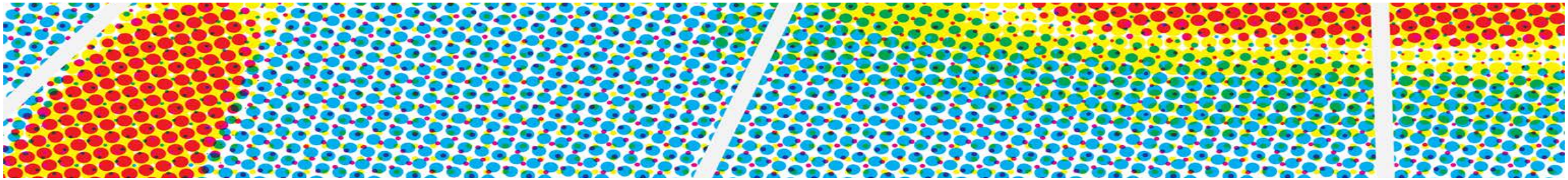
BIRGIT LIGTVOET

CROWDSENSING AS A TOOL FOR UP-TO-DATE ROAD ASSET DISTRESS DETECTION

P5 PRESENTATION

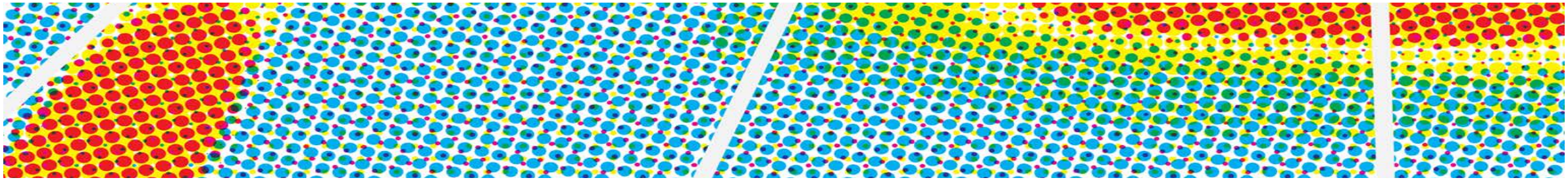


IN COOPERATION WITH

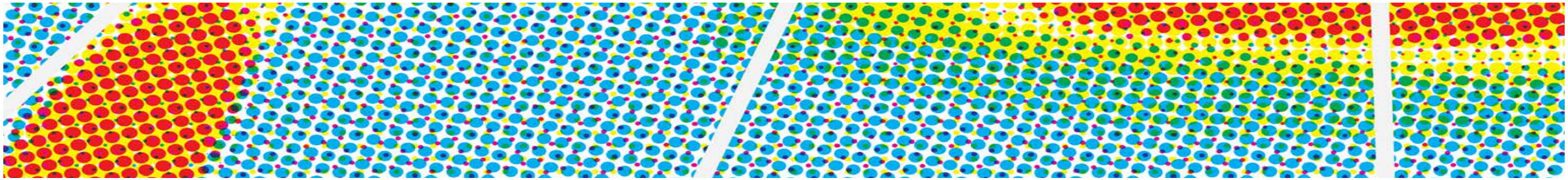
- Ir. E. Verbree
- Dr.ir. B.G.H. Gorte

- Dr.ir. H.K.M van de Ruitenbeek

Delegate: Dr.ir G. Bracken



INTRODUCTION



INTRODUCTION

Slecht wegdek Haringvlietbrug

16 juni 2017, 10:26

Tweeten

Het verkeer moet de komende weken rekening houden met enige vertraging op de A29 bij de Haringvlietbrug. Vanwege een slecht wegdek zijn ze daar bezig met werkzaamheden.

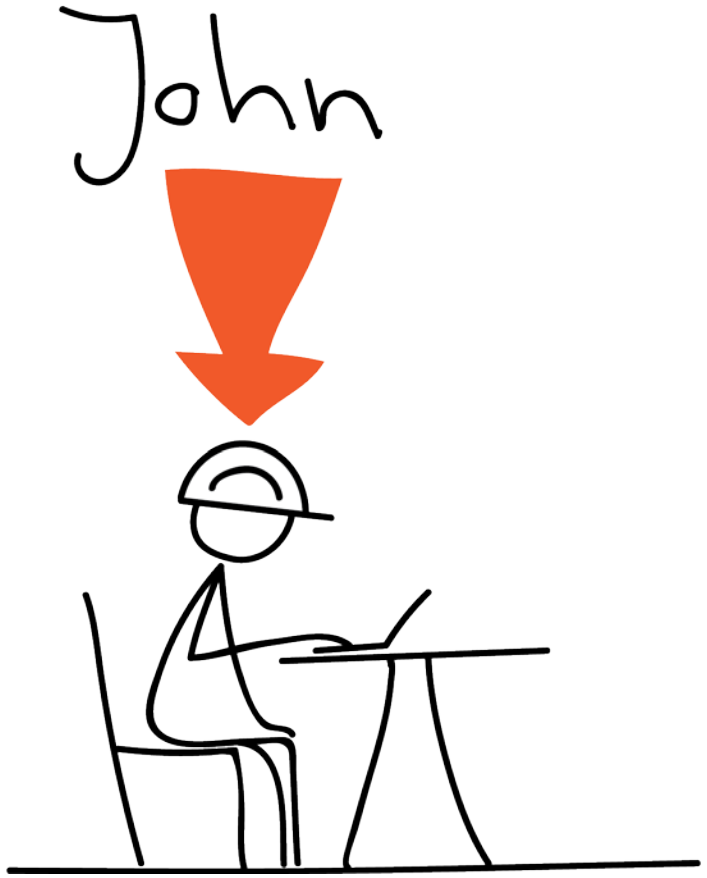
Hinder

De komende 2 a 3 weken is Rijkswaterstaat bezig met het repareren van het wegdek. Vanwege deze werkzaamheden kan het verkeer ook na de spits enige hinder ervaren. Het wegdek wordt in beide richtingen vernieuwd en daardoor moet het verkeer in beide richtingen dus rekening houden met files en vertraging.

Snelheidsbeperking

Vanwege de werkzaamheden geldt daar de komende weken een snelheidsbeperking.

