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A STUDY OF NON-RESPONSE IN THE GPS SUB-SAMPLE OF THE FRENCH NATIONAL TRAVEL SURVEY 2007-08

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1. INTRODUCTION: RECENT EVOLUTION OF GPS AND TRAVEL SURVEYS

In the travel behaviour field, since the mid 1990s, attention has focussed on the potential of location-aware systems such as GPS (Global Positioning Systems), RDS (triangulation on FM radio stations) or GSM (Global System for Mobile communications). "We have seen a diversity of efforts to take advantage of such systems to collect temporal and spatial data on human mobility with unprecedented levels of detail and accuracy and, moreover, to collect data in an automatic or semi-automatic manner over much longer periods of observation than are covered by the vast majority of travel and activity diary methods" *(1)*. RDS is interesting for freight transport or long distance travel, but does not provide accurate enough data for the analysis of daily mobility, on which this paper is focussed. Initially, the use of GPS was mostly limited to travel in private motor vehicles, because the power requirements of equipment in continuous use could easily be met with a connection to vehicle electrics, the problems of reception were minimized, and the linking of movement to ground features was simplified by staying on road networks (see examples in North America *(2, 3, 4)*, in Paris and London *(5)*, in Denmark *(6)*. Nevertheless, even in the 1990s, some experiments took place to use GPS to survey personal mobility in all modes of transport and off road networks *(7)*. A recent review of the status of the use of location/time-aware devices in activity and travel surveys will be found in *(1)*.

These successful experiences in the US, in Canada, in Japan, in Australia or in Europe have been conducted on relatively small samples, generally at a local/regional level. Very positive technical improvements (smaller units, better precision, greater storage capacity, less power-hungry units) and decrease in prices allow its application to large scale surveys such as

National Travel Surveys, and it is now thinkable that an instrument package built around a tracking device could replace conventional methods in the future. This paper describes the design of a first nationwide experience with embedding such a package in a traditional survey. This is an opportunity to compare measurement tools before a larger deployment of new technology, while maintaining the ability to measure long-term trends.

Section 2 presents the National Travel Surveys conducted in France and describes the design of the GPS component of the 2007-2008 NTS, while section 3 provides a first look at evidence on the limits of this type of data collection, and the solutions to be developed in future stages. Section 4 offers some interim conclusions from this research in progress.

2. THE FRENCH NATIONAL TRAVEL SURVEY

Once per decade, the Ministry of Transport and the National Institute of Statistics conduct a National (household) Travel Survey (FNTS) with the scientific support of INRETS. It is the data source providing the most comprehensive and consistent overview of mobility, by all travel modes and the covering full range of transport supply situations of people living in France. The 2007-2008 survey started on 1st May 2007. The aim of these surveys is the description of short and long distance trips made by households living in France, as well as their access to and use of public and private transport means. Figure 1 gives an overview of FNTS 2007-2008.

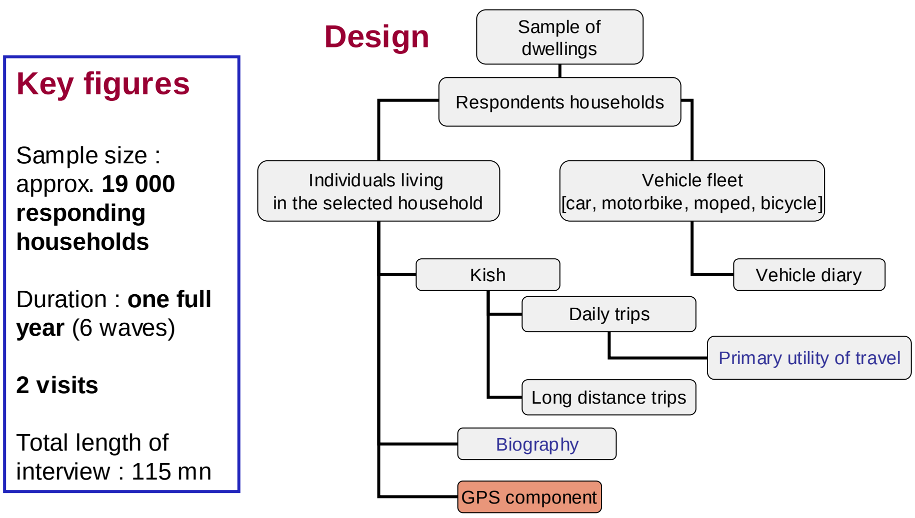

FIGURE 1: Overview of the French National Travel Survey (FNTS 2007-2008)

The survey is organized around the three following topics:

- Description of trips;
- Vehicle ownership and use;
- Accessibility to public transport.

