U.PORTO

LIACC

artificial intelligence and computer science laboratory

Vehicular Sensing

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Departamento de Ciência de Computadores

Outline

- Sensing land survey data through vehicles
- A communication network connecting vehicles: VANET (Vehicular Ad Hoc Network)
- Study of VANET connectivity: large-scale microscopic simulation
- Example: a car localization protocol through a vision-enaled VANET
- **Application: automatic construction and updating of road maps**

Real-time land survey data

- Land survey data is acquired through a variety of sensors:
  - Fixed sensors, such as weather stations;
  - Mobile sensors, such as polar orbiting imagery satellites
- Such sensors are typically connected through some type of communication network: real-time information.
- A communication network is being proposed for vehicles, through DSRC, motivated mainly by the goal of improving driving safety, but also to improve traffic flow and allow infotainment applications.

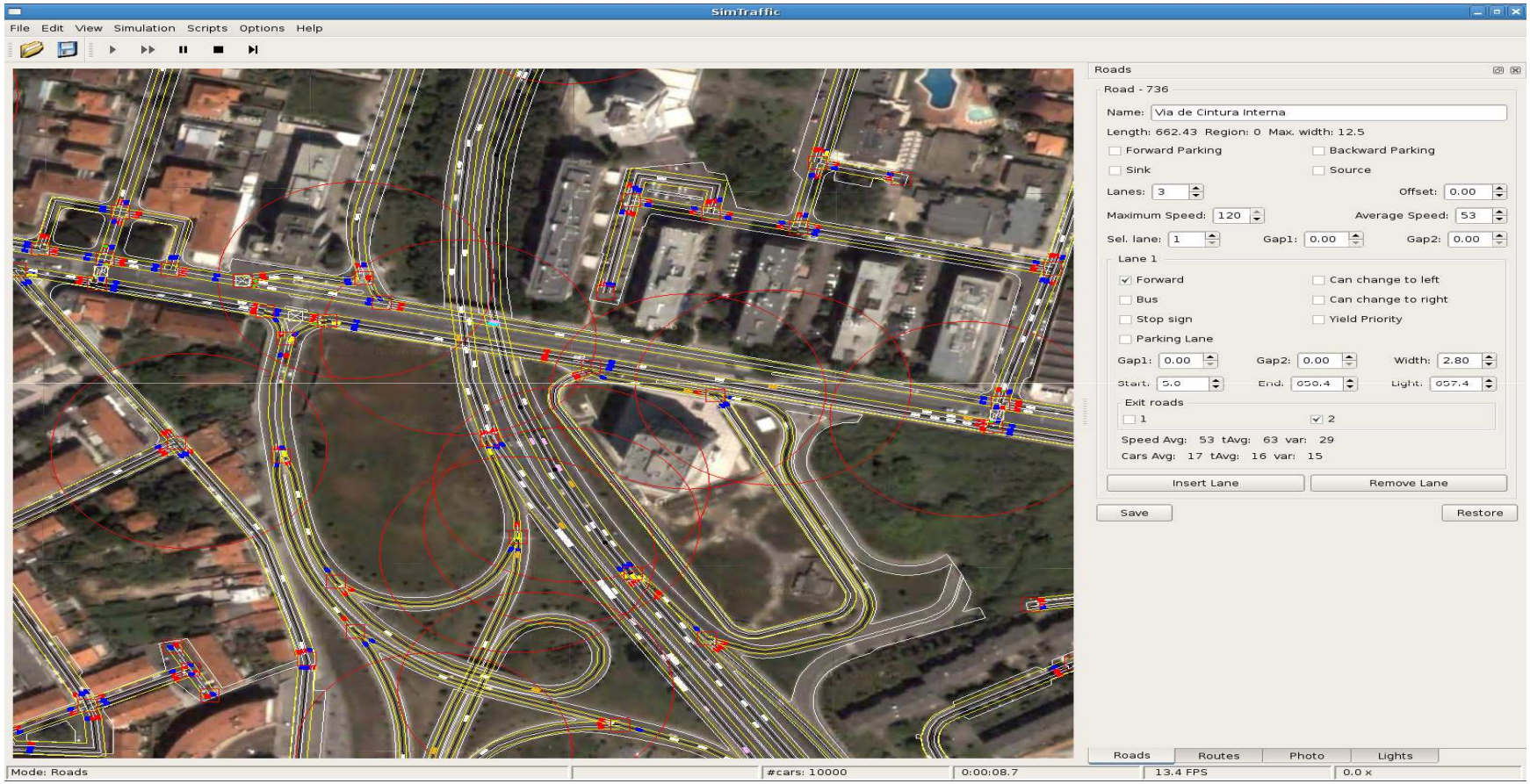
SENSORS IN VEHICLES

- Mobility based: GPS, accelerometers;
- Environment monitoring: outside temperature, rain, CO2, altitude, etc;
- Radio monitoring: GSM/GPRS/3G cell coverage, wifi coverage;
- Image-based: windshield cameras.

SIMULATION OF A VANET

- We developed a microscopic VANET simulator: DIVERT
- Has been supporting the analysis of connectivity
- Allows prototyping sensing protocols, such as vision-enabled distributed search

DIVERT DEMO


SimTraffic
File Edit View Simulation Scripts Options Help
Roads
Road - 736
Name: Via de Cintura Interna
Length: 662.43 Region: 0 Max. width: 12.5
Forward Parking
Backward Parking
Sink
Source
Lanes: 3
Offset: 0.00
Maximum Speed: 120
Average Speed: 53
Sel. lane: 1
Gap1: 0.00
Gap2: 0.00
Lane 1
Forward
Can change to left
Bus
Can change to right
Stop sign
Yield Priority
Parking Lane
Gap1: 0.00
Gap2: 0.00
Width: 2.80
Start: 5.0
End: 650.4
Light: 657.4
Exit roads
1
2
Speed Avg: 53 tAvg: 63 var: 29
Cars Avg: 17 tAvg: 16 var: 15
Insert Lane
Remove Lane
Save
Restore
Roads
Routes
Photo
Lights
Mode: Roads
#cars: 10000
0:00:08.7
13.4 FPS
0.0 x

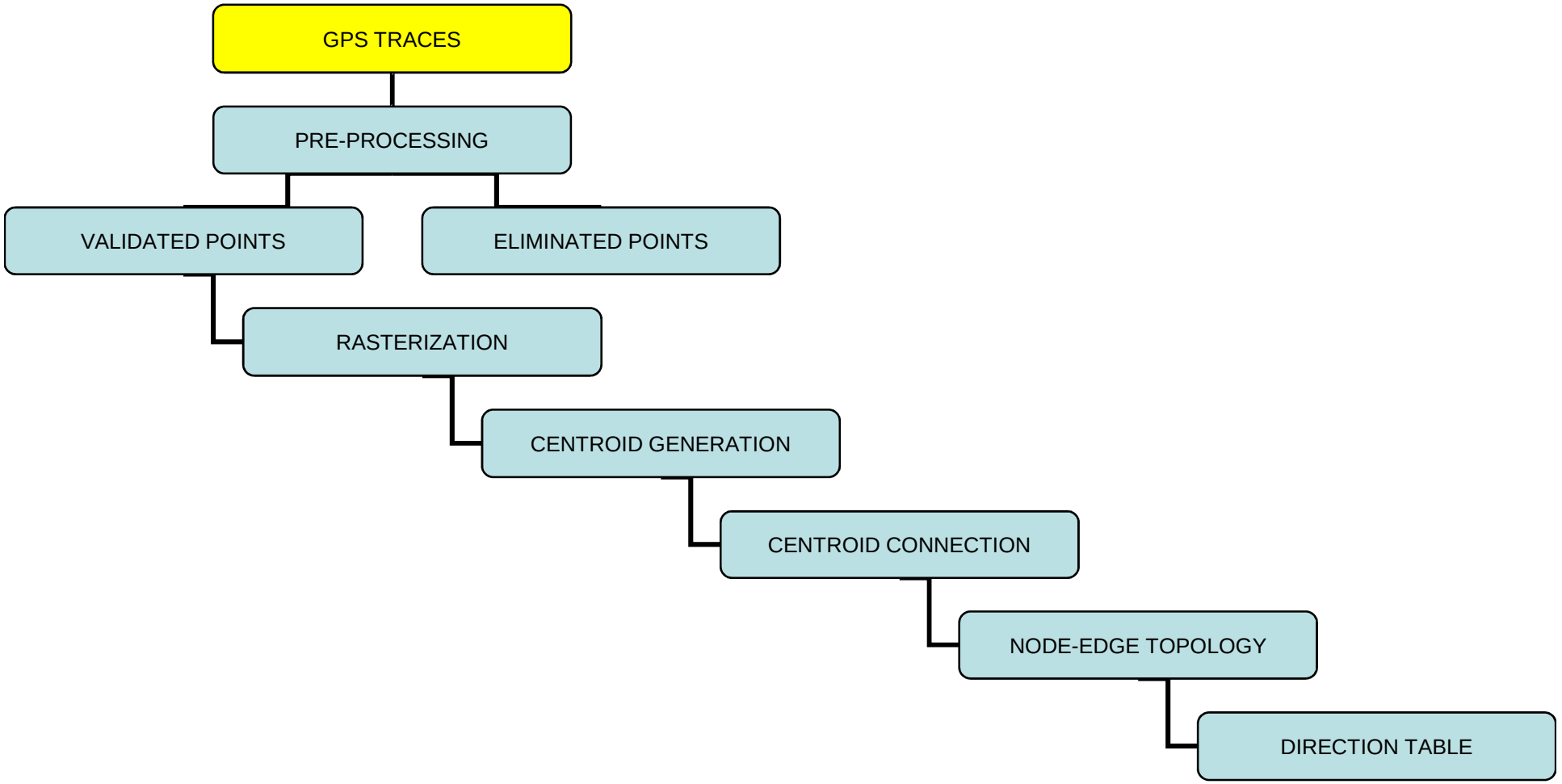
CONNECTIVITY ANALYSIS

output.swf

AN APPLICATION

- Automatic construction and updating of road maps.

Automatic Map Generation

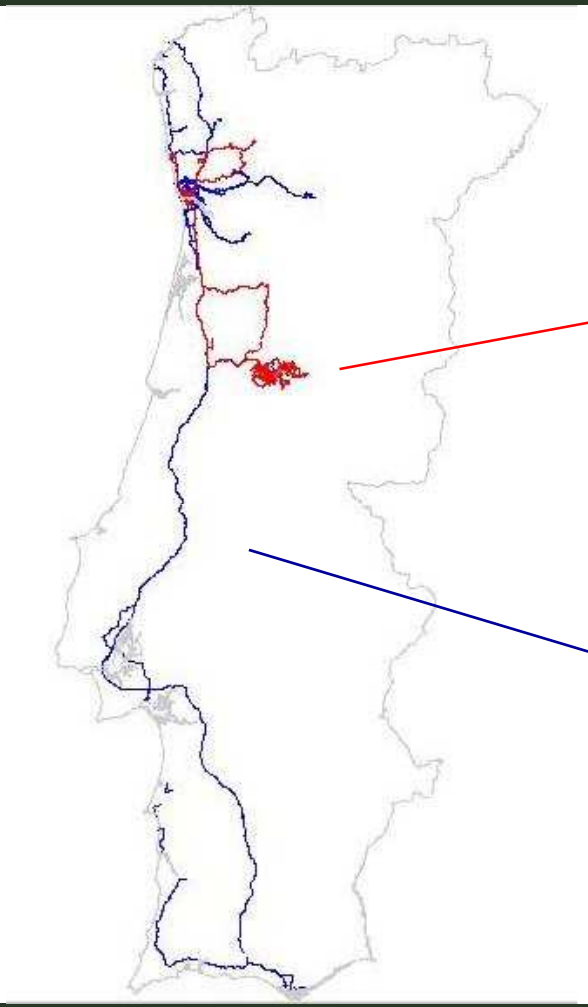


ACQUISITION OF GPS TRACES

. We started collecting offline traces, using manually started GPS devices, which logged to a file that was again manually upload to a database;
. Later we created a company, Geolink, which **sells** very inexpensive vehicle tracking services in exchange for the traces!
.The rationale is that the most expensive part of vehicular sensing is having the vehicle moving.
. Devices are now installed in vehicles and transparently start logging when ignition is activated. Transmission is automatic and almost real-time (2 minutes lag).
. We currently use GPRS but the idea is to eventually use V2V and wifi.

