2020/2021

Project Management Report

Usability & User Experience design project

TPER APPLICATION

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NEXT →

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Introduction

This report is the final result of a user experience design project conducted for Tper (Emilia-Romagna Passenger Transport), the main public company overseeing public transportation in the Metropolitan City of Bologna, in the province of Ferrara and in parts of the provinces of Modena and Ravenna, Italy. The goal of this project is to simplify the life of modern-day individuals in accomplishing well identified and useful goals by radically simplifying some tasks they need to complete in order to reach them.

Therefore, this report includes all the research, design and user tests carried out for the creation of an ancillary application of the main website currently deployed by Tper. The application has been designed to work on a specific domain, with a specific audience, for the accomplishment of a specific complex task, which, in this case, refers to the planification and gathering of information of public transportation, including both informative content and active services.

Audience research showed us that users have problems in understanding how the relevant interfaces deployed on the website can be used to carry out these tasks, for them being dislocated in a complex and outdated website, which do not replicate in its layout, structure, or design any type of real-life experiences related to the field of action. This leak has not only prevented potential users from completing some tasks because of their complexity but has also allowed other companies to take advanced of the data that Tper has made available and open for everybody, leaving an empty space in the market for an official application that would more faithfully convey the company beliefs of reliability, autonomicity and accountability.

We believe that planning a small trip to a specific place and checking all the relative information about bus stops, lines, timetables, and tickets must be an accessible service, easy to use and managed in a unique step by step process. For all these reasons, we believe that the application proposal could provide a convincing case for the investment and a good example for further developments of the company’s approach on digital platforms.

1. Ethnographic research

1.1 Segmentation of target user

In order to study the Tper platform to improve the service for a specific target audience, it has been firstly necessary to understand which users and of which kind the platform has. As the website does not provide any information about its public, a divergent way to approach its users has been to study the users of public transport and analyse their type of use and travel habits. Indeed, although it may not happen that all of those who use the Tper public transport use the website as well, it may be assumed that only those people who actually use the bus are interested in using the Tper site. The analysis of public transport habits, as we will see, has helped us in understanding which segments of users the Tper public transport has in Bologna and Emilia-Romagna. In order to do this, we have relied on authoritative reports with data concerning the entire region of Emilia Romagna and then, more specifically, the metropolitan area of the city of Bologna.

According to "L'inquadramento della domanda di mobilità", available on the Emilia-Romagna regional website, the first macro-distinction we can make among public transport categories of users concerns the use of intra-municipal and extra-municipal transport. Intra-communal means all journeys within one's own commune of residence, while extra-municipal means all those journeys whose place of arrival is in a different municipality from that of departure. From the table below, even though the reported data concern 2008, we can see that transport within the municipality of residence is higher than outside the municipality.

Tabella 6
Spostamenti infra ed extra comunali/ giorno 2008 (mgl)

Emilia-Romagna	Infracomunali		Extracomunali		Totali	
	v.a.	%	v.a.	%	v.a.	%
Spostamenti	5.798	65	3.129	35	8.927	100

Fonte: Isfort

Another important indicator to understand the habits of potential users of Tper's transport site concerns the average daily distance which a single person travels with public transport, computed for different age groups and gender in Emilia-Romagna.

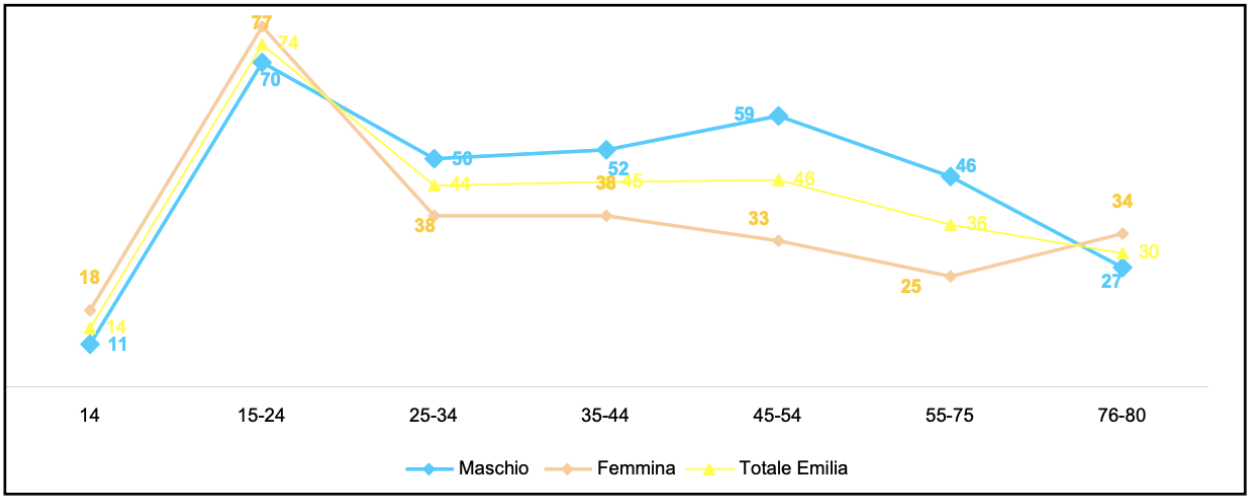
Tabella 10
Percorrenze medie pro capite giorno per classi di età Emilia-Romagna 2008 (km)

Classi di età	14	15-24	25-34	35-44	45-54	55-75	76-80	Val medio
Maschio	11	70	50	52	59	46	27	51
Femmina	18	77	38	38	33	25	34	36
Totale Emilia-Romagna	**14**	**74**	**44**	**45**	**46**	**36**	**30**	**44**

Fonte: Isfort

The table shows that the highest distance values are found among young people aged between 15 and 24. Another peak involves men in the 45-54 age group, while women in their 25-75 generally seem to travel less with public transport. As a final observation, we can see a reversal of the trend in the 76-80 age group, where women travel more frequently than men.

Figura 19
Percorrenze medie pro capite giorno per classi di età Emilia-Romagna 2008



N.B.: the data in the previous tables date from 2008

In Emilia-Romagna, work and study are the main reasons for travelling, with a 41% share, followed by leisure time with about 30%, while the remaining 29% is dedicated to family management. In non-municipal areas the percentage of trips for work and study purposes rises to about 56%, while in municipal areas it falls to 33%.

Tabella 14
La segmentazione della domanda in Emilia-Romagna 2008 per motivo dello spostamento (val. %)

Motivo	Infracomunali	Extracomunali	Valori medi
Lavoro	30,3	49,3	36,9
Studio	2,9	6,4	4,1
Gestione familiare dedicata ai servizi	23,0	9,9	18,4
Gestione familiare dedicata alle persone	13,2	6,4	10,8
Tempo libero	30,5	28,1	29,7
Totale	**100,0**	**100,0**	**100,0**

Fonte: Isfort.

By examining the two most frequent motivations, study and work, we can also compare the data with ISTAT statistics concerning the region of Emilia-Romagna and the respective urban and suburban areas, and therefore also the city of Bologna. In the following two tables we can observe the data concerning the travel habits of the population in Emilia Romagna, divided by areas and number of inhabitants. The use or not of means of transport and the type of transport is analysed: train, tram or bus, metro, private car as passenger or driver, moped and bicycle. In the last two fields the parameter of trip length is reported. The first table concerns the habits of people travelling for work and the second for school.

Out of 100 people, we can note that immediately behind the private car, used as a form of transport by 50% of people with the same characteristics, i.e. users who travel for work reasons, we can note that the second highest number, as far as the central metropolitan area is concerned, involves travel by tram and bus (16.6 people out of 100). Regarding the duration of the trip, most people (23.9 %) make trips lasting more than 31 minutes.

Misura	per 100 persone con le stesse caratteristiche												
	occupati di 15 anni e più che escono di casa abitualmente per andare a lavoro per mezzo di trasporto utilizzato e tempo impiegato												
Tipo dato	vanno a piedi	usano mezzi di trasporto	treno	tram, bus	metropolitana	pullman, corriera	pullman aziendale	auto privata (come conducente)	auto privata (come passeggero)	motocicletta, ciclomotore	bicicletta	tempo impiegato fino a 15 minuti	tempo impiegato 31 minuti e più
Seleziona periodo / Territorio													
2019 Emilia-Romagna	9.9	90.1	2.6	2.8	0.4	0.4	0.2	74.1	5.1	2.8	6.6	37.6	12.8
centro area metropolitana	16	84	3.4	18.6	11.9	0.9	0.7	46.6	4	8.3	3.8	21	23.7
periferia area metropolitana	8.4	91.6	7.5	4.3	5.9	3.7	0.2	72.1	5.6	3	2.6	27.3	25.2
fino a 2.000 ab.	12.6	87.4	1.5	1.4	0.8	0.9	0.5	76.5	5.9	0.6	0.7	36.9	15.2
2.001 - 10.000 ab.	11.2	88.8	2.1	1	1.1	1.9	0.3	76.3	6.1	2.2	2	40.2	14.1
10.001 - 50.000 ab.	11.8	88.2	2.8	1.5	0.9	1.3	0.3	75.2	6.2	2	3	41.8	13.2
50.001 ab. e più	12.6	87.4	2.6	4.6	0.7	0.8	0.1	69	5.4	4.1	6.6	40.7	12.4
2020 Emilia-Romagna	9.7	90.3	1.6	3.4	0.2	0.8	0	74.8	4	3.6	6.8	42.4	10.4
centro area metropolitana	14.2	85.8	4	16.6	14.5	1	0.4	50.2	2.5	9.5	2.7	19.6	23.9
periferia area metropolitana	8.8	91.2	6.1	3.6	6.4	3.3	0.1	73.5	4.7	3.4	2.3	29.6	23.1
fino a 2.000 ab.	9.5	90.5	2.6	0.9	1	1.3	0.4	79.1	6.7	0.9	1.1	34	14.9
2.001 - 10.000 ab.	10.7	89.3	2.1	1	0.8	1.5	0.6	77.7	5.1	2	2.7	40.6	14.1
10.001 - 50.000 ab.	11.9	88.1	2.7	1.7	0.9	1.7	0.3	74.7	6	2.5	3.2	42	11.6
50.001 ab. e più	13.4	86.6	2.2	4.3	1	1	0.2	69.2	5.5	3.8	5.3	44.4	10.1

Even if we consider the data of users who travel for study purposes, from pre-school children to 34-year-old students leaving home to attend university, we can observe that the proportions are respected: in particular, although the highest number of users use private vehicles as passengers, almost 17% use trams and buses for school purposes.

Misura	per 100 persone con le stesse caratteristiche												
	bambini dell'asilo, della scuola dell'infanzia e studenti fino a 34 anni che escono di casa per andare a scuola o all'università, per mezzo di trasporto utilizzato e tempo impiegato												
Tipo dato	vanno a piedi	usano mezzi di trasporto	treno	tram, bus	metropolitana	pullman, corriera	pullman aziendale	auto privata (come conducente)	auto privata (come passeggero)	motocicletta, ciclomotore	bicicletta	tempo impiegato fino a 15 minuti	tempo impiegato 31 minuti e più
Seleziona periodo / Territorio													
2019 Emilia-Romagna	20.9	79.1	7.2	13.7	0	11.1	1.9	5.7	45.2	0.5	6.6	61	14.8
2020 Emilia-Romagna	27.2	72.8	5.4	16.6	0.5	12.5	2.9	5.6	35.8	1.2	6.5	60.2	16

Focusing on the data extracted from the Tper website concerning the number and types of subscriptions and tickets sold in the metropolitan area of Bologna, we can further refine our target segmentation.

It can be seen that the highest number of tickets sold is for the "*city pass*" type, a combined ticket for 10 journeys; from this we can deduce that the purchasers of this category of tickets are occasional visitors to the city or people who use the means of transport occasionally. In second place in terms of numbers we can see single trips, hourly tickets, which however confirm an occasional use of transport also by these buyers. As a third result we observe the purchase of monthly subscriptions, divided between young subscriptions (i.e. within 27 years of age) and impersonal ones, i.e. from 27

years of age upwards: these are regular users, who study or work in the metropolitan area but who do not derive the economic advantage of buying an annual subscription. Lastly, there are far fewer annual season tickets, which are probably purchased by people living in the urban area of Bologna who use public transport every day.

Anno: 2018

Mese	Biglietti orari	Corse con City pass	Abbonamenti mensili		Abbonamenti annuali	
			Giovani	Impersonali	Giovani	Personali
gennaio	719.559	1.067.730	9.962	25.250	967	2.158
febbraio	740.254	1.073.030	9.766	23.170	416	1.387
marzo	853.126	1.118.820	10.972	23.291	267	1.962
aprile	744.029	954.030	9.072	19.767	143	876
maggio	856.614	1.107.630	8.836	22.650	106	1.465
giugno	717.101	882.280	5.284	17.614	76	389
luglio	691.879	756.700	3.110	13.617	118	408
agosto	484.601	526.880	4.862	17.447	1.324	1.003
settembre	772.072	991.420	8.599	21.431	9.060	2.267
ottobre	887.187	1.125.730	9.341	23.077	2.895	1.348
novembre	809.820	1.061.270	10.828	23.668	1.189	936
dicembre	755.663	1.100.020	8.203	21.096	874	1.530
TOTALE	9.031.906	11.765.540	98.835	252.079	17.436	15.729

Fonti e note sono consultabili nelle **Informazioni**.

At this point, we can describe the target group of public transport users in the Emilia Romagna Region according to these criteria:

- age group
- motivation of movement
- type of ticket purchased

In the table below, we have tried to articulate the information we have by mixing it with the data found so far.

Age	study motivation	work motivation	other motivations	subscriptions
14	x	/	x	/
15-24	x	/	x	x
25-34	x	x	x	x
35-44	/	x	x	/

45-54	/	x	x	/
55-75	/	x	x	/
76-80	/	/	x	/

At the end of this analysis, we can identify some possible users of the Tper website:

- students aged between 18 and 27 who use the monthly "Youth" season ticket to go to school or university: in this case they could be users of the public transport but not regular users of the site, since they would only use the site to renew their subscription;

- workers between 27 and 65 years of age who use public transport to travel in the metropolitan area of Bologna and who benefit from the monthly impersonal season ticket;

- mixed target group users who use the **city pass or single journey ticket,** who visit the city and the metropolitan area only occasionally for events, tourism, or certain periods of time and who therefore do not know the city well.

Since we think that regular users of public transport within the city of Bologna are familiar with the city and the routes, we thought we would focus on **occasional users** (the last category listed above), who are not familiar with the bus routes and the city and may need more support.

1.2 User research

User research is the methodic study of target users, including their needs and weaknesses, so as to have the sharpest possible insights of the user exigencies to be satisfied by the design. User researchers use various methods to expose problems and design opportunities, finding crucial information for the design process. The main scope is to gather data from users, which can be of two different kinds:

1. Qualitative research = ethnographic field studies and interviews to build a deep understanding of why users behave the way they do (requires great care, as it involves collecting non-numerical data but opinions);

2. Quantitative research = more-structured methods, such as surveys, to gather measurable data about what users do and test assumptions you developed from qualitative research (useful within a large user group, nevertheless, quantitative data alone cannot expose deeper human insights).

Usually, you can get the sharpest view of a design problem when you apply a mixture of both quantitative and qualitative research.

Quantitative research: Google form questionnaire

In order to better define the profile of our target user, we decided to structure a survey able to return quantitative data on users habits and exigencies with respect to the use of public transport in the metropolitan area of Bologna, particularly focusing on the ways they organize their movements in the city. Due to the necessity to gather information from very different people for provenance and belonging to a group, an online questionnaire to be filled by remote has been considered the best tool to conduct this research.

The questionnaire was created using the Google Form tool, which allows a rather large-scale dissemination together with a valid option to consult the results obtained.
The questionnaire 'Survey on the use of the Tper (Emilia-Romagna Passenger Transport) site for the urban and extra-urban area of Bologna' is divided into different sections:

- user profiling (age, sex, area of residence, aptitude of the user to use Internet and apps, aptitude of the user to use public transport)
- habits in planning a trip with public transport
- survey on the use of the Tper site

The objectives of the questionnaire are:
1. a better understanding of the target user with regards to all the habits of using Tper public transport;
2. a better understanding of the propensity to use the Tper site compared to other ways of planning a trip and the following reasons;
3. a better understanding of the expectations of users in a website for planning their trips.

The questionnaire has been created in Italian only due to the fact that no one of the people asked to answer to it needed an English version.

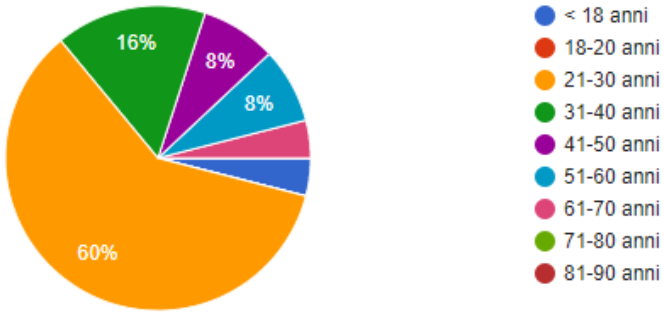
Questionnaire results and interpretation

User profiling

Ethnographic profiling
After disseminating the questionnaire among friends and acquaintances who could correspond to the profiles highlighted in the user segmentation, it was necessary to analyze and interpret the results obtained. 25 people answered the questionnaire, belonging to a rather heterogeneous and varied target. Most of them belong to the age group between 21 and 30 years, but there is also a conspicuous portion of participants between 30 and 60 years, while only two participants identified themselves respectively as minors under 18 and belonging to the 61-70 years old. They have a fairly high level of education, and are roughly divided between males and females, with a slight prevalence of female participants. Furthermore, the vast majority of participants reside in Emilia-Romagna, with 28% divided between central Bologna and the metropolitan area of Bologna and 60% outside Bologna but always within the region.