Six survey instruments are used:

1. During the first visit a CAPI questionnaire is designed to collect, at the level of households and their members: socio-demographic variables; characteristics of commuting trips to work, school or kindergarten; driving licenses and car use, traffic accidents; season tickets and discounts in public transport; description of vehicles available in the household; and the housing environment;
2. A 7-day vehicle diary is attributed to one of the household's vehicles (selected with unequal probability distribution to give motorised two wheelers greater chance of selection, as these are particularly interesting from the point of view of road safety); the diary is to be completed by all users of the vehicle;
3. During the second visit, a "Kish" individual above 6 years old, selected with unequal probability distribution giving highly mobile persons greater chance of selection, is asked to describe her/his long distance trips made during the past three months (as recalled from memory);
4. The same "Kish" person is asked to describe her/his trips made one weekday before the interview, and one weekend day (either Saturday or Sunday);
5. A sub-sample of approximately 1000 individuals fill a biographical grid in order to describe the transport means used throughout their whole past life;
6. A sub-sample of approximately 800 volunteers are given a GPS receiver.

The final sample size will be approximately 19,000 responding households (including 5 regional add-ons). Data collection is spread over six waves covering 12 months, in order to neutralize the seasonal variations that affect mobility (especially for long distance travel). Taking into account the overall length of the interviews (approximately a total of 115 minutes), the data will be collected in two visits to the household. This also makes it possible to distribute the vehicle diary and the GPS receiver (for volunteers) at the first visit, and to collect them at the second one.

2.1. General scheme of the GPS component in the French NTS

For this first experimental attempt, it has been authorized by the French National Commission for Data protection and the Liberties (CNIL) under the condition that the GPS component should be implemented only with volunteers. When a respondent agrees to the GPS option (Figure 2):

- At the first face-to-face interview, the interviewer gives the "GPS Pack" to the respondent (older than 17), and explains how to use the equipment;
- Between the two visits, the respondent travels and the unit records trips;
- At the second face-to-face interview:
    - The respondent gives back the "GPS Pack" to the interviewer;
    - Immediately the interviewer downloads the GPS data on his laptop computer using a Bluetooth transfer, for a brief additional interview;
    - The interviewer checks the GPS unit, reloads it; the equipment is ready for a new interview.

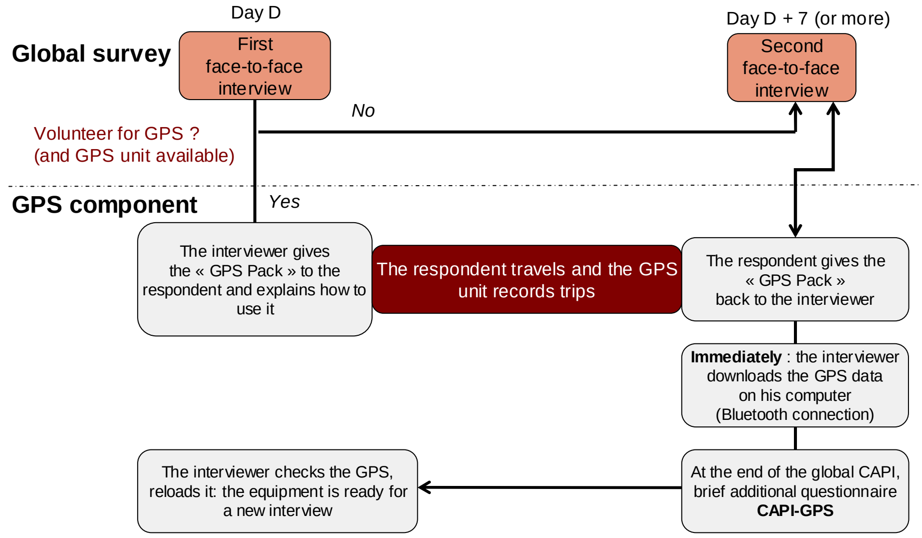

FIGURE 2: General scheme of the GPS component

2.2. Limitations owing to the general scheme of the GPS in the FNTS, and the GPS units selected

As the FNTS runs on a full year (from May 1st 2007 to April 30 2008) and employs about 450 interviewers; however, interviewers do not "stay" for a full year on the FNTS. We bought 170 GPS receivers under a strategy that aimed to implement the GPS component on 9% of the FNTS sample.

The large number of interviewers means that we had to manage a large number of laptops that were supposed to be equipped with identical versions of the survey and GPS software. After a time learning the GPS component, the interviewers handled it correctly, and were quite proud to be using high quality new technology and to "show if off " to the interviewees.

For road safety reasons, and to minimise any influence of the presence of GPS tracking on travel behaviour, we chose a passive monitoring platform with no graphical interface. It has only one button (on/off). The respondent has the possibility to skip some trips, if desired for confidentiality reasons. In the FNTS, data are recorded every 10 seconds. No data are transmitted on real-time: the device is only a datalogger. Data are downloaded to the interviewer's laptop during the second visit, at which time they are deleted from the unit's memory registers.

