Are We Ready for Mobility as a Service? Smartcard Data Says Yes!

Itzhak Benenson

**Porter School of Environment and Geoscience,
Tel Aviv University**

Eran Ben Elia, Bella Ackerman
**Department of Geography and Environmental Development,
Ben Gurion University of the Negev**

# Are we ready for Mobility as a Service? Smartcard data says yes!

Content

1. The sources of the big data on public transport
2. Aggregate analysis of the smartcard data
3. Analysis by user's profiles
4. Daily and weekly travel patters
5. Once-a-day travelers

The sources of transport and transportation data

GTFS

GTFS (General Transit Feed Specification):
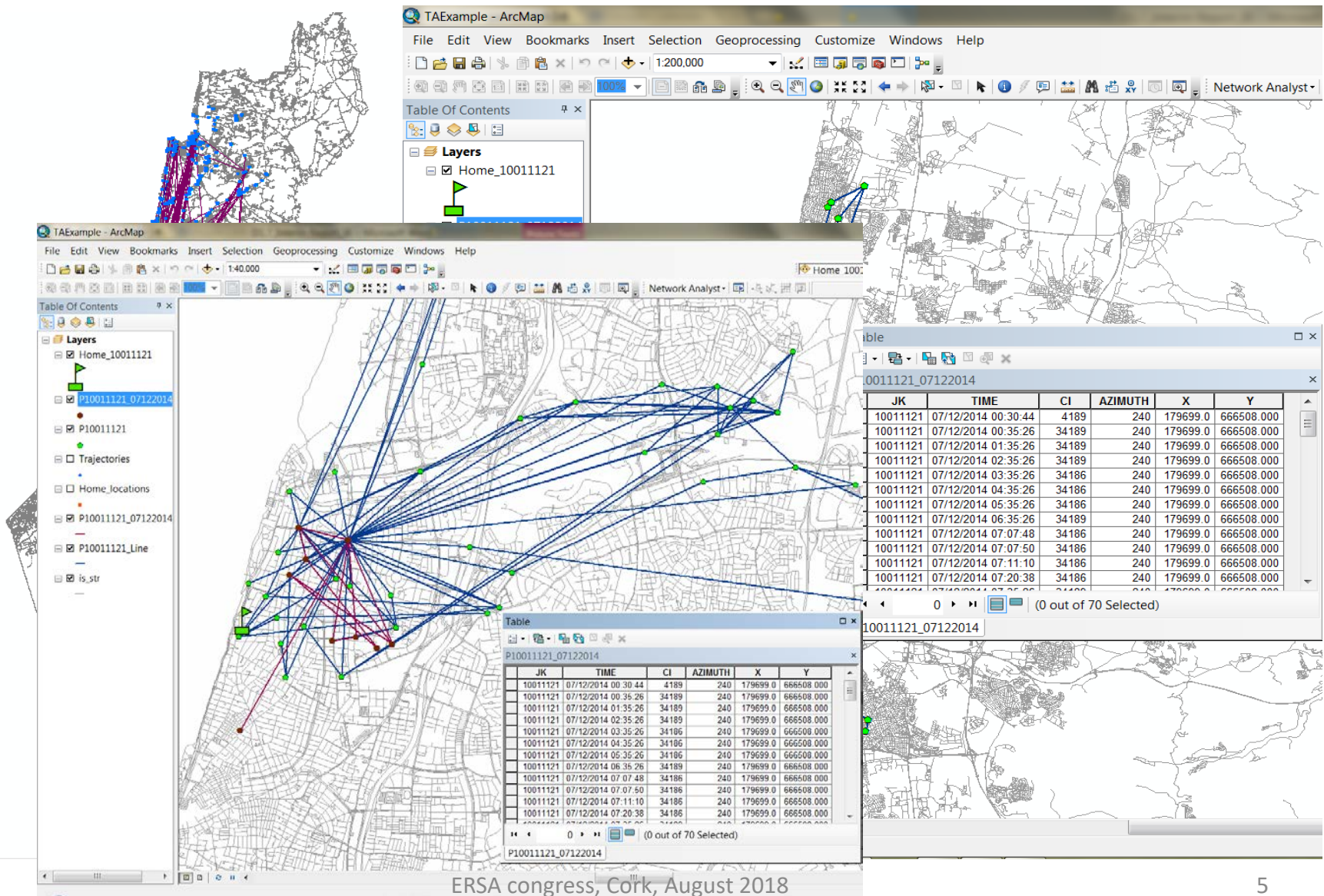Data on stops, lines, bus trips and timetable.
Updated every day.
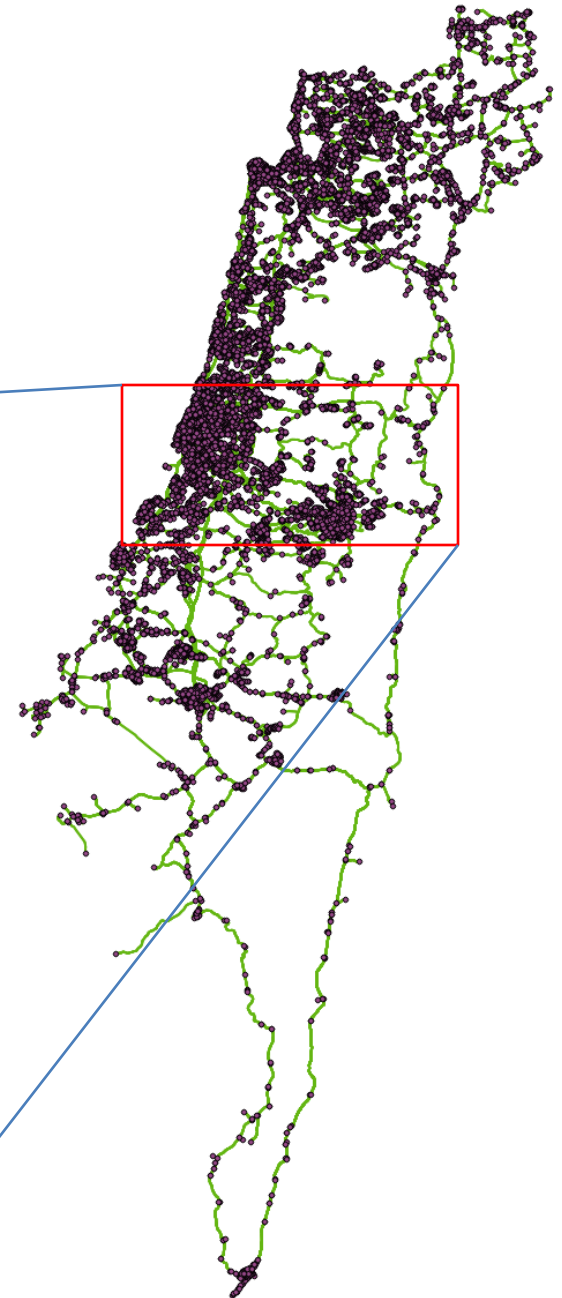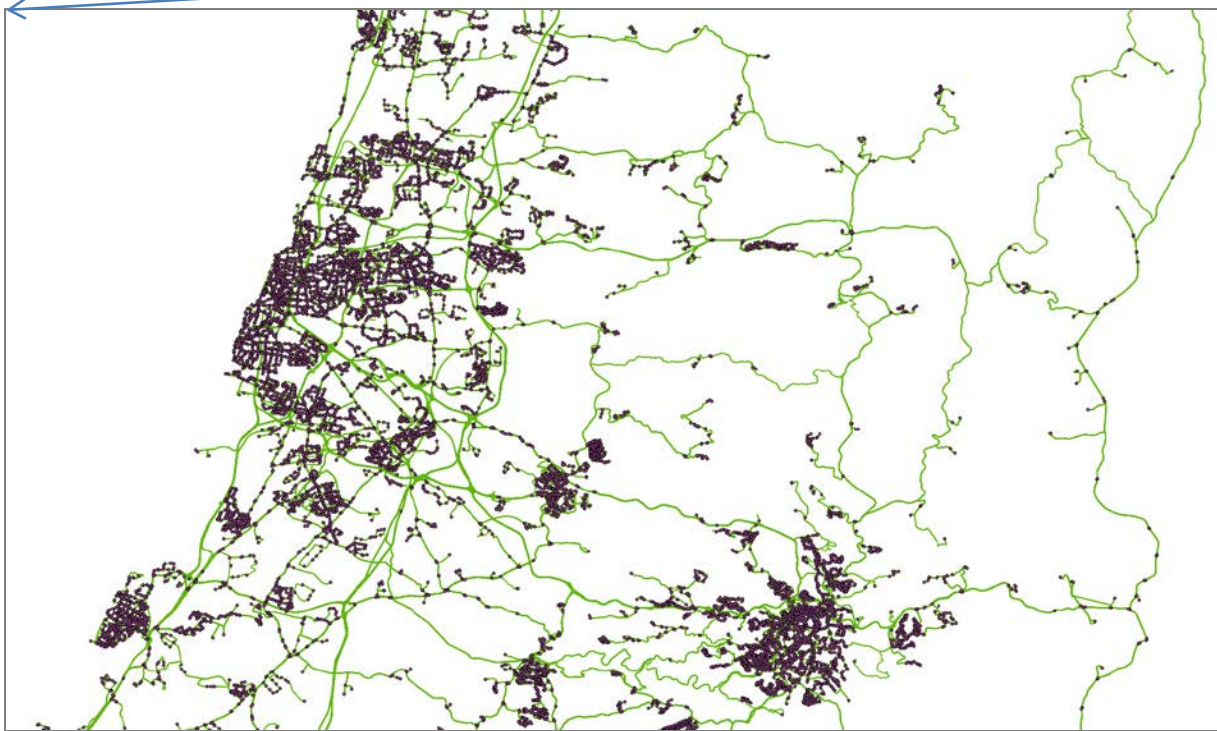
Israel totals:
Stops: ~27,500; Bus lines: ~7,700; Bus trips: ~250K, Timetable: ~10M records

Cellular Phone (+ PT VEHICLES GPS + BOARDING COUNTS) data

Israeli Smartcard system is "TAP-on" only

- Like almost everywhere in the world, Israeli **<u>bus</u>** Smartcard system is **Tap-on.** Traveler is registered only when boarding

- Israeli **<u>train</u>** Smartcard system is **Tap on/Tap off**

THE INVESTIGATED DATASETS – RAV-KAV + GTFS
"RAV-KAV" database for Oct 14- Nov 10, 2017 - 4 weeks, ~4M records of all types per day

Each boarding record includes (*% of valid records*):

- Unique SmartCard_ID – **100%**
- ID of Boarding Station (GTFS) **for all but EGGED** (35%), **94%**
- Boarding Time (date + time) – **100%**
- Bus line ID according to MOT – **80%**
- Operator (Egged, Dan, Train, …) – **100%**
- User profile – **100%**
- Type of payment; agreement type, fare code – **100%**
- **Full records ~ 50%**

Info | Table | Preview

alltrips2304

General info

Relation type:	Table
Owner:	postgres
Pages:	54303
Rows (estimation):	3265510
Rows (counted):	3254322
Privileges:	select, insert, update, delete

