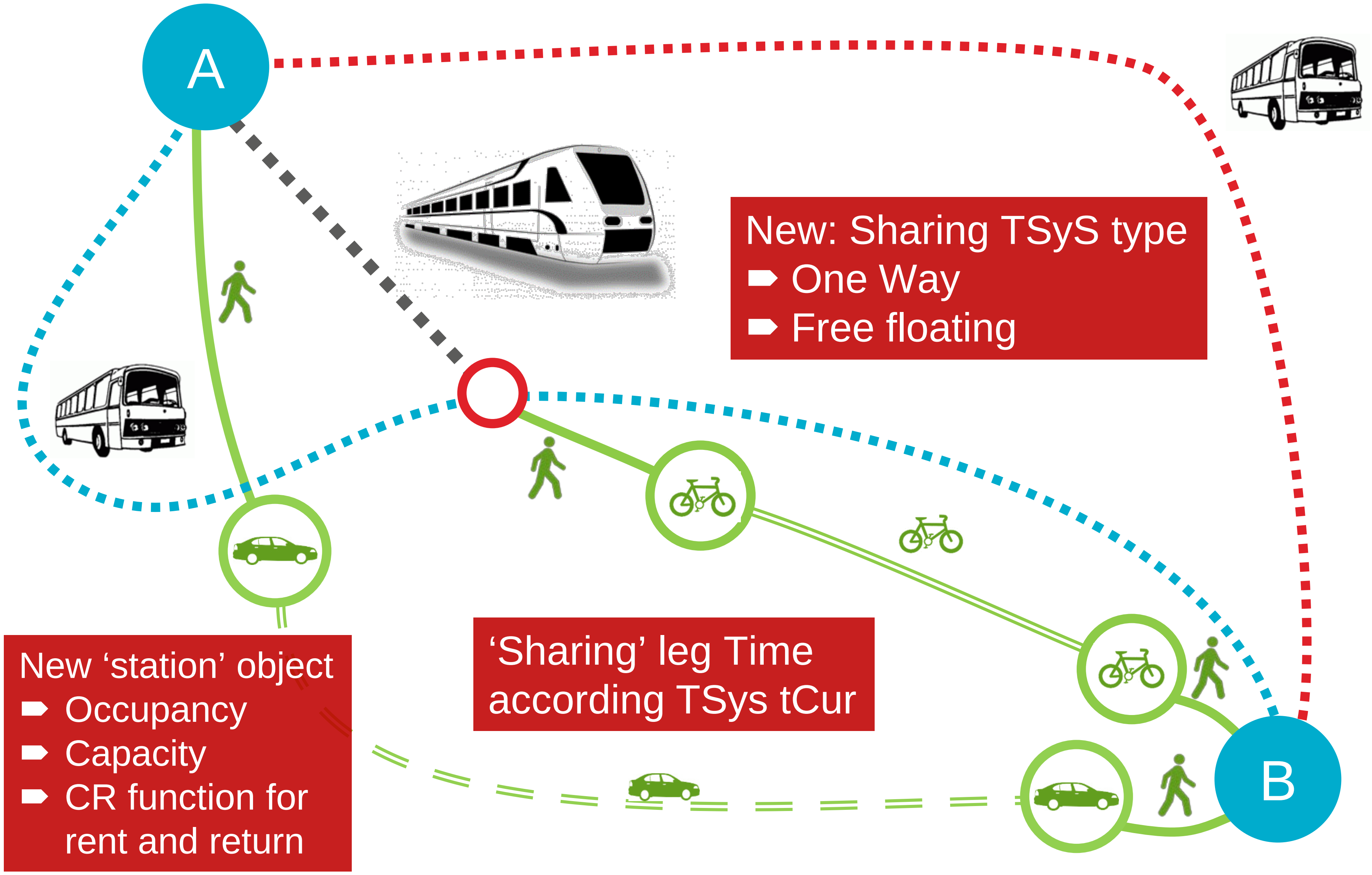
Vehicle sharing (cars, bikes)

- One vehicle is shared **sequentially** by several travellers. Each traveller has **exclusive use** of the vehicle for a certain time.

Ride sharing

- One vehicle is shared **simultaneously** by several travellers. Travellers travel **together in one vehicle**.

VEHICLE SHARING: NETWORK MODEL



VEHICLE SHARING: ASSIGNMENT

Extension of timetable based assignment

- PuT supply is extended by sharing systems
- Time segmentation to represent dynamics of the system
- Cost for renting and returning is capacity restraint

