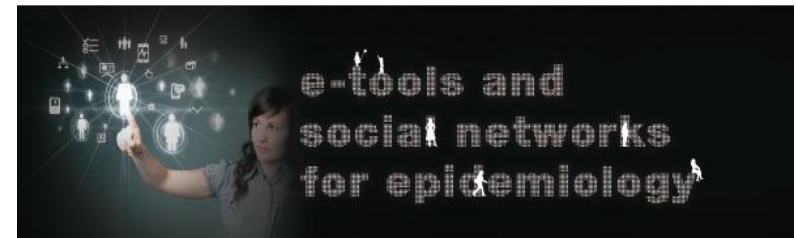


Managing large cohorts and collecting data on mobility and health behaviour : Novel solutions and challenges



Paris, 21th May 2013

Yan Kestens

Montreal University, Social and Preventive Medicine

Montreal Hospital University Research Center (CRCHUM)



SPHERE Lab.org



Aim

Presentation of tools/methods that facilitate the collection of data in large cohorts (with a focus on spatial data)

Three tools that have been pilot tested or implemented in existing cohort studies

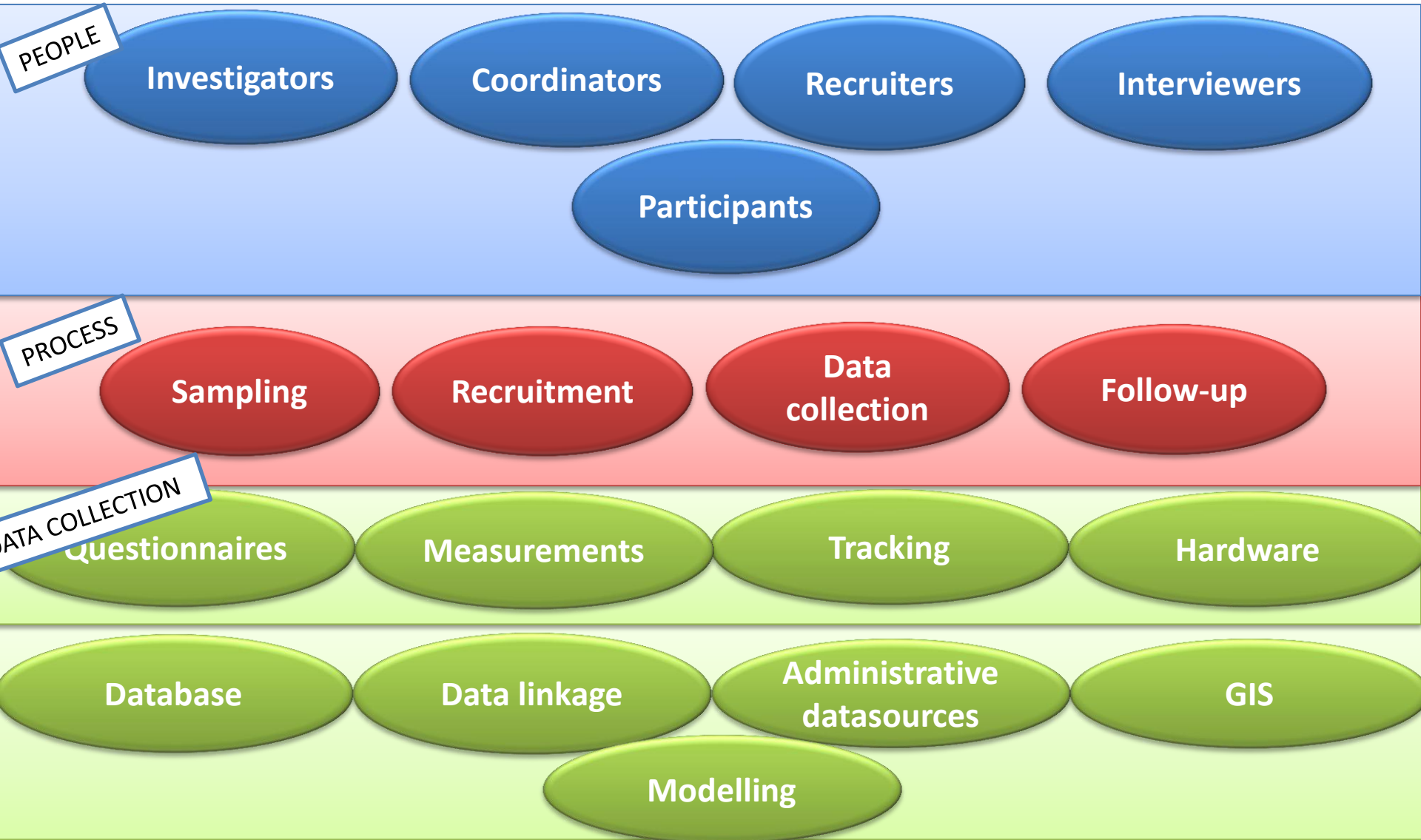
- Tool 1: Study Management Application
- Tool 2: VERITAS interactive mapping questionnaire
- Tool 3: Multisensor platform for real-time tracking

Managing a cohort

Large cohorts → All kinds of challenges!

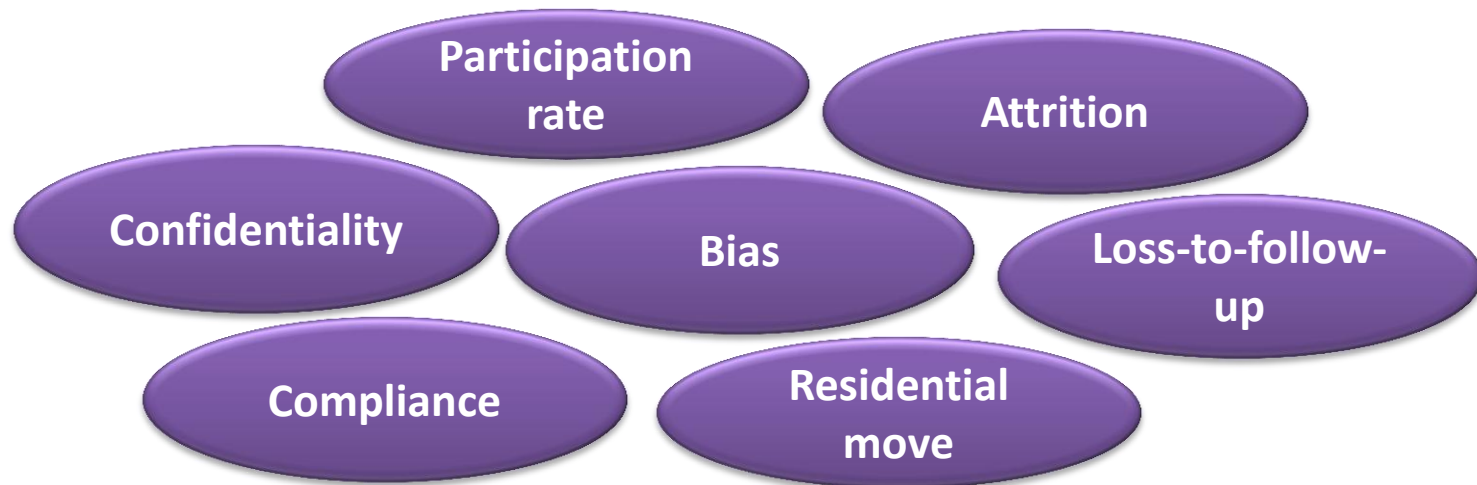


Managing a cohort



Managing a cohort

Transversal Challenges!



Tool 1: Cohort Management Application

Use of a study management application to manage

- People
- Procedures
- Questionnaires
- Devices
- Procedures

Usagers [7938]

#	Coho.	Prénom	Nom	ID Usager	Type ?	Temps	Étape ?	Statut ?	Qrt	S/R	A/D
7913	C-03			306093	POT	T-03	INI	INI	VER	088.00	1041
7914	C-03			306094	POT	T-03	INI	INI	VER	088.00	1034
7915	C-03			306095	POT	T-03	REC	ACT	VER	085.00	1047
7916	C-03			306096	POT	T-03	INI	INI	VER	088.00	1041
7917	C-03			306097	POT	T-03	REC	ACT	VER	085.00	1047
7918	C-03			306098	POT	T-03	INI	INI	VER	087.00	1028
7919	C-03			306099	POT	T-03	INI	INI	VER	088.00	1034
7920	C-03			306100	POT	T-03	INI	INI	VER	302.00	1144
7921	C-03			306101	POT	T-03	INI	INI	VER	311.00	1213
7922	C-03			306102	POT	T-03	INI	INI	VER	093.00	1035
7923	C-03			306103	POT	T-03	INI	INI	VER	311.00	1170
7924	C-03			306104	POT	T-03	INI	INI	VER	087.00	1031
7925	C-03			306105	POT	T-03	INI	INI	VER	310.00	1193
7926	C-03			306106	POT	T-03	INI	INI	VER	311.00	1163
7927	C-03			306107	POT	T-03	INI	INI	VER	093.00	1035
7928	C-03			306108	POT	T-03	INI	INI	VER	303.00	1182

--- ? Filtrer... Actions **Activités** Questionnaire Éditer... Ajouter... Effacer

Usagers [7936]			
#	Coho.	Prénom	No
7770	C-03	Véronique	Ge
7771	C-03		
7772	C-03		
7773	C-03	Savannah	Itto
7774	C-03		
7775	C-03	Alain	Tru
7776	C-03		
7777	C-03		
7778	C-03		
7779	C-03		
7780	C-03		
7781	C-03		
7782	C-03		
7783	C-03		
7784	C-03		
7785	C-03		

--- ? Filtre...