A CURRENT SCENARIO IN ASSET MANAGEMENT



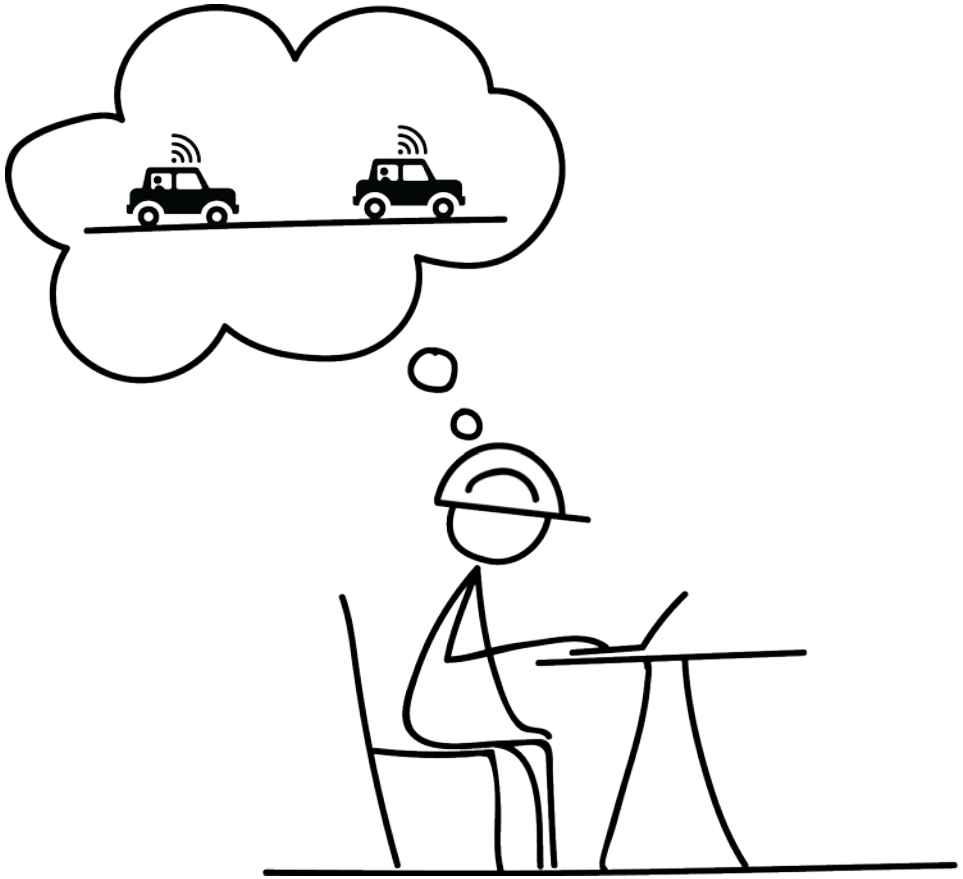
A CURRENT SCENARIO IN ASSET MANAGEMENT

PROBLEM STATEMENT

- Contracts shift to performance based contracting
  - Contractors bear risks
- Reliability & availability needs to be guaranteed
  - Additional information is needed

A FUTURE SCENARIO

A FUTURE SCENARIO



RELATED WORK - CROWDSENSING

- **Roadroid** calculates road roughness per road length and classifies it
- **Nericell pothole detection** sends detection - multiple detections define a hole
- **Streetbump** sends detection + data - multiple detections define a hole

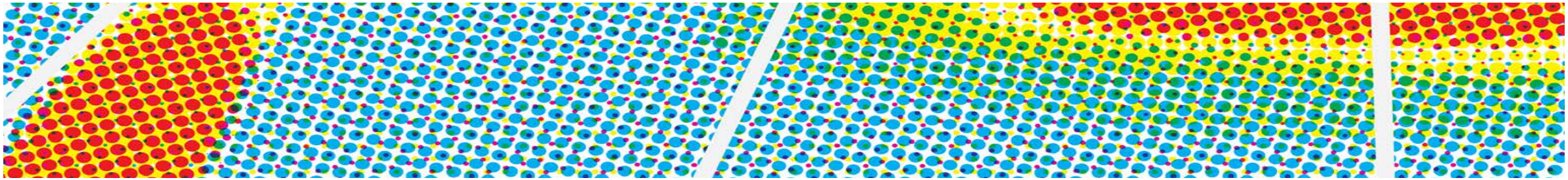
RESEARCH QUESTION

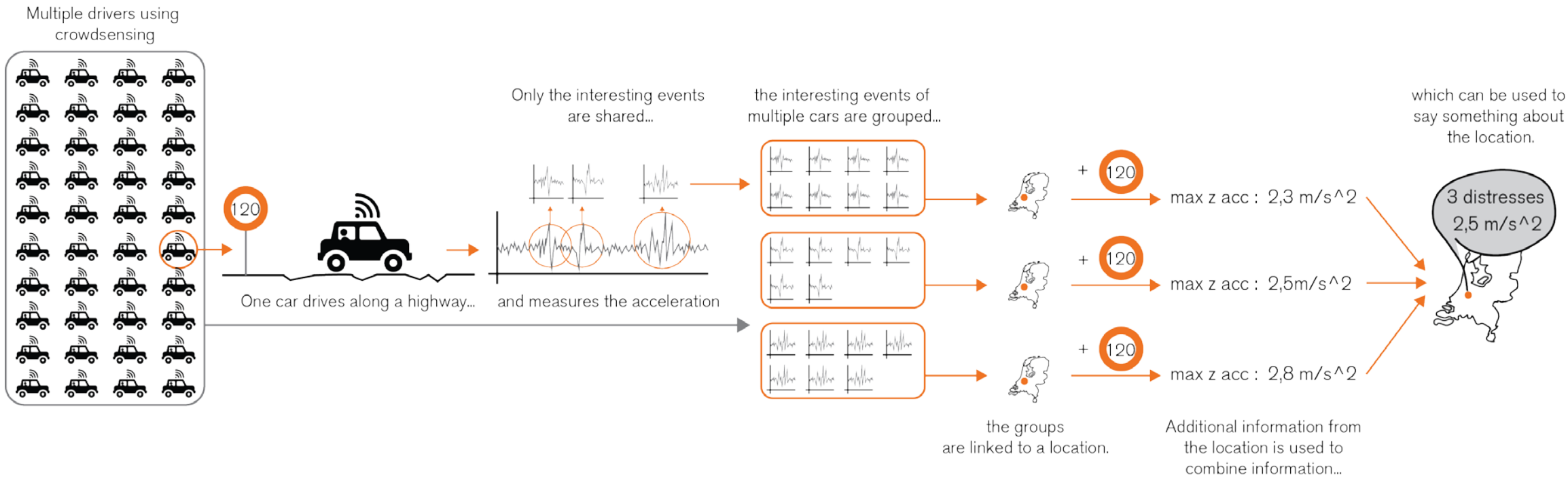
To what extent can the current state and the degradation of a road pavement asset be measured using mobile crowdsensing?

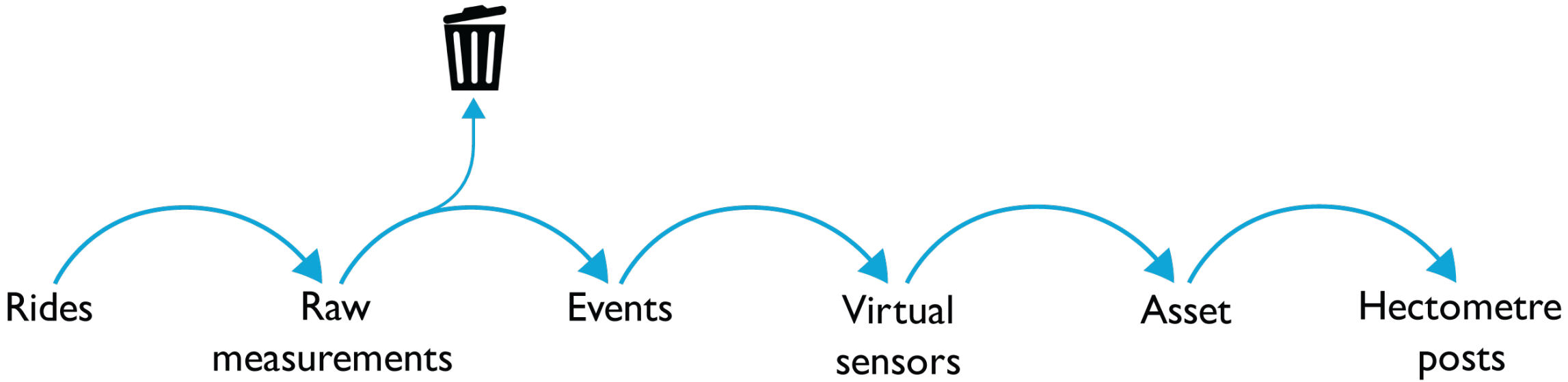
SCOPE

- Collect data through premade app
- Along the Dutch highway system
- Focus on Single lane
- Phone is stationary