Two types of GPS unit are used for the survey: 100 are "normal", with 15-17 hours autonomy; 70 have 10 hours autonomy, but are modified to incorporate movement detection and a so-called "blinking" mode. The movement detection makes it possible to automatically shut down the unit when the respondent forgot to do it, for example at the office. The blinking mode allows the recording of "partial traces" (10 min segments) in case of long distance trips, increasing "useful autonomy" of the GPS.

3. NON-RESPONSE, MEASUREMENT ERRORS AND BIAS IN TRANSPORT SURVEYS VS GPS-BASED SURVEYS

Data accuracy is a combination of sampling errors and non-sampling errors. It can be misleading to compute confidence intervals that take no account of non-sampling errors such as non-response errors and measurement errors. This is a particular concern in travel surveys because respondents are often unable to describe their travel behaviour exhaustively, and may have a vague or even biased perception of the main characteristics of their trips (for instance the distance travelled). Interviewees are generally unable to record their mobility with the precision suggested in the questionnaire (for example, in the 1993-94 NTS: 1 min for departure and arrival time; 1 km for annual car kilometrage and daily mobility, and even 100m for trips under 2 km). For most analysis, we do not need so much precision, but we have to be aware that rounding modifies the distributions of variables. Summarizing the main findings obtained by comparing different instruments used in previous NTSs *(10)*, it appears that:

- Time variables are less rounded when reported in diaries than when collected by interview;
- Fortunately, memory effects affect timing (of departure or arrival) more than duration, which latter needs to be known more accurately especially for modelling;
- The deterioration due to memory obviously increases when the facts reported have occurred a long time before the interview (such as during the last weekend or three months ago);
- The car-diary is more accurate than the other methods, probably because of the clock that is found on most car dashboards.

The measurement of trip distances is also an important issue. Controlled by the odometer, trip distance is well estimated by car diaries. If we compare trips by class of crow-flight distance between origin and destination, we notice a substantial underestimation of trip distance for trips with their origin and destination in the same municipality (about 25%); this underestimation is also observed for travel time, but it is less important. For longer trips (between municipalities within 15 km) the underestimation has dropped from 10% in the weekly stage-diary of 1981-82 to 5% in the 1993-94 interview. This improvement is probably due to the local maps that were given to interviewers. On the other hand, long distance trip length seems a little overestimated.

In many surveys concerning car use a question is asked on the mileage driven on different types of network (generally motorways, urban networks and normal roads). Often it is only a yearly proportion, but it is sometimes more precise (e.g. during one week in the SECODIP panel). In the 1993-94 French NTS we asked for the distance driven on these three types of network for each trip made by individual modes of transport (car or two-wheels, as driver or as passenger). The maps given to interviewers could be used to check these distances. For comparison with vehicle based data sources, only car driver trips are considered here. The proportions of "Road" and "Urban network" depend on survey methods: more precise is the question (referring to recent trips), lower seems to be the share of urban network traffic. It is even lower when we modify the initial answers according to the geographical characteristics of the origin and destination of the trip (in the same urban area or in the same rural municipality). The different estimates of the share of motorway traffic are congruent. It increases as new infrastructures are built. However it is about 10% higher than traffic count data, because people consider many roads offering a high level of service as motorways although they do not have this administrative status (e.g. the ring road around Paris).

Since households are reluctant to answer questions on types of network used, because they have a too vague idea of the real numbers, in the main part of the 2007-2008 NTS we will derive this information from origin/destination using network assignment software. The sub-sample of GPS data will allow us to check on the quality of this assignment.

However a GPS datalogger allows the measurement of some details that are never given by respondents in conventional surveys:

- Description of very short trips, which are often forgotten;
- Route choice;
- Precise information on access/egress time and waiting time;
- The description of short trips made from an unusual place of residence (e.g. during holidays or long professional trips).

Moreover, the relatively low burden for the respondent (once she/he is trained) allows substantially extended survey duration: at least one week with GPS, compared to two days with the conventional questionnaire. The gain in accuracy is moderated because of the cluster effect (travel patterns are quite similar on weekdays for the same person).

We should point out, that there are some drawbacks such as:

- A device problem such as energy (batteries currently last about 15 hours);
- A signal reception problem;
- A problem from the interviewee, for example:
  - The interviewee may forgot to take the GPS receiver with him (for some trips; some days, ...);
  - The interviewee may lend the GPS receiver to another person;
  - The interviewee may want “to play” with the device and therefore we record more trips than it should be.

But the last item may happen also in “conventional” survey, especially in face-to-face interviews, where the selected individuals may want to appear socially well integrated and therefore may not describe what they think it is not acceptable and may invent some other alternative response *(11)*.

3.1. Acceptability of the GPS component in the FNTS

In small scale applications of GPS, the interviewer generally have a large degree of freedom to “choose” those who are willing to cooperate, and therefore this rate of participation is much higher than in a large random case study. This clearly means that we have to pay attention in the weighting procedure to the non-response mechanism (is this due to socio-demographics or due to the mobility behaviour of the interviewees?). As we will have the behaviour (of the same individual) with the FNTS, it should be interesting to analyze the type of non-response, ignorable or non-ignorable *(12)* that we gathered in this large scale GPS study.