Usager ✕

Cohorte Temps Étape Statut

Dernier INTW. Prochain INTW.

Alias MdP

Homme Femme

Date de naissance État matrimonial Langue

Éducation Profession Prof. code

Revenu Code rev.

Maison

Téléphone Portable

Disponibilité (sem.) à

Étape	Statut	Qrt	S/R	A/D
N	COM	VER	307.00	1160
EC	NRE	VER	090.00	1004
	INI	VER	093.00	1044
N	COM	VER	307.00	1160
	INI	VER	308.00	1177
T	NIW	VER	090.00	1004
	INI	VER	088.00	1042
	INI	VER	311.00	1172
	INI	VER	087.00	1031
	INI	VER	088.00	1038
EC	NRE	VER	305.00	1222
EC	ACT	VER	317.02	3254
	INI	VER	305.00	1153
	INI	VER	089.00	1018
	INI	VER	089.00	1003
	INI	VER	307.00	1156

- [Usagers](#)
- [Activités](#)
- [Matériel](#)
- [Admin](#)
- [Aide](#)

Activités [13461]

#	Activité ?	État ?	Code ?	Description ?	Début	Fin	ID Resp.	ID Participant	Type ?	Temps	Étape ?	Stat
5	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2007-11-20	2007-11-20	INT004	10	PAR	T-01	FIN	COM
6	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2009-09-23	2009-09-23	INT004	10	PAR	T-02	INT	COM
7	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2012-02-23	2012-02-23	INT011	10	PAR	T-03	INT	COM
8	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2008-06-23	2008-06-23	INT004	145	PAR	T-01	INT	NIW
9	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2012-04-12	2012-04-12	INT001	167	PAR	T-03	FIN	COM
10	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2008-08-18	2008-08-18	INT001	167	PAR	T-01	INT	COM
11	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2010-04-12	2010-04-12	INT001	167	PAR	T-02	INT	COM
12	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2012-04-17	2012-04-17	INT001	168	PAR	T-03	INT	COM
13	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2008-02-18	2008-02-18	INT001	168	PAR	T-01	INT	COM
14	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2009-11-16	2009-11-16	INT001	168	PAR	T-02	INT	COM
15	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2011-12-22	2011-12-22	INT001	207	PAR	T-03	INT	DH2
16	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2007-08-13	2007-08-13	INT006	207	PAR	T-01	INT	COM
17	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2009-12-22	2009-12-22	INT001	207	PAR	T-02	INT	COM
18	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2007-11-19	2007-11-19	INT017	208	PAR	T-01	INT	COM
19	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2009-09-10	2009-09-10	INT005	208	PAR	T-02	INT	COM
20	EVT	FIN	GEN	INTERVIEW (QUESTIONNAIRE)	2008-08-09	2008-08-09	INT006	223	PAR	T-01	INT	COM

--- ?

Usagers Activités Matériel Admin Aide

Activités [13461]

#	Activité ?	État ?	Code ?	Description ?
5	EVT	FIN	GEN	INTERVIEW (QU
6	EVT	FIN	GEN	INTERVIEW (QU
7	EVT	FIN	GEN	INTERVIEW (QU
8	EVT	FIN	GEN	INTERVIEW (QU
9	EVT	FIN	GEN	INTERVIEW (QU
10	EVT	FIN	GEN	INTERVIEW (QU
11	EVT	FIN	GEN	INTERVIEW (QU
12	EVT	FIN	GEN	INTERVIEW (QU
13	EVT	FIN	GEN	INTERVIEW (QU
14	EVT	FIN	GEN	INTERVIEW (QU
15	EVT	FIN	GEN	INTERVIEW (QU
16	EVT	FIN	GEN	INTERVIEW (QU
17	EVT	FIN	GEN	INTERVIEW (QU
18	EVT	FIN	GEN	INTERVIEW (QU
19	EVT	FIN	GEN	INTERVIEW (QU
20	EVT	FIN	GEN	INTERVIEW (QU

--- ? Filtrer... Actions

Filtre activités

Type activité

Tâche Événement

État activité

À faire aujourd'hui À faire cette semaine
 En cours
 Planifiée Finalisée Annulée

Entre --- et ---

Mode / Code / Description activité

Usager Système

Code --- ?

Description ---

ID Participant	Type ?	Temps	Étape ?	Stat
10	PAR	T-01	FIN	COM
10	PAR	T-02	INT	COM
10	PAR	T-03	INT	COM
145	PAR	T-01	INT	NIW
167	PAR	T-03	FIN	COM
167	PAR	T-01	INT	COM
167	PAR	T-02	INT	COM
168	PAR	T-03	INT	COM
168	PAR	T-01	INT	COM
168	PAR	T-02	INT	COM
207	PAR	T-03	INT	DH2
207	PAR	T-01	INT	COM
207	PAR	T-02	INT	COM
208	PAR	T-01	INT	COM
208	PAR	T-02	INT	COM
223	PAR	T-01	INT	COM

Éditer...

Ajouter...

Effacer

Usagers

Activités

Matériel

Admin

Aide

Inventaire matériel [3]

#	Type ?	SKU	Description
1	COM	COM001	LAPTOP 15" S...
2	MEM	MEM001	MEMORY STIC...
5	GPS	GPS003	GPS CHUM

Item d'inventaire

Type ? SKU N° de série
COM COM001 4532345-34535
Statut ? Description
INV LAPTOP 15" SAMSUNG

Acquisition

Date Coût
2012-04-02 1200.00

Enregistrer

Annuler

Assignment à l'usager

ID Usager Nom usager
? ?

Début Fin D.R.E.
? ? ?

Livré le Mode de livraison
? ?

(u) ID Usager D.R.E. (s)

Éditer...

Ajouter...

Effacer

Usagers

Activités

Matériel

Admin

Aide

Questionnaires

Questionnaires

GPMT Recrutement	GPMT-R
------------------	--------

ID Participant

4061

Nom participant

John Kennedy



Réponses

Démarrer

Annuler

Usagers

Activités

Matériel

Admin

Aide

7. Shopping and Services - Convenience Stores

Q7a. Have you been to a convenience/corner store/small grocery store in the last 6 months?

Yes No

Q7b. Can you **locate on the map** the convenience/corner store/small grocery store where you go most often?

Yes No

Place

13 Passage de l'Industrie, 75010 Paris, France,

Q7c. How often do you go there?

5 times per week month year

Q7d. How do you normally get there?

Car Public transit
 Walk Skateboard/scooter
 Bicycle Other (please state) ---



Study Management Application

- A comprehensive application to manage cohorts
- Facilitates the process
- Keeps track of activities
- Integrates questionnaires