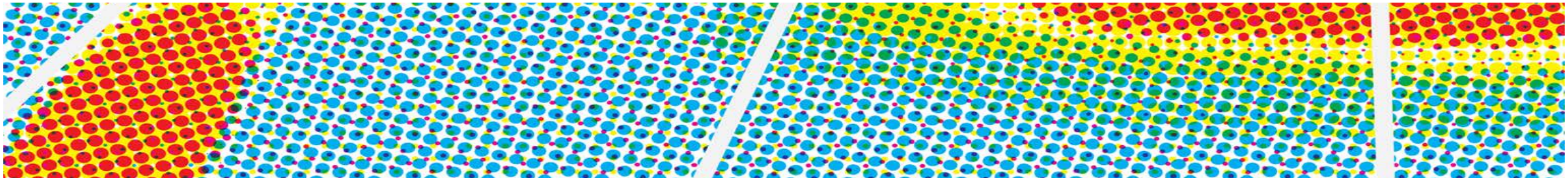
RESEARCH APPROACH



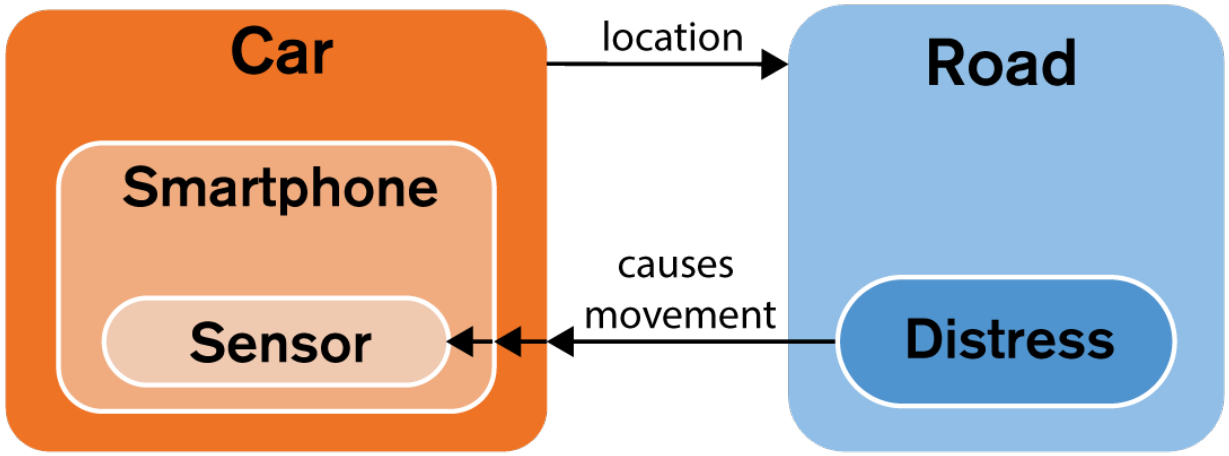

Multiple drivers using crowdsensing
120
One car drives along a highway...
Only the interesting events are shared...
and measures the acceleration
the interesting events of multiple cars are grouped...
the groups are linked to a location.
+ 120
max z acc : 2,3 m/s^2
+ 120
max z acc : 2,5m/s^2
+ 120
max z acc : 2,8 m/s^2
Additional information from the location is used to combine information...
which can be used to say something about the location.
3 distresses
2,5 m/s^2


