LEARNING FROM SIADE

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1. Objectives of the project

The topic addressed by the Project SIADE SaaS - Spatial Decision Support System for Transportation Planning - is “Small business innovation research for Transport and Smart Cities’ Mobility”.

SIADE SaaS, led by Terrain Technologies SL, Gijon, Spain, is a spatial decision support system for bus transportation planning and other transportation systems where user destination is unknown. It delivers O/D matrices using GIS and AFC data. SIADE SaaS can support the planning activities of mobility agencies and Public Authorities, enabling economic and sustainable operations and providing a service more adapted to the actual demand.

Before the COVID 19 pandemic, the demand for passenger transport was estimated to grow 51% by 2050, triggering a market growth to €100.6 billion. Smart Mobility enabled by Smart Public transport is key for cities’ economy and development. Worldwide transport operators are implementing AFC (Automated Fare Collection), generating Big Data, but lacking passenger destination information. However, turning these data into knowledge is challenged by the difficulty of accurately describing transport network states and the computational burden coming from processing Big Spatial Data.

Using raw data obtained from AFC systems, SIADE generates an Origin-Destination (O/D) Matrix, segmented by more dimensions (e.g. route, day, time, fare group, occupancy, etc.). This information is combined with geospatial data including Automatic Vehicle Location (AVL) data in order to provide information and knowledge about the network and people’s mobility patterns.

With the support of EMTUSA, the public transport operator in Gijón (Spain), SIADE has developed a product that can allow the company to understand the citizens’ mobility patterns, assisting EMTUSA’s decisions affecting changes in terminuses, routes, bus stops, etc.

The system, in particular, allows us to obtain the following main objectives:

- Mobility patterns. GIS (Geographic Information System) representation of user mobility patterns, inferred by the SIADE SaaS algorithms, guarantee attainment of the destination without investment in devices or surveys;
- Bus bunching. Analysis of the groupings of buses on the same line and the events with other lines with which they share sections of their routes are made possible;
- Occupancy ratio. Percentage of average occupation of a vehicle for a certain line, route and time zone is highlighted;
- Speed and time. The system aims at calculating the average speed and the elapsed time of a bus for each line and section, taking into account weather factors, traffic, etc.;
- Spatial analysis. Calculation of distance between two points, total route of the line, slope of each section of the route of a line, as well as detailed spatial analysis, is made by the system.

In the test phases, Italian data was provided by aMo and SETA SpA (Società Emiliana Trasporti Autofiloviari), the local public transport service operator in the provinces of Modena, Reggio Emilia and Piacenza. Analysis and experimentations were carried out with the support of T Bridge.

2. Pilot/project preparations

2.1. Stakeholder involvement

In SIADE the participation by project stakeholders was intended as a sharing of common understanding in the decision-making process of the project and in order to increase the participation, the project started with a consultation process to define the main goals.

Participation by project stakeholders was principally intended to ensure that it is a reflection of the real needs and priorities.

For this reason, the audience of stakeholders was mainly made up of four types:

1. Stakeholders with experience in the macro management of public transport companies (people within the company with managerial roles and external consultants with skills dealing with the problems that concern this type of company), especially aware of the economic and organizational repercussions that can be caused by problems in the performance of services;
2. Stakeholders directly involved in the management of public transport services who have direct experience of the repercussions that problems in performing the service may have on regularity and for users and drivers;
3. Stakeholders belonging to the category of regulators and involved in the planning of services which have a great interest both in the quality of the services provided and in the problems that concern the services in order to derive indications to improve their planning;
4. National and local public bodies interested in mobility as subjects who provide the guidelines for carrying out transport services and finance them.

The involvement of such a vast and varied audience of stakeholders was aimed at the production of a new instrument that took into account not only the contingent problems concerning the management of local public transport but which had a broader vision, based on points of view also linked to the vision behind the design and execution of a public transport service.

With their involvement, these stakeholders provided indications that were then implemented by the project and some of them, in terms of categories, were also involved in the implementation of the system and in its functional analysis.

The involvement of the various stakeholders therefore made it possible to concretize a starting idea that originated the Project, focusing it according to the real needs of the various subjects involved in the planning, production and financing of public transport services.

In particular, the stakeholders involved were:

- T Bridge which is an ICT consultancy firm specializing in the field of public transport;
- aMo which is the agency for mobility and public transport in Modena, Italy;
- SETA which is the operator of local public transport services in the provinces of Modena, Reggio Emilia and Piacenza, Italy;
- Metropolitan Research Institute (MRI), that is an internationally recognized independent research, planning and consultancy company based in Budapest, Hungary;
- Oradea Local Transport, Operator of public transport services in the city of Oradea, Romania
- Ministry of Transport and Road Safety of Israel that is responsible for planning, development and regulation of infrastructure and integrated transport systems;

- Barkodes which is a Turkish company specializing in RFID systems and electronic payment and ticketing systems;
- IETT which is the manager of the public transport services of the city of Istanbul, Turkey;
- BLIC that is an independent company with a team of engineers, communication and IT experts involved in traffic and mobility planning based in Berlin, Germany;
- Ruhrbahn GmbH that is a joint transport company between the cities of Essen and Mülheim an der Ruhr, Germany;
- Gijon bus that is the public transport company of Gijon, Spain;
- EMT Madrid that is the public transport company of Madrid, Spain;
- Ulster University, University of Northern Ireland with four distinct campuses in Belfast, Coleraine, Jordanstown and Magee;
- Edinburgh Napier University is a public university in Edinburgh, Scotland;
- Universidad de Oviedo, the public university of the city of Oviedo, Spain.

The identification of these Stakeholders was made starting from the four categories described above and by identifying subjects belonging to them.

Concretely the choice was then made starting from companies that had previously collaborated with Terrain Technologies which in turn extended the invitation to other companies with which they had partnerships in particular inside other European projects.

2.2. Methods and technologies

The system was implemented using multiple types of technologies; some of the endogenous type used for the realization of the software, others of the exogenous type and used for its feeding.

- Endogenous technologies refer to these areas:

A cartographic management of all databases that was implemented using the technology and APIs (Application Program Interfaces) made available by ESRI, a world leader in the production of cartographic software.