Fields
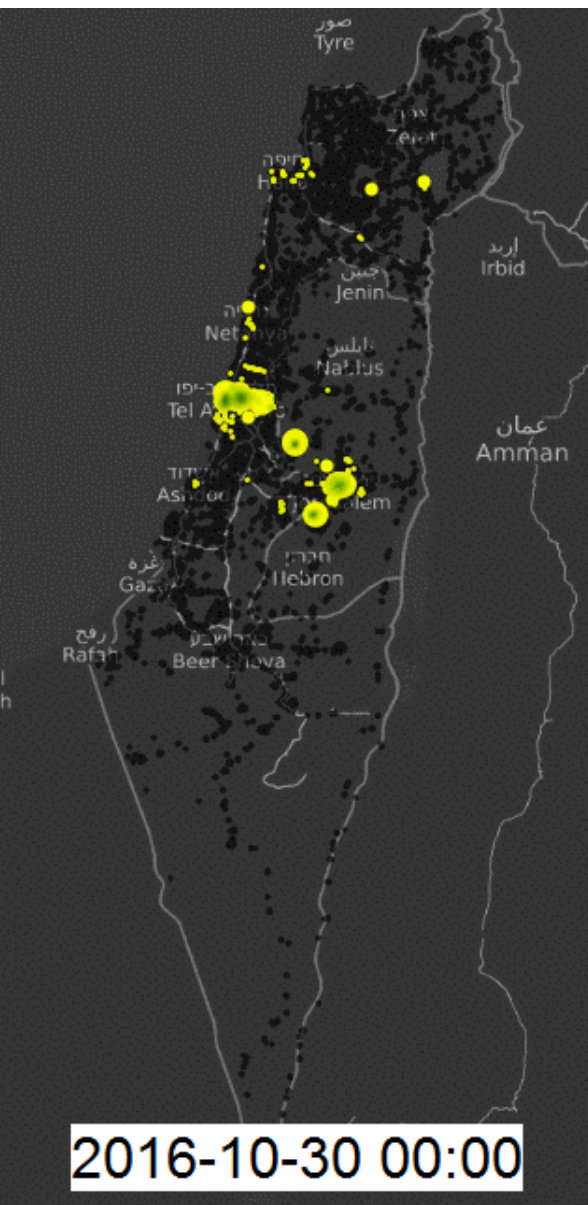
#	Name	Type	Length	Null
1	id	int4	4	N
2	smartcard_id	int8	8	Y
3	agreementtype	int4	4	Y
4	predefinedcontract	int4	4	Y
5	farecode	int4	4	Y
6	contractcustomeprofile	int4	4	Y
7	smartcardtype	int4	4	Y
8	boardingstop	int4	4	Y
9	boardingtime	varchar		Y
10	datetimefirststamp	varchar		Y
11	jouneyinterchange	int4	4	Y
12	validationtype	int4	4	Y
13	line_id	int4	4	Y
14	trip_id	int4	4	Y
15	line_direction	int4	4	Y
16	line_alternative	varchar		Y
17	eventprovider	int4	4	Y
18	eventdevice	int4	4	Y

DB Manager — □ ✕

Database Schema Table

Tree

- GeoPackage
- Oracle Spatial
- PostGIS
  - Four
  - Large
  - april
    - public
      - alltrips2304
      - bus_lines
      - codealldays

Info | Table | Preview

id	smartcard_id	eementt	efinedcor	farecode	tcustome	artcardty	ardingst	boardingtime	imefirsts	eyinterch	lidationty	line_id	trip_id	e_directi	_alternat	entprovic	ventdev
1	1	37821526	61	200	NULL	0	1	7001	2017/04/23 12:59:44	2017/0...	0	22	1	NULL	NULL	NULL	2	3
2	2	38742813	10	0	NULL	4	1	7001	2017/04/23 07:17:09	2017/0...	0	22	1	NULL	NULL	NULL	2	3
3	3	38742813	10	0	NULL	4	1	7001	2017/04/23 07:17:10	2017/0...	0	22	1	NULL	NULL	NULL	2	3
4	4	38742814	10	0	NULL	4	1	7001	2017/04/23 07:16:51	2017/0...	0	22	1	NULL	NULL	NULL	2	3
5	5	38742814	10	0	NULL	4	1	7001	2017/04/23 07:16:53	2017/0...	0	22	1	NULL	NULL	NULL	2	3
6	6	38902616	11	0	NULL	0	1	7001	2017/04/23 10:56:42	2017/0...	0	22	1	NULL	NULL	NULL	2	3
7	7	39130185	20	141	NULL	0	1	7001	2017/04/23 18:09:04	2017/0...	0	22	1	NULL	NULL	NULL	2	3
8	8	39678989	61	200	NULL	0	1	7001	2017/04/23 12:40:43	2017/0...	0	22	1	NULL	NULL	NULL	2	3

Aggregate analysis

Israel PT pulse

(Nadav Levy, TAU + BGU)

Number of passengers boarding at a stop, per week

Stops241017
- 0 - 1000
- 1000 - 5000
- 5000 - 12000
- 12000 - 23000
- 23000 - 36000
- 36000 - 116000

Trips and travelers, by days of the week (03:00 – 03:00 next day)

More than 12 boarding per day (0.5% of smartcards, 4% of boardings) – excluded

Legend: ■ Unique RAV KAV travelers ■ RAV KAV payments ■ Paper tickets

Unexpected outcome #1 – 27% of travelers board once a day
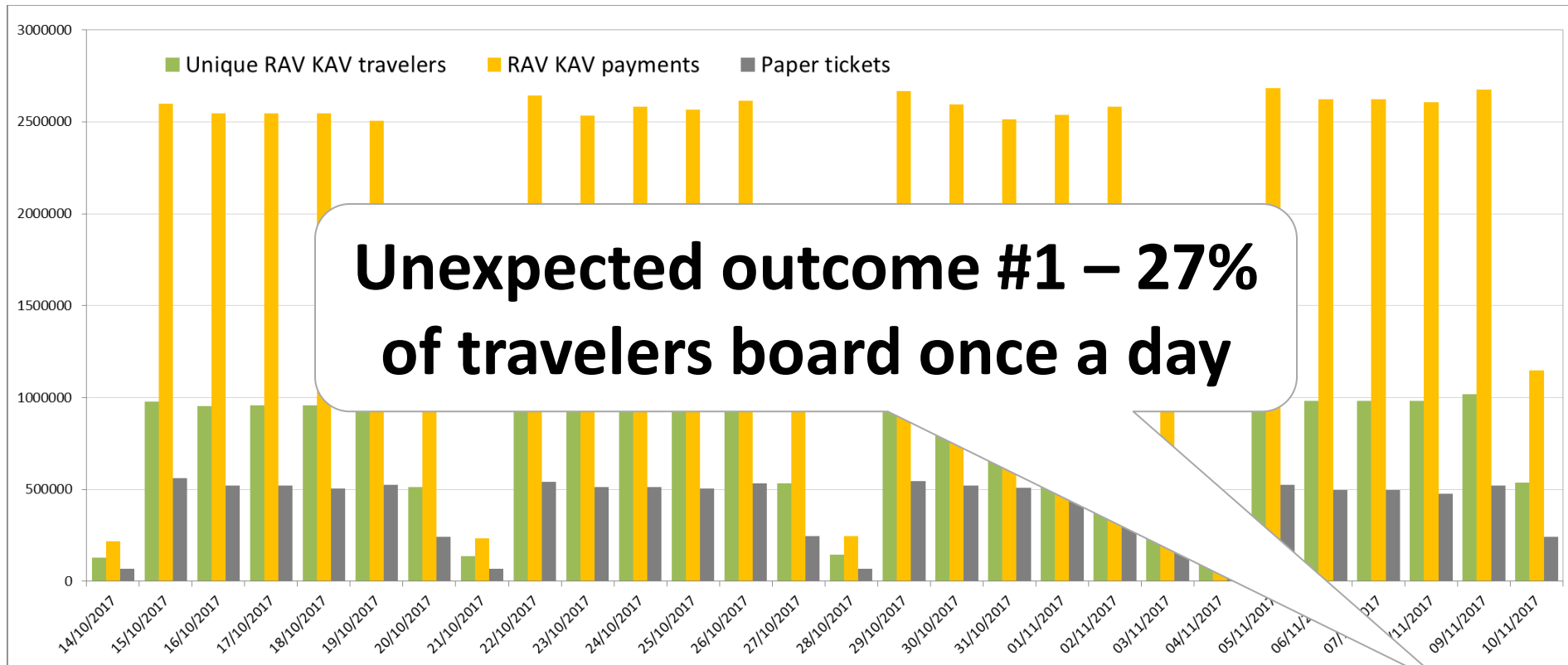
WEEKLY STATISTICS

14M RAV-KAV + **3M** paper tickets

1.7M unique RAV-KAV travelers

Average boardings per traveler (workday) **2.7**

Average PT use - **3** days per week

1	**boarding ONLY per day – 27%**
2	boardings per day – **35%**
3-4	boardings per day – **27%**
5-6	boarding per day – **8%**
7-12	boarding per day – **3%**

Boarding by half-hours of the day,
for the working days and two days of the weekend
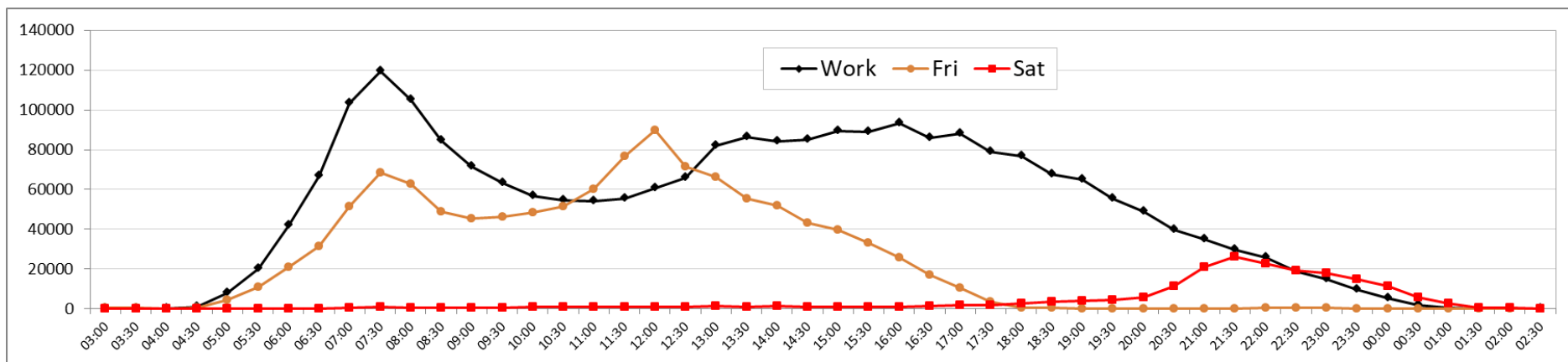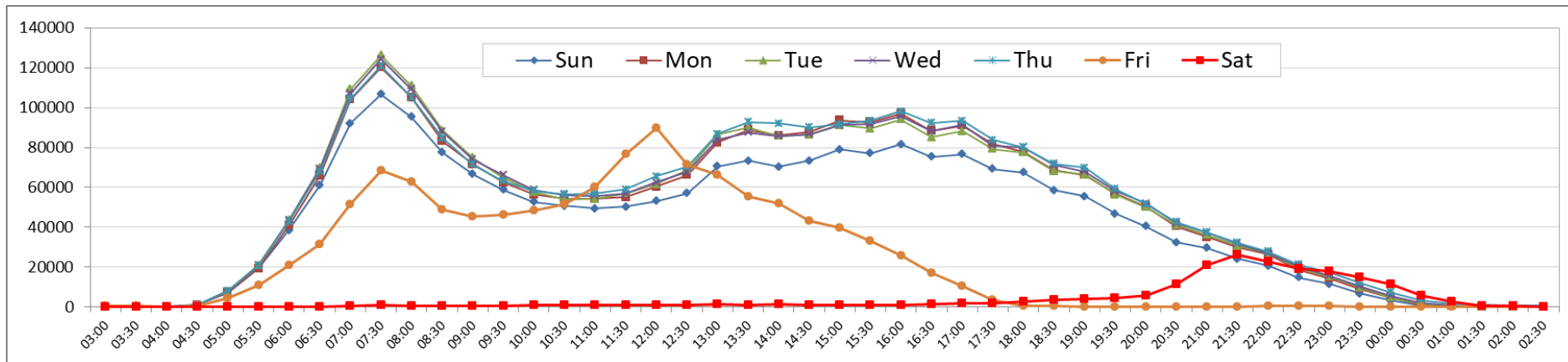
Number of travel days per week