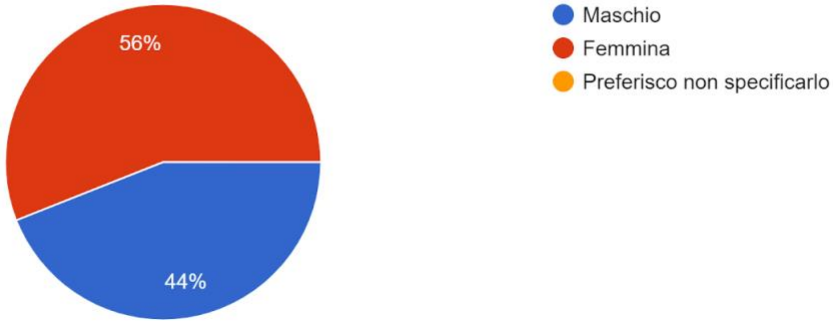
Indica a quale fascia d'età appartieni

25 risposte



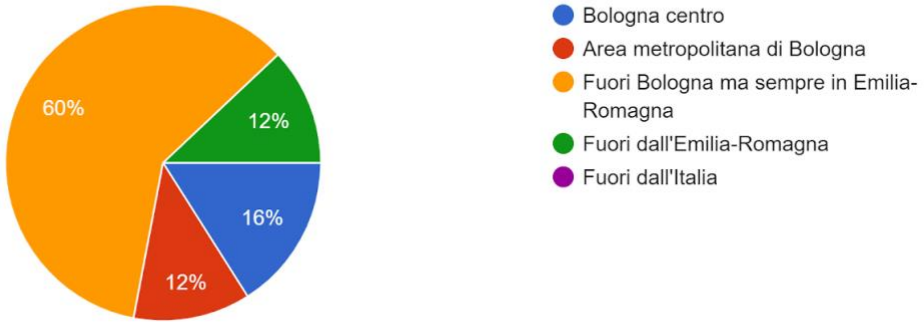
Indica a quale categoria appartieni

25 risposte



Indica dove risiedi

25 risposte

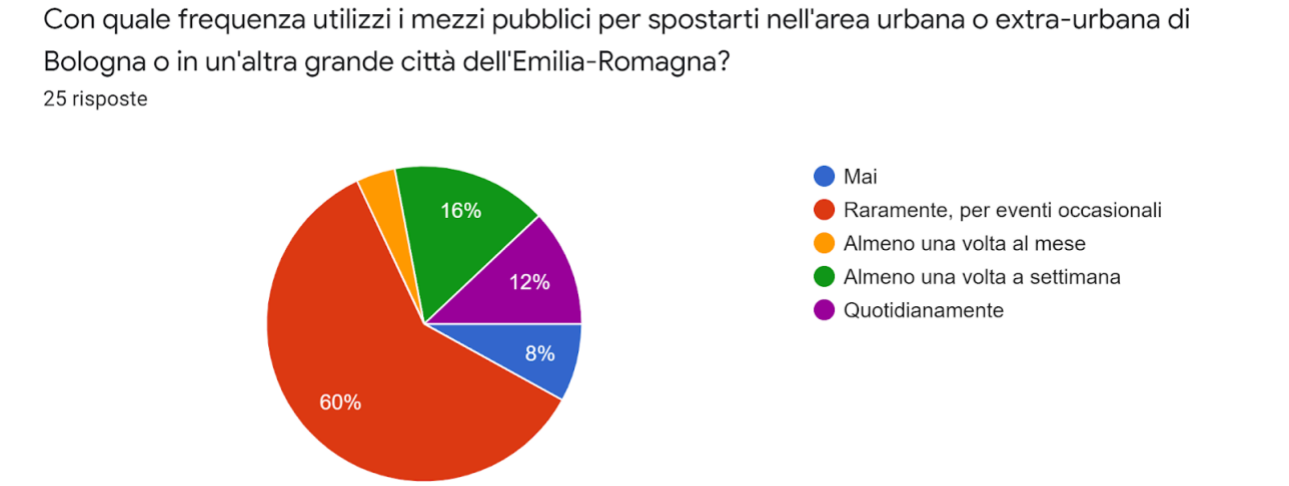


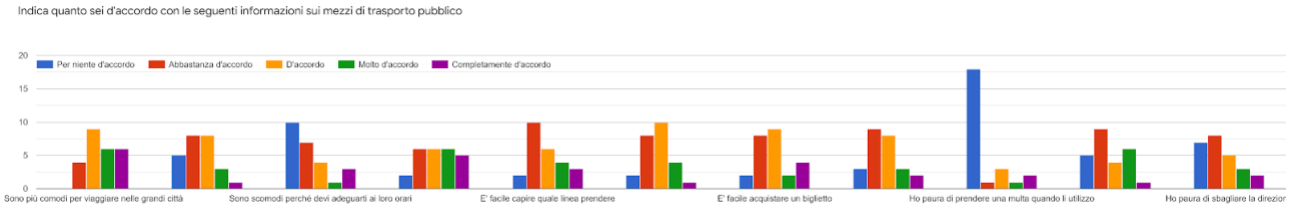
Aptitude for technology

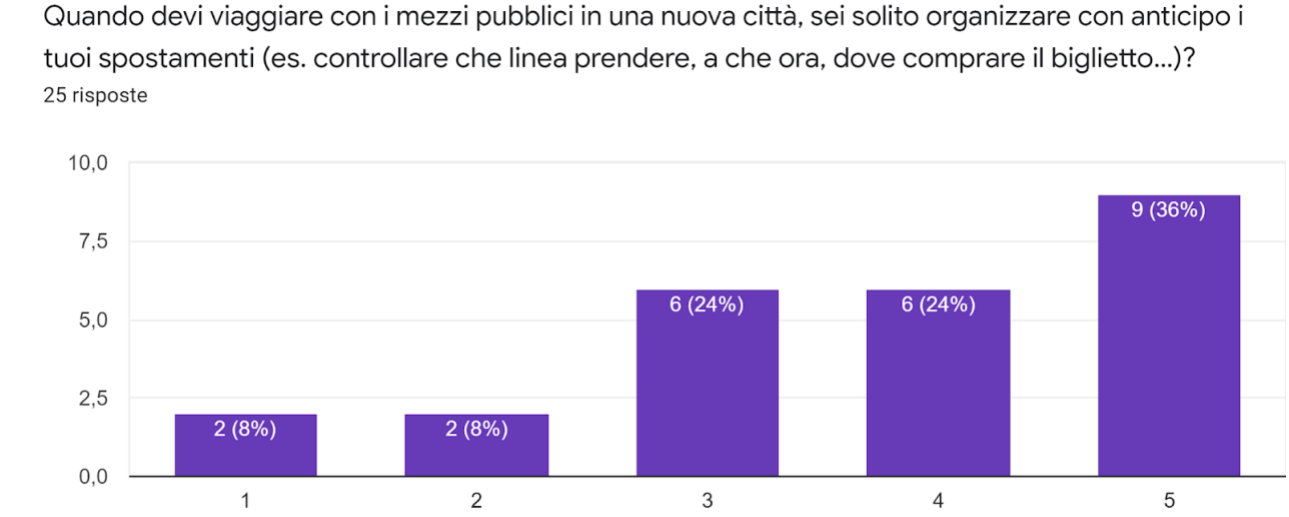
In this case, other aspects relevant to user profiling were considered as the aptitude for technology. As for the first, the vast majority of users say they consider the Internet as indispensable for their everyday life, use their smartphone more than 4 hours a day and rely heavily on mobile applications for daily services. The target user is therefore rather technological and well inclined to use technology - and an easily accessible technology such as that of mobile apps - to manage the activities of everyday life.

Aptitude for the use of public transport

As for the second point, the majority of users declare that they rarely use public transport, mostly for occasional events. Although a good portion uses them even more often (at least once a week or daily), it is precisely this user segment with little familiarity with the continuous use of public transport that is the subject of our research, as it is more in need of finding from external sources information on their use. Furthermore, although public transport is considered more comfortable for getting around in big cities and it is declared that it is rather easy to understand how to use it, a good portion of participants said they were afraid of getting the wrong line, direction or ticket price when using it: a sign that some problems in the use of public transport persist in those who use it sporadically and occasionally. Perhaps for this very reason, in fact, most of the participants declare that they feel the need to plan their trips on public transport in advance.

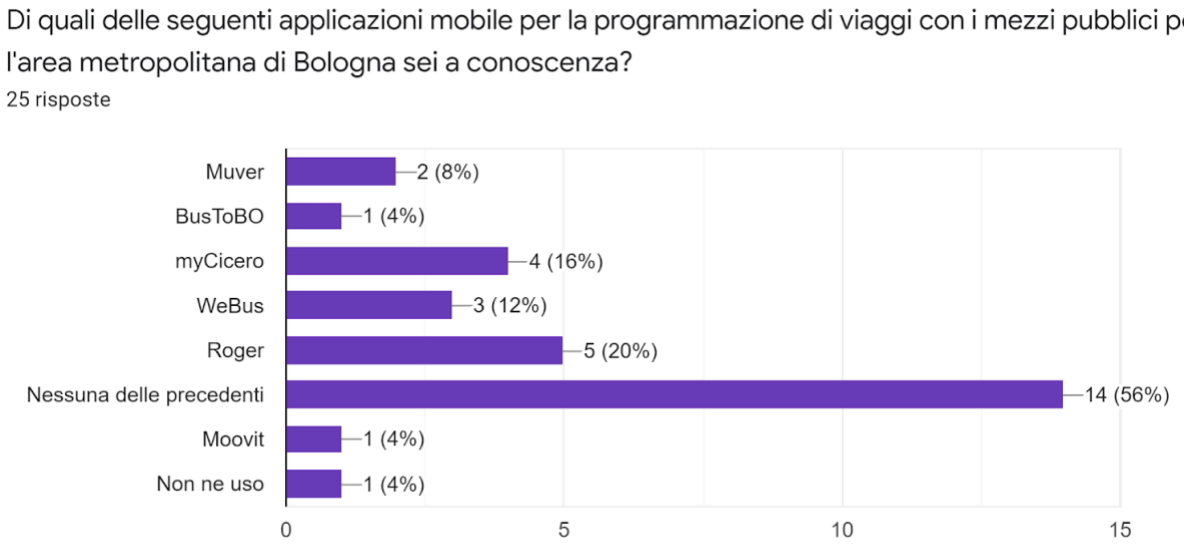


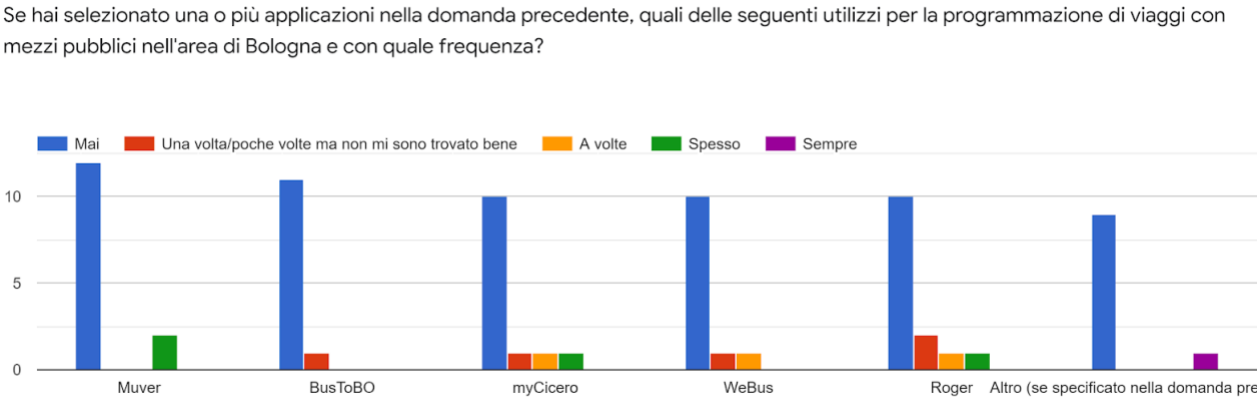




Habits in planning a trip with public transport

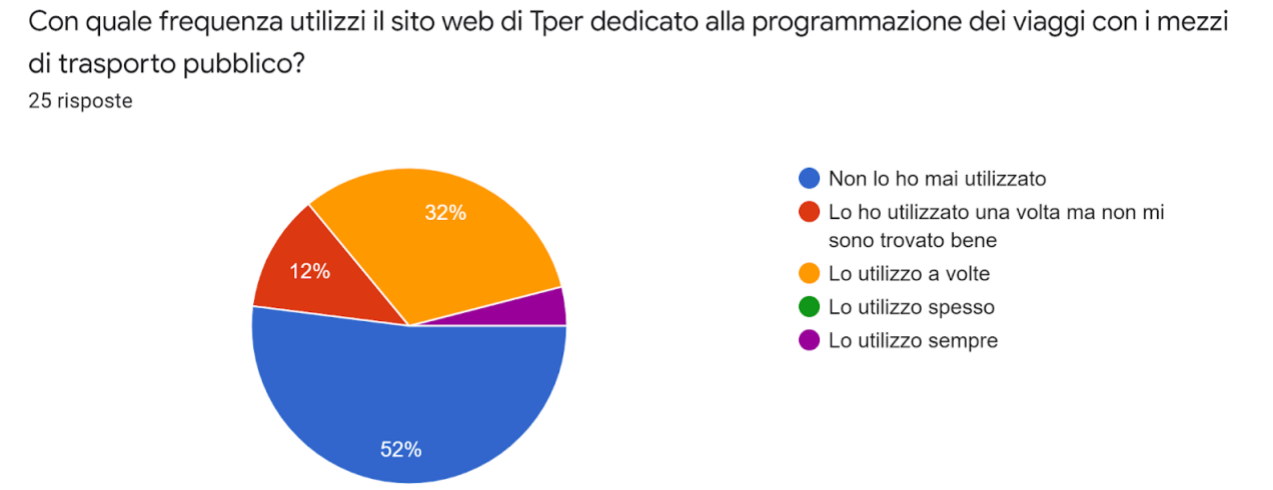
In the second section of the questionnaire, the most frequent habits and behaviors of users in planning a trip by public transport are investigated. In particular, participants were asked which means they would use to find out about the following needs: understanding which bus line to take, consulting timetables, deciding which fare to buy. From the results of the questionnaire, it is possible to note a clear prevalence in the use of applications to know the line to take and the times of passage of the means: most users inquire about specific public transport applications for the city in question or to a more general application such as Google Map. On the other hand, they are less used to inquire about the type of ticket to buy, for which one instead favors the request for information at the point of sale. The official public transport website is rarely or sometimes used to get any of this information. However, the answers to the following questions suggest that it is instead considered to be far more reliable and more up-to-date than the other modalities presented. The real discriminating factor in the user's choice is, as could be imagined, in the ease and comfort of use: considered minimum for the official website and maximum for Google Map and the request for information directly to the point of sale. It is in this aspect that it becomes necessary to intervene to allow users to consult an official, reliable and updated source for planning their trips.
Furthermore, a short survey showed that although there are many public transport applications that are based on the open source data of the official Tper website, few of them are known and even less used by our research participants.

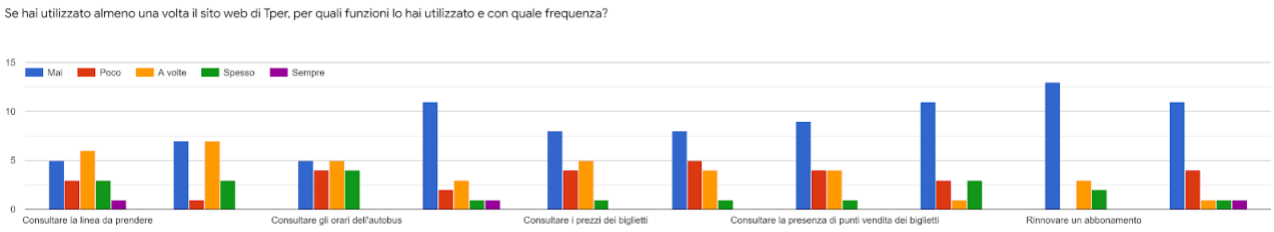




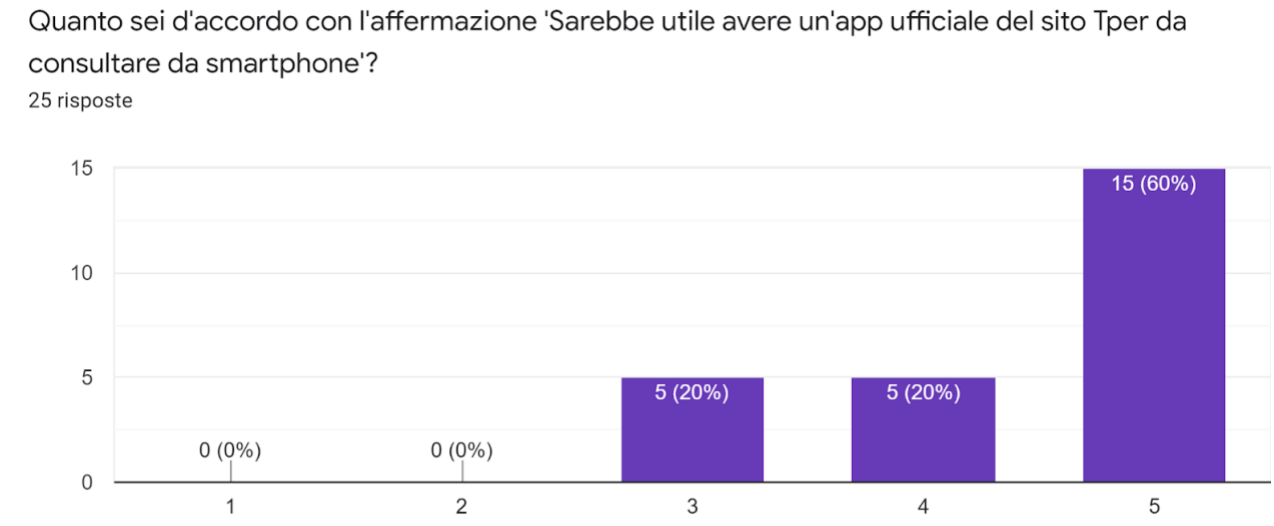
Survey on the use of the Tper site

Finally, the third and last section of the questionnaire concerned the participants' use of the Tper site. Most of the participants (52%) said they had never used the site, 12% used it once but were not happy, 32% use it sporadically and only one user (4%) always use. 22 of them are not registered in the personal area of the site, against 3 registered. The site was used by smartphones for 66% of users, and more for functions such as consulting the line to take, finding a stop near places of need and activating a subscription.





The great majority of participants agreed with the need to develop an official app linked to the site, while none of them disagreed.



Qualitative research: interacting with users/direct observation

In conducting qualitative research, an interview was instead proposed to various users falling as much as possible within the target user. A semi-structured interview was elaborated in order to gather users' opinions in a more flexible format and compare their answers for the traits of the Tper website interesting for our research.