The platform ArcGIS Enterprise was principally used; this platform gives the tools to make maps, analyse data, and share geospatial data showing them with a web browser as UI (User Interface). It was used in a “behind the firewall” configuration that means that the servers for the delivery of SIADE services are hosted by Terrain Technologies.

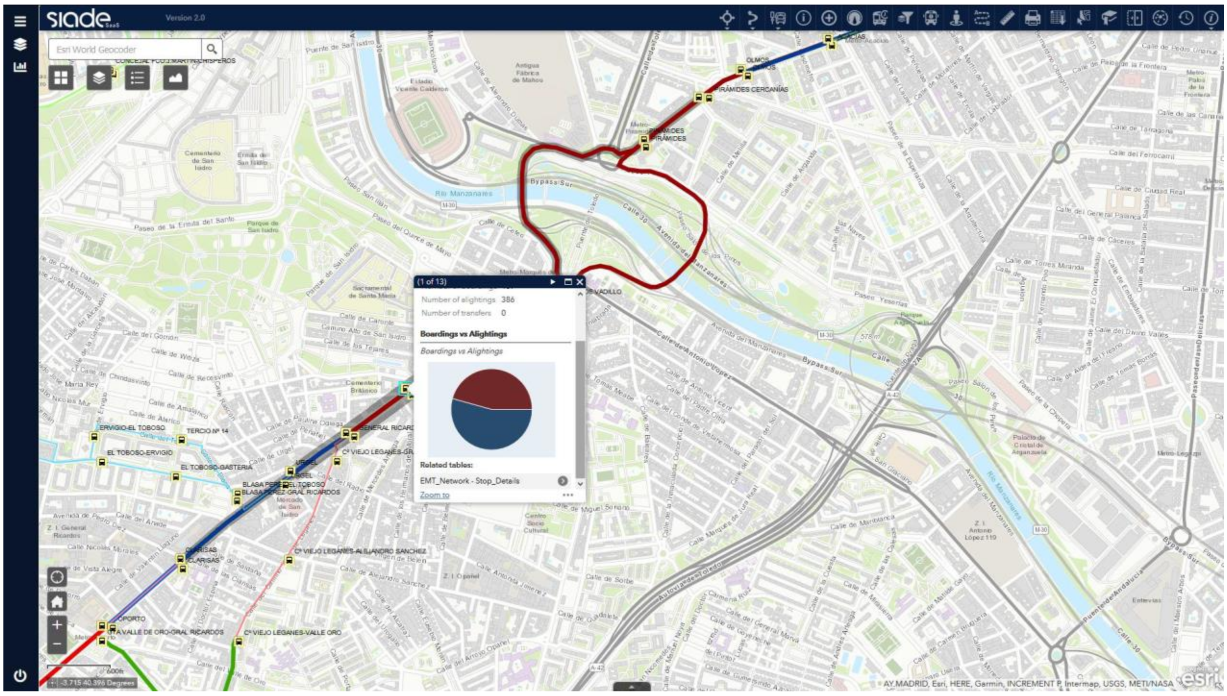

Figure 1 - The platform ArcGIS Enterprise (example)

With this platform it is possible to connect existing data stores and take advantage of ESRI's extensive collection of curated geospatial data for enhanced perspective displaying them for maximum impact and usability.

Moreover, this platform performs analysis with a web browser using its own algorithms in parallel with ArcGIS Enterprise tools covering a heterogeneous field of data and making it easier to perform analysis on big data.

- Exogenous technologies refer to these areas:

Electronic ticketing systems that are able to supply numerous detailed data about the usage of the public transport services;

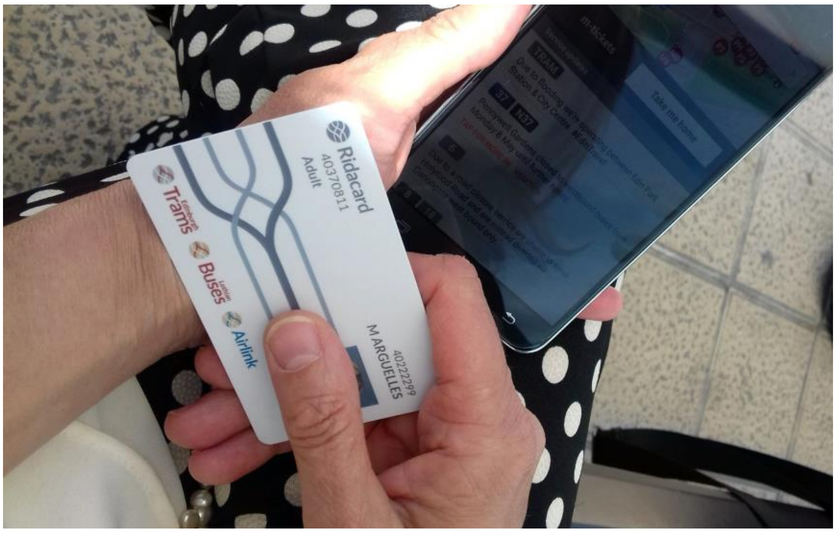

Figure 2 - Electronic ticketing systems (example)

AVM (Automatic Vehicle Monitoring) systems which are able to provide data on how the vehicles move during the execution of public transport services, highlighting any irregularities in the services allowing the construction of very accurate travel times according to the traffic on the roads.