Number of the days per week the users use PT
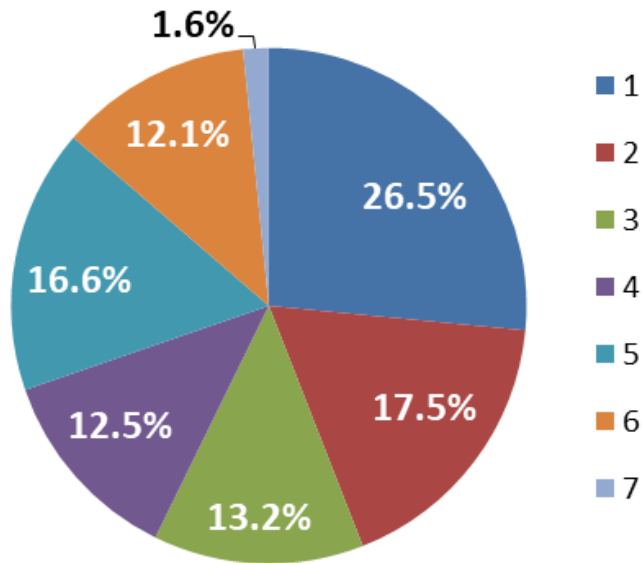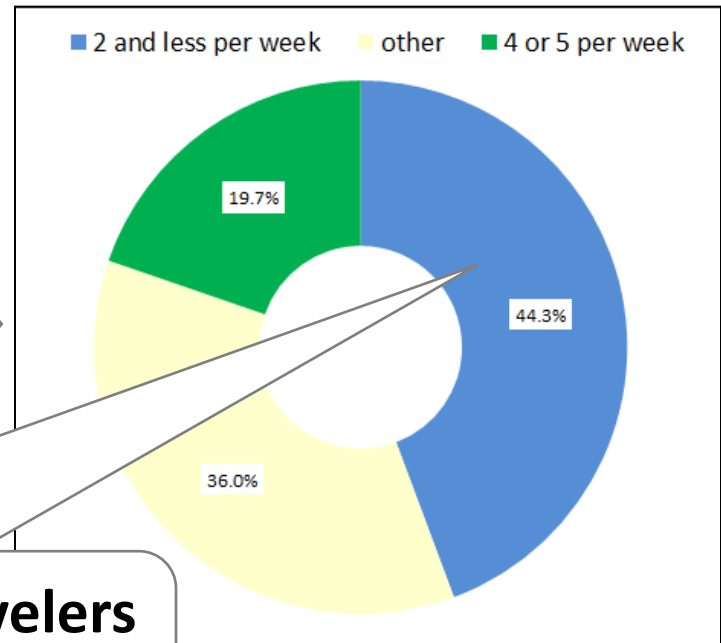

14-20.10 – 1,709,401 unique users

Legend: 1, 2, 3, 4, 5, 6, 7

26.5% — 1
17.5% — 2
13.2% — 3
12.5% — 4
16.6% — 5
12.1% — 6
1.6% — 7

Number of boarding, by week
Week 14-20/10 - 17,019,401
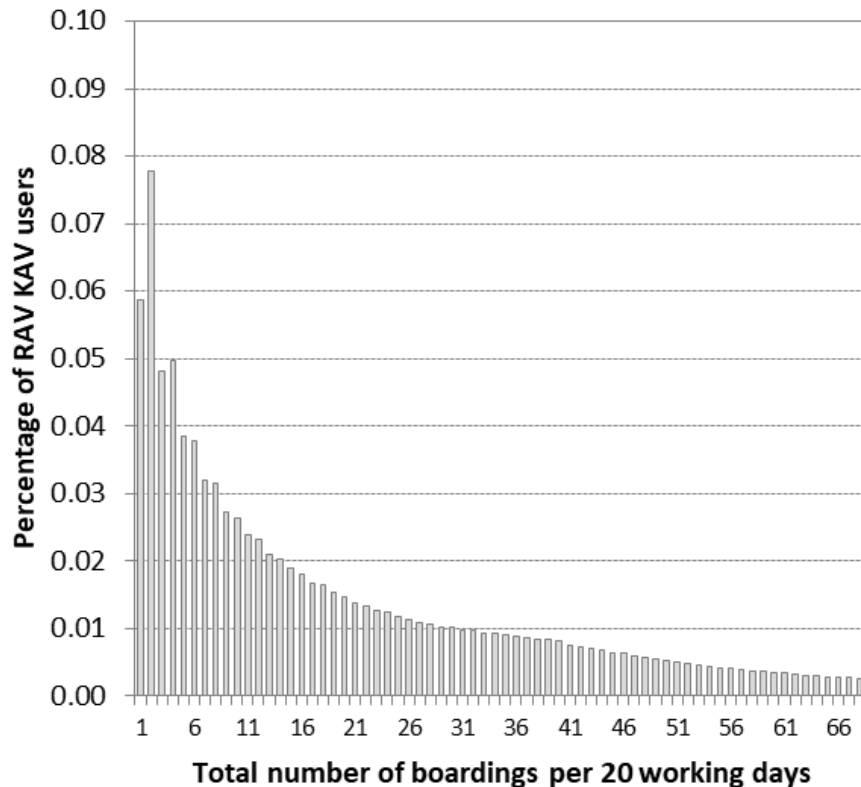Week 21-28/10 - 17,231,461
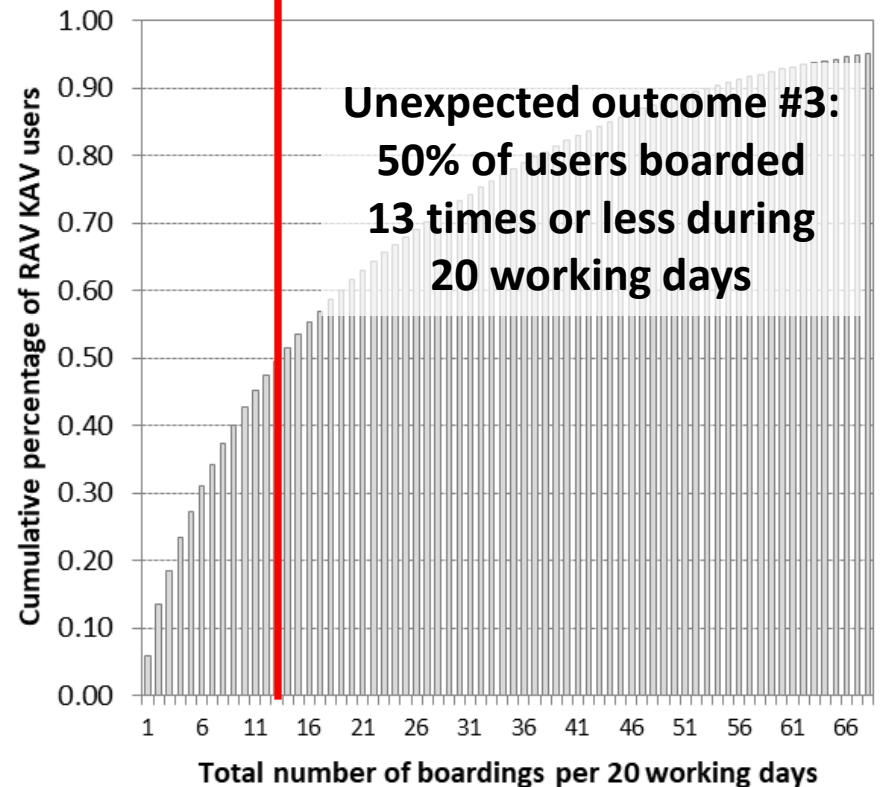Week 29-03/11 - 17,161,609
Week 04-11/11 - 17,469,340

Legend: 2 and less per week, other, 4 or 5 per week

44.3% — 2 and less per week
36.0% — other
19.7% — 4 or 5 per week

Unexpected outcome #2 - *45%* of travelers use PT one or two days per week

Many travelers use PT only few times a month
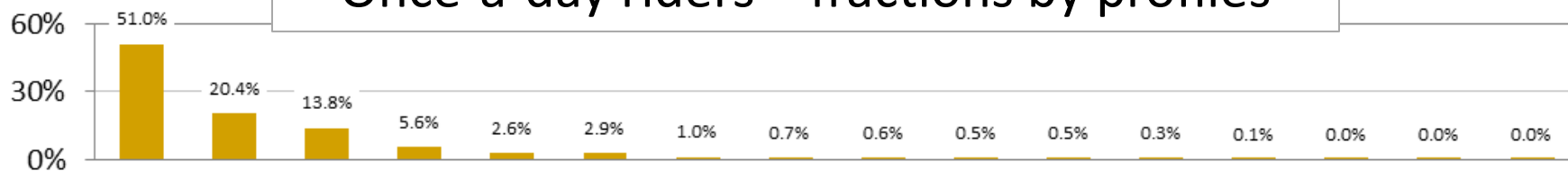

Left chart — "95% of PT-users"
- Y-axis: Percentage of RAV KAV users (0.00 to 0.10)
- X-axis: Total number of boardings per 20 working days (1 to 66)

Right chart — "95% of PT-users"
- Y-axis: Cumulative percentage of RAV KAV users (0.00 to 1.00)
- X-axis: Total number of boardings per 20 working days (1 to 66)

**Unexpected outcome #3:
50% of users boarded
13 times or less during
20 working days**

Aggregate analysis
by users' profiles

Fraction of travelers by profiles
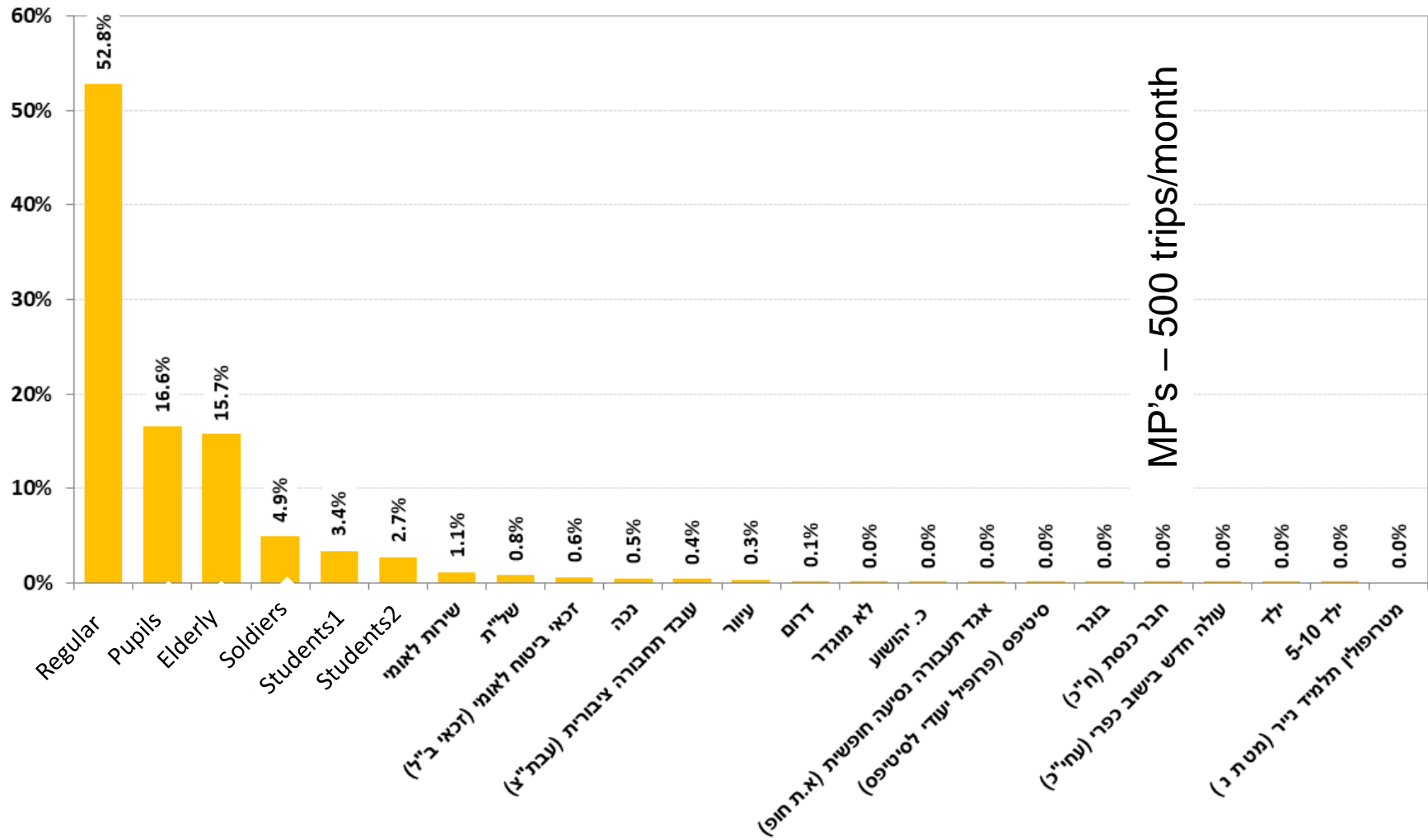
Once-a-day riders – fractions by profiles