Questions	User 1	User 2	User 3
Name, age, gender, profession	Asia, 19 years old, student	Claudia, 50 years old, employee	Michele, 60 years old, photographer
Residence	I still have my residence in Calabria, where I come from, instead my domicile is in Bologna, where I have been living away from home for about a year	Province of Bologna	Born in Bologna, now I live in the province of Bologna
How important do you think the presence of the Internet is in your everyday life? Do you mainly use it from your computer or smartphone?	Internet is definitely important in my everyday life, especially in this situation where, due to COVID, everything has been managed remotely, through the Internet. In the last year I would say that I use the Internet equally on both my computer and my smartphone, but I generally use it more on my phone.	Very much, and I use it equally from a smartphone and a computer.	Very much so, and I practically only use it from my smartphone.
Do you often use apps from your smartphone? For which activities in particular?	I use my smartphone a lot, even apps. In particular, I use social media, of any kind, and since I am in Bologna I also use many apps to move, to take the bus or the train to go home.	Yes, I use them often. I mainly use banking apps, messaging apps and internet search apps.	Yes, I use them often. I mainly use the information and messaging apps.
If you have to move to Bologna or a big city,	Personally, I prefer to move on foot or by bike, especially	If I have to move around in a big city, I prefer to do it on	I prefer private transport because I don't get clear

do you use public transport or do you prefer to move with a private vehicle or on foot / by bike? Why? Do you think public transport is advantageous or disadvantageous for a big city? Why?	since I live quite in the center and therefore everything is easily accessible in this way. However, I believe that it is advantageous to get around by public transport, because they are comfortable for traveling around the city and can help those who, like me, do not have a car to get around here.	foot or by public transport, mainly to avoid parking and traffic problems and because I don't know the city well. In general I think that public transport in cities is advantageous because it saves a lot of time.	enough information on how to use public transport so I think it's a waste of time. Public transport could be advantageous for those who know how to manage it, for those who come from outside and know nothing. Milan and Rome are better governed because there are metro lines, but buses are unclear.
Have you ever used public transport in Bologna? If so, for what kind of occasion and how often?	I use the train a lot since I have to go to Imola every day for lessons. I use the bus much less often, only for special occasions.	Yes, I have used public transport in Bologna, for events such as an exhibition or to visit friends. I have used it to go from the station to the Arco del Meloncello before setting off on a walk. I rarely use them and only for specific occasions.	Yes, occasionally at a very low frequency.
If you have to travel by public transport to a new city, would you plan your travels in advance? Eg check which line to take, at what time, where to buy the ticket ...	Yes, I plan ahead.	Yes, I plan ahead.	No, I do not program them in advance.
When you have to travel by public transport, what are the most relevant information you would like to know to better organize your trip?	Surely, the line to take, the stops it makes, where are the stops and what is the terminus. This is the most relevant information to me. Then, of course, the times at which they pass. Ah, another information I would like to know in	I would like to know the timetable, where I am and whether the stops coincide with the places I need to go.	I don't usually plan trips in advance.

	advance is whether it is possible to buy a ticket on the bus, and if only with cash or even with a card.		
When you have to travel by public transport, how do you find out to know which line you need to take? How do you find out about timetables? How do you find out what type of ticket to buy? Do you use the same method for all three options? Why do you choose these methods (eg reliability, ease, update on any news ...)?	I am a bit old-fashioned from this point of view. For example, I often go directly to the bus stop board to find out about the timetables and consult that one. As for the line, I always consult the scoreboards or sometimes the Moovit app. But I have some problems, not knowing the stops or the streets of the city yet.	I use the internet and do a free search. I use the Tper website if I have to use buses, otherwise the Trenitalia website. I mainly get information about the line I have to take and the timetables, weekdays and holidays. I'm not interested in information about the ticket.	I would try to find out at the bus stops.
Do you know that there are apps to plan your trips by public transport? Do you know some of these apps to use in the city of Bologna or in your city? Do you use them? If so, how often? What advantages do you find in apps compared to other ways of planning trips (eg official website or ask the point of sale ...)?	Yes, as I said before, I know and use Moovit to move in Bologna with the buses. I know the app because my cousin, who lives in Bologna, made me download it. He told me it was very easy to use, but I still have problems, especially since I never used buses where I lived before, so I'm not used to this type of research. However, I find it very useful when traveling. For example, when I'm on the bus, I use it to see how many stops are missing from mine and to orient myself when to get off.	No, I did not know.	I know they exist but I don't know them and I don't use them.

Are you aware of the existence of an official website for Tper public transport in Bologna or Emilia-Romagna? Do you use it? For which functions in particular? How often?	No, I didn't know it existed.	Yes, I am aware of it and I use it occasionally.	No, I didn't know it existed.
If you use it / If you don't use it, why? What is your opinion on the site?		I use it to find out the route of the lines. I use it mainly to plan and understand school bus fares and routes for my 17-year-old son. I compared annual and monthly passes to see what the advantages and convenience were for school transport. It is a very clear site in my opinion. During the covid the Tper site gave the possibility to receive a refund for the transport and the unused season ticket and the forms were very clear.	I don't use it because I don't use transport.
(Solo per chi lo utilizza) Sei registrato all'area personale del sito Tper? Quali sono i vantaggi del sito Tper?		Yes, for my son's school reasons. In my experience it was useful. I was always informed about school transport and the information was clear.	
What do you think a site of this kind should have to be really useful?	The possibility of buying the ticket directly on the app, the possibility of knowing the bus timetables, perhaps even coinciding with those of the train.	The interactive route calculation and that there is a clear reference to places of interest, a list of cultural and public places to use as a reference without having to do a double search: i.e.	Be very clear, exact and easy to consult.

		I found myself having to search for the street of a certain place and then to search for the street on the site. If there was the possibility of being able to filter these results by type (e.g. stadiums, gyms, cinemas, museums, hospitals) and to have information on bus stops within a radius of 500 m it would be very useful. The desired room radius could also be selected.	
Do you think that an app that can be consulted from a smartphone is more convenient for information of this type? Why?	Certainly an application.	Yes, because you always have it at hand; from the computer you have to do it much earlier.	Yes, if there are the elements you need, like typing the name of the street and seeing the stops. Like google maps with buses. And I'd like it if there was also information about traffic or peak times for bus traffic, whether they are full, whether they arrive in front of or behind the hospital for example, so I can make better use of it.

1.3 Task analysis

Now we will proceed with the analysis of the tasks our target user might employ when using the Tper website. We used this analysis in order to identify how many tasks can be performed, in what context and the goal directly related to the process. The analysis of each task will be a hierarchical representation of what steps it takes to perform it. Hierarchical Task Analysis, in fact, is focused on decomposing a high-level task subtask into smaller units for which there is a goal and for which there is some lowest-level interaction between humans and machines. It is also taken into consideration the user interaction between the website and other resources (digital or physical).

First, it is assumed that users access the website through their smartphones, computers or any other device able to connect to the Internet. The webpage is reachable from different official sources, touristic and informational web pages related to the metropolitan city of Bologna, or by looking for it with the help of a general web search engine. This initial step is always taken for granted and will be analyzed separately and recalled every time it will be needed. The same applies for the registration process.

Lead-in tasks
A. Preliminary step
B. Registration process

We analyzed 5 tasks that correspond to the actions that can be undertaken in the open section of the website and 3 additional tasks for which registration is required. Some of these tasks are immediately displayed in the homepage of the website. Others are hidden inside the many branches of textual pages. We chose to highlight the tasks that we believe are fundamental in order to perform a visit or to accomplish the use of public transportation in the best and the easiest way possible. The tasks are the following:

Open services
C. Plan route
D. Check timetables
E. Buy a ticket
F. Talk with Tper
G. Hello Bus

Closed services
H. Plan an appointment
I. Buy a citypass
J. Other online services (car related)

A - Preliminary step	
Context	You are looking for transportation information and related tasks.
Goal	Accessing the Tper webpage.
Steps	1) Open the browser and make sure your Internet connection works; 2) Use a search engine and write the query "Trasporto Pubblico Emilia-Romagna" in the search bar; 3) Click on the link "TPER - Trasporto Passeggeri Emilia Romagna"; 4) Eventually, directly type the url of the website in the address bar; 5) Access the webpage.

B - Registration process	
Context	You already explored and used the tasks on the Tper webpage.
Goal	Register and access the online services provided by Tper.
Steps	0) Preliminary step; 1) From the homepage click “Servizi online”; 2) Click on the human bust icon or from the slide down menu select “Account” and then “Accesso”; 3) Scroll down to the text section and click on“Se non sei ancora registrato, puoi procedere alla registrazione al sito”; 4) Select the typology of the user account. In our case, we are not a company nor a tourist guide. Select “Privato” and go on; 5) Fill the form with your personal information: surname, name, gender, birth date, nationality, place of birth, social security number; 6) Fill the form with your contact information: address, email, cellphone; 7) Choose your account credentials: username, password, security question, security answer; 8) Look at the resume of information and give authorization to process personal data; 9) Check the confirmation email that was sent to your address; 10) Click on the link attached to the confirmation email;

C - Plan route	
Context	You have no information about public transportation in the city.
Goal	Planning, evaluating and finding a transportation solution for moving from one position to another inside the metropolitan city of Bologna.
Steps	0) Preliminary step; 1) From the homepage click “Calcola il tuo percorso”; 2) Look at the map and select “Etichette” in order to see the names of the streets; 3) Click on “Legenda” and leave it open; 4) Click on the red bus icon in the right top corner of the map; 5) Activate both the “Rivendite” icon and the “Fermate” icon, in order to take a look at the bus stops and the nearest ticket sale spots; 6) Click on the red bus icon of your interest. You can now see the name of the bus stop, the name of the street point and the bus lines; 7) Click on the bus line number if you want to know the update status of satellite monitoring of upcoming bus to the bus stop; 8) Otherwise, type the name of your departure stop in the “Partenza” form, and the name of your destination stop in the “Arrivo” form. 9) Click on “Calcola il percorso” to plan the route; 10) No route is shown; You have now two alternatives: 11) Calculate the route on Google Maps by using the alternative link provided after the failed query; or 11) Add to the search query the name of the city where your position is located (ie. “Bologna”) and click “Calcola il percorso again; 12) Select one of the suggested paths and follow the instructions.

D - Check timetables	
Context	You have no information about public transportation in the city.
Goal	Check information about specific bus lines and find out about transportation schedules during business days or during weekends.
Steps	0) Preliminary step; 1) From the homepage click “Consulta gli orari”; 2) Alternatively, you can reach the same page from the main menu by clicking “Percorsi e orari”; 3) Select one of the following categories in order to filter out only the lines that work in the metropolitan city: • Aeroporto • Extraurbana Bologna • Linea Ferroviaria • Suburbana Bologna • Urbana Bologna 4) Apply filters; 5) If there are still too many results, filter again by date or by name using the appropriate sections. Use suggestions to help you out; 6) Apply filters again; 7) Select the line of interest. You’ll be redirected to the line’s page; 8) Scroll down and take a first look at the drawings of the line. Here you can check what stops are available during business days, weekends and Tdays; 9) Now, in order to check the actual timings of the line, scroll back up and choose one of the available pdf files containing all the information about timing schedules; 10) Open the pdf file in another page or download it; 11) Check the information manually; 12) Go back to the line page and select the latest update inside the News section; 13) Open the news section on another page; 14) Read the information and open the pdf attachment; 15) Confront the information from the two pages and the information from the pdf files.

E - Buy a ticket	
Context	You have no information about public transportation in the city.
Goal	Get information about bus tickets and buy one for your ride.
Steps	0) Preliminary step; 1) From the homepage click “Biglietteria”; 2) Alternatively, you can reach the same page from the main menu by clicking “Biglietti e abbonamenti”; 3) Choose one of the first two options from the menu. There are three different categories available: • Area Urbana • Extraurbani a zone • Servizio ferroviario We will take *Area Urbana* as an example of the step by step procedure, being it identical to the one offered by clicking on *Extraurbani a zone*. *Servizio Ferroviario* redirects you to a different webpage hosted by Trenitalia.

	4) Click on “Area Urbana”; 5) Select the city of interest and click on “Bologna”; 6) Choose now between tickets or pass; 7) If you choose tickets, click on “Biglietti”; 8) Take a look at tipologies and related prices; 9) Select a typology and read information about validity, modality of use and purchasing methods; 10) Scroll down. You can now choose to buy the ticket physically, using one of these methods, which are represented with icons: • TPER points • Tickets sale spots • Onboard 11) Go directly to one of these physical points and buy a ticket. or online, using third party apps: • App ROGER • App Muver 11) Download the apps and buy a ticket. 7) If you choose pass, click on “Abbonamenti”; 8) Take a look at tipologies and related prices; 9) Select a typology and read information about validity, modality of use and purchasing methods; 10) Scroll down. You can now choose to buy the ticket physically, using one of these methods, which are represented with icons: • TPER points • Tickets sale spots • Onboard 11) Go directly to one of these physical points and buy a pass. or online, using Tper Online services: 11) Select the “Internet” option clicking on its icon; 12) Click on “Vai alla pagina della biglietteria online”; 13) Scroll down and click on “Procedi con l’acquisto di un abbonamento”; 14) Access the closed section of the website and follow the steps of task I.

F - Talk with Tper	
Context	You are looking for transportation information but you couldn't find them using the main website.

Goal	Send a message, file a complaint or defense cases.
Steps	0) Preliminary step; 1) From the homepage click “Parla con Tper”; 2) Select one of the three radio buttons: • Information request 3) Call one of these numbers: +39 051 290290, 840 151152; 4) Otherwise, double click on “Richiesta informazioni”; 5) Fill the form with name, surname, date of birth, type of user and email; 6) Write a message; 7) Click on “Avanti”; 8) Look at the resume of information and give authorization to process personal data; 9) Go on and click on “Conferma” to confirm. • Complaint 3) Double click on “Reclamo”; 4) Fill the personal information form; 5) Click “Avanti” and share communication data; 6) Look at the resume of information and give authorization to process personal data; 7) Go on and click on “Conferma” to confirm. • Defense cases 3) Double click on “Scritti difensivi”; 4) Choose between personal request or for others; 5) Fill the applicant information form and click “Avanti”; 6) Fill the sanctioned information form and click “Avanti”; 7) Share communication data and click “Avanti”; 8) Look at the resume of information and give authorization to process personal data; 9) Go on and click on “Conferma” to confirm.

G - Hello Bus	
Context	You are physically located or near a bus stop.
Goal	Check the real time of arrival of the bus at the bus stop.
Steps	0) Preliminary step; 1) From the homepage click “Consulta gli orari”; 2) Alternatively, you can reach the same page from the main menu by clicking “Percorsi e orari”; 3) Search for “Informazioni in tempo reale” in the left sidebar and select it; 4) Here, you can use “Chiamatreno” or “Hello Bus”. Select the latter; 5) Hello Bus is meant to be used on the phone. However, if you scroll down you can use the online version of the service; 6) Specify the name or number of the bus stop; 7) Specify the bus line; 8) Specify time of the day and click on “Vai”; 9) Read the textual information about the time of arrival.

H - Plan an appointment	
Context	You already explored and used the tasks on the Tper webpage.
Goal	Book an appointment with Tper.
Steps	0) Preliminary step; 1) From the homepage click “Servizi online”; 2) Click on the human bust icon or from the slide down menu select “Account” and then “Accesso”; 3) Insert credentials if available, otherwise go back to the Registration process and follow the steps; 4) Click on the golden square with the calendar icon; 5) Check the correctness of personal information; 6) Select the typology of service from the drop down menu; 7) Select the office for the appointment; 8) Look for the first available date on the calendar; 9) Select the appointment time from the suggested list; 10) Look at the resume of information and give authorization to process personal data; 11) Go on and click on “Conferma” to confirm.

I - Buy a citypass	
Context	You already explored and used the tasks on the Tper webpage.
Goal	Register and pay for a long-period citypass.
Steps	0) Preliminary step; 1) From the homepage click “Servizi online”; 2) Click on the human bust icon or from the slide down menu select “Account” and then “Accesso”; 3) Insert credentials if available, otherwise go back to the Registration process and follow the steps; 4) Click on the green square with the card icon; 5) Click on “Continua” and check if the personal information already stored are correct; 6) Select a shipping address; 7) Check contact info and upload a portrait photograph to be displayed on your citypass; 8) Choose the starting date of activation and then choose among the different typologies of long-period or short-term passes; 9) The subscription prize and additional costs will be shown. Confirm and go on; 10) Choose a payment option between: • Online Sofort transfer • Credit card 11) Look at the resume of information and give authorization to process personal data; 12) Complete the payment with Nexi; 13) Take a look at the resume of information and click on “Conferma” to confirm.

For the sake of completeness and clarity we decided to analyze and list most of the tasks offered by the website. However, among the aforementioned and analyzed tasks, only some can actually be considered relevant for our purposes. In fact, we will be focusing on tasks that usually are fulfilled on a daily-basis, in order to allow their usage in an intuitive and easier way. Talking with Tper, sending papers or planning appointments are all important services, but they are ancillary if compared to the others. Planning a route (C), checking timetables (D) and buying tickets (E), on the contrary, are all fundamental actions that need to be guided in a proper and meaningful way in order to allow everyone to access them and reach the prefixed goal. In the next section we will better understand the key features and the flaws of these tasks.

2. Assessment of existing resources

2.1 Expert usability review

2.1.1 Identification of guidelines

The inspection can't be carried out without proper guidelines against which to evaluate the usability of the website. In order to do that, we have chosen to base our inspection on well established usability principles. The main goal of heuristic evaluations is, in fact, to identify any problems associated with the design of user interfaces. Usability consultant Jakob Nielsen developed this method on the basis of several years of experience in teaching and consulting about usability engineering. Many researchers use Nielsen's heuristics developed in 1996, while others propose their own heuristic sets. For the purposes of our review, we decided to adopt an extended and more precise version of Nielsen's Principles, that is the heuristics identified in 2000 by Susan Weinschenk and Dean Barker.

The 20 heuristics of Weinschenk and Barker (2000)

1. **User Control**
   The interface will allow the user to perceive that they are in control and will allow appropriate control. Heuristics that check whether the user has enough control of the interface.

2. **Human Limitations**
   The interface will not overload the user's cognitive, visual, auditory, tactile, or motor limits. The design takes into account human limitations, cognitive and sensorial, to avoid overloading them.

3. **Modal Integrity**
   The interface will fit individual tasks within whatever modality is being used: auditory, visual, motor or kinesthetic.

4. **Accommodation**
   The interface will fit the way each user group works and thinks. The design is adequate to fulfill the needs and behaviour of each targeted user group.

5. **Linguistic Clarity**

The interface will communicate as efficiently as possible. The language used to communicate is efficient, clear and adequate to the audience.

6. **Aesthetic Integrity**
   The interface will have a tractive and appropriate design. The design is visually attractive and tailored to appeal to the target population.

7. **Simplicity**
   The interface will present elements simply. The design does not use unnecessary complexity.

8. **Predictability**
   The interface will behave in a manner such that the user can accurately predict what will happen next. Users will be able to form a mental model of how the system will behave in response to actions.

9. **Interpretation**
   The interface will make reasonable guesses about what the user is trying to do. There are codified rules that try to guess the user's intentions and anticipate the actions needed.

10. **Accuracy**
    The interface will be free from errors. The result of user actions corresponds to their goals.

11. **Technical Clarity**
    The interface will have the highest possible fidelity. The concepts represented in the interface have the highest possible correspondence to the problem domain they are modeling.

12. **Flexibility**
    The interface will allow the user to adjust the design for custom use.

13. **Fulfillment**
    The interface will provide a satisfying user experience. The user experience is adequate and the user feels good about the experience.

14. **Cultural Propriety**
    The interface will match the user's social customs and cultural expectations.

15. **Suitable Tempo**
    The interface will operate at a tempo suitable to the user.

16. **Consistency**
    The interface will be consistent. Different parts of the system have the same style, also linguistically, so that there are no different ways to represent the same information or behavior.

17. **User Support**
    The interface will provide additional assistance as needed or requested. The design will support learning and provide the required assistance to usage.

18. **Precision**
    The interface will allow the users to perform a task exactly.

19. **Forgiveness**
    The interface will make actions recoverable. The user will be able to recover to an adequate state after an error.

20. **Responsiveness**
    The interface will inform users about the results of their actions and the interface's status. It should provide the user enough feedback information about the system and their task completion.

2.1.2 First inspection of the system

Tper website is accessible from the following url: https://www.tper.it/. The website is owned by TPER and has been designed for the company by LOGITAL srl.

Data are freely accessible to all, without patents or other forms of control that limit their reproduction and whose copyright restrictions may be limited to oblige to cite the source or to release the changes in the same way. The use, in all its forms, of Tper's open data is subject to the Creative Commons Attribution 3.0 Italian license agreement and the acceptance of the conditions set out in the legal notes on the use of Tper's open data. Tper also makes real-time interactive services available on the availability of its vehicles, through the Chiama Train and Hello Bus services (by telephone, also available online).