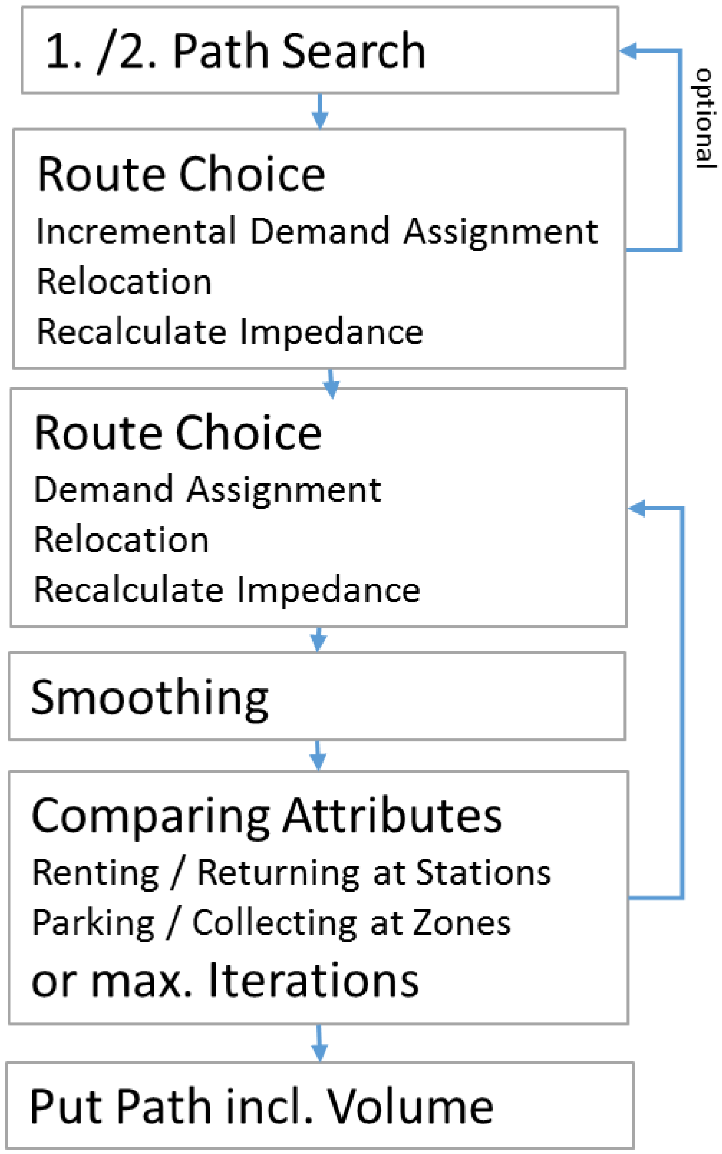
Iterative Procedure

- Initial and second search after first route choice
- Choice iteration based on fixed path set
- MSA

Relocation

- To reach the optimal occupancy at stations / areas

Details → TRB 15-1598



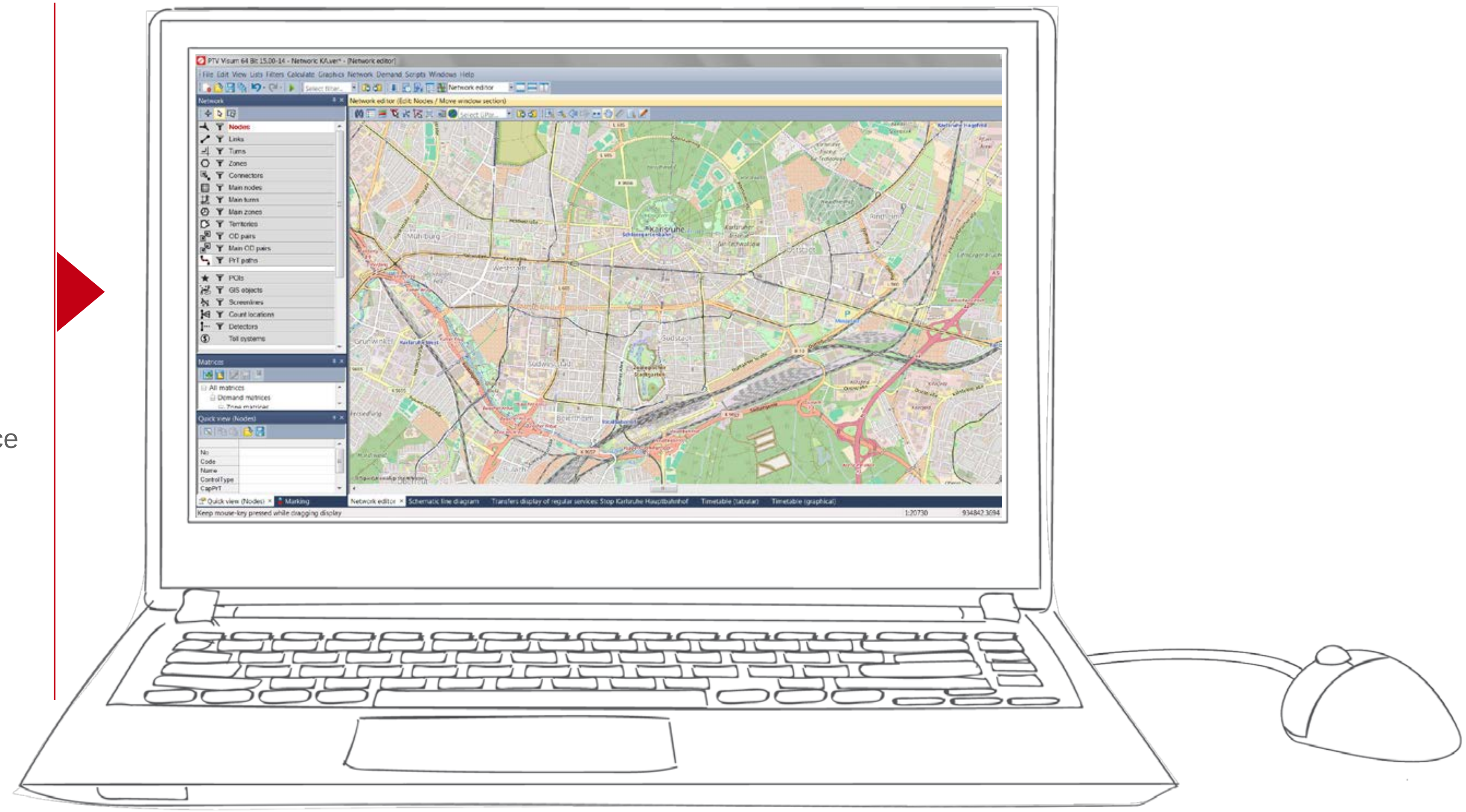
RIDESHARING: MODEL INPUT

DATA INPUT

DIGITAL REPLICA OF A CITY

- City road networks
- City public transport networks
- Key city hubs and interchanges
- City travel demand
- Typical traveler behavior, e.g. mode choice

