An experience in high productivity lidar mapping and noise modelling

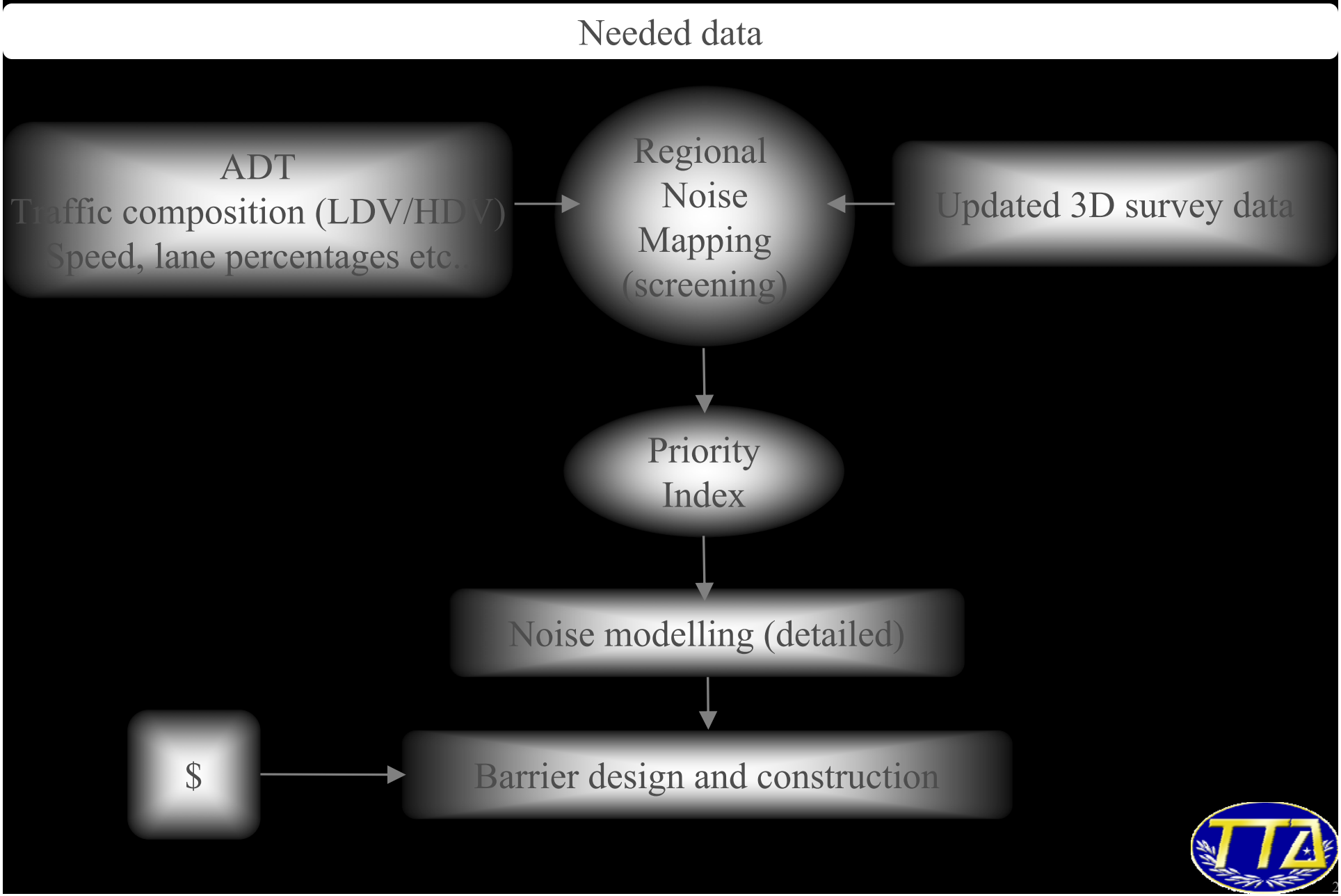
TRB Summer Meeting

Williamsburg, VA

July 11, 2006

Presented by: Douglas Tommasi Crudeli

Noise mapping as a regulatory requirement (Italy)



Updated 3D survey Data

• Italy has a very dense population → practically every highway/freeway passes through many urban areas

• New buildings are erected even near existing highways → cartography is outdated already after a couple of years

•Building density in urban areas: up to 1.000 per square mile

• Available national data (like USGS in US) is outdated (>3years)

• Distances to be surveyed:

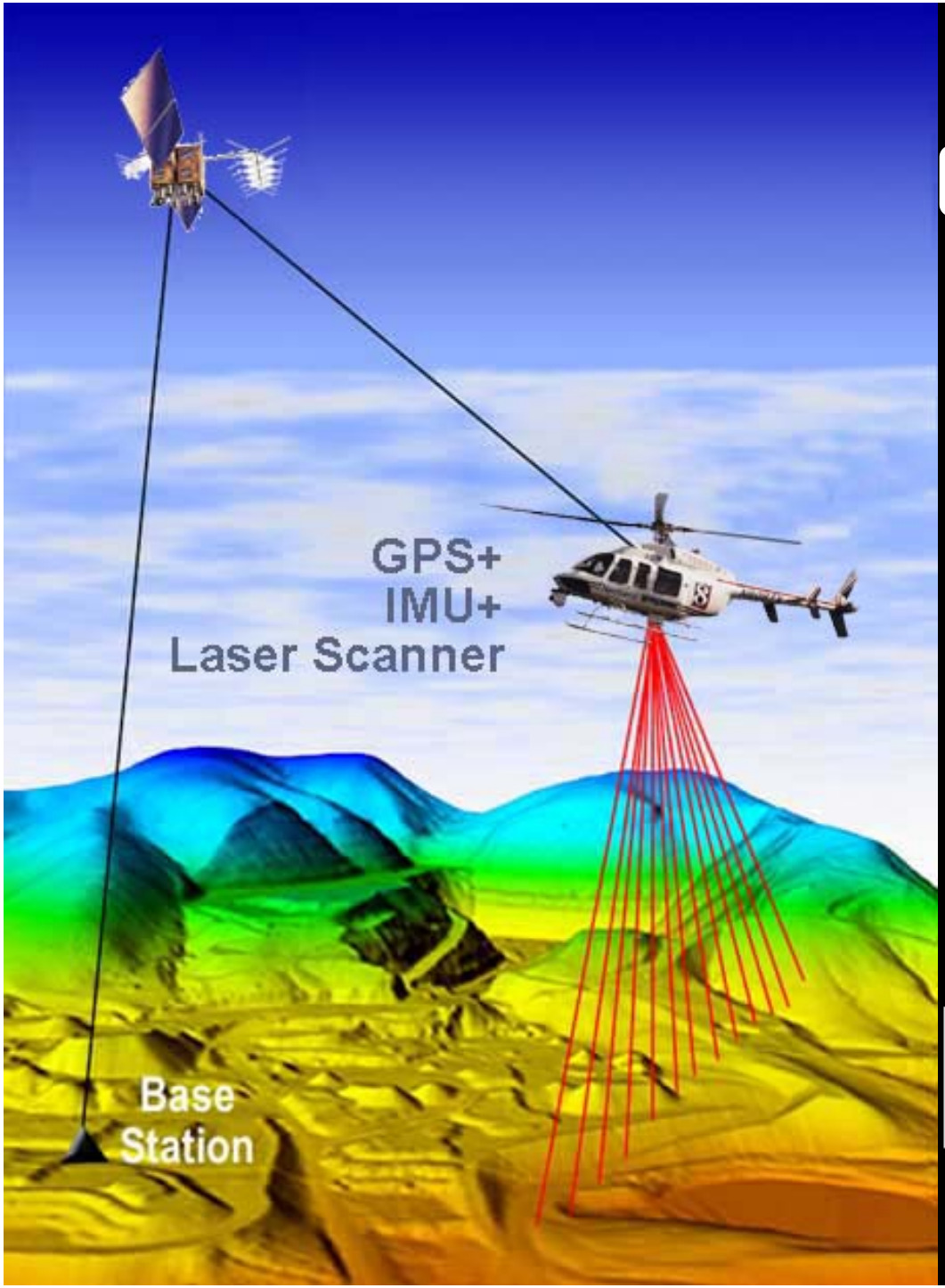
at least 820 ft per side from the roads

→ about 1800 ft overall

•Traditional survey too expensive and takes too long

• Aerial photogrammetry is very precise but takes long and is expensive

• An excellent compromise is a Lidar acquisition



Acquired data:

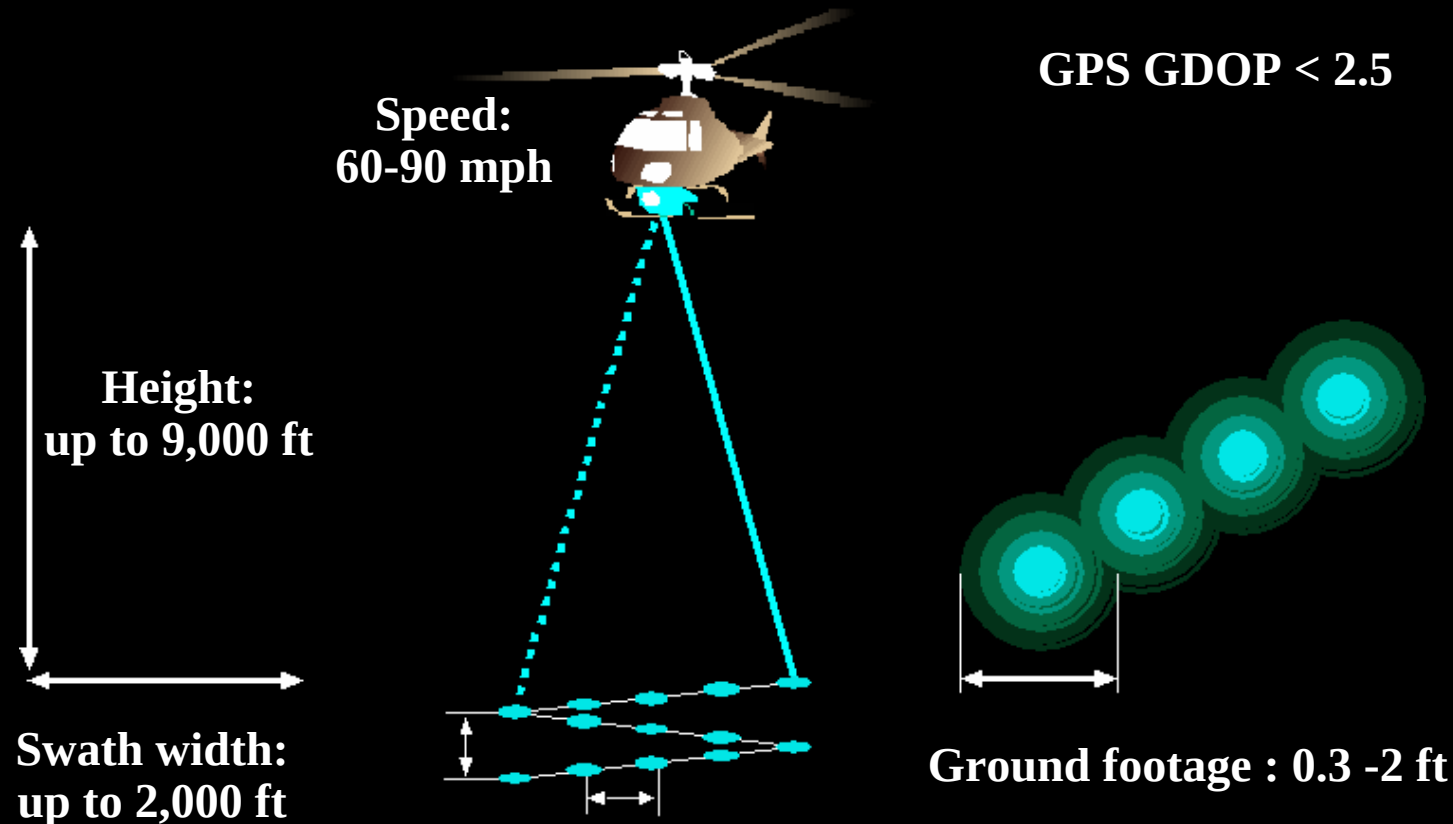
- Airborne laser ranger (distance)
- GPS (position)
- Inertial Unit (angles)