The methods implemented were principally focused on the production of the following issues:

- construction of O/D (Origin Destination) matrices which represent a database of primary importance for any type of performance analysis in local public transport and which is traditionally difficult to build without the commitment of temporary and economic resources; inside SIADE, sophisticated algorithms have been built that can build O/D matrices starting from the data provided by electronic ticketing systems, thus drastically reducing the time and investments necessary to produce them;

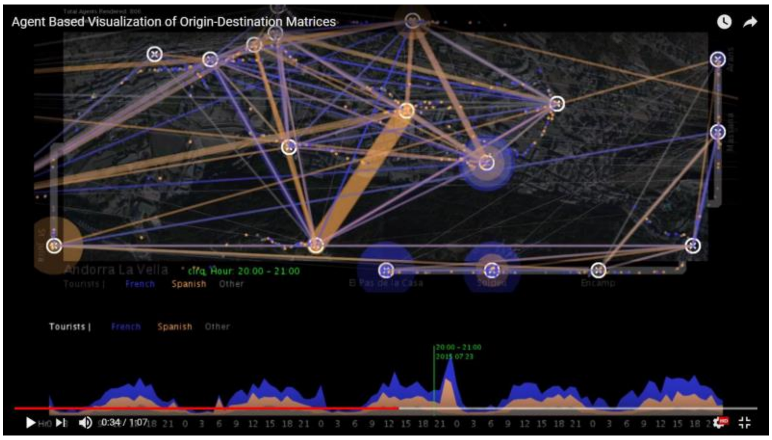

Figure 3 - Agent based visualization of Origin-Destination Matrices (example)

- analysis of the so called bus bunching which is a problem that often affects public transport services especially in heavily trafficked areas and which results in the close circulation of vehicles on the same line that are unable to maintain the distance foreseen by the timetables. This methodology provides a very important indication of the quality of the service provided and a problem that is not always easy to identify or correct;

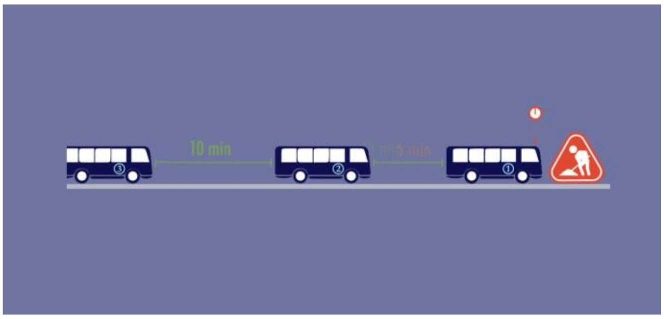

Figure 4 - Avoiding bus bunching

- calculation of average occupation of a vehicle for a certain line, route and time zone;
- calculation of the average speed and the elapsed time of a bus for each line and section, taking into account weather factors, traffic;
- calculation of distance between two points, total route of the line, slope of each section of the route of a line, as well as detailed spatial analysis;
- AI (Artificial Intelligence) methodologies used principally to perform “What if” analyses used to predict the effects of changes in the structure of a public transport service.

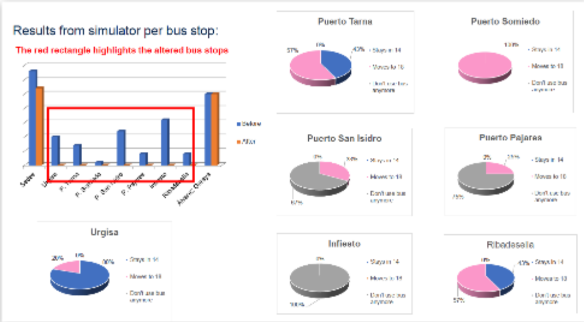

Figure 5 - Visualization of results (example)

2.3. Risks and obstacles

It is natural that the development of innovative and also highly articulated systems foresees many risks and obstacles. These can mainly be identified in the following points.

About the risks:

- the main risk was probably to create an instrument not completely responding to the needs of end users. This risk is often underestimated because the perception of the problems related to a sector (in this case local public transport) can be very different among those who do not belong to this sector such as the software producer who before the SIADE project operated in other types of market. The phase of strong involvement of the stakeholders was therefore crucial to minimize this risk;
- another risk that was identified in the planning phase was to create a tool too complicated in its management and in the evaluation of the final results. In fact, it was considered that, for example, transport companies have very different dimensions and only the largest and most structured ones have study offices capable of dedicating themselves in depth to the use of complex technological systems. For this reason, an attempt was made to make the software usable on a broader basis of subjects by providing results capable of identifying contingent and important problems for operators but also for local authorities which are often even less structured entities. This aspect was identified as crucial especially in a marketing perspective that does not address only a few subjects;
- the previous risk entails another: creating a complicated tool to use would have created a difficulty in finding collaboration in the test and evaluation phase. In fact, it is difficult for a company to allocate resources to the collaborative implementation of a system that is too difficult to develop or understand.

As for the obstacles, which are obviously not independent from the risks, these can be identified as follows:

- the main obstacle was perhaps to define the specifications for the implementation of the new system parameterized as much as possible in order to make it accessible to most end users, both as regards the analysis provided but also as regards the import of the data necessary for its operation. So, getting in touch with different realities in the planning phase was therefore fundamental in order to build software that was suitable for many;
- another obstacle, when testing and using the system, was that related to the fact that it was realized that the data provided often cannot be used “as they are” but must be filtered to identify inconsistencies that could compromise the quality of the analysis produced. For this reason, it was necessary to implement software routines capable of identifying these critical issues in order to be able to either discard or remedy them.

3. Pilot/project implementation

The pilot project coincided with the entire project since the funding was completely aimed at the production of the new software.

The project was therefore born from the idea of providing, especially to transport companies and planners, a new tool that was able to use the information that exists in the world of public transport, with a specific reference to big data and functionalities that has not yet been implemented or implemented with considerable efforts by the companies described above.

It was decisive the innovative choice to try to correlate databases existing in many transport companies that are not fully exploited, in order to “distil” as much information as possible.

The transition from data to information is often not easy especially in a sector such as public transport which has received more slowly than others the evolution of technologies, especially related to Information Technology; then it is very important to have tools that allow to analyse a huge amount of data which are sometime available in an "unaware" way.

SIADE was therefore born in the logic of offering an all-inclusive tool with respect to different problems that often afflict the execution of public transport services, problems that are inevitably connected to their planning and to the continuous and rapid change that occurs in the situations surrounding the field where these services are performed.

The project was therefore preceded by a careful analysis of what were the shortcomings and needs of the operators and planners in order to prepare a tool that was not only a test to evaluate the application of innovative technologies but that could lead to the realization of a complete package ready to be used intensively and completely, providing reliable answers to the various problems analysed.