PTV VISUM



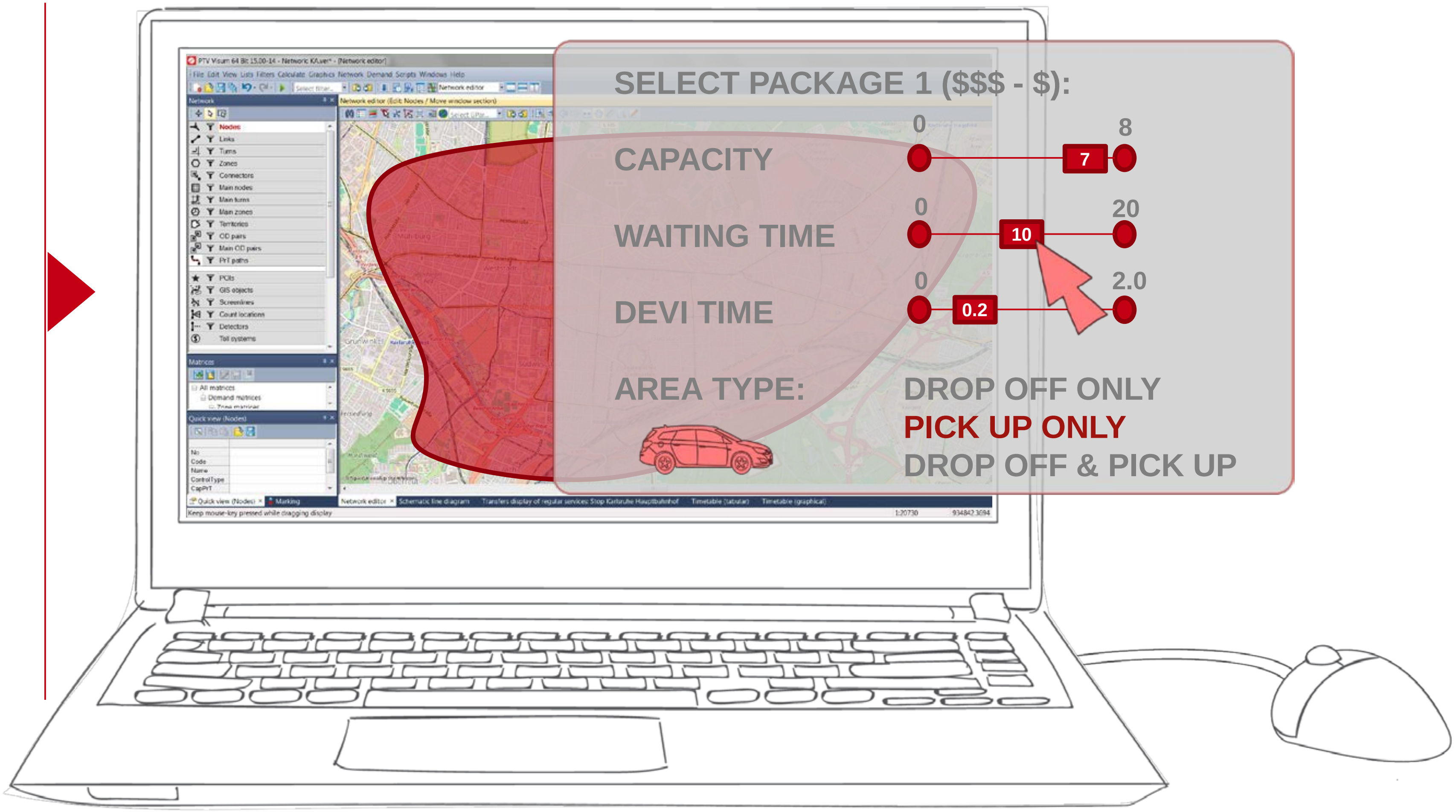
RIDESHARING: MODEL INPUT

DATA INPUT

SERVICE SPECIFICATION

- Pre-booking time
- Departure time window
- Detour time
- Fare
- Vehicle capacity
- Max. fleet size
- Boarding/alighting time
- Pick-up/drop-off points
- Geographical coverage
- Average vehicle lifespan

PTV X SERVER



RIDESHARING : MAP METHOD TO SOFTWARE TOOLS

Experimental setup similar to the OECD ITF study for Lisbon

- Generate trip requests from OD demand by spatial and temporal disaggregation

SOLVER

- Solve dial-a-ride-problem (DARP) → set of schedules for vehicles and assignment of passengers (= trip requests) to vehicles

- Visualize optimization result: create public transport timetable from DARP result. Each vehicle becomes a PT line with a single run.
- Extract user cost components for feedback into mode choice
- Calculate operating KPIs (fleet size, veh-km, empty veh-km, …) from operator perspective → economic evaluation

PTV VISUM

the mind of movement

RIDESHARING: DYNAMIC DIAL-A-RIDE-PROBLEM

```
dt = small time slice (5-15 min)
Schedule = empty
For t = t_start to t_end step dt
   TR = all trip requests with birthtime in [t; t+dt)
   Freeze each tour in Schedule until first event after t
   Schedule = Solver(Schedule, TR)
Import Schedule into PTV Visum for post-analysis
```

Formulate task as a **vehicle routing problem with pickup and delivery and with time windows**. Solve it by very large-scale neighborhood search.

Basis: R.K. Ahuja, J.B. Orlin, D. Sharma: Very large-scale neighborhood search, *Intl. Trans. in Op. Research* 7 (2000) 301-317

RIDESHARING: EXAMPLE FOR TRIP REQUESTS

Request (60)