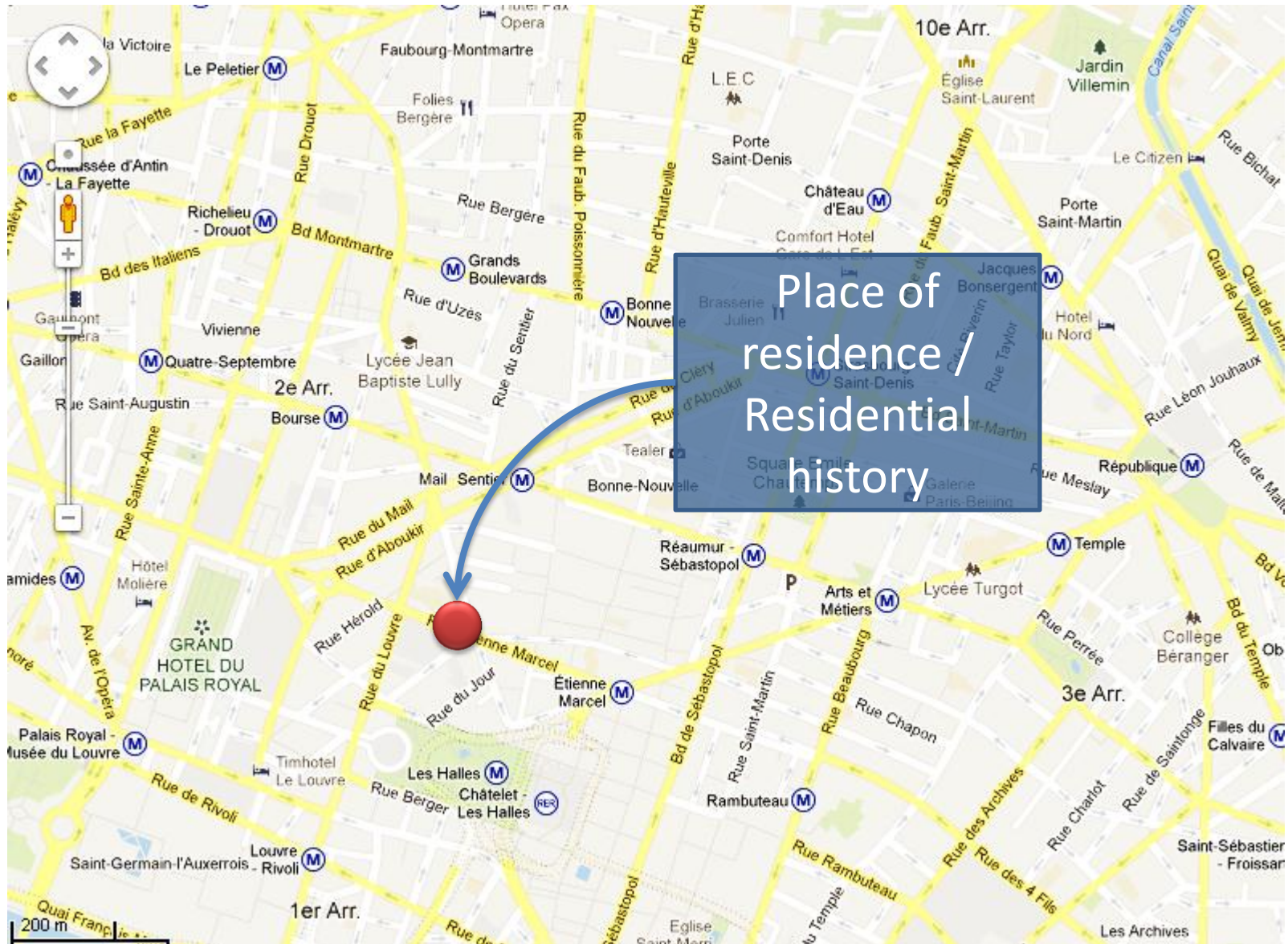
Tool 2: Spatial data collection tool

- Environmental determinants increasingly at stake, both as a cause of disease, social health inequalities, and as a target for intervention
- Current shift to improve integration of daily mobility and multiple exposures in epidemiological models

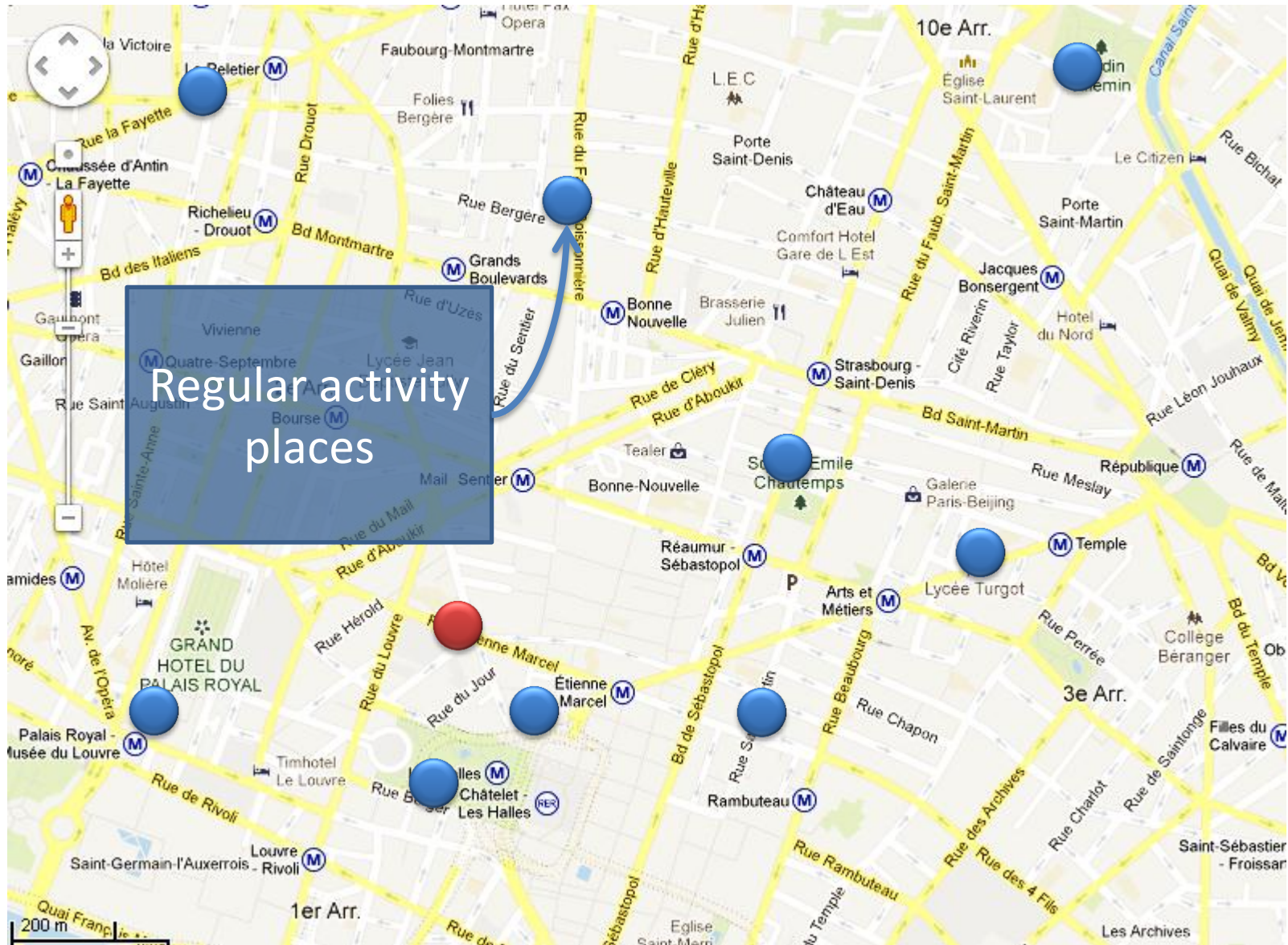
Collecting spatial information

- Tools to collect location information include:
 - Residential history questionnaires – lifecourse
 - Travel surveys – often one day of detailed mobility
 - Activity space questionnaires – asking people's regular destinations
 - Real-time tracking using GPS receivers