In particular with respect to the databases and the so-called big data on which the SIADE project was based, those were principally linked to electronic ticketing systems (AFC) and satellite control of bus fleets (AVM).

Date and time of validation	Bus #	Line #	Zone #	Zone name	Ticket type	Ticket description	Serial #	Validation type
28/10/2017 16.06.00	261	4002	96	MODENA	4302	Monthly season card	30429153	3
28/10/2017 16.06.00	262	4731	419	CASTELVETRO	4103	One way ticket	26543328	1
28/10/2017 16.06.00	262	4731	419	CASTELVETRO	5301	Monthly season card	30413334	1
28/10/2017 16.06.00	262	4731	419	CASTELVETRO	5301	Monthly season card	30430251	1
28/10/2017 16.06.00	262	4731	419	CASTELVETRO	5331	Yearly season card under 27	30416880	1
28/10/2017 16.06.00	262	4731	419	CASTELVETRO	5331	Yearly season card under 27	30430005	1
28/10/2017 16.06.00	314	4800	104	SERRAMAZZONI	5331	Yearly season card under 27	30380099	1
28/10/2017 16.07.00	5	4006	96	MODENA	3821	Elder yearly season card	30361393	1
28/10/2017 16.07.00	5	4006	96	MODENA	5300	Monthly season card	30406697	1
28/10/2017 16.07.00	5	4006	96	MODENA	5320	Yearly season card under 27	30377189	3
28/10/2017 16.07.00	5	4006	96	MODENA	5330	Yearly season card under 27	30373359	3
28/10/2017 16.07.00	5	4006	96	MODENA	5330	Yearly season card under 27	30437699	3
28/10/2017 16.07.00	80	4010	96	MODENA	5300	Monthly season card	30373597	1
28/10/2017 16.07.00	80	4010	96	MODENA	5300	Monthly season card	30422109	1
28/10/2017 16.07.00	80	4010	96	MODENA	5324	Bus train integration	30411221	1
28/10/2017 16.07.00	85	4001	96	MODENA	5301	Monthly season card	30327920	3
28/10/2017 16.07.00	91	4008	96	MODENA	5250	Multi trip one way	30433737	1
28/10/2017 16.07.00	120	4009	96	MODENA	4226	Multi trip one way Urban service	30419921	1
28/10/2017 16.07.00	130	4013	96	MODENA	3820	Elder yearly season card	30405778	1

Figure 6 - Sample of AFC data

Line #	Route #	Trip #	Bus #	Stop #	Stop description	X	Y	Sequence	Measured time	Planned time	Delay in seconds
7	702	21	25	6909	GRAMSCI	653865	4947190	1	01/10/2018 06:02:40	01/10/2018 06:03:00	-20
7	702	21	25	3125	Gramsci bv Toniolo	653680	4946930	2	01/10/2018 06:05:19	01/10/2018 06:03:59	20
7	702	21	25	3123	Gramsci edicola	653559	4946745	3	01/10/2018 06:06:25	01/10/2018 06:04:40	45
7	702	21	25	3122	Gramsci farmacia	653440	4946568	4	01/10/2018 06:06:46	01/10/2018 06:05:19	27
7	702	21	25	6132	STAZIONE FS	653045	4946356	5	01/10/2018 06:09:39	01/10/2018 06:08:00	39
7	702	21	25	2575	Monte Kosica bv Ganaceto	652852	4946228	6	01/10/2018 06:11:52	01/10/2018 06:09:11	41
7	702	21	25	2579	Monte Kosica stadio	652384	4946123	7	01/10/2018 06:12:50	01/10/2018 06:10:48	2
7	702	21	25	2578	Monte Kosica Barozzi	652282	4946094	8	01/10/2018 06:13:01	01/10/2018 06:11:08	53
7	702	21	25	6121	MODENA AUTOSTAZIONE	652215	4945895	9	01/10/2018 06:13:40	01/10/2018 06:12:00	40
7	702	21	25	2571	Sant'Agostino museo	652410	4945672	10	01/10/2018 06:16:21	01/10/2018 06:13:22	59
7	702	21	25	2570	Piazza Matteotti	652637	4945561	11	01/10/2018 06:16:54	01/10/2018 06:14:24	30
7	702	21	25	2566	Piazza Mazzini	652774	4945475	12	01/10/2018 06:17:24	01/10/2018 06:15:05	19
7	702	21	25	2567	Emilia centro Posta	652892	4945389	13	01/10/2018 06:17:46	01/10/2018 06:15:41	5
7	702	21	25	30	GARIBALDI	653170	4945234	14	01/10/2018 06:18:51	01/10/2018 06:17:00	51
7	702	21	25	6301	Emilia Est Aci	653455	4945078	15	01/10/2018 06:21:32	01/10/2018 06:18:21	11
7	702	21	25	6303	Emilia Est bv S.Giovanni Bosc	653661	4944961	16	01/10/2018 06:22:27	01/10/2018 06:19:20	7
7	702	21	25	6305	Emilia Est Finanza	653857	4944832	17	01/10/2018 06:23:06	01/10/2018 06:20:19	47
7	702	21	25	1214	Emilia Est Hotel Fini	654073	4944708	18	01/10/2018 06:23:39	01/10/2018 06:21:21	18
7	702	21	25	6313	Del Pozzo	654009	4944584	19	01/10/2018 06:24:18	01/10/2018 06:22:09	9
7	702	21	25	259	Policlinico	654030	4944438	20	01/10/2018 06:24:47	01/10/2018 06:23:00	47
7	702	21	25	241	Poliambulatorio	653855	4944249	21	01/10/2018 06:26:21	01/10/2018 06:23:50	31
7	702	21	25	223	Campi Università	654149	4943987	22	01/10/2018 06:27:47	01/10/2018 06:25:40	7
7	702	21	25	208	Braghiroli	654357	4944092	23	01/10/2018 06:29:00	01/10/2018 06:26:34	26
7	702	21	25	234	Gottardi bv Araldi	654566	4943944	24	01/10/2018 06:29:37	01/10/2018 06:27:19	18
7	702	21	25	149	GOTTARDI	654692	4943772	25	01/10/2018 06:30:02	01/10/2018 06:28:00	2

Figure 7 - Sample of AVM data

This aspect has already represented a significant challenge because for example there are no standard record layouts for the supply and import of these types of data.