Collecting GPS Traces

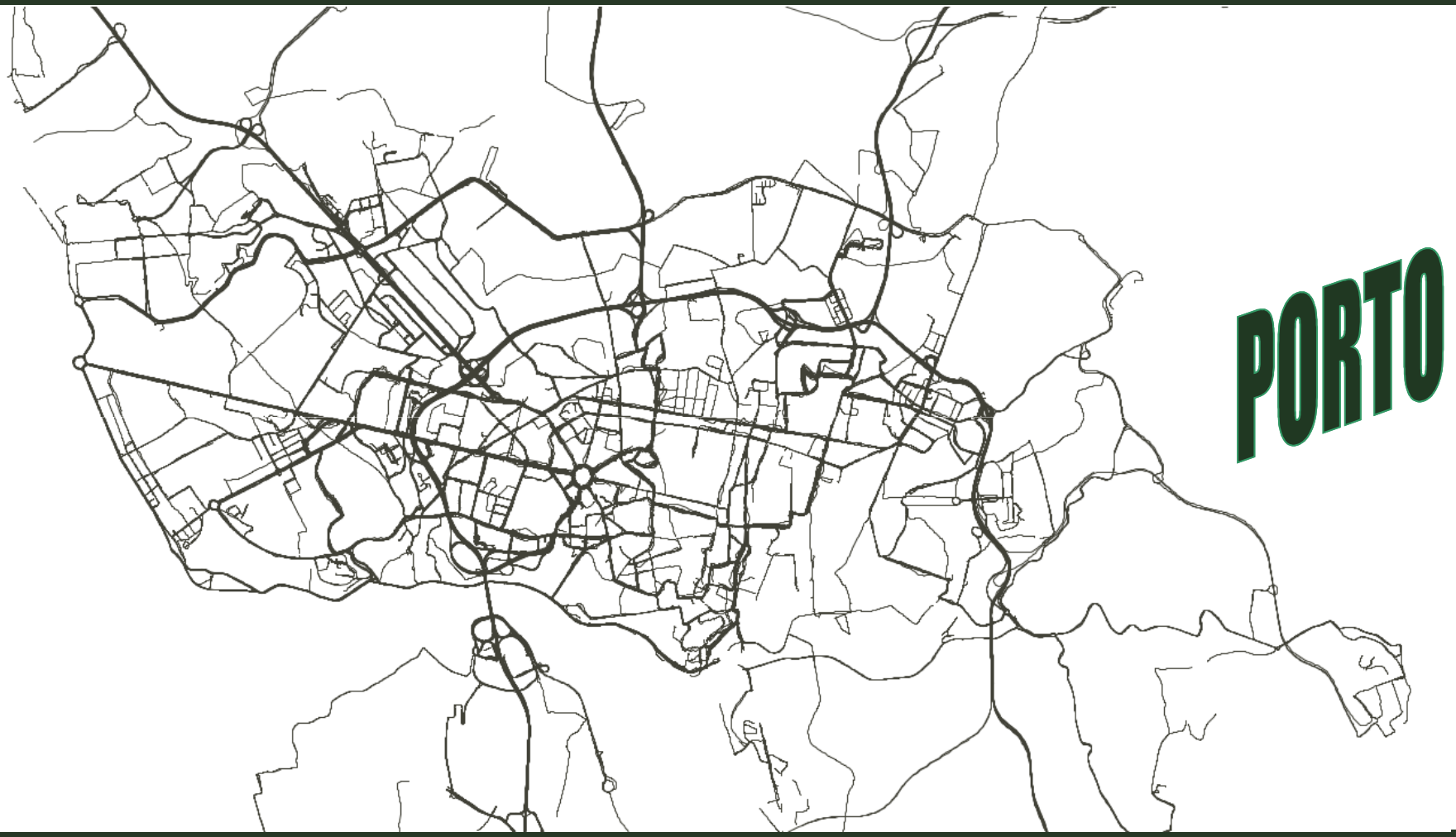
GPS Traces



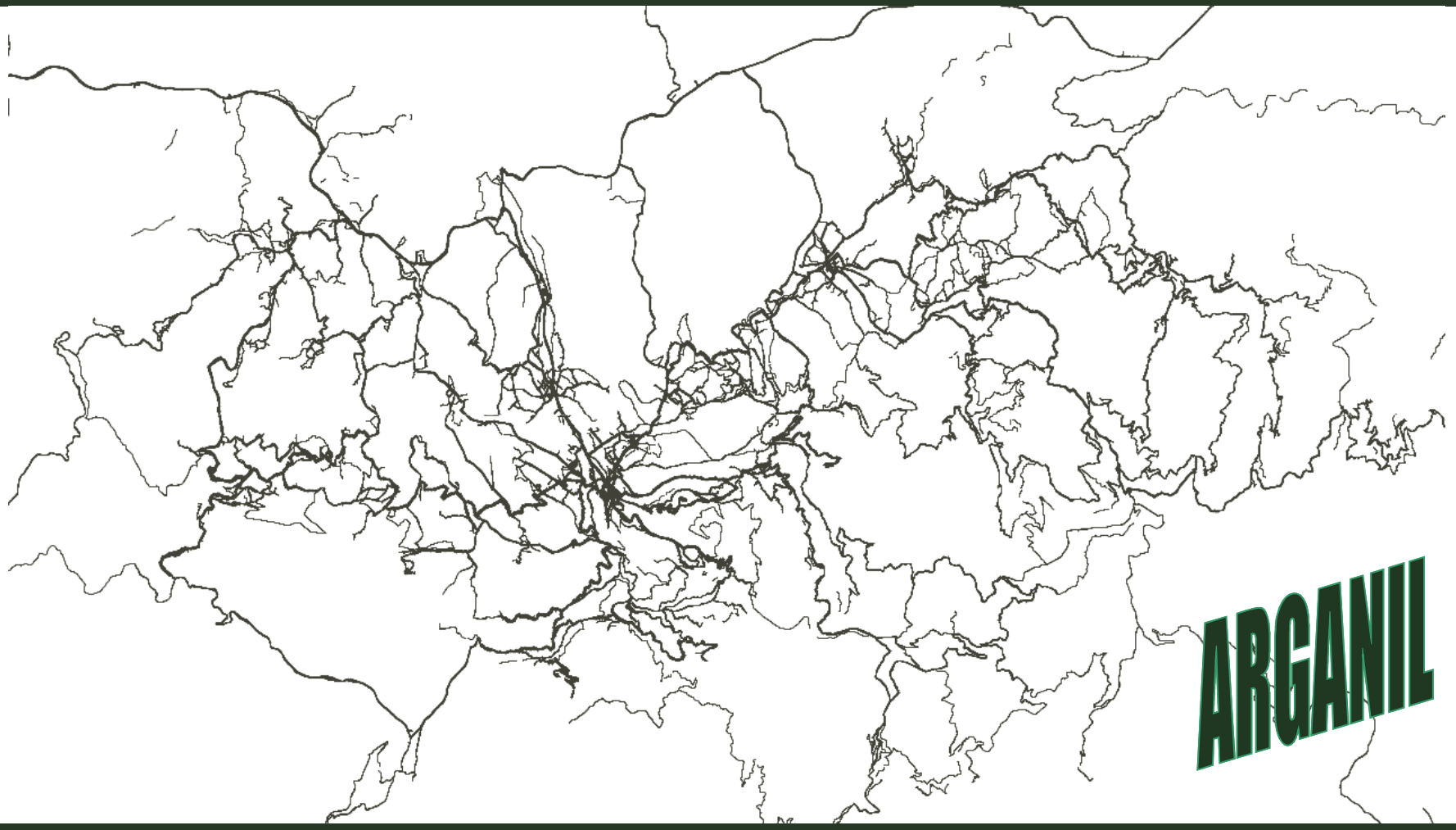
Real-time traces

Off-line traces

GPS Traces



GPS Traces



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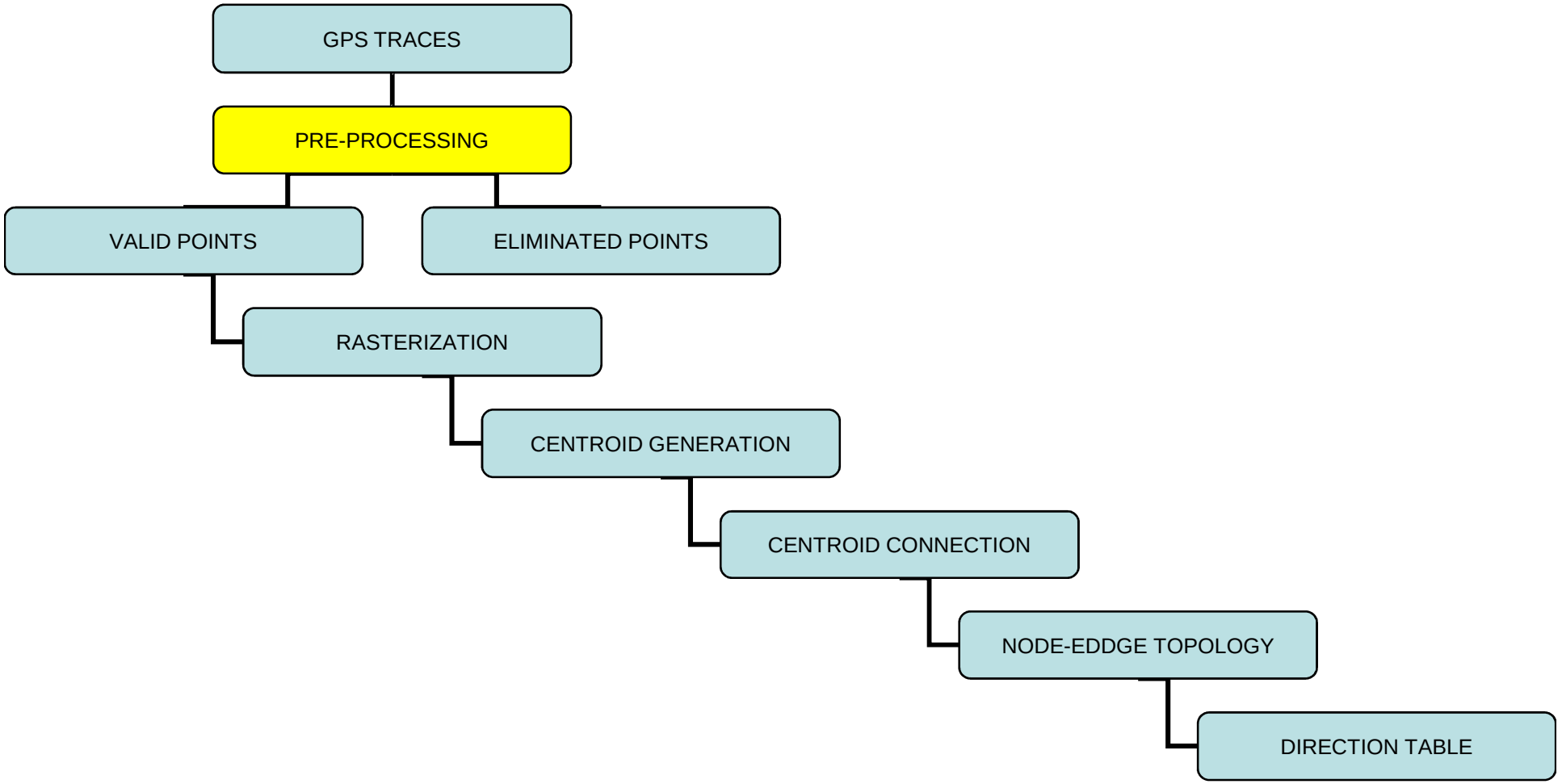
PRE-PROCESSING OF DATA



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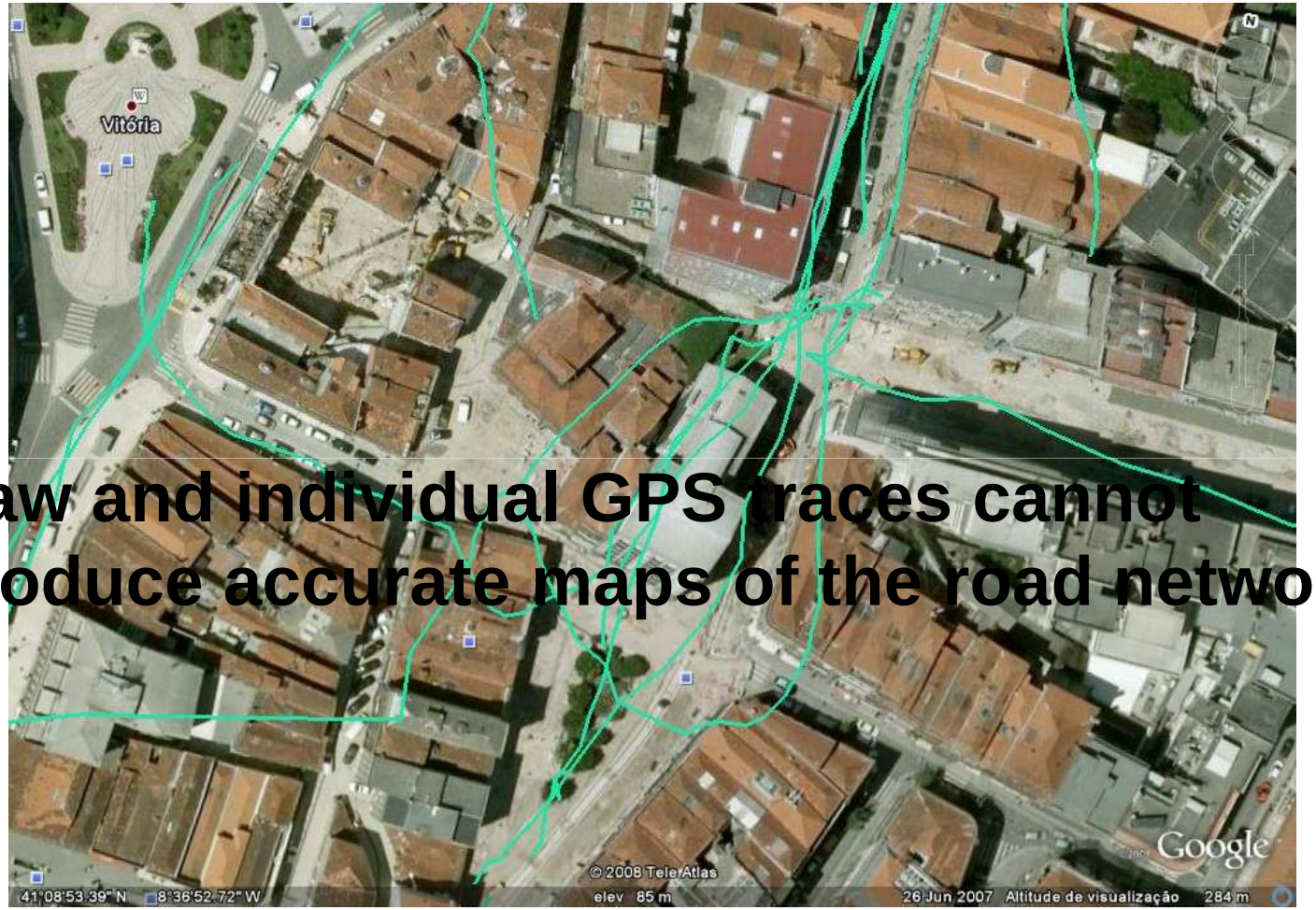


Raw and individual GPS traces cannot produce accurate maps of the road network

PRE-PROCESSING OF DATA

Data is filtered based on:

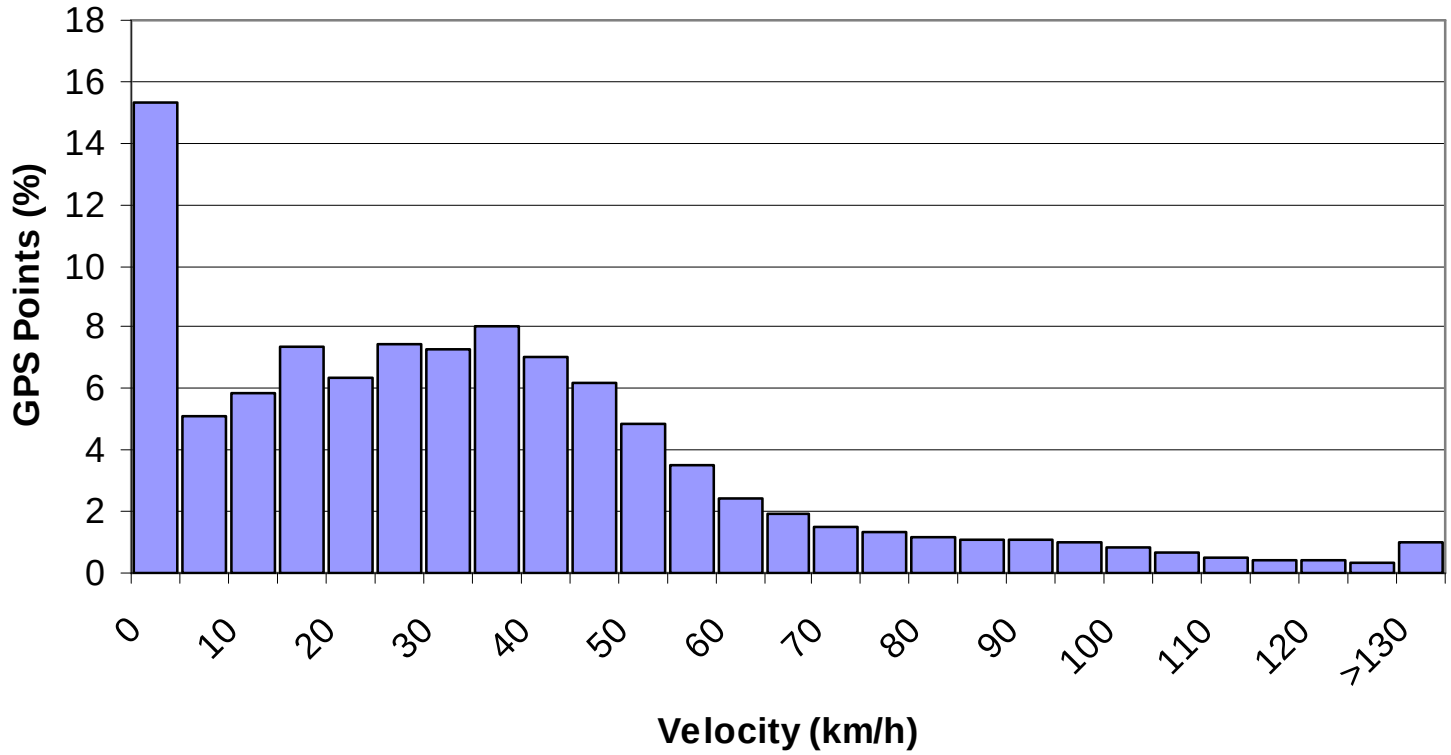
- vehicle speed;

- horizontal dilution of precision value (HDOP);

- number of tracked satellites;

- distance between consecutive points.