At a first glance, we can notice the predominance of the color red, which reflects the main color of the logo of the company and the recognisable palette used also for public transportation. The homepage looks standard in its layout and graphically outdated. Analyzing it from top to bottom, we can distinguish a banner containing the logo of the company and a generic search bar, placed at the opposite corners of the page. Below, a generic menu bar displays six different sections of the website.

Going on, we reach the secondary region of the home page. It contains, directly beneath, three slideshow blocks of different widths, showing images, graphics and advertisement material concerning public events held in the metropolitan city of Bologna. It is the only animated section of the website.

The tertiary region contains an additional menu with six buttons, each depicting with an icon a service offered by the website. Some of the services are reachable using the aforementioned main menu, but they are listed with different names despite having the same ending point. Immediately below we have a wide block dedicated to news. News are updated to current date and can be filtered according to some criteria. You can in fact filter news related to a specific city (Bologna and Ferrara), based on the service (bus, railway, car, bike) or based on the content of the information shared (deviations, strikes, parkings). Filters do not include other cities or other options.

The last section is a footer divided in four columns, each containing references and links to external resources. It also shows off the commercial partners of Tper, useful links and a registration button. A final textual section contains legal information, credits, copyright notices and a rss feed button.

Overall, the homepage looks crowded with a lot of information, images and text. Sections are standardized, all arranged in straight boxes with different widths and similar heights. All the images are in bad quality. The website is responsive, not perfectly adjusted at every width. The quality of layout and related information quantity decreases drastically when accessing the webpage from smartphones or from smaller screens, making it easier to understand, access and use the sections, but less complete from a presentational point of view. It adopts fixed dimensions and it never takes advantage of the full width of the screen. Width of every page of the site is in fact fixed to 1000 pixels. Only the sections accessible with the registration have a smaller width, fixed to 800 pixels.

More generally, pages contain the same menu bar of the homepage and long text sections with forms, lists, buttons and tables. Every page is divided in two columns: a left sidebar occupying 25% of the fixed screen size and a right content column occupying the remaining space. Sidebars can be very long and contain multiple options and sub-options, making it very difficult to orientate inside the site and to understand the branches of every single section. Pages always showcase a footer containing useful links, such as the one in the homepage. Text is available only in italian. Choosing another language is not possible.

These are the main usability issues that can be identified at a first inspection:

- **Information overload:** too much information collapsed in huge textual units.
- **Linguistic limitations:** the website is available only in Italian.
- **Lack of consistency:** different paths and buttons lead to the same endpoints.
- **Poor quality graphics:** low quality images, low quality graphics, not homogeneous and containing text which is not accessible.
- **No customization available**: the website has fixed parameters and the organization of information is the same for every user. Filtering is unclear.
- **Bad navigation system:** no breadcrumb navigation bars or other indications are used to help the navigation and overall understanding of the webpage.

These are the main usability issues identified during the first task analysis:

- It is impossible to know what tasks can be performed with the registration if you are not registered.
- Planning a route is almost impossible for users who are not familiar with the city.
- The map is useless and very difficult to understand.
- Planning a route fails and redirects to other services, usually Google Maps.
- Timetables are available only in pdf files, no interaction or manipulation is allowed.
- Hello bus is hidden among the branches of the webpage, despite it being a very useful tool. It is not included among the other services.
- There are no clear and explicit paths.
- There is not a map of the entire website.
- Sections are isolated, there’s no sign of continuity between tools that should be used in parallel.
- Images are used instead of clear and accessible data.
- It is not possible to buy tickets directly from the website.
- Ticket prices are listed inside pdf files, no interaction or manipulation is allowed.

2.1.3 Direct analysis

After detecting the main visible issues of the website through a fast inspection, we are now ready to go ahead with a systematic exploration of the application with respect to the guideline chosen. The evaluation has been based on the functions available within the system and it is independent of expected user. We have proceeded by analysing every screen, in order to find out which guidelines are violated, how often and with what impact.

PAGE	VIOLATION
Homepage	2: Information overload. 5: Only one language available. Words used are too generic or too specific. There is no correlation between the words used and the page they allow access to. 6: Aesthetics are dated and not attractive at all. There's just one color and no contrast at all. Everything looks the same. 9: Unclear priorities. There's no visual hierarchy. Important elements are not highlighted enough. 11: Different buttons with different words are linked to the same page. 16: When on small screens the interface is inconsistent. New sections are added when screen sizes are changed. These sections allow access to pages hidden in full screen mode. 18: When on small screens it is impossible to use the homepage. Images, useless arrows and text are overlapped. 20: No guidance, explanations or feedback are available. Also no map of the entire website contents is provided.
Timetables page	1: There are too many instruments for controlling the page. 2: Information overload. Too many different icons and symbols to remember. 5: Only one language available. 6: Aesthetics are dated and not attractive at all. There's just one color and no contrast at all. Everything looks the same. 7: The system for checking timetables is complex. Pdf timetables are long, with a lot of textual information condensed and not enough white space. 9: Unclear priorities. There's no visual hierarchy. Important elements are not highlighted enough. Sidebar shows icons that link to the page you are looking at, without being highlighted or checked. Arrows inside pdfs are logically incoherent; they indicate left and right, while the bus stops are listed from top to bottom.

	13: The experience is stressful. The user must go from one page to a pdf and back to the page in order to open another pdf. 14: The searching experience does not reflect real-life timetables or real life experience. 16: The name of the page differs from the ones that redirect to it. Different parts of the timetables have the same style. Some pdfs are totally different from the rest in terms of layout and typography. 18: When on small screens it is impossible to use the homepage. Images, useless arrows and text are overlapped. 20: Line pages are not isolated from the context. It is impossible to understand how to go back or to use a breadcrumb.
Planning page	1: There are too many instruments for controlling the page. You can't detect your position inside the map. 5: Only one language available. Language is inconsistent. 6: Aesthetics are dated and not attractive at all. Google Maps graphics are not integrated in the design. 7: Understanding how to use the map is complex and counterintuitive. 8: The use of the search query is not predictable at all. The user must understand after many attempts, and without any guiding, that he needs to add to the query the name of the city where the position is located (ie. "Bologna"). 9: There should be an algorithm for inserting the names of the bus stops, but it doesn't work properly. 10: The goal is never reached. It redirects the user to Google Maps. 13: The experience is stressful. Understanding how to use the map and the query method requires a lot of attempts. 16: The name of the page differs from the ones that redirect to it. In this page there's no sign of the sidebar, content occupies the entire width of the page.
Tickets page	1: There are too many instruments for controlling the page. The organization of information is redundant. The layout is disorienting. 2: Information overload. Too many different sections for sharing similar information, all in the same page. Download section is useless and unnecessary. 5: Only one language available. Language is inconsistent.

	6: Aesthetics are dated and not attractive at all. Choice of colors is disorienting. Predominance of red makes every section look the same. Colors used inside the pdf do not reflect the ones used on the webpage. 7: Understanding which section you're consulting is difficult and disorienting. 9: There should be an algorithm for inserting the names of the bus stops, but it doesn't work properly. 10: The page is called "Biglietteria", which means Ticket Office. However it is impossible to buy a ticket. It is just an informational page about the costs of tickets. You can reach the goal by buying city cards, but not single tickets. 13: The experience is stressful. It is very easy to misunderstand the information because of the layout. 16: The name of the page differs from the ones that redirect to it. Different sections look too similar. The selection and filtering method is different from all the other, and more efficient, methods used in the other pages.
Chat page	1: The layout changes completely and resembles the one used on online services with registration. 5: Only two languages are available. It is called "Chat", but it is not an actual chat. It is a *Contact Us* page. 6: Aesthetics are dated and not attractive at all. 8. Menu collapsed in full screen view. Log off icons and language settings are weirdly placed at the top center of the page. 11: Select options are available but they are useless. You can only select one option, which is the one you already check before accessing the chat page. 18: Radio buttons act like actual buttons for going on if clicked twice. There's no button for going back in the second part, it only appears in the final part before submitting the message. If you click on the logo you are not redirected to the homepage as on the other pages.
Citypass page	1: The layout changes completely and resembles the one used on online services with registration. 5: Only two languages are available. The page is called "Online services" and it makes no sense, since all the other services are also online. In the form sections verbs are used improperly, i.e. "Select address" is used for specifying a new address. 6: Aesthetics are dated and not attractive at all. We moved from one aesthetic with just one color to a page with eight different colors. Colors convey no meaning.

	7: If you are already logged in it is even more difficult to reach the subscription page. 8. Menu collapsed in full screen view. Log off icons and language settings are weirdly placed at the top center of the page. Select option slide down slides upwards. 11: Breadcrumb with names of pages that are never mentioned before. It is always the same and never shows new progression. 16. The same color is used to indicate completely different sections. 18: There's no button for going back in the second part, it only appears in the final part before submitting the message. If you click on the logo you are not redirected to the homepage as on the other pages. The photograph chosen is not shown.
Registration page	1: The layout changes completely and there's no way of going back to the homepage. It looks like you are on a completely different website. 5: Only two languages are available. The page is called "Online services" and it makes no sense, since all the other services are also online. 6: Aesthetics are dated and not attractive at all. We moved from one aesthetic with just one color to a page with eight different colors. Colors convey no meaning. 8. Menu collapsed in full screen view. Log off icons and language settings are weirdly placed at the top center of the page. Select option slide down slides upwards. 11: Breadcrumb highlights when clicked but does not show the following passages. 14: Gender filling possibilities inside the registration form are culturally outdated. You can only chose to declare biological sex. Non binary or gender non comforming people can't register. 16: The same color is used to indicate completely different sections. Here you can find social media information in the footer, which are not shown in the other pages' footers of the website. 18: If you click on the logo you are not redirected to the homepage as on the other pages.

At the end of this first analysis we have collected 59 violations of guidelines. We decided to list them from the most recurrent to the least recurrent and we have also included the total number of violations for each guideline inside the parenthesis. We have analyzed seven pages, so (7) means the issue is present in every task-oriented page of the website. Guidelines without violations (0) are not included in this list and will be inspected again during the reverse analysis phase.

5. Linguistic Clarity (7)
6. Aesthetic Integrity (7)

1. User Control (6)
16. Consistency (6)
18. Precision (5)
7. Simplicity (4)
8. Predictability (4)
9. Interpretation (4)
11. Technical clarity (4)
2. Human Limitations (3)
13. Fulfillment (3)
10. Accuracy (2)
14. Cultural Propriety (2)
20. Responsiveness (2)

We did the same with the pages, listing them from the most problematic to the least problematic. The number of violations for each page is written inside the parenthesis. Among the analyzed pages, no one respected all the guidelines.

Timetables page (11)
Tickets page (9)
Planning page (9)
Home page (8)
Registration page (8)
Citypass page (8)
Chat page (6)

2.1.4 Reverse analysis

We will now repeat the same systematic exploration of the website, but this time looking at the guidelines with respect to the system. Once again, the evaluation will be based on the functions available within the system and it is independent of expected user. We will proceed by considering every guideline in order to find out which functions breaches it, how often and with what impact. This time we will only write down new problems that have not already been found in the direct analysis process.

GUIDELINE	**VIOLATION**
1. User control	/
2. Human limitations	/
3. Modal integrity	*Homepage*: no auditory stimulus is provided. *Planning page*: no kinesthetic or motor implementation for understanding position inside the map is provided. *Chat page:* no auditory stimulus is provided.
4. Accommodation	*Timetables page:* the service is based on the task rather than on typology of the user.

	Planning page: differences between user groups are not taken into consideration. *Tickets page:* differences between user groups are not taken into consideration. Chat page: the service is based on the task rather than on typology of the user.
5. Linguistic clarity	/
6. Aesthetic integrity	/
7. Simplicity	/
8. Predictability	/
9. Interpretation	*Planning page:* no suggestions are provided for bus stop names or numbers.
10. Accuracy	/
11. Technical clarity	*Tickets page:* the contents inside the page do not correspond to the problem domain they are modeling. Tickets are not available and there's no visual representation of tickets, only written paragraphs. Buttons with underlying text saying "otherwise click here", but they redirect to the same page.
12. Flexibility	*Homepage:* low level of customization. *Timetables page:* low level of customization. *Planning page:* customization is disorienting and not useful. *Tickets page:* no customization available. *Chat page:* no customization available. *Citypass page:* no customization available. *Registration page:* no customization available.
13. Fulfillment	/
14. Cultural propriety	/
15. Suitable tempo	*Timetables page:* it requires too much time. *Planning page:* it requires preliminary time spent in order to understand how the system and the map work. *Tickets page:* buying tickets requires too much time on different platforms and applications.

	Chat page: it requires too much time. *Citypass page:* it requires too much time.
16. Consistency	/
17. User support	*Homepage:* no assistance to usage or learning support is provided. *Timetables page:* no assistance to usage or learning support is provided. *Planning page:* no support is provided in the compilation of search query, the user must figure it out by himself. *Tickets page:* no assistance to usage or learning support is provided. Chat page: no assistance to usage or learning support is provided. *Citypass page:* no assistance to usage or learning support is provided. *Registration page:* no assistance to usage or learning support is provided.
18. Precision	/
19. Forgiveness	*Chat page:* you can go back during the completion of the task, but you can't undo it once it has been sent. *Citypass page:* you can go back during the completion of the task, but you can't undo it once it has been submitted.
20. Responsiveness	*Planning page:* no status is provided about bus stop names correctness. *Chat page:* not enough feedback information about the system status and their task completion. *Citypass page:* not enough feedback information about the system status and their task completion. *Registration page:* not enough feedback information about the system status and their task completion. When present, they are not immediately visible or directly related to the source of the feedback.

At the end of this second analysis, we collected 34 new violations of guidelines, for a total of 93 issues found. We decided to list the guidelines again according to the same criteria applied before. This time, however, we are going to divide the violated guidelines into three groups. We will define "*systematic"* the violations that appear in every single page (7) or in almost everyone (6). On the contrary, violations which appear just once (1) or twice (2) will be called "*rare*". All the other infringements will be addressed as "*common*".

Systematic

5. Linguistic Clarity (7)
6. Aesthetic Integrity (7)
12. Flexibility (7)
17. User support (7)
1. User Control (6)
16. Consistency (6)
20. Responsiveness (6)

Common

18. Precision (5)
15. Suitable tempo (5)
11. Technical clarity (5)

9. Interpretation (5)
4. Accommodation (4)
7. Simplicity (4)
8. Predictability (4)
13. Fulfillment (3)
2. Human Limitations (3)
3. Modal integrity (3)

Rare

10. Accuracy (2)
14. Cultural Propriety (2)
19. Forgiveness (2)

We will now update the numbers for the pages, listing them from the most problematic to the least problematic, and also making a comparison between the numbers before and after the reverse analysis. The number of violations for each page is written inside the parenthesis. Among the analyzed pages, no one respected all the guidelines.

Direct analysis

Timetables page (11)
Tickets page (9)
Planning page (9)
Home page (8)
Registration page (8)
Citypass page (8)
Chat page (6)

Reverse analysis

Planning page (16)
Timetables page (15)
Tickets page (14)
Citypass page (13)
Chat page (13)
Home page (11)
Registration page (11)

2.2 User Testing

In the assessment of existing resources, it is important to understand not only the main features and services offered by already available tools, but also, and maybe mostly, the ways in which users approach and use them. The usability tests seek to better understand the behavior of users in using already existing resources, verifying the frequency and severity of errors with regard to a task of theirs.

2.2.1 Definition of testing protocols

The approach used for the test is the so-called discount or guerrilla usability test. This is less structured than the so-called deluxe test, that involves a large number of participants as well as a team of experts in usability; nonetheless, it proves to have, beyond a cheaper benefit of resources and money, many advantages in effectively identifying and categorizing users' errors and thus providing significant insights for powerful and new design ideas.

Therefore, considering these advantages, combined with the scarcity of budget and timing related to our project, the choice of a discount usability test was unanimous. Furthermore, to conduct this

test, the so-called 'thinking aloud' methodology was chosen, which consists in asking participants to express their actions and thoughts while they try to complete the tasks within the testing.

Three tests have been conducted in different sessions, each of them addressing different people belonging to the critical user segment identified through our research. The subject of the research has been briefly introduced to each of the participants. They received information about content, structure and goals of the testing, and were asked for permission to record audio of the session. In order to return the validity of the test, here their anonymous profiles are defined:

User 1	is a 26 year old girl who lives in Emilia-Romagna and works as a waitress. Due to the fact she arrived in Italy from Ecuador when she was a child, Italian is not her mother tongue but after many years she is able to speak it at a medium-high level. She has good technology skills, uses social media a lot and recently was asked by her boss to manage reservations via a digital platform for the restaurant she works at. She often accompanies her boyfriend to Bologna for medical visits, but never uses buses.
User 2	is a 23-year-old boy in his last year of university. He lives in Reggio Emilia, and is a commuter. Therefore, he knows the city quite well, but does not use buses frequently, as all points of interest for him are within walking distance. He loves to travel and has visited many European cities, always organizing his trips by himself. He is very familiar with travel planning sites and often uses means, such as the train, plane, subway, even in foreign countries.
User 3	is a 40-year-old man who lives in Milan and moves around a lot for work; he is very used to travelling but uses mainly private means of transport. He has visited Bologna as a tourist and to visit some friends. He loves to travel, in Italy and abroad and has also visited many foreign countries. He is used to planning trips and often uses websites to book and buy tickets online.

The participants have been required to perform the following tasks resulting, as previously outlined, as the most relevant for the user segment:

Task 1	Travel calculation: understanding which bus line they have to take given an arrival and a departure point
Task 2	Timetable consultation: understand what time they have to take the bus to get to their destination within a certain time
Task 3	Ticket purchase: understand which fare to buy, how much it costs, and where to buy it

After their completion of the different tasks, participants have been asked to fill a System Usability Scale (SUS) questionnaire comprehending 10 questions, alternatively proposed with positive and negative enunciation, which are asked to respond according to a 5 levels Likert scale. Although its recognized genericity and dirtiness in providing results, this method has been chosen because of its reasonableness and simplicity. Moreover, it has been completed through a Single Easy Question (SEC) asking for the ease of completion of each single proposed task.

Success evaluation criteria

Success of the tests will be measured through the following metrics:

- Task completion rate higher than 75%: completion will be considered as binary data: if the users completes the task successfully they score 1, otherwise they score 0. Reference: https://measuringu.com/task-completion/

- Error-free rate higher than 75%: errors will be treated as binary data: the user either committed a least one error and scores 1, or committed no errors and scores 0. Reference: https://measuringu.com/errors-ux/
- SUS higher than 68%: scores will be calculated following this report https://usabilitygeek.com/how-to-use-the-system-usability-scale-sus-to-evaluate-the-usability-of-your-website/

2.2.2 Testing phase

The user tests have been performed in three different sessions, one for each user. The participants have been informed about the scope and the modality of the test and they have been asked for permission to record their speech.

We asked our users to surf the Tper website imagining a scenario in which they need to program a trip in Bologna using public transport. They were asked to search for a way to understand which bus to take, at which hour in order to get to the destination in time and which ticket they have to buy. They had to explain the steps they take as well as the reasons why they did what they did.

User 1

User 1 surfed the website through her smartphone, a Huawei P smart +. She imagined a scenario in which she has to reach Bologna Fiere before 6pm the day after.