There are often conceptual differences in these data which can be constructed with very different design logics.

In fact, do not even exist standards for data formats as regards the characterizing elements of a local public transport service such as the concept of line, travel, stop coding, interchange nodes, geographic reference systems, etc.

And often it occurs that the data provided cannot be used as they are without highlighting discrepancies or inconsistencies typical in the large amounts of data that are also affected by the complication of the systems that are used to create and make them available; in fact in most cases it is data collected on computers on board of buses, using other infrastructures such as that of the GPS network or smart card in the possession of travellers or data transmission infrastructures such as those of telephone operators.

Any problem in each of these elements can create "noises" in the data that a software that wants to use them must be able to identify in order to make the information produced reliable.

For this reason, a lot of work was done in the SIADE project on these aspects and their implementation represented a really important challenge.

And to face it, it was essential to have the support of various subjects, many of whom were part of the group of Stakeholders who were able to provide databases that allowed to analyse in depth the problems described above in order to then be able to solve them.

The subjects most concerned were, as mentioned before, planners and service operators as they were able to have multiple roles: Stakeholders as interested in the conceptual definition of the project, as data suppliers to be able to represent as completely as possible the possible cases and finally as users of the finished product.

The last two roles were covered also by aMo which collaborated intensively in the supply of data from the AVM and AFC systems in its possession, providing its experience deriving from the knowledge of these types of data in terms of usability but also of possible correlations between the two large databases.

aMo was also involved in analysing the result of the processing in order to provide both a benchmarking on the quality of the information obtainable from the system and for the consequent search for critical issues in the designed services.

The project timeline has developed over two years from September 2017 to August 2019 with this scan:

- from 09/17 to 12/17: involvement of the Stakeholders for the sharing of the starting idea of the SIADE project and a refinement of the possible outputs of the system according to the real needs of those operating in the public transport sector with a view to bearing sustainable mobility;
- from 01/18 to 05/18: definition of the detailed specifications (operational and technological) of the new system and their sharing with the Stakeholders in order to refine them and make them as close as possible to their expectations;
- from 06/18 to 02/19: implementation and operational development of the new system concluded by making the first test versions available;
- from 03/19 to 05/19: system test with the first data imports and analysis production on known situations in order to evaluate the responses of the system with respect to known contexts in order to fine-tune it as much as possible by bringing the results to the operating reality;
- from 06/19 to 08/19: massive use of the system in order to test it in a context of so-called "production" and making the final changes capable of making it a usable and marketable tool to a potentially broader base of potentially users.

In chapter 4 about results, it is possible to see some of the outputs that have been developed in collaboration with aMo which, once the project was concluded, was able to use the complete system for a few months, supplying various series of data (school periods, vacancy periods, different seasons, etc.) in order to make the analysis of the problems as close as possible to reality.

As already mentioned, T Bridge and aMo have been involved in many of these phases and in particular T Bridge has participated in the identification of possible marketing and commercial channels as regards mainly Italy; Terrain Technologies itself has instead tried to identify marketing channels for Spain and Israel.

The result was the activation of marketing channels aimed above all at the audience of local public transport operators and the planning Authorities who were identified as the main potential users of the developed tool.

4. Results

SIADE allowed the users to obtain the trips in a specific period of time (1 month for example, as in the case of Modena pilot) of the bus subscribers thanks to the punching of the electronic ticket at the bus check-in.

Concerning the Italian pilot of the project, after the login the following map appears showing in this case Modena with the related database regarding the public transport network and its zones.

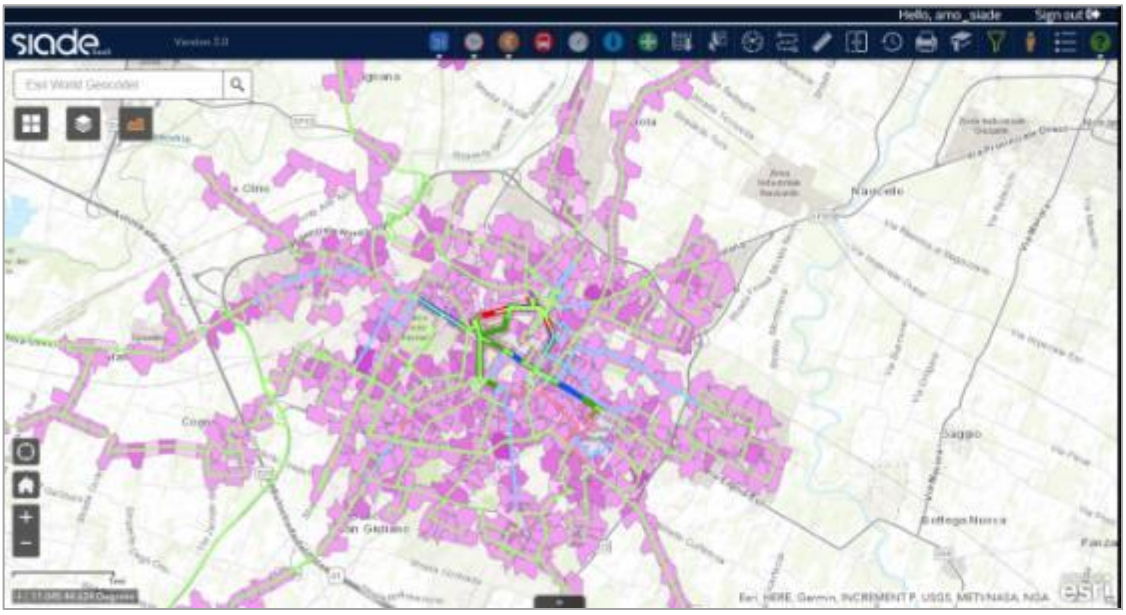

Figure 8 - Map view after login (Modena urban and suburban area)

The main output is the matrix of the boarding/alighting passengers who have a card seasonal ticket. Regarding the Modena pilot, this matrix includes about 300,000 records (150,000 trips) in one month in the entire bus and trolleybus system in Modena and in two important extra-urban lines (Modena-Sassuolo and Modena-Carpi). In this light, each trip is composed of at least two records: the first for the boarding and the second for the alighting stop. The final matrix can be showed in its entirety or by filters.