It is possible to obtain ground points directly in WGS84/UTM

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_{WGS84} = \begin{bmatrix} \Delta x \\ \Delta y \\ \Delta z \end{bmatrix}_{Antenna} + R_{WGS84} R_E R_{INS} \left(\begin{bmatrix} \delta x \\ \delta y \\ \delta z \end{bmatrix} + R_A R_L \begin{bmatrix} 0 \\ 0 \\ -r \end{bmatrix} \right)$$

Lidar concepts

System specifications & typical performances

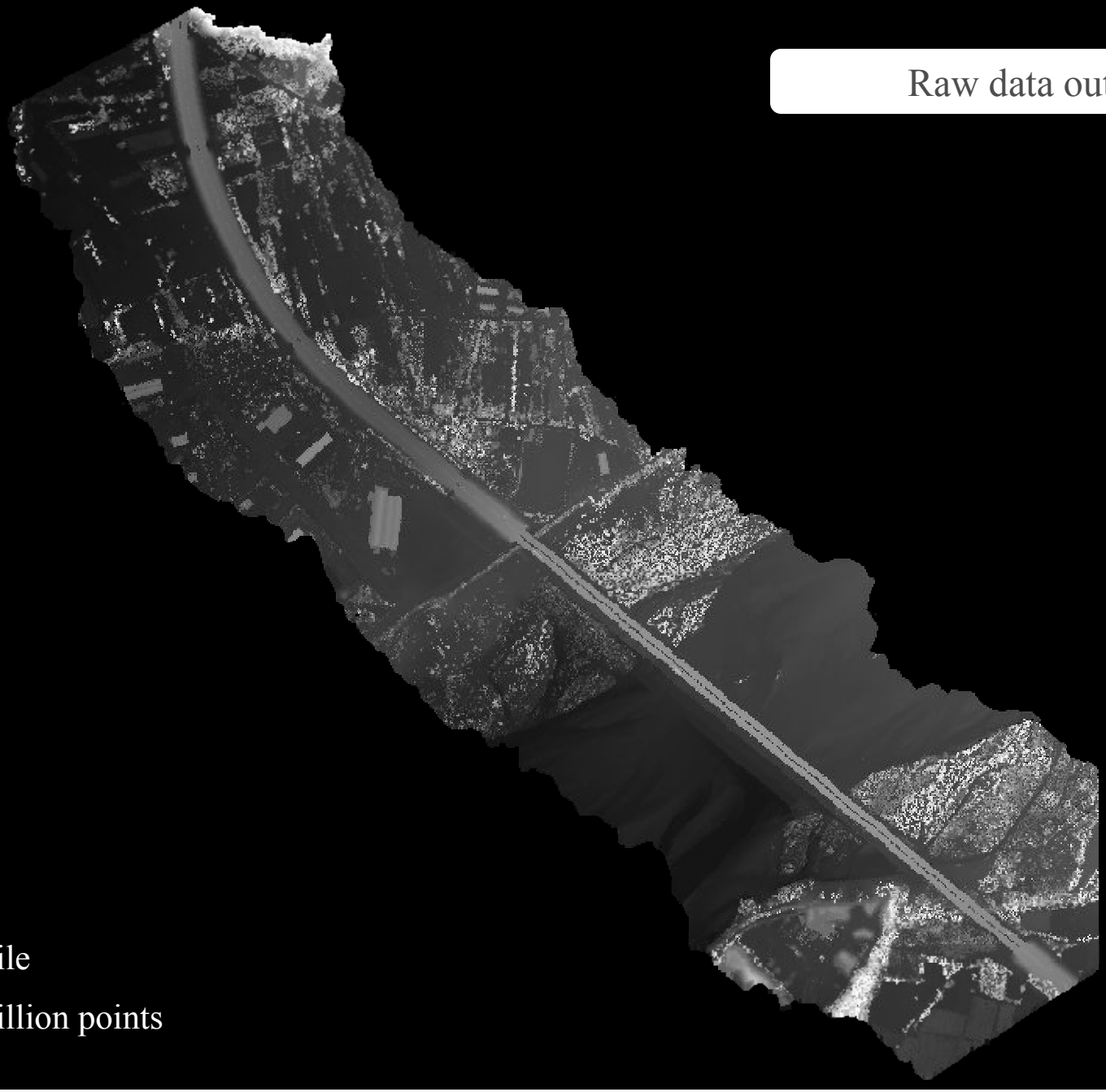


- Acquisition rate: up to 100,000 points per second
- Point density: 1 to 4+ pt/sqm (more points, higher costs)
- Point precision: 0.3-0.5 ft rms

Auxiliary digital pictures

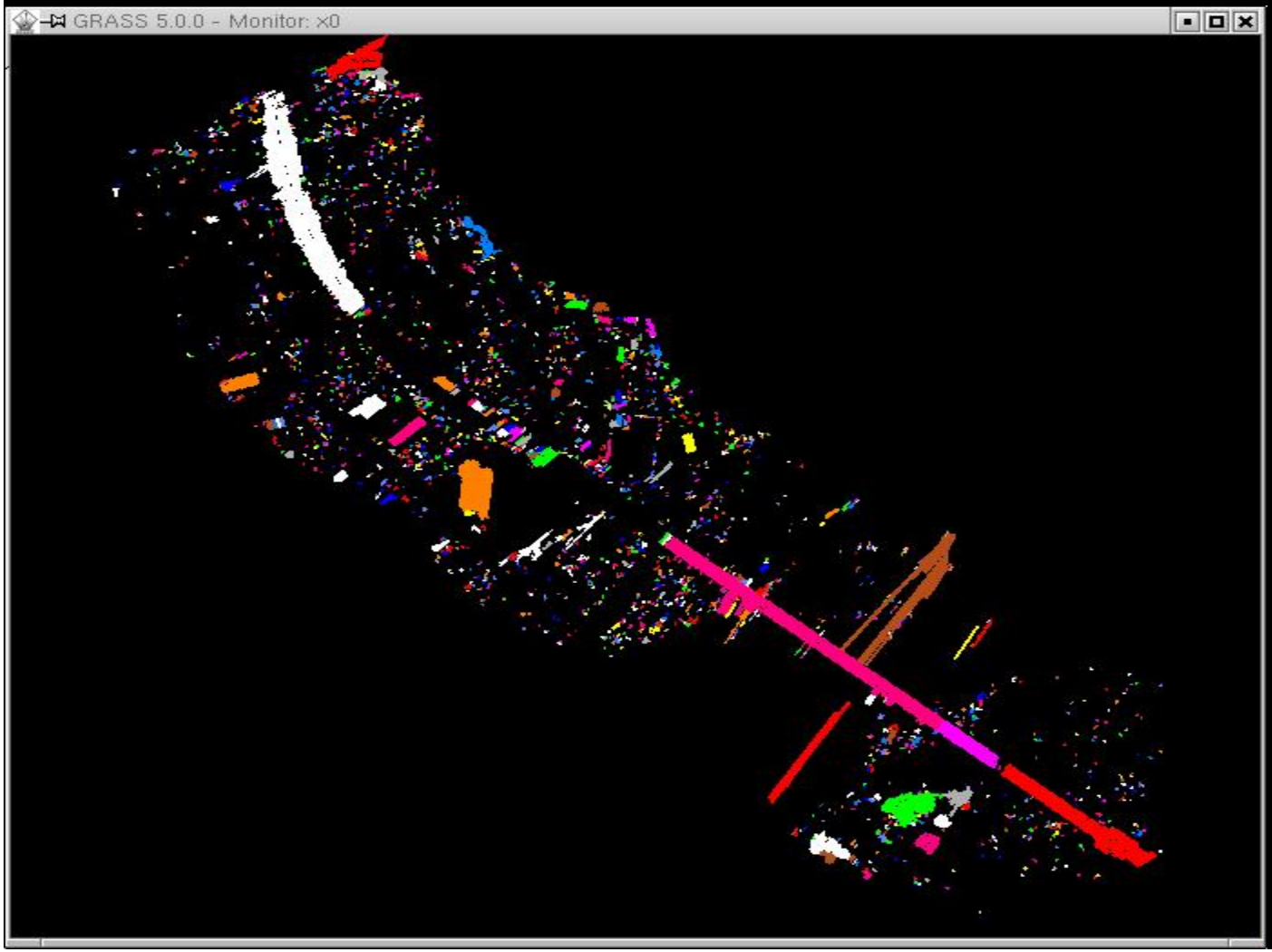
Color, RGB (20 Mpx) or RGB+IR
8-16 bit/channel (24-48 bits in RGB)
Ground resolution: 0.3 - 3 ft/pixel
GPS position and orientation