In the FNTS questionnaire we have a question on the acceptability of the GPS component (with the following possible answers: “Yes, without condition”; “Yes, if it’s possible to turn it off”, “Yes, but with other condition” and “No”). Among the first 4 waves (out of 6) of responses of the FNTS, the “No” had 67% and the “Yes, but with other condition” had 1.5% which is rather different from the FNTS pilots and other small scale studies of GPS: about

60% in the FNTS pilots (with about 200 Households) and about 50% in the test on 200 Households conducted in Lille by ISL said “No”. Among the households that said, “Yes, without condition” or “Yes, if it’s possible to turn it off” in the FNTS pilot, when the interviewer actually proposed them a GPS, 19% refused the receiver (12 out of 63).

TABLE 1: Acceptability by household characteristics

	Acceptability of the GPS				
	yes. without condition	**Yes. on the condition of being able to Switch of when I want**	**Yes. on other conditions**	**No**	**Total**
Marital status					
Single	31.5%	6.3%	1.5%	60.7%	100%
Married	28.2%	4.7%	1.2%	65.9%	100%
Widowe	12.2%	2.2%	0.8%	84.8%	100%
Divorce	27.7%	4.3%	1.5%	66.5%	100%
Size of the household					
1 person	20.5%	4.1%	1.1%	74.3%	100%
2 persons	25.5%	4.5%	1.2%	68.8%	100%
3 persons	32.4%	6.1%	1.1%	60.4%	100%
4 persons	34.2%	5.1%	1.5%	59.1%	100%
5 persons or more	35.1%	5.7%	2.0%	57.2%	100%
Household car fleet					
0 car	13.5%	3.5%	0.6%	82.3%	100%
1 car	26.0%	4.3%	1.2%	68.5%	100%
2 cars	33.3%	6.0%	1.6%	59.1%	100%
3 cars or more	34.0%	4.7%	1.4%	59.9%	100%
Household with computer					
No	16.5%	2.7%	0.9%	79.9%	100%
Yes	33.4%	6.0%	1.4%	59.2%	100%
Household with TV					
No TV	27.4%	4.6%	1.2%	66.8%	100%
TV	25.9%	4.9%	1.3%	68.0%	100%
Pay TV	30.1%	4.7%	1.3%	63.9%	100%
Household with internet connection					
No	20.1%	3.0%	1.0%	75.8%	100%
Yes	30.1%	6.2%	1.7%	61.9%	100%
Yes. ADSL	33.6%	6.3%	1.4%	58.6%	100%
Household with at least one mobile phone					
Yes	30.2%	5.4%	1.3%	63.1%	100%
No	12.0%	1.4%	0.9%	85.7%	100%
Household income (in € per month)					
Non-reponse	14.4%	2.6%	0.6%	82.4%	100%
1 - 1000	18.3%	3.3%	1.1%	77.3%	100%
1001 - 1500	22.9%	3.3%	1.0%	72.8%	100%
1501 - 2500	27.7%	4.9%	1.4%	66.0%	100%
2501 - 4000	33.7%	6.2%	1.3%	58.8%	100%
4001 or more	34.0%	6.3%	1.7%	58.1%	100%
Total	**27.3%**	**4.8%**	**1.3%**	**66.7%**	**100%**

Sources : French NTS 2007-08 (4 first waves out of 6)

TABLE 2: Acceptability by individual characteristics

	Acceptability of the GPS				
	yes. without condition	**Yes. on the condition of being able to Switch of when I want**	**Yes. on other conditions**	**No**	**Total**
Age group					
18 – 24	37.7%	6.2%	2.0%	54.2%	100%
25 – 34	36.2%	7.3%	1.5%	55.0%	100%
35 – 49	33.4%	6.0%	1.4%	59.3%	100%
50 – 64	27.1%	4.6%	1.0%	67.3%	100%
65 – 74	16.2%	2.9%	1.5%	79.4%	100%
75 and more	8.1%	0.8%	0.7%	90.4%	100%
Gender					
Male	28.7%	5.4%	1.2%	64.6%	100%
Female	26.3%	4.4%	1.3%	68.1%	100%
Diploma					
None	17.2%	3.1%	1.2%	78.5%	100%
CEP	14.9%	2.4%	0.7%	82.0%	100%
BEPC	24.6%	5.1%	1.1%	69.2%	100%
CAP/BEP	31.0%	4.4%	1.2%	63.3%	100%
Baccalauréat technologique	35.6%	5.1%	0.9%	58.4%	100%
Baccalauréat Général	30.6%	5.9%	1.6%	61.8%	100%
Baccalauréat + 2	35.6%	7.0%	1.5%	55.9%	100%
Baccalauréat + 3	30.8%	6.5%	1.7%	61.0%	100%
Impairment					
Yes and can make trips alone	20.3%	1.9%	0.9%	76.9%	100%
Yes and can make some trips alone (but not all of them)	10.7%	1.5%	0.7%	87.1%	100%
Yes. but can't make trips alone	2.9%	0.6%	1.0%	95.5%	100%
No	28.9%	5.2%	1.3%	64.6%	100%
General health					
Very good	34.3%	6.0%	1.6%	58.2%	100%
Good	28.0%	5.4%	1.3%	65.3%	100%
Medium	20.0%	2.6%	0.9%	76.4%	100%
Bad and very bad	15.3%	0.8%	0.4%	83.6%	100%
Total	**27.3%**	**4.8%**	**1.3%**	**66.7%**	**100%**