Rides
Raw measurements
Events
Virtual sensors
Asset
Hectometre posts

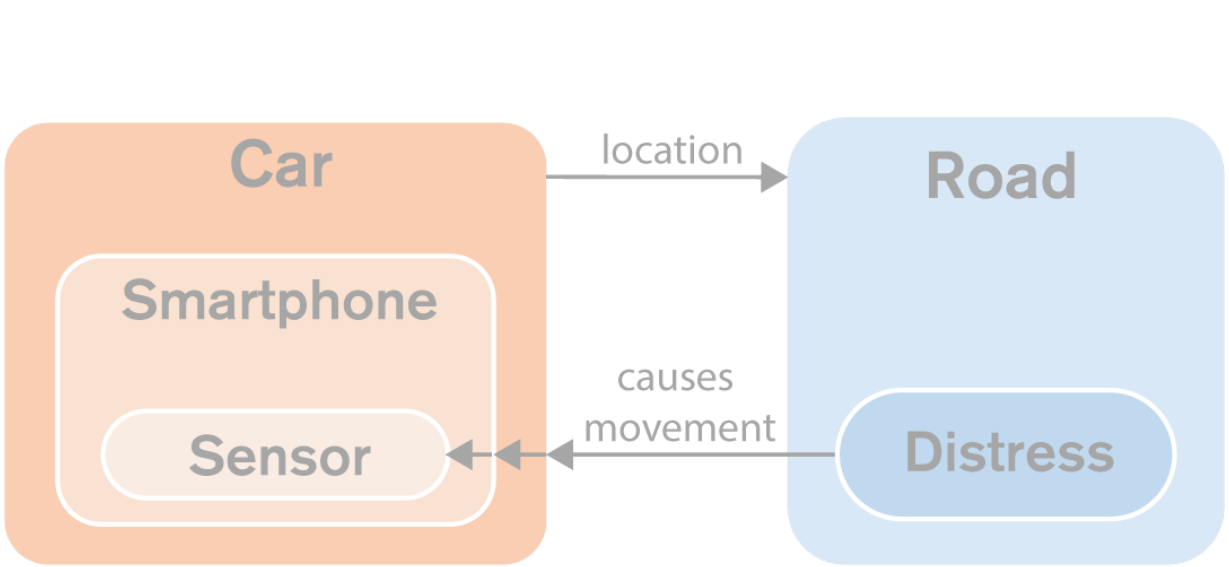
IMPLEMENTATION

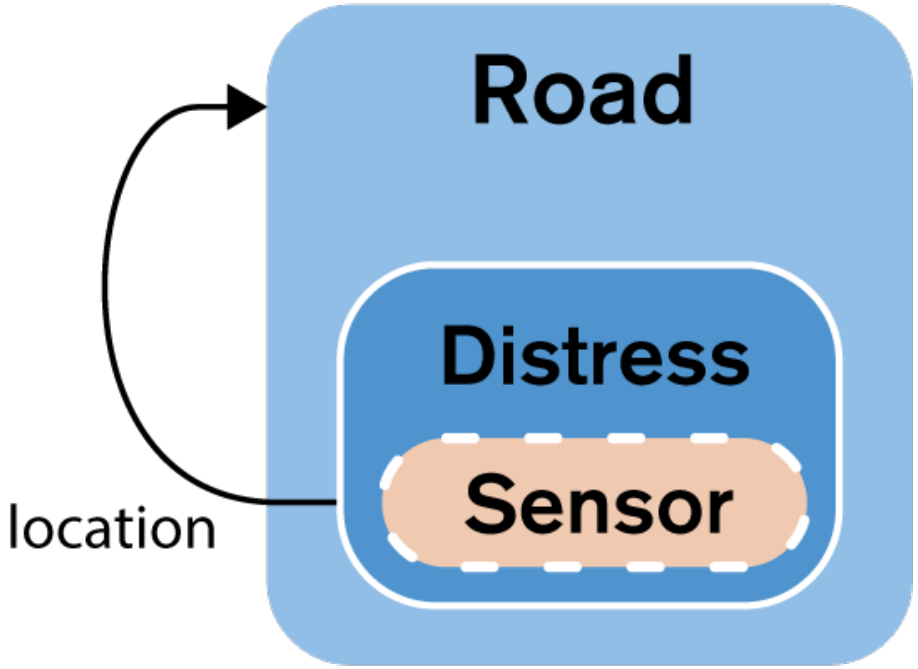


IN-CAR MOBILE CROWDSENSING

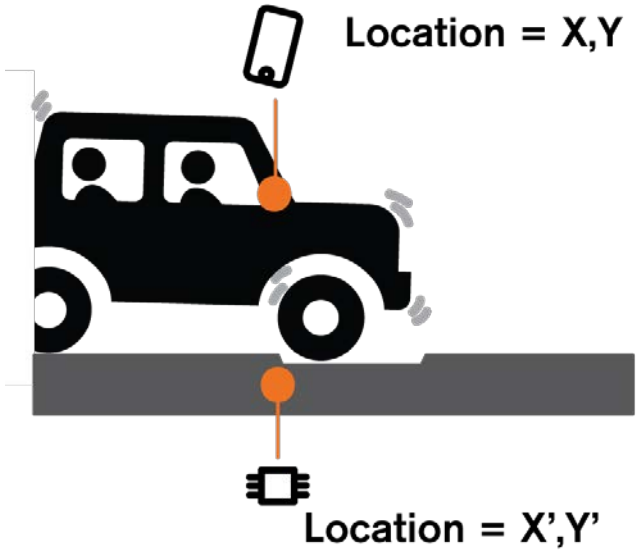


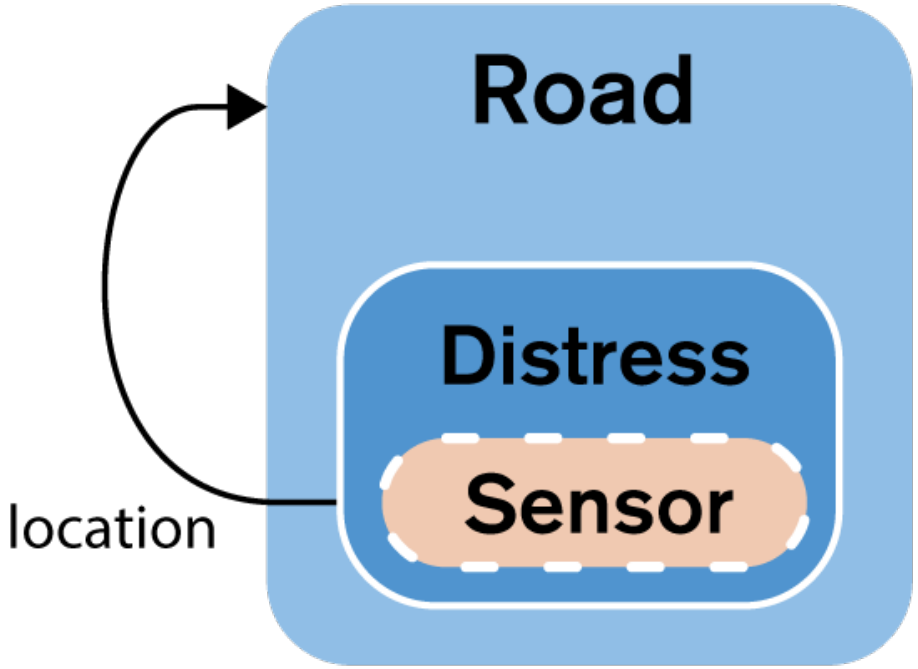
IN-CAR MOBILE CROWDSENSING - DESIRED SITUATION





THE VIRTUAL SENSOR





DATA CAPTURE

25 rides

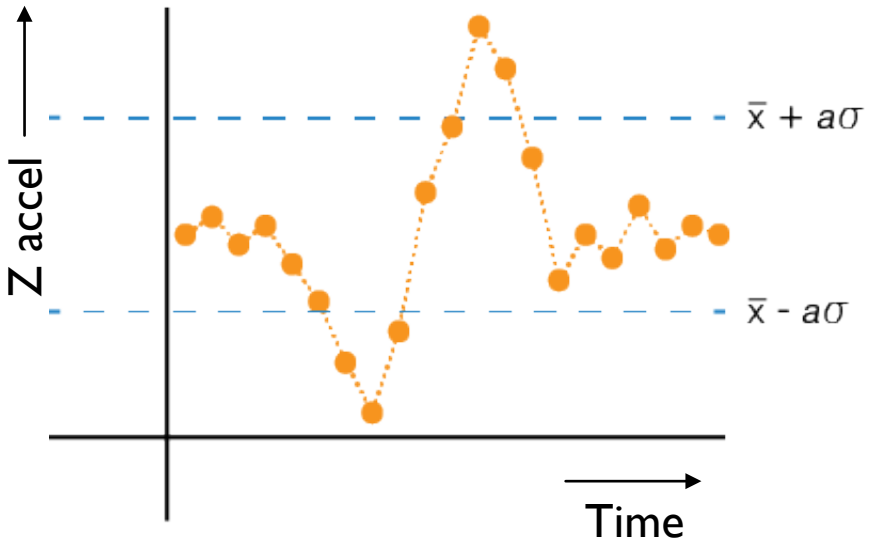
Timestamp	Accel_X	Accel_Y	Accel_Z	Quat.X	Quat.Y	Quat.Z	Quat.W	Lat	Long
515758008.998631	0.487305	0.054138	-0.988220	0.002185	0.035758	-0.486183	0.873123	51.840896	4.713939
515758009.008631	0.565353	-0.129547	-0.980057	0.002185	0.035758	-0.486183	0.873123	51.840896	4.713939
515758009.018706	0.569519	-0.111786	-0.884033	0.002185	0.035758	-0.486183	0.873123	51.840896	4.713939
515758009.029128	0.557892	-0.121658	-0.879868	0.002185	0.035758	-0.486183	0.873123	51.840896	4.713939
515758009.038610	0.542511	-0.107513	-0.910187	0.002185	0.035758	-0.486183	0.873123	51.840896	4.713939
515758009.047712	0.542511	-0.107513	-0.910187	0.002185	0.035758	-0.486183	0.873123	51.841132	4.714005
515758009.059124	0.551941	-0.113892	-0.930771	0.002185	0.035758	-0.486183	0.873123	51.841132	4.714005
515758009.068899	0.554184	-0.124146	-0.979355	0.002185	0.035758	-0.486183	0.873123	51.841132	4.714005
515758009.078653	0.566284	-0.125107	-0.918335	0.002185	0.035758	-0.486183	0.873123	51.841132	4.714005

68 rides

Data consists of:

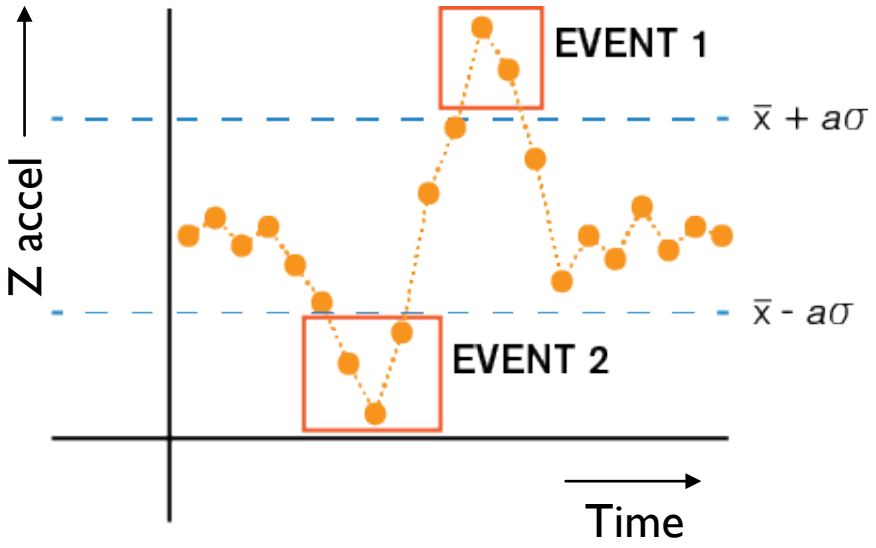
- Timestamp
- Z acceleration
- X,Y,Z Quaternion
- Position