Raw data output

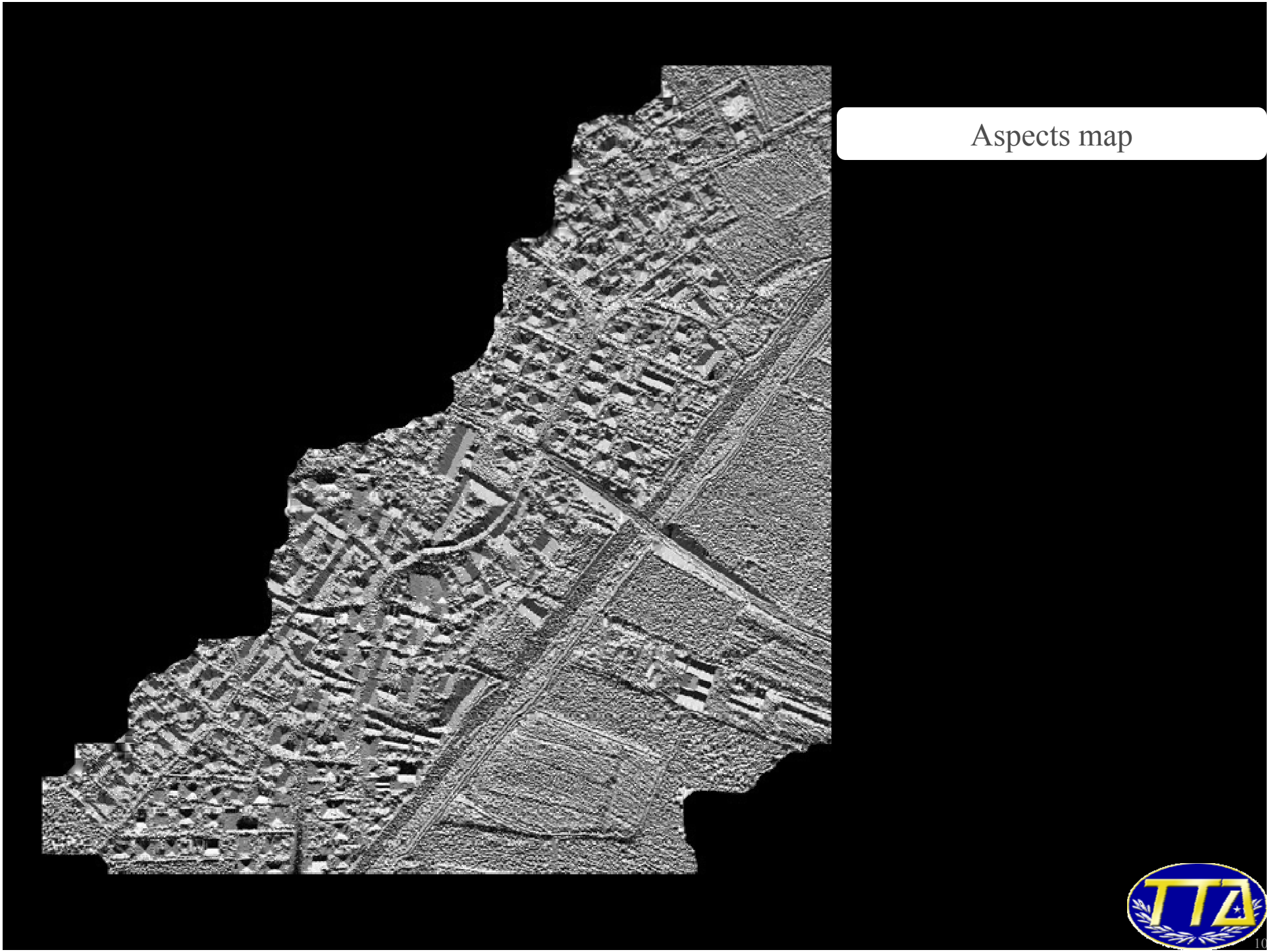


- About 1.5 mile
- About 2.5 million points

Object recognition

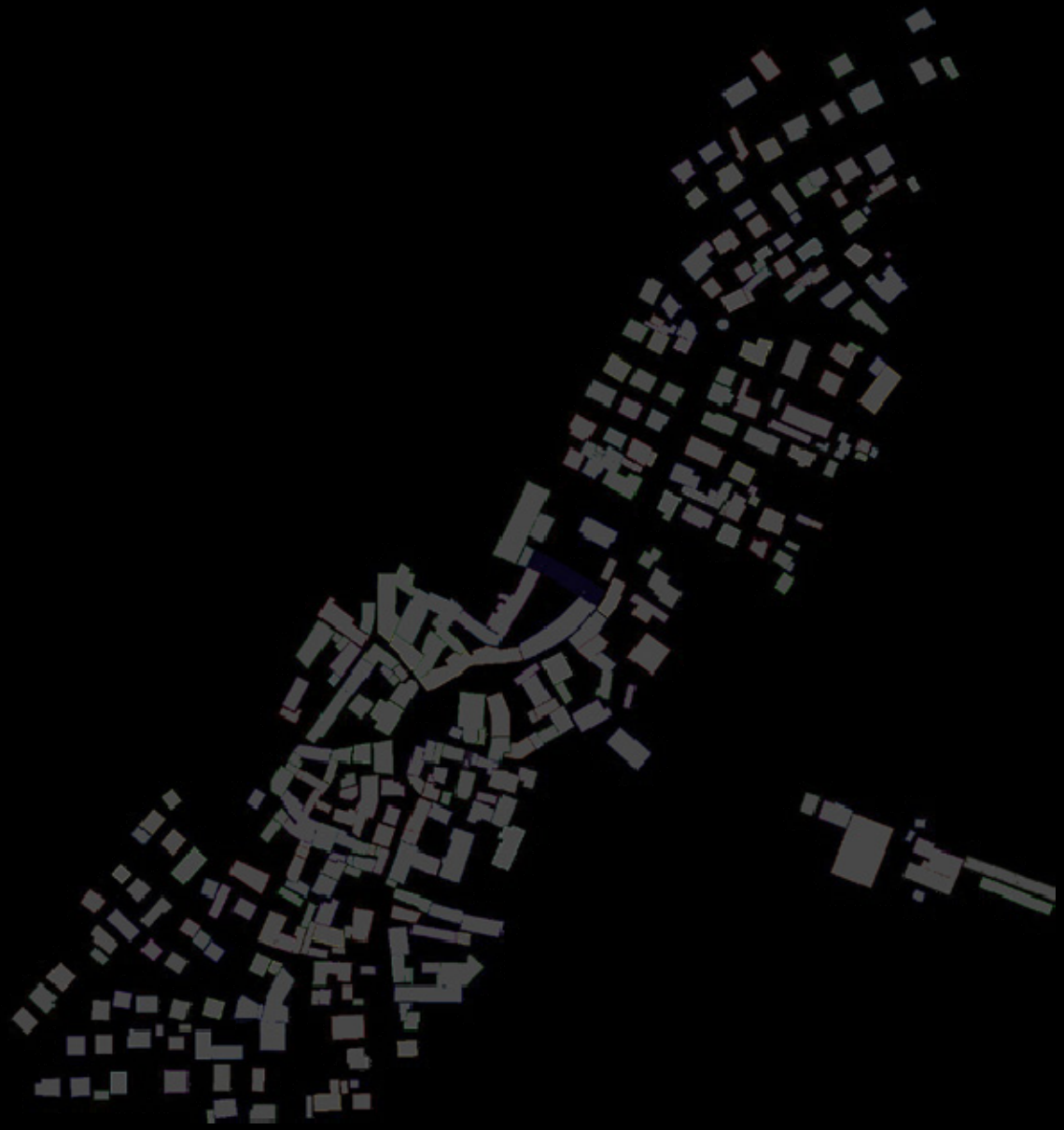


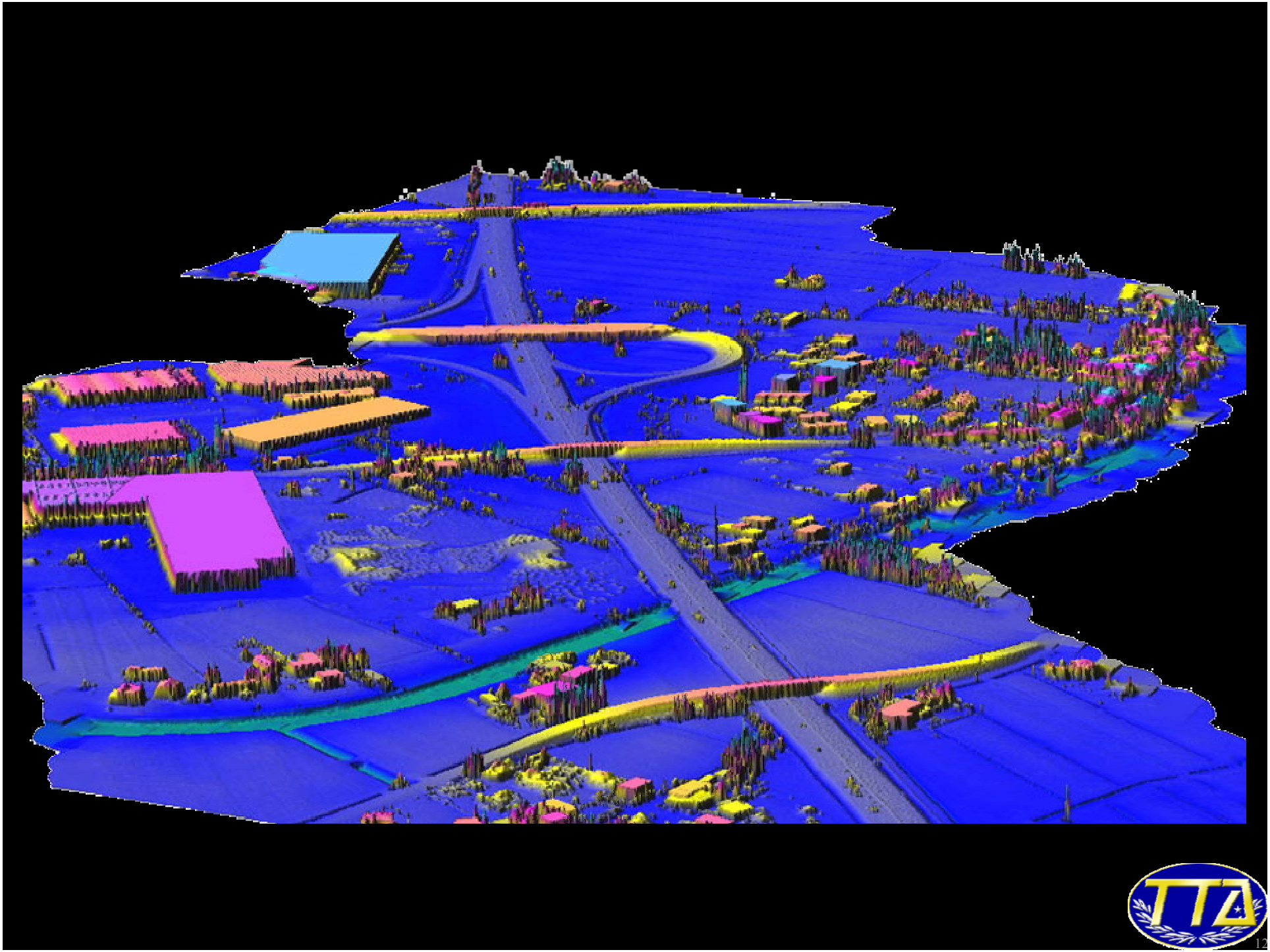
Edge detection

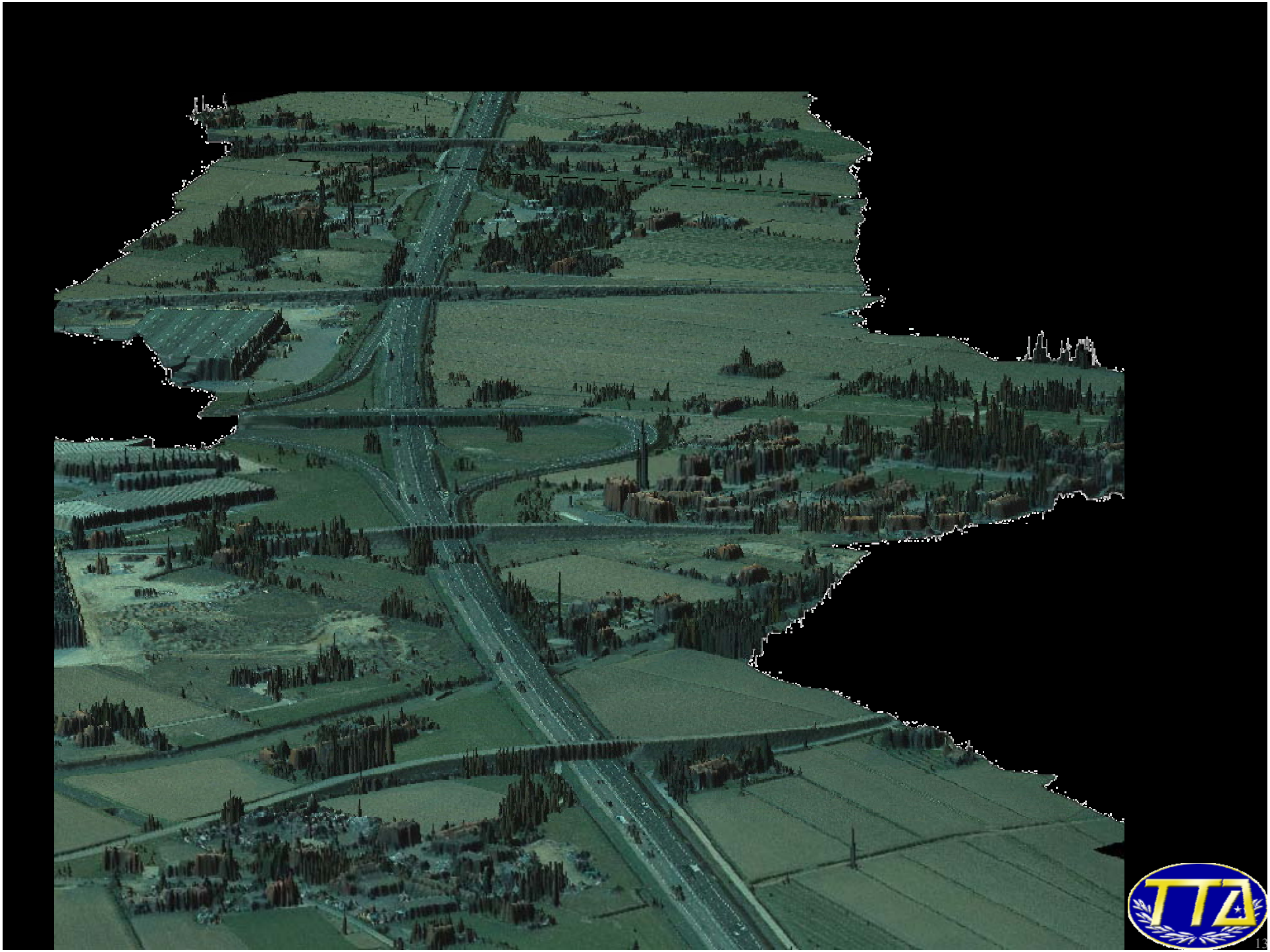


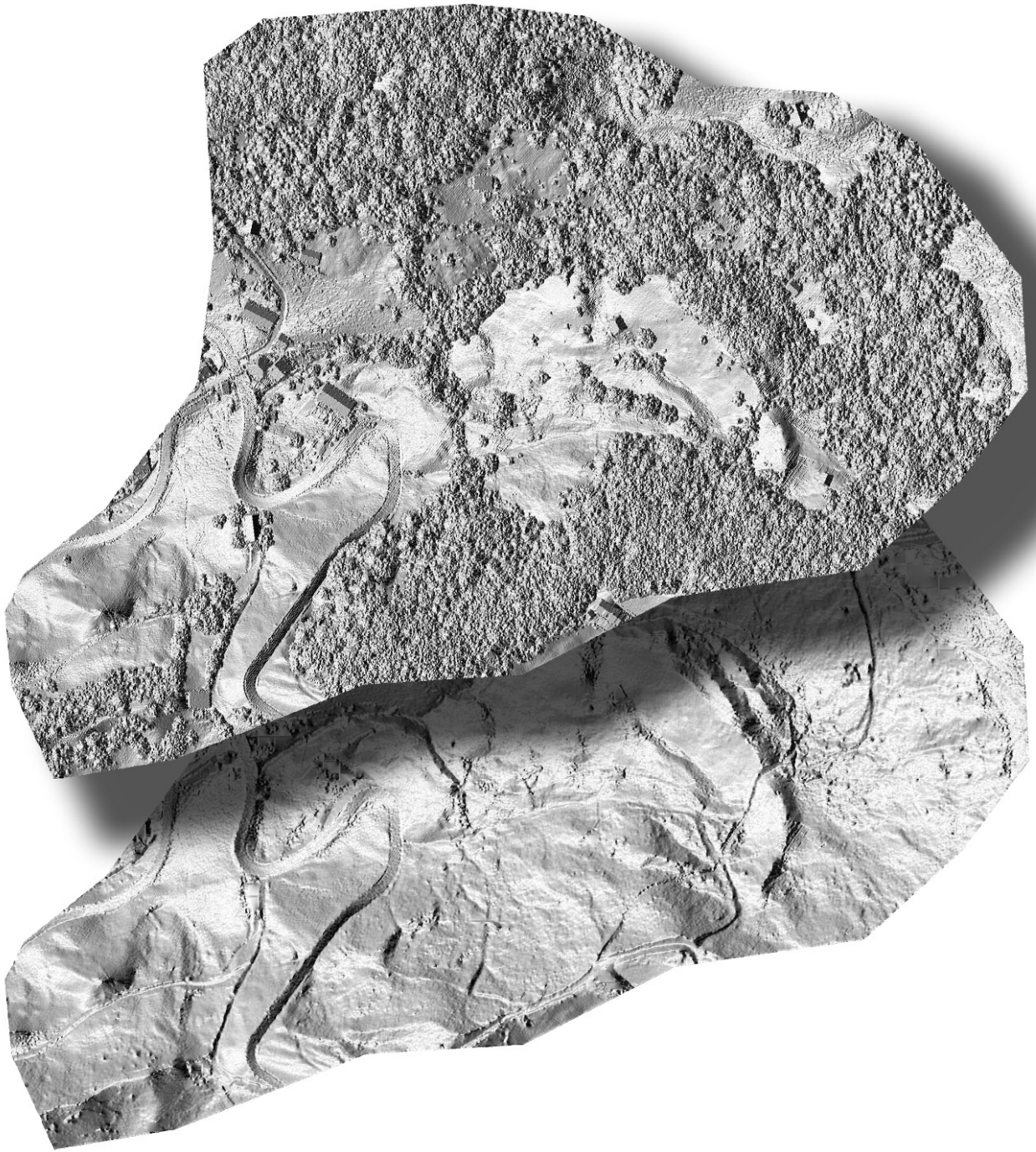
Aspects map

Building occupation

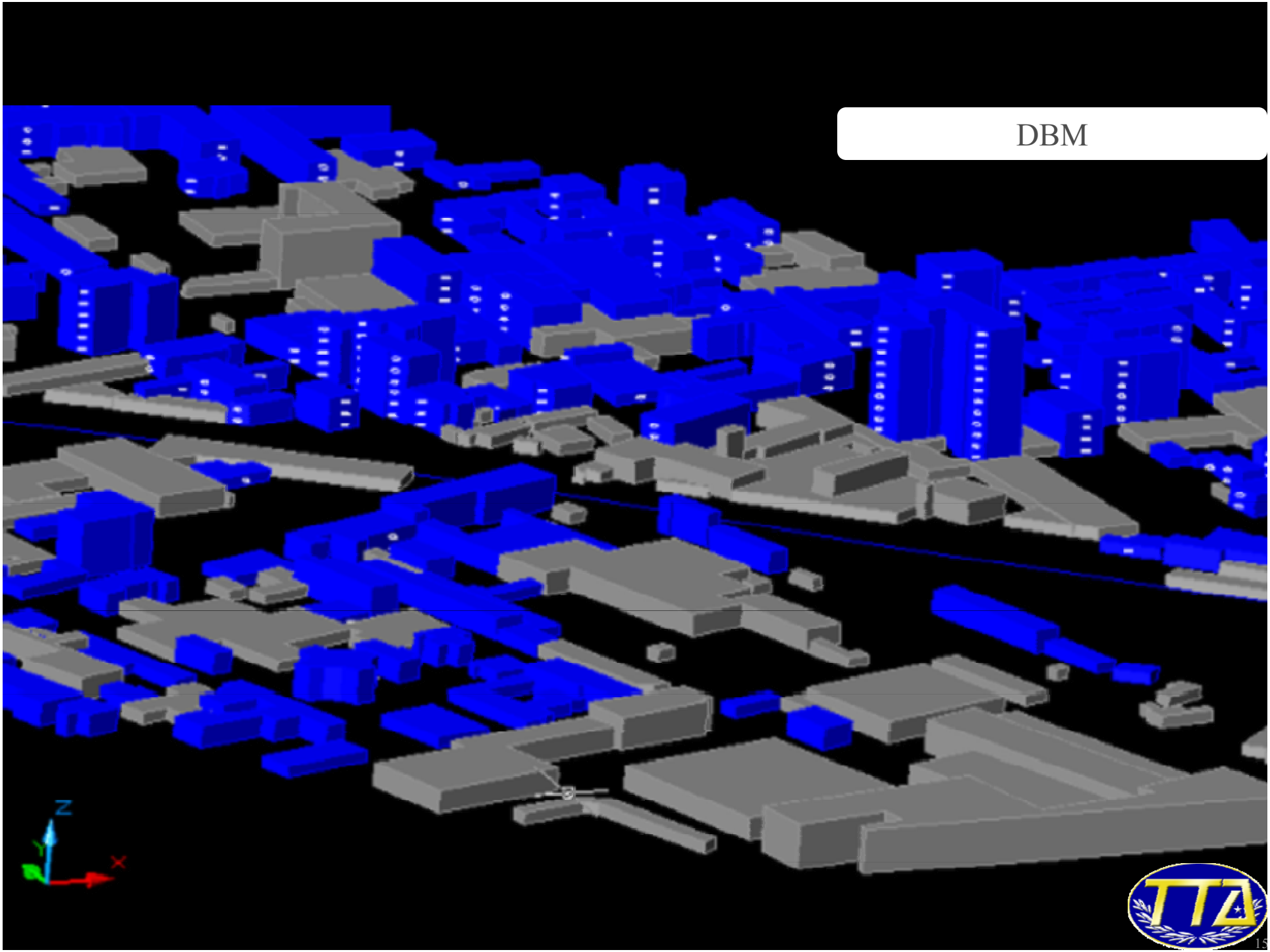