Sources : French NTS 2007-08 (4 first waves out of 6)

TABLE 3: Acceptability by measures of personal mobility

	Acceptability of the GPS				
	yes. without condition	**Yes. on the condition of being able to switch of when I want**	**Yes. on other conditions**	**No**	**Total**
Number of days 'not staying at home'					
0	9.0%	0.5%	1.1%	89.4%	100%
1	15.8%	1.8%	1.1%	81.3%	100%
2	16.0%	3.2%	0.0%	80.8%	100%
3	20.4%	3.3%	0.5%	75.8%	100%
4	25.5%	3.9%	0.8%	69.7%	100%
5	25.7%	3.2%	1.0%	70.1%	100%
6	29.6%	4.9%	1.6%	63.9%	100%
7	30.8%	5.8%	1.6%	61.7%	100%
No answer (not the same person)	28.8%	5.2%	0.9%	65.1%	100%
Numbre of trips (made the day before)					
0	13.2%	2.5%	1.0%	83.3%	100%
1 - 2	23.1%	4.2%	1.1%	71.6%	100%
3 - 4	29.5%	5.3%	1.3%	64.0%	100%
5 or more	36.8%	5.9%	2.1%	55.2%	100%
No answer (not the same person)	28.8%	5.2%	0.9%	65.1%	100%
Number of km (made the day before)					
0	19.8%	3.2%	1.1%	75.8%	100%
1 - 10	25.5%	4.8%	0.9%	68.8%	100%
11 - 20	30.0%	5.3%	1.5%	63.2%	100%
21 - 40	32.0%	6.6%	1.4%	60.1%	100%
40 and more	35.8%	5.6%	2.1%	56.5%	100%
No answer (not the same person)	28.8%	5.2%	0.9%	65.1%	100%
Number of long distance journeys					
0	21.3%	3.3%	1.0%	74.4%	100%
1	27.0%	5.1%	1.1%	66.8%	100%
2 - 3	33.6%	5.8%	2.1%	58.5%	100%
4 or more	38.6%	7.7%	2.2%	51.4%	100%
No answer (not the same person)	28.8%	5.2%	0.9%	65.1%	100%
Total	**27.3%**	**4.8%**	**1.3%**	**66.7%**	**100%**

Sources : French NTS 2007-08 (4 first waves out of 6)

A logit model shows the influence of each dimension "everything being equal in other respects".

TABLE 4: A first logit model with all variables in Tables 1 – 3

Model Fit Statistics		
Criterion	**Intercept Only**	**Intercept and Covariates**
AIC	14842.975	13742.502
SC	14850.317	14168.372
-2 Log L	14840.975	13626.502

Testing Global Null Hypothesis: BETA=0			
Test	**Chi-Square**	**DF**	**Pr > ChiSq**
Likelihood Ratio	1214.473	57	<.0001
Score	1075.9307	57	<.0001
Wald	905.0074	57	<.0001

Type 3 Analysis of Effects			
Effect	**DF**	**Wald Chi-Square**	**Pr > ChiSq**
Marital status	3	7.1374	0.0676
Size of the household	4	5.8482	0.2108
Household income	4	3.5758	0.4664
Household car fleet	3	71.8708	<.0001
Household with computer	1	17.9614	<.0001
Household with TV	2	0.3105	0.8562
Household with internet	2	1.2403	0.5379
Household with mobile phone	1	5.1982	0.0226
Age groupe	5	90.4216	<.0001
Gender	1	7.9227	0.0049
Diploma	7	17.5523	0.0142
Impairement	3	13.7193	0.0033
General health	3	1.9894	0.5746
Number of days ‘not staying at home’	8	63.6253	<.0001
Number of trips (made the day before)	3	39.0093	<.0001
Number of km (made the day before)	4	7.6185	0.1066
Number of long distance journeys	3	34.563	<.0001

Sources : French NTS 2007-08 (4 first waves out of 6)

TABLE 5: A second logit model with selected variables

Model Fit Statistics		
Criterion	**Intercept Only**	**Intercept and Covariates**
AIC	16125.693	14879.994
SC	16133.132	15177.566
-2 Log L	16123.693	14799.994

