Geographical localization of road accidents on WGS84 system and use of Open Street Map for road safety performance indicators on the Italian road network

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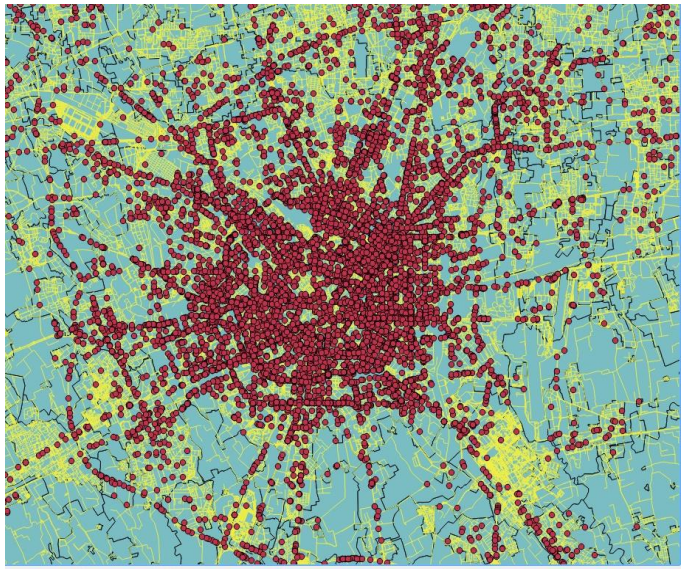
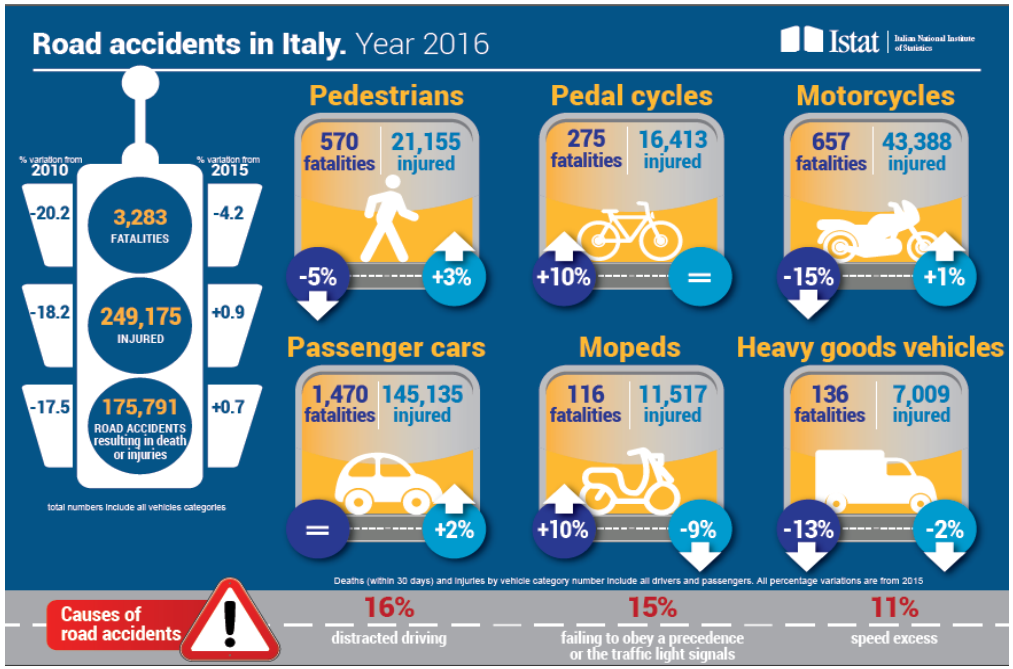


CARE experts group meeting
Brussels 24 January 2018

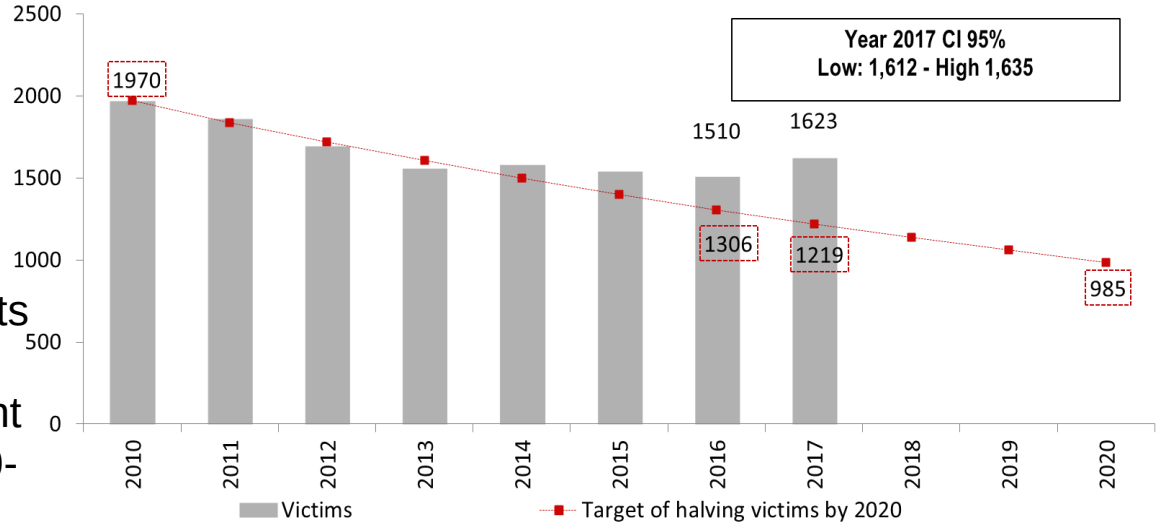
Highlights from Italian Road Accidents statistics



Infographic link:
https://www.istat.it/en/archive/202807

During the first semester of 2017, the preliminary estimates data shows a reduction of both road accidents resulting in death or injury and injured persons, with a decrease of 4-5%, with respect to the final data for the same period in 2016. In this context, a reversal trend for victims is recorded, with a new growth and increases between 6.7 and 8.2%.
https://www.istat.it/en/archive/207867

EUROPEAN UNION TARGET 2020: NUMBER OF DEATHS IN ROAD ACCIDENTS. First semesters years 2010-2016, preliminary estimates first semester 2017, low and high limits (Confidence Interval 95%) and hypothesis of halving with constant speed, first semesters years 2010-2020. *Absolute values.*



Broccoli M., Bruzzone S. – Istat – Brussels 24 January 2018

Istat

Geolocalization of road accidents: a priority in Italy

- A complete and effective analysis of road accidents data requires **information systems with detailed spatial and descriptive data**.
- The use of geographical information is necessary to locate the accident ***hotspots*****,** used to plan intervention on roads structure and mobility at local level, but is useful, for other important purposes too, for example, to determine the best emergency services location along the roads according to black spot information.
- As regards the **effort from Italy**, to improve this information, since about 10 years a new organisational model for road accidents survey has been adopted.
- A **memorandum of understanding**, signed by Istat, national organisations involved and Regions (NUTS2), is in force for Road Accidents data collection and monitoring in Italy.
- During the last decade **11 regions out of 20 adopted the new model** and improved gradually the quality of coordinates and coverage.
- In Italy 3 different authorities are in charge to verbalize road accidents occurred: Motorway Police (17%), Local Police (66%), Carabinieri (17%). Carabinieri, since 2012, send data with a **complete coverage for geo-coordinates**.