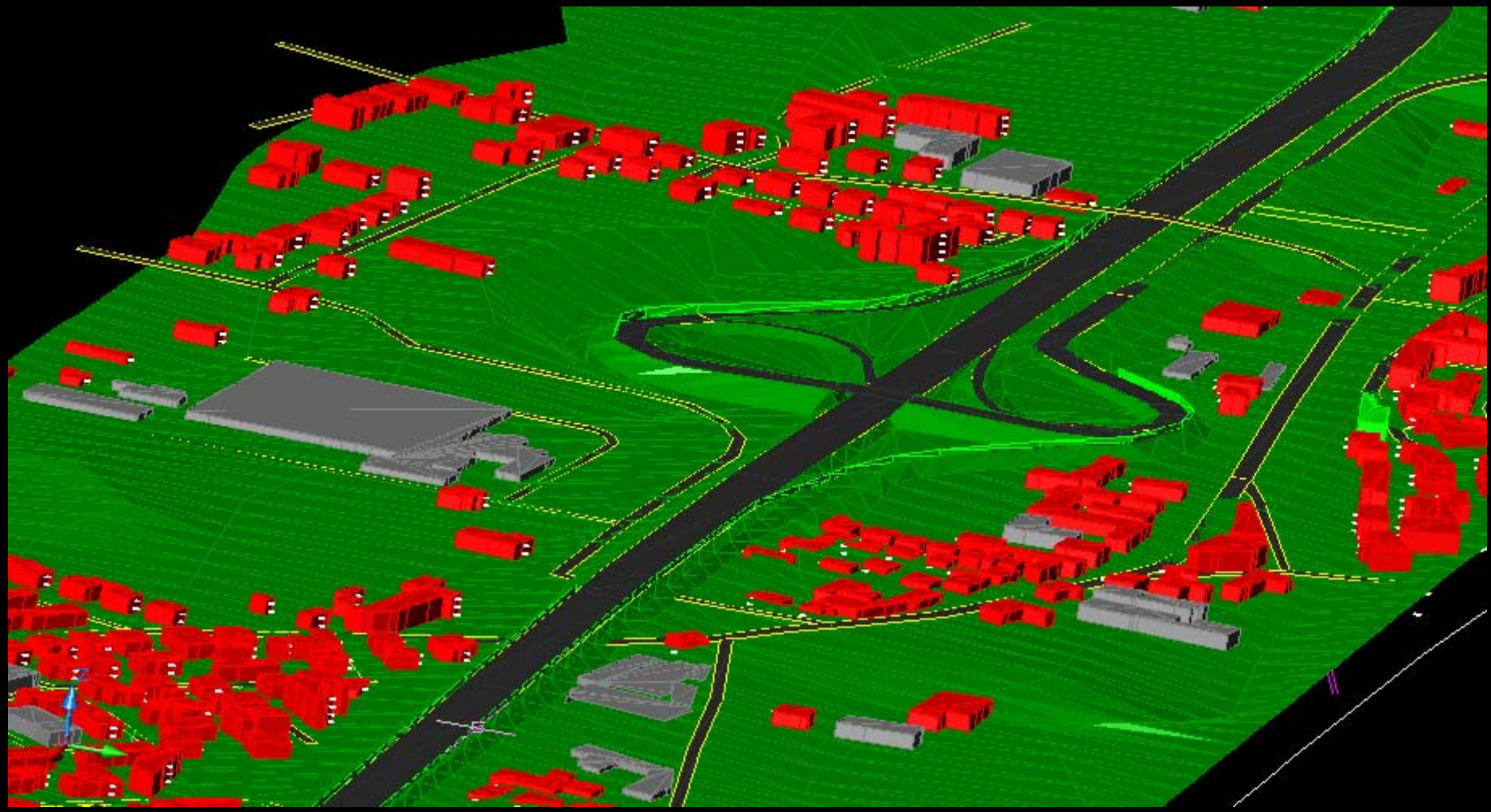




DBM



3D Output



New roads

			Sensible receptors		Other receptors	
	Road class	Width	Day	Night	Day	Night
		[ft]	[dBA]	[dBA]	[dBA]	[dBA]
A	Toll highway	820	50	40	65	55
B	Freeways	820	50	40	65	55
C	Interstate - main	820	50	40	65	55
D	Interstate - secondary	500	50	40	65	55
E	Local - main	100	50	40	65	55
F	Local	100	50	40	65	55

Width: always 1640 ft