Testing Global Null Hypothesis: BETA=0			
Test	**Chi-Square**	**DF**	**Pr > ChiSq**
Likelihood Ratio	1323.6993	39	<.0001
Score	1176.1542	39	<.0001
Wald	997.2571	39	<.0001

Type 3 Analysis of Effects			
Effect	**DF**	**Wald Chi-Square**	**Pr > ChiSq**
Household car fleet	3	83.9309	<.0001
Household with computer	1	39.1174	<.0001
Household with mobile phone	1	4.9527	0.026
Age groupe	5	171.6278	<.0001
Gender	1	7.5817	0.0059
Diploma	7	26.7764	0.0004
General health	3	11.1188	0.0111
Number of days 'not staying at home'	8	67.0447	<.0001
Number of trips (made the day before)	3	36.9742	<.0001
Number of km (made the day before)	4	8.3205	0.0805
Number of long distance journeys	3	41.6734	<.0001

Sources : French NTS 2007-08 (4 first waves out of 6)

TABLE 6: Parameter estimates

Analysis of Maximum Likelihood Estimates						
Parameter		**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept		1	-0,8497	0,1029	68,2349	<.0001
Household car fleet	0 car	1	-0,4254	0,0532	63,9022	<.0001
	1 car	1	0,0247	0,0335	0,5446	0,4605
	2 cars	1	0,2403	0,0338	50,4726	<.0001
	3 car or more	1	0	.	.	.
Household with computer	No	1	-0,1671	0,0267	39,1174	<.0001
	Yes	1	0	.	.	.
Household with mobile phone	Yes	1	0,0877	0,0394	4,9527	0,026
	No	1	0	.	.	.

TABLE 6: Parameter estimates (continued)

Age groupe	18 – 24	1	0,5204	0,073	50,8126	<.0001
	25 – 34	1	0,4232	0,0514	67,8147	<.0001
	35 – 49	1	0,2489	0,0417	35,6378	<.0001
	50 – 64	1	-0,0511	0,0407	1,5745	0,2096
	65 – 74	1	-0,3555	0,0612	33,7331	<.0001
	75 and over	1	0	.	.	.
Gender	Male	1	0,0562	0,0204	7,5817	0,0059
	Female	1	0	.	.	.
Diploma	None	1	-0,1661	0,0585	8,0476	0,0046
	CEP	1	-0,1513	0,068	4,9431	0,0262
	BEPC	1	-0,0468	0,0675	0,4802	0,4883
	CAP/BEP	1	0,0747	0,0405	3,4102	0,0648
	Baccalauréat technologique	1	0,0605	0,0665	0,8268	0,3632
	Baccalauréat Général	1	0,1421	0,0647	4,8206	0,0281
	Baccalauréat + 2	1	0,144	0,0548	6,907	0,0086
	Baccalauréat + 3	1	0	.	.	.
General health	Very good	1	0,33	0,1102	8,9689	0,0027
	Good	1	0,046	0,1407	0,1067	0,7439
	Medium	1	-0,6212	0,2197	7,9943	0,0047
	Bad and very bad	1	0	.	.	.
Number of days 'not staying at home'	0	1	0,1575	0,2974	0,2806	0,5963
	1	1	0,4671	0,1763	7,0201	0,0081
	2	1	0,142	0,1559	0,8299	0,3623
	3	1	0,3559	0,1258	8,008	0,0047
	4	1	0,497	0,1088	20,8521	<.0001
	5	1	0,3349	0,0886	14,2717	0,0002
	6	1	0,4112	0,0739	31,0078	<.0001
	7	1	0,3924	0,0656	35,7358	<.0001
	No answer (not the same person)	1	0	.	.	.
Number of trips	0	1	-0,2754	0,2634	1,0933	0,2958
	1 – 2	1	-0,363	0,0598	36,8592	<.0001
	3 – 4	1	-0,2209	0,0597	13,6689	0,0002
	5 or more	0	0	.	.	.
	No answer (not the same person)	0	0	.	.	.
Number of km	0	1	-0,1588	0,069	5,2996	0,0213
	1 – 10	1	-0,1908	0,0824	5,3615	0,0206
	11 – 20	1	-0,0468	0,0736	0,4053	0,5244
	21 – 40	1	-0,0706	0,0716	0,9732	0,3239
	40 and more	0	0	.	.	.
	No answer (not the same person)	0	0	.	.	.
Number of long distance journeys	0	1	-0,4204	0,0763	30,3722	<.0001
	1	1	-0,4041	0,0775	27,1697	<.0001
	2 – 3	1	-0,1715	0,0781	4,8209	0,0281
	4 or more	0	0	.	.	.
	No answer (not the same person)	0	0	.	.	.