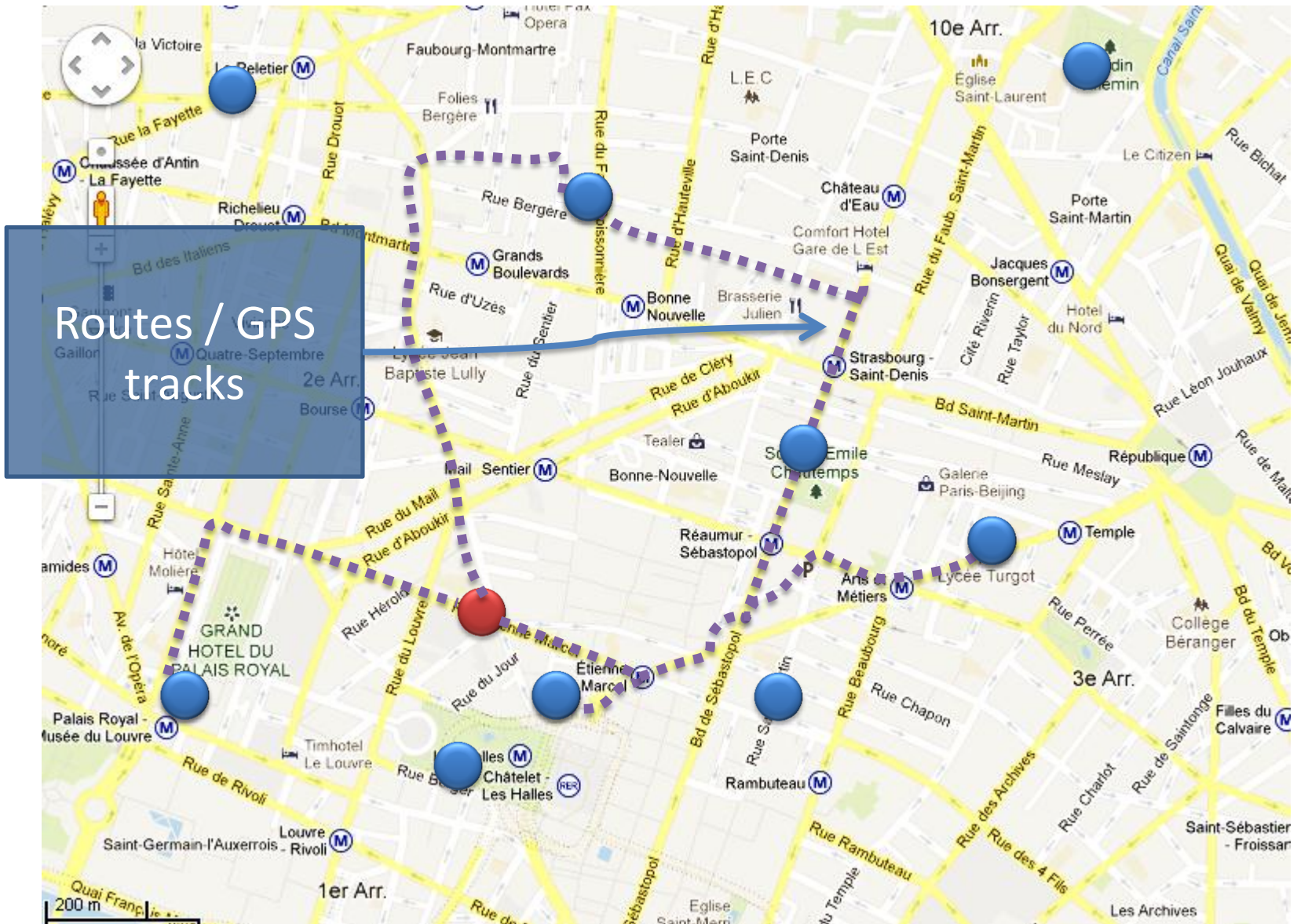
Spatial data used in health research



Spatial data used in health research

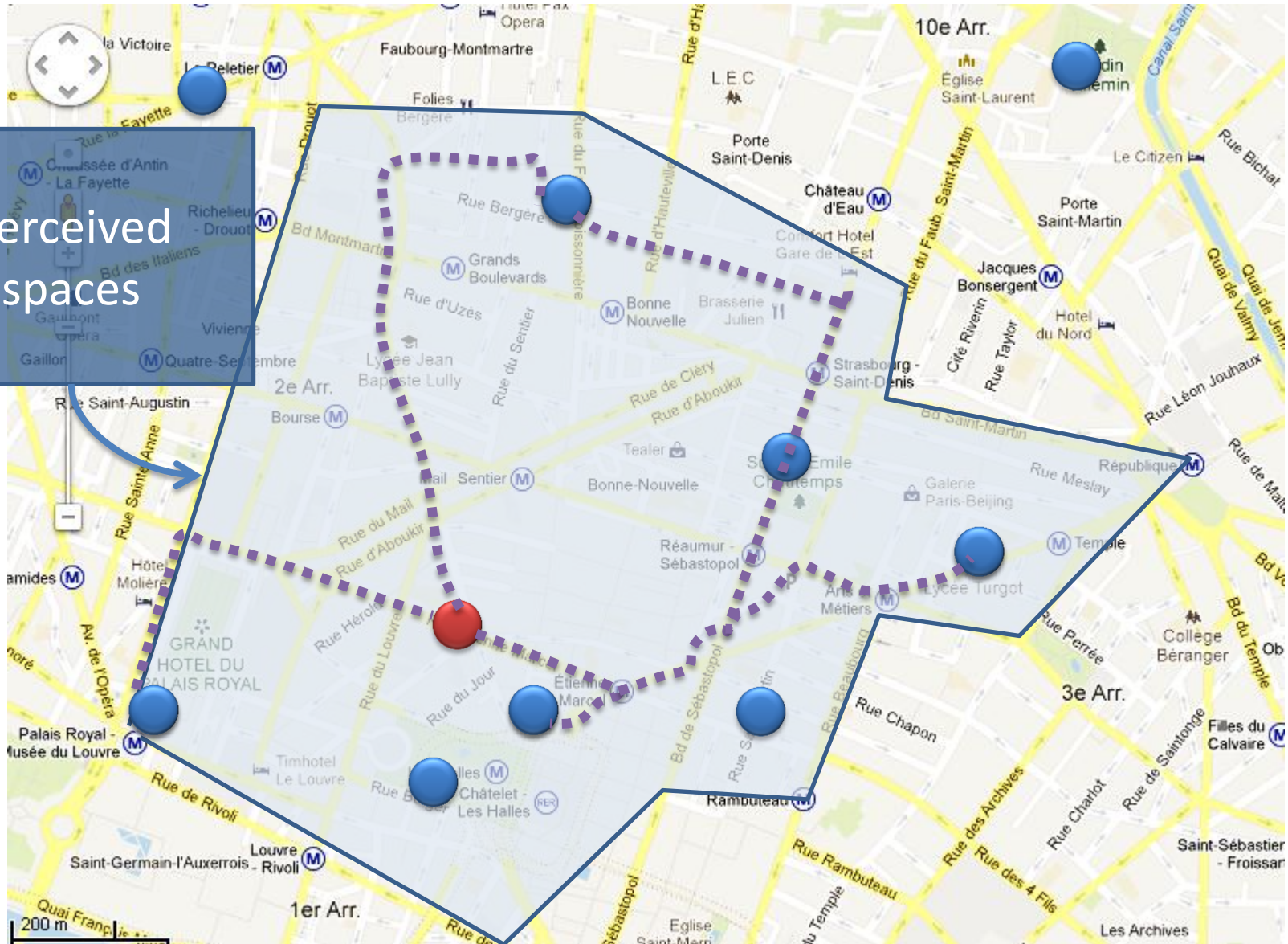


Spatial data used in health research



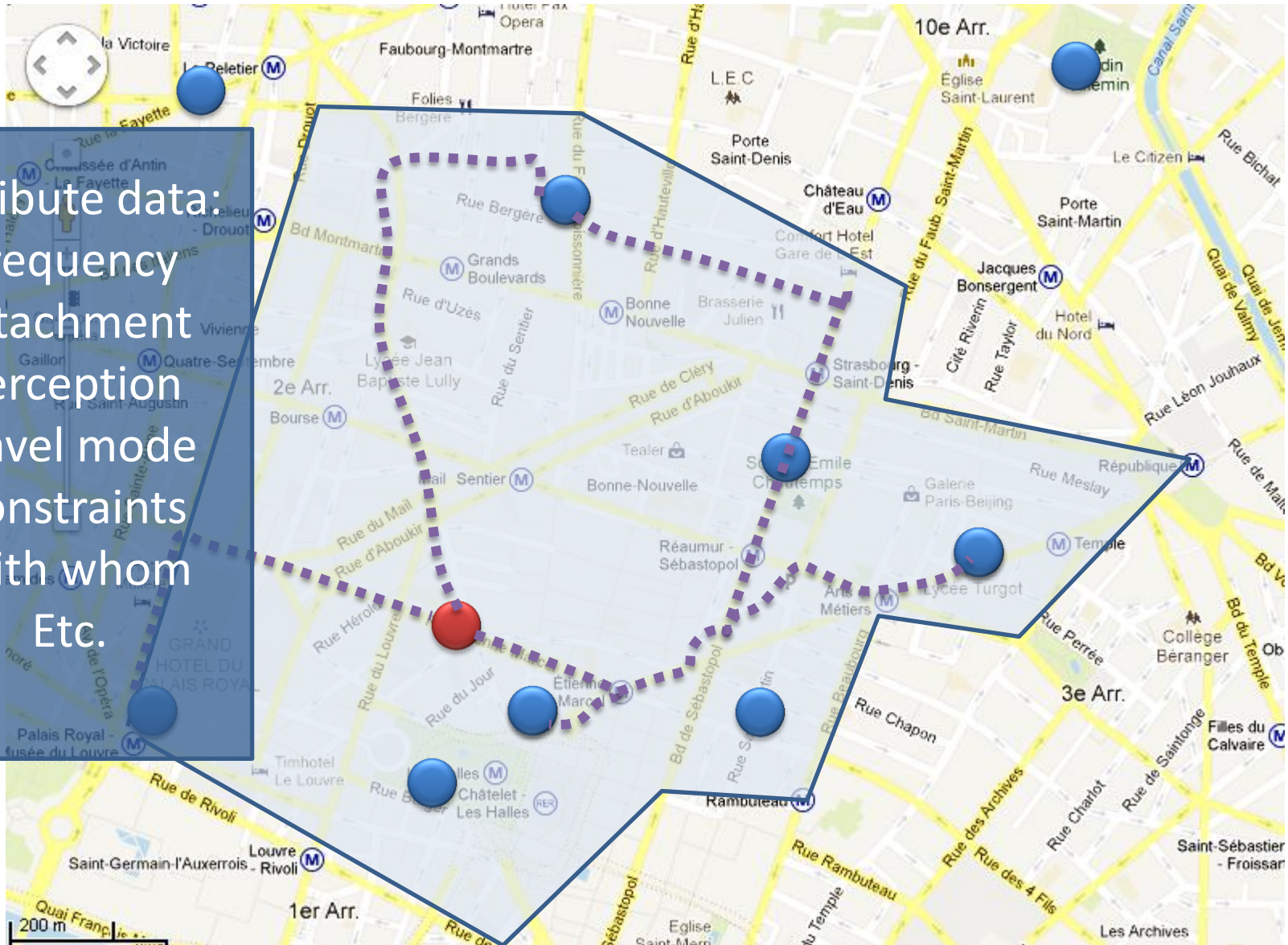
Spatial data used in health research

Perceived spaces



Spatial data used in health research

Attribute data:
Frequency
Attachment
Perception
Travel mode
Constraints
With whom
Etc.



VERITAS, an online mapping questionnaire

- Uses an interactive map to collect spatial data
- Can be administered or self-administered
- Flexible and scalable
- Allows to collect information on locations, routes, spaces and related qualitative assessment
- Is linked to mapping and search APIs to facilitate the process and increase validity (Openstreetmap, Google Map, etc.)