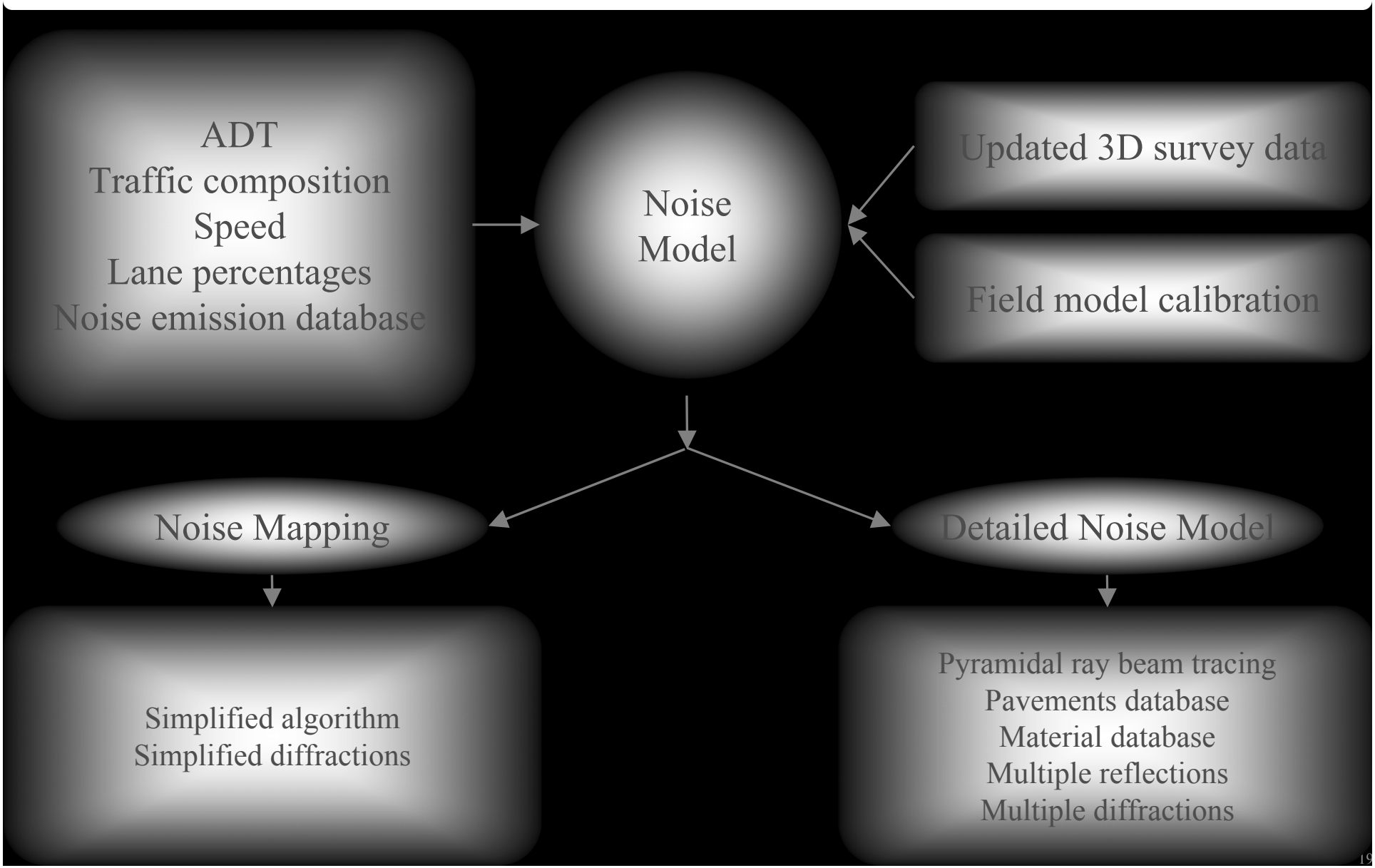
Existing roads

	Road class	Width	Sensible receptors		Other receptors	
			Day	Night	Day	Night
		[ft]	[dBA]	[dBA]	[dBA]	[dBA]
A	Toll highway	280	50	40	70	60
		820			65	55
B	Freeways	280	50	40	70	60
		820			65	55
C	Interstate - main	280	50	40	70	60
		820			65	55
D	Interstate - secondary	280	50	40	70	60
		500			65	55
E	Local - main	100	50	40	65	55
F	Local	100	50	40	65	55