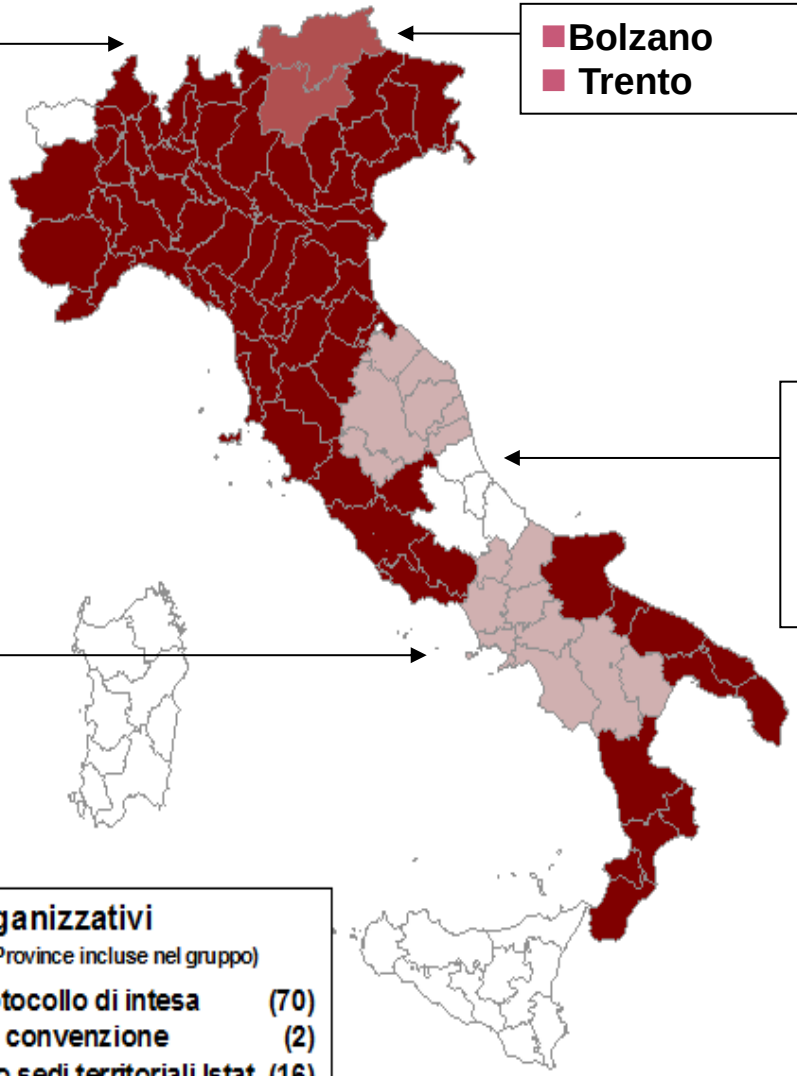
Road accidents in Italy: organisational model. Update 2018

Memorandum of understanding regions:
- Piemonte
- Lombardia
- Veneto
- Friuli Venezia Giulia
- Emilia Romagna
- Toscana
- Puglia
- Calabria (1/1/2016)
- Liguria (1/1/2016)
- Lazio (1/1/2018)

- Bolzano
- Trento

Standard FLOW:
- ❑ Valle d'Aosta
- ❑ Abruzzo
- ❑ Sicilia
- ❑ Sardegna

Regional Istat offices collect data:
- Umbria
- Marche
- Molise
- Campania
- Basilicata



Modelli organizzativi
(in parentesi numero delle Province incluse nel gruppo)

Regioni aderenti a Protocollo di intesa	(70)
Province autonome in convenzione	(2)
Decentramento presso sedi territoriali Istat	(16)
Regioni a flusso standard	(22)

Road accidents Data flow : Italy

Reparti di Polizia Stradale
Questure
Commissione di Pubblica Sicurezza

Polizia Stradale

Elaborazione Dati di Settebagni (Roma)

Istat
Directorate Data Collection DCRD/RDC

Directorate Social Statistics DCSS/SSC

Motorway Police 17% 30,000 accidents

Carabinieri 17% 30,000 accidents

N. O. Radiomobile
Stazione dei Carabinieri
(utilizzo dell'applicativo GESTINC per la trasmissione centralizzata dei dati)

Flusso standard

Istat

Comando di Polizia Municipale o Locale

Ufficio di Statistica Comune Capoluogo di Provincia

Flusso decentrato

Ufficio Statistica di Regione o Provincia o Centro di Monitoraggio incaricato

Local Police 66% 115,000 accidents

Geocoordinates Collection and providing

Geolocalization in Italy: check and update process

- ✓ Istat has a partnership with **ACI Automobile Club d'Italia** to check all geographical data (type and name of road, km and meters, coordinates).
- ✓ A **check on coordinates** data received, by means a control of all information sent (road description, km and meters, municipalities), is performed.
- ✓ **Main mistakes** found are: inversion of coordinates, comma or dot to separate digits, incorrect position if compared with NUTS/LAU info, systems used.
- ✓ **Missing coordinates** replacing if additional information available, is done (**8%**).
- ✓ A **conversion in WGS84 system** of coordinates provided with other system is processed.

Coordinates systems used in Italy for road accident location (2016 data):

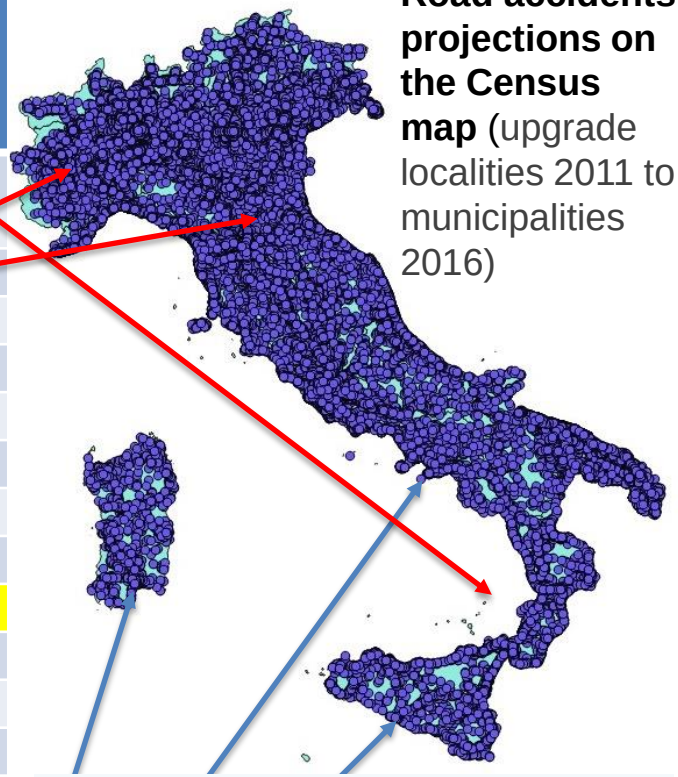
Coordinates types	Number of accidents	Percentage
WGS84	90,885	71,8
EDS 50 UTM	14,738	11,6
Gauss_Boaga	13,629	10,8
Monte Mario	7,233	5,8
Degrees	130	0,1
Total (out of 175,791 road accidents - 72%)	**126,615**	**100.0**

Conversion system used: WGS84 Astronomic WGS84 system limits - Italy

GEO LIMITS		LATITUDE	LONGITUDE	LOCALITIES
LATITUDE	NORTH	47.09235	12.185898	Predoi (BOLZANO-BOZEN)
	SOUTH	35.49327	12.605889	Punta Pesce Spada (LAMPEDUSA)
LONGITUDE	EAST	18.52016	40.107159	Faro di Capo d'Otranto (LECCE)
	WEST	6.627674	45.101093	Testata della Valle Stretta (TURIN)