Once-a-day riders among all profile's travelers
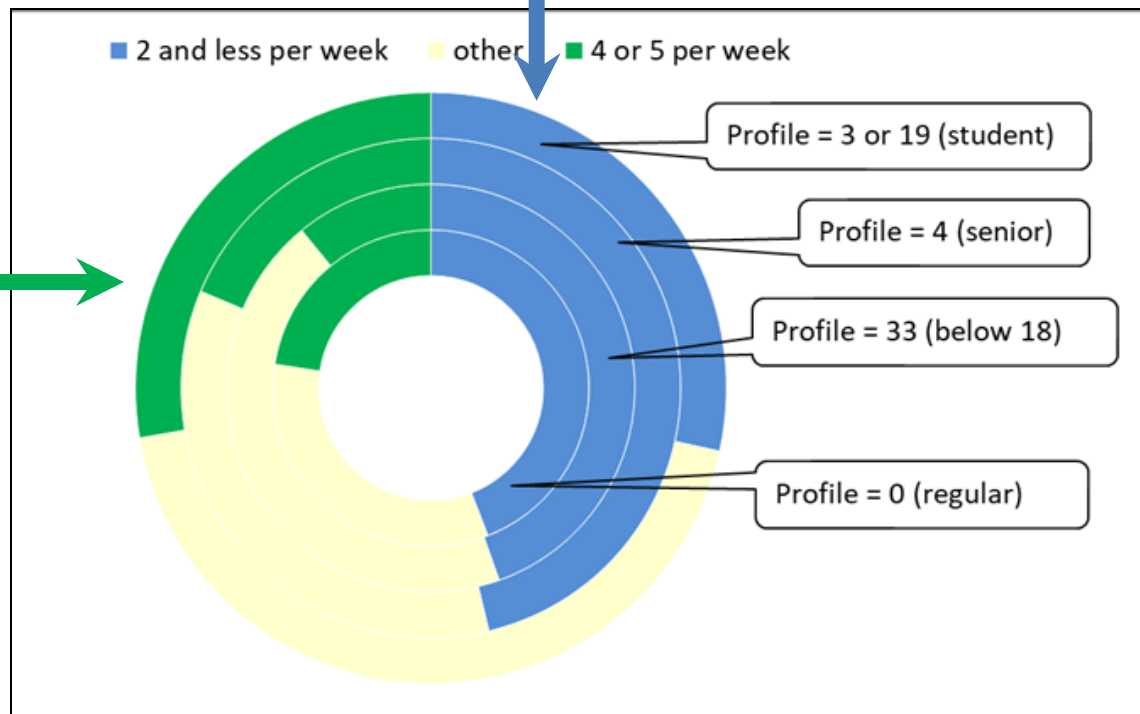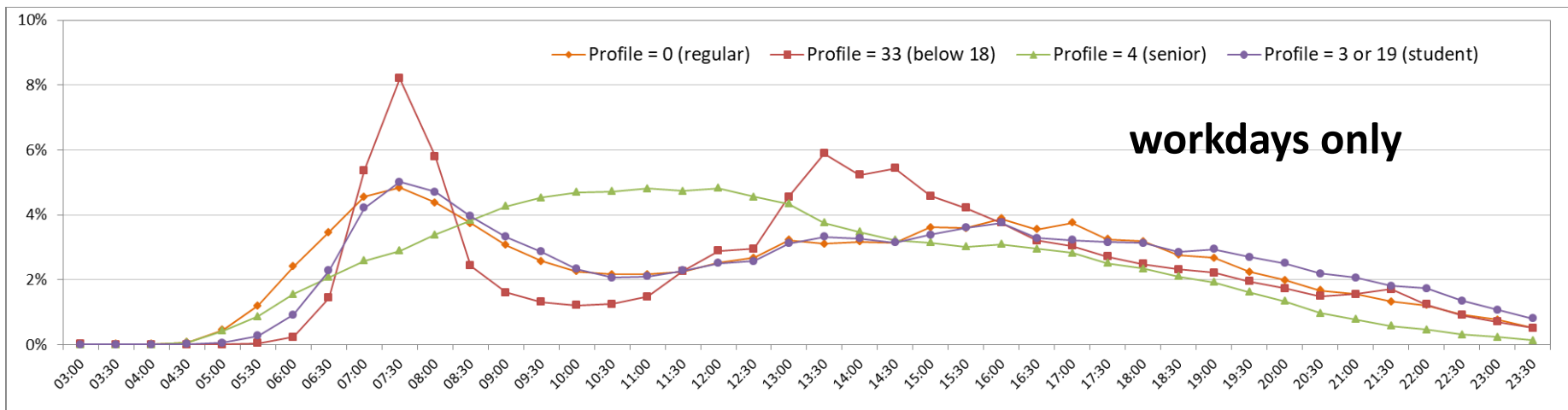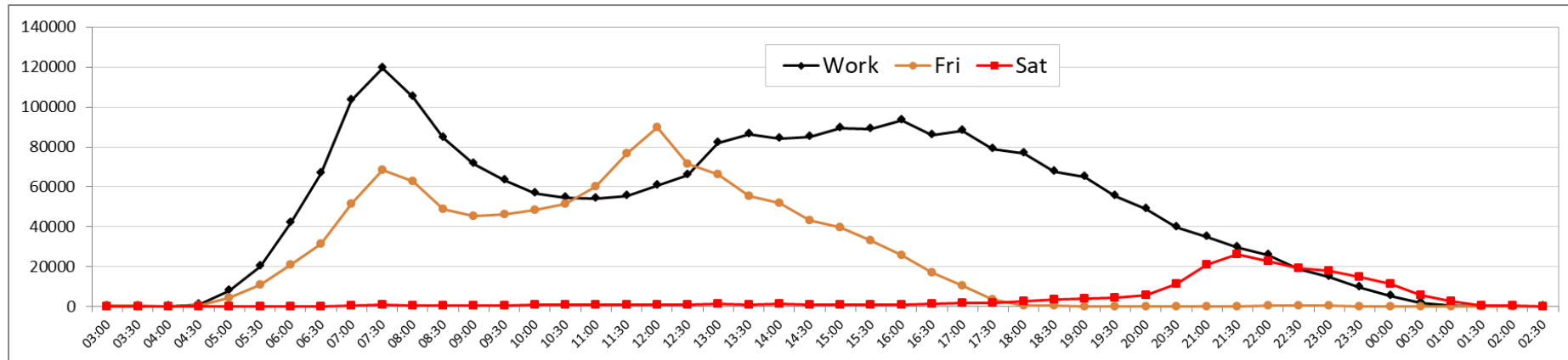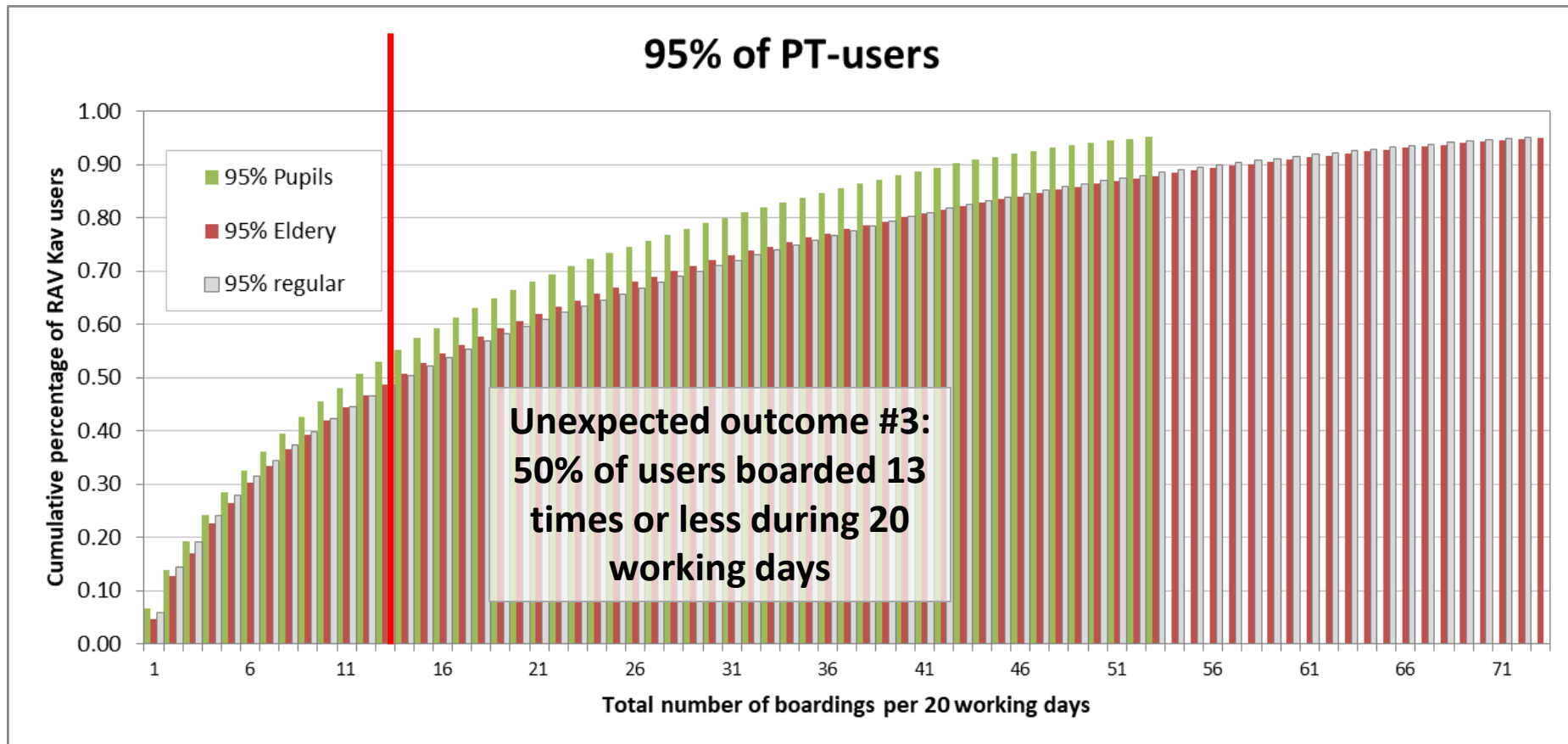
Population average – 27%