PRE-PROCESSING OF DATA



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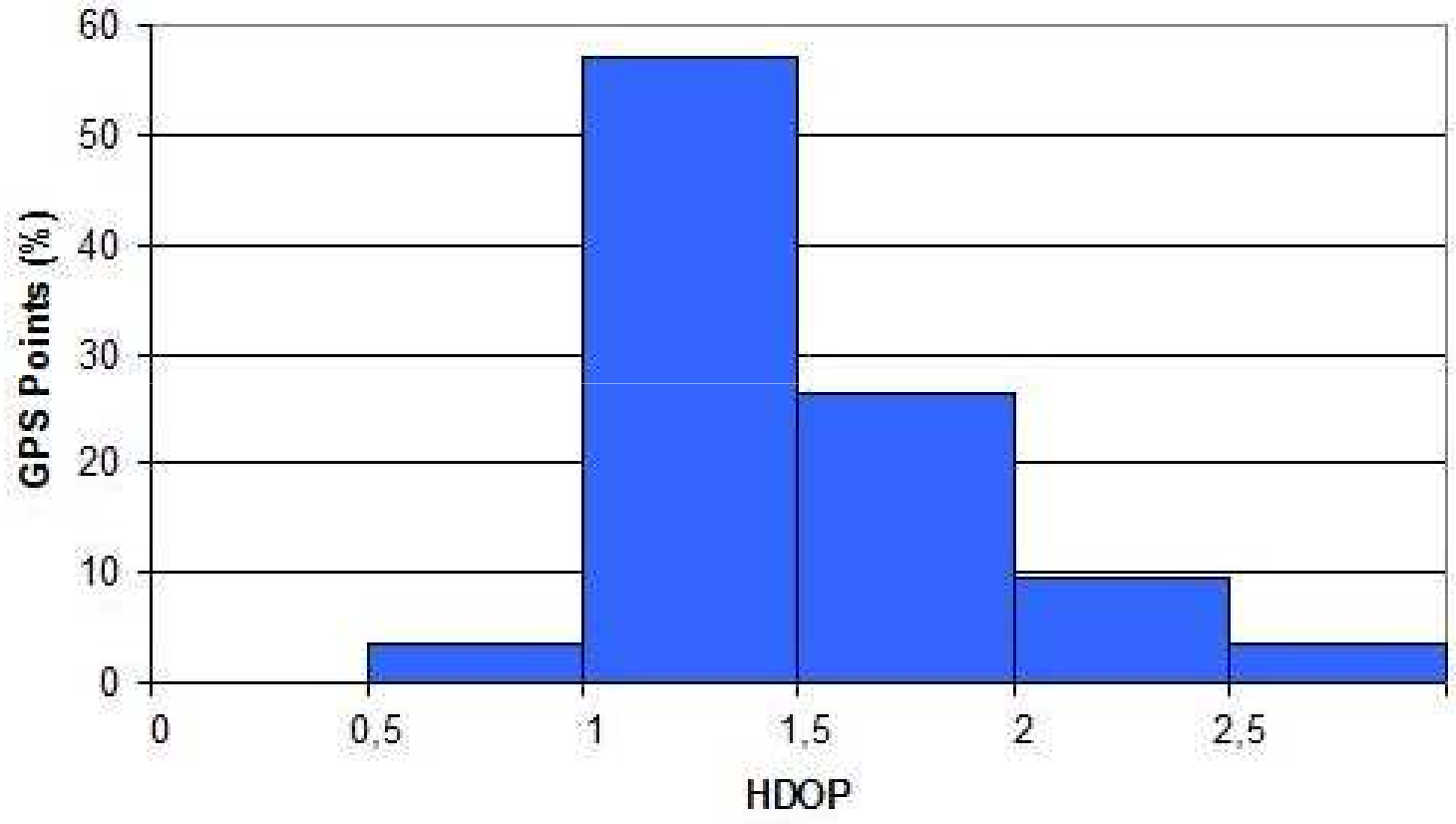


PRE-PROCESSING OF DATA

PRE-PROCESSING OF DATA

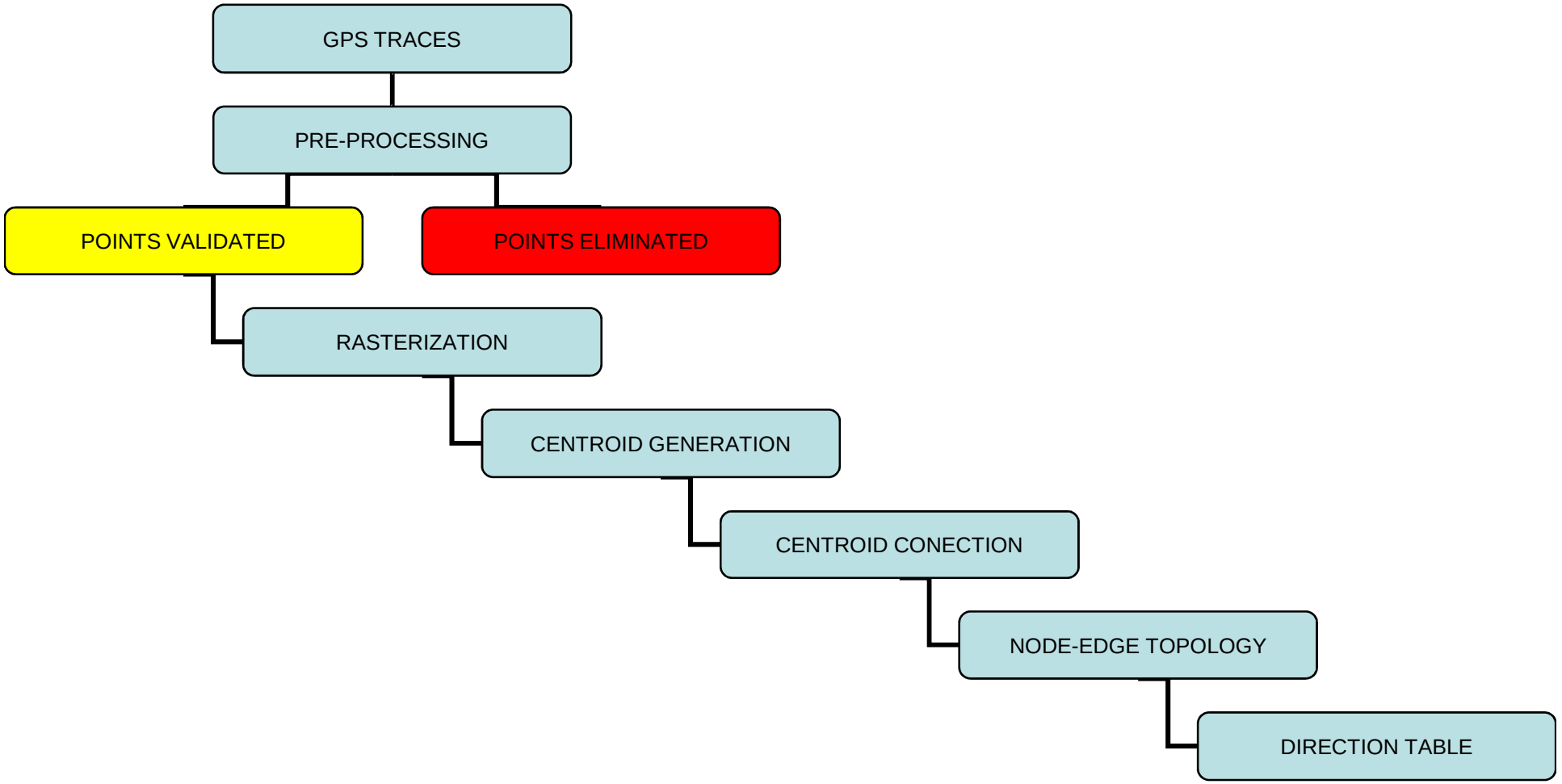
Line simplification

Douglas-Peucker algorithm

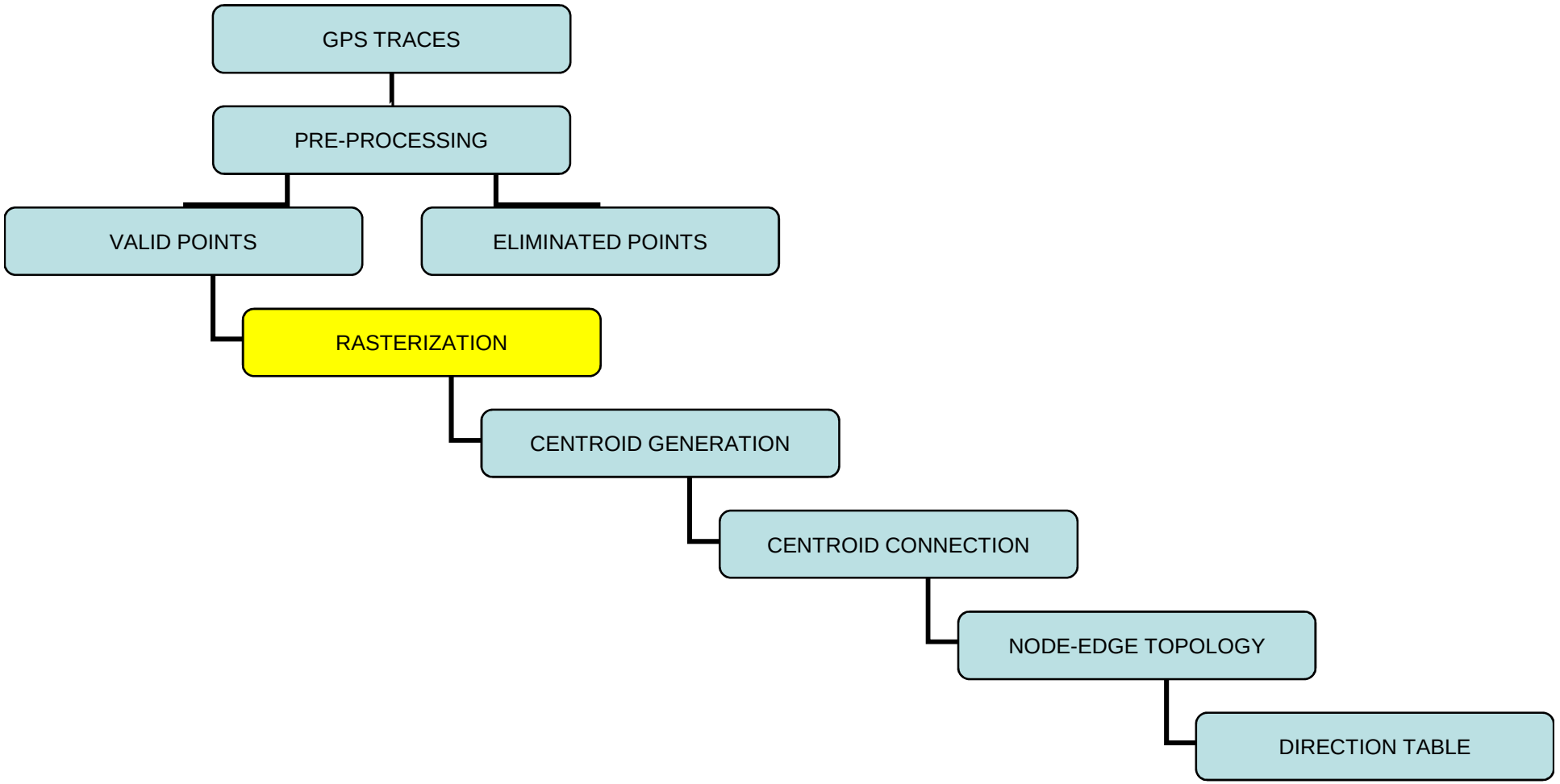
	Post-processing GPS traces	Simplified traces	Elimination percentage
Total number of points	14.423.505	2.683.217	81%

	GPS traces	Simplified traces	Total length deviation
Total of Km	182.369	181.785	0,32%

PRE-PROCESSING OF DATA



AUTOMATIC GENERATION OF MAPS



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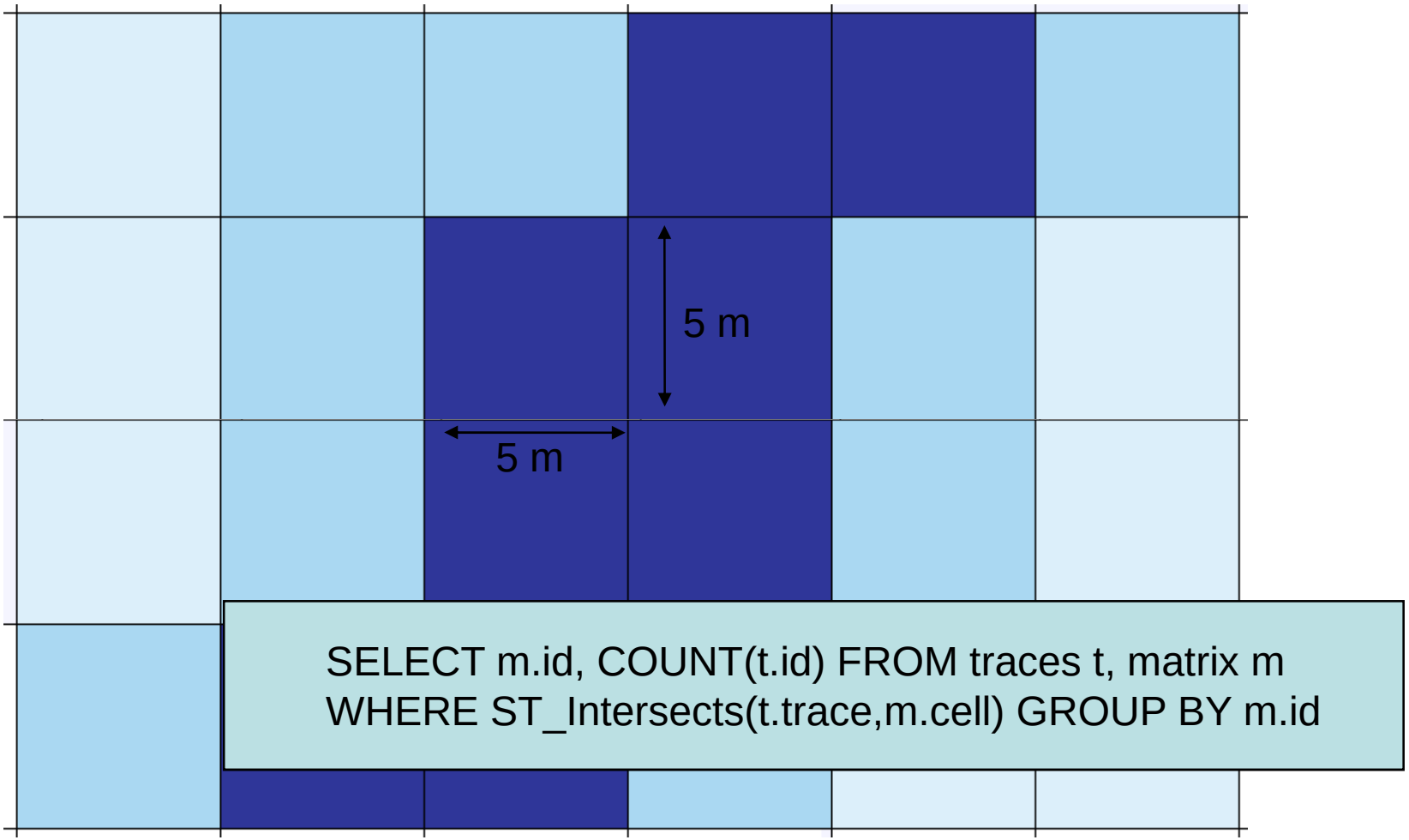