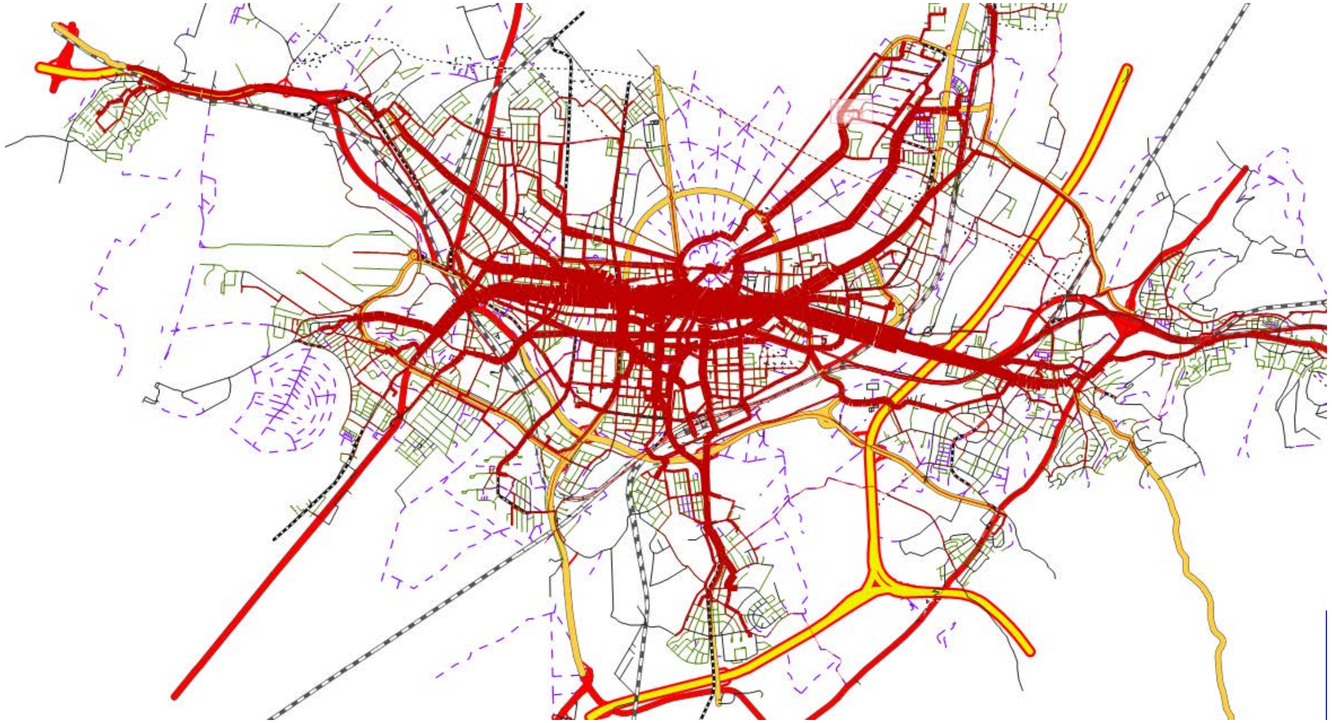
Count: 2063	No	OID	NumPax	FromZoneNo	ToZoneNo	DesiredDepTime	LatestDepTime	LatestArrTime	BirthTime
1	1	1	1	110	114	02:38:03	02:43:03	03:04:15	02:23:03
2	2	2	1	110	117	02:00:54	02:05:54	02:23:02	01:45:54
3	3	3	1	110	126	02:38:22	02:43:22	03:04:59	02:23:22
4	4	4	1	110	211	02:53:15	02:58:15	03:24:03	02:38:15
5	5	5	1	110	212	02:03:58	02:08:58	02:20:24	01:48:58
6	6	6	1	110	214	02:28:04	02:33:04	02:48:22	02:13:04
7	7	7	1	110	217	02:49:44	02:54:44	03:26:08	02:34:44
8	8	8	1	110	234	02:47:34	02:52:34	03:30:19	02:32:34
9	9	9	1	110	333	02:45:26	02:50:26	03:24:40	02:30:26
10	10	10	1	110	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	11	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	12	12	1	110	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	13	13	1	111	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	14	14	[illegible]	111	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Number passengers
Origin
Destination
Ideal departure
Latest Departure
Latest Arrival
Time of booking

PTV MaaS Modeller: prototype

Prototype:

- PTV MaaS Modeler optimizes trip schedules for 50 vehicles
- Ridesharing modeled within constraints set by user
- Different parameters set :
  - Max wait time
  - Booking time
  - Max detour factor (for ridesharing)
- Random departure times assigned



RIDESHARING: EXAMPLE OF RESULT

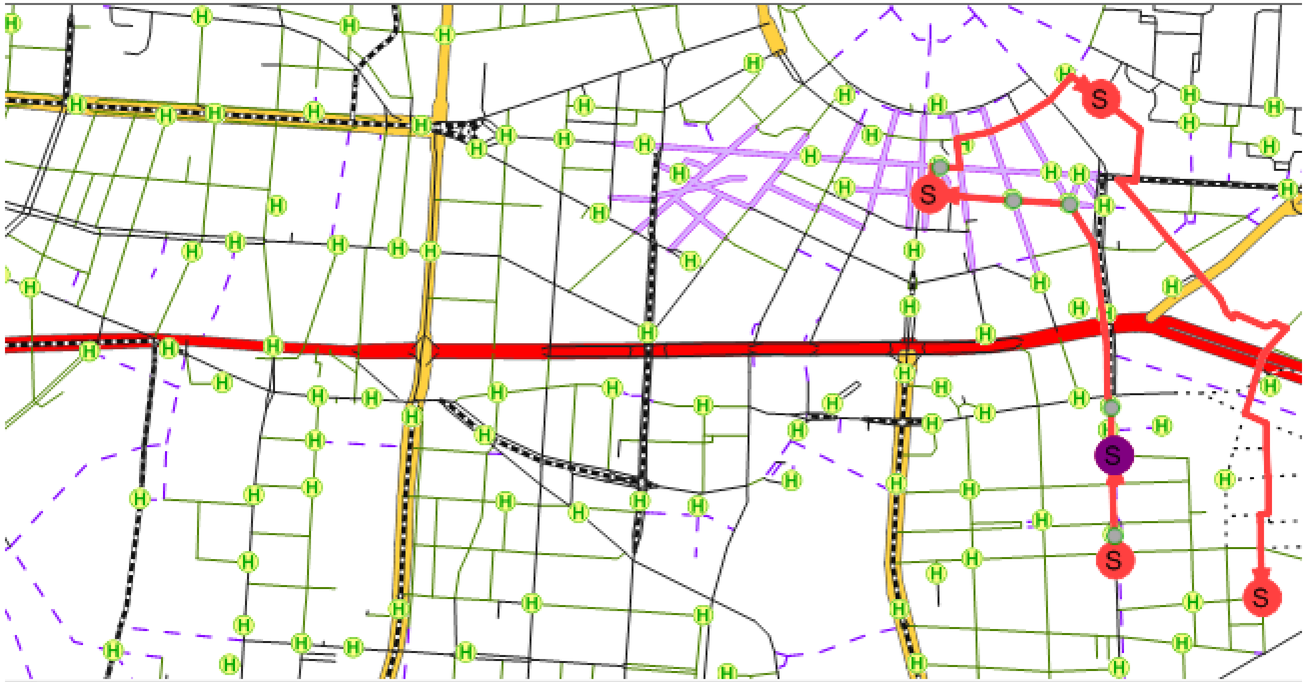
List (Vehicle journey items)

Select list layout...