ERSA congress, Cork, August 2018
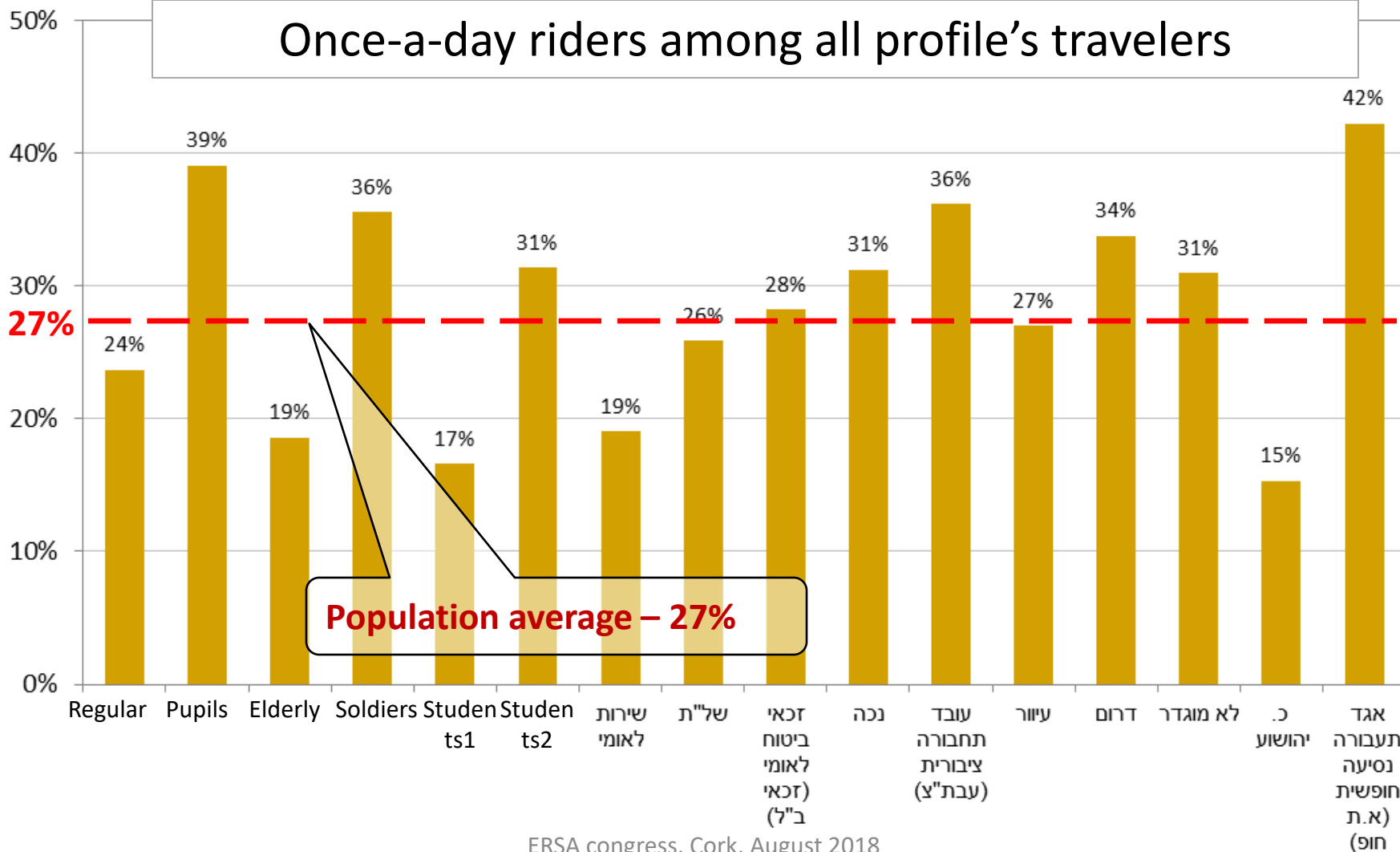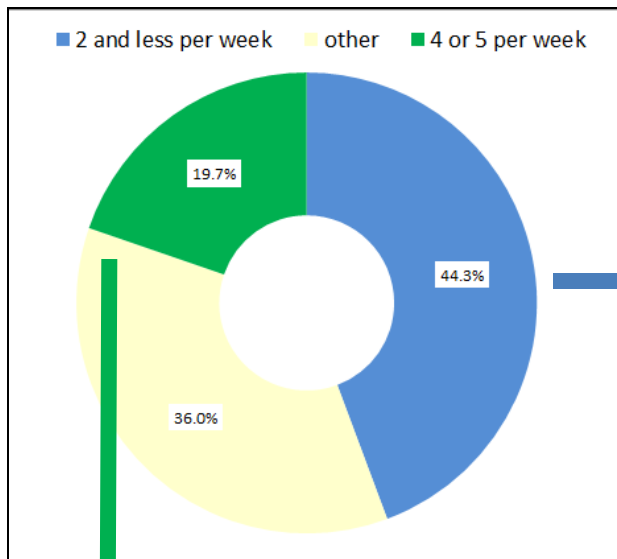
Weekly PT-use pattern, by profiles

Legend (top chart): 2 and less per week · other · 4 or 5 per week
- 19.7%
- 44.3%
- 36.0%

Legend (bottom chart): 2 and less per week · other · 4 or 5 per week
- Profile = 3 or 19 (student)
- Profile = 4 (senior)
- Profile = 33 (below 18)
- Profile = 0 (regular)

Boarding time, average and by profiles

Monthly use of PT is similar for most of the profiles, besides pupils ("below 18"), who travel less than the rest


95% of PT-users

Legend:
- 95% Pupils
- 95% Eldery
- 95% regular

Unexpected outcome #3: 50% of users boarded 13 times or less during 20 working days

Y-axis: Cumulative percentage of RAV Kav users

X-axis: Total number of boardings per 20 working days

Disaggregate analysis

What are the spatial habits of PT-users?

Travelers who use PT regularly have definite *activity centers*
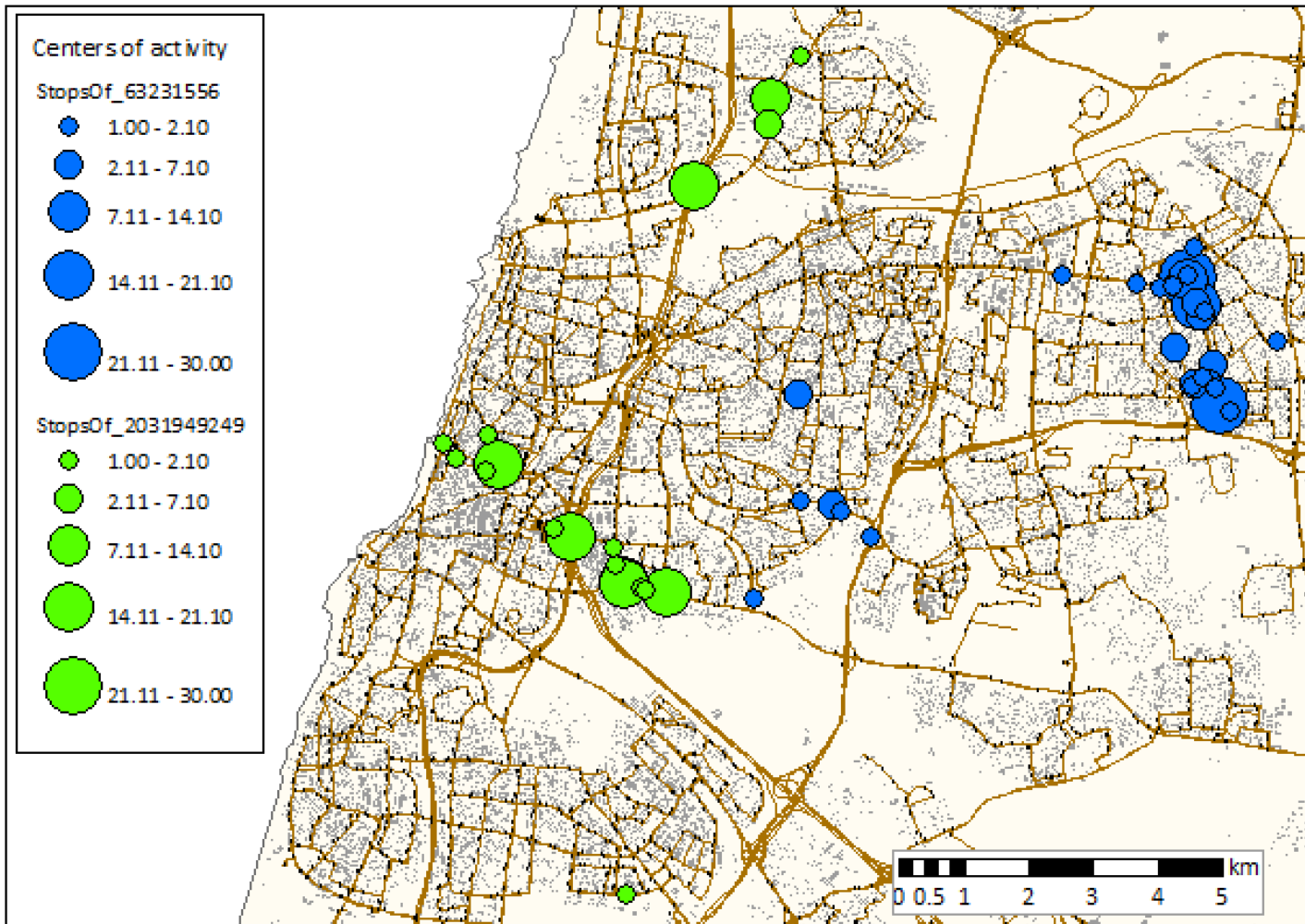
# Typical number of activity centers is 5 – 8, the rest 70% of stops are used for less than 25% boardings

Number of most visited stops given a percentile of boardings
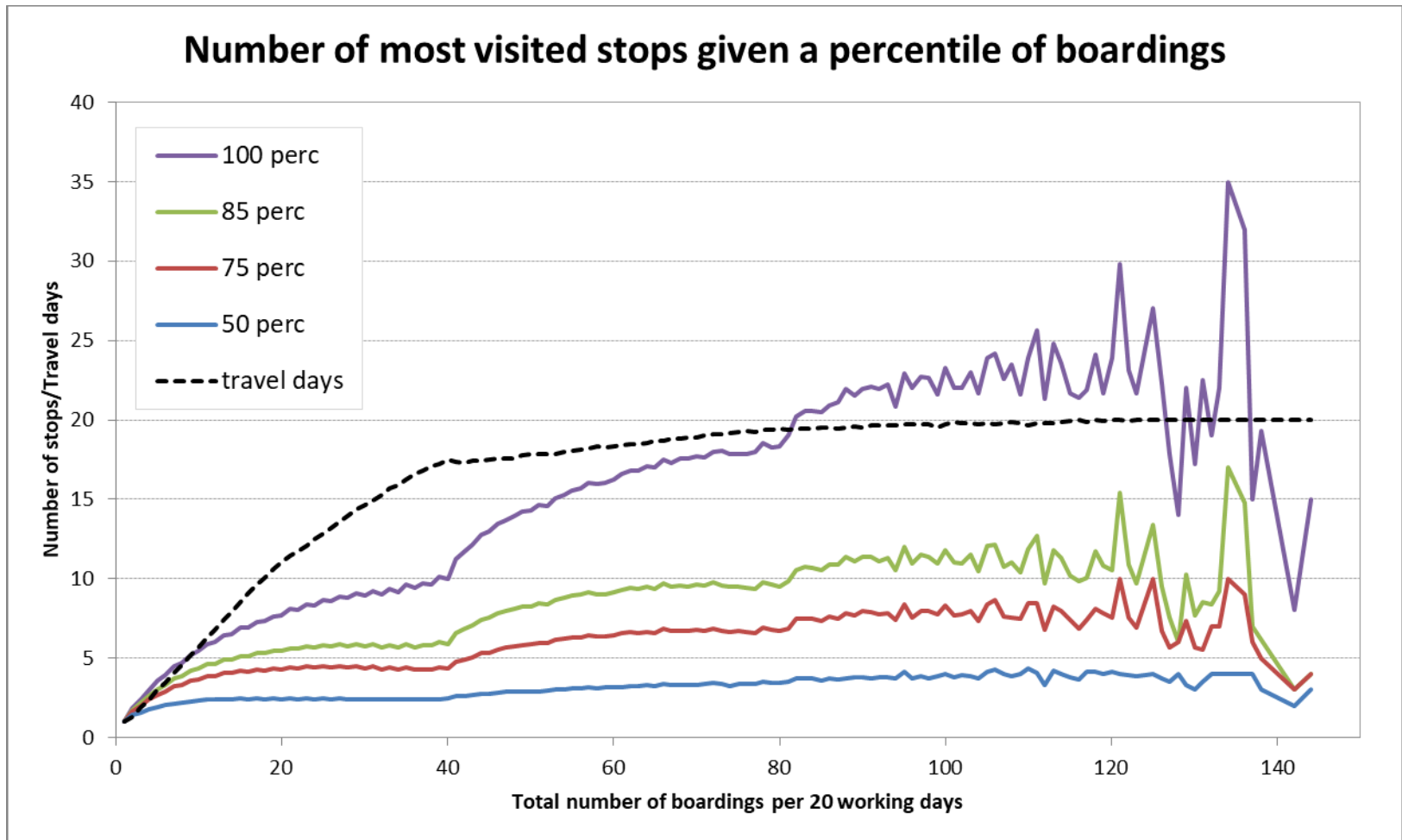
# How do travelers, who start their day with the PT, return home?