VERITAS

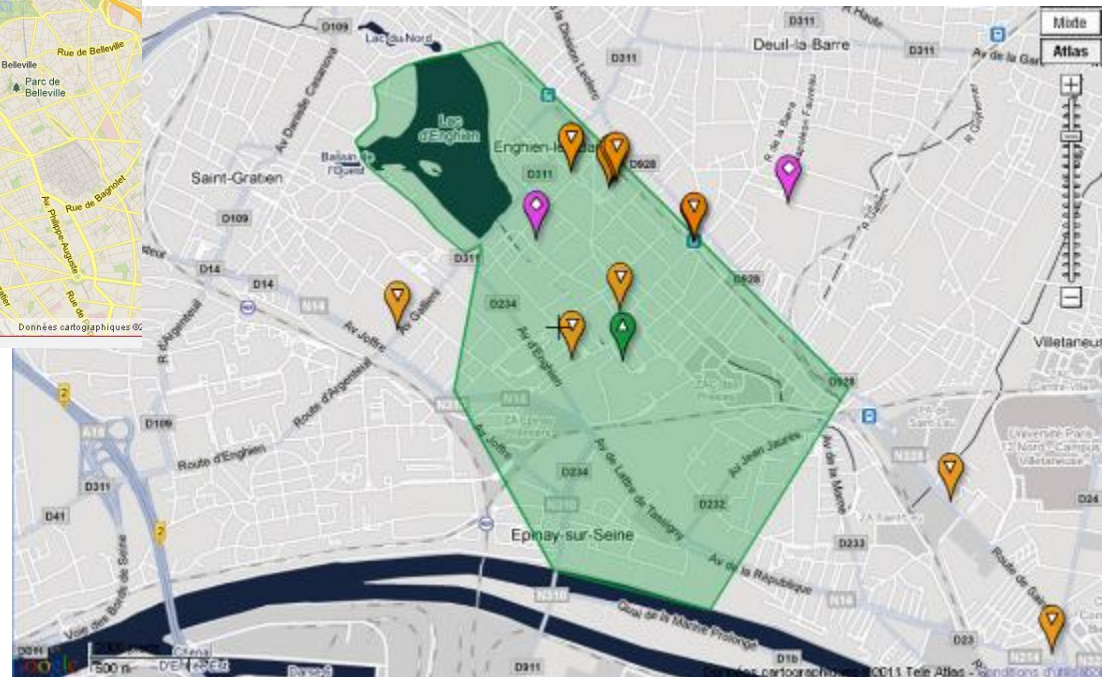
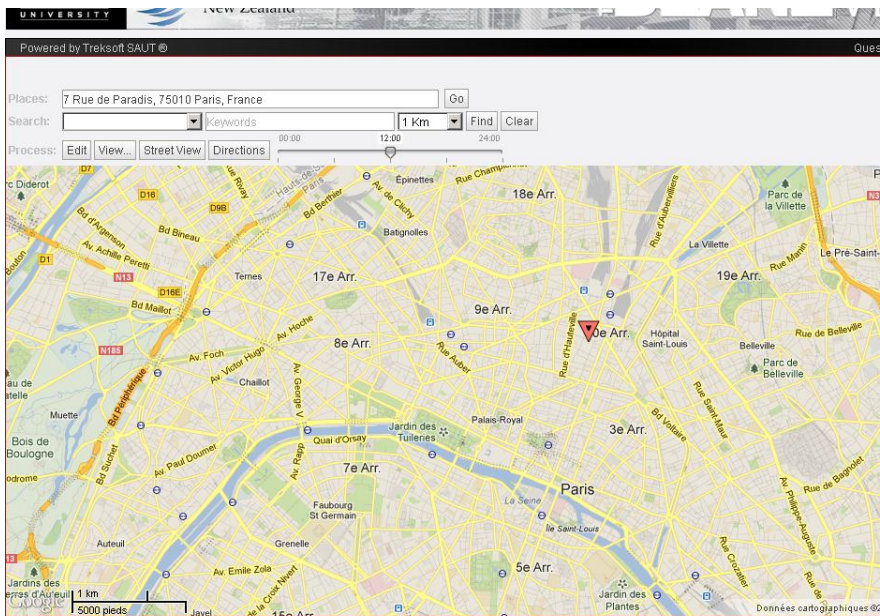
A series of questions which can be answered on a map through creation of:

- A point location (marker)
- A line (polyline)
- An area (polygon)

Map searching capabilities / streetview functionalities can help identifying known locations/destinations.

VERITAS

Example: Where do you shop for food most often?



VERITAS RECORD

- Illustration: VERITAS in the RECORD Study
- RECORD Study: Large Paris area cohort on Cardiovascular health (n = 8,000)
- Wave 1 in 2007-2008, Wave 2 in 2012-2014
- VERITAS RECORD administered to some 4,800 participants as of today
- 27 spatial questions including destinations for food shopping, sport activities, leisure, friends, family, etc.
- Over 65,000 locations collected – Median of 14 locations collected per participant
- Median completion time of 20 minutes

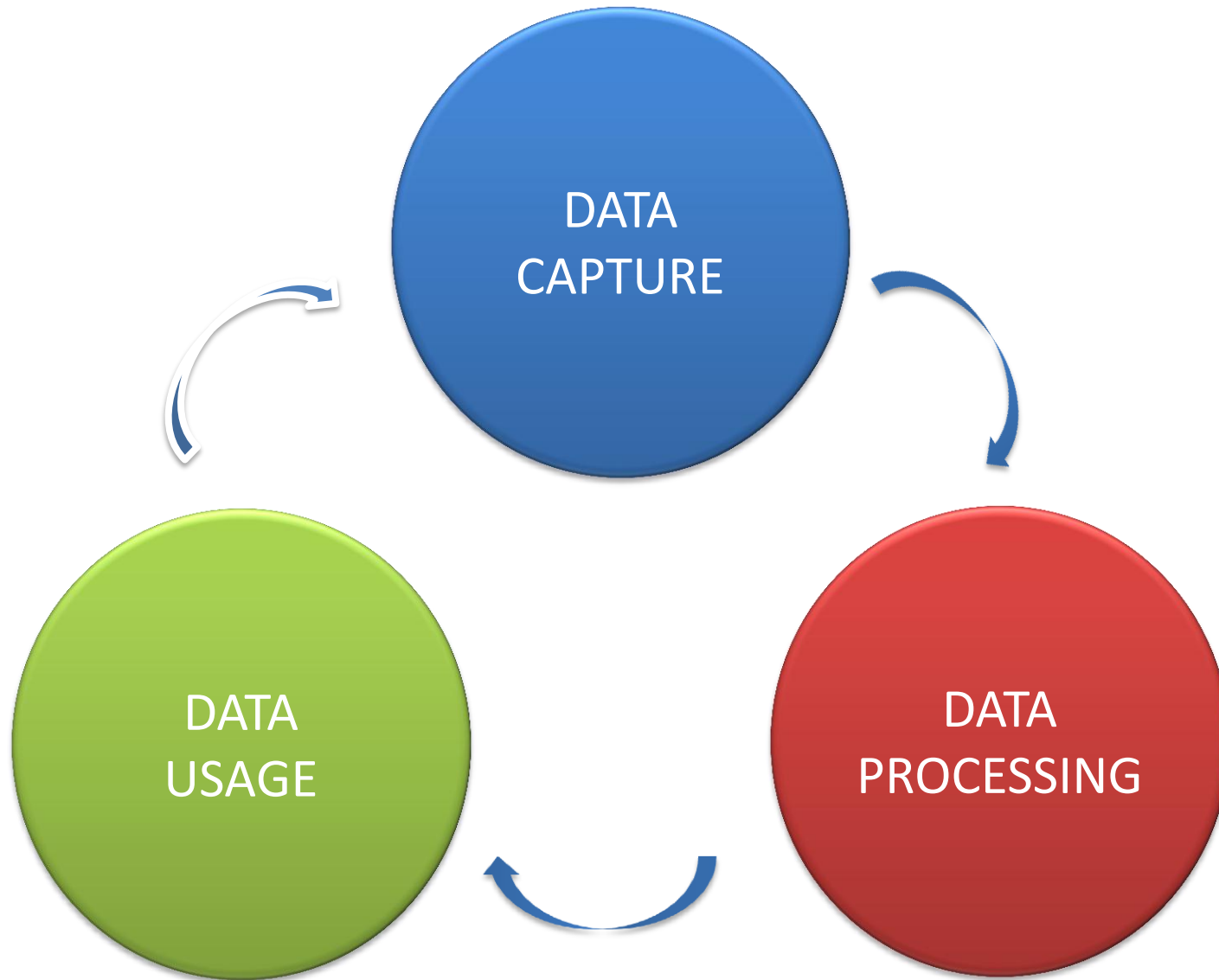
VERITAS RECORD

- Rich spatial information on regular destinations which can serve to identify multiple environmental exposures and inequalities
- Spatial information transformed into spatial indicators to feed epidemiological models (Activity space size, maximum distance, concentration etc.) (Camille Perchoux, Ph.D. candidate)
- Interesting information to monitor spatial health inequalities, mobility behaviour and guide intervention in the distribution of resources/infrastructures