Task 1: travel calculation

The user, from the website homepage, immediately decides to solve this first task by entering the website section named 'Calcola percorso'. Once she clicked on the corresponding button, she enters the section and types 'Bologna Stazione Centrale' in the input box named 'Partenza'. She is a little surprised by the blue clock icon that appears to the right of this same box, wondering if the system was about to propose a more correct way to define that destination. After a few seconds, as the icon has disappeared with no results, she continues entering the destination by typing 'Fiere di Bologna' in the input box named 'Arrivo', without paying too much attention to the clock icon anymore, then clicks on the 'Calcola il percorso'. The user consults the results produced by the search and immediately understands which bus lines she can take (35 or 38), with the respective timetables of the first available buses. She remains a bit confused by the following indication: 'Walk to Central Station - About 2 min' and 'Central Station - 35 - Bus to Rotonda Baroni'; however, by consulting the map, she understands clearly which route to take to reach the stop and take the correct bus.
Task 1 can thus be said to be completed..

Task 2: Timetable consultation

The user initially believes that it is easy to find timetables, as some options were presented to her in the 'Calcola il percorso' section. However, she immediately realizes that, in a scenario in which she has to plan a trip to reach his destination at a certain time of the following day, the information provided is not sufficient. In fact, this section only provides the timetables of the first buses available with respect to the search time, without the possibility of extending the search by date or time. The user thus decides to return to the homepage. From here she clicks on the button in the 'Orari' section. Within the section, she discards the option to select a line category and choose the 'Filtra per data' option, entering the date required by the scenario, then digits the line indicated in the 'Calculate the route' section and clicks on 'Apply '. She has a moment of uncertainty about the completion of the operation, as the system seems to have produced nothing. After a few seconds, click on an icon to the right of the bus line inserted and then on the writing of the line itself. This last option opens the information and updates section on the line, then the user goes back. She clicks again on the icon to the right of the line, but nothing happens. Only later she realizes that the first click has produced the download of a file that she opens from the mobile phone notification curtain. Upon opening the

file she is discouraged by the amount of information and their format (the file is a pdf file with the classic timetables). Above all, she complains that she is not given the possibility to choose a time in any way. Starting to read them, she worries that none of the destinations listed in the file match his search input entered in 'Calculate route'. The user then returns to this section and enters the same input again, and then the destination indicated in the timetable file. Seeing that they are the same, she becomes convinced that they are probably two different ways of calling the same place. She then goes back to the timetable file again, but declares that she does not understand how to look at it. She says she is not very good at checking timetables. The user starts to feel a little uncomfortable. She tries for a few minutes then decides to abound the task.
Due to this fact, Task 2 can be said not completed. Errors preventing the completion of the task are related to the failure to memorize the input entered by the user of the first phase of the search, and therefore the need to memorize the name of the stops, the quantity and the non-user friendly format of the data shown by the website. Furthermore, there is no possibility to query it with respect to a chosen option.

Task 3: Ticket purchase

From the homepage, the user reads all the icons and chooses to click on the one corresponding to the 'Biglietti' section to complete this last task. In this section, the user quickly scrolls down by reading all the titles of the paragraphs on the page, but without finding information on which ticket fare to buy. In particular, she reads the last paragraph of the page aloud: '*on the rates page you will find the details on where to buy the securities*' but decides not to click on the 'rates' link being interested in which one to buy and not where to buy it. She goes back to the 'Calcola il percorso' page again, entering the Departure and Arrival inputs for the fourth time and looking for information on the ticket fare. Failing to find them, still from the 'Calcola il percorso' section, click on the button with a ticket icon in the upper navigation. A page entitled 'Tariffe' opens, with different opening sections. It is defined as the 'Circolare urbana periferica', immediately opens the one entitled 'Area Urbana' and selects Bologna as the area of interest. From here, she selects 'Biglietti' and, reading the various descriptions, she believes she has found the one corresponding to the needed ticket: ordinary ticket at a price of 1.50 euros. Task 3 can thus be said completed.

User 2

User 2 surfed the website through his computer, an Asus of last generation.
The scenario imagined by the user is one in which he must plan a trip to arrive in time for a university exam to be held in a branch of the University, namely the Santa Cristina complex, on Monday 28 June at 9.00.

Task 1: travel calculation

The user, starting from the Homepage, immediately accesses the 'Calcola il tuo percorso' section. Here, he enters his starting point in the 'Partenza' input box, typing 'Bologna Stazione'. When the blue clock icon appears, wait for the site to load your choice, but without getting a satisfactory response. He then tries to type 'Stazione Centrale', but even in this case he cannot get an answer. He decides to leave the input box and move around the map. On the map, he enlarges the section of interest and clicks on the icon of a bus near the Bologna Central Station, without obtaining relevant information and thus closing the pop-up that has opened. He states that he does not understand how to set this as a starting point. Return to the input boxes and try to enter 'Santa Cristina' as the destination, without getting any results yet. The user then claims to try to enter an address that he knows well ('Via Zamboni 38'), to be sure that the problem does not concern the information entered by him but the site itself. Not getting any feedback even with this strategy, he decides to leave the 'Calcola il tuo percorso' section.
Returning to the Homepage, the user enters the 'Orari' section. Here, apply the search filters by category (by entering 'Urban' as it must be in the city) and by date (by entering '28/06', or the date of your exam). After applying the filters, the user consults the results thus obtained, intuitively moving between lines based on the indications of place. Specifically, it only opens lines where it reads a

place it recognizes near its starting or ending point. Following this criterion, Line 15 opens, since it starts from a place, Piazza XX Settembre, which seems close to the station. By clicking on the image of the route, he finds that the line contains a stop of interest to him, namely 'Strada Maggiore', which he remembers to be near the Santa Cristina complex. The user then decides, for safety, to contact an external source, Google Map, to verify this information. Opening Google Map in a new navigation window, he searches for the two reference routes and, discovering that he was right, he feels comfortable enough with this solution.
Therefore, Task 1, suitable for calculating the route and consulting the bus stops, can be considered completed, albeit with the significant help of an external source for consulting the places of the stops. Errors are here related to the complete absence of feedback provided by the website to the input of the users and also no hints on how to insert more correct ones. The input boxes do not provide any hints on possible selectable options or what the error of incorrect input is; while the map, although functional and responsive to user inputs, does not allow you to select a point as a starting or ending point.

Task 2: Timetable consultation

Already in the 'Orari' section, the user clicks on the pdf icon of the timetables corresponding to the chosen Line. He complains that the file is particularly slow to download, but in the end he immediately manages to find the right timing to reach the destination according to his schedules.
Task 2 is therefore completed without major problems.

Task 3: Ticket purchase

Directly from the 'Orari' section, the user uses the contextual navigation to access the 'Biglietti e Abbonamenti' section. Here you will find different rates and, knowing that he already has to move inside the city walls, clicks without a doubt on 'Urbana', then select 'Bologna' and then select 'Ordinary ticket'. He sees that the ticket price is 1.50 euros. He clicks on the ticket, reads the information relating to the use of the ticket and, scrolling down the page, reads that it can also be purchased on board at the price of 2.00 euros or in other ways indicated with icons. He clicks on the icon relating to TPER points and then on the link 'Go to the page with the list of all TPER points' in the relevant pop-up. On the page opened by the link, he reads in the table that there is a Tper point in Piazza XX Settembre, therefore corresponding to its starting point by bus. He decides he will buy his ticket here.
Task 3 can therefore also be considered effectively completed, with the only complaint of the impossibility to buy the ticket online directly from the website.

User 3

User 3 surfed the website through his computer, a Macbook pro. The scenario imagined by the user concerns moving from Bologna airport to the station and then moving inside the city to reach the meeting place with some friends, with whom he has an appointment in Piazza Maggiore at 11 a.m. As he does not know the city well, he organises the route in advance.

Task 1: travel calculation

The user schedules to leave the airport at 9 a.m. on Saturday 26th of June and has to take a transport from the airport to the station. The user, starting from the Homepage, accesses the 'Calcola il tuo percorso' section. Here, he enters his starting point in the 'Partenza' input box, typing 'Aeroporto di Bologna', and in his ending point in the "Arrivo" input box, typing "Stazione Centrale". After that, he clicks on the red button "Calcola il percorso". The search returns no results and immediately below the button just clicked is the message 'Per ulteriori opzioni di ricerca consulta direttamente Google Map'. Not wanting to leave the site, the user goes back to the homepage and sees the banner

dedicated to transport from Marconi Airport to the station; he clicks on the white button above the image with the words "Find out more".
The search returns no results and immediately below the button just clicked is the message 'For further search options, please consult Google Map directly'. Not wanting to leave the site, the user goes back to the homepage and sees the banner dedicated to transport from Marconi Airport to the station clicks on the white button above the image with the words "Find out more". At this point the page of the Tper website dedicated to the Marconi express, also called People Mover, the train dedicated to transport to and from the airport from the central station, opens up. From there he consults information about the timetables and ticket rates. We can therefore say that, although the first attempt was unsuccessful, the user managed to complete the task by remaining on the Tper website.

Task 2: ticket purchase

Directly from the previous section, i.e. the page dedicated to the transport service from the airport to Bologna station, the user has selected the link to the Marconi Express direct site. Here, in addition to seeing the various train stops, the user can also directly purchase a ticket. The task can be considered as completed, but the user had to be redirected to another site, also within the transport systems of the Emilia Romagna Region.

Task 3: timetable consultation

At this point the user has to figure out, once at the station, which bus to take to go to Piazza Maggiore, where he will meet his friends. From the homepage of the site, he clicks on "Percorsi e orari". In the input area in which to write the name of the terminus or filter the names of the lines, the user, who does not know the city, tries to write the name of the place where he has to go. The search is unsuccessful. The user tries again using the "Calcola il percorso" section as before and enters "Stazione centrale" as the starting destination and "Piazza Maggiore" as the arrival destination, but again the user is sent back to Google maps. The user is therefore forced to use Google maps to calculate the route from the station to the city centre. The task can be said to be completed, even if the solution provided by Tper is an alternative resource for the lack of the route calculation service.

2.2.3 Post testing phase

After having conducted all the user tests, it has been necessary to analyze their results in order to understand which are the main problems of the website.

Task-completion rate

Although considering task completion as a binary datum (1 if the task has been successfully completed, 0 otherwise), user tests have raised the problem of how to consider those tasks which have been completed only by recurring to the aid of external resources.

	User 1	User 2	User 3
Task 1	completed	completed (with the aid of external resources)	completed
Task 2	not completed	completed	completed

Task 3	completed	completed	completed (with the aid of external resources)

This issue is even more complicated due to the fact that User 2 recurred to external resources for his own choice, while User 3 accessed them after the suggestion of Tper website. In the first case, it can be said that the Tper website is actually missing information without which the task would not have been completed, while in the second one it is the website itself to provide an alternative solution. Due to this reason, although 2 tasks on 9 have been completed by recurring to external resources (and actually the same resource, Google Map), we have decided to consider as completed only the one where external resource were reached from Tper website. In conclusion, we have 7/9 tasks which have been successfully completed, which provides a task completion rate of 77%.

	User 1	User 2	User 3
Task 1	completed	completed (with the aid of external resources)	completed
Task 2	not completed	completed	completed
Task 3	completed	completed	completed (with the aid of external resources)

Error-free rate

Error-free rate is 44%

	User 1	User 2	User 3
Task 1	non-critical errors	critical errors	critical errors
Task 2	critical errors	no errors	no errors
Task 3	no errors	no errors	critical errors

SUS score

SUS score is: 39,16.

2.2.4 Curves of urgency

The analysis of the results of the user tests, integrated with the previously conducted task analysis, was functional to the evaluation of errors and their categorization on the basis of the priority of their solution.
The evaluation of the errors was conducted through the creation of a table showing all the errors identified by our expert user and the actual feedback that they have had on users during the user tests. Three different scores have then been assigned to each of them, based on:

- **Frequency:** the number of different users by whom the problem is noticed.
  The scores have been assigned within a range of 4 users: the 3 people who have conducted the user tests and the expert users himself.

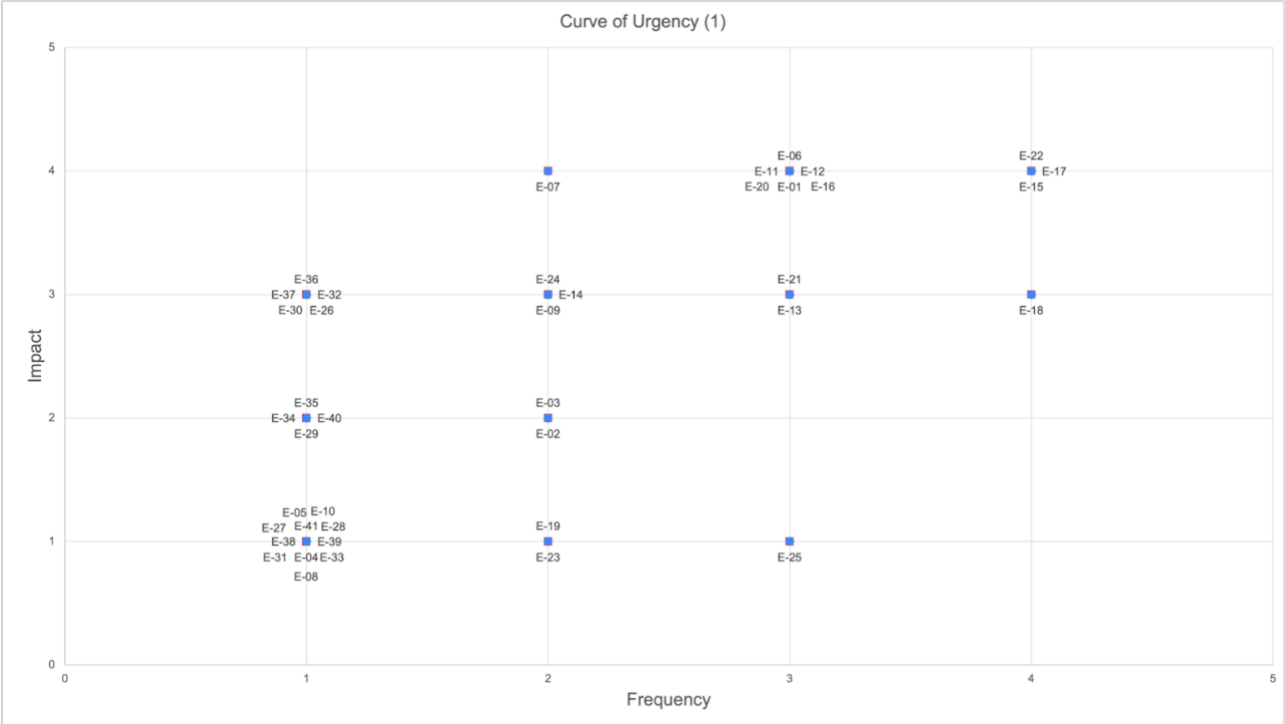
- **Impact:** the effect the problem has on completing the task.
  Nielsen Severity Scale is a unidimensional scale that has a range of 5 points from 0-4:
  - 0 = I don't agree that this is a usability problem at all
  - 1 = Cosmetic problem only: need not be fixed unless extra time is available on project
  - 2 = Minor usability problem: fixing this should be given low priority
  - 3 = Major usability problem: important to fix, so should be given high priority
  - 4 = Usability catastrophe: imperative to fix this before product can be released

  All the scores have been assigned after having been discussed by the member of our team that conducted the task analysis and the one that conducted the user tests. No relevant disagreements have been raised, due to the fact that the errors impacted homogeneously both on the expert user and on the beginners.

- **Persistence:** the number and the relevance of the tasks that are affected by the problem. For maintaining the results homogeneous with the previous metrics, we decided to adopt a 0-5 scale for persistence.
  - 0 = I don’t agree that this problem has impact on any of the tasks
  - 1 = It affects only one task, where the task is marginal
  - 2 = It affects more than one marginal tasks
  - 3 = It affects only one task where the task is relevant
  - 4 = It affects any of the subsequent tasks and avoids the achievement of the goal

  The assignment of the scores has been conducted following the same method as above.

Finally, the scores have been employed in building the curve of urgency. Here below we provide a graphical representation of the relevance of the errors on the use of the system that contributes in understanding which ones should be given higher priority of solution to. Our curve of urgency is based on the evaluation of the impact and the frequency of the errors. We set the severity threshold at impact=2 and frequency=3.