Coverage of geographical coordinates in Italy: year 2016

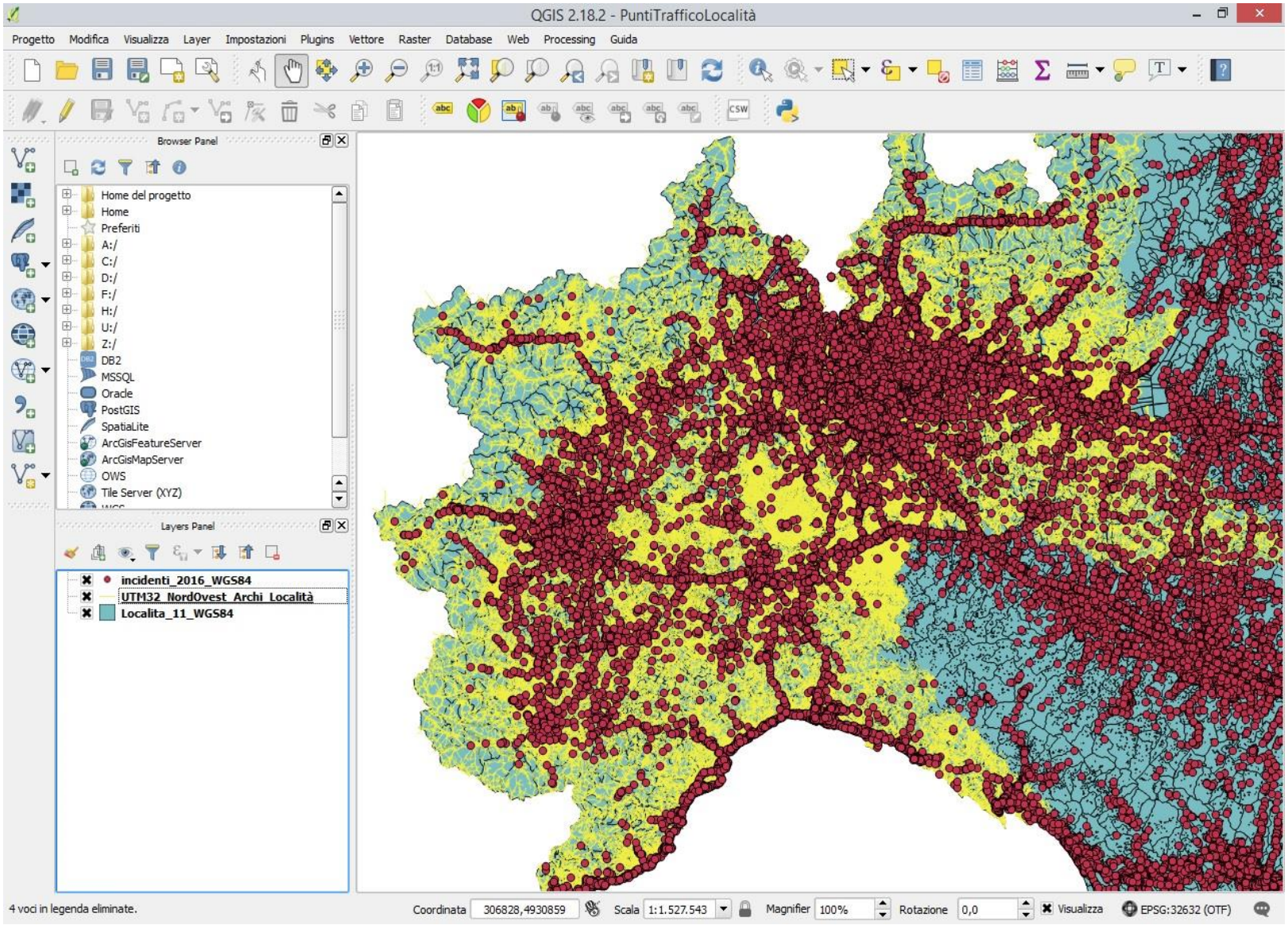
NUTS2 Italy	Italian Regions	Number of coordinates	Road Accidents Total number	Coverage %
ITF6	Calabria	2,735	2,851	95.9
ITC1	Piemonte	10,118	10,905	92.8
ITH5	Emilia Romagna	15,324	17,406	88.0
ITH4	Friuli Venezia Giulia	2,980	3,455	86.3
ITF4	Puglia	8,488	9,854	86.1
ITI1	Toscana	14,218	16,507	86.1
ITC4	Lombardia	26,787	32,785	81.7
ITI4	Lazio	15,988	19,939	80.2
ITH3	Veneto	11,167	14,034	79.6
	ITALY	**126,615**	**175,791**	**72.0**
ITH10-20	Trentino-Alto Adige	2,162	3,105	69.6
ITI2	Umbria	1,460	2,382	61.3
ITF2	Molise	258	479	53.9
ITF1	Abruzzo	1,622	3,037	53.4
ITC2	Valle d'Aosta	138	285	48.4
ITF5	Basilicata	445	945	47.1
ITC3	Liguria	3,729	8,282	45.0
ITI3	Marche	2,159	5,185	41.6
ITG2	Sardegna	1,414	3,508	40.3
ITF3	Campania	3,205	9,780	32.8
ITG1	Sicilia	2,218	11,067	20.0



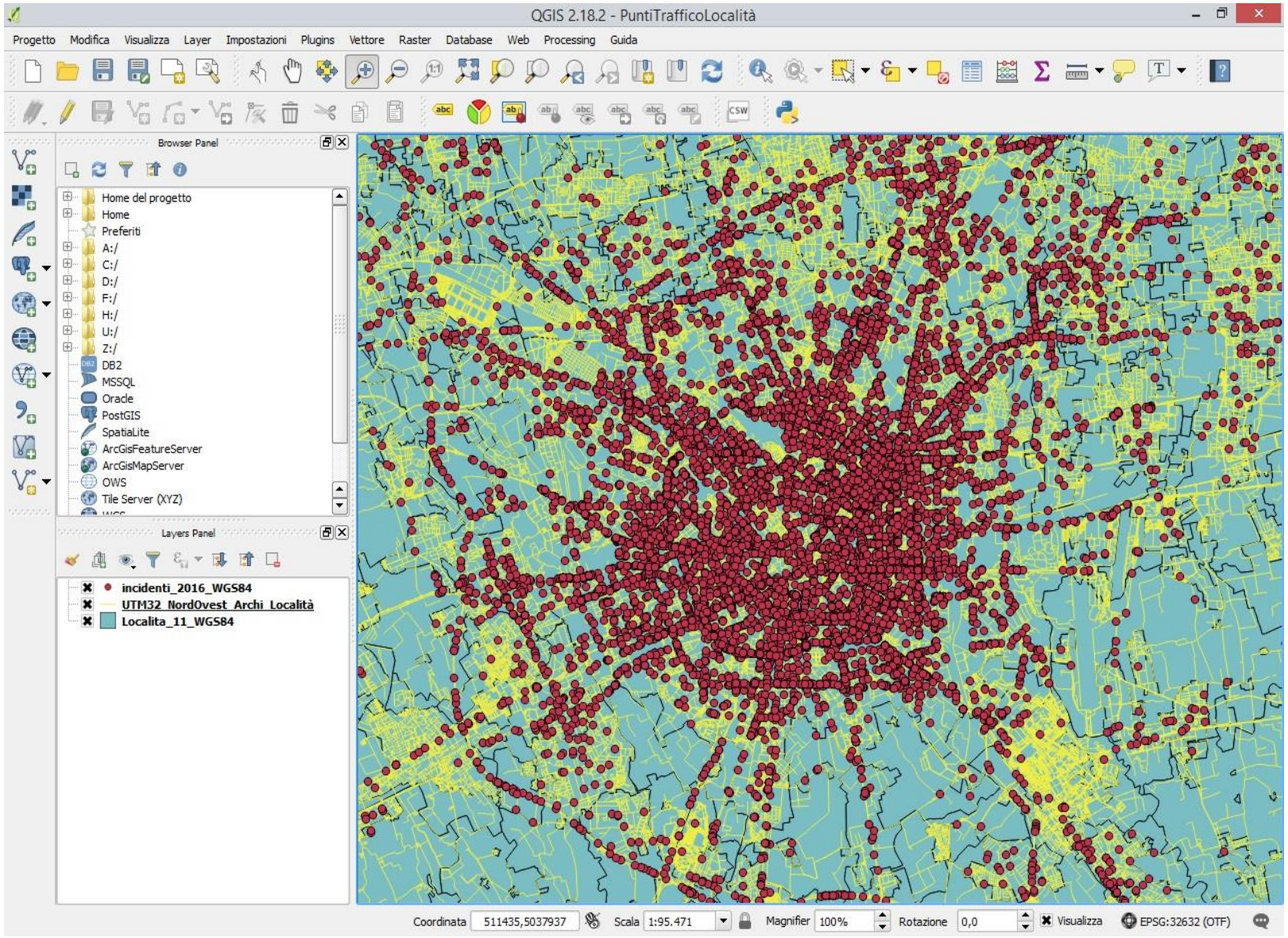
Road accidents projections on the Census map (upgrade localities 2011 to municipalities 2016)

For 2013 data, **only 43%** (78,045) out of 181,227 total road accidents, included information on the geographical coordinates.
Plus 30% of coverage in 3 years.