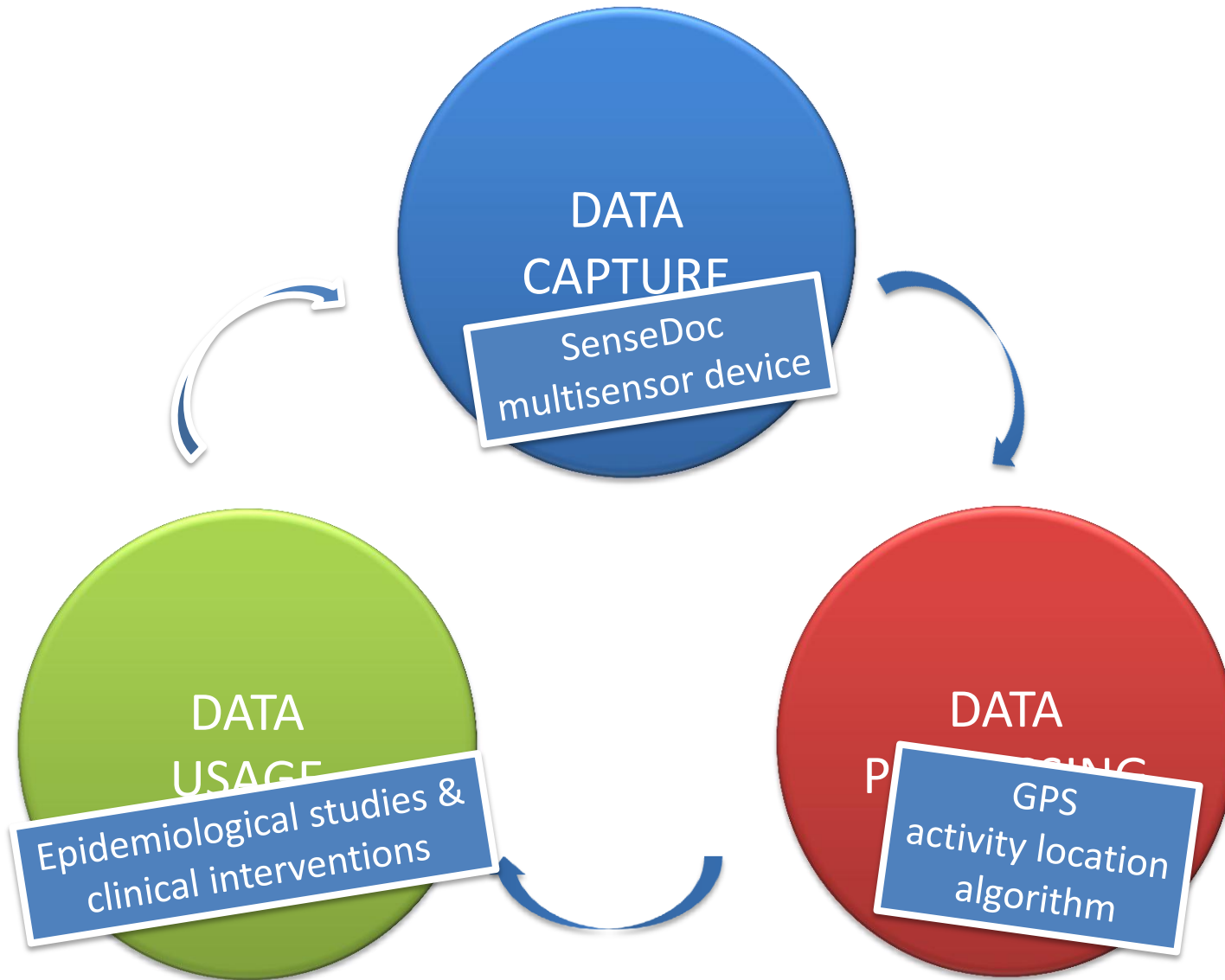
Tool 3: A multisensor platform for real-time tracking

- Self-reported locations vs. objective measures
- Multisensor device for tracking of:
 - Mobility (GPS, RFID)
 - Physical activity (Accelerometer)
 - Physiology (Various sensors)

Multisensor platform



Multisensor platform





Sensors

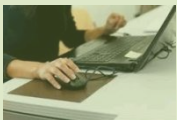
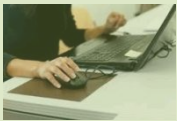


GSM tower



Acquisition server

End users



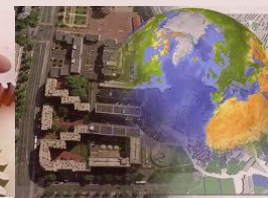
Web server



Outputs / Applications



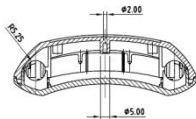
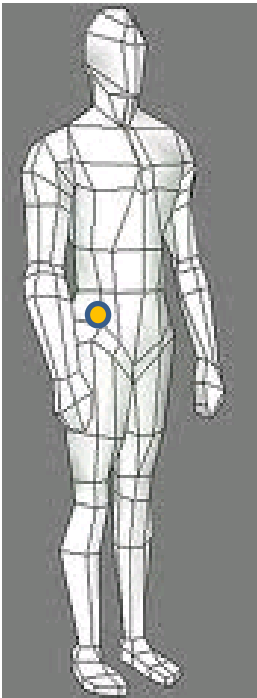
Algorithms



GIS

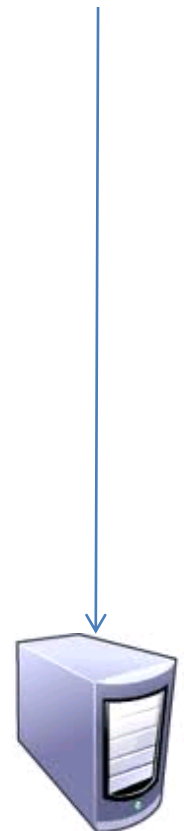
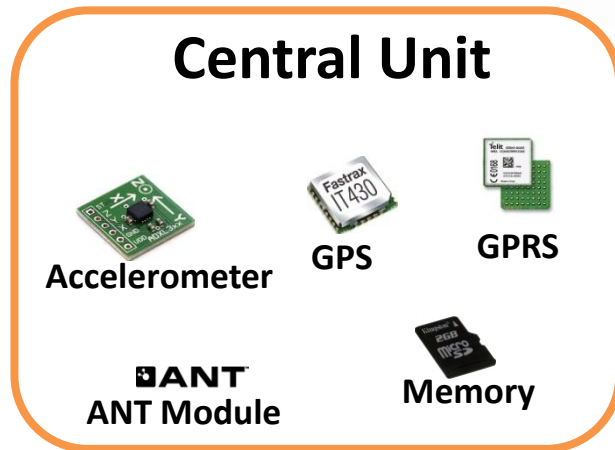


SenseDoc multisensor wearable device



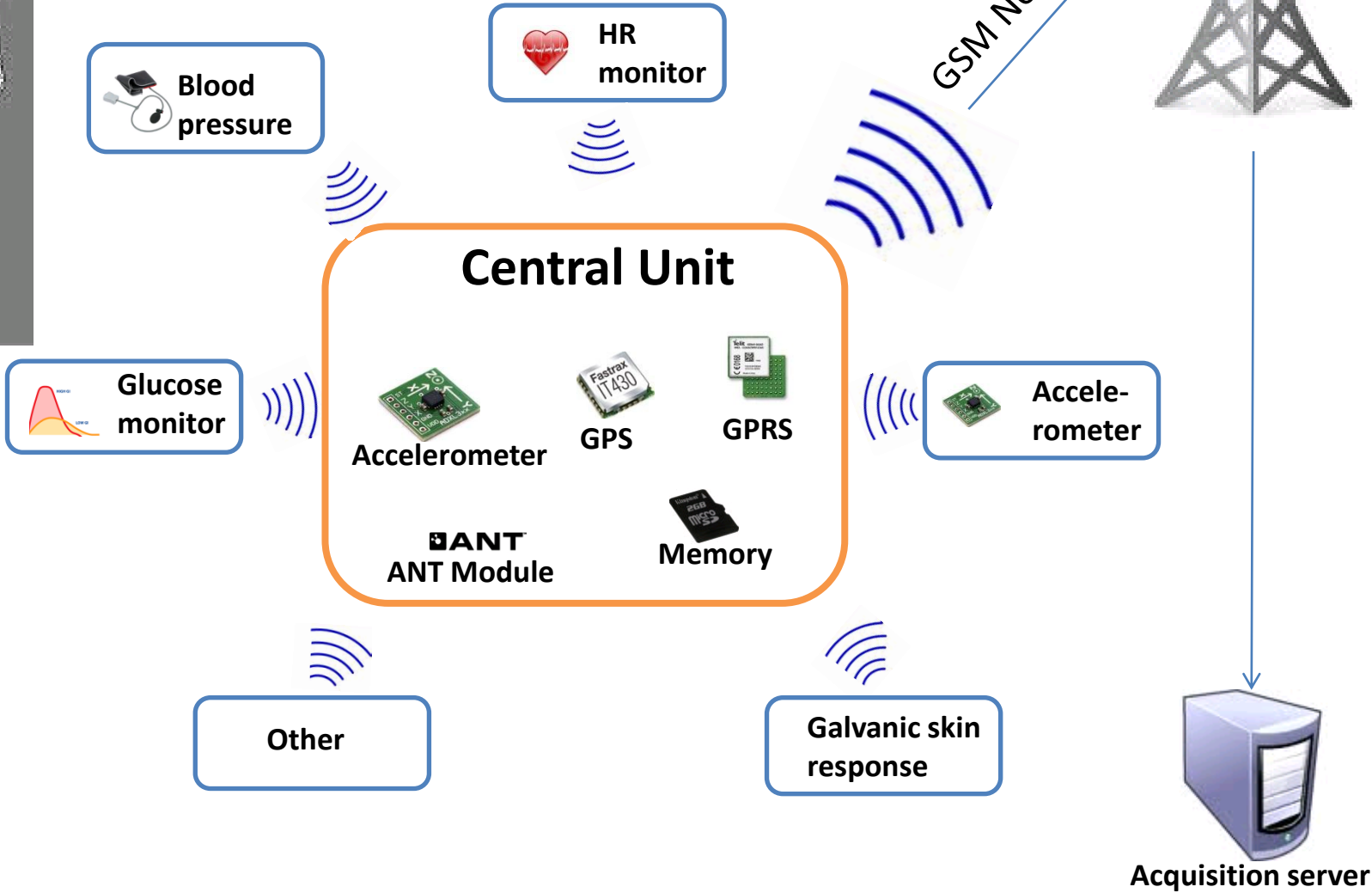
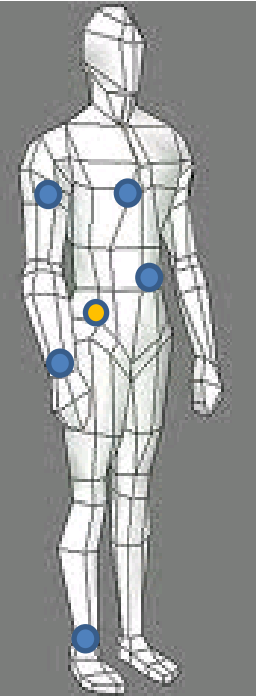
96 * 80 mm 125 g