Vehicle journey 558 (line: AV, name: 116

Count: 5	Index	VehJourneyNo	Arr	Dep	PostLength	ShBoard	ShAlight	ShVol	ShTasks
1	1	7658		02:04:15	0.269km	1	0	1	p1424
2	2	7658	02:11:54	02:13:22	1.000km	1	0	2	p1179
3	3	7658	02:37:14	02:39:14	0.641km	1	1	2	p138 d1179
4	4	7658	02:49:14	02:51:14	1.656km	1	1	2	p81 d1424
5	5	7658	03:23:01		0.000km	0	2	0	d81 d138

RIDESHARING: EXAMPLE OF RESULT



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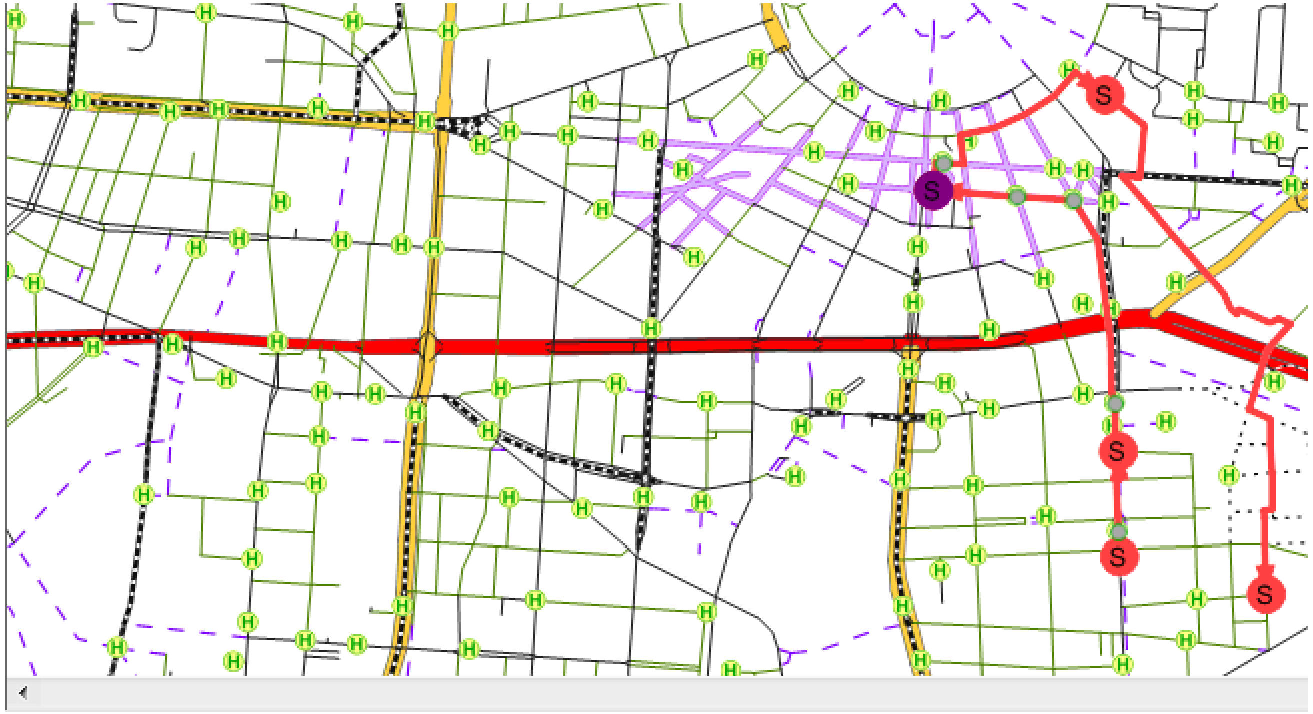

List (Vehicle journey items)

Select list layout...

Vehicle journey ;58 (line: AV, name: 116

Count: 5	Index	VehJourneyNc	Arr	Dep	PostLength	ShBoard	ShAlight	ShVol	ShTasks
1	1	7658		02:04:15	0.269km	1	0	1	p1424
2	2	7658	02:11:54	02:13:22	1.000km	1	0	2	p1179
3	3	7658	02:37:14	02:39:14	0.641km	1	1	2	p138 d1179
4	4	7658	02:49:14	02:51:14	1.656km	1	1	2	p81 d1424
5	5	7658	03:23:01		0.000km	0	2	0	d81 d138

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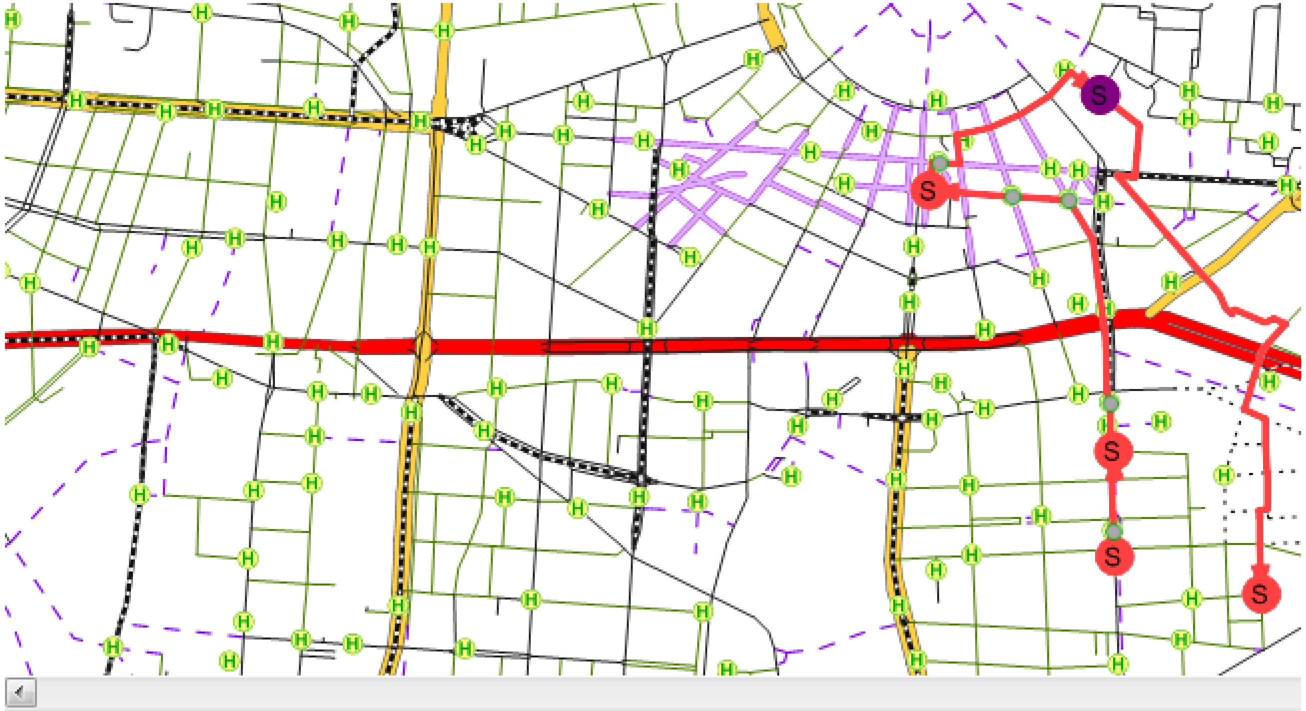