Curve of Urgency (1)
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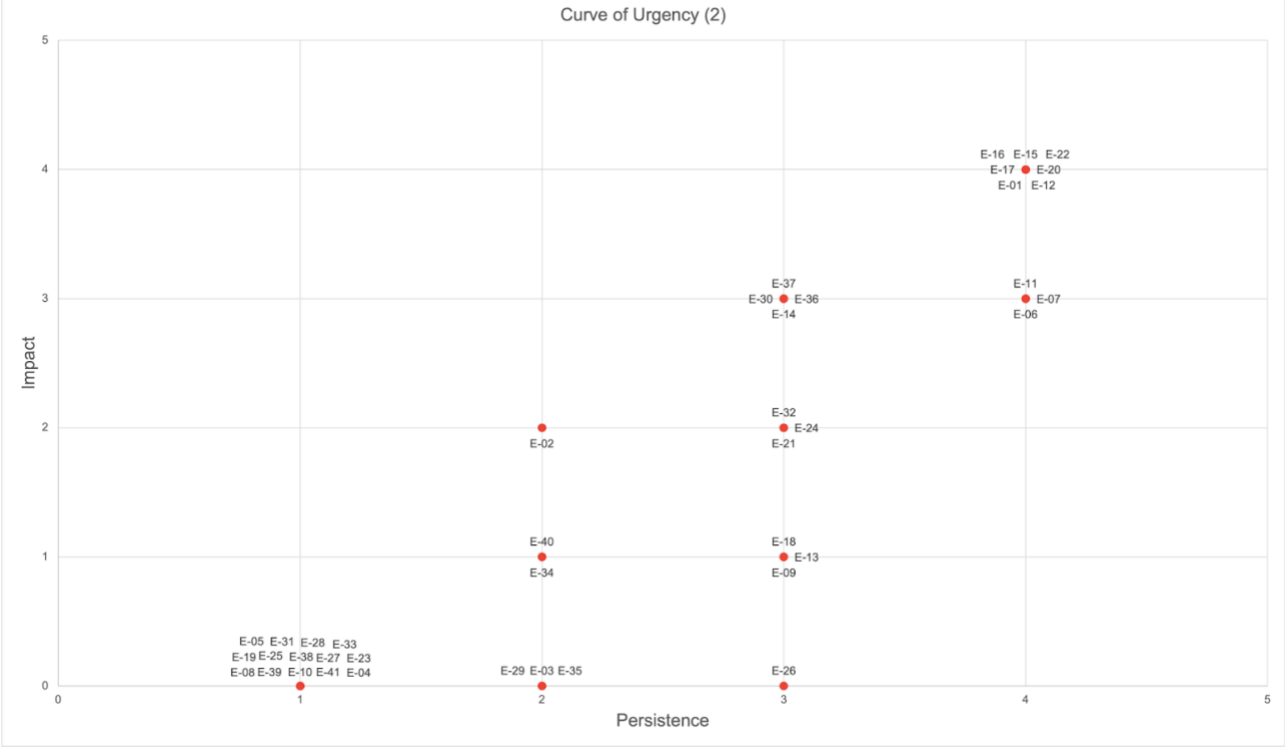
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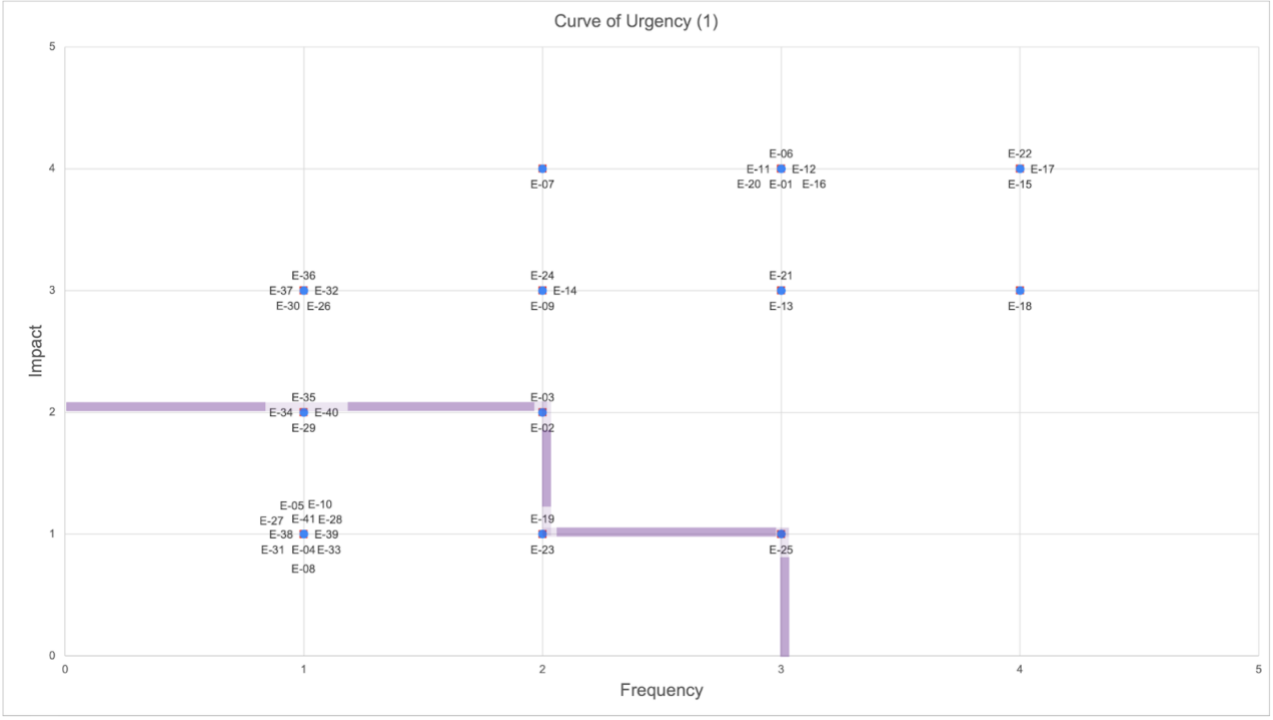
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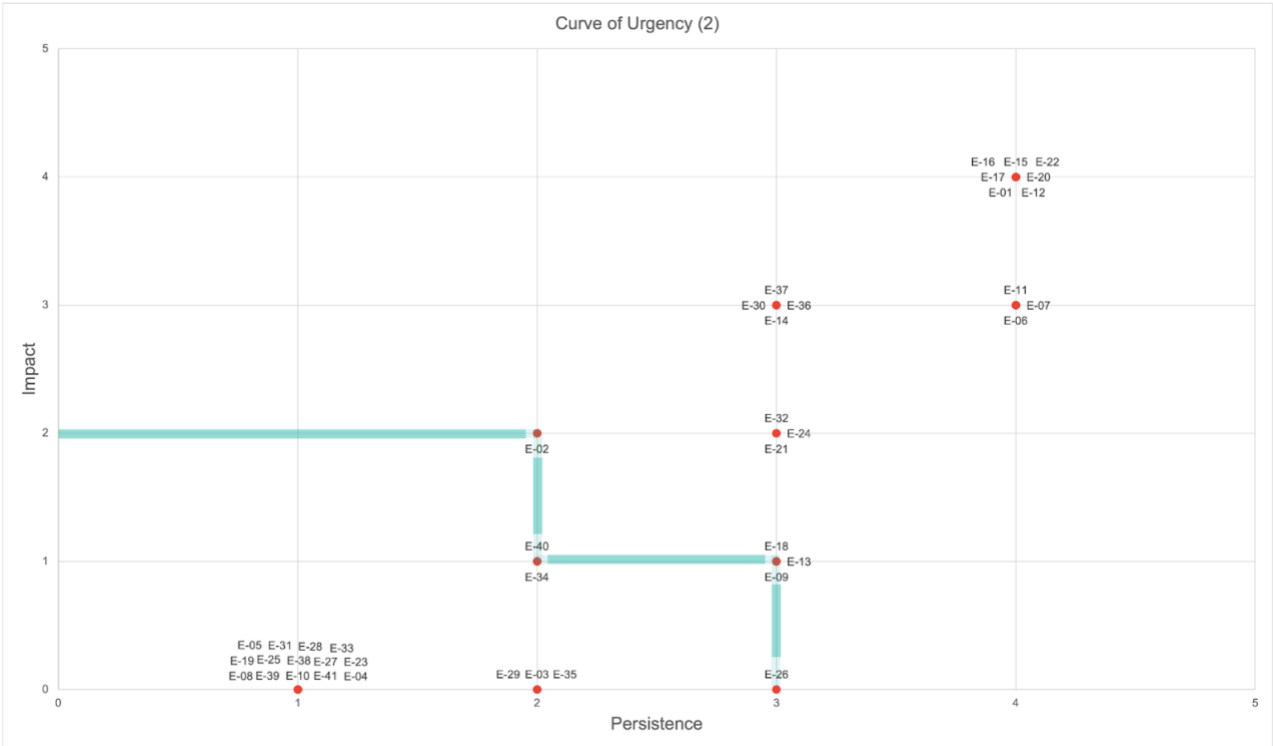
Curve of Urgency (2)
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3. Feasibility study

3.1 Context of use

The Context of Use represents the actual conditions under which our final design will be used. This section is in fact drafted on the basis of the data analyzed in the ethnographic and user testing phase, in order to ensure that all factors that relate to the use of the system are identified before design work starts and to provide a basis for designing later usability tests. Accordingly, we will here present the information about the intended users, their tasks, and the technical, cultural and environmental constraints related to the usage of the service.

3.1.1 Intended users

The users identified for this platform are adult people between 35 and 55 years of age. They can be male, female or identify as any gender. They live outside the metropolitan city of Bologna. In particular, they live outside Bologna but they have the possibility of having an accomodation, owned or rented, within the borders of Emilia-Romagna. Their native language is mostly Italian, but they are able to speak another language without much problems. The general level of instruction is very high, with a majority of users being graduates. They work as employees for private companies or inside public institutions and have a low or medium income.

They use the Internet every day. They prefer using mobile applications over navigating the web with a computer, especially for carrying out daily tasks. They mostly buy online, trust e-commerce services and electronic payments for planning out visits, trips, flights and more. They are subscribed to many online services and use electronic tickets for concerts, medical check-ups, post office queues and movie theatres. They love to schedule the calendar for the date in advance and to have everything under control.

They usually do not use public transportation and when they do so, occasionally, they carry out an activity which deviates from the range of standard daytime duties. However, on these occasions, they find public transportation to be highly reliable. They have a driving license, but are not used to driving in big cities and don’t want to lose time or energy in finding a free parking spot. They also are not willing to spend a lot of money for parking and do not want to face the problem of limited traffic areas or special day restrictions. This would affect their great organization skills and make them late to the unusual appointment they have for the day.

3.1.2 Tasks

As anticipated in the task analysis phase, we have chosen to highlight the tasks that we believe are fundamental in order to perform a visit or to accomplish the use of public transportation in the best and the easiest way possible. The following tasks are listed from a sequential perspective, going from the most essential to the least fundamental in the context of a day by day use of the service.

- Registration
- Plan a small route
- Plan a visit
- Check timetables
- Check information about bus lines
- Check information about bus stops
- Check real-time arrival timings
- Buy a ticket

- Buy a citypass
- Buy a subscription pass
- Renew subscription pass
- Ask for help/Chat

3.1.3 Technical constraints

The services are provided through a website, so the user must possess a smartphone, a computer or a smart device able to connect to the Internet. An internet connection is of course required as well. Access to the main sections of the website do not require any authentication, with the exception of the *Online services* area. In case of application development, the user must have the app already installed and logged in on its device. The user must also have a credit card or a debit card connected to an account for online payment services that supports online money transfers, and serves as an electronic alternative to traditional paper methods like checks and money orders. The user has also to make sure to have a device which is able to share its real-time location with other services and agree to do that.

3.1.4 Cultural constraints

The user must have a clear understanding of how public transportation systems work in modern day cities. He needs to be acquaintanced with the concept and operations related to online e-commerce systems. Having previous experience in systems that allow online planning and buying plays a critical role in improving accessibility for all users. According to the data analyzed most of the users are Italian. However, more languages should be integrated. The user should therefore have a clear understanding of at least one of these languages: Italian, English, German, Spanish, French. There are no legal constraints regarding the age of the users.

3.1.5 Environmental constraints

Environmental distractions can have a direct effect on mobile or website usability, so a calm and isolated environment should be ideal. Different viewports and device screen sizes may also influence the usability.

3.2 Scenarios

Scenario 1: work event

Who: Stefano
Where: on a train
With whom: with his colleagues
With device: personal tablet

Stefano is on the train headed towards Bologna. This is one of the most important weeks of the year for people who work in the makeup industry. He and his colleagues have booked tickets for Cosmoprof, the most important international show dedicated to the cosmetics supply chain and all of its various components. They decided to take the train from Milan and to arrive in the city early in the morning. While travelling, he has been instructed to understand how to arrive at the location. He tries to book some cars using the Uber app, but he surprisingly discovers that there are not enough cars to bring them all to the fair. He also tries to reserve a taxi. But, as he tries, he finds out that all the taxis have been booked for their arrival hour because of the incredibly high number of people

that are trying to reach the fair in the morning. Undeterred, he looks for the information section on the Cosmoprof website. The *How To Reach Us* section of the general information page says:

> Bologna Central Station is one of the largest railway hubs at national and European level. It is only 10 minutes from the Exhibition Center and it is connected by bus to the entrances Costituzione and Aldo Moro. BUS lines: Railway Station > Exhibition Centre = lines 35 and 38 Exhibition Centre > Railway Station = lines 35 and 39 For more information visit TPER.IT.

He follows the link provided inside the page and he is redirected to the Tper page. He immediately checks for line 35 and calculates the route. It will take 14 minutes and there are busses every ten minutes! Stefano buys tickets for himself and for his colleagues. Now they can enjoy the train ride without worries.

Scenario 2: medical checkup

Who: Giorgia
Where: in her home
With whom: alone
With device: personal computer

Giorgia is planning her week and sees that her son's medical checkup to a specialized dentist in Bologna is on the agenda in a few days. They usually go to their hometown dental practice, but during the last check-up the dentist advised her to bring him to this new site for a more thorough check-up. Since she doesn't like the idea of driving in Bologna traffic, she decides to plan her journey using public transport. Therefore, she plans to arrive in Bologna with her son by train and then they move by bus to reach the dental practice. Giorgia types in her usual search engine 'Bologna urban buses' and opens the first search result: the Tper official website. Giorgia then calculates the route that she and her son will have to take starting from the station to get to the practice. Then she consults the timetables in order to arrive at their destination well in advance. Finally, she looks at where and how to buy the ticket and looks for a reduced fare for underage children. From time to time, she finds what she is looking for, Giorgia marks it on the agenda, sure that she will consult that information the day before the visit and during the journey itself.

Scenario 3: touristic visit

Who: Sofia
Where: Venice
With whom: with her partner
With device: personal smartphone

Sofia’s day is almost over. She visited Venice today, one of the many stages of her Italian vlogging tour, and she’s very content with the videos she shot during the visiting day. Now it is time to look forward to the next stop: Bologna. She already booked the train tickets for the next day and the only thing she needs to do is look for some interesting facts about the city. She wants to film all the unusual places and suggest them to her YouTube viewers. Sofia is very tired, so she decides to lay on the bed with her smartphone and check information in some blogs, through social media and also on the old school paper travel guide her boyfriend decided to bring in the suitcase. After a while, she discovers something called “The Seven Secrets of Bologna”. Intrigued, she discovers that it consists of seven peculiar places hidden inside the city. Basically, a map of alternative things to see, some of which are also quite tasty! The idea sounds great, she will create a vlog about all these places, showing also her movements from one place to the other. Some of them are quite near and some

others are instead very distant from each other. She immediately clicks on Google Maps, but if she types in “Seven secrets Bologna” she gets nothing in return. She doesn't trust it anymore; during her travels it has failed her several times and made her lose so much time and scenes to film. She then looks for the official app for public transportation inside the city. She decides to check for the closest stop to the hotel. She also checks the route of the bus line and all the other bus stops. It looks like she got the perfect match. Finally, she decides to buy two citypasses, one for herself and one for her boyfriend. Now she’s ready to enjoy a well-earned rest.

3.3 Personas

Name	Stefano Mangiagalli
Age	53
Gender	Man
Marital status	Divorced
Family status	Two daughters
Location	Bergamo, Italy
Job	Cosmetics Sales Representative
Education level	High School diploma
Income level	€ 37,000 per year
Driving license	Yes
Language	Italian, English, Chinese

Personality type	**Moving habits**
Personality Stefano is truly a smart man. Wherever he goes he creates order, follows the rules, and works to ensure that his work and the work of those around him is completed to the highest standards. He projects natural authority, but sometimes he expects this authority to be abided unconditionally, resisting change and demanding that things be done by the book.	**Working days** He needs to drive every day to the cosmetic company he works for and for daily activities. He doesnt love to drive or to stay in the car for hours. He specifically hates having to find parking spots and long traffic lines on the highway. He usually takes the train for longer movements when he’s with his colleagues.

Strengths Dedicated Strong willed Direct Enjoys creating order Excellent organizer **Weaknesses** Inflexible Stubborn Uncomfortable with unusual situations Difficult to relax Difficulty in expressing emotions	**Free time** During the weekends Stefano prefers using the bike or going for a walk in his neighborhood. He loves sports, playing in the open air or going out in nature. **Environmental awareness** He is very environmentally aware and goes to ecology strikes whenever he can with her daughters. He is interested in eco-friendly and sustainable companies. When he can, he always makes the most ecological choice possible.
Technology attitude	**Needs & Goals**
Online behaviour Stefano spends more than 8 hours per day on his devices. He uses both his smartphone, when he's not working, or his iPad, when he is in the office or when he is working abroad. He prefers applications over navigating the web with a computer. He buys online almost every day, especially delivery food or flight tickets. He loves apps for organizing the day and improving his productivity. **Platforms & apps** Linkedin Google Calendar Facebook Telegram Amazon Zoom Google Meet Uber Eats	**Personal** He's interested in improving his presentation and public speaking skills. He set a goal to wake up as early as 5:00 am every day, to exercise at least four times a week and to read more books. He's also very interested in increasing his productivity by learning to manage or beat his social media addiction. **Career** Networking events are fundamental for him, he's interested in connecting with old colleagues and meeting new people. He's willing to gain a general knowledge of everything he can learn about industry. His ultimate goal is to lead in his career or organization and establish the steps to achieve a leadership role.

Name	Giorgia Morelli
Age	38
Gender	Female
Marital status	Married
Family status	A 11-year-old child
Location	Castelfranco Emilia, Italy
Job	Mathematics teacher
Education level	Master Degree in Mathematics
Income level	€ 22,000 per year
Driving license	Yes
Language	Italian, English

Personality type	**Moving habits**
Personality Giorgia is a sensible and affectionate woman, with a strong practical sense and a good sense of humor. Although very sensitive, especially when it comes to helping her loved ones, she has excellent analytical skills that allow her to always have the situation in hand. She would do anything for her husband and son, but she also knows how to make time to spend with a group of friends with whom she meets every week to chat and share reading tips. She loves her job, even if it is very stressful at times. **Strengths** Supportive Reliable and Patient Loyal and Hard-Working Good Practical Skills **Weaknesses** Sometimes too rational	**Working days** Giorgia uses the car as little as possible. She doesn't like to drive, especially in big cities or for long journeys. That is why she goes to work by bicycle or on foot, and in the same way, as much as possible, she runs daily errands. However, he uses the car to take his son to soccer practice and to go shopping. **Free time** Giorgia likes to take a walk with her husband and son to relieve the stress of work and keep a healthy lifestyle. Sometimes they take a day out for the whole family by organizing small trips around their region. **Environmental awareness** Giorgia is very worried about her son's future due to big climate changes. She tries to contribute in a small way, reducing plastic

Takes Things Too Personally	consumption and using the car as little as possible.
Technology attitude	**Needs & Goals**
Online behaviour Giorgia often uses the computer for work. She mainly uses programs that help her prepare for lessons or register online, but she is also perfectly capable of surfing the Internet to find out about her interests and needs. For example, she organized her last vacation with the family by searching for all the places of interest on the Internet and also booking some visits. **Platforms & apps** Online register and work-related accounts Post app Bank app Whatsapp	**Personal** Giorgia is very keen to be a present mother. She wants the best for her loved ones and for herself. **Career** Giorgia wants to be a good teacher. For this, he keeps up to date and tries to understand the needs of his students even beyond the grades.

Name	Sofia Santiago Ramos
Age	33
Gender	Female
Marital status	Engaged
Family status	No children
Location	Valencia, Spain
Job	Vlogger
Education level	High School diploma
Income level	€ 30,000 per year (Unstable)
Driving license	Yes
Language	Spanish, Catalan, English, French, Italian

Personality type	Moving habits
Personality Sofia is a very energetic and resourceful woman. She is fiercely independent, and much more than stability and security, she craves creativity and freedom. She couldn't live without travelling, so she decided to leave her part-time job and to open her Youtube channel where she shares her travelling experiences. She is cheerful and supportive, always sharing and developing ideas, and staying open-minded, taking in others' thoughts and feelings. She is a true free spirit. **Strengths** Curious Observant Enthusiastic Excellent Communicator Friendly **Weaknesses** Overthinking Easily Stressed Highly Emotional Prone to Burnout	**Working days** She does not have a fixed routine. It depends on the country she is visiting at the moment. She does not own a personal car, but she's willing to drive one if she can rent one. She prefers to move fast and to plan her movements early, in order to manage her time and respect her schedule. She an hardcore walker and never gets tired of exploring new ways of moving. **Free time** During her free time Sofia prefers relaxing and staying at home with her boyfriend. She avoids public transportation during her free days. **Environmental awareness** Given the frequency and number of her travels, Sofia is worried about the impact of her actions on nature. Her videos show clear preferences for places characterized by biodiversity, natural quiet and absence of other people, reflecting a desire to distance herself from contemporary urban society.
Technology attitude	**Needs & Goals**
Online behaviour Sofia spends more than 10 hours per day on her devices. When travelling, she uses her smartphone to keep in touch with her followers and to get information about the locations she is visiting. She is interested in curating her social media feed as much as possible and to update everyone about her current location. She spends a lot of time on editing tools. She loves to get information from other blogs, especially the local ones. **Platforms & apps** Instagram YouTube Twitter Planoly Adobe Lightroom Wordpress	**Personal** Sofia is very keen to always earn more. She's interested in religions, languages and cultures. She loves travelling, but she's also looking for a place where to settle down and spend her golden years. She always thinks about buying a house and opening up her own studio. **Career** Sofia is willing to collaborate with social influencers to co-create high-quality, engaging content that can increase traffic to her YouTube page. Her great desire is to become a brand ambassador for travelling agencies and travel even more.