115 * 59 mm 137 g



Acquisition server

SenseDoc multisensor wearable device



SenseDoc Multisensor Device



GPS – SIRF IV

GPS performance validation

Spatial accuracy

Time to First Fix (TTFF)

Indoor – Outdoor

Fixed - Moving



Average of dist_moy	Column Labels				Grand Total
Row Labels	Etrex	HTC	MS	Qstarz	Grand Total
Indoor					
cold	13,6	9,0	7,7	16,7	12,3
Brick building, hallway	14,1	5,7	4,1	15,4	10,4
Brick building, window	14,4	12,4	7,6	15,5	12,5
Concrete building, window	12,3		11,6	19,4	14,4
hot	12,9	11,3	10,0	15,5	12,6
Brick building, hallway	11,2	7,2	6,3	15,8	10,5
Brick building, window	7,6	5,0	6,9	12,8	8,5
Concrete building, window	19,9	21,8	16,9	17,9	18,7
warm	14,0	13,5	20,3	15,8	16,1
Brick building, hallway	10,4	15,6	22,1	11,1	14,8
Brick building, window	7,8	10,4	21,7	13,2	13,7
Concrete building, window	23,8	12,2	17,0	23,0	20,0
Outdoor					
cold	7,8	16,6	11,0	17,6	13,0
Narrow streets	21,4	20,0	16,2	35,3	23,2
Open surroundings	2,8	12,0	1,4	1,1	4,3
Residential areas	2,4		4,1	0,9	2,5
Sky scrapers	4,7	17,8	22,2	33,0	19,4
hot	5,5	10,6	3,4	4,8	6,1
Narrow streets	12,9	18,6	4,9	9,5	11,5
Open surroundings	1,5	1,8	2,2	1,8	1,8
Residential areas	3,2	3,4	1,9	3,1	2,9
Sky scrapers	4,4	18,4	4,6	4,8	8,5
warm	8,6	9,1	6,5	10,0	8,5
Narrow streets	26,7	21,9	16,2	20,5	21,3
Open surroundings	3,0	5,4	3,3	4,1	3,9
Residential areas	4,1	4,6	2,8	5,0	4,1
Sky scrapers	5,0	8,9	7,4	15,2	9,1
Grand Total	10,3	11,4	9,5	13,0	11,0



Row Labels	Etrex	HTC	MS	Qstarz	Grand Total
Indoor					
cold	136,3	255,0	33,2	86,3	102,3
Brick building, hallway	68,0	104,0	12,5	23,0	44,4
Brick building, window	252,0	406,0	9,5	193,0	187,9
Concrete building, window	89,0		77,5	43,0	69,8
hot	18,5	181,3	5,5	13,5	36,6
Brick building, hallway	6,5	82,0	6,0	2,5	16,0
Brick building, window	41,0	143,0	4,0	35,0	43,3
Concrete building, window	8,0	319,0	6,5	3,0	50,6
warm	101,7	293,3	46,5	204,7	149,5
Brick building, hallway	27,0	563,5	0,0	69,0	164,9
Brick building, window	107,0	26,0	84,5	191,0	113,0
Concrete building, window	171,0	20,0	55,0	354,0	168,6
Outdoor					
cold	37,8	171,7	26,0	40,5	62,1
Narrow streets	44,0	247,0	36,0	40,0	91,8
Open surroundings	39,0	104,0	37,0	57,0	59,3
Residential areas	26,0		20,0	26,0	24,0
Sky scrapers	42,0	164,0	11,0	39,0	64,0
hot	16,5	36,1	21,9	10,1	21,5
Narrow streets	11,5	110,0	29,0	12,5	40,8
Open surroundings	10,5	15,0	4,5	1,0	7,8
Residential areas	8,5	10,0	7,5	3,0	7,3
Sky scrapers	35,5	9,5	46,5	38,0	31,6
warm	26,4	46,8	39,4	31,6	36,1
Narrow streets	40,0	45,0	45,0	40,0	42,5
Open surroundings	21,0	36,0	45,0	35,0	34,3
Residential areas	30,0	68,5	44,5	29,5	43,1
Sky scrapers	11,0	16,0	18,0	24,0	17,3
Grand Total	55,8	130,6	28,2	65,2	65,3

SenseDoc Multisensor Device



Accelerometer

Marie-Lyse B elanger, M.Sc. Student in kinesiology

Accelerometer validation using indirect calorimetry

Lab – 14 controlled exercises from sedentary to vigorous PA

Eleven adult subjects

Calculation of Vertical Magnitude Acceleration (VMAG)

Testing of various bandpass filters

Comparison with Actigraph GT3X performance

Best results obtained with Bandpass filter 0.1 Hz – 3.5 Hz

Modelling of Energy Expenditure: Adj. R-square of .79

Use of Vector Body Dynamic Acceleration (VEDBA)

SenseDoc Multisensor Device

CAPTURE



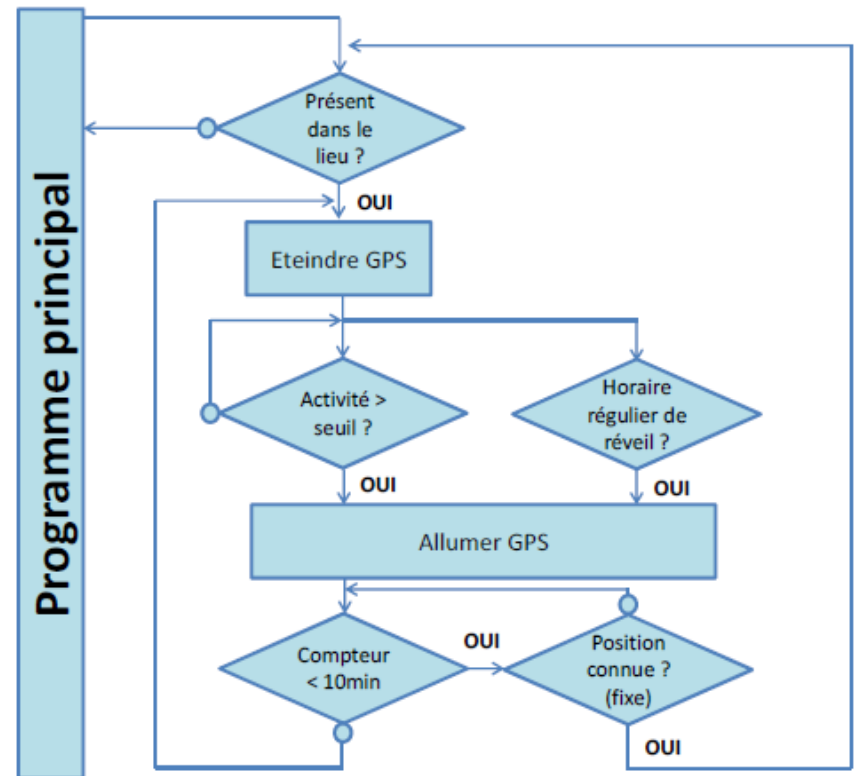
Battery life

Strong battery (3200 mAh)

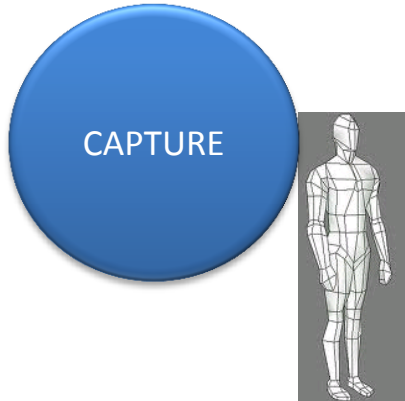
Axelle Chevallier, M.Sc. Student in
Electrical Engineering
Mohamad Sawan, Professor,
Electrical Engineering