List (Vehicle journey items)

Select list layout... Min. Max. Ø Σ

Vehicle journey ;58 (line: AV, name: 11(

Count: 5	Index	VehJourneyNo	Arr	Dep	PostLength	ShBoard	ShAlight	ShVol	ShTasks
1	1	7658		02:04:15	0.269km	1	0	1	p1424
2	2	7658	02:11:54	02:13:22	1.000km	1	0	2	p1179
3	3	7658	02:37:14	02:39:14	0.641km	1	1	2	p138 d1179
4	4	7658	02:49:14	02:51:14	1.656km	1	1	2	p81 d1424
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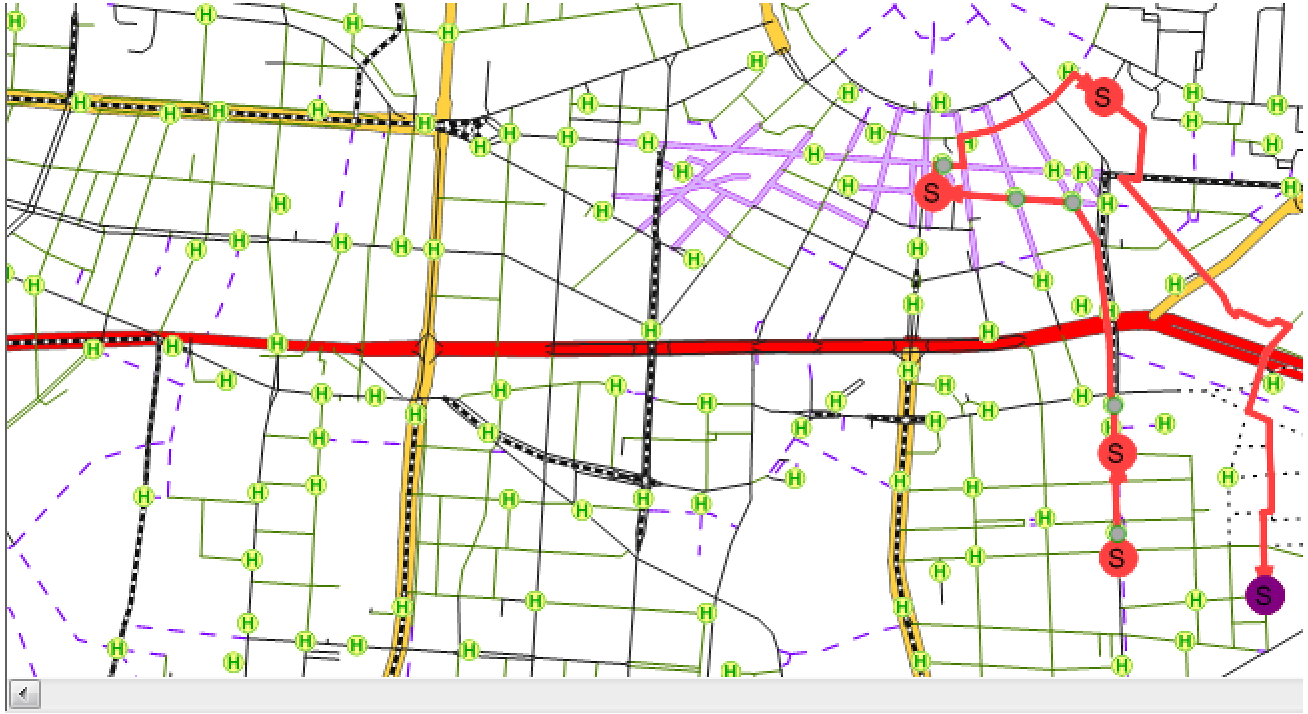
RIDESHARING: EXAMPLE OF RESULT



List (Vehicle journey items)

Select list layout... Min. Max.

Vehicle journey 558 (line: AV, name: 116

Count: 5	Index	VehJourneyNo	Arr	Dep	PostLength	ShBoard	ShAlight	ShVol	ShTasks
1	1	7658		02:04:15	0.269km	1	0	1	p1424
2	2	7658	02:11:54	02:13:22	1.000km	1	0	2	p1179
3	3	7658	02:37:14	02:39:14	0.641km	1	1	2	p138 d1179
4	4	7658	02:49:14	02:51:14	1.656km	1	1	2	p81 d1424
5	5	7658	03:23:01		0.000km	0	2	0	d81 d138

RIDESHARING: RESULTS

OUTPUT

OPERATIONAL EFFICIENCY

- Actual no. of vehicles used
- Schedule for each vehicle
- Estimated number of vehicles required over 10, 20, 30 years

Individual or total KPIs:
- Operating time
- Service time
- Idle time
- Drive time
- Board/alight time
- Vehicle wait time