Thanks to the univocal key “ID_CARD”, it is possible to identify:

- possible bus-bus interchanges;
- return trip, by:
    - origin of the outward trip, if the same bus users made another trip in the same day;
    - history of the data set of the trip of the bus users.

Based on the evaluation of the outcome of SIADE trials and implementations carried out by mid-2019, the direct interviews of the aMo internal contacts on the project and the analysis of the data and information made available by Terrain Technologies, SIADE has been evaluated from the following perspectives, starting from:

- completeness: data evaluation capabilities implemented;
- correctness: plausibility of generated results;
- usability: handling of SIADE tool and user interface, effort necessary for the end-user to reach an adequate self-reliance level;
- reports: reports for different levels of information and different applications:
    - daily operation;
    - commercial usage;
    - management information, taking into account all kinds of information (maps, statistics, graphs, etc.);
- personal effort: the end-user’s effort for data preparation and running of SIADE.

In relation to each perspective mentioned above, the following evaluations have been highlighted on SIADE:

- Completeness: thanks to the integration of functionalities related to different software, such as graphical representation and analysis tools (GIS), filtering options (Excel), monitoring tools related to service performances of PT lines and especially simulation of OD matrix of passengers, SIADE can be identified as a complete multi-dimensional software.
- Correctness: the correctness of SIADE results could be highlighted, for example, in the Demo version of SIADE for Italian market. In this light, illustrating the comparison between the OD matrix derived from SIADE and a similar planning tool, which requires more effort but already on the market, would be efficient.
- Usability: the representation of the results related to queries are illustrated in different ways being tables, charts and plots which makes SIADE more interactive and time-saving for decision making. SIADE appears to be user-friendly and practical according to the simple language and the number of examples assumed in the user guide. On the other hand, although the interface has been improved recently, categorizing the functions, the tool that generates O/D matrix could be more highlighted or visible and even completed by new fields.
- Reports: SIADE allows the users to carry out several reports for different levels of information and different applications. The diversified analysis tools and visualization results in an immediate manner facilitate the evaluation procedures in order to individuate critical situations and to outline new interventions.
- Personal effort: Regarding data preparation, what kind of data would need to be imported can be interpreted from the pilot project. However, including in the user guide the list of data needed to be prepared for different analysis and also the standards to be respected to import the data would be efficient.

Overall, SIADE appears to be a useful instrument both for mobility planners and for transport operators as it satisfies their needs with diversified tools.

As a user-friendly software, it needs much less time to be learned in comparison to other leading software on the Italian market that tend to be specialized in specific functionalities. On the other hand, there are some aspects (“weaknesses”, which are pointed out in the next chapter) that could be improved to promote the added value of SIADE.

Concerning the main functionalities, a resume of the results reached is reported.

4.1.1. Boarding passengers/load factor

The system is planned to show the Load Factor (considered as number of boardings) of each route on the basis of journey (corresponding to “corsa” in Italian).

It is possible to visualize the boarding passengers of the routes in a specific day of a typical month, in working days of the week, in weekends or even in a specific slot of time. This toolbar makes it possible to choose a specific part of a route or the whole route.

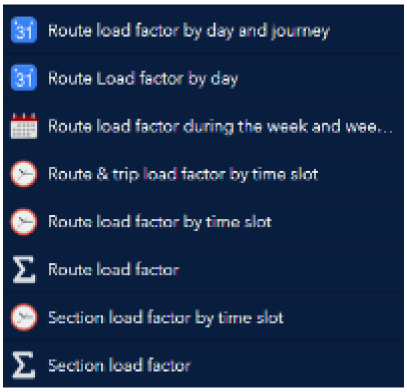

Figure 9 - Route selector

The Load Factor is shown by histograms in which each column is related to a specific route that can be shown on the map, moving on the relative column in the diagramm (see the red line in the map below).