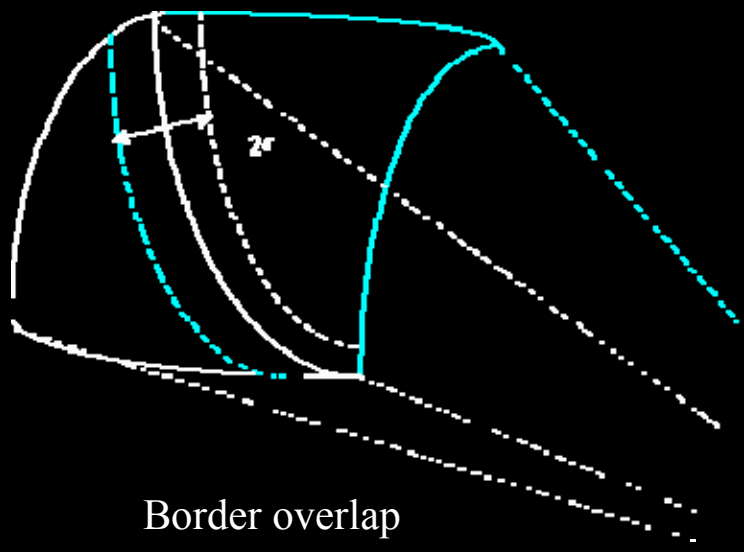
Width: always 1640 ft

Noise modelling

Model Flowchart

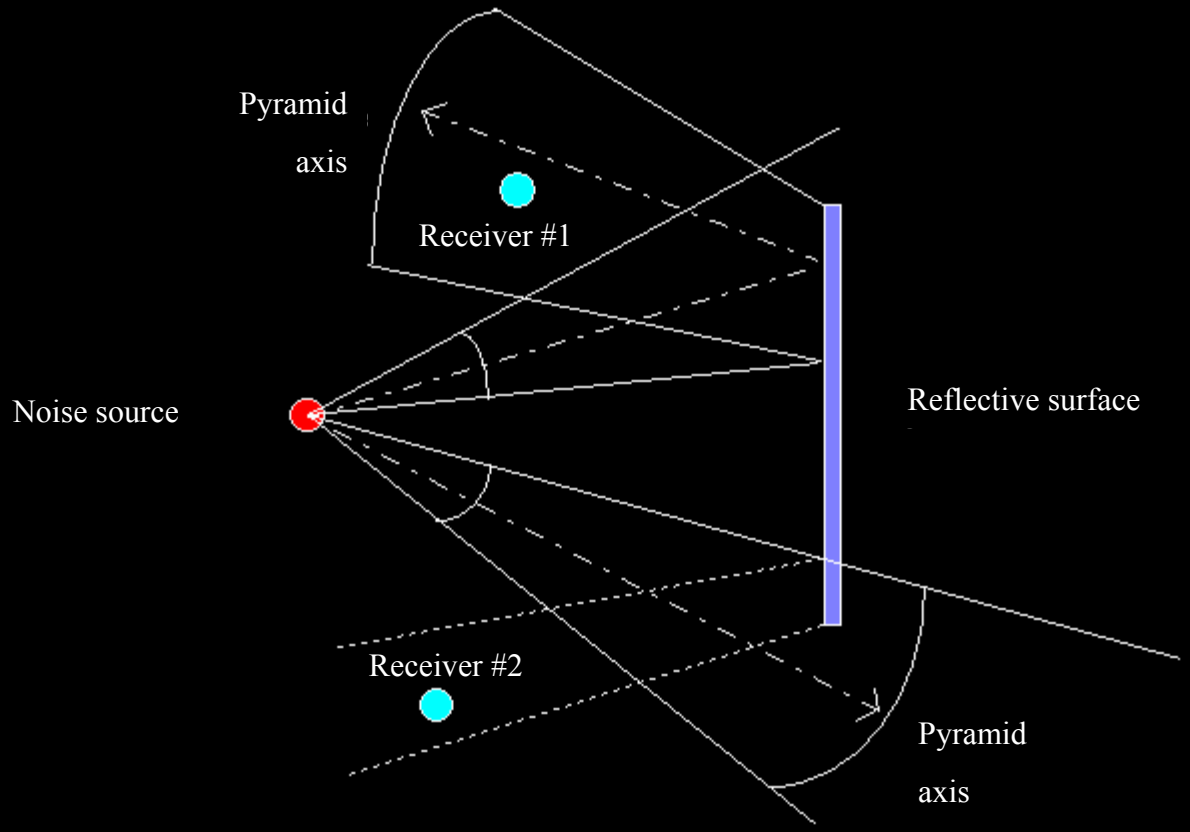


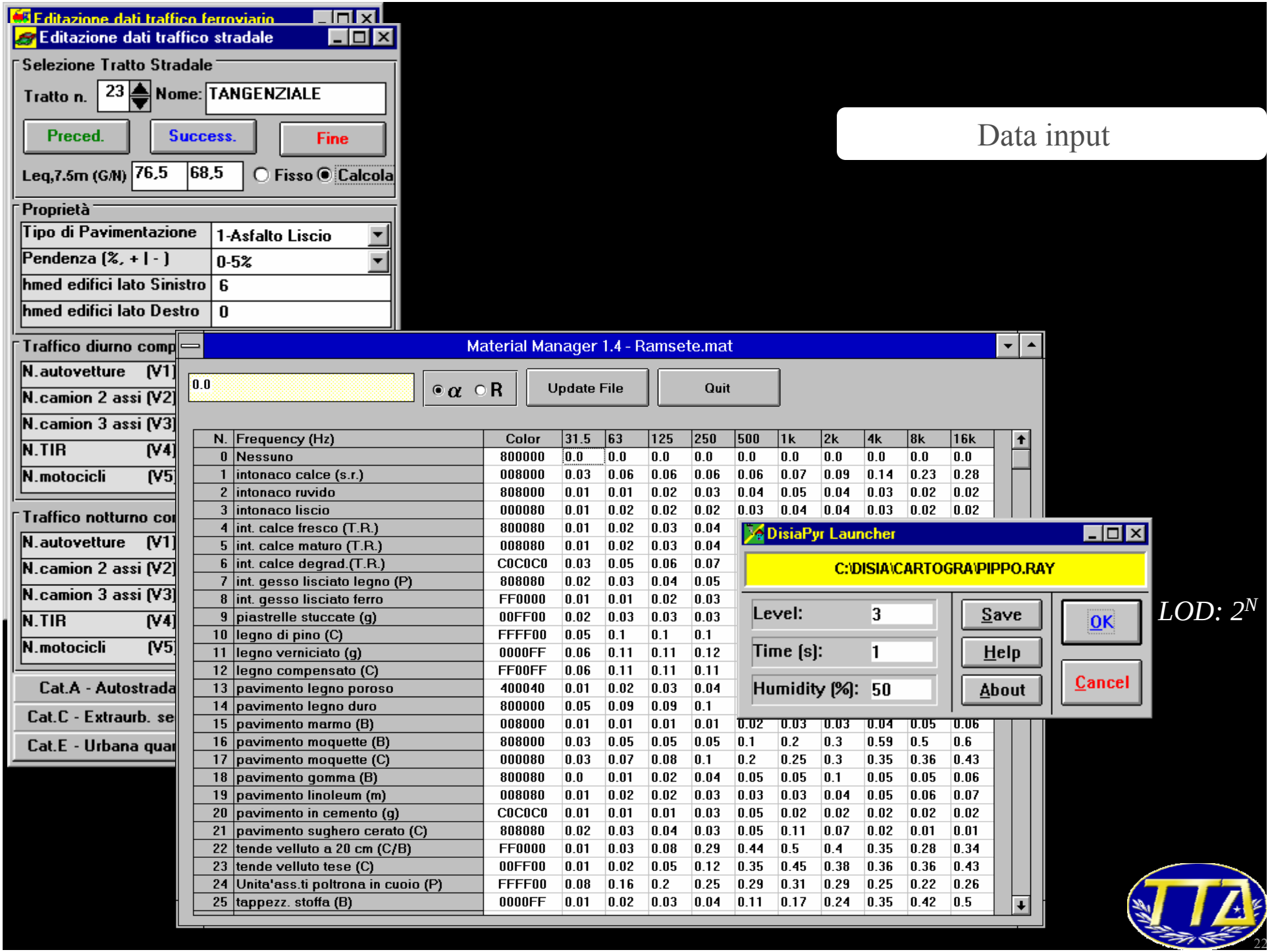
Noise sphere tasselation



Border overlap

Example

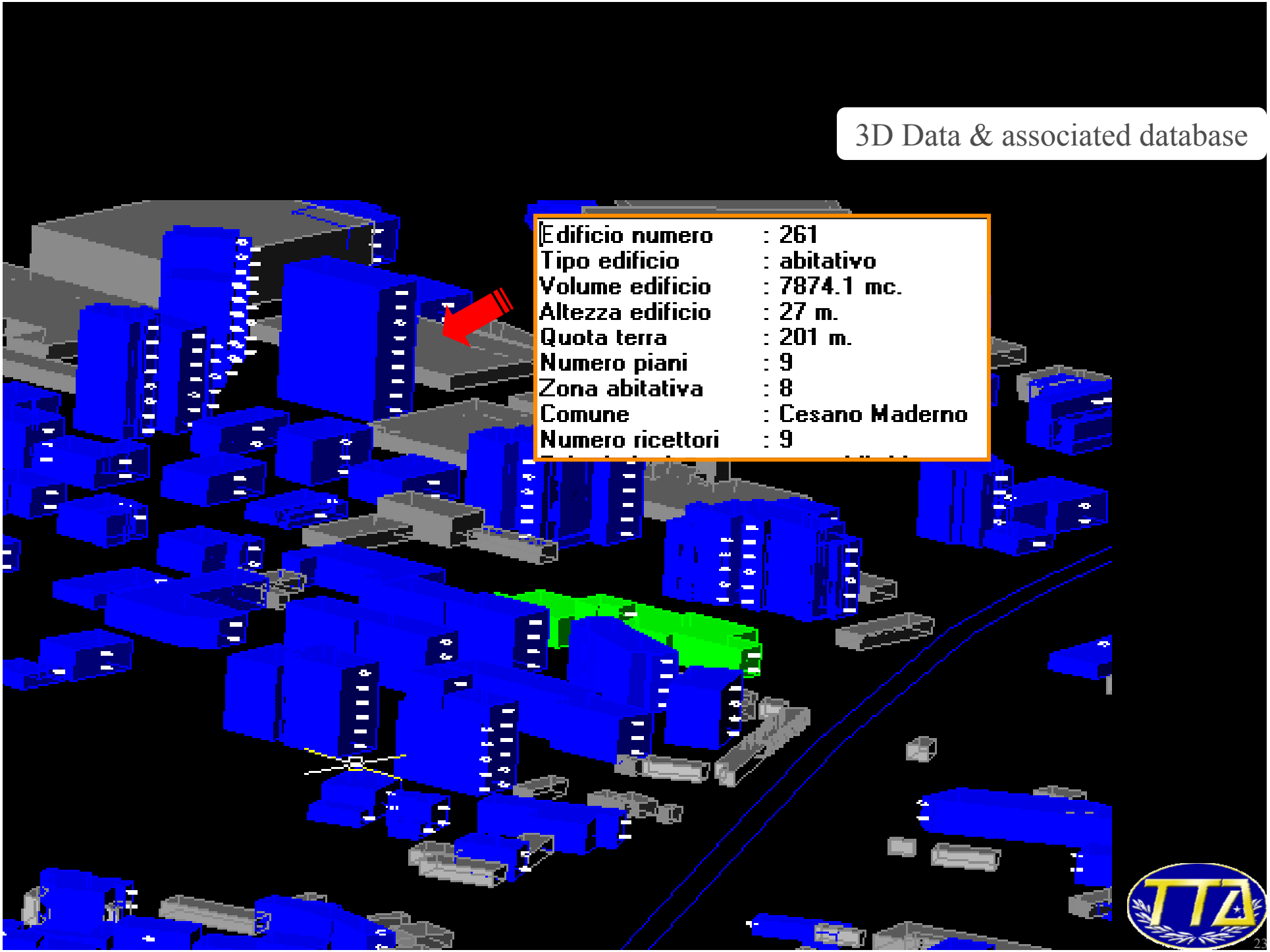

Pyramid
axis
Receiver #1
Noise source
Reflective surface
Receiver #2
Pyramid
axis