Road accidents geolocalisation in North-Western Italy: QGIS tool



Road accidents geolocalisation in Milan municipality: QGIS tool



Geographical coordinates: data in CADaS format

R-1 ACCIDENT LOCATION - LATITUDE (L)
R-2 ACCIDENT LOCATION - LONGITUDE (L)

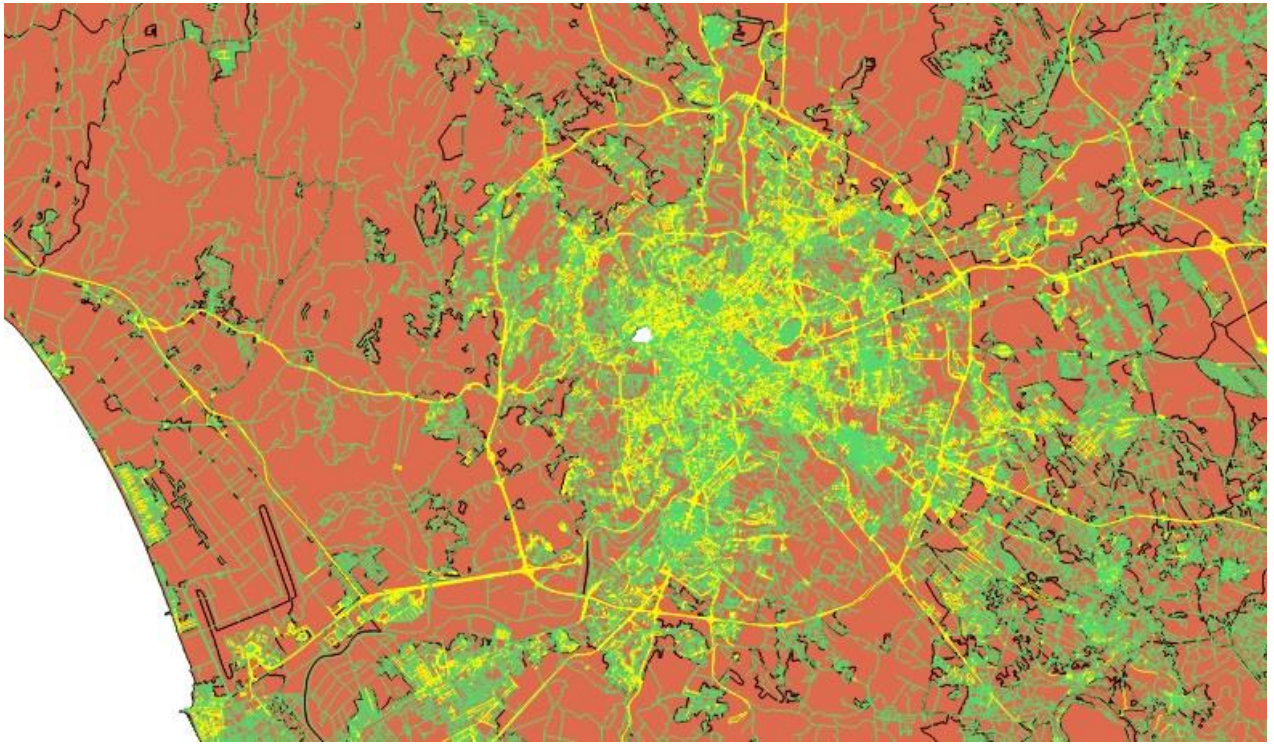
- To allow the providing of coordinates data for IT road accidents in CADaS format, some changes in the currently used Italian Data Base have been done.
- Geographical coordinates and other supplementary variables were included in a renewed DB architecture, implemented to face the recommendation of the European Commission and the new Istat strategy.
- A pilot test on the IT 2016 coordinates was performed by the European Commission, in a DG_MOVE workspace to test quality, data features, geographical shape files fit.
- First test results leaded to a good performance and acceptable data fit.

Use of Open Street Map for accident investigation on the road and motorway networks

Istat

Marco Broccoli

24 January 2018



Road Safety Performance Indicators (RSPI) give a multidimensional approach for accident investigation concerning roads, vehicles and persons involved.

Combining the use of statistical surveys, administrative **geographical information systems (GIS) and Big Data (BD)** sources the result gives new elements on planning infrastructure solution, applying policies to reduce deaths and serious injuries, reducing social costs on collectivity and estimating efficiency and effectiveness of safety initiatives.

Preventing road trauma on public roads is a core responsibility for government, its agencies and stack holders. It requires a common and shared responsibility.

The scale of the road safety challenge and the diversity of the effects of road traffic injury underline the importance of exploring synergies among the decision makers of the road network.

Nowadays there is a **clear information bias** as regards the appropriate reference denominators to be placed as basis in construction of statistical indicators linked to road accidents.

Resident population is used as a common proxy for exposed at risk in a specific geographical area, but not always an appropriate solution, especially in the light of the seasonal nature of road accidents and concentration, in some periods of the year, in specific locations.

The estimate **traffic flows**, would undoubtedly provide a key to understanding integrated and innovative phenomenon. Resident population doesn't mean present population at the time of the event.

Vehicle fleet can be another administrative source that gives a more accurate information, but the characteristic of the phenomenon implies a deductible distortion on measures due to the mobility of road users.

The **length of the road network** gives for sure a consistent first set of information concerning the different territories.

The first output of the project, in line with the process of modernization of Istat's statistical production is the focus on the exploitation of existing administrative sources, the scouting of new sources and the analysis of integrated and auxiliary data.

The basis of the renewal in the statistical production is to upload any source integration, even any new technique implemented and applied methodology. Every small change that overall effect becomes a process of improvement of the quality of the statistical information provided by Istat.

The purpose of the project is to expand statistical information with the supply of traffic flows, measuring the frequencies of the events in order to be interpreted not only as absolute values, but as probability of being involved in the accident, taking into account the different exposure to risk.

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data.

GIS applications are tools that allow users to analyze spatial information, edit data in maps and present the results of all these operations.

In order to relate information from different sources, GIS uses spatial location as the key index variable. Just as a relational database containing text or numbers can relate many different tables using common key index variables, GIS can relate otherwise unrelated information by using location as the key index variable.

This key characteristic of GIS has begun an alternative frontier on producing statistical information.

Any variable that can be located spatially using an x, y, and z coordinates representing, longitude, latitude, and elevation, respectively. These GIS coordinates may represent other quantified systems of territories (polygons), road networks (lines) and point of traffic (points).

Join attributes by location is the algorithm that takes an input vector layer and creates a new vector layer that is an extended version of the input one, with additional attributes in its attribute table.

The additional attributes and their values are taken from a second vector layer. A spatial criteria is applied to select the values from the second layer that are added to each feature from the first layer in the resulting one.

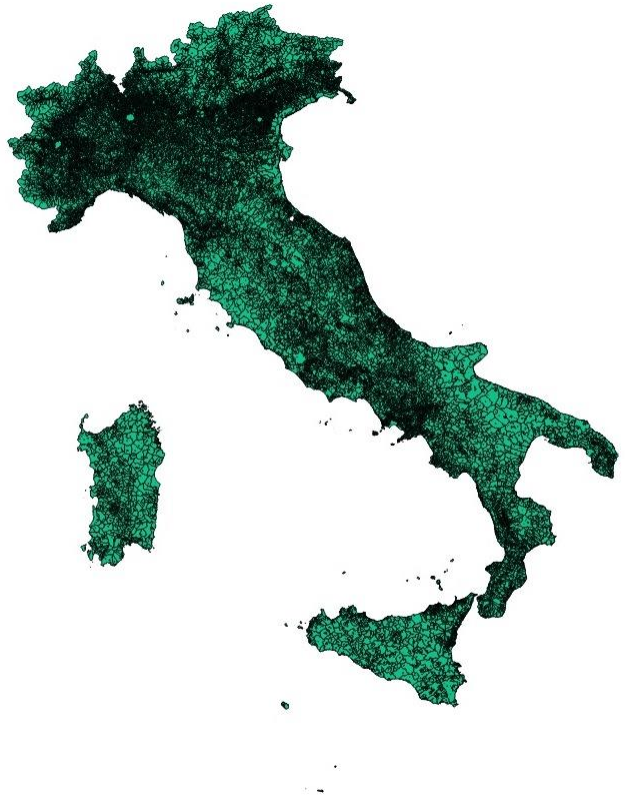
The Istat Census map sources of GIS data are for administrative territories by:

- Regions
- Provinces
- Municipalities (updated every year)
- Localities (only at census 2011)

Administrative Units	2011	2016
Regions	20	20
Province	110	110
Municipalities	8090	7998
Localities	51227	NA

The upgrade of localities of 2011 to municipalities 2016 has been possible building a link table that aggregated the territory of 8090 local administrative units at 2011 to the 7998 municipalities at 2016 Italian territory.