Name	Niccolò Mezzadri
Age	18
Gender	Male
Marital status	Celibate
Family status	with a younger sister
Location	Bologna
Job	Student
Education level	Middle School diploma
Income level	€ 0 per year
Driving license	No
Language	Italian, English a little bit

Personality type	**Moving habits**
Personality Niccolà lives in San Lazzaro and studies in a technical institute in Bologna. Studying is not his passion, but he likes to go to school because he has a lot of fun with his classmates. In fact, he is a natural entertainer: he's sociable, outgoing, fun, talkative, witty, and almost never runs out of things to discuss. He plays rugby and enjoys playing every kind of sport. He is always full of ideas and things to do, so he does not like to waste his time on useless activities. **Strengths** Bold Practical Observant Excellent People Skills **Weaknesses** Strongly emotional Conflict-Averse	**Working days** Niccolò needs to take the bus every day to go to school. His journey is quite long, since it takes about 50 minutes to go from his home to the school. He has an extra-urban pass that his mom renews every year. Also, he drives his motor scooter to go to rugby practice twice a week and since some friends of his have recently taken the driving licence, he is now usul to share the trip with them. **Free time** Niccolò doesn't travel much in his spare time. Being very busy during the week and on weekends for matches, he uses his little free time to rest. From time to time he goes to Bologna even on weekends, taking advantage of the annual bus pass. **Environmental awareness** Niccolò is aware of the gravity of the contemporary environmental situation

Easily Bored Poor Long-Term Planners Unfocused	because he studied it at school. Personally, he is careful not to waste water and not to use too much water, but he is not yet fully aware of how much his movements impact on the environment.
Technology attitude	**Needs & Goals**
Online behaviour Niccolò uses social media a lot, mostly to keep in touch with friends and to follow his sports idols. Every now and then he plays video games, even if he is not a big fan of them. He lives in symbiosis with his mobile phone and always has some conversation going on on Whatsapp. **Platforms & apps** Whatsapp Instagram Tiktok Twitch	**Personal** Niccolò needs to know that he is as important to his friends as they are to him. His goals for this year are to get his team at least to the podium in the regional rugby tournament and to have managed to organize a holiday with his friends after the High school final exam. **Career** The only problem that Niccolò just can't solve thanks to his gab and sympathy is the one with mathematics. Although he has been working hard since the second semester, he is afraid of risking failure by the end of the year.

4. Design proposal

4.1 Design model

By considering the results given by the previously conducted research, we have realized that the best way to redesign the information and services presented in the Tper website was through the realization of an associated official application. Indeed, the choice of a mobile application would answer to the users habits of accessing everyday services through their smartphones and at the same time to their exigency of reliability and clarity in the retrieved information.

The adopted design model: CAO=S
In designing our application, we decided to use the so-called CA=OS design model, i.e. a draft model for low-budget projects based on a simplified implementation of the goal-oriented model. CAO=S has been considered the best choice due to the economical constraints of our project, which do not allow us to employ budget for a systematic analysis of the target users nor to involve an outside usability expert, and to its strategic approach that allows to reach a good quality development even to a team without specific experience in the field of usability. Indeed, CAO=S offers a parameterized design process of the overall project that, if correctly employed, could make the designers avoid the most common major usability errors. This is based on the study of the information types (**Concepts**) that the application must manipulate on behalf of the user types (**Actors**) by providing commands (**Operations**). The analysis of these three factors is then aimed at generating the three types of **Structures** managed by the model: Views (display screens of properties of the concepts), Data structures (patterns for the persistent storage of concepts' properties) and Navigation (mechanisms for navigating from one view to another).
Nonetheless, the CAO=S model has been enriched through specifical individual researches whenever felt the necessity.

4.2 Information architecture

Information Architecture aims at organizing, structuring and labeling content within digital products so that users would easily adjust to the functionality of the products and could find everything they need without big effort. IA is thus focused on how information items are related to each other within the system and how they can be managed as part of the system itself.

The IA assumes a strong relevance in a context such as that of the Tper website in which a lot of information is provided to the user, who must be able to filter it according to their exigencies and purposes. As highlighted through the user tests, managing to plan a trip with public transport is a complex task for the user, who needs to find the right combination of lines, timings and rates suitable for them. This information needs to be reliable, easily queryable with respect to the user's needs and, finally, provided in a sequence that has to be coherent with the user's mental model. The transport company, on the other hand, has the duty to provide all the information that may be useful for its whole public and at the same time structure it in such a way it is adaptable to individual exigencies.
A proper IA is thus necessary both to improve the user experience in planning a trip and to allow Tper company to organize and display their information in a consistent and most of all useful manner.

Information ecology
Information ecology is a metaphor realized by Davenport and Prusak in order to represent the strong connection between the different aspects of digital products the IA has to consider. Particularly, they refer to the close relationship that exists between the context, the content and the users of a system.

The Context

The Tper website is undoubtedly classifiable as a public utility website providing information about public transport. It has to take in consideration a wide public and a huge variety of users with different needs and capabilities. Not only the Tper website users have many different scopes in using its information (and the information they need are actually referred to unique situations), but they also have different technological as well as cultural constraints. For these reasons, the Tper app has to maintain a simple, linear and universally understandable language, and at the same time manage a serious, reliable tone that is required to be adequate for the communication of a public body.

The Content

The Tper app, as well as the website, has to manage a great amount of content and heterogeneous information. They can be analysed regarding different aspects:

- **Volume**: the volume of the content of the website is very large, as it displays information related to trip planning (eight pages only for the consultation of the lines, each with images of the paths and a multiple page pdf document with the respective timings), information related to ticket rates, to sell points, to parking and sharing points, a part from the online services, the reserved area and the news section.
- **Control**: the data is managed by the centralized control of the company itself.
- **Format**: the main part of the data are provided in a textual format, nonetheless some of them are dynamically provided by the webpages (i.e. indications about the lines) and some others are stored in pdf format (i.e. timetables). Also, the website provides information about line stops in two different ways: on the one hand through fixed images of the line route, which cannot be queries of interactively consulted, and on the other through an interactive map where the user can visualize their position and search for points of interest.
- **Structure**: the data are deeply granular. In order to provide information about the bus lines and timetables, for example, the Tper website has to display data related to each single stop and each single timing of each line. The level of the details is extremely high and data cannot be classified out of a general categorization.
- **Dynamicity**: finally, some of the data provided by the website can be considered permanent or long-term ones (e.g. lines, timetables, stops indications) while some others are short-term ones and need continuous changements and upgradings (e.g. news and situational information about the lines).

The Users

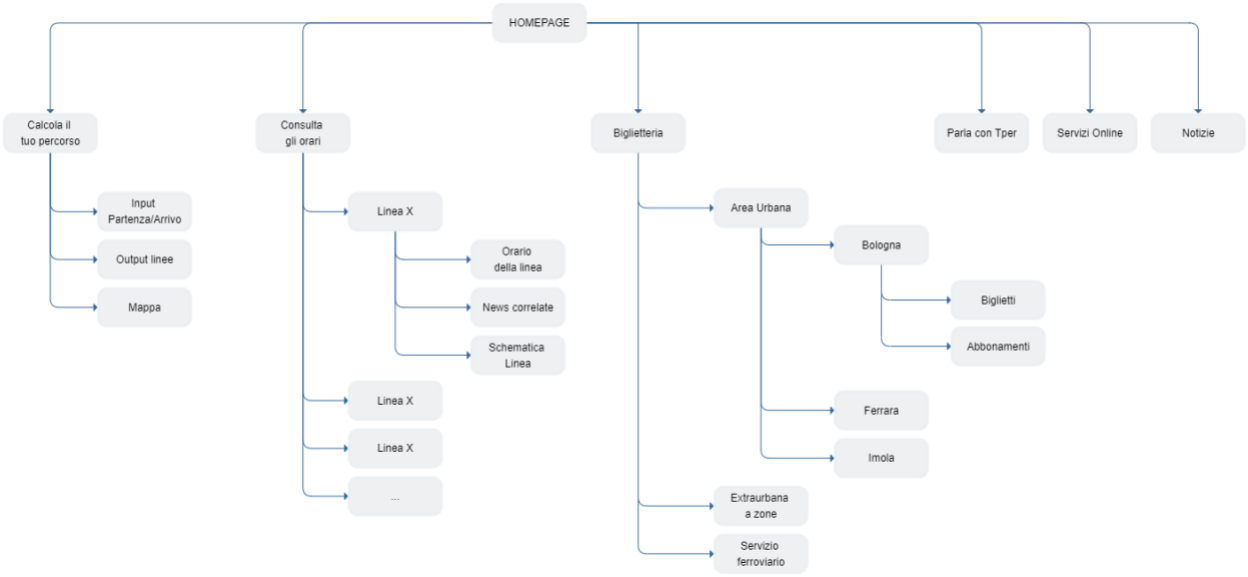
As previously outlined, the users the Tper app has to address are heterogeneous for background, domain knowledge, ethnographic profiles and technological attitude. However, all of them, beyond their individual goals in using the system, are united by the same information-seeking behaviour. Indeed, all of them have the need to retrieve particular and punctual information through the app. May they be looking for information on a bus line or on the cost of a subscription or on news, each of the users consults the official app in search of specific information in response to a specific question.

The approach to IA

The Tper website approach to IA

Before proposing an approach to the IA of our application, we analyzed how the information is structured and organized in the current Tper website.

The approach the current version of the website has adopted seems to be classifiable as a top-down approach, with a general formulation of the structure of the website as divided in main sections reachable from the Homepage (*Calcola il tuo percorso*, *Orari*, *Biglietteria*, *Parla con Tper*, *Servizi Online* e *Notizie*) each of which is then deepened with various level of details.



Nonetheless, navigating the Tper website seeking for information is difficult and sometimes misleading. Although the role and content of each dedicated section is quite clear and predictable by the user, confusion is generated by some incoherences and abstruseness in the way information is organized and displayed within the sections themselves. Particularly, some of the major problems related to IA highlighted by our analysis and user tests are:

- incoherences between the homepage entries and the main navigation ones, e.g. the same page related to line timetables is reachable by clicking on the button 'Orari' in the homepage and on the link 'Percorsi e Orari' in the main navigation.
- confusion in retrieving bus lines in the ‘Percorsi e Orari’ section and in understanding timings in the PDF documents related to each line given by the overload of information the user is invested by, the non-user friendly format they are provided in and finally the absence of a consistent structure of the data.
- inconsistency between the way the information is provided and the user mental model, e.g. the user has to search in three different sections (Calcola il tuo percorso, Orari and Biglietteria) the information they need to organize their route, in a flow that obliges them to memorize the information in passing to the following section, without any hint on how to store and retrieve it, and with the grat risk of losing the information itself
- unfounded assumptions about the user's knowledges, e.g. in the Ticket office section, no information is given about the way in which a user should check for a ticket rate, but it is assumed that they already know what they are looking for

The redesigning approach

The redesigning of the Tper website IA into one more suitable for a mobile application properly aims at solving the aforementioned problems. Particularly, our main scope in designing the IA are:

- Solve incoherences in the entries
- Make the flow coherent with the user mental model
- Provide all the information related to the same trip together
- Provide easier ways to query the system with respect to individual exigencies related to space and time
- Merge the three section related to the organization of a trip (Calcola, Orari e Tariffe) in a single one
- Provide information about which step of the process the user is addressing in every moment

For all these reasons, we decided to adopt a top-down approach for the design of the IA, in a way that would have allowed us to have a clear initial idea of the various sections in which to divide the information and dedicate oneself to structuring them within them only at a later time.

Structuring

Firstly, we structured our data by determining their relationships among them and between the context. As we previously outlined, the Tper website provides a large amount of very different information. Particularly, it provides information about:

- bus lines, terminals and stops
- timings and differences in timings along the year
- ticket rates, selling points and rate zones
- subscriptions
- constant news and updates on the status of the lines
- real-time information on the bus route

Organizing

Secondly, we needed to organize the information in sections which are coherent for the information provided and consistent with the user mental model. In doing that, we realized that the provided information can be divided in four different categories with respect to what is the goal of the user while surfing the website. Indeed, they may search for:

- *planning a route*: and therefore they need information about lines, timings and ticket, plus optional real-time information on the bus route;
- *make or renew a subscription*: and therefore need information on prices and subscription categories;
- *general information about lines and timings*: and therefore they need information about situational updates and news, number and timings of the stops;
- *general information about a ticket rate* they may be interested in buying: and therefore they need general information about the ticket rates, the rate zones and all the possible options

Classifying and labeling

Then, we decided the best way to group all these components into distinct categories which have to be clearly labeled. The final definitions we reached:

- *Calcola il tuo percorso*
- *Linee e orari*
- *Abbonamenti*
- *Promozioni e Tariffe*

Making findable

In order to make the information findable, we needed to make the user able to predict where to search for them in the application. We decided to realize four different sections (the ones described in 4.3.2.3) in the homepage each of which is identified by a clear and explicit role that allows the user to understand which kind of content they may find in them. In each of the sections, we then preferred to realize a sequential flow of navigation that guides the user in browsing the information and avoids information overload. The layout of each single page is composed of few and well-identified elements among which the user can choose without the need of browsing aids or contextual navigation.

Navigation

As previously outlined, the navigation of the application is sequential rather than hierarchical. After having entered a section from the homepage, the user is usually guided step-by-step through all the activities necessary to complete their task. This aspect of the navigation allows the user to dedicate little effort in choosing which action to do and, even most relevantly, stores every information inserted in the previous step so that they are not required to memorize it nor to go back in order to retrieve it again, with the risk of losing it.
Furthermore, navigation aids have been developed in order to allow the user to constantly understand which step they are at.

Search

Obviously, in organizing a trip that must correspond to the particular needs of a user, the search for timely and precise information plays a very important role. However, despite the user's need to carry out searches that are absolutely individual, we have tried to provide him with some ways that could guide him in his choice. For example, the input to calculate the departure of your journey in the 'Calculate your route' section can be entered not only manually (stop or address), but also chosen from several pre-established categories, such as 'My position' , 'Favorites', 'Points of Interest'. Likewise, each research action is enriched with aids that not only guide the user in selecting the inputs to be entered, but also anticipate his needs and desires.

Making manageable

It was extremely important to us not only that the user was able to predict the information contained in each of the sections defined by the application, but also that the information within it was well structured. We have preferred the segmentation of each task into several sub-tasks, favoring the development of the action through sequential and mandatory steps.
In particular, we focused on the processes necessary on the one hand to calculate the route by the user and on the other hand to find more general information on lines and timetables.

Encouraging serendipity

Finally, the main scope of a system is to provide more than the result specifically sought by the user, creating a context for the results, or in the path to reaching them, to facilitate the discovery of unexpected and curious and useful things. We tried to encourage serendipity by providing some activity that may be helpful to the user even if they were not aware of their existence, e.g. 'Segui il viaggio' function and ‘Salva il percorso’ function.

4.3 CAO=S model

Concepts

According to the CAO=S model, the *Concept* indicates the way in which the user perceives and comprehends information, independent of the way it is stored in data structures. The information is

deduced from the analysis of the basic requirements collected in the field. The interface must indicate the operations on the concepts, not the functions of the data structures. The users' perception of these operations may give rise to usability errors which must be resolved by the application designers. Let us now see the different types of errors and how they are resolved during the design of our application:

- **Standardization problems**: the case in which actors and teams use different words to express the same thing, or indirect and direct actors use different words to express the same thing. The words used in the application are the same as those used in the original Tper website so the terms are unique for direct and indirect users.

- **Lexical differences:** the situation in which different types of actors use different words to express the same things. Since the application in question provides a service, it is our concern to choose words that are acceptable and understandable to all actors and common to other applications with the same purpose.

- **Conceptual differences:** the same word is used by different actors to describe different things. In case we find this problem in the development of the site, we will never use the word in question, but specific words and provide clarification to disambiguate the concept and specify what type of meaning corresponds to that word.

- **Polysemy** is the situation in which the same word is used by the same actors to describe different things. In order to solve this problem, we will never use a polysemic word, but find acceptable synonyms for each different meaning.

Actors

Actors are the categories of users who act on the application interfaces to perform their tasks by manipulating the data structures that they perceive through the concepts. They are differentiated by the role they play within the application. We can distinguish between **direct actors** (those that for some reasons will personally use the system and are organized by roles and given a specific role name) and **indirect actors** (all those who for some reason have a say in specifying system features, but will not use their interfaces directly).
Actors are described through the essential characteristics that have an impact on the interaction. They correspond to competences and abilities of exactly six basic characteristics specific to the user with a clear impact on the implementation. For each feature, a numerical score from 1 to 5 is assigned, where 1 corresponds to a very low value and 5 to a very high value.

The characteristics in question are:

1. **Technical competence**: indicates the mastery of technical vocabulary, the use of applications and the use of related devices. Today, it is no longer one-dimensional, given the complexity of today's technology, from PCs to tablets, and other devices;

2. **Domain competence**: the knowledge of practices, terminology, subtleties on the subject of the system;

3. **Language competence**: knowledge of the language of the system (e.g., Italian) and the ability to understand subtleties, innuendo, irony, sarcasm, different communication registers;

4. **Physical ability**: the set of physical limitations, even partial and/or temporary, reducing the ability to use the device the system is running on;

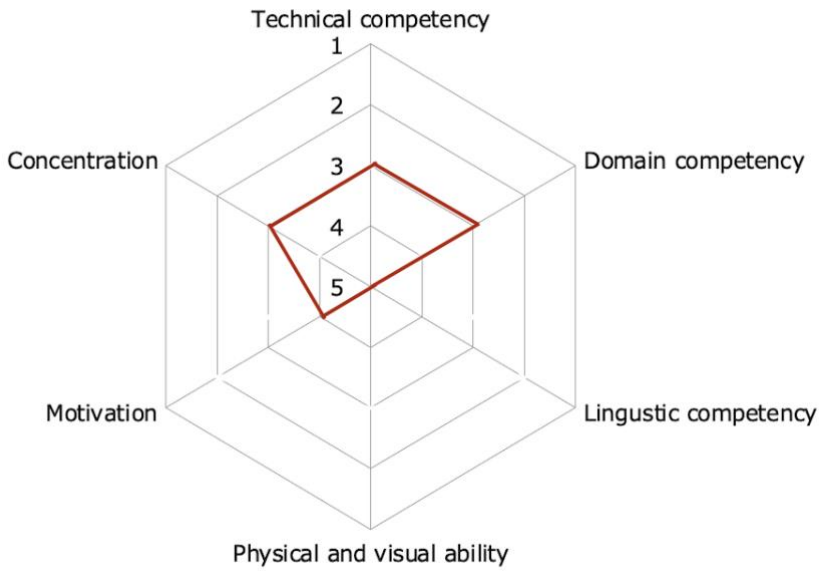
5. **Motivation**: the set of motivations that cause the user to be interested in a task, to use a system for the task, to use this system for it;

6. **Concentration (environmental distraction)**: the ability or possibility, to provide adequate focus on the task.