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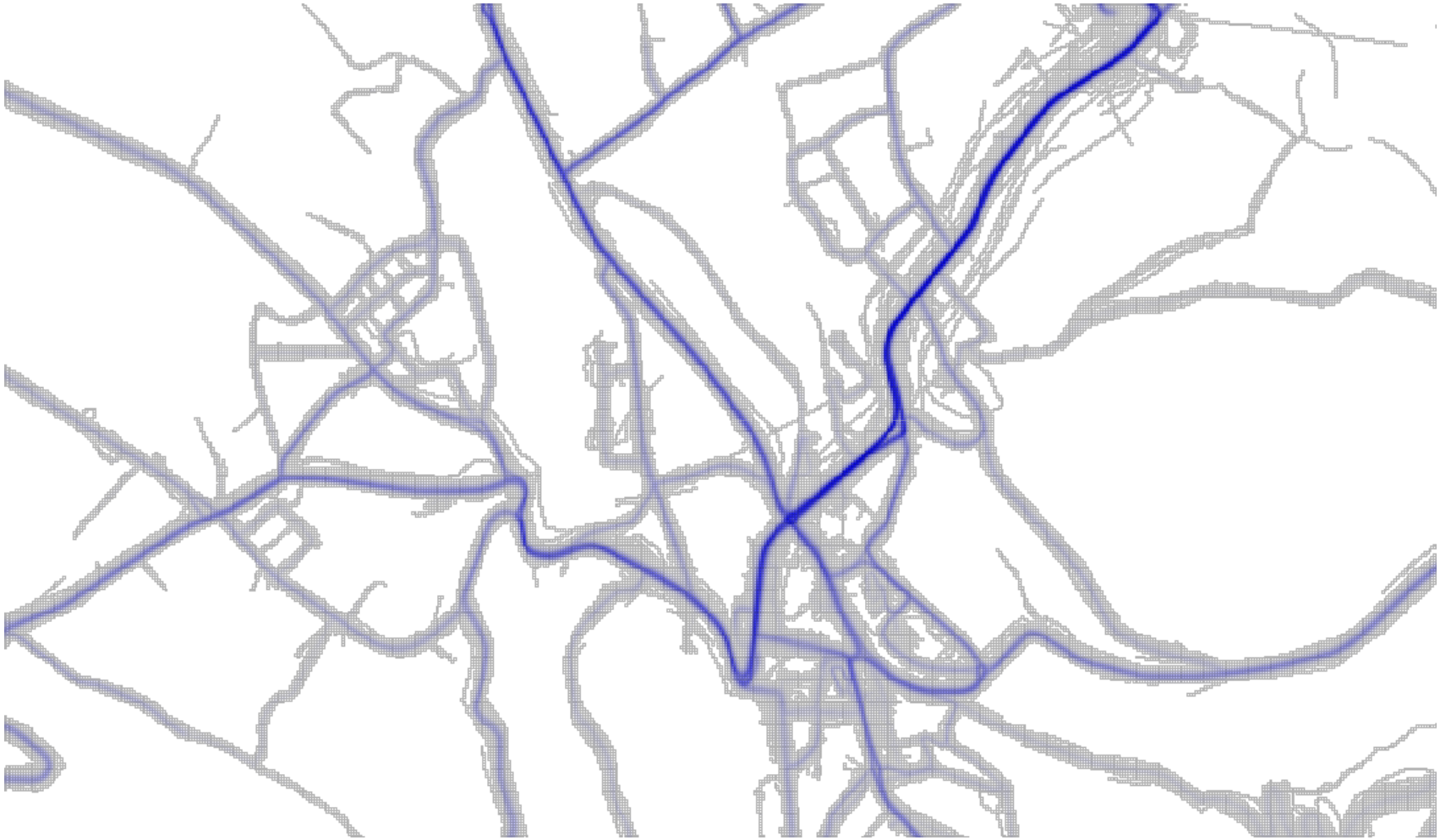

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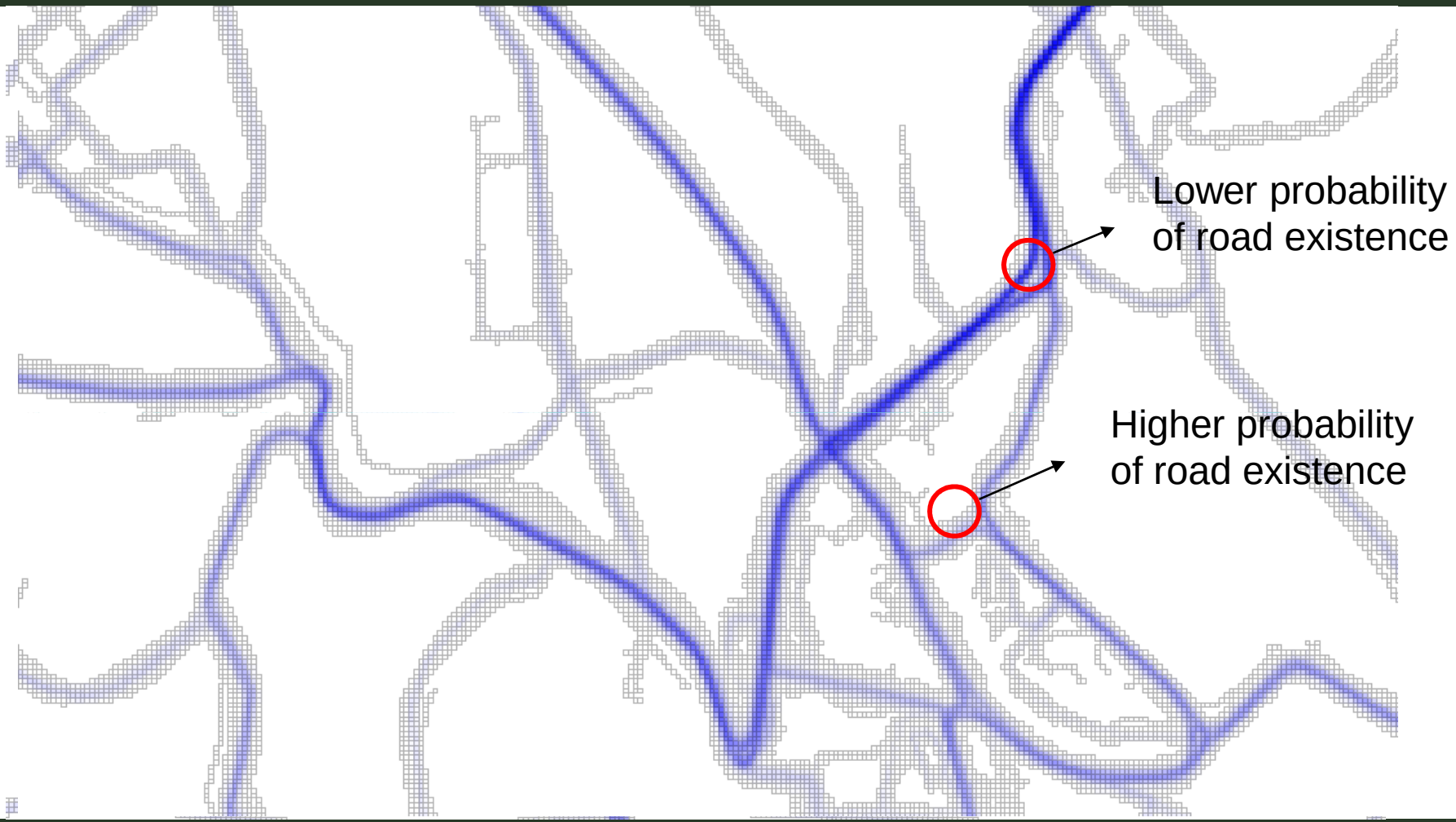

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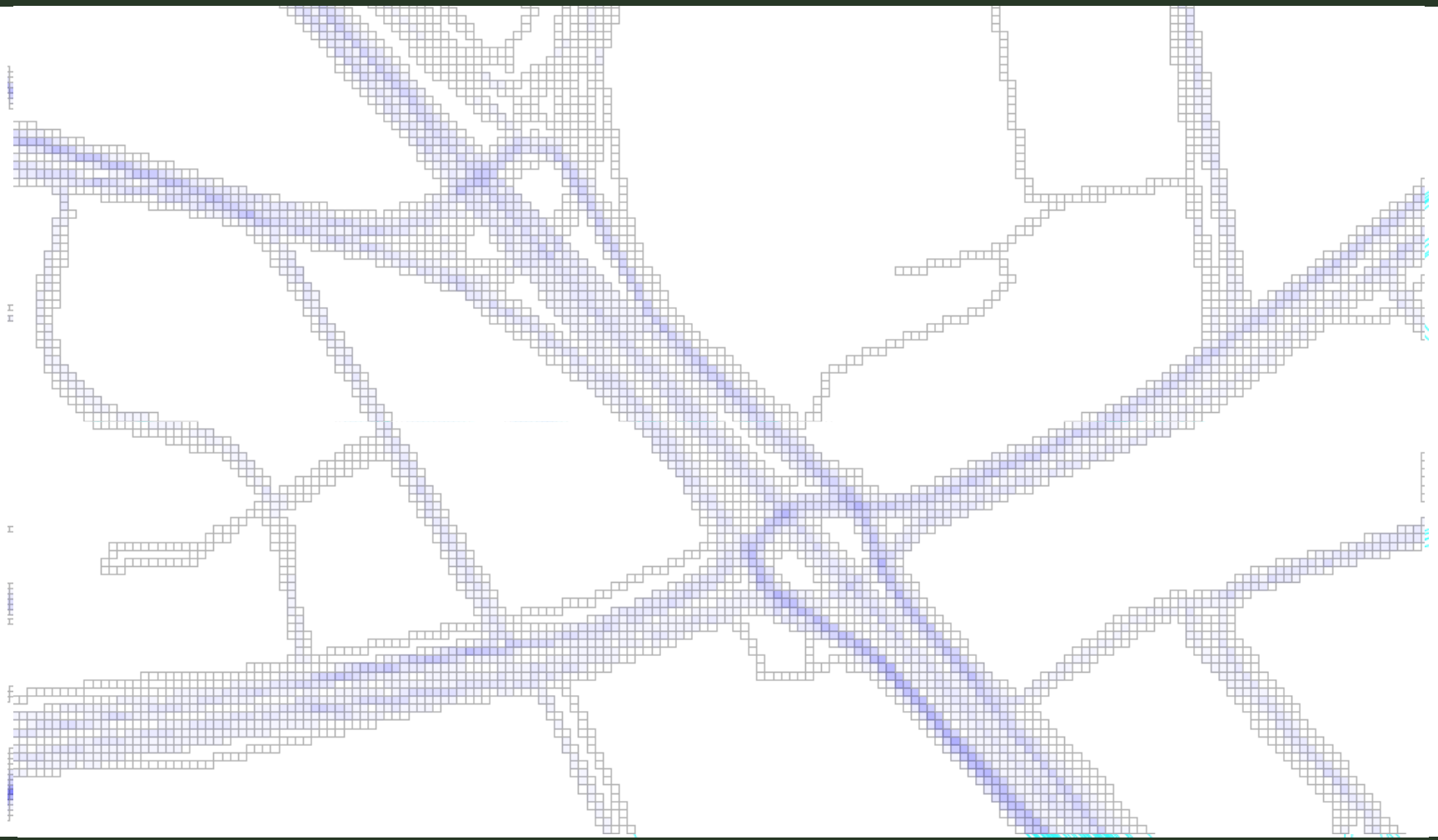

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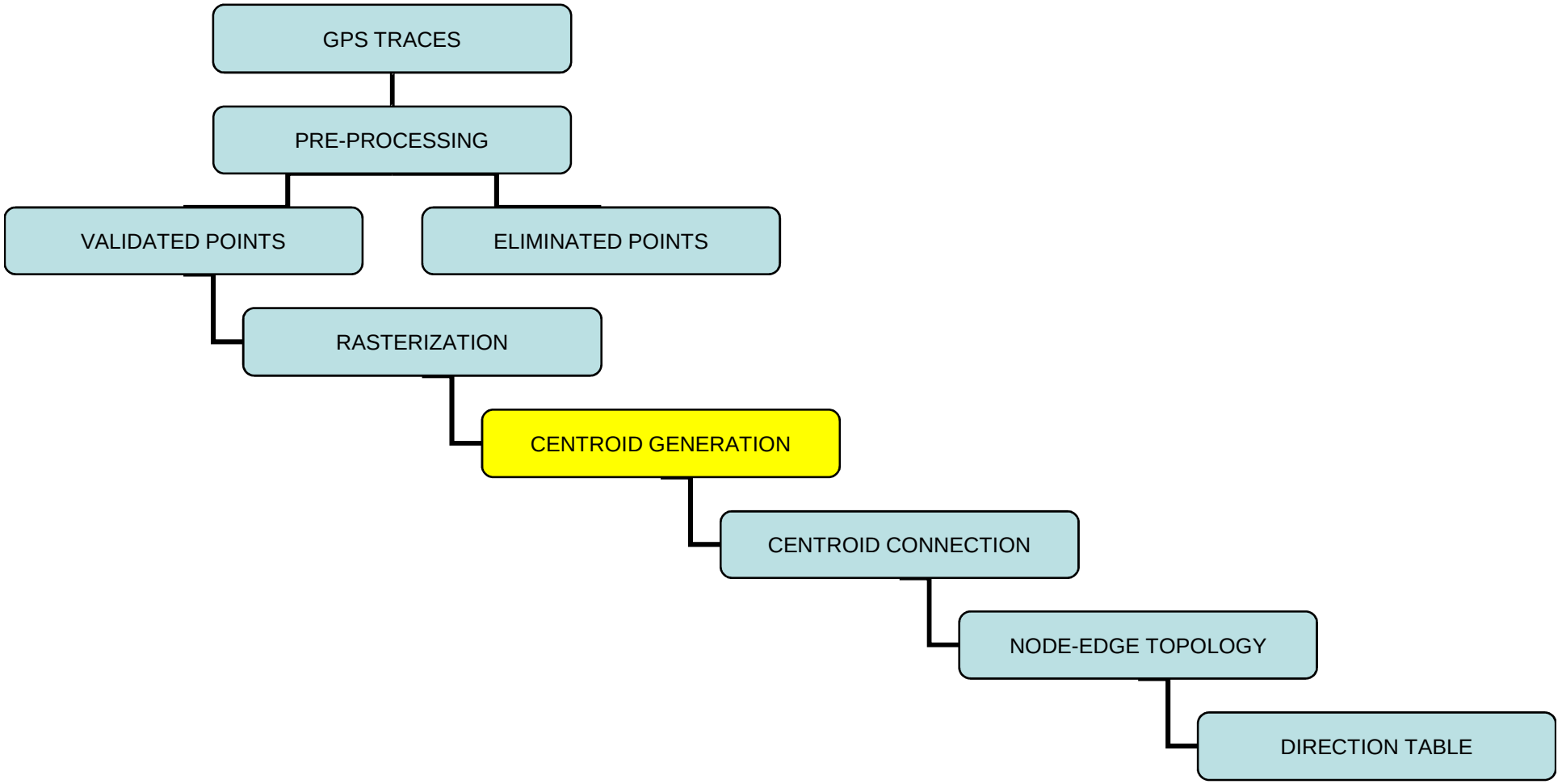