EVENT DETECTION



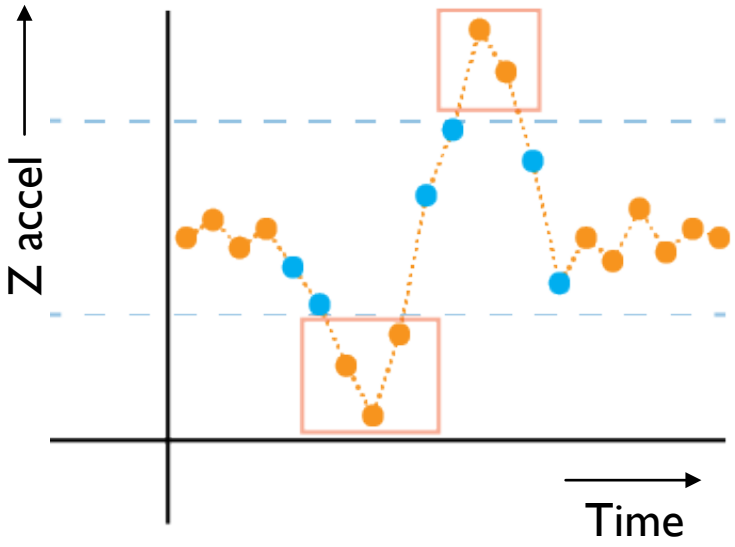
- Use σ tolerance for detection
  - Detect events regardless of suspension
- *aσ* based on manual validation