The choice of the localities shape is due to harmonize the road graph to the location road variable of the road accident survey.



(OSM) is a collaborative project aimed on creating free content maps of the world. The project aims at a collection world of geographical data, with the main purpose of creating maps and cartography.

The key feature of the geographic data present in OSM is having a free license, the Open Database License. It is therefore possible use them freely for any purpose with the only constraint of mentioning the source. Everyone can contribute by populating or correcting data.

The maps are created using the data recorded by portable GPS devices, aerial photographs and other free sources.

Today

Few years ago

The Open Street Map vector layers daily updated and free downloadable data are:

- Road graphs
- Point of traffic

Territories	Archs
North East	905.953
Nord West	999.451
Center	642.777
South	565.582
Islands	376.449
Italy	**3.490.212**

Additional shapes are:

- Buildings
- Land Use
- Natural
- Places
- POWF (Point of Worship)
- POIS (Point of interest)
- Railways
- Transport
- Water
- Waterways

Territories	POT
North East	60.128
Nord West	105.509
Center	29.109
South	16.904
Islands	16.593
Italy	**228.243**

Most of the Android and iOS GPS navigation software on portable devices are powered by OSM as WisePilot, Maps.me, NavFree, Scout etc.

The **following arch types are used for the motorized vehicles**:

motorway, trunk, primary, secondary, tertiary, unclassified, residential, living_street, motorway_link, trunk_link, primary_link, secondary_link, tertiary_link, service, unknown.

Pedestrian, track, track_grade, bridleway, cycle way, footway, path, steps are not object of the survey definition.

	Urban areas + Small inhabited areas		Productive areas + Wide spread houses	
	Motorway	**Urban Road**	**Mortorway**	**Rural Road**
5111 - motorway	X		X	
5112 - trunk	X		X	
5113 - primary		X		X
5114 - secondary		X		X
5115 - tertiary		X		X
5121 - unclassified		X		X
5122 - residential		X		X
5123 - living_street		X		X
5131 - motorway_link	X		X	
5132 - trunk_link	X		X	
5133 - primary_link		X		X
5134 - secondary_link		X		X
5135 - tertiary_link		X		X
5141 - service		X		X
5199 - unknown		X		X

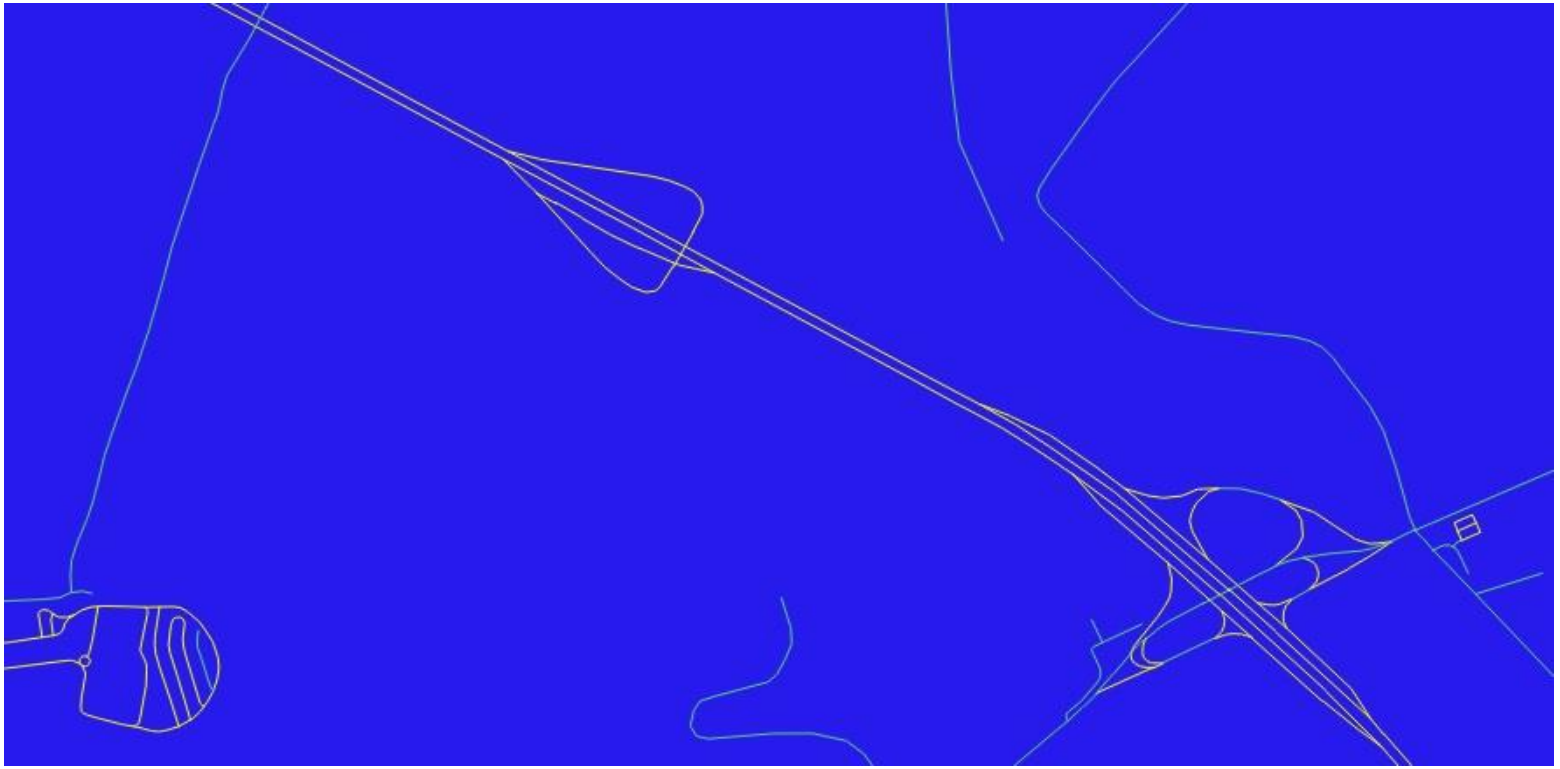
The classification of type locality has 4 values:

1. Urban areas
2. Small inhabited areas
3. Productive areas
4. Wide spread houses

An innovative method of measuring the length in meters of the road graph is given by the information on the number of carriageways of each road arch of OSM.

The following snapshot shows how the yellow arches are one way, while the green ones are two-ways.

In the future, in order to provide even more detailed information, the use of the number of lanes containing each carriageway is being evaluated.



The Istat **“road accidents survey”** in Italy collects all road accidents resulting in deaths (within the 30th day) or injuries, involving at least a vehicle circulating on the national road network (by road type) and documented by a Police authority.

The **denominators of indicators proposed** are calculated by the sources:

- **GIS computing** (Census Map + Open Street Map road graph at 1st January 2017) expressed by length in meters per carriageway;
- **ACI Vehicle fleet** (Automobile Club of Italy) all motorized vehicles excepted the trailers on 31st December 2016;
- **Resident population** (demo.istat.it) on 31st December 2016.