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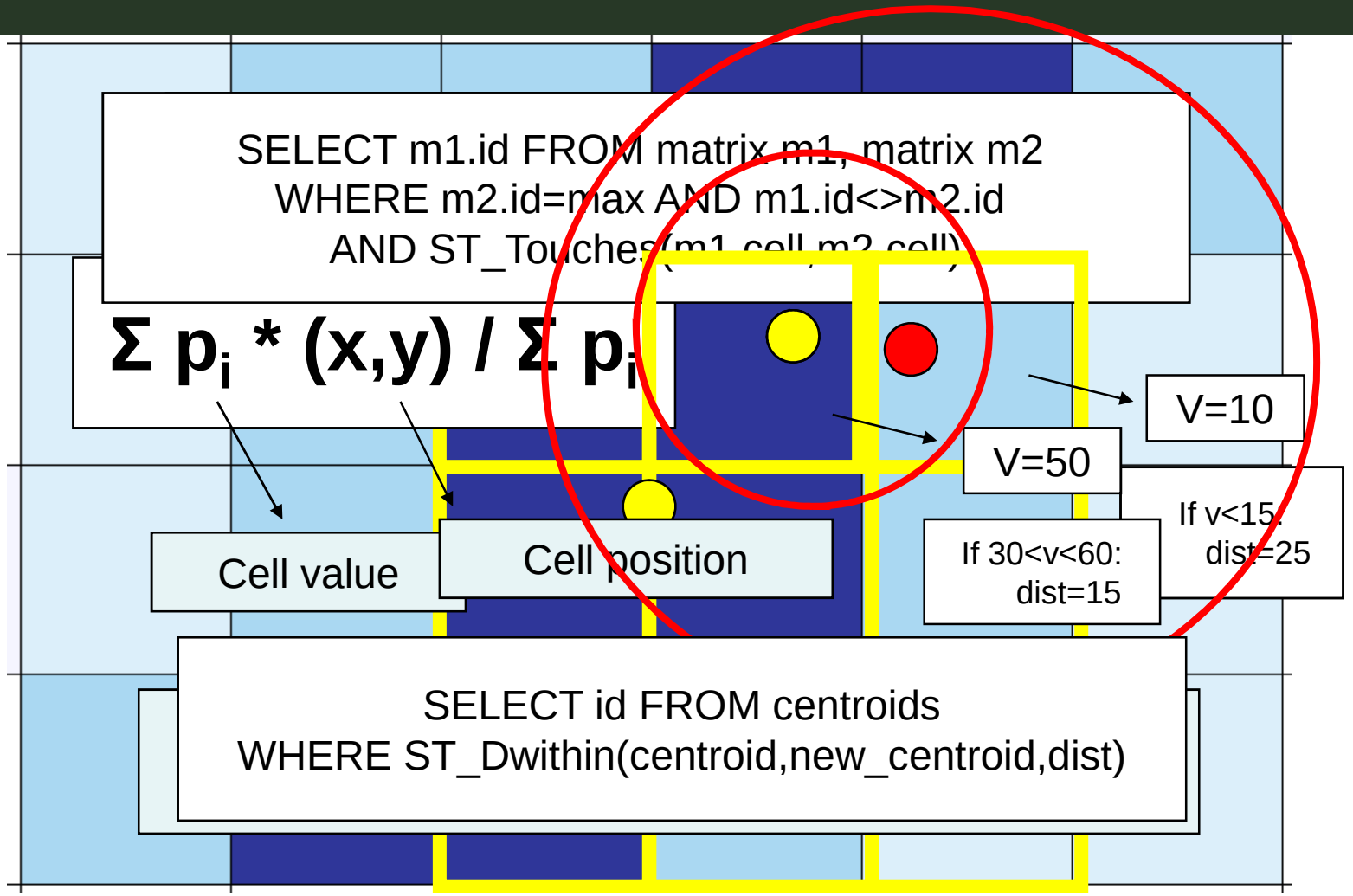

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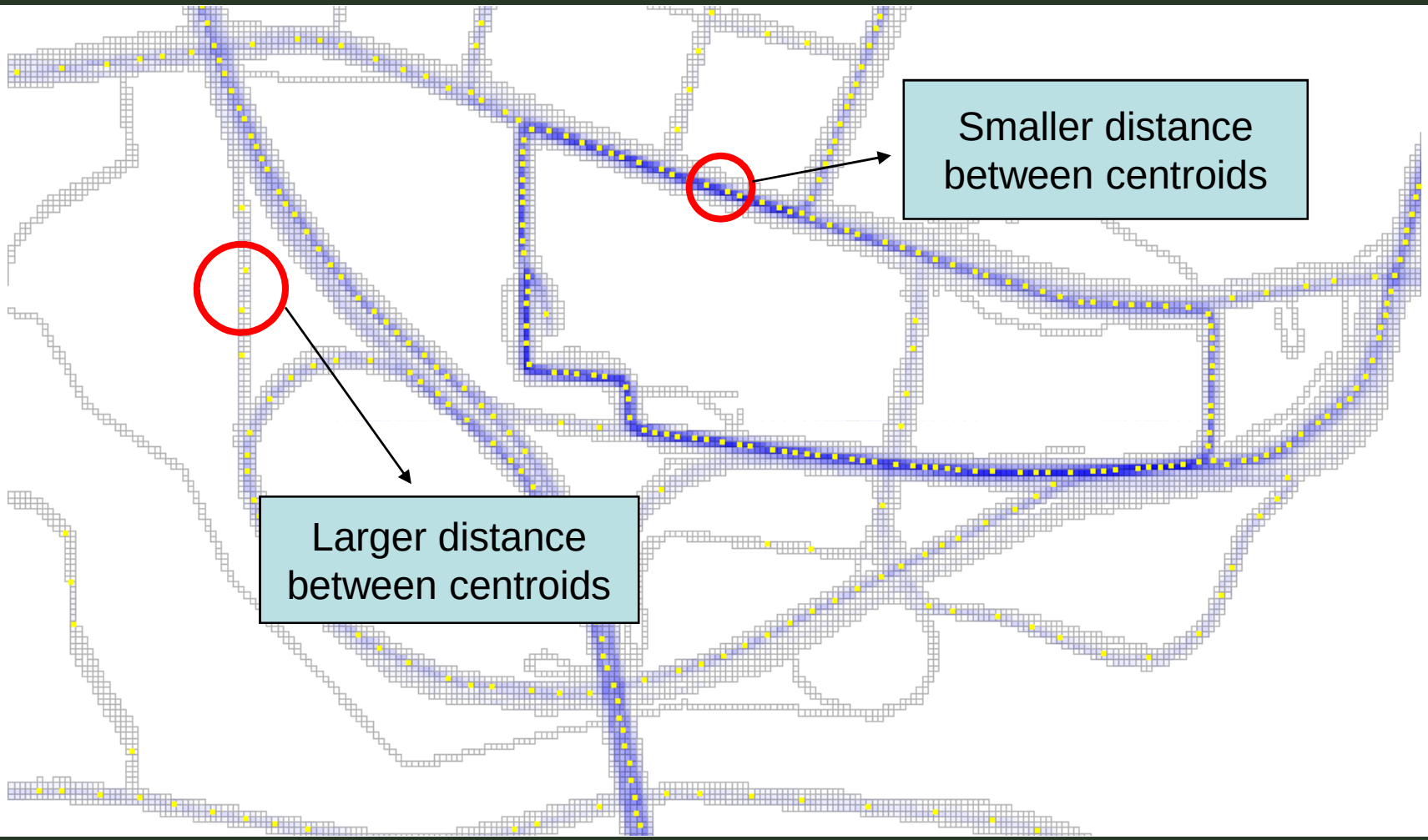

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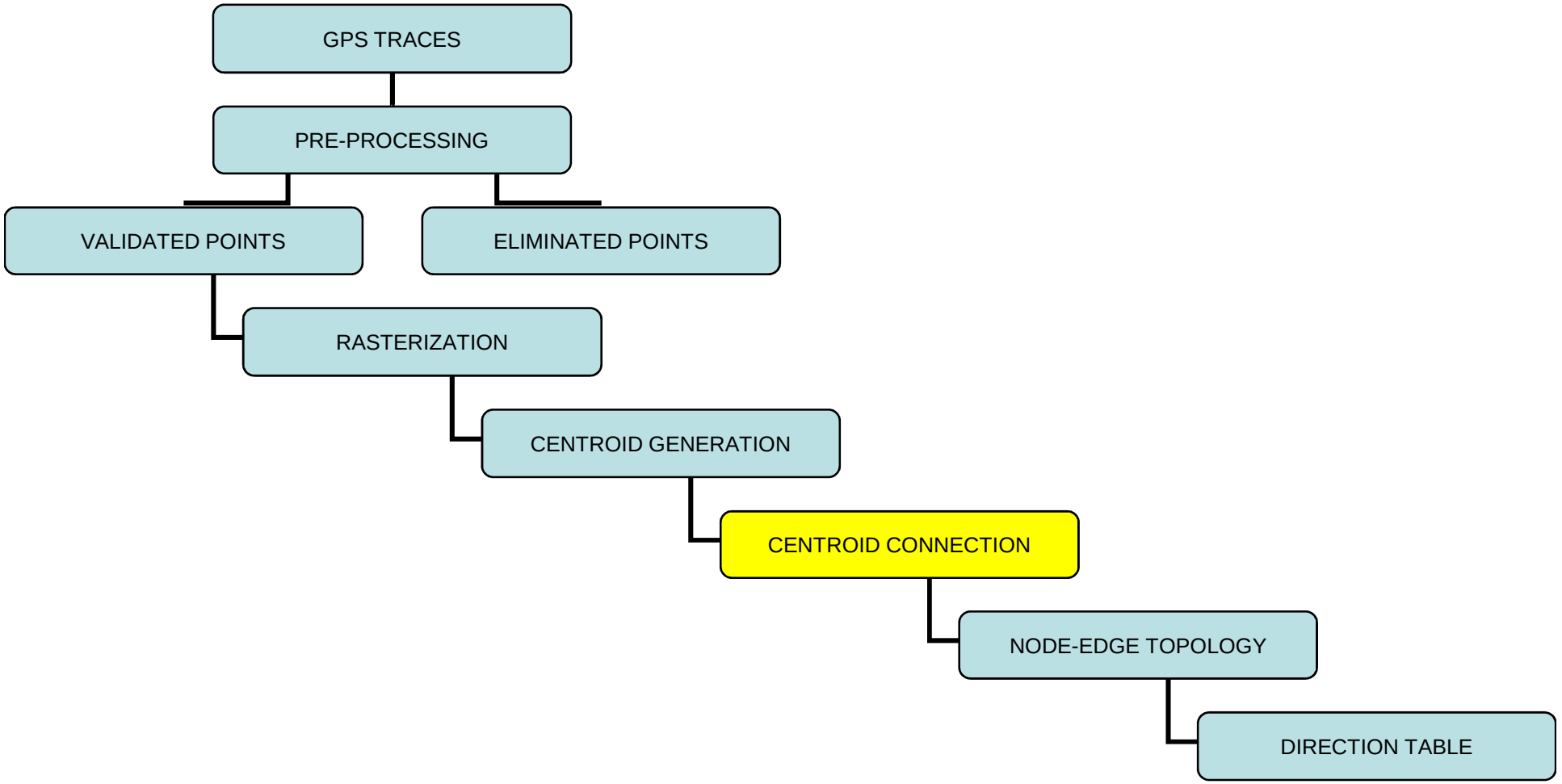