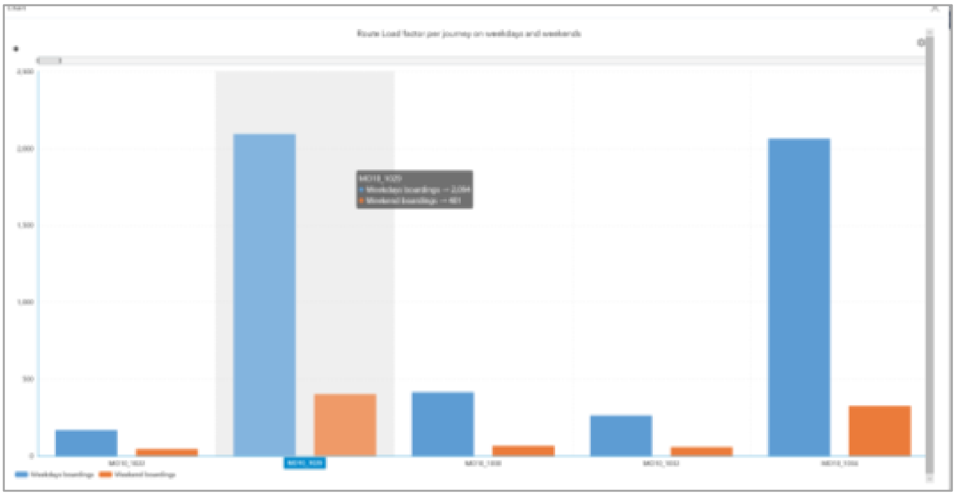

Figure 10 - Load factor in histograms

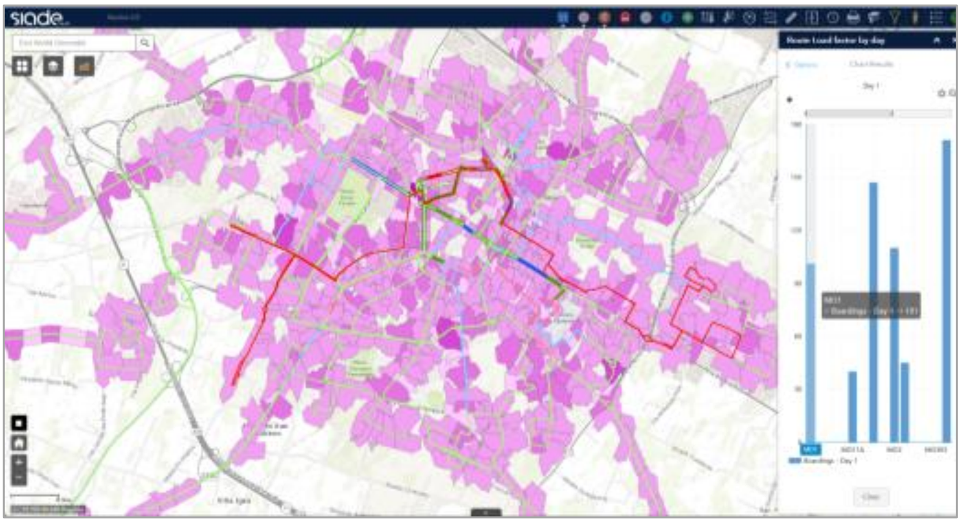

Figure 11 - Specific route shown on map

The number of boarding passengers (here named “Load Factor”) related to route or to each journey can be visualized also for each hour from 1am to 12pm, either as a weekend day or as weekday. This seems to be calculated on the basis of medium number of boardings at a specific hour in weekend or in weekdays.

During the training session and workshop in Gijon (2018) with Terrain Technologies, aMo and T Bridge agreed on adding the option to show the Load Factor by hour differentiated for each day of the week which was not developed.

4.1.2. Statistics of boarding and alighting passengers

The statistics related to the number of boarding and alighting passengers in each stop either for routes or for the journeys are reported in:

- each hour of the day divided by weekday and weekend day;
- a typical weekday or weekend;
- a day of a month.

Figure 12 - Statics selector

4.1.3. Statistics of tickets punched

The option shows the statistics related to the number of tickets punched in relation to the routes, journeys, sections and stops distinguishing the different types of tickets. The number of tickets is related to the input databases made available.

Figure 13 - Route selector

If a specific type of ticket is chosen, e.g. “Students fare”, for two specific routes, the result is shown as a pie chart. Otherwise, if you choose “Pass distribution”, the chart is represented in columns, showing all different tickets punched for that specific route.

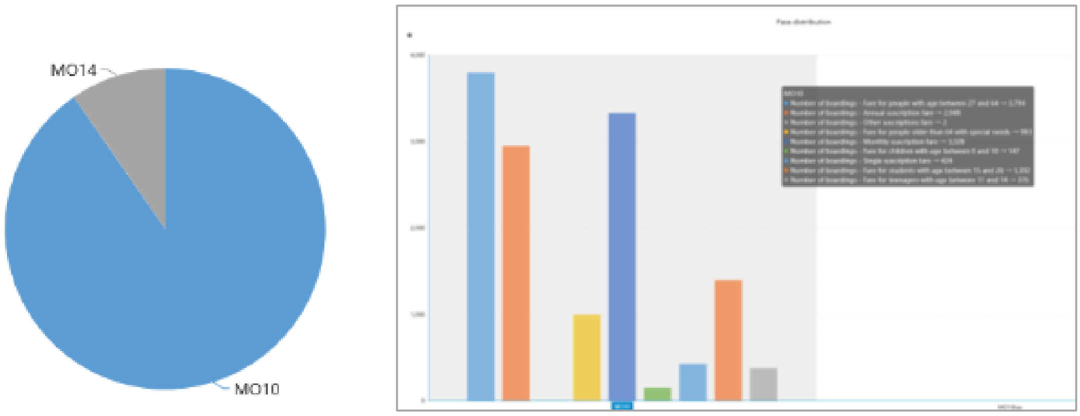

Figure 14 - Visualization of statistics

4.1.4. Bus bunching

The Bus Bunching refers to a situation when at least one of the vehicles running along the same route is unable to keep to its schedule and therefore ends up in the same location as one or more other vehicles. The toolbar here dedicated to this function enables to show the position and the number of bus bunching occurring in each section.

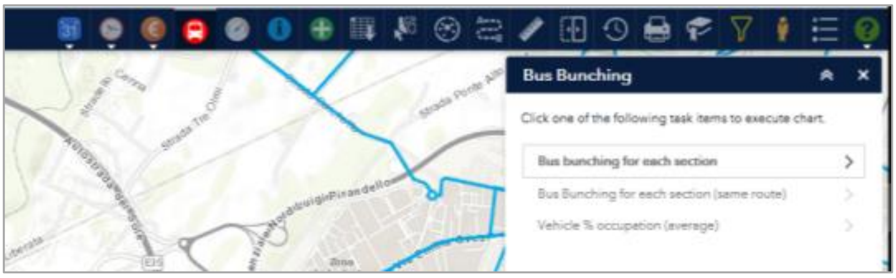

Figure 15 - Bus bunching selector

The specification of the vehicles causing bus bunching in different sections could be certainly useful.