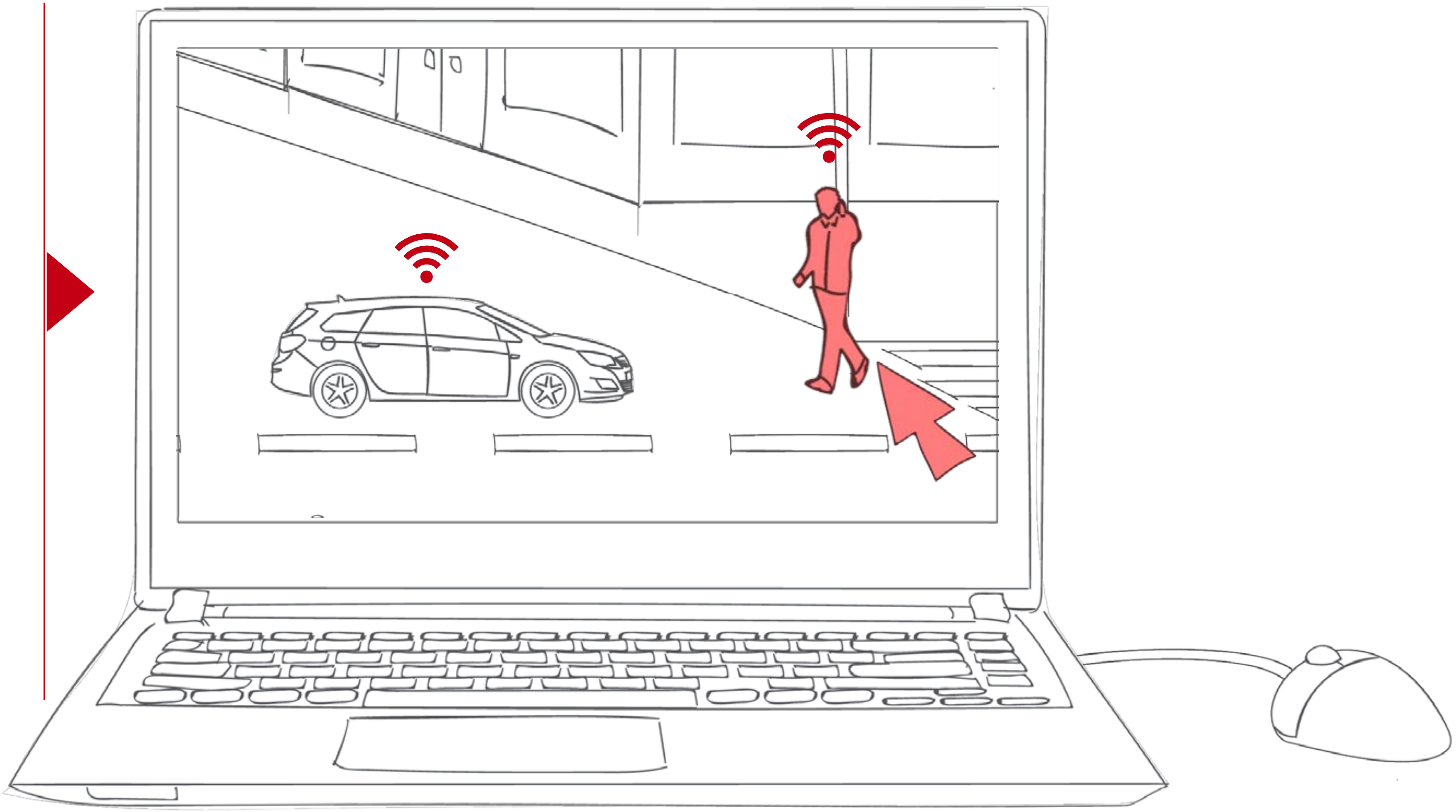
Same KPIs in km instead of time
- Operating cost – time-dependent
- Operating cost – distance-dependent
- Operating cost – fixed
- Operating cost – total
- Revenue

RIDESHARING: RESULTS

OUTPUT

SERVICE QUALITY

Individual or total KPIs:
- Waiting time
- Travel time
- Journey time
- Revenue
- Unserved demand
- Max. number of other passengers in vehicle during trip