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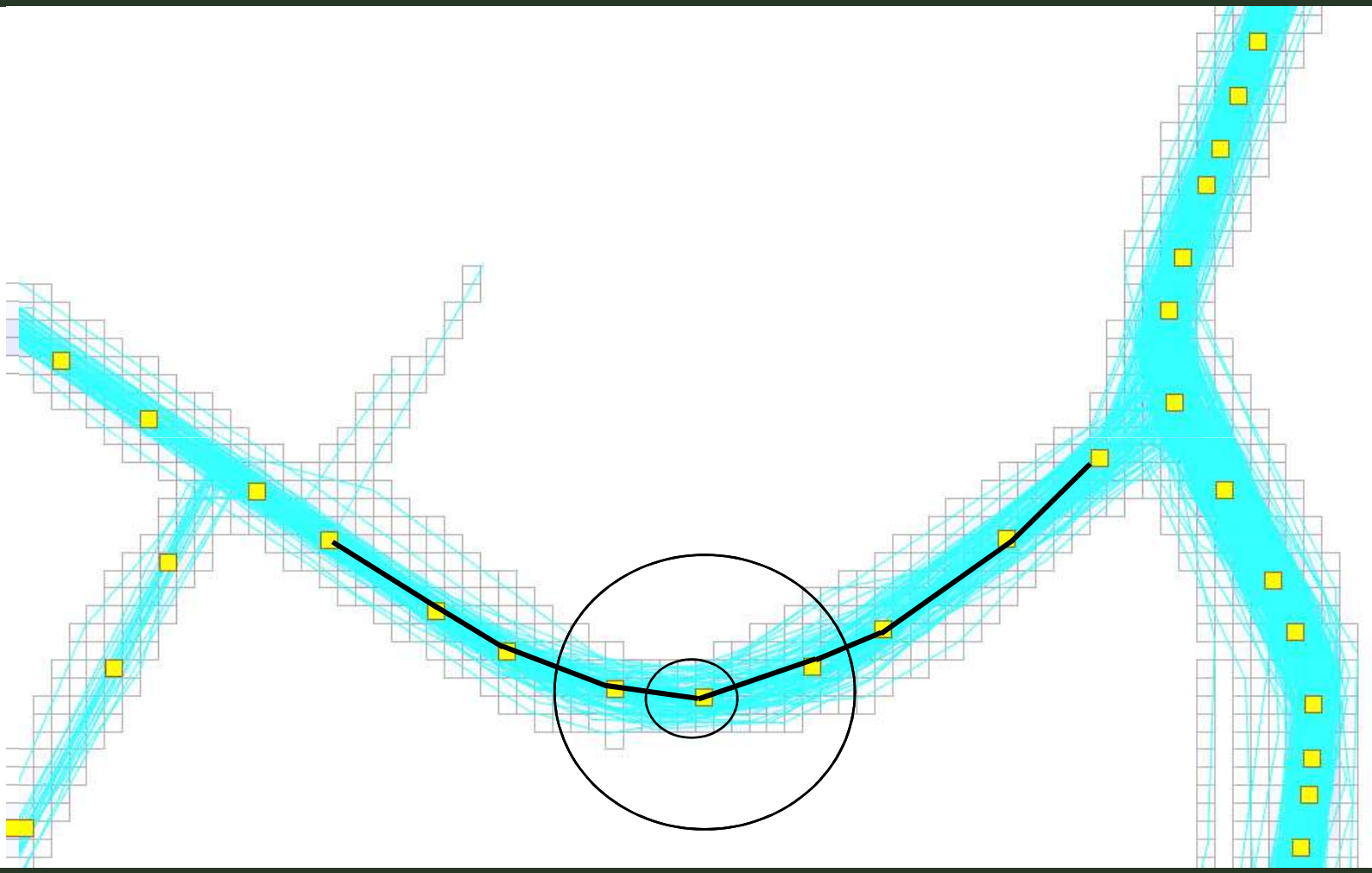
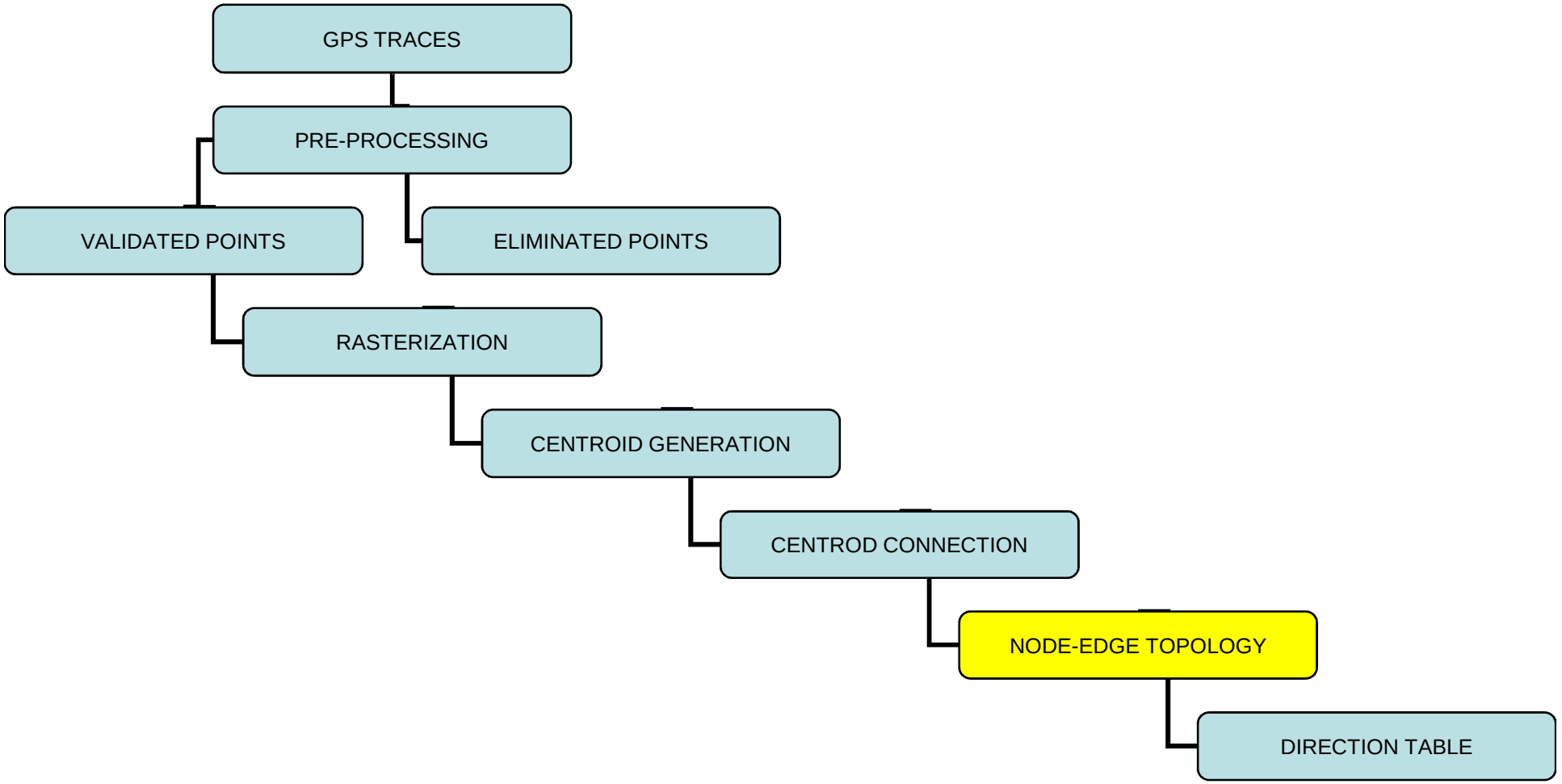


AUTOMATIC GENERATION OF MAPS

```
SELECT c1.id,c3.id FROM centroides c1,centroides c2,centroides c3
WHERE c2.id=id AND c1.id<>c3.id AND c1.id<>c2.id AND c3.id<>c2.id
AND ST_DWithin(c1.centroide,c2.centroide,dist)
AND ST_DWithin(c3.centroide,c2.centroide,dist)
AND ST_Distance(c1.centroide,c3.centroide)>ST_Distance(c2.centroide,c3.centroide)
AND EXISTS (SELECT t.id from trajetos t WHERE ST_DWithin(trajeto,c1.centroide,2.5)
AND ST_DWithin(trajeto,c2.centroide,2.5)
AND ST_DWithin(trajeto,c3.centroide,2.5)
AND (ST_line_locate_point(trajeto,c1.centroide)<ST_line_locate_point(trajeto,c2.centroide))
AND (ST_line_locate_point(trajeto,c2.centroide)<ST_line_locate_point(trajeto,c3.centroide))
AND (ST_Length(ST_line_substring(trajeto,ST_line_locate_point(trajeto,c1.centroide),ST_line_locate_point(trajeto,c2.centroide)))
<(ST_Length(ST_MakeLine(c1.centroide,c2.centroide))+5))
AND (ST_Length(ST_line_substring(trajeto,ST_line_locate_point(trajeto,c2.centroide),ST_line_locate_point(trajeto,c3.centroide)))
<(ST_Length(ST_MakeLine(c2.centroide,c3.centroide))+5)))
ORDER BY ST_Distance(c1.centroide,c2.centroide),ST_Distance(c3.centroide,c2.centroide)
```

AUTOMATIC GENERATION OF MAPS



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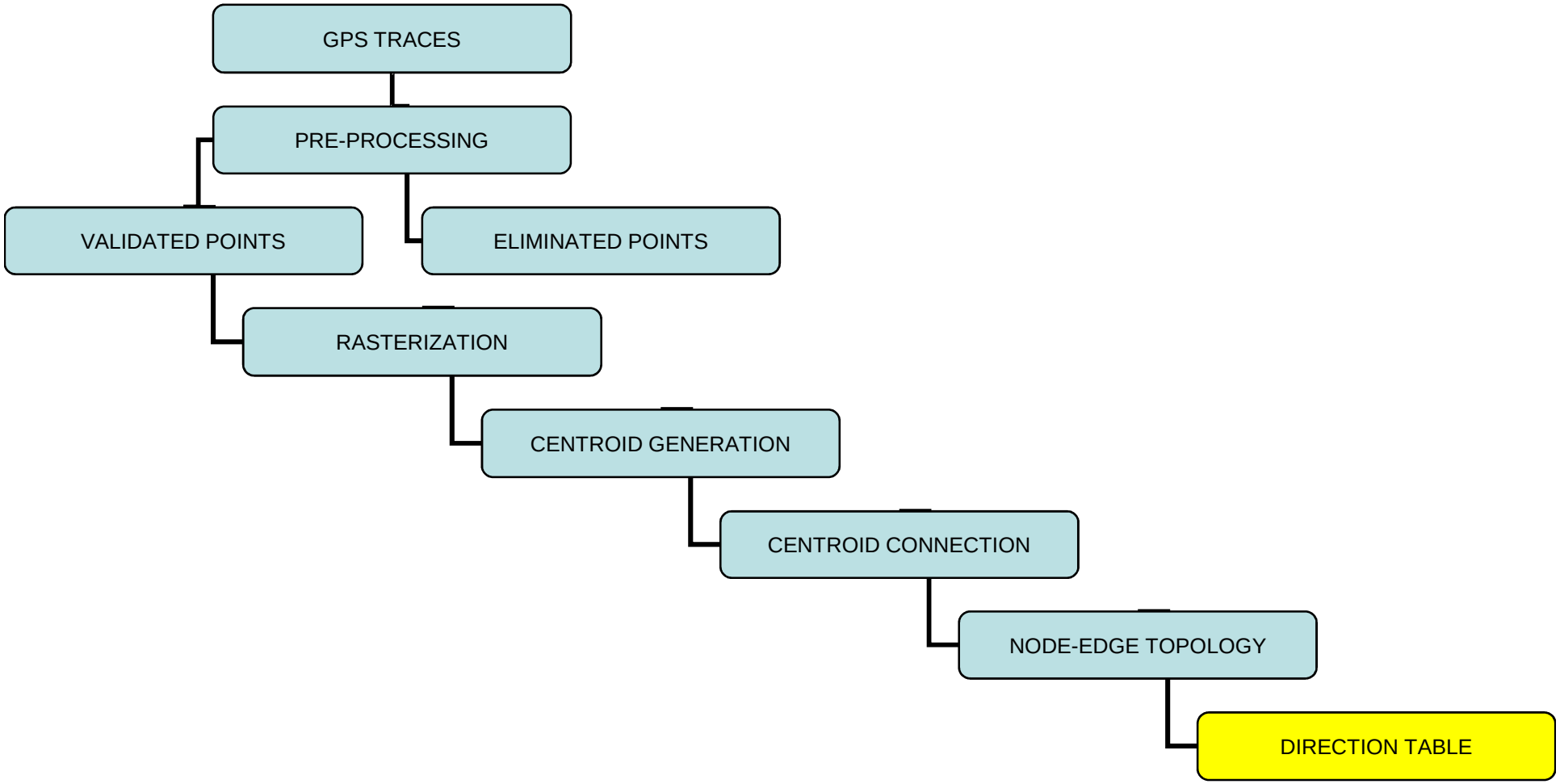

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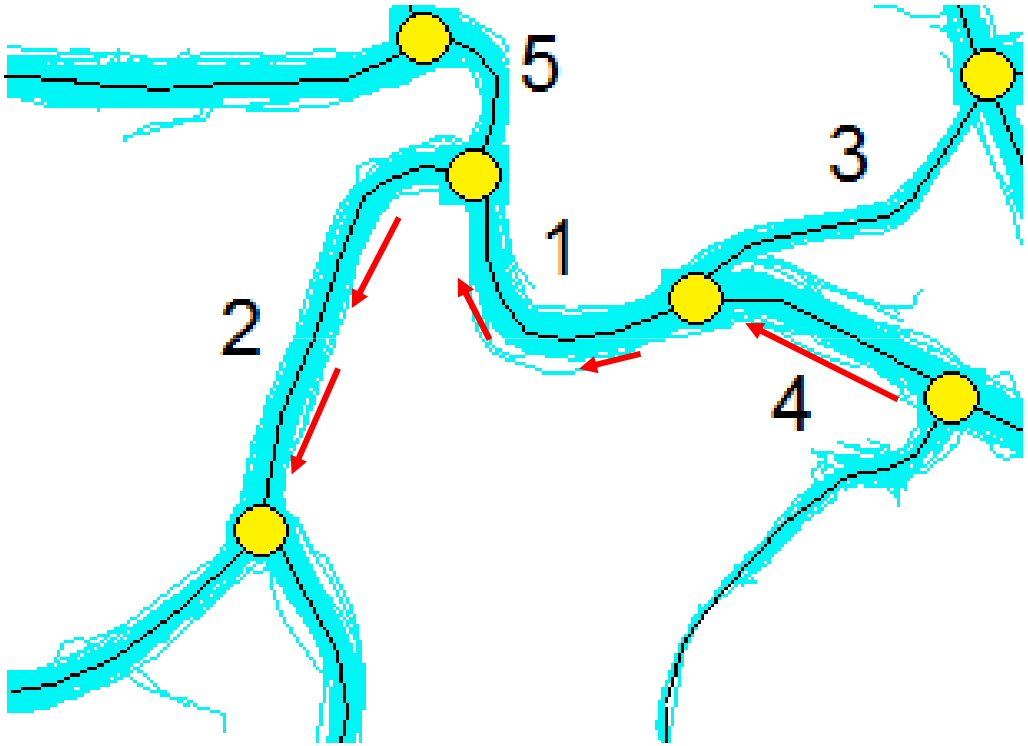
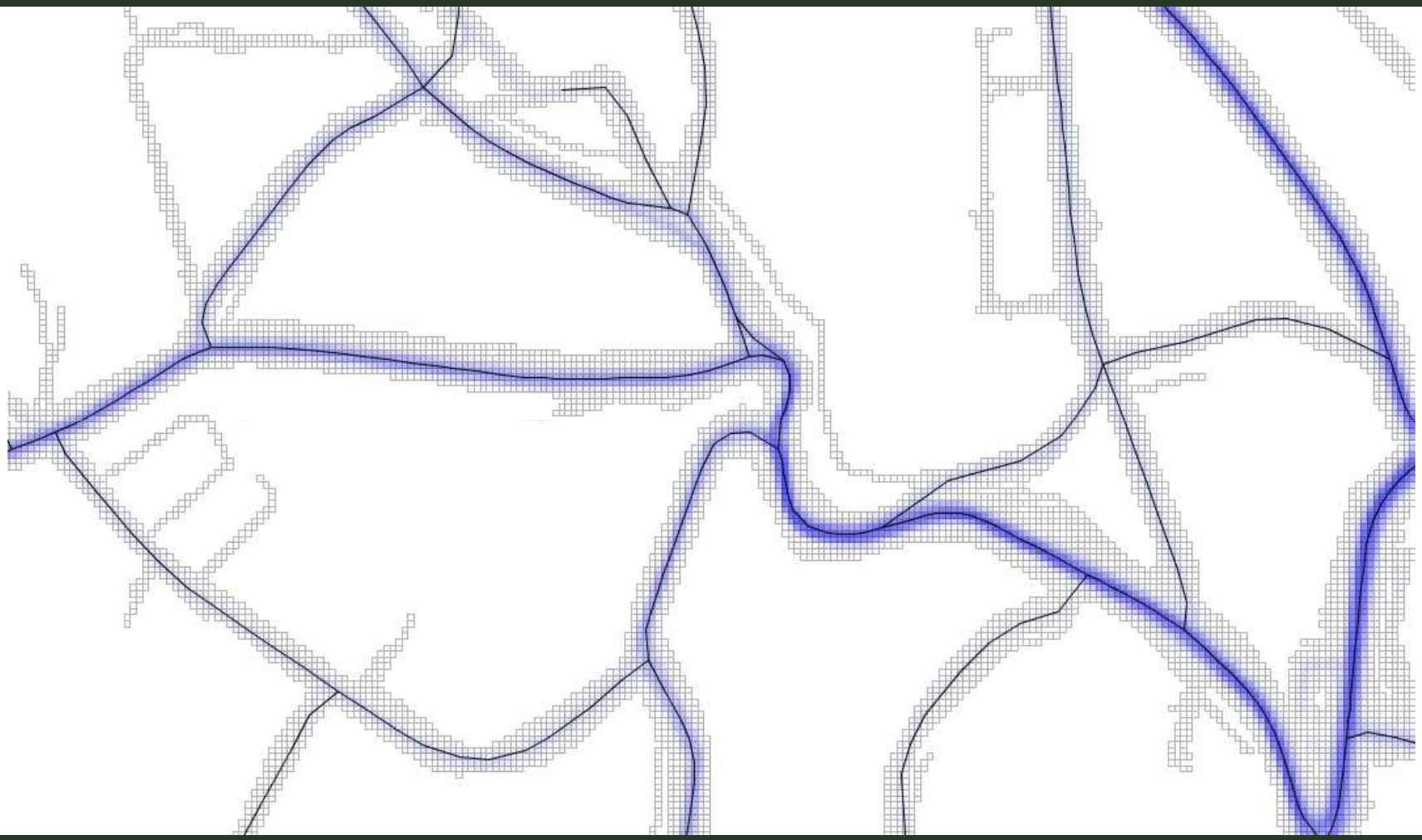