EVENT DETECTION



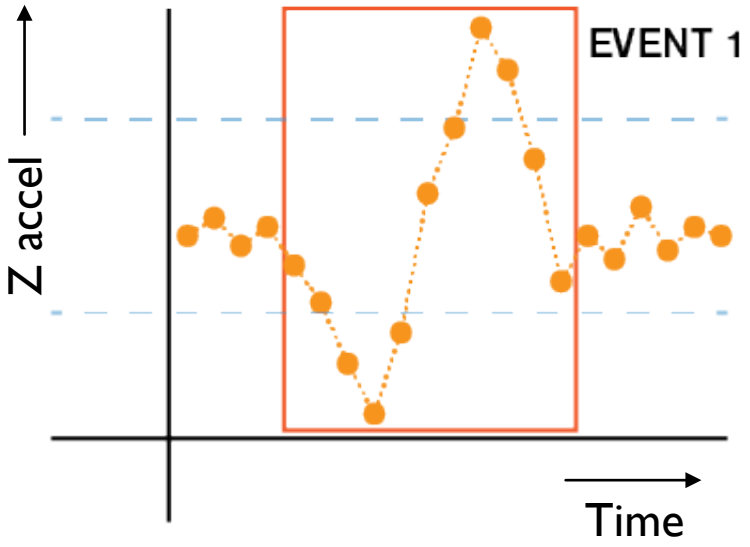
- Event = measurements outside 2.75 σ

EVENT DETECTION



- Look at measurements around events

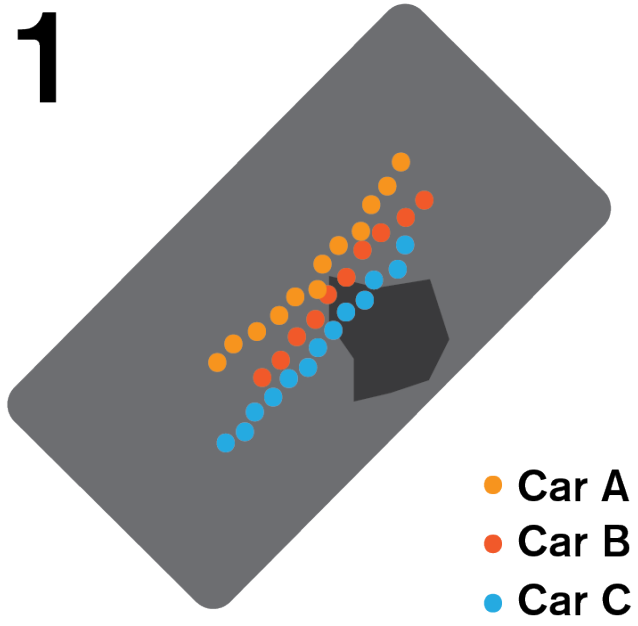
EVENT DETECTION



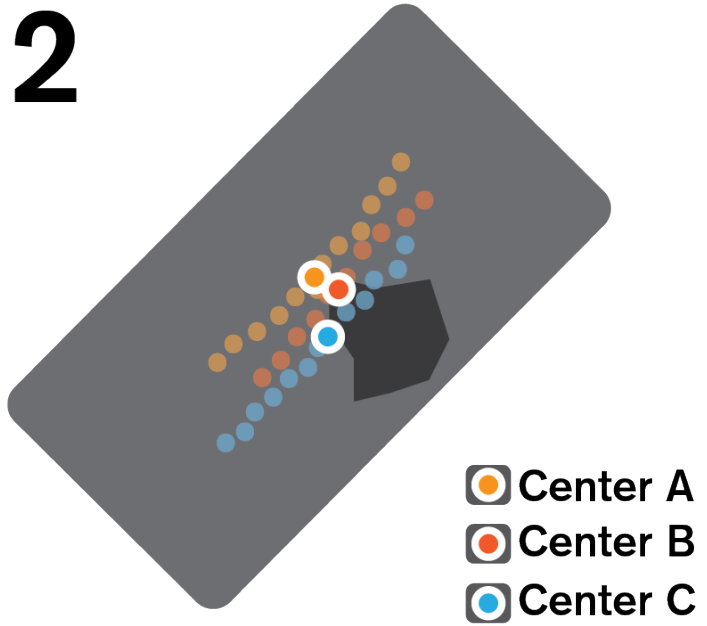
- Merge events into one

VIRTUAL SENSOR CREATION

1

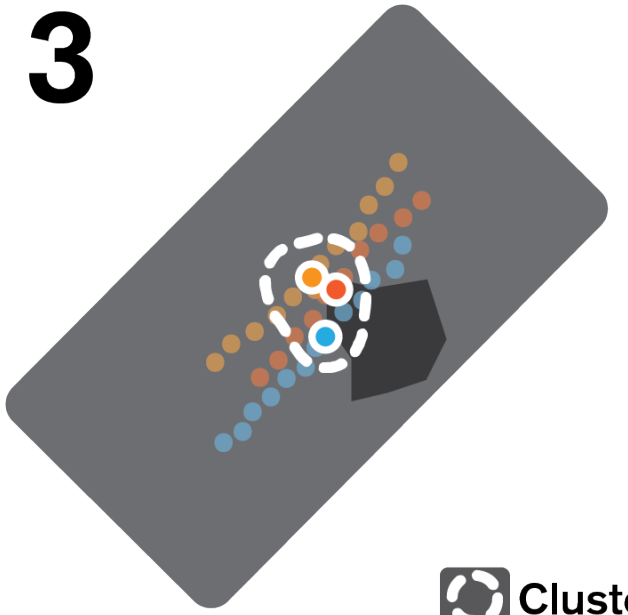


2



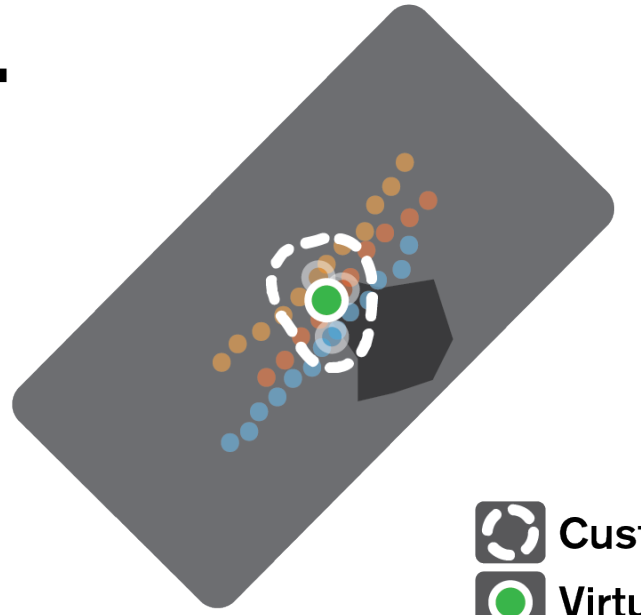
VIRTUAL SENSOR CREATION

3



Cluster

4



Custer

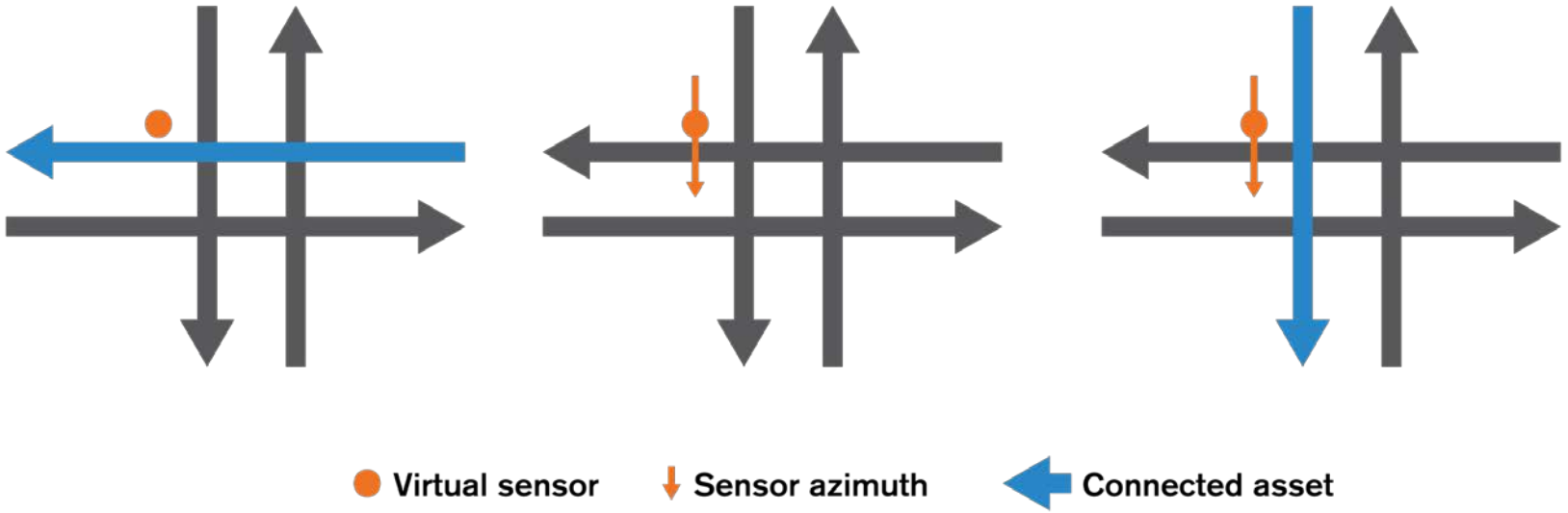
Virtual sensor

CONNECT VIRTUAL SENSOR TO ASSET

- Road section (weggeg)
- Hectometer post (nwb)