Province	Motorways	Urban Roads	Rural Roads	Vehicle fleet	Residents
001 - Torino	873556	15301844	12603986	1876378	2277857
002 - Vercelli	243776	2251290	2959959	152282	173868
003 - Novara	304807	4081506	2866519	306233	370143
004 - Cuneo	384649	9628313	14445118	541730	589108
005 - Asti	150811	3502354	4731805	195536	216677
006 - Alessandria	468421	6057635	8566751	374777	426658
007 - Aosta	256429	2395474	3039503	214669	126883
008 - Imperia	172538	2508094	2733964	204588	215130
009 - Savona	297265	3606841	3190305	264570	279408
010 - Genova	383194	5920446	4378129	681833	850071
011 - La Spezia	188628	2521119	2354129	180879	220698

Province/ 100KM	Accidents Motor ways	Accidents Urban Roads	Accidents Rural Roads	Vehicles Motor ways	Vehicles Urban Roads	Vehicles Rural Roads	Killed Motor ways	Killed Urban Roads	Killed Rural Roads	Injured Motor ways	Injured Urban Roads	Injured Rural Roads
015 - Milano	**102,80**	**87,77**	21,48	**129,10**	**111,83**	25,46	1,91	0,51	0,61	**159,82**	**115,75**	34,53
058 - Roma	93,75	66,00	13,05	115,34	86,08	16,19	1,82	**0,69**	0,50	147,86	85,93	20,42
010 - Genova	83,25	78,86	2,58	109,61	103,46	3,27	0,26	0,27	0,09	123,70	94,72	3,47
037 - Bologna	64,94	35,15	7,03	91,29	43,67	8,39	1,33	0,36	0,30	116,96	45,25	10,69
100 - Prato	62,69	73,45	5,48	70,78	95,41	6,36	0,00	0,41	0,11	93,02	93,45	8,44
048 - Firenze	62,46	62,75	10,67	82,56	79,75	12,80	0,48	0,46	0,20	102,90	76,48	15,21
108 - Monza e della Brianza	60,97	40,65	**43,89**	69,68	50,10	**54,35**	1,09	0,30	0,43	89,82	54,43	**64,80**
012 - Varese	50,97	25,66	13,91	69,64	32,21	17,07	0,36	0,36	0,10	95,49	33,97	20,59
063 - Napoli	45,38	44,84	12,71	60,43	60,86	16,33	1,77	**0,69**	0,30	70,92	62,85	21,18
102 - Vibo Valentia	16,83	5,08	2,43	24,41	7,17	3,65	**5,05**	0,04	0,15	21,88	7,98	4,37
049 - Livorno	3,07	46,92	11,14	5,22	58,67	13,90	0,00	0,33	**0,67**	5,22	59,66	16,48
097 - Lecco	0,00	23,01	16,63	0,00	30,14	20,87	0,00	0,35	0,41	0,00	30,39	24,82

The set of **road indicators** is developed by accidents, vehicles involved, killed and injured persons every 100 kilometers of carriageway in the province.

The cells highlighted in **bold red** show the maximum values of the distributions.

Looking at the provinces selected, the table shows a maximum risk exposure for motorways and urban infrastructure mainly in large centers.

Instead, in the rural roads, the medium-sized provinces are more affected by prevention measures.

Province/ 100K	Accidents Motor ways	Accidents Urban Roads	Accidents Rural Roads	Vehicles Motor ways	Vehicles Urban Roads	Vehicles Rural Roads	Killed Motor ways	Killed Urban Roads	Killed Rural Roads	Injured Motor ways	Injured Urban Roads	Injured Rural Roads
Savona	**67,28**	382,13	89,96	**95,25**	489,10	107,72	0,76	1,13	2,27	**109,99**	466,80	129,64
Genova	46,79	**684,77**	16,57	61,60	**898,31**	20,97	0,15	2,35	0,59	69,52	**822,49**	22,29
Ferrara	15,86	307,30	103,81	26,21	370,41	129,33	0,34	**7,59**	5,52	30,35	379,72	153,13
Grosseto	0,00	264,40	**161,39**	0,00	333,57	**212,40**	0,00	2,94	10,30	0,00	340,93	**256,55**
Nuoro	0,00	87,99	124,58	0,00	124,58	174,41	0,00	2,34	**14,79**	0,00	104,34	189,99
V. Valentia	15,06	89,59	48,18	21,83	126,48	72,27	**4,52**	0,75	3,01	19,57	140,78	86,58
Milano	37,16	538,02	36,64	46,66	685,56	43,42	0,69	3,11	1,04	57,76	709,58	58,89
Bologna	48,84	352,07	84,72	68,65	437,41	101,16	1,00	3,61	3,61	87,96	453,24	128,94
Brindisi	0,00	225,39	132,30	0,00	301,18	179,99	0,00	1,96	5,88	0,00	352,79	236,83
Prato	15,35	538,14	24,75	17,33	699,04	28,71	0,00	2,97	0,50	22,77	684,68	38,12
Piacenza	35,83	270,57	100,48	55,18	338,52	121,49	2,88	1,65	4,12	72,89	360,76	153,61

The set of **vehicles fleet** indicators is developed by accidents, vehicles involved, killed and injured persons every 100 thousand registered vehicles in the province.

The cells highlighted in **bold red** show the maximum values of the distributions.

In the motorway sector, the low incidence of vehicles registered in the province with the presence of important infrastructural nodes and seasonal factors amplifies the distortion of the distribution of the indicators.

Commuting is not highlighted in the construction of the vehicle fleet in urban areas.
in the rural area, this category of indicators does not show the presence of a dense network of consular roads on the territory.

Province/ 1M Residents	Accidents Motor ways	Accidents Urban Roads	Accidents Rural Roads	Vehicles Motor ways	Vehicles Urban Roads	Vehicles Rural Roads	Killed Motor ways	Killed Urban Roads	Killed Rural Roads	Injured Motor ways	Injured Urban Roads	Injured Rural Roads
Savona	**637,06**	3618,36	851,80	**901,91**	4631,22	1020,01	7,16	10,74	21,47	**1041,49**	4420,06	1227,60
Genova	375,26	**5492,48**	132,93	494,08	**7205,28**	168,22	1,18	18,82	4,71	557,60	**6597,10**	178,81
Ferrara	132,05	2557,68	864,04	218,16	3083,00	1076,47	2,87	**63,15**	45,93	252,61	3160,51	1274,54
Grosseto	0,00	2416,55	**1475,04**	0,00	3048,71	**1941,31**	0,00	26,90	94,15	0,00	3115,96	**2344,82**
Nuoro	0,00	723,91	1025,01	0,00	1025,01	1435,01	0,00	19,22	**121,72**	0,00	858,45	1563,14
Vibo Valentia	123,75	736,30	395,99	179,43	1039,48	593,99	**37,12**	6,19	24,75	160,87	1157,04	711,55
Bologna	388,42	2800,21	673,79	545,97	3478,96	804,59	7,93	28,74	28,74	699,56	3604,80	1025,55
Isernia	0,00	559,41	1177,09	0,00	780,84	1666,57	0,00	0,00	58,27	0,00	804,15	2109,43
Prato	121,76	4269,31	196,38	137,47	5545,78	227,80	0,00	23,57	3,93	180,67	5431,88	302,43
Olbia-Tempio	0,00	1736,46	1213,65	0,00	2253,04	1742,68	0,00	6,22	49,79	0,00	2452,20	2103,66
Piacenza	303,39	2291,13	850,89	467,29	2866,53	1028,74	24,41	13,95	34,87	617,25	3054,84	1300,75
Livorno	29,64	4248,02	883,40	50,40	5312,24	1102,76	0,00	29,64	53,36	50,40	5401,18	1307,31

The set of **population** indicators is developed by accidents, vehicles involved, killed and injured persons every million residents in the province.

The cells highlighted in bold red show the maximum values of the distributions.

The low provincial population in the presence of infrastructural nodes of the motorway network highlights the values of the indicators.

Port areas, transit areas and production settlements in their urban areas do not moderate the values of the indicators according to the present population.

In rural areas the low resident population greatly influences the correct computing of the indicators showing a distorted incidence of risk without valuating the real traffic flows.

There are two generalized tools available for the analysis and benchmarking of results produced by different composite indicators.