Direction table	
Src_edge	Dest_edge
1 →	2
4 →	1
3	1
1	5
5	1
1	4

CURRENT RESULTS

- Evaluation against vectorial cartography from InfoPortugal
- Geometric evaluation – Arganil county:
  - Identification of 82% of InfoPortugal road segments
  - Average deviation of 1.8 meters
  - Identification of 26% of new roads!
- Topological and direction evaluation is undergoing

CURRENT RESULTS



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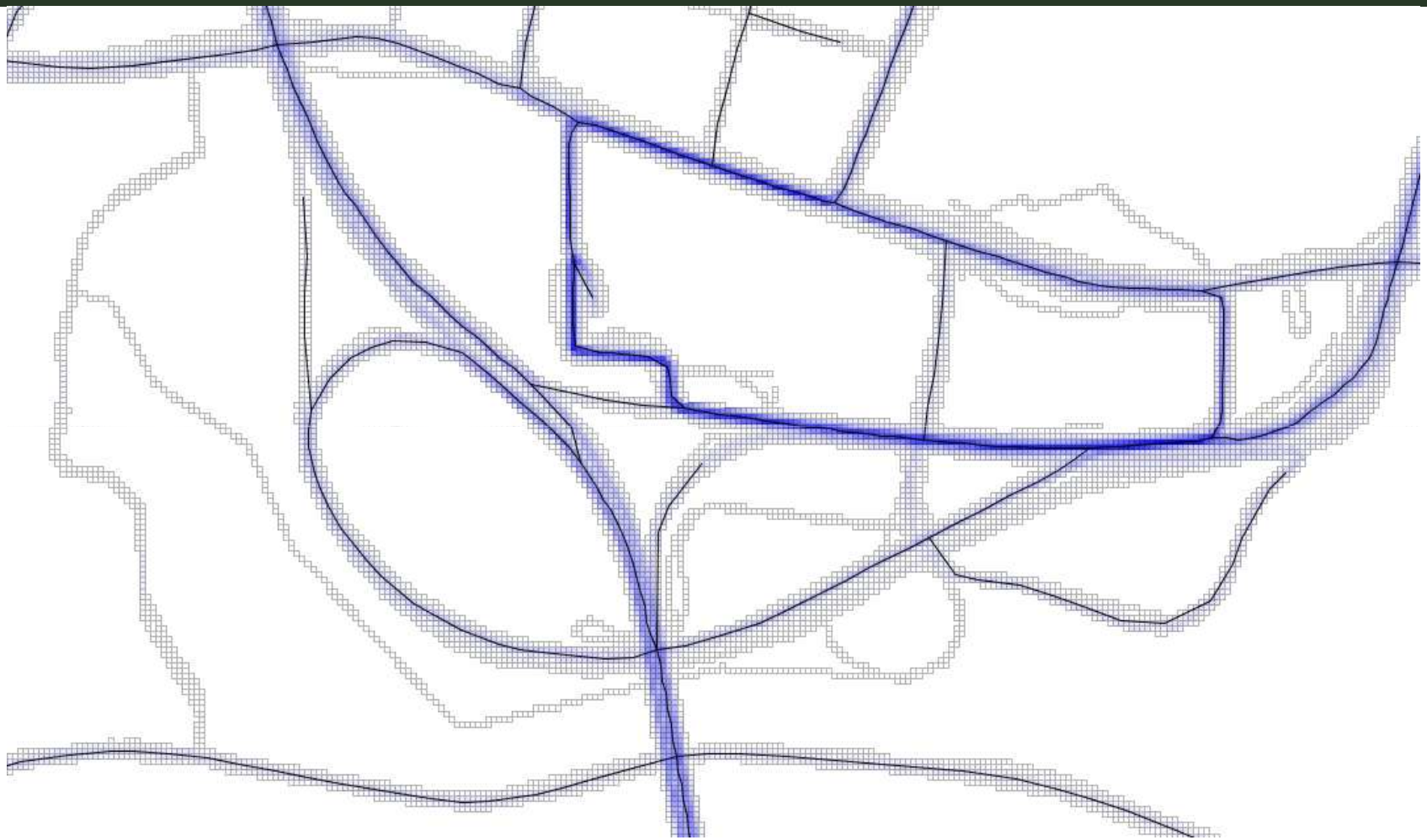

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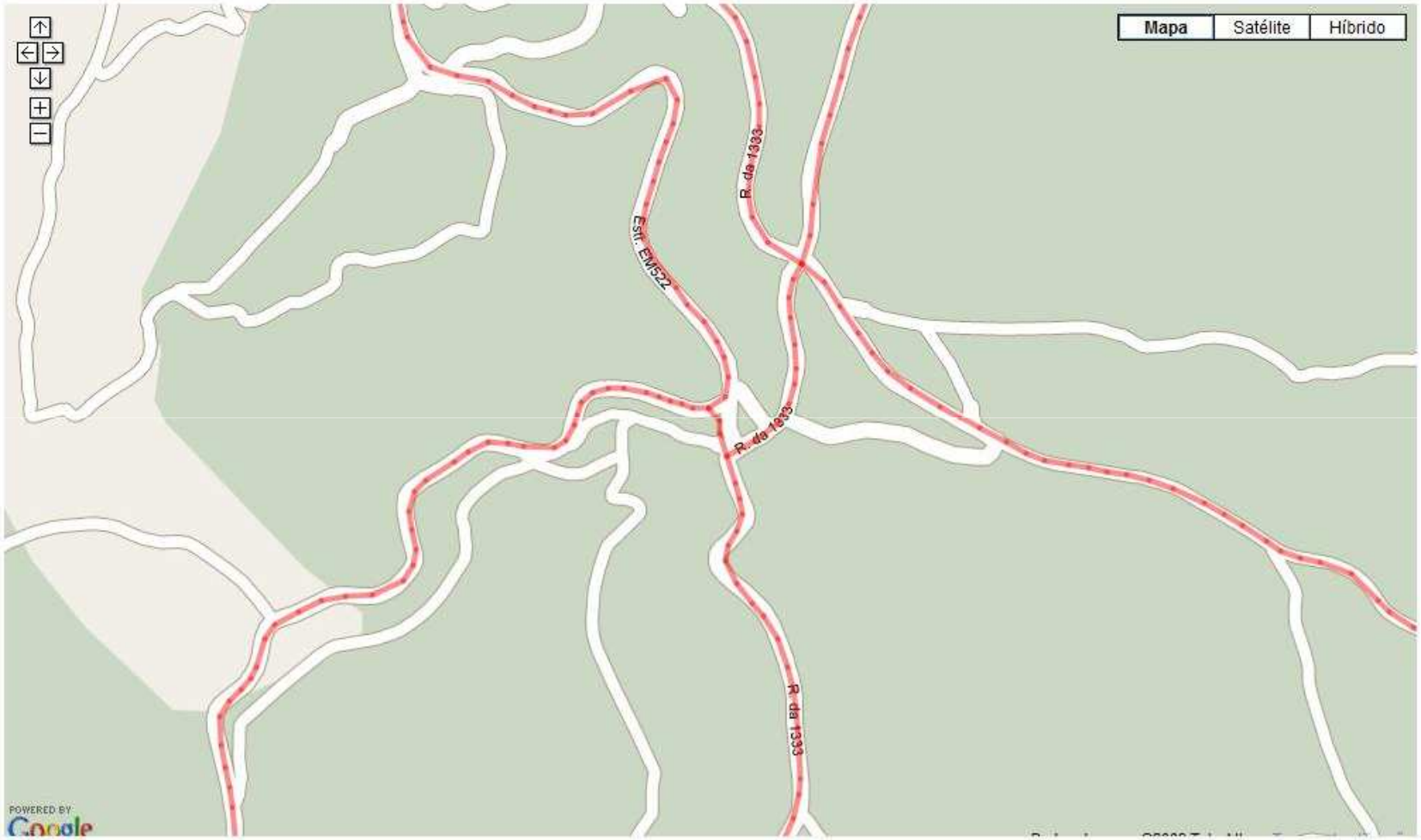

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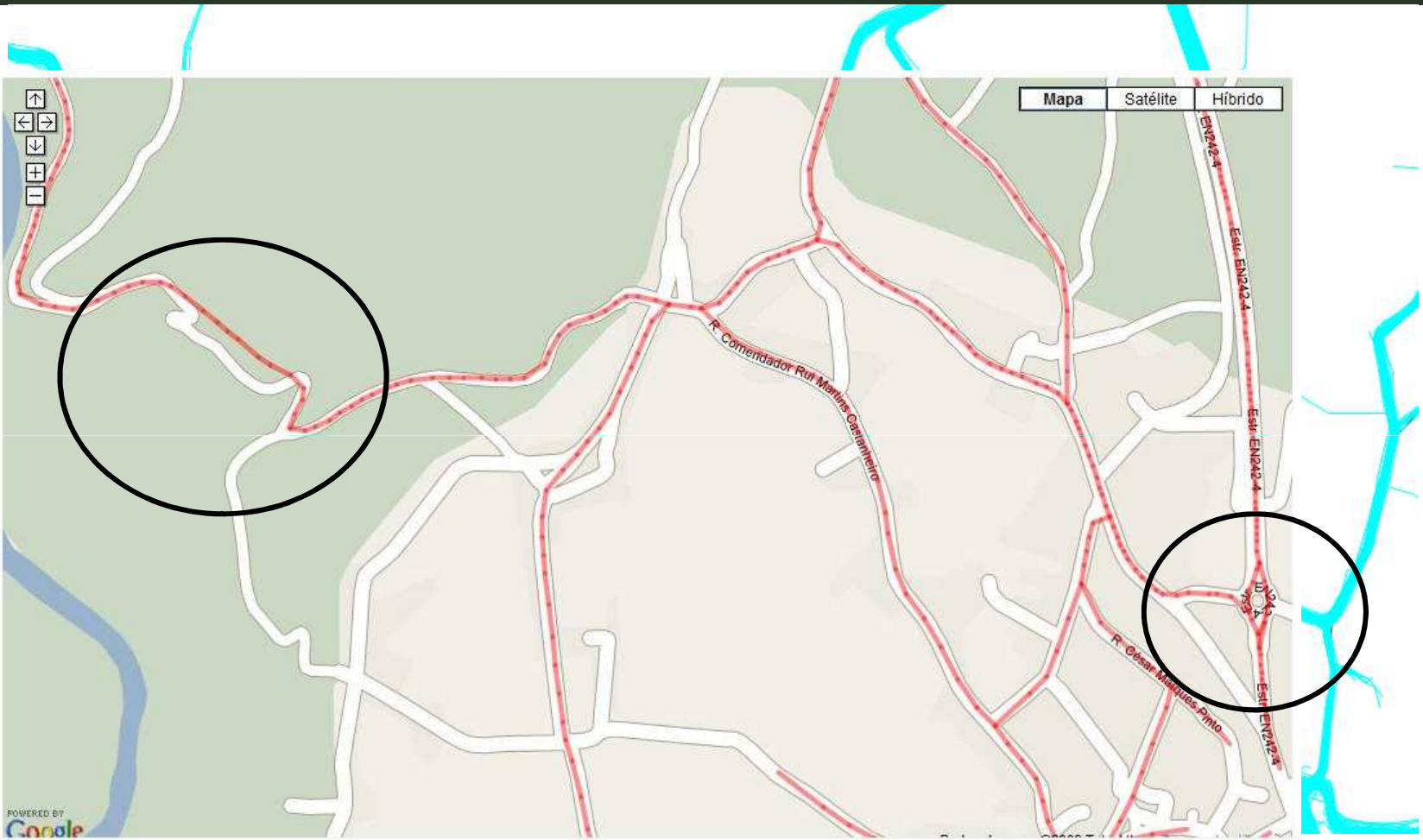