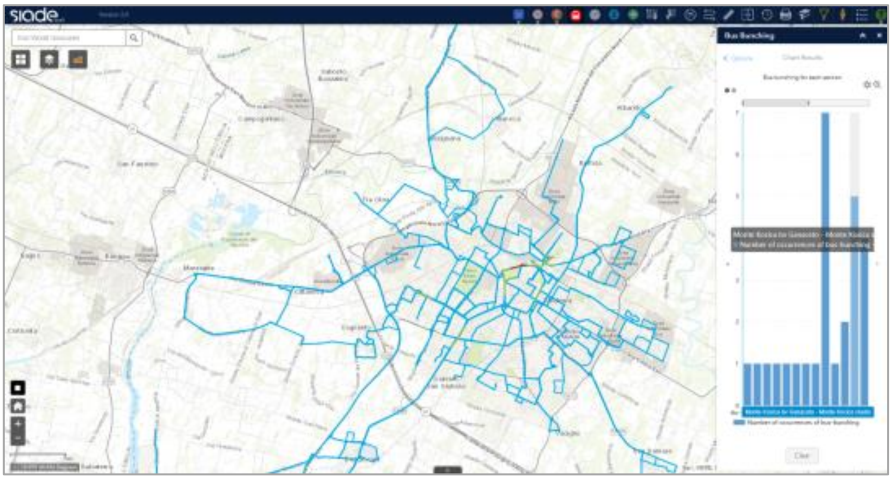

Figure 16 - Visualization of bus bunching on map

5. Lessons learned

The lessons learned are listed thanks to the SWOT analysis of SIADE, basing on a detailed analysis derived from the training session and workshop to which aMo and T Bridge participated in Gijon in 2018, a series of practical exercises conducted by means of the user guide.

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Furthermore, the evaluations depend upon a knowledge of PT planning requirements, similar planning tools currently leaders in the Italian market and their perspective of an innovative instrument for planning. Not only, this analysis has been carried out considering both the point of view of mobility planners and that of transport operators who need to be convinced by the DEMO version of the software.

The SWOT analysis goes through the following four aspects: strengths, weaknesses, opportunities and threats, according to which a series of recommendations are outlined in order to make SIADE a more appealing instrument for PT planning especially in the Italian market. The **strengths** detected through the SWOT analysis are:

- No installation - SIADE is a cloud PT planning instrument that does not require any installation so that it does not occupy any space in desktop devices;
- User-friendly - the different ways of illustrating the results (plots, charts, graphs or tables) make SIADE easier to use and more interactive;
- Interactivity and operational flexibility - the possibility to filter in map-view the contents of a layer through the related table of contents or to visualize just a specific journey makes SIADE more interactive;
- Innovative OD Matrix - SIADE applies a new method to create OD Matrix basing on actual demand derived from smart card punching while getting on means of transportation;
- Time-saving - the immediate graphically displayed representation of data over urban cartography makes it more user-friendly and contributes faster decision-makings;
- Performance evaluation and monitoring of existing PT services - SIADE makes it possible to geolocalize all the data and statistics relative to routes, sections and stops by separate widgets. The operational flexibility offered by the relative tools fosters a better evaluation of existing system in order to plan eventual new interventions;
- Availability of real-time traffic - in SIADE are available Google real-time traffic data which are based on mobile phone tracking;
- Diverse personalized queries - “Create layer from custom query” is a useful widget giving the opportunity to generate detailed queries related to public transport demand in relation to OD matrix and to illustrate different statistics regarding stops, routes, sections and bus bunching.

The **weaknesses** are:

- Partial OD matrix (undersized occasional demand due to the data available) - the OD Matrix generated by SIADE is based on personalised travel card punching which represents mainly the systematic demand. The people who move just occasionally, instead, tend to buy single tickets since they are more convenient for them. This means that the occasional demand of PT is being undersized in the related OD matrix;
- Partial OD Matrix (undersized demand due to the shortage of penalty measures) - the OD matrix generated by SIADE is based on the surveys of the passengers who has punched their Pass Card. In reality,

not all the passengers would punch their Pass Cards while getting on buses where there is not any infraction penalty;

- Need of emphasise on data security - as SIADE is available in cloud it is important to ensure the privacy of data;
- Need of emphasise on data capacity limit - the process speed is permissible with imported data that concern a bus transport system of an urban area but it is not clear, in the case of a complex system of a metropolitan or regional area with huge database, how SIADE would perform;
- Need of emphasise on the data input normalization - in the user guide, there are not any information regarding the standards to be respected in order to normalize data to be imported and processed.

The **opportunities** are:

- Make clearer the possibility to obtain O/D matrix - it is advisable to give more value to the availability of this output by a specific more visible widget;
- Extend the analysis to different period of year or to different years - it could be interesting to extend the ticket distribution to different months or even years in order to estimate the variation of OD corresponding to tariff policies;
- Integrate “Directions” widget with PT lines suggestions – the widget related to “Directions” shows the routes that should be taken in order to move from an origin to a destination. It is not clear how the time traveled by bus is calculated on the route where there is not any bus line;
- Integrate with other public transport modes – SIADE can be more useful in contexts where Tariff Integration is implemented for different modes of transportation;
- PT assignment instrument - it is recommended to add the total number of passengers moving between each two stops, as new fields, in order to represent the so-called “flussogramma” or “OD matrix assignment to the transport network”.

And, finally, the **threats** could be similar tools available on the market, which are more focused on the weak points of SIADE, such as:

- No data on passengers that do not punch – some SWs available on the market, even if more complicated, give the possibility to simulate the total demand of transportation either systematic or occasional;
- Currently lacking tools for future demand simulation – other simulation software available on the market have dedicated special tools in order to simulate the future PT demand.

The training activity and the analysis done on SIADE have allowed us to point out the following list of recommendations and lessons learned which should be carried out in order to make the SIADE more appealing and improve the performances:

- the standard of the data input for SIADE is not evident. This could be very useful to make clear the specific requirements of the data that the possible users, e.g. public transport operators and mobility agencies, should have in order to use SIADE;
- data security and exclusive access are not correctly emphasised;
- an approximate estimation of data capacity limit would clarify adaptability of SIADE to the user’s need.
- In order to bridge the gap in O/D matrix related to “paper tickets” or “lack of passing pass-cards”, a complementary method to integrate or calibrate the present O/D matrix generated by SIADE should be found;
- It should be highly recommended to add the total number of passengers moving between each two stops, as new fields, in order to represent the so-called “demand flow chart” (in Italian “flussogramma”) or

"OD matrix assignment to the transport network". This kind of plot is commonly employed in PT studies as the final step of PT simulation.

- It is not evident if and how the socio-economic parameters of each zone can contribute to calibrate the total number of passengers generated and attracted by each zone. The difference can be allocated on the basis of distribution percentages calculated by means of the matrix available at the moment.