The problem of destination:
travelers' destination and possible mode are estimated based on
spatial proximity of bus lines and boarding stop stops

Stop#1

Line#1
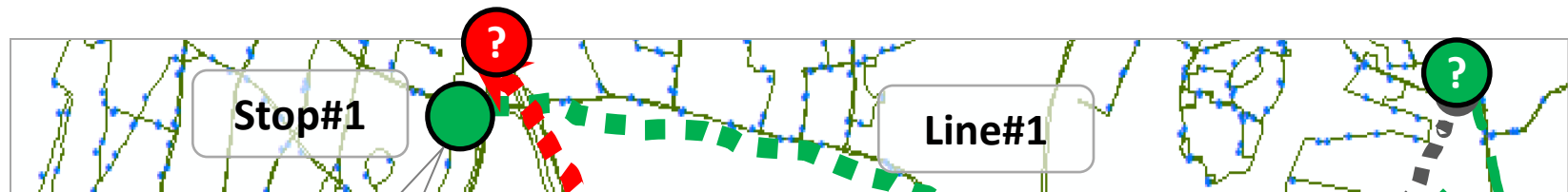
Due to mismatch between line coding in GTFS and SmartCard data, we are able to identify distances between the boarding stop and the nearest stop of the last return line for 10% of daily bus users only…
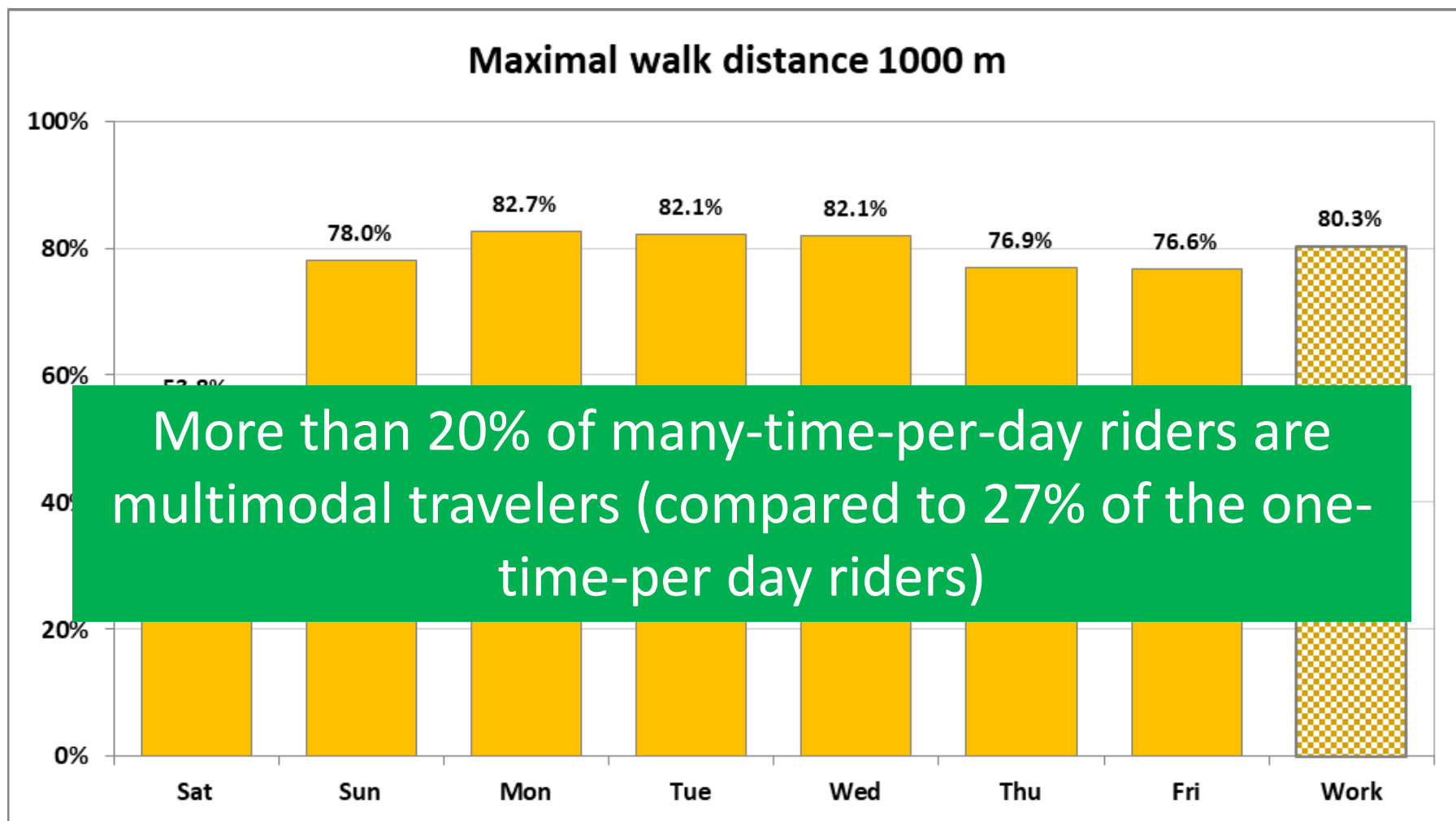
Is there a stop on Line #2 that is close to the 1st boarding stop?

Line#2

Stop#2
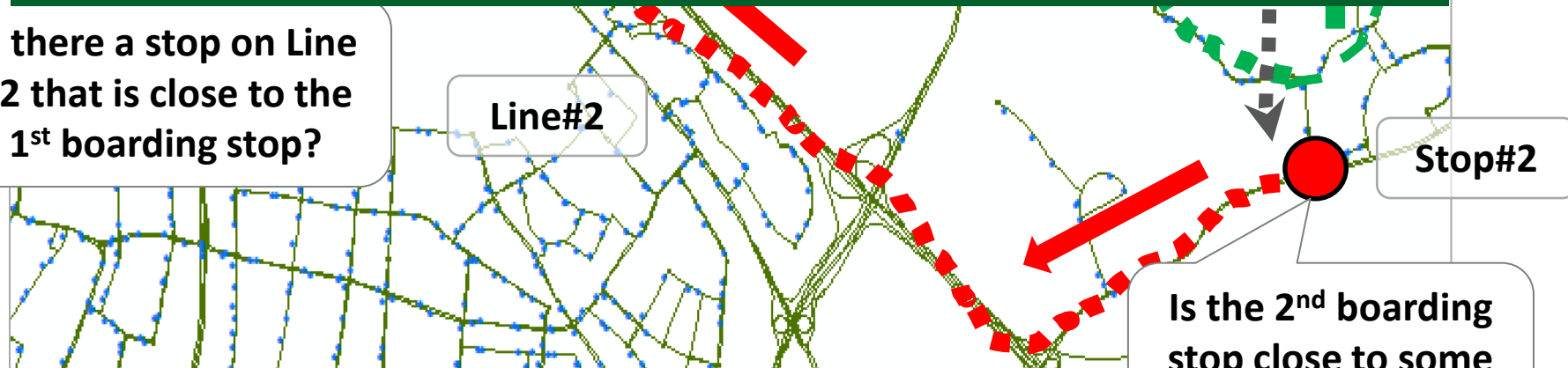
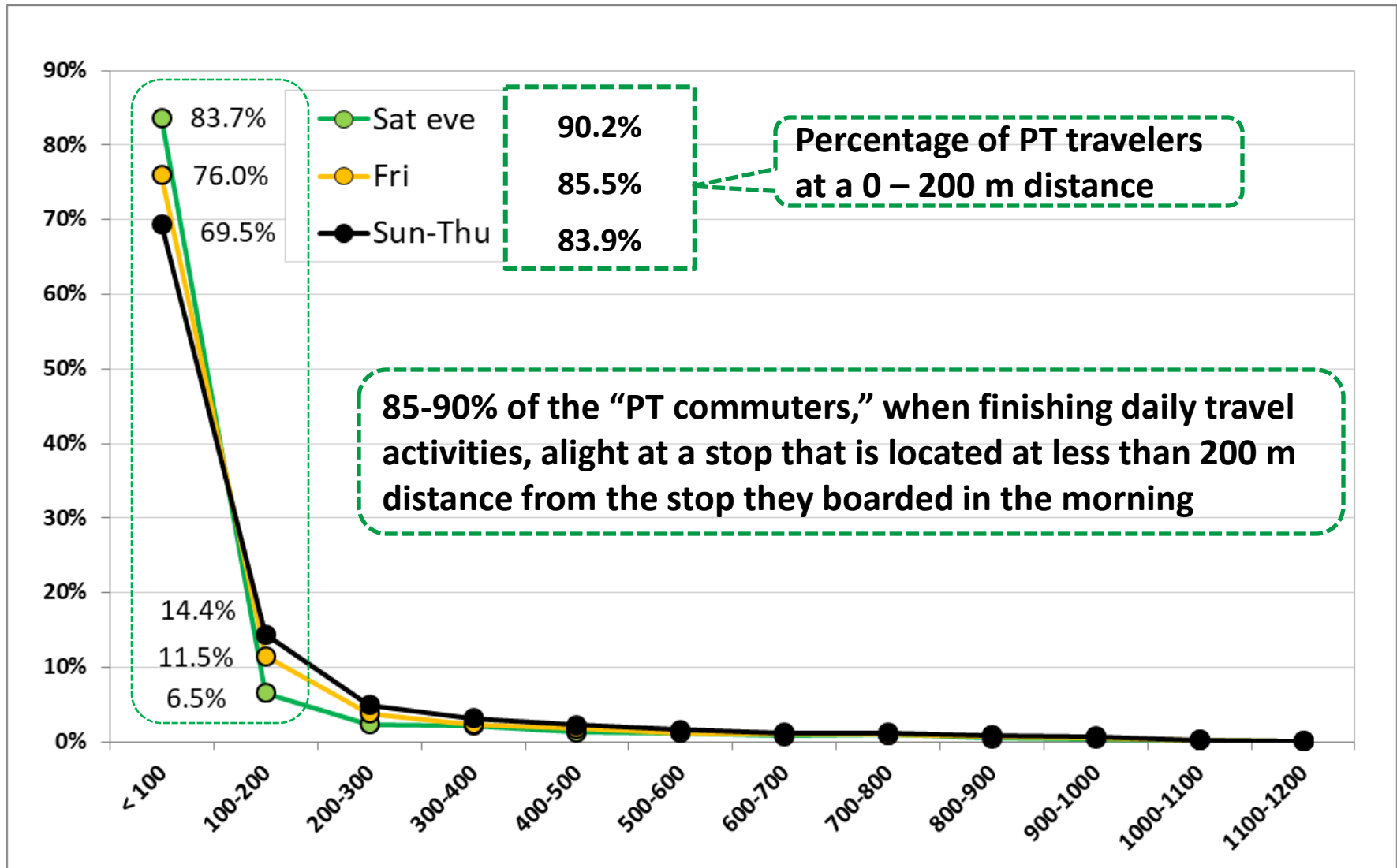**Is the 2nd boarding stop close to some stop of Line #1?**

Identification of destination stop demands heavy spatial querying that accounts for the distances between 28K boarding stops, 7K lines and 28K possible alighting stops