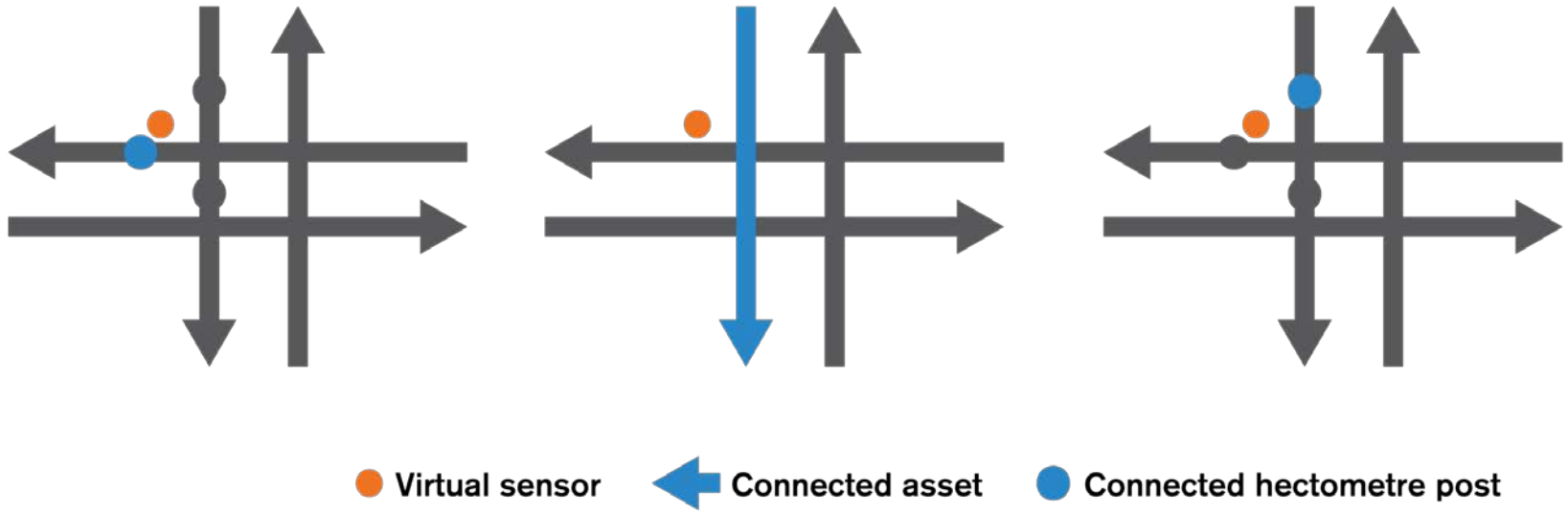
CONNECT VIRTUAL SENSOR TO ASSET

- Road section

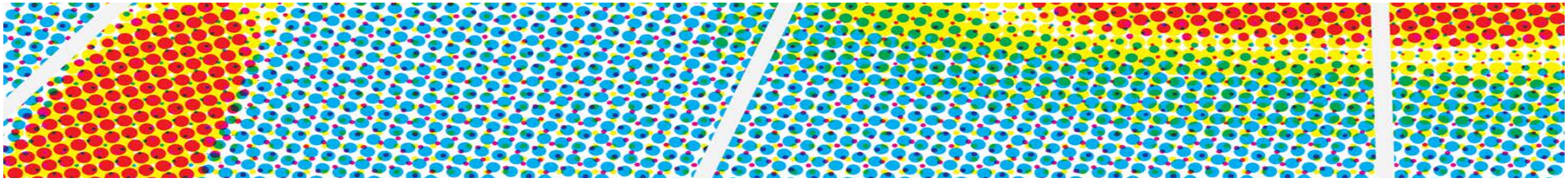


CONNECT VIRTUAL SENSOR TO ASSET

- Hectometre post



RESULTS



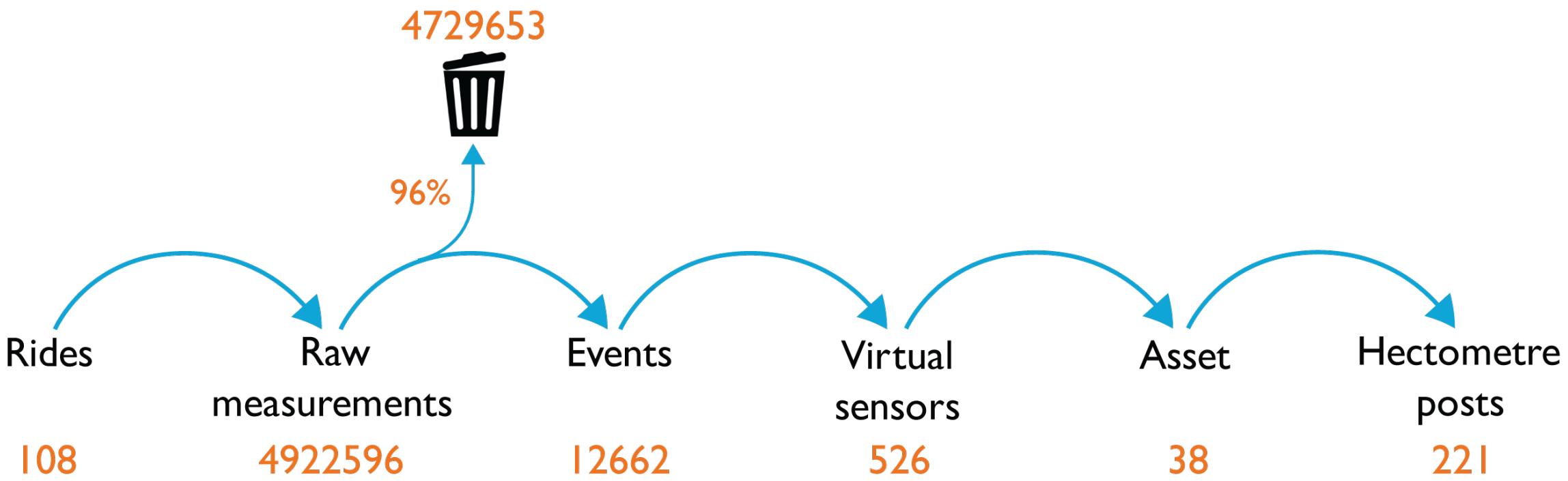
PRECISION

- GPS precision events
  - Average distance to lane centreline: 3 m
  - Standard deviation: 2.4 m
- Transversal precision of virtual sensor

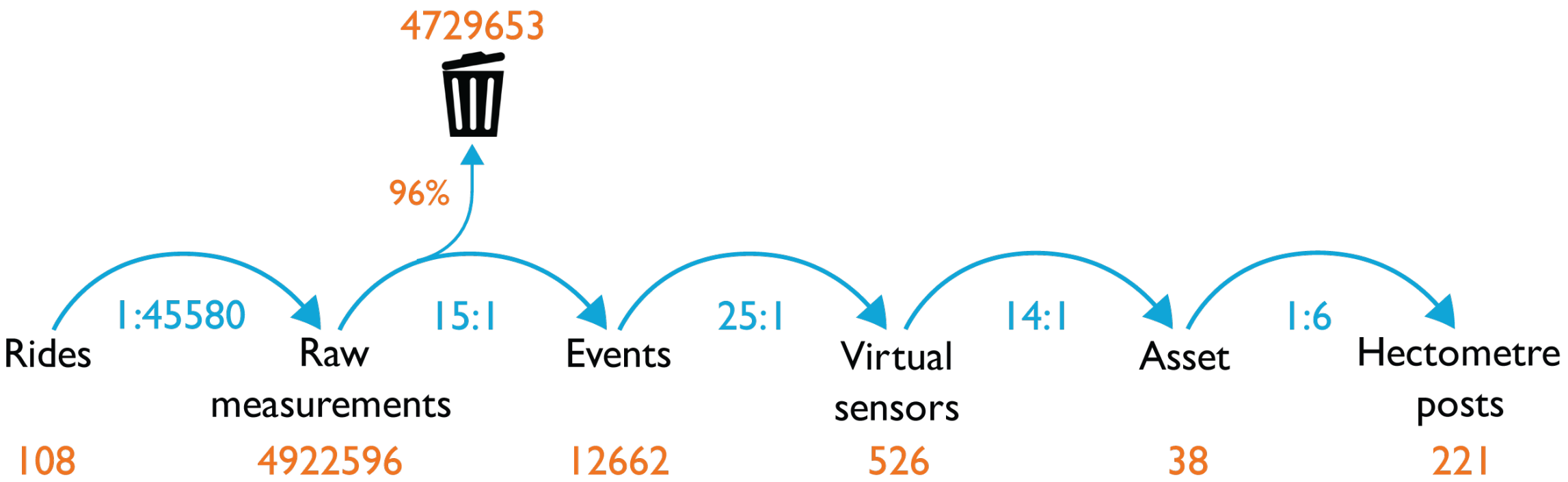
Nr of rides	Nr of clusters	Average distance to lane centreline (m)	Standard deviation (m)
10	27	1.54	0.96
20	26	0.98	0.92
30	32	0.82	0.66

ACCURACY

DATA FLOW


4729653
96%
Rides
108
Raw measurements
4922596
Events
12662
Virtual sensors
526
Asset
38
Hectometre posts
221

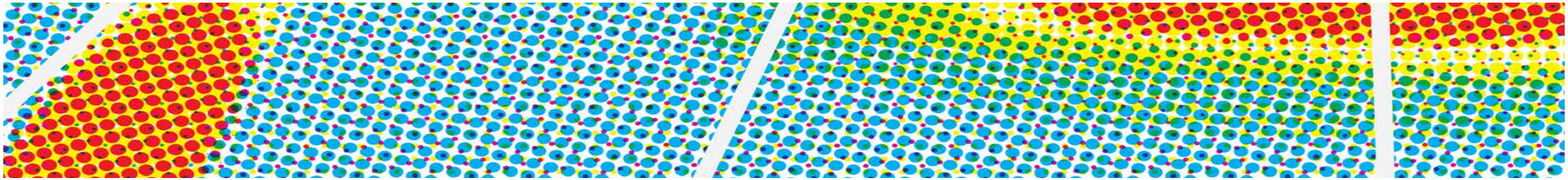
DATA FLOW


4729653
96%
1:45580
15:1
25:1
14:1
1:6
Rides
Raw measurements
Events
Virtual sensors
Asset
Hectometre posts
108
4922596
12662
526
38
221