Sources : French NTS 2007-08 (4 first waves out of 6)

When we compute the parameter estimates we can find the probability to be willing to participate in a GPS-based survey. Many of the trends, for example the increasing acceptance of GPS participation with household income and the presence of computers in the home

(Table 1), as well as increasing individual acceptance with education and declining individual acceptance of GPS with age and poor health (Table 2), are rather predictable, but there are important cautions here about unit response bias. Arguably, the most interesting results among all the indicators are the mobility measures and car ownership. (Tables 3 and 1) The general picture (Tables 4-6) is that GPS survey participation is positively associated with greater mobility and higher access to cars. This result is the more interesting in that the GPS component of the FNTS was an optional and additional (not a substitute) instrumentation: nevertheless, could FNTS respondents who were more mobile have tended to favour GPS expecting that their response burden would somehow be lower? But regardless of cause, the potential for overestimating mobility from a survey using only a GPS package must be considered.

3.2 Item Non-Response

3.2.1 The CAPI-GPS design

If there are days without GPS record, the first step is to understand the reasons why. For each day without any record, the following question is asked:
"During this day, we have no data recorded, could you tell me why?

- I have forgotten the GPS unit
- Unit off
- No trip
- Problem with the GPS unit (battery)

Based on the analysis of the downloaded GPS data, a day is selected, avoiding to ask questions on days already described in the traditional CAPI interview (the day before and the last Saturday or Sunday). The GPS records are split into trips according to a 10 minutes stop (at the same place) between two trips (we will discuss this threshold in section 5.2). First, memory is prompted with trip characteristics (day of the week, date, departure time, duration, municipalities of origin and of destination). Then the following questions are asked:

- "For what purpose ?"
- "Number of accompanying persons?"
- "Means of transport used"

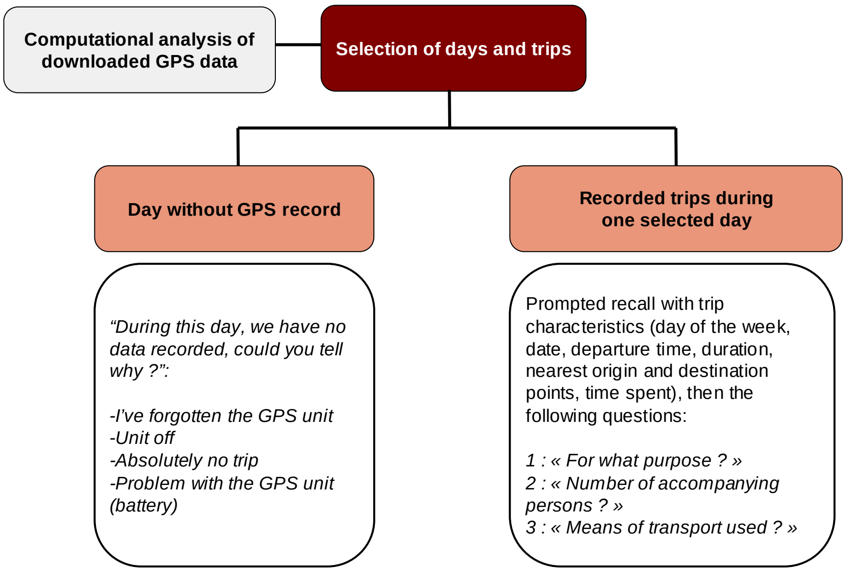

FIGURE 3: CAPI-GPS design

3.2.2. Some limits... and solutions to be developed

There are clear technical limits, notably with signal loss in tunnels and subways. It works better when it is positioned near the window in public transports and starts after a few minutes when getting out of a building. But we have noticed a substantial improvement between the first and the second generation of devices that we have tested.
There are also human limits:

- The respondent may forget it at home or elsewhere, or forget to put it on;
- The battery might turn uncharged (it has to be plugged in every night).

3.2.3. Segmentation of trips

When post-processing the data, trips are split by activities, which correspond to a stop on the GPS trace. What duration to adopt for this stop to consider that a new trip is starting? Too long means that we will miss short activities (e.g. Kiss-and-ride); too short (e.g. waiting for the train or the bus) means that we will consider changing modes during one trip as two separate trips.

The individual weekly diary in the 1981 French NTS is the "most recent" stage-based instrument available in France. Connections between two modes split two stages inside one trip, not two different trips. For 44% of them, the arrival time of the previous leg corresponds exactly to the departure time of the next one (0 min), 13% are between 1 and 4 min, 20% are of 5 min, etc. This is a good example of rounding phenomena mentioned in section 3.

Let us now take the example of trips made on a weekday in the 1993 French NTS, as described face-to-face for the day before the interview. Escorting represents about half of "short activities" (40% of escorting to the station for an activity lasting less than 5 min, which is the case for only 23% on the way back home because of waiting time). It legitimates the question about accompanying persons in the CAPI-GPS interview. Six percent of shopping in small shops lasts less than 5 min, which is 10 times more than in super-markets. The trip after the "short activity" is often made on foot (8% <5 min, one third of 0 min stops) or as driver with passenger (9% <5 min, one fourth of stops <5 min), but not as passenger (2% <5 min) or solo driver.