Battery optimisation algorithm

- Movement
- Location and movement



SenseDoc Multisensor Device



Battery life

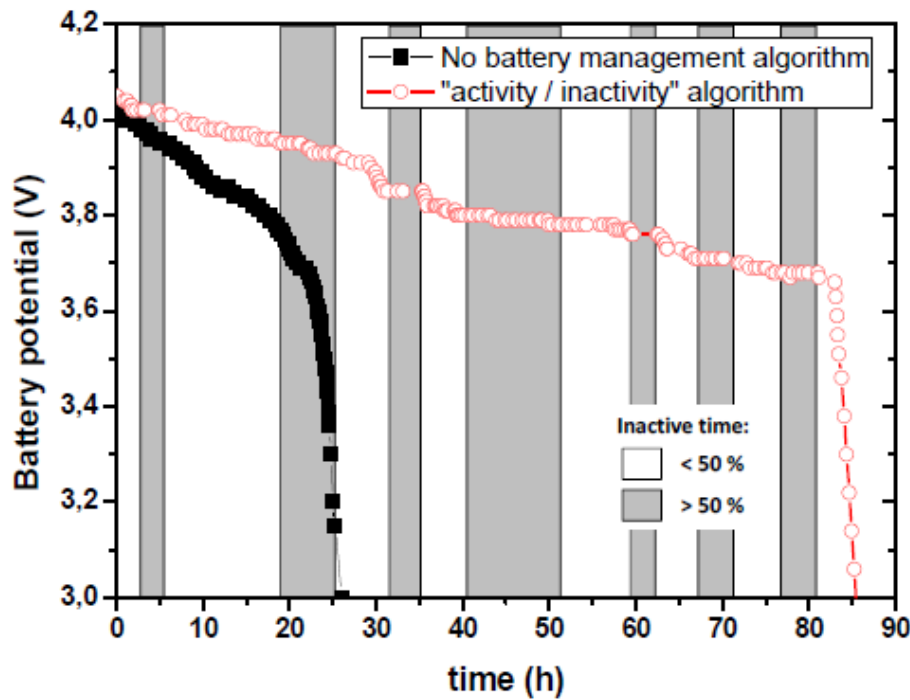


Figure 6-7 Décharge de pile avec et sans détection de l'inactivité

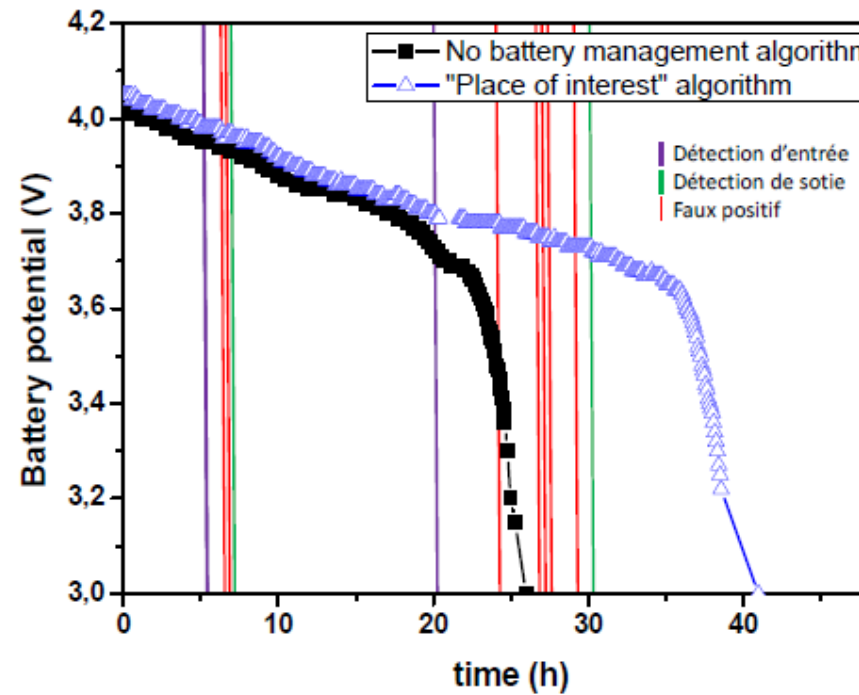
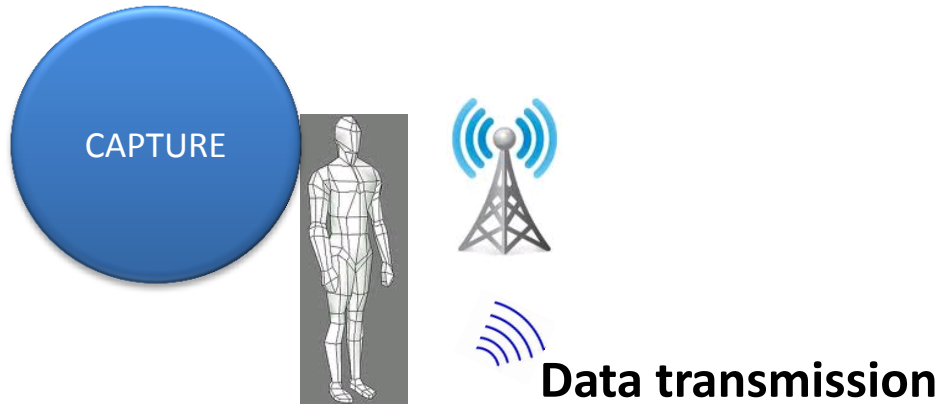


Figure 6-8 Décharge de pile avec et sans détection des lieux d'activité

SenseDoc Multisensor Device



GPS Data sent over the air (cellphone network) every 30 minutes

Possible alerts depending on

- Location
- Activity
- Time

Connection to other sensors (2.4 GHz ANT+) Heart rate monitor, footpod, RFID tags, etc.

Issues in data processing

PROCES
SING

Transforming raw GPS data into meaningful and useful information, combining with accelerometry

- 'Putting things into context'
- Activity locations
- Trips between locations





Usage

Using GPS/Accel to locate behaviour and assess exposure

Improve the understanding of mechanisms linking environments to health behaviours and profiles

Use GPS to prompt recall and gain additional insight

Use GPS to support qualitative studies (go-along, geo-ethnography, geo-tagged photos, environmental perception, etc.)

Use GPS/Accel data to assist clinical practice (mHealth)



Usage

RECORD GPS Study, Paris

191 participants wearing GPS & Accelerometer for 7 days

Estimates of:

- Number of steps walked
- Energy expenditure
- Moderate to Vigorous physical activity
- Sedentary time

Analyses possible at the trip level and by travel mode



Usage



During wear time, transportation was responsible for:

- 39% of steps walked
- 32% of total energy expenditure
- 33% of MVPA
- 15% of sedentary time



Usage

Geographic variations in contribution of transport to physical activity

	Geographic location (vs. far suburb)	
	Proximate suburb	Paris
% of steps	+3.3% (-1.8%, +8.3%)	+11.6% (+6.1%, +17.1%)
% of EE (Sasaki)	+2.9% (-1.8%, +7.5%)	+11.8% (+6.7%, +16.9%)
% of MVPA	+2.7% (-2.2%, +7.6%)	+12.8% (+7.4%, +18.2%)

	Geographic location (vs. far suburb)	
	Proximate suburb	Paris
Steps (#)	+ 2451 (-1854, +6756)	+7205 (+2526, +11884)
EE (Sasaki) (kcal)	+113 (-113, +339)	+269 (+22, +516)
MVPA (mn)	+18 (-19, +56)	+54 (+13, +94)



Usage

Differences in PA compared to car driving, per 10 min of trip
(n=4,984 trips with unique mode)

	Mn of MVPA per 10 mn of trip	Mn of sedentary time per 10 mn of trip	Kcal of energy expenditure (Sasaki)
Transportation mode (vs. car driving)			
Car, passenger	-0.3 (-0.8, +0.1)	+0.5 (+0.1, +0.9)	-2.0 (-4.9, +0.8)
2-wheel motor vehicle	+0.1 (-0.5, +0.6)	-1.7 (-2.2, -1.2)	+1.4 (-2.0, +4.8)
Metro	+1.9 (+1.5, +2.2)	-1.0 (-1.3, -0.7)	+10.0 (+7.9, +12.0)
Bus / coach	+1.1 (+0.6, +1.6)	-0.5 (-1.0, -0.1)	+7.1 (+4.0, +10.1)
Train	+2.0 (+1.5, +2.6)	-0.5 (-1.0, -0.0)	+12.9 (+9.5, +16.3)
Tramway	+3.6 (+1.8, +5.3)	-1.8 (-3.4, -0.2)	+16.0 (+5.3, +26.6)
Biking	+0.7 (+0.2, +1.2)	-3.0 (-3.4, -2.5)	+6.0 (+2.9, +9.1)
Walking	+3.9 (+3.7, +4.1)	-3.1 (-3.3, -3.0)	+22.7 (+21.6, +23.7)

Conclusion

- Large cohorts = challenges!
- A study management tool to manage people, processes and questionnaires
- An interactive mapping questionnaire to collect rich spatial data
- A multisensor platform to collect data on mobility, behaviour and health

Thank you!



www.SPHERE Lab.org



Contact: yan.kestens@umontreal.ca