RankerTool is a desktop software at
http://www.istat.it/en/tools/methods-and-it-tools/analysis-tools/ranker

i.Ranker instead is a web application at
https://i.ranker.istat.it

Both (just with few differences) allow the user to:

- acquire in standard format values of the different indicators available for each unit (eg. geographical areas), compute for each unit one or more implemented methods;
- display the values and rankings of each method both in tables and graphics;
- compare the rankings of the different methods.

The steps on the computing process in divided in three phases:

- **Standardization of elementary indicators**. The standardization aims to make the indicators comparable as they are often expressed in different units of measurement and may have different polarities. Therefore, it is necessary to bring the indicators to the same standard, reversing the polarity, where necessary, and turning them into pure, dimensionless numbers.
- **Aggregation of standardized indicators**. It is the combination of all the components to form the synthetic index (mathematical function).
- **Validation of the synthetic index**. It consists in verifying that the synthetic index is consistent with the general theoretical framework. In particular, the ability of the index to produce stable and correct results (robustness) and its discriminating capacity must be assessed.

The three methods applied on this work are:

- MZ - Arithmetic Mean of the z-scores;
- MR - Relative index;
- MPI - Mazziotta-Pareto Index (MPI) (De Muro et al. 2010)

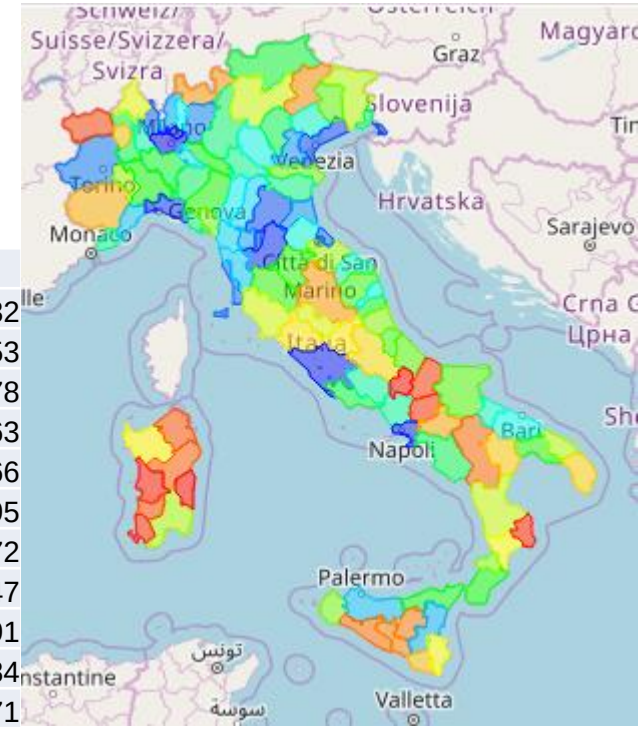
The methodological note and the user guide is available online at:
http://www.istat.it/en/files/2014/03/RANKER-manuale.pdf

https://i.ranker.istat.it/wr_guida.htm

https://i.ranker.istat.it/wr_guida_notametodologica.htm

On the set of **road** indicators, the application of the three methods shows a high correlation between the values of the three distributions, confirmed also by the respective indexes of cograduation.

MZ - Arithmetic Mean of the z-scores is the method that better fits the rankings with the MR and MPI-.



PROVINCE	MZ	MR	MPI-		MZ	MR	MPI-
Torino	14	11	13		0,6416	0,3375	106,0732
Vercelli	48	45,5	50		-0,017	0,2116	99,1453
Novara	36	40	35		0,1605	0,2289	101,4378
Cuneo	91	92	91		-0,6395	0,0902	93,5663
Asti	71	61	70		-0,2648	0,1702	96,9966
Alessandria	55,5	54	55		-0,1287	0,1884	98,5395
Aosta	103	103	102		-0,8391	0,0508	91,5172
Imperia	39	41	38		0,0967	0,2248	100,6247
Savona	22	19	22		0,4706	0,3014	104,0491
Genova	6	4	7		1,2715	0,4707	109,4584
La Spezia	42	38	41		0,0711	0,2355	100,3471

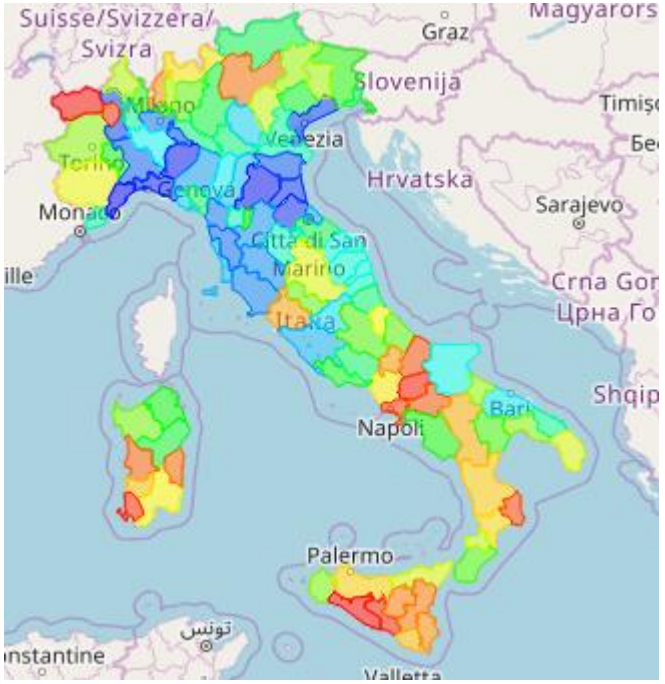
Ranks	MZ	MR	MPI-	Average
MZ	1,0000	0,9958	0,9980	**0,9979**
MR	0,9958	1,0000	0,9942	0,9967
MPI-	0,9980	0,9942	1,0000	0,9974

Values	MZ	MR	MPI-	Average
MZ	1,0000	0,9948	0,9960	**0,9969**
MR	0,9948	1,0000	0,9945	0,9964
MPI-	0,9960	0,9945	1,0000	0,9968

The set of **vehicles fleet** indicators using the same methods gives very different rankings of the synthetic indexes.

MZ - Arithmetic Mean of the z-scores is not the best method but anyway the difference with the relative index (MR) is acceptable.

PROVINCE	MZ	MR	MPI-		MZ	MR	MPI-
Torino	70	74	73		-0,1878	0,2623	97,3081
Vercelli	8	13	12		0,7045	0,4262	105,3578
Novara	40	41	38		0,1674	0,3327	101,4093
Cuneo	81	80	78		-0,3135	0,2508	96,5824
Asti	57	55	52		-0,0094	0,3001	99,5173
Alessandria	11	11	7		0,6703	0,4279	106,237
Aosta	109	109	109		-1,0611	0,1066	89,1809
Imperia	37	39	39		0,2196	0,3356	101,3224
Savona	1	1	1		1,2361	0,5369	109,5656
Genova	4	6	28		0,8225	0,4441	102,8264
La Spezia	23	26	30		0,4339	0,3781	102,5037

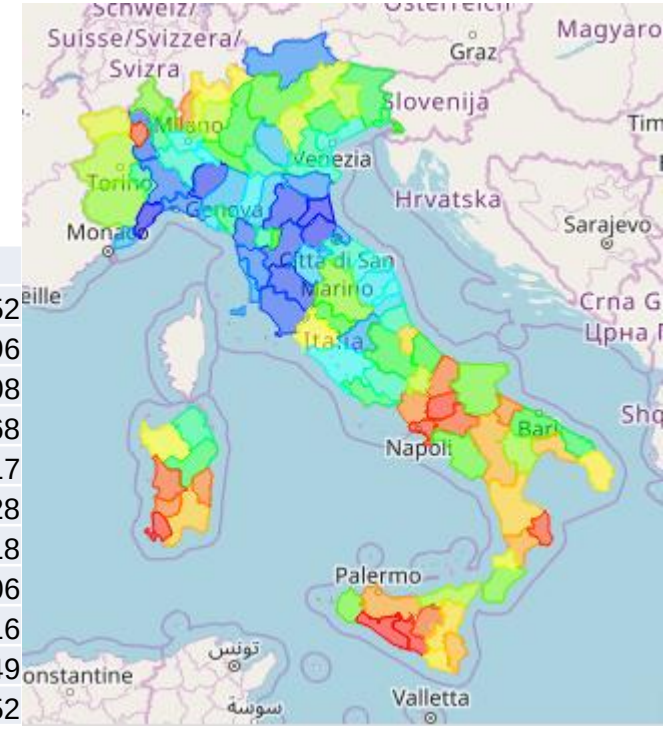


Ranks	MZ	MR	MPI-	Average
MZ	1,0000	0,9980	0,9862	0,9947
MR	0,9980	1,0000	0,9866	**0,9949**
MPI-	0,9862	0,9866	1,0000	0,9909

Values	MZ	MR	MPI-	Average
MZ	1,0000	0,9984	0,9857	0,9947
MR	0,9984	1,0000	0,9867	**0,9950**
MPI-	0,9857	0,9867	1,0000	0,9908

The set of **population** synthetic indexes are similar as ranking to those for vehicle fleet.