TABLE 7: Stops between two Stages according to their Duration

	Activity	Changing mode
0 min	3%	44%
1 to 4 min	2%	13%
5min	5%	20%
6 to 9 min	1%	5%
10 min	4%	7%
> 10 min	85%	11%
Total	100%	100%

Source : INRETS Weekly stage diary 1981-82 NTS.
N.B.: About 8% of stops were for "changing modes" versus 92% for real activities.

3.3. Next steps

For checking and analyzing data, we can combine three measurement tools:

- The conventional questionnaire;
- GPS traces; and
- CAPI-GPS results (purpose, transport means, accompanying persons).

Based on the comparison between data produced by each of these instruments, we will build methods for imputation (of purpose and mode) from the GPS traces only.

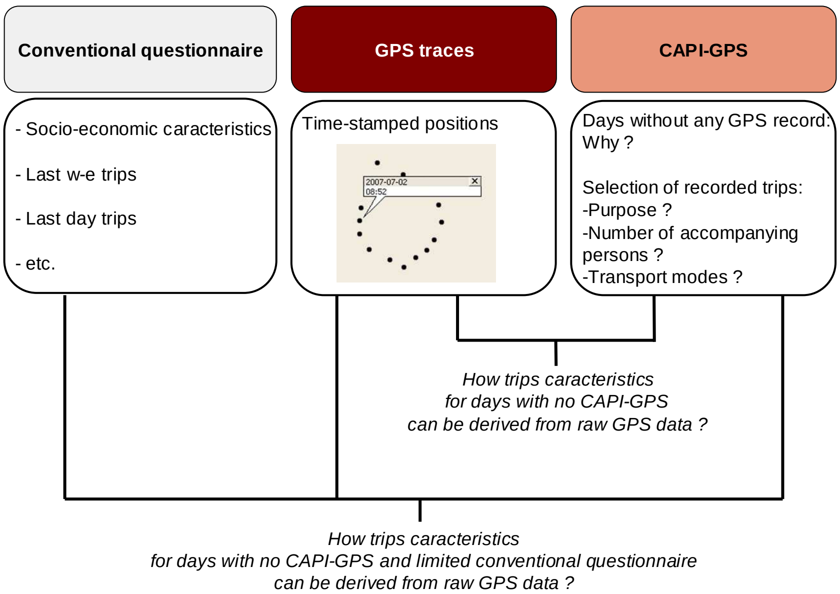

FIGURE 4: A data collection framework with three combined measurement tools

Our research program is:

a. Following up the comparison with data from NTS
b. Improvement/validation of the trace segmentation tool (5 min or 10 min stop, turning point at a station for kiss-and-ride, etc.),
c. Imputation of modes and transfer places from average speed and its variability, route, etc.;
d. Imputation of purpose from destination location, arrival time, etc.; and
e. On longer term, the question of missing data: automated reconstitution of continuous sequences in space as well as in time (omitted parts, technical problems).

In the case of b, c and d, some generic solutions for post-processing person-based GPS data have been tested, notably in Canada *(e.g. 14)* and Australia *(e.g. 15).*

4. INTERIM CONCLUSIONS

This paper has reported on survey methodological work in progress, but it is not too early to conclude that GPS is certainly a promising technology for surveying travel behaviour, because it provides much more accurate spatial and temporal data than conventional methods. However, raw data are not directly usable:

- Traces are not segmented;
- There are missing segments;
- There is information neither on transport means nor on trip purposes.

Thus, for post-processing these data, more or less sophisticated software packages have to be elaborated depending on the accuracy needed by the users (e.g. much more spatial accuracy for the assessment of advertising by posters than for other users of travel survey results).

The introduction of a large-scale deployment of GPS in a substantial sub-sample of a conventional National Travel Survey prepares the transition toward more use of cheaper new technologies, which are less burdensome for the respondent and allow surveying over a longer period. Our experimental design takes advantage of the general characteristics of a long survey (with two face-to-face interviews) to obtain, through the CAPI-GPS, additional information on the reliability of the device and on more detailed characteristics of a few trips, which will be useful for the calibration of the post-processing software. However, it is difficult to generalize this experience if the acceptance rate remains so low. Further analysis will explore the characteristics of the individuals who have accepted to carry the GPS unit during the one to two week survey period.

The comparability with previously collected data is essential for the assessment of long-term trends. The 2007 NTS is designed to prepare correctly for this transition. Moreover, the comparability with data collected in the other countries is also important. EUROSTAT harmonizes several surveys in most of Member States in Europe (e.g. on time use or family expenditure), but nothing seems to be planned for surveys on daily mobility. We have shown that Time Use Surveys (a grid of activities performed during each 10 min time slot) provides data quite comparable with surveys on daily mobility *(13)*. Should a harmonized Time Use Survey with GPS (such as is underway in Halifax, Canada), and a few additional questions (e.g. description of vehicles), be considered to fulfil this need for comparable data?

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