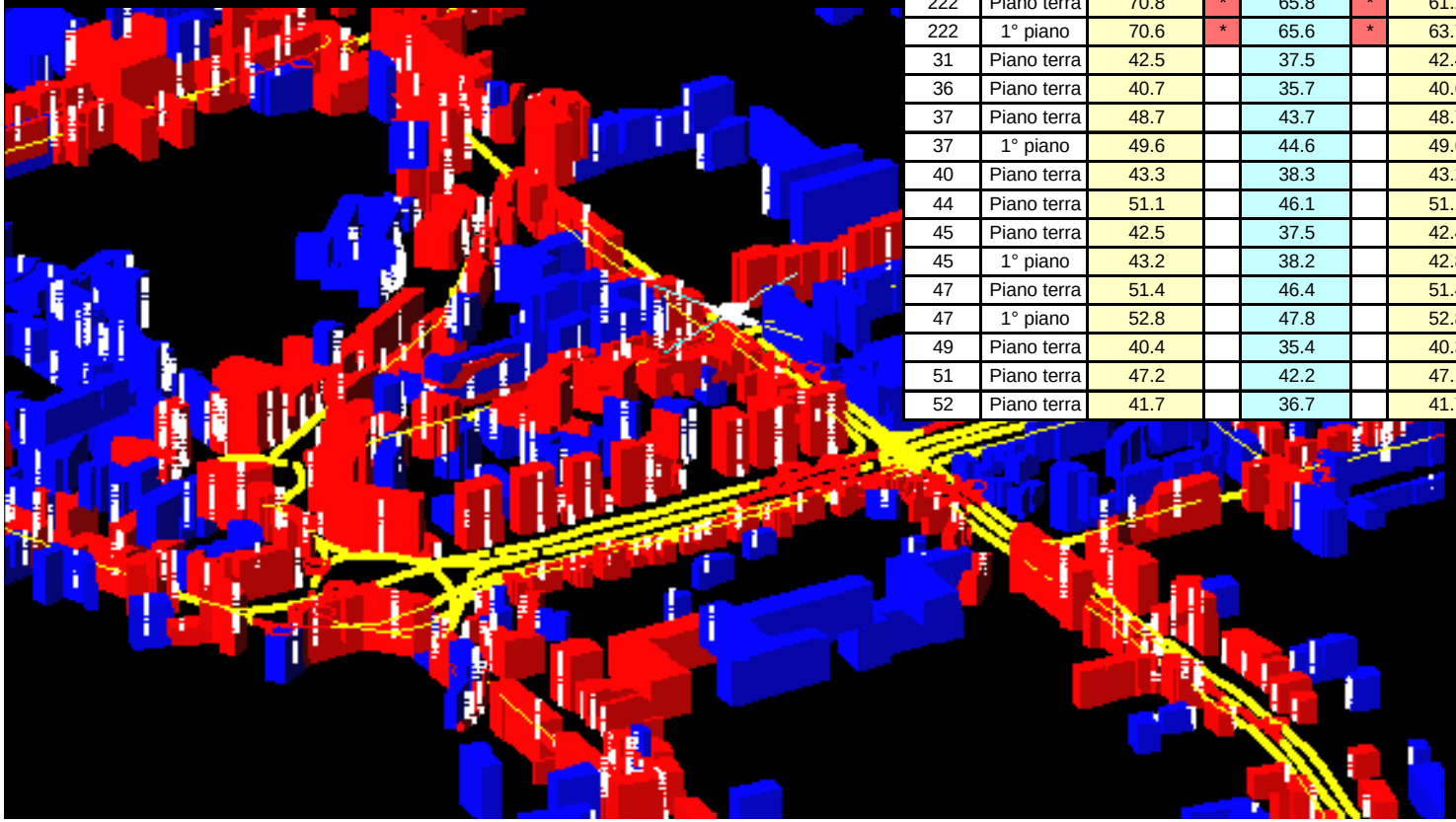
Data input

LOD: 2^N

3D Data & associated database



Overexposed buildings

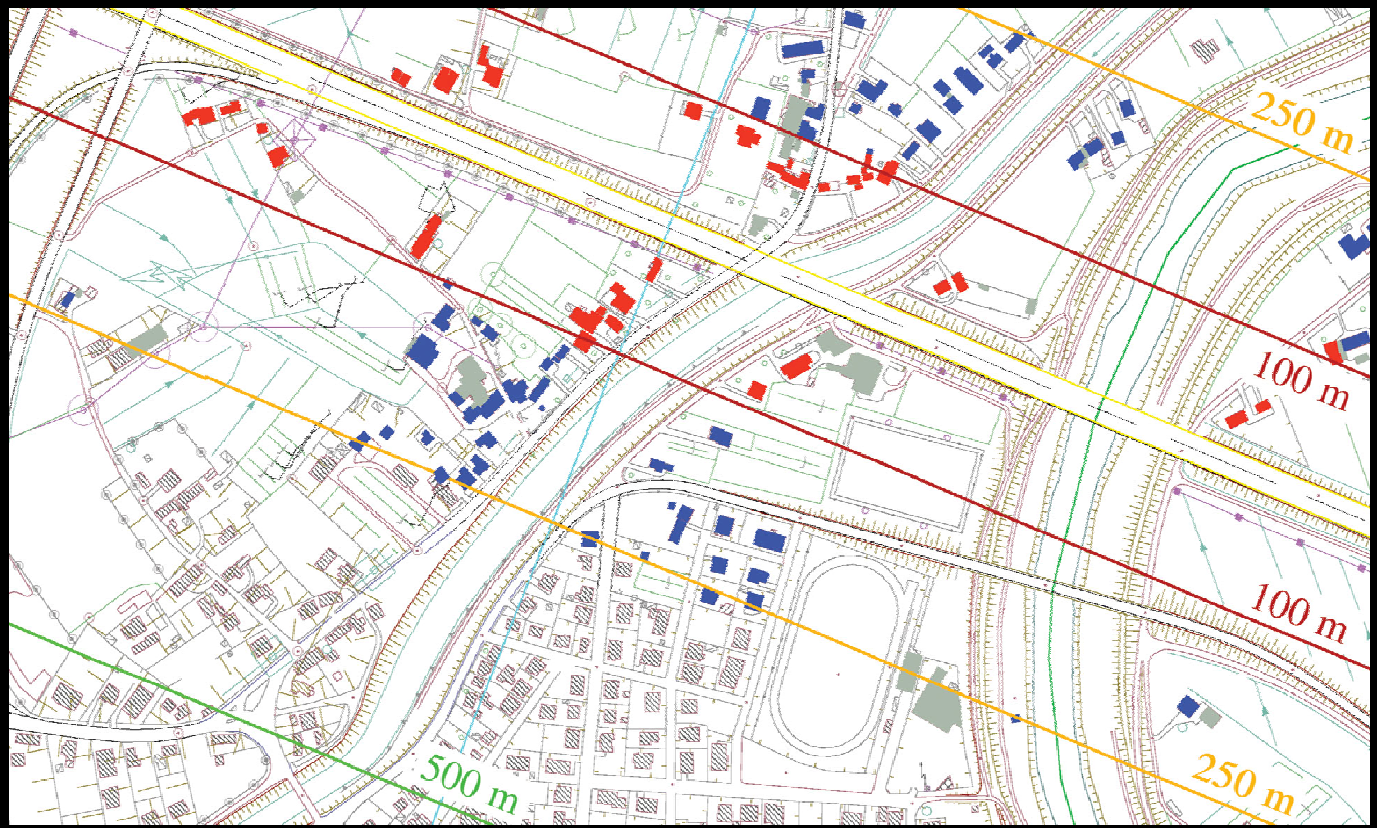


Casa n.	Piano n.	A] - Situazione attuale [dB(A)]				B] - Situazione post interventi di bonifica [dB(A)]				Efficacia interventi di bonifica acustica	
		day		night		day		night		day	night
174	2° piano	66.8		61.8	*	58.0		53.0		8.8	8.8
180	Piano terra	54.4		49.4		50.2		45.2		4.2	4.2
180	1° piano	54.8		49.8		51.2		46.2		3.6	3.6
182	Piano terra	66.2		61.2	*	56.1		51.1		10.1	10.1
182	1° piano	67.8		62.8	*	56.9		51.9		10.9	10.9
183	Piano terra	67.5		62.5	*	52.2		47.2		15.3	15.3
184	Piano terra	69.5		64.5	*	62.0		57.0		7.5	7.5
184	1° piano	69.6		64.6	*	63.0		58.0		6.6	6.6
192	Piano terra	62.4		57.4		48.3		43.3		14.1	14.1
201	Piano terra	77.8	*	72.8	*	69.5		64.5	*	8.3	8.3
210	Piano terra	60.4		55.4		48.3		43.3		12.1	12.1
210	1° piano	60.4		55.4		49.7		44.7		10.7	10.7
212	Piano terra	69.2		64.2	*	63.5		58.5		5.7	5.7
212	1° piano	69.0		64.0	*	65.4		59.6		3.6	4.4
214	Piano terra	61.7		56.7		49.6		44.6		12.1	12.1
214	1° piano	63.5		58.5		50.5		45.5		13.0	13.0
214	2° piano	63.9		58.9		51.7		46.7		12.2	12.2
222	Piano terra	70.8	*	65.8	*	61.2		56.2		9.6	9.6
222	1° piano	70.6	*	65.6	*	63.7		58.7		6.9	6.9
31	Piano terra	42.5		37.5		42.4		37.4		0.1	0.1
36	Piano terra	40.7		35.7		40.6		35.6		0.1	0.1