~80% of PT-users starting their day with a bus trip will travel back home also by bus; ~20% use other modes to get back.
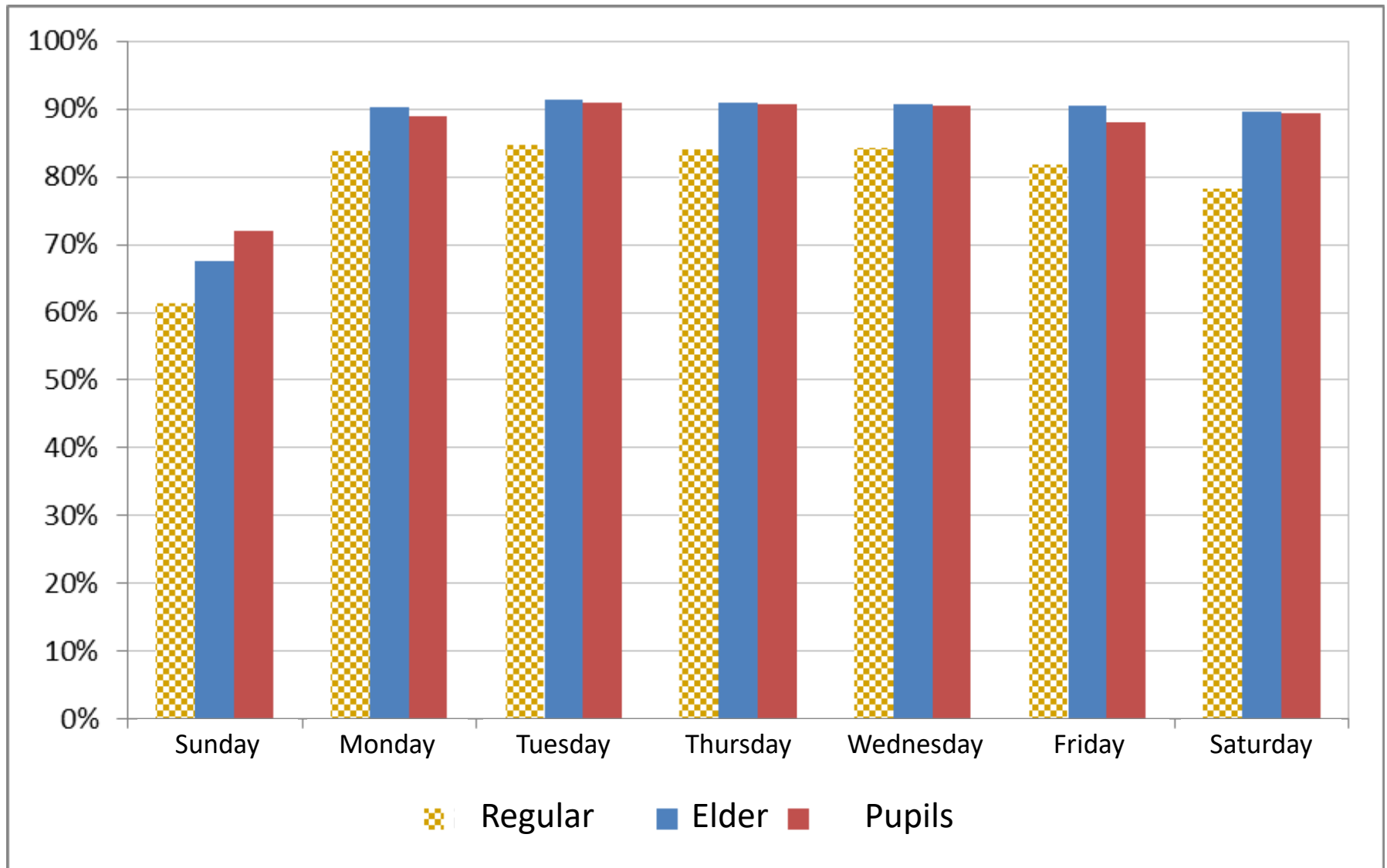

Maximal walk distance 1000 m

	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Work
	5?.?%	78.0%	82.7%	82.1%	82.1%	76.9%	76.6%	80.3%

More than 20% of many-time-per-day riders are multimodal travelers (compared to 27% of the one-time-per day riders)

"Stop-Line distance" view overestimates PT commuting…

The stop used for boarding in the morning is, usually, very close to the nearest stop of the line of the last trip


Percentage of PT travelers at a 0 − 200 m distance

90.2%
85.5%
83.9%

85-90% of the "PT commuters," when finishing daily travel activities, alight at a stop that is located at less than 200 m distance from the stop they boarded in the morning

Profiles with a high (90%+) fraction of PT commuters

Do travelers who start their day with the PT and return home with it ("commuters") repeat their patterns in days?
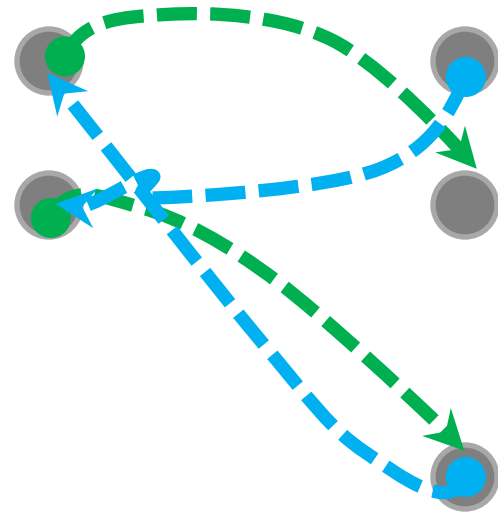
First   **Last**

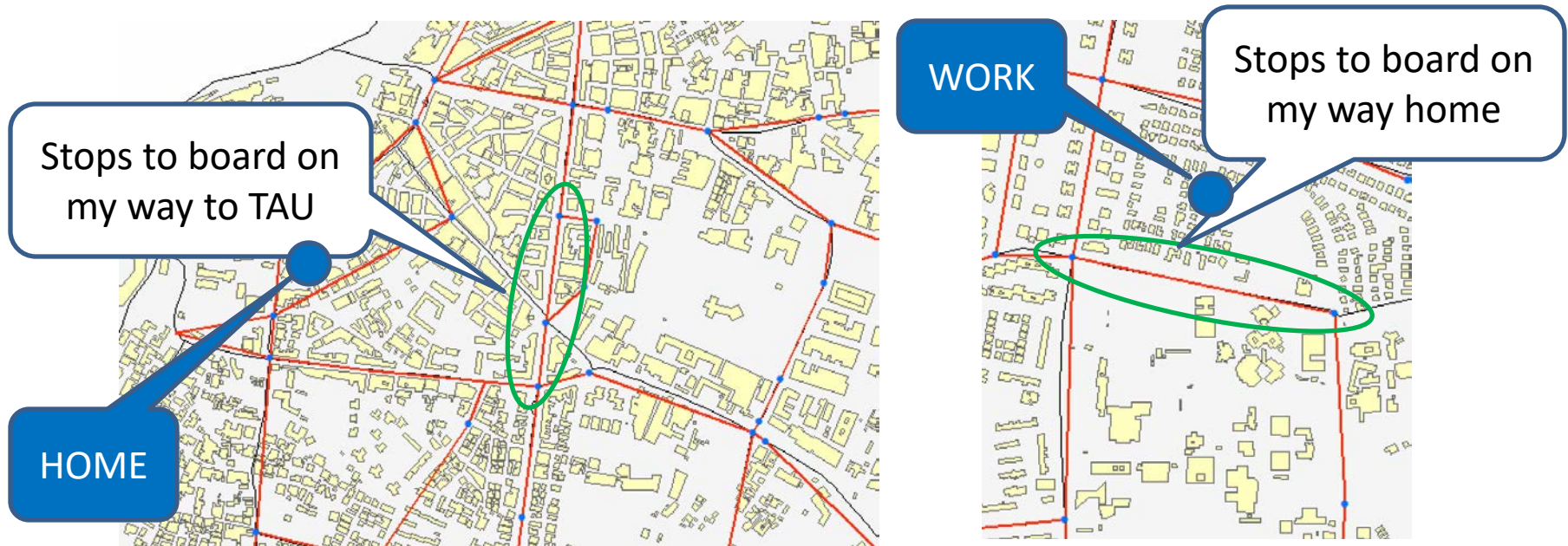**First**   **Last**

?
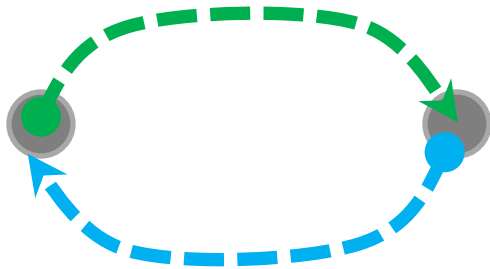
Commuters

Free PT-users

How can we recognize commuters?

Proxy of Ma et al., (2017):

Commuters start their daily travel activities not far from their home and board last daily trip near the same location.
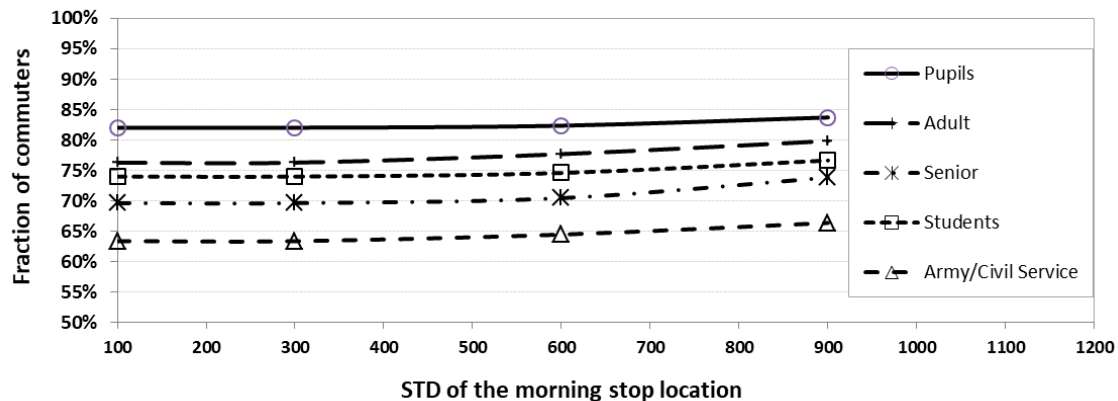Broader than home-work-home travelers, e.g. students

Ma X, Liu C, Wen H, Wang Y, Wu Y-J. 2017, Understanding commuting patterns using transit smart card data. J Transp Geogr., 58:135–145.