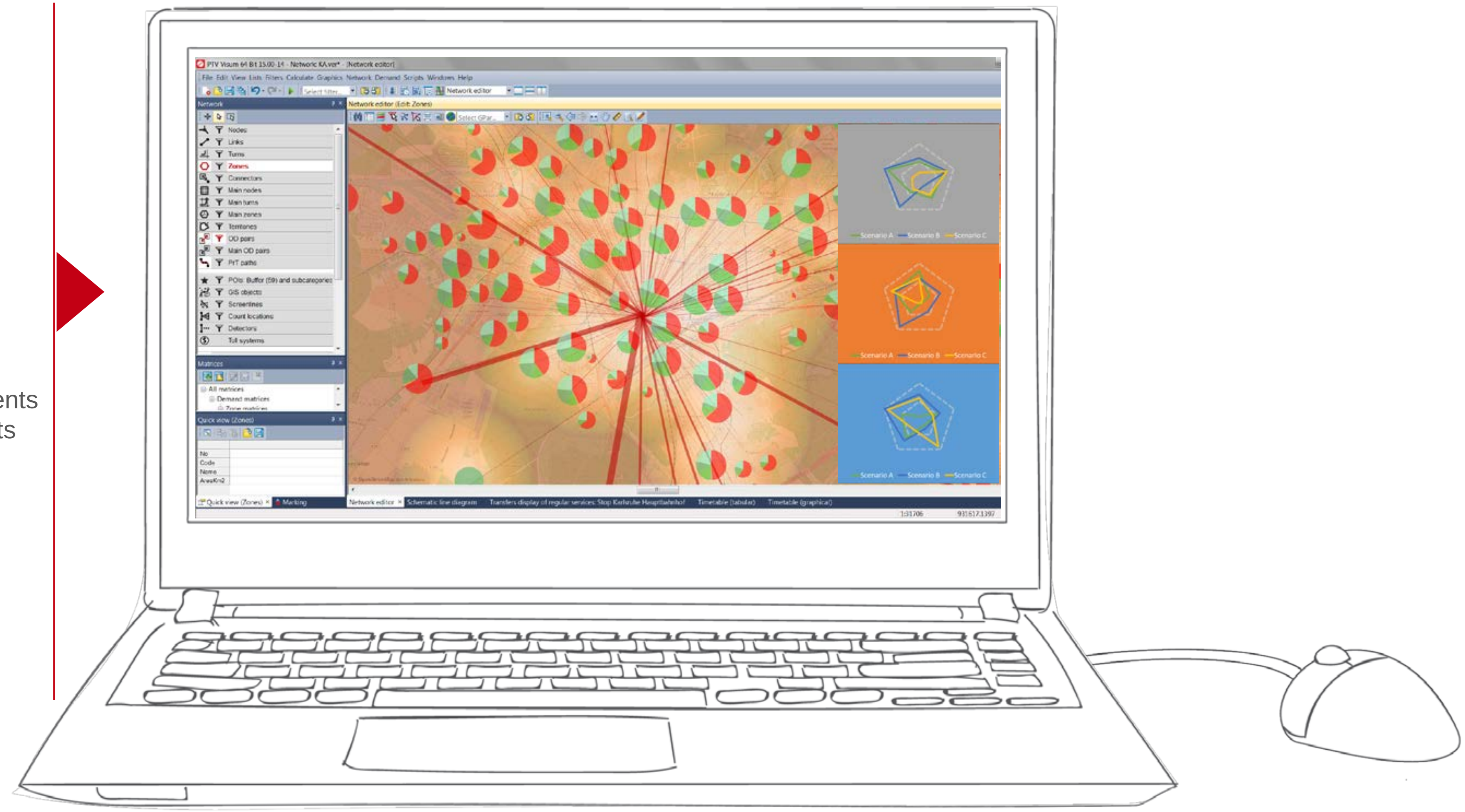


RIDESHARING: RESULTS

OUTPUT

IMPACT ON SOCIETY

- Congestion impacts
- Energy requirements for e-fleet
- Potential for decarbonisation
- Potential shift from existing modes
- Potential reduction in car trips → parking
- Vision Zero
  - Increase in kilometres → increase in accidents
  - Increase autonomy → decrease in accidents
- Impact on existing transport providers



RIDESHARING: RESULTS FROM PASSENGER PERSPECTIVE

OID	FromZoneNo	ToZoneNo	DesiredDepTime	LatestArrTime	LatestDepTime	ActualBeginPickup	ActualDepTime	ActualArrTime	WaitTime	TravelTime
2362	1514	1514	01:14:58	05:15:38	01:19:58	01:18:53	01:20:46	04:56:35	4min 1s	237min 45s
482	217	1415	00:54:01	02:05:45	00:59:01	00:37:22	00:54:01	01:45:21	0min	51min 20s
483	217	1421	00:33:41	02:11:18	00:38:41	00:37:22	00:54:01	02:07:47	3min 41s	90min 25s
484	217	1422	00:33:13	01:58:55	00:38:13	00:33:24	00:34:24	01:51:46	11s	78min 22s
485	217	1513	00:16:26	02:49:18	00:21:26	00:00:00	00:17:09	02:44:29	0min	148min 3s
486	218	329	00:52:37	01:45:23	00:57:37	00:00:00	00:52:37	01:43:50	0min	51min 13s
487	218	416	00:56:26	01:39:17	01:01:26	00:58:50	00:59:50	01:28:58	2min 24s	30min 8s
488	218	523	01:06:39	02:03:30	01:11:39	01:05:10	01:06:39	01:47:34	0min	40min 55s
489	218	611	00:58:21	02:55:22	01:03:21	00:54:09	00:58:21	02:35:22	0min	97min 1s
490	218	813	00:31:44	01:51:42	00:36:44	00:32:37	00:33:37	01:45:02	53s	72min 25s
491	218	842	01:04:45	02:22:11	01:09:45	01:07:27	01:09:27	02:07:07	2min 42s	59min 40s
492	218	931	01:04:52	03:21:15	01:09:52	01:07:27	01:09:27	03:15:10	2min 35s	127min 43s
493	218	1118	00:51:19	02:35:14	00:56:19	00:53:52	00:54:52	02:10:59	2min 33s	77min 7s

RIDESHARING: RESULTS FROM OPERATOR PERSPECTIVE

Fleet size and service statistics

List (Vehicle journeys)

Select list layout...

Count: 702	LineName	Name	Dep	Arr	Count:VehJourneyItems	ServiceKm(AP)	ServiceTime(AP)
1	AV	0	00:57:11	02:25:18	4	3.504km	1h 28min 7s
2	AV	1	00:17:28	03:25:18	7	8.452km	3h 7min 50s
3	AV	2	00:54:47	03:16:36	4	6.571km	2h 21min 49s
4	AV	3	00:20:41	02:55:44	6	7.021km	2h 35min 3s
5	AV	4	00:43:34	03:46:55	8	8.061km	3h 3min 21s
6	AV	5	00:42:06	03:28:54	9	7.294km	2h 46min 48s
7	AV	6	00:29:25	02:53:36	6	5.462km	2h 24min 11s
8	AV	7	00:27:24	02:07:18	8	4.714km	1h 39min 54s
9	AV	8	00:18:24	02:54:52	5	6.933km	2h 36min 28s
10	AV	9	00:16:14	03:17:25	9	8.266km	3h 1min 11s
11	AV	10	00:18:31	01:40:28	3	3.799km	1h 21min 57s

List (Vehicle journey items)

Select list layout...

Vehicle journey: All

Count: 7	Grp(ShVol)	Sum(PostLength)
Sum	21	4159.342km
1	0	7.878km
2	1	1502.522km
3	2	1127.166km
4	3	704.810km
5	4	410.963km
6	5	266.209km
7	6	139.795km

Km travelled for each occupancy level

CONCLUSION

The challenge

- Shared economy principle is rapidly transforming transportation
- Traditional tools are not sufficient

Our vision

- Software components to facilitate equitable planning, implementation and operation of MaaS

What to do?

1. **Plan now**: extend current travel demand models to include MaaS
2. **Collaborate**: facilitate discussion between PTV, cities, practitioners, operators and researchers to shape tools

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