37	Piano terra	48.7		43.7		48.7		43.7		0.0	0.0
37	1° piano	49.6		44.6		49.6		44.6		0.0	0.0
40	Piano terra	43.3		38.3		43.2		38.2		0.1	0.1
44	Piano terra	51.1		46.1		51.1		46.1		0.0	0.0
45	Piano terra	42.5		37.5		42.4		37.4		0.1	0.1
45	1° piano	43.2		38.2		42.8		37.8		0.4	0.4
47	Piano terra	51.4		46.4		51.4		46.4		0.0	0.0
47	1° piano	52.8		47.8		52.8		47.8		0.0	0.0
49	Piano terra	40.4		35.4		40.3		35.3		0.1	0.1
51	Piano terra	47.2		42.2		47.1		42.1		0.1	0.1
52	Piano terra	41.7		36.7		41.7		36.7		0.0	0.0

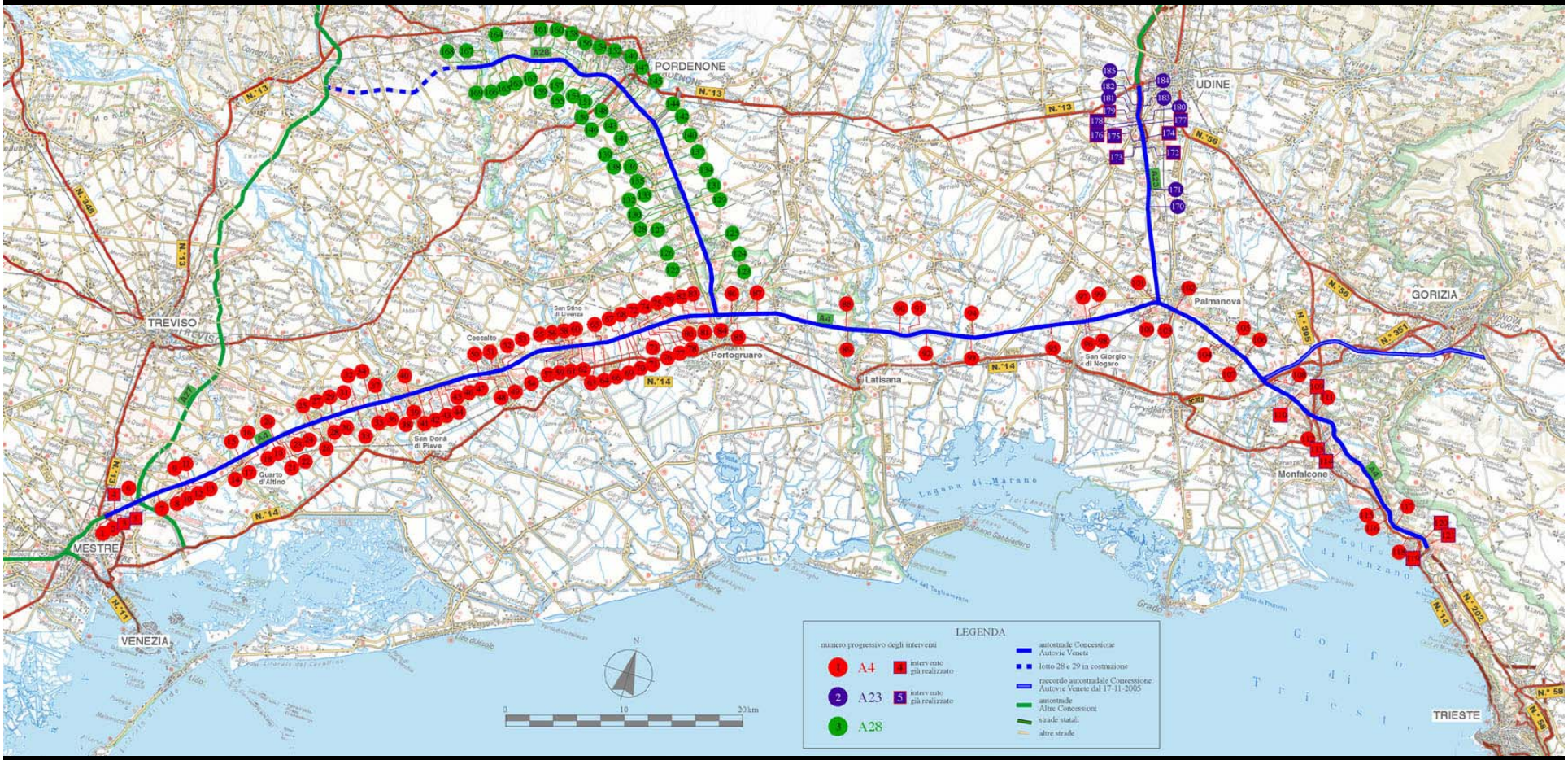
Definition

$$p = \sum_{i=1}^{n} R_i \left(L_i - L_i^* \right)$$

Ri: Exposed inhabitants
Li: measured/calculated level
Li*: regulatory limit



An Example Mapping



Conclusions

- Lidar survey for noise modelling: fast response, accurate data
- Delivery times, from scratch: first 100 mi in 1-2 months (depending on atmospheric conditions)
- Useful decision support for identifying –numerically- where to invest to maximize effects
- Regulatory complaint

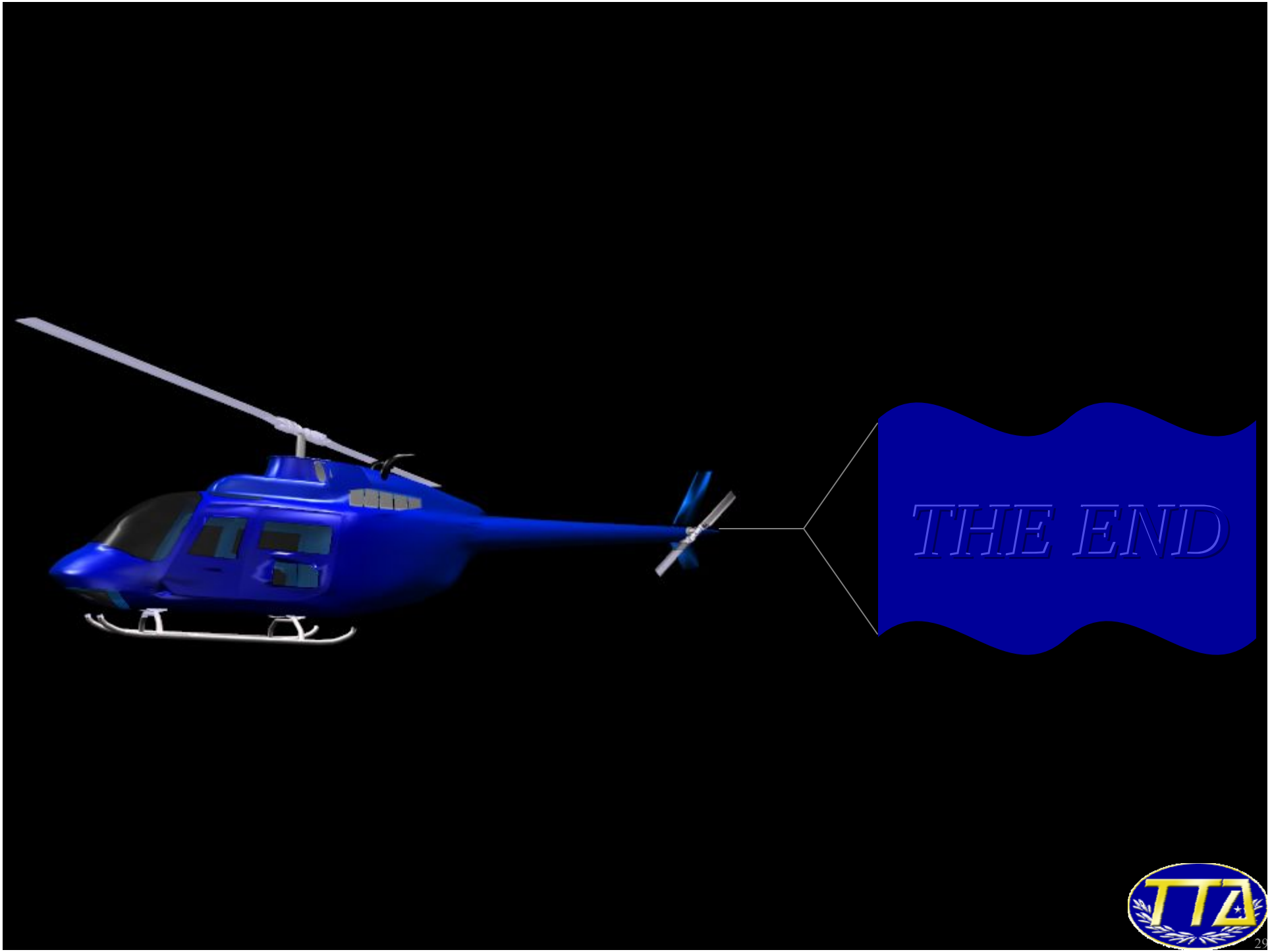
….

- Effectively maximizes benefits for the population

Open issues….

Ho do we protect the drivers…..

….. from **shouting**???


THE END

An experience in high productivity lidar mapping and noise modelling

TRB Summer Meeting

Williamsburg, VA

July 11, 2006

www.tommasitommasi.com