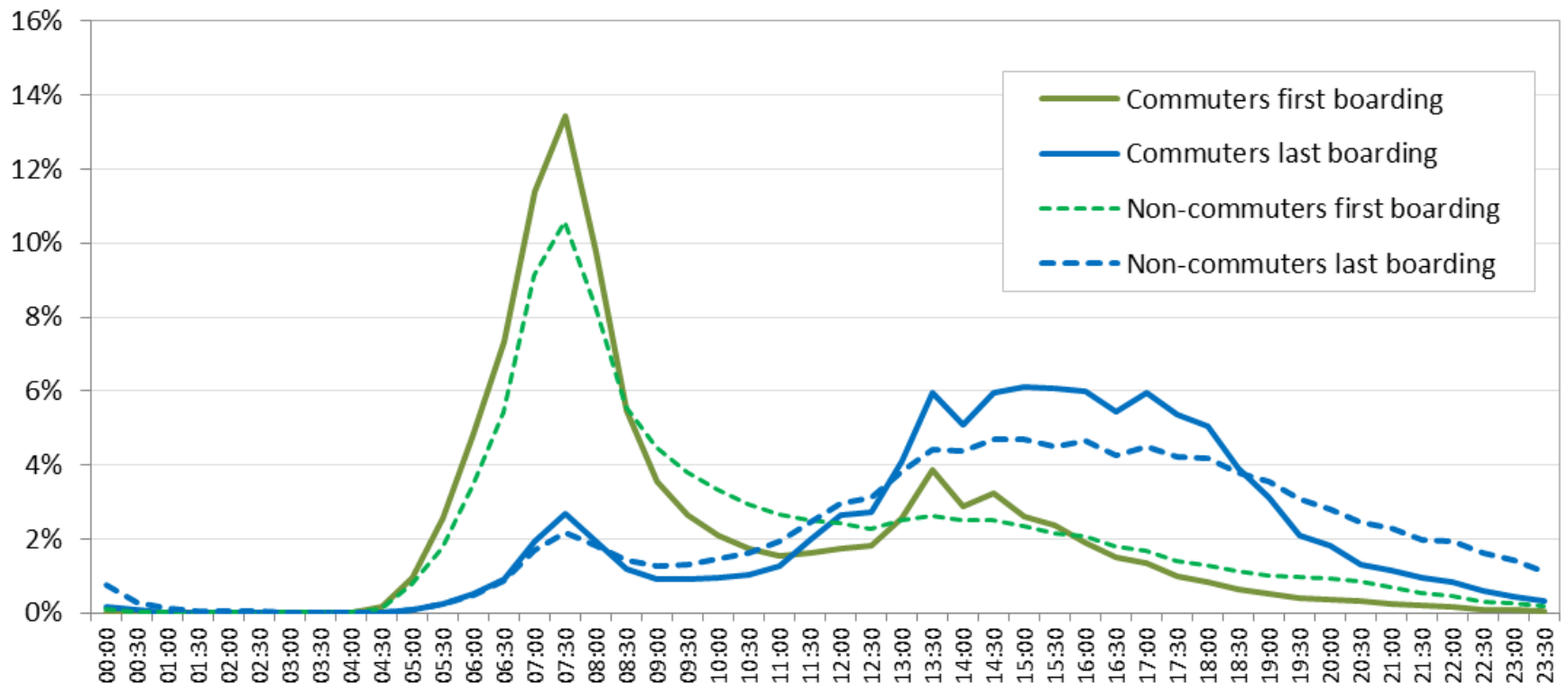Fraction of BUS commuters depending on STD of the stop locations
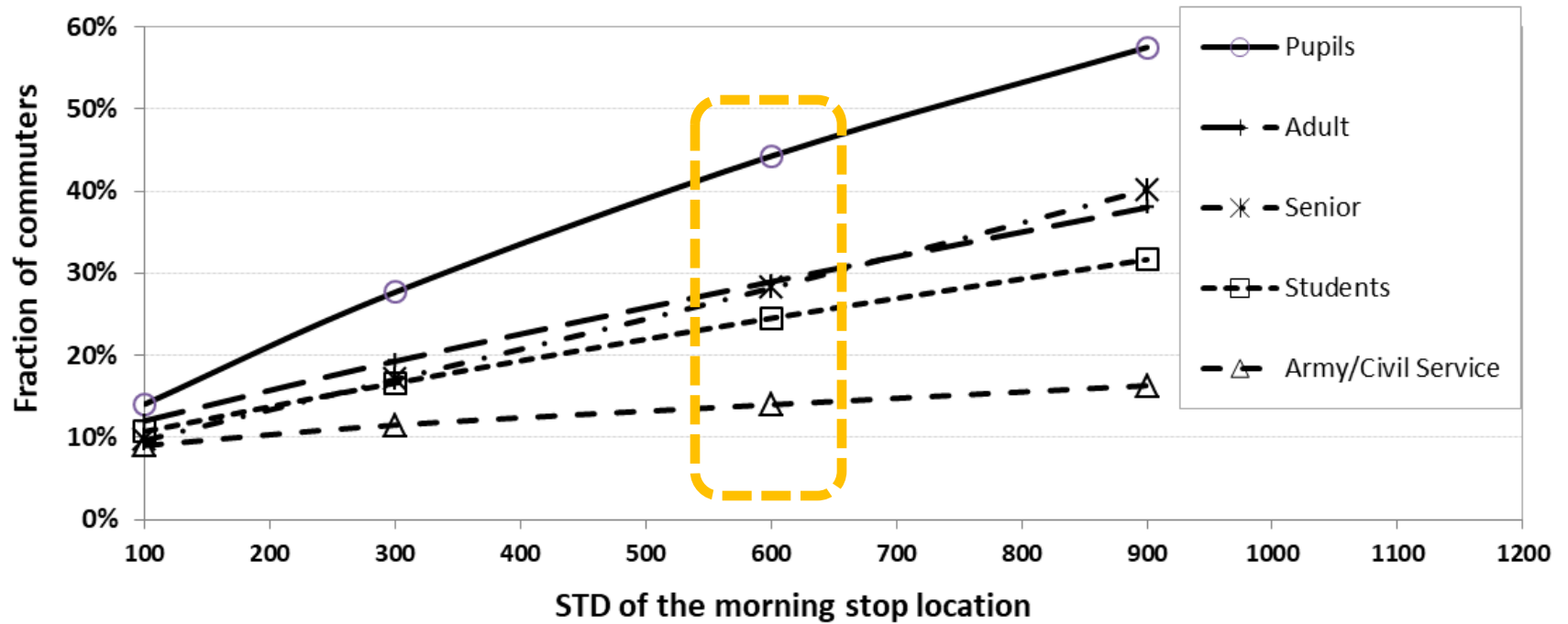
Fraction of TRAIN commuters depending on STD of the stop locations

Commuters daily schedule is concentrated around the peak hours (STD = 600m)
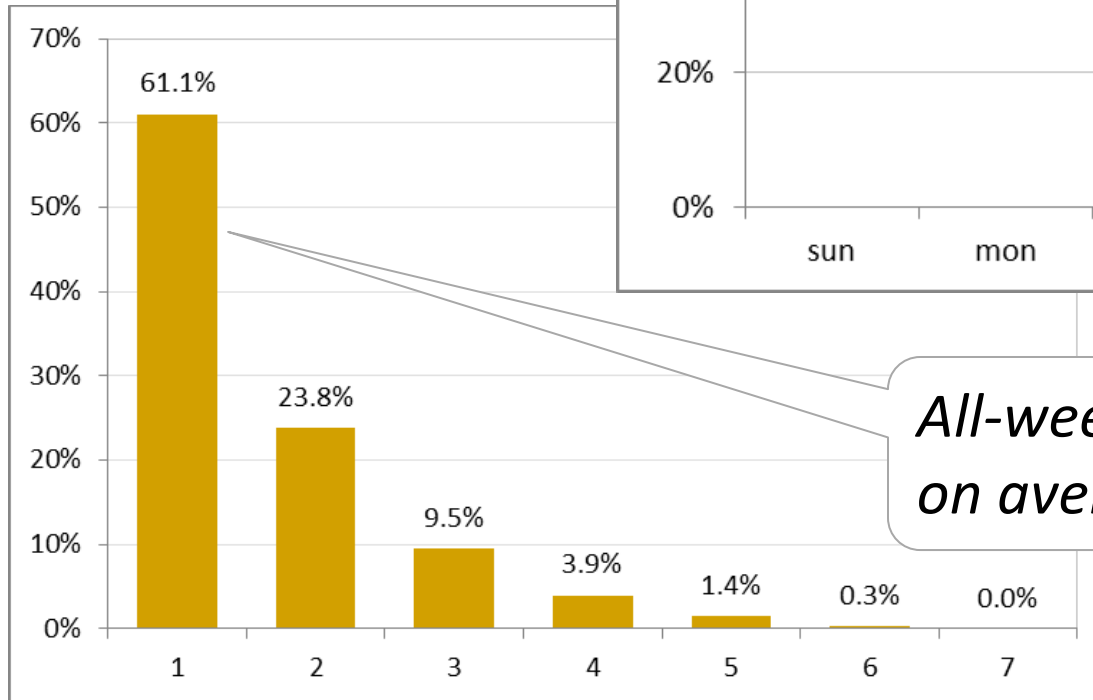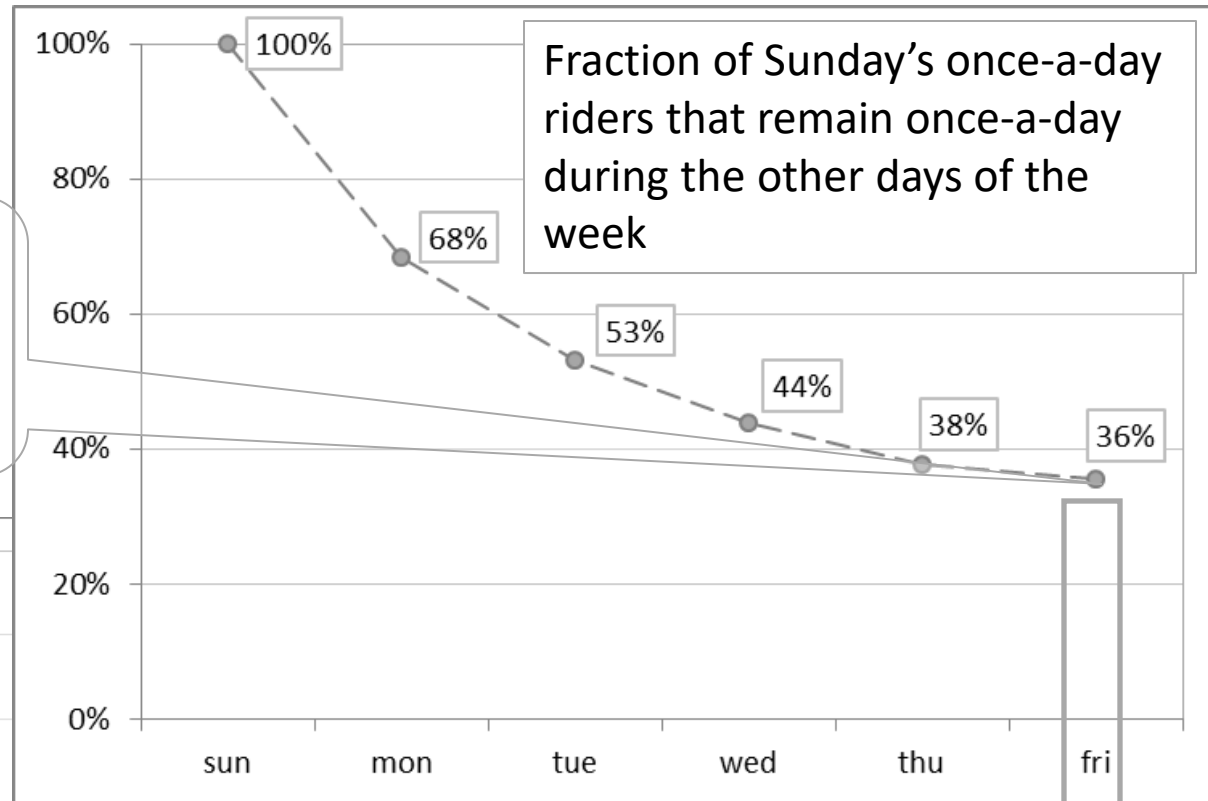

Commuters vs the rest of travelers, time of the first and last trip

Legend:
- Commuters first boarding
- Commuters last boarding
- Non-commuters first boarding
- Non-commuters last boarding

Once-a-day riders

Once-a-day riders
27%

2/3 of once-a-day riders board twice or more some other day of the week. 1/3 of them are all-week once-a-day riders

Fraction of Sunday's once-a-day riders that remain once-a-day during the other days of the week

100% — sun
68% — mon
53% — tue
44% — wed
38% — thu
36% — fri

All-week once a-day riders use PT on average, 1.6 days per week

61.1% — 1
23.8% — 2
9.5% — 3
3.9% — 4
1.4% — 5
0.3% — 6
0.0% — 7

Number of travel days per week

25% Rules of thumb

- At least 25% of bus travelers combine between the PT and non-PT modes to reach their daily activities
- At least 25% of travelers use PT very infrequently – not more than one day a week or not more than 6 trips per month
- Only 25% of travelers constantly repeat the same morning trip to work and evening trip home

The share of the "non-routine" trips, when travelers decide anew on the mode, is much higher than we expected.

Travelers would accept, for these trips, any mode that provides better service, **they are waiting for MaaS!**

Special thanks to
TAU: Nir Fulman, Yulia Grinblat
BGU: Nadav Levy

QUESTIONS?

bennya@post.tau.ac.il

benelia@bgu.ac.il

Funded by the Israeli Ministry of Transport