MZ - Arithmetic Mean of the z-scores is the method that better fits the rankings with the MR and MPI-.



PROVINCE	MZ	MR	MPI-		MZ	MR	MPI-
Torino	72	77	72		-0,2167	0,2505	97,0752
Vercelli	9	11	11		0,7949	0,4289	106,1896
Novara	42	44	39		0,1218	0,3157	100,9608
Cuneo	68	66	66		-0,1865	0,2656	97,7868
Asti	44	45	41		0,1165	0,3118	100,7817
Alessandria	11	12	8		0,7584	0,4287	107,128
Aosta	79	79	75		-0,2783	0,2464	96,718
Imperia	19	19	21		0,4857	0,3828	103,8206
Savona	1	1	1		1,5918	0,5768	112,7116
Genova	13	13	30		0,7105	0,4179	102,2049
La Spezia	25	30	33		0,376	0,3566	102,052

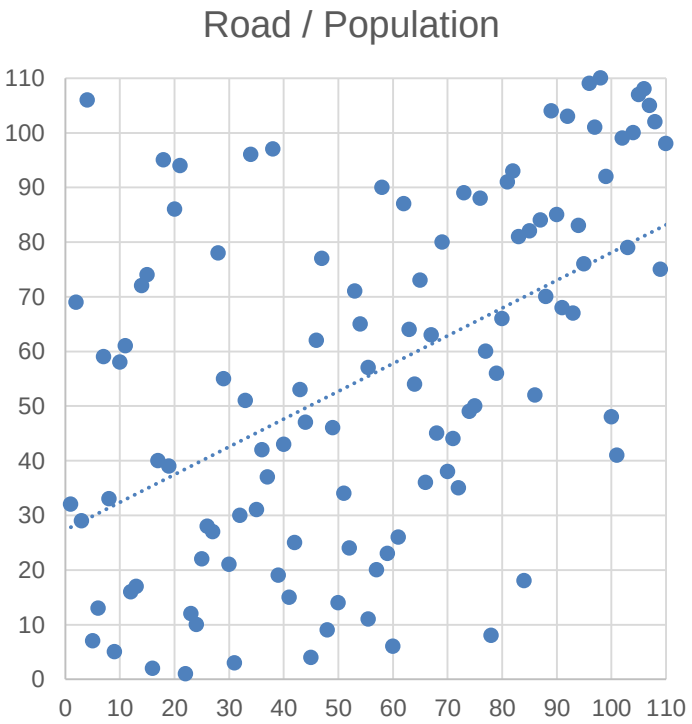
Ranks	MZ	MR	MPI-	Average
MZ	1,0000	0,9980	0,9866	**0,9949**
MR	0,9980	1,0000	0,9862	0,9947
MPI-	0,9866	0,9862	1,0000	0,9909

Values	MZ	MR	MPI-	Average
MZ	1,0000	0,9988	0,9988	**0,9992**
MR	0,9988	1,0000	0,9983	0,9990
MPI-	0,9988	0,9983	1,0000	0,9990

The application of different weighting criteria leads to very divergent results.
The analysis according to the road infrastructures allows to purify a component of mobility of the phenomenon.
The seasonal factor due to a more objective measurement also improves the concept of exposure to the risk of being involved in a traffic accident.

Rank	MZ Road	MZ Fleet	MZ Population
1	Milano	Savona	Savona
2	Monza e della Brianza	Bologna	Ravenna
3	Roma	Piacenza	Forli
4	Napoli	Genova	Piacenza
5	Firenze	Forli	Bologna
...	...	...	...
106	Carbonia - Iglesias	Carbonia - Iglesias	Napoli
107	Crotone	Caltanissetta	Benevento
108	Oristano	Benevento	Carbonia - Iglesias
109	Isernia	Aosta	Caltanissetta
110	Ogliastra	Agrigento	Agrigento

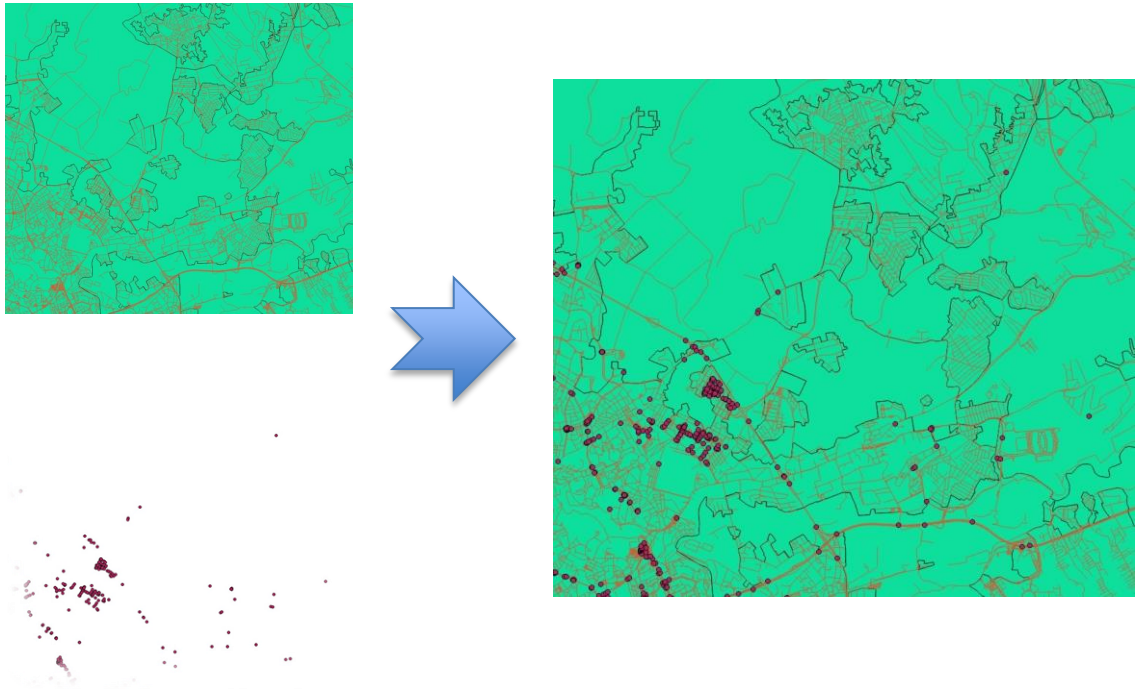
Cograduation	Road	Fleet	Population
Road	1,0000	0,6006	**0,5079**
Fleet	0,6006	1,0000	0,9432
Population	0,5079	0,9432	1,0000



This first result leads us towards the right direction to relate road accidents to traffic flows for a correct measurement of the phenomenon.

It was essential to start from the knowledge of the registry of the national road graph at localities level to reach soon the final indicator of “vehicles per kilometer” per road arch.

The next step of the process is to identify the road arcs involved in heavy traffic intensity (POTs) by implementing the construction of new synthetic indicators.



Using other Big Data sources are already in a experimental phase:

- the determination of the total kilometers traveled by vehicles on the national road arch with webscraping tools as an alternative to administrative sources;

- the measurement of traffic flows from video sensors and images with computer vision tools;

- the storage of traffic intensities from online monitoring systems with webscraping tools.

Geographical localization of road accidents on WGS84 system and use of Open Street Map for road safety performance indicators on the Italian road network

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