MAPS

MAPS

CONCLUSION



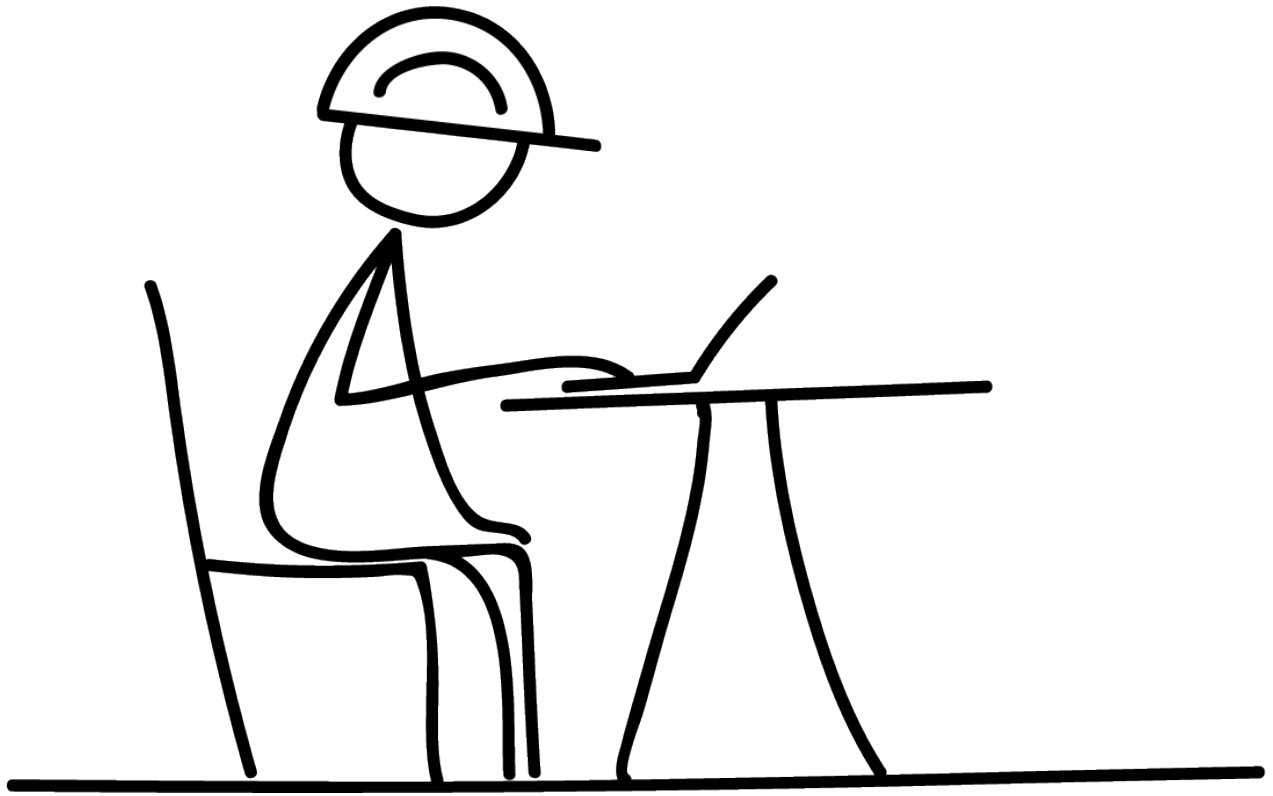
TO WHAT EXTENT CAN THE CURRENT STATE AND THE DEGRADATION OF A ROAD PAVEMENT ASSET BE MEASURED USING MOBILE CROWDSENSING?

Road pavement distresses are:

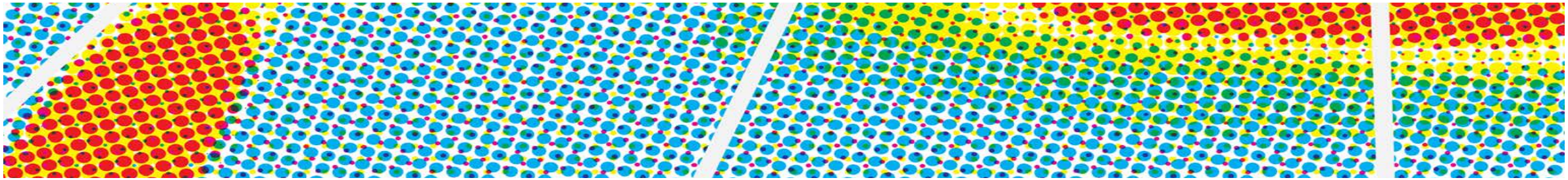
- Detected by using multiple indications
- Connected to assets
- Enriched with additional information

RESEARCH LIMITATI0NS

- Average suspension for Dutch cars
- Smartphone location in car
- Hit direction of car on distress



FUTURE WORK



FUTURE WORK

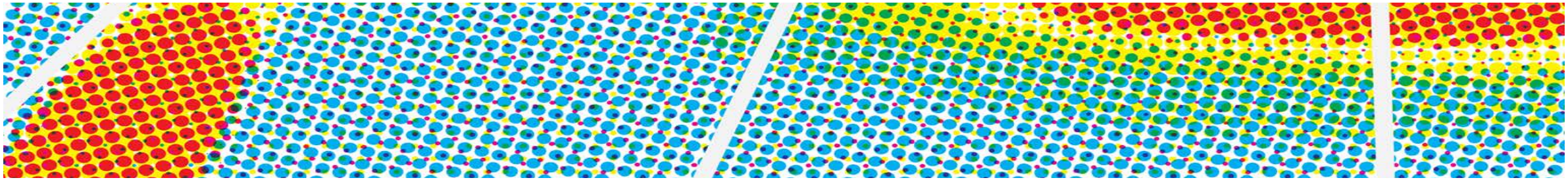
Implementation

- Local analysis
- App adoption by users
- Cars as sensors

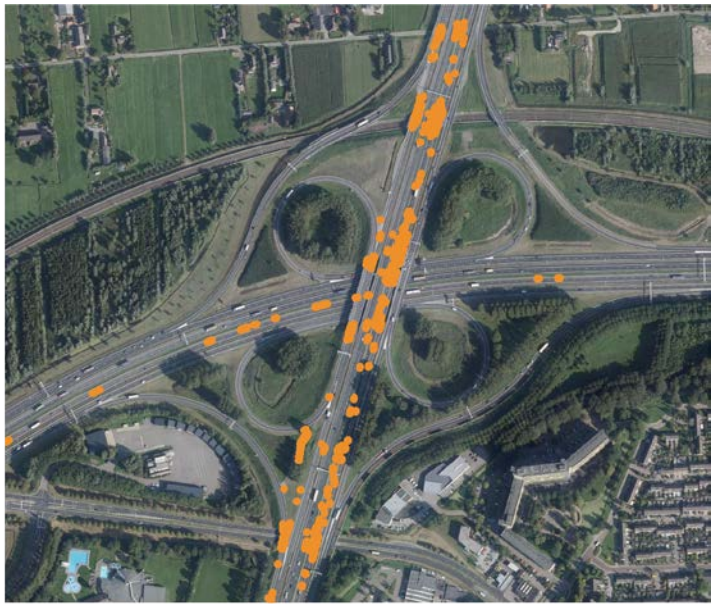
Academic

- Average Dutch car
- Relationship suspension - speed - distress size - car weight
- Low level info -> high level info

THANK YOU FOR YOUR ATTENTION

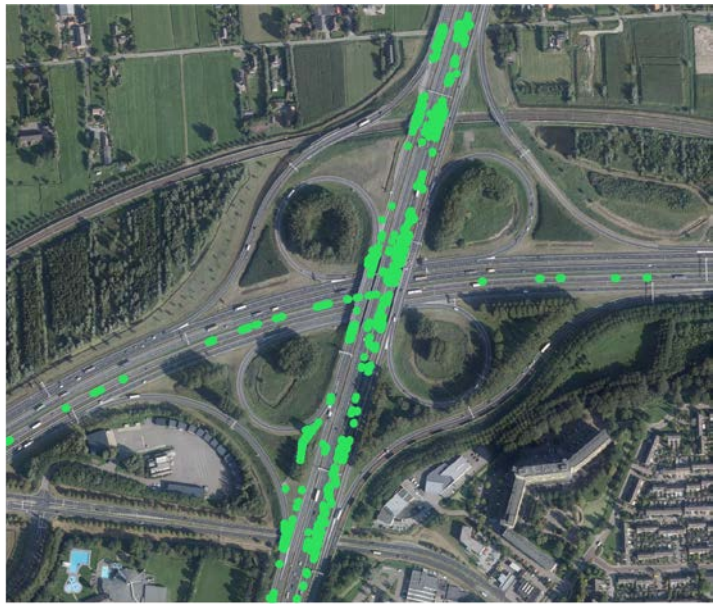


EVENT DETECTION



3.0 σ

2.5 σ



2.75 σ

DATA FLOW