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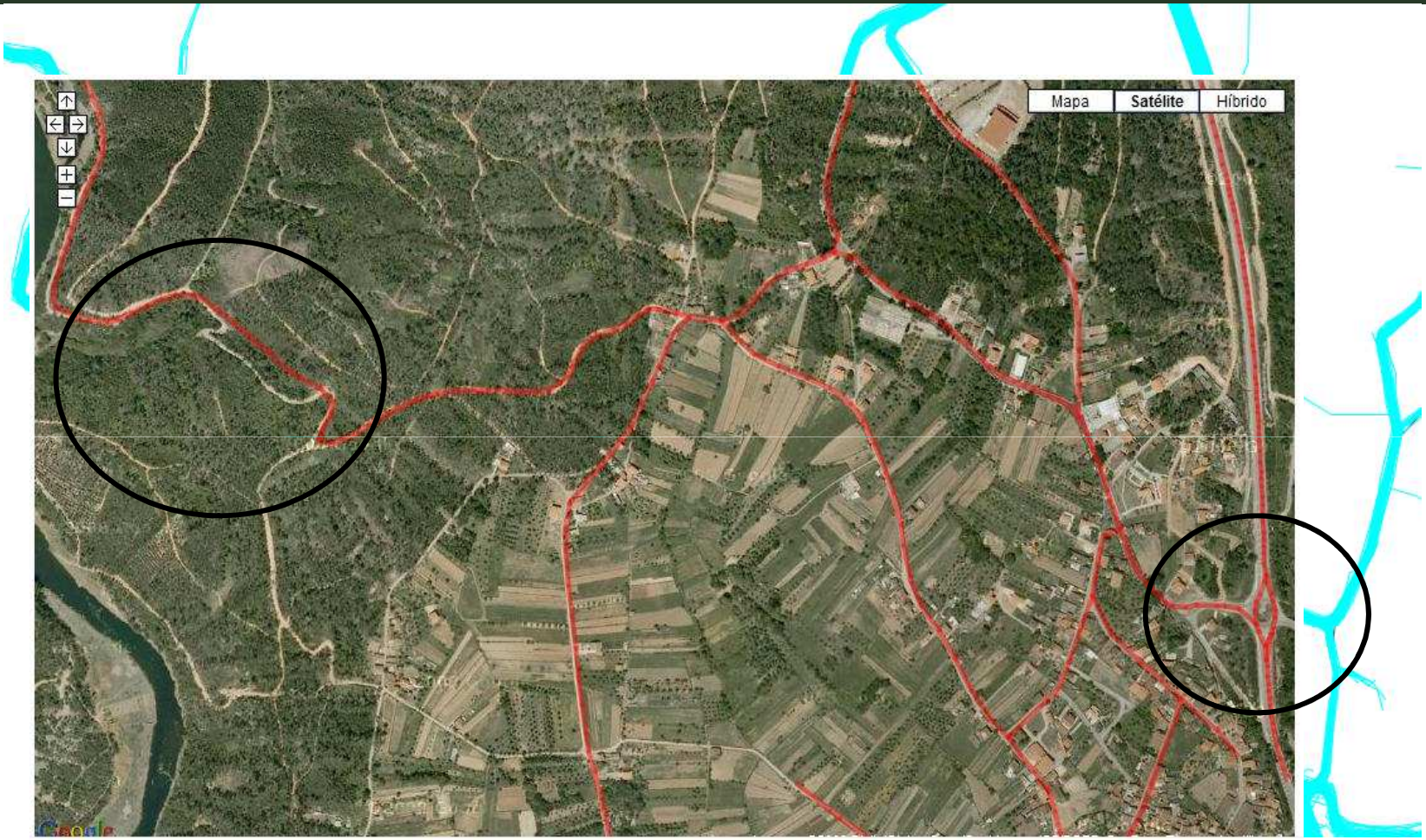

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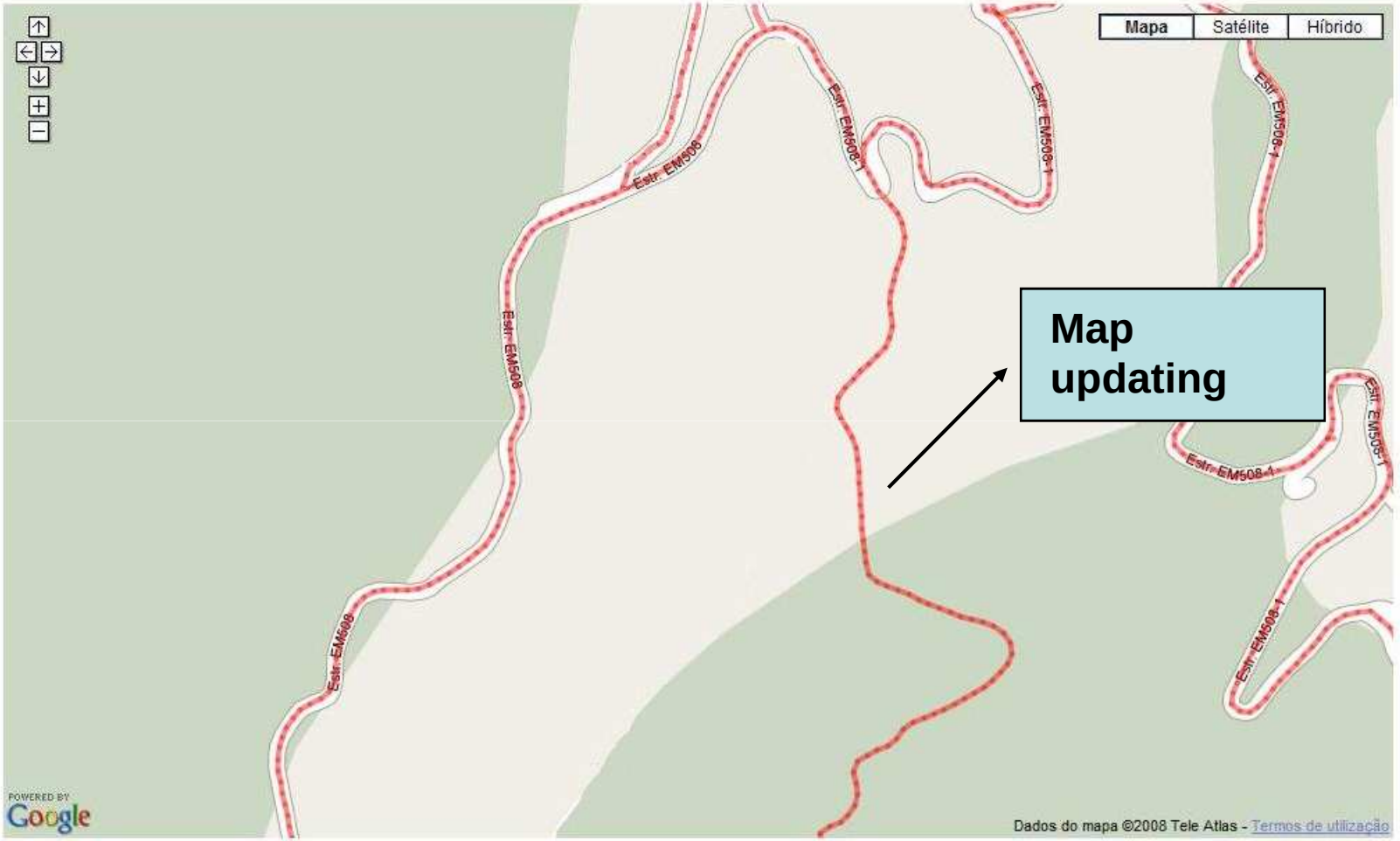

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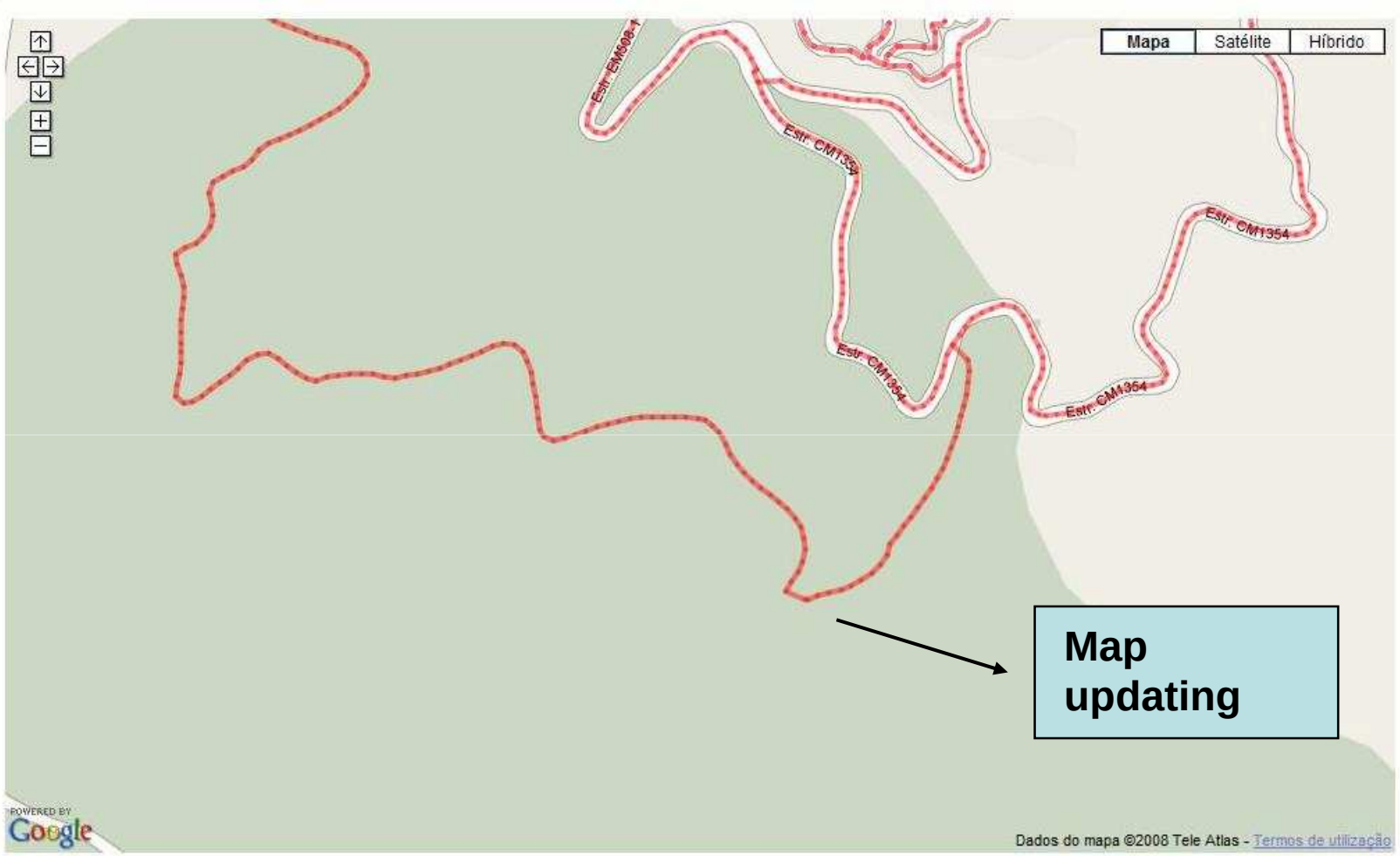
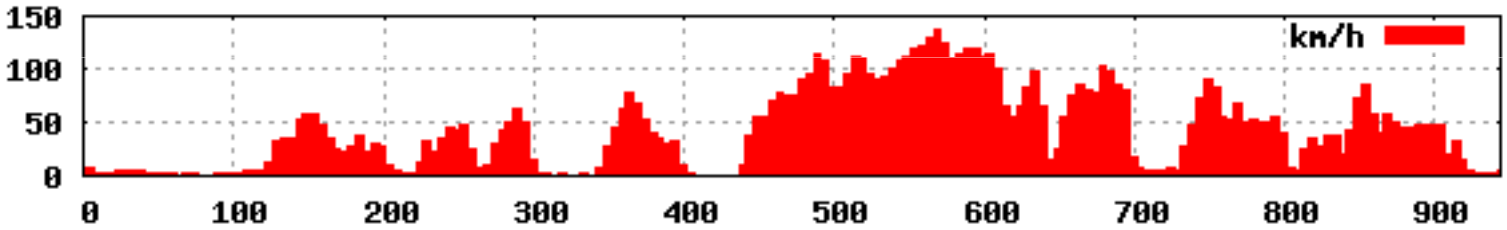


AUTOMATIC GENERATION OF ROAD MAPS

Speed profile of a GPS trace



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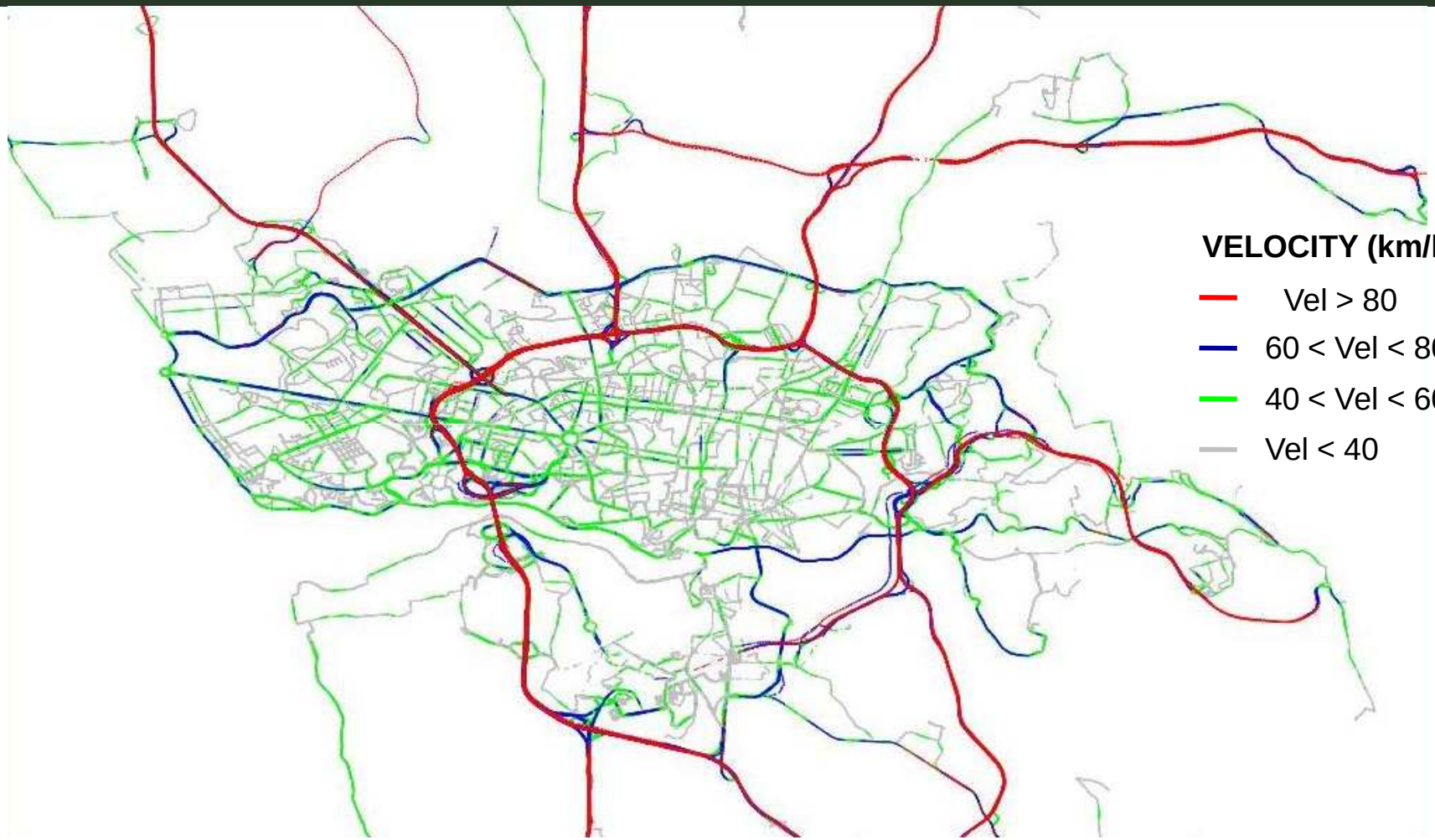

CONCLUSIONS

- Construction and updating of road maps can be done automatically through the collection of large datasets of GPS traces.

- Geometric precision of such maps can have an error smaller than 2 meters.

- Much more details about the road can be extracted from sensing vehicles:
  - Traffic rules;
  - Traffic lights location, parking information;
  - Real-time mobility.

- Constructing maps about more continuous and loose phenomena (e.g. wireless coverage) should be easier than construction of the road network layer.

QUESTIONS?