Let us now proceed with the analysis of the competences of our personas.

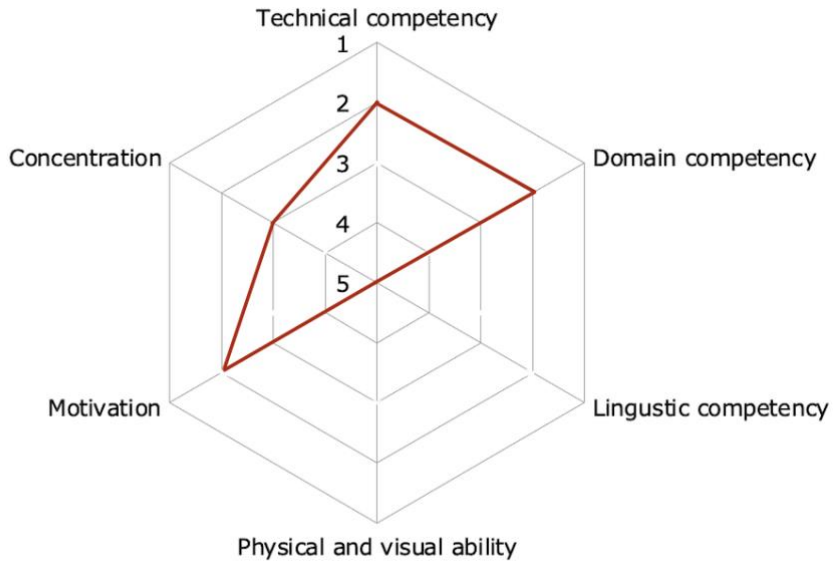
Stefano Mangiagalli

- Technical competence: 3
- Domain competence: 3
- Language competence: 5
- Physical and visual ability: 5
- Motivation: 4
- Concentration: 3



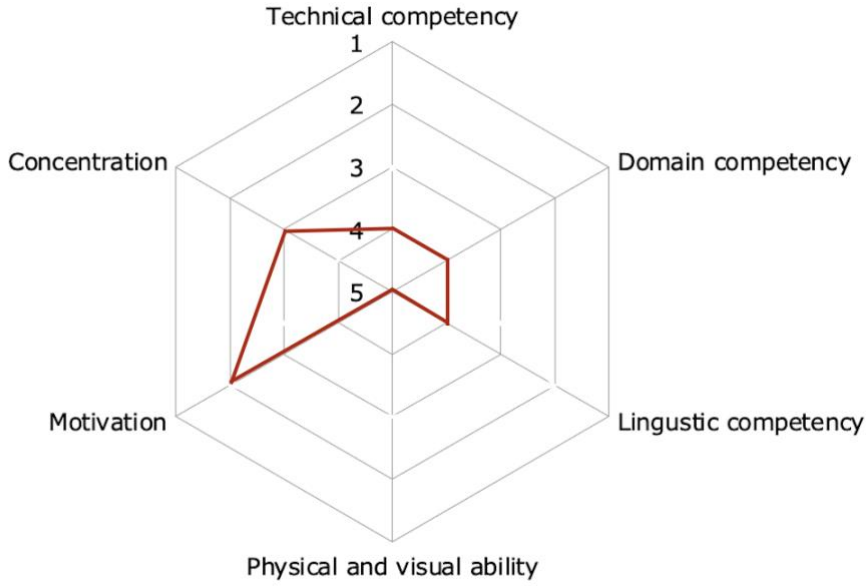
Giorgia Morelli

- Technical competence: 2
- Domain competence: 2
- Language competence: 5
- Physical and visual ability: 5
- Motivation: 2
- Concentration: 3

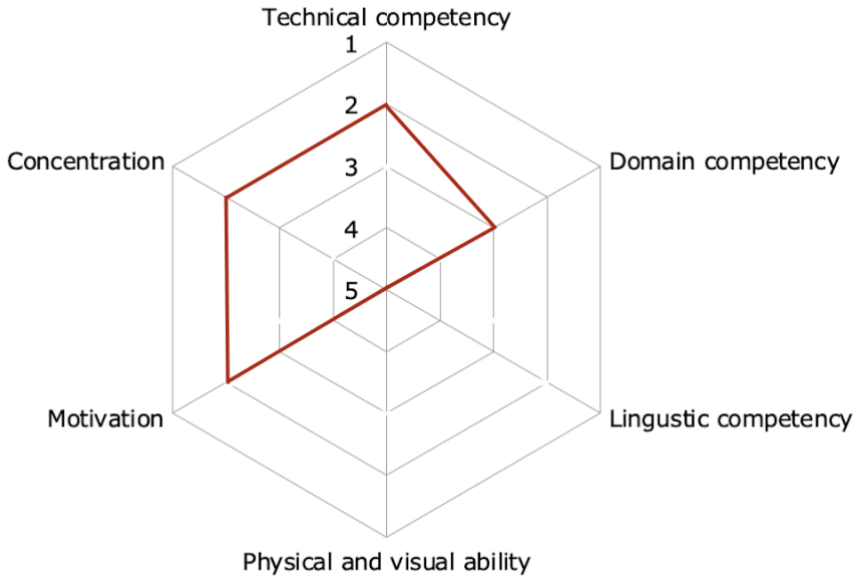


Sofia Santiago Ramos

- Technical competence: 4
- Domain competence: 4
- Language competence: 4
- Physical and visual ability: 5
- Motivation: 2
- Concentration: 3



Niccolò Mezzadri

• Technical competence: 2 • Domain competence: 3 • Language competence: 5 • Physical and visual ability: 5 • Motivation: 2 • Concentration: 2	

Operations

Operations are actions available on the interface that correspond to handling concepts. Operations coincide with the task, since the user believes he is manipulating concepts and not data structures. For each operation we may have to deal with several actions that manipulate data in the underlying structures. Each operation acts on one or more instances of the concept, directly or indirectly, permanently or temporarily. Since operations are operations on concepts, not on data structures, each command, each label, each widget must include the terms associated with the concepts, and not the terms of the associated system. In this section are reported the types of operations that each actor can perform on the concepts described above.

The operations according to CAO = S are of four types:

1. **Creation:** consists in the generation of one or more instances of concept in the initial state. Within our application we can associate the following fields with this operation: **status bus, route, favourite lines and stops, profile, subscription.**

2. **View**: concern to display one or more instances of the concept in an understandable way. Within our application we can associate the following fields with this operation: **profile, status bus, route and timetable, subscription cards, promo and prices, news, realtime information**.

3. **Update**: regards the modification of one or more properties of one or more instances of the entity, without creating new ones. Within our application we can associate the following fields

with this operation: **profile, favourite lines and stops, route and timetable, news, real time information and maps**.

4. **Remove**: is the removal of one or more entities from the system or from the attention of the user. Within our application we can associate the following fields with this operation: **status bus, favourite lines and stops, profile, route calculation**.

Structure

The structures provided by the CAO=S model are three:

1. **Data structures**, which is concerned with studying how concept normalisation generates persistent storage models of entities;

2. **Views**, that are models of screen through which the properties of entities are displayed. Each view is composed of:

   a. actual visualization;
   b. commands that can be activated during viewing;
   c. some of these commands are navigation-related;

3. **Navigation**, that concerns the mechanism for activating views and commands to switch from a view to the next.

The CAO=S model is based on the creation of a three-dimensional table, having as axis *concepts*, *actors* and *operations*, and inside each cell all annotations of how actor A should be able to perform the operation O on the concept C.

The diagram shows views that collect several cells that are consistent with each other in purpose and boundary action and therefore allow the specified operations on the specified concepts by the specified actors. On each view the diagram shows the designed navigation, consisting of access to the various parts, and, if needed, disambiguation pages and sorting. The last step concerns the design of the data structures to satisfy the view and navigation restrictions in the simplest and most correct form.

USER	Profile	Status Bus	Route calculation	Favourite lines and stops	Route and timetable	Subscription cards
Creation	The user can create the profile as soon as he logs on to the application.	At the end of the route calculation, the user generates the bus status of the route to be taken.	The user can select the "Calcola il percorso" option and generate the route to be	You can select a favourite line and add it to your preferences.	no	A subscription can be created and taken out.

			travelled by bus.			
View	The user can view the profile for every need.	The user can view the status of the bus and follow its route from the app's home screen.	no	You can view your favourite lines and stops from the profile section.	The routes and timetables can be viewed in the appropriate section of the homepage.	It is possible to renew a subscription.
Update	The user can update profile information.	no	no	You can update your preferred routes and stops from the profile section.	Routes and timetables can be updated via a selector switch depending on the time of day and route.	no
Remove	The user can delete the profile and create a different one.	The user can remove the bus status from the app's home page if he no longer needs it.	no	Preferred lines and stops can be removed from the profile section.	no	no

USER	Promo and prices	News	Real time information	Maps
Creation	no	no	no	no
View	Promotions and prices for tickets and subscriptions can be viewed.	News about public transport can be consulted.	Real-time information on transport can be displayed.	Maps with location and bus route indications can be visualised.
Update	no	News about public transport can be updated.	Real-time information on transport can be updated.	Maps with location and bus route indications can be updated.
Remove	no	no	no	no

4.4 Interaction design approach

The interaction design is the design of the interaction between users and products. Its goal is to create products that enable the user to achieve their objective in the best way possible, generating positive emotions like happiness and satisfaction and annulating negative ones like frustration, anger, disappointment. Interaction design is thus part of the overall experience of the using of a system and it refers primarily to all the componentes, physical and visual, the user interacts with when using a system.

The interaction design of the user experience in using our application has the fundamental constraint of the device from which they access. The user can download the app on his smartphone or tablet, so the interaction with the system takes place exclusively through the touch screen. In fact, this type of interaction seemed to us the most appropriate for our target user who very often uses the mobile phone and the various apps installed on it.

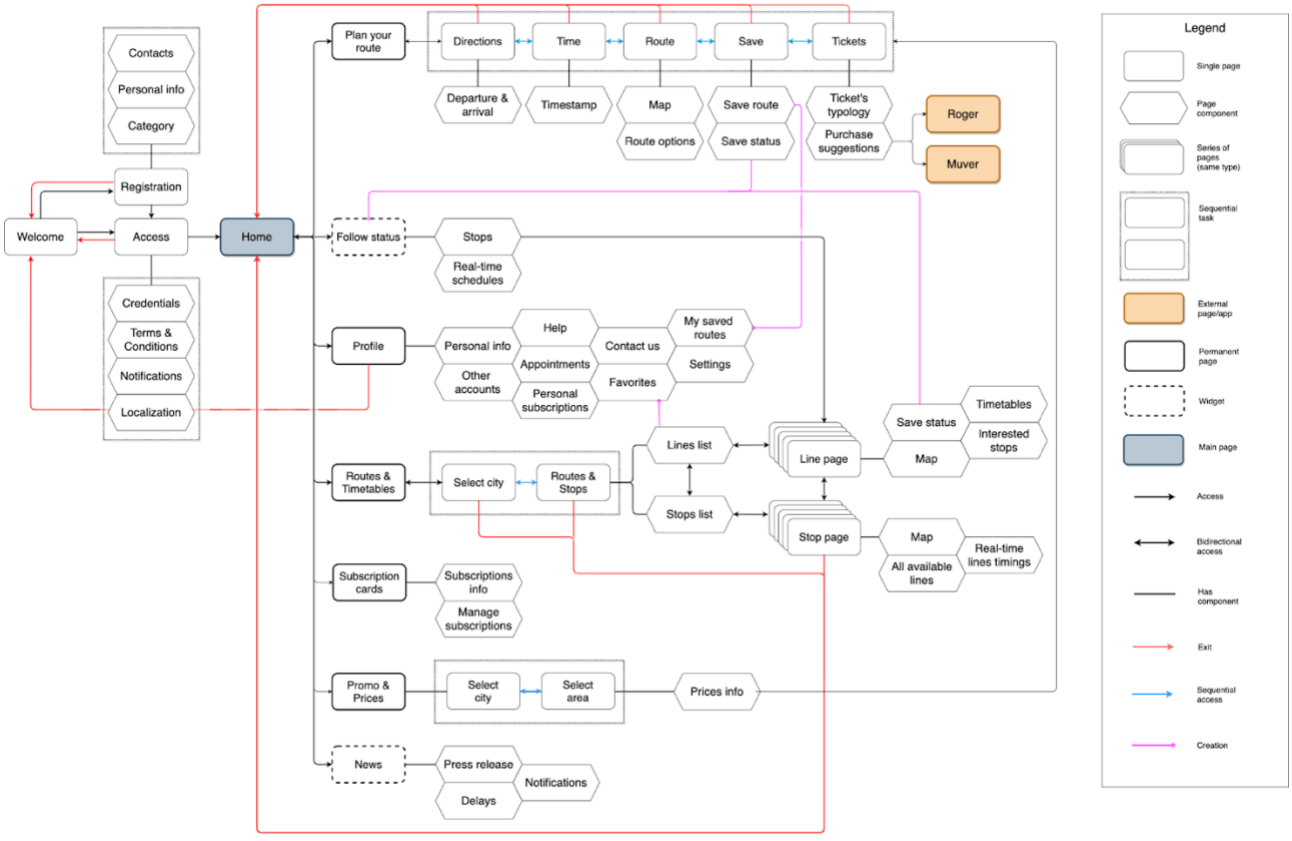
However, aware of the fact that many, especially older people, may have difficulty viewing and managing the elements on the page, we took care to create a layout made up of large, easily clickable elements, whose appearance would favor in every way understanding by the user. In the same way, particular attention was paid to the representation of an adequate feedback to each of the user's actions, and in particular in all those points where the user could perform a significant action (eg. route planning). Finally, interaction design has played a significant role in allowing the user to get to all the necessary information and thus to fulfill their purposes in a new and interactive way, which allowed them to filter information based on their needs. This is particularly visible in the ‘Calcola il percorso’ section, in which all information is calibrated to the user's needs, but above all in the 'Linee e Orari' section, in which the search methods have been greatly modified compared to the traditional ones.

Interaction device	Smartphone
Interaction type	Touch
Element appearance	**Few components**: modeled accordingly to the Gestalt principles, it avoids short-memory load and assumes a predictable aspect for users; **Task segmentation**: step-by-step guidance and traceback of the activity completion augment the user feeling of control; **Task completion traceback**: it provides guidance to users by updating them with the level of completion of tasks and saving already inputted information; **Input facilization**: pre-compiled formulas for input information light the user effort and reduce errors; **Intuitive output**: graphic solutions and easy visualizations help user in better understanding the output; **Skeumorfism**: a skeuomorphic representation of the ticket help the user in identify the correct one without compromising the app layout.
Element format	Interactive and step-by-step guided
Feedback and manageability of the errors	**Information recap**: at the end of the task, the user is provided with the possibility to control again all the inserted information in order to avoid mistakes and misunderstandings; **Choice confirmation**: confirmation is a lock-in startegy which provides feedback and avoids user errors;

	Lock-in strategies: pop-ups are used to realize constraints and lock-in strategies so that users are prevented from exiting the task before the completion.
Customization	The homepage changes according to user needs and provides shortcuts to their interests

4.5 Blueprints

Blueprints are very useful instruments that allow us to understand which components make up our application and how they are organized. We decided to start from the graphical representation of the entities that characterize our scenario and the relations among them, providing a more articulated relational context to the content of our application. This entity-relationship model follows a top-down approach and it uses natural language to name its elements. Relationships are identified by different types of arrows and links. Items have different levels of specificity and may act like containers of other entities. In order to make the blueprint intelligible, we provided a legend.

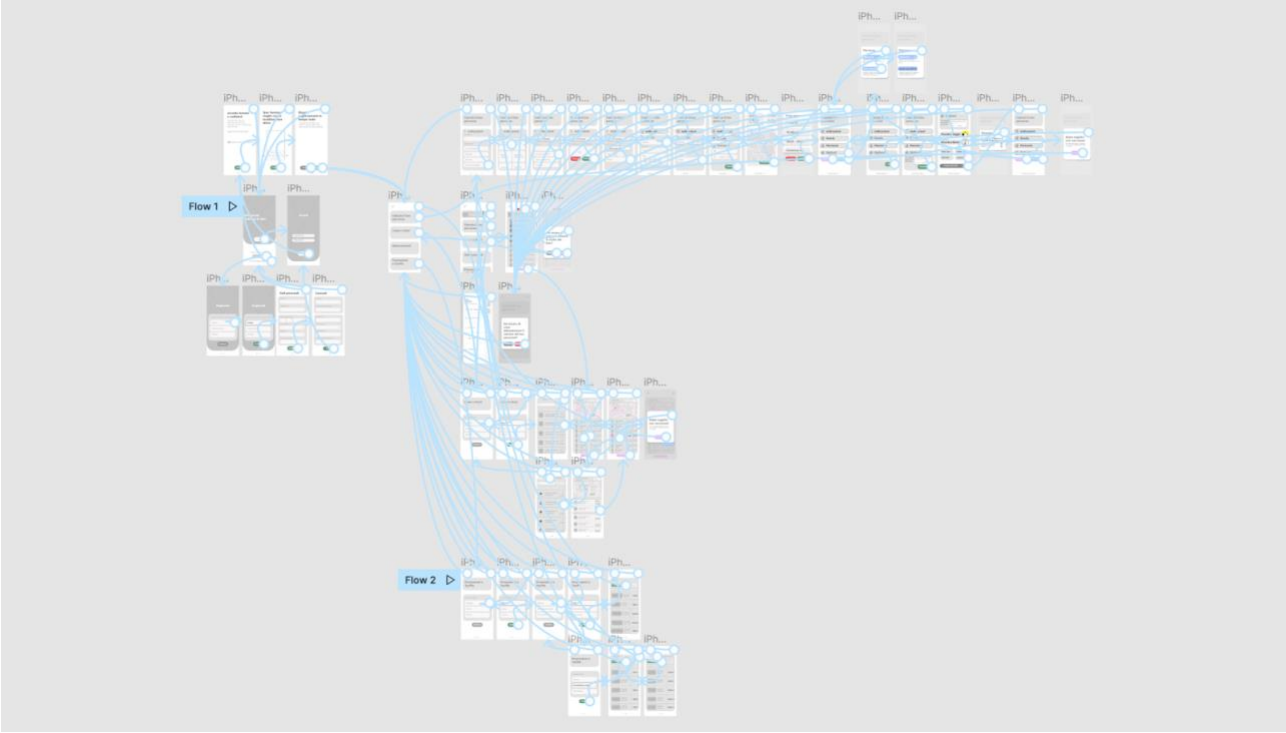


4.6 Wireframes

For accomplishing our design purposes we decided to create a wide range of wireframes of the application, which will help us display the functional elements of the system. In order to do that we used Figma, a web-based graphics editing and user interface design app. We not only designed the

mobile app interfaces, but we also produced a small and quite limited prototype for planning the app's functionality and for testing the usability of relational patterns between elements.

All wireframes developed by the team are documented and explained in a file named FinalDesign.pdf, which you can find attached to this report.



Prototype’s interaction’s view.

Wireframe prototype: three sample interfaces.

5. Evaluation of design

5.1 Inspection

Cognitive walkthrough

In order to determine the plausibility of the usability of the interface for the chosen user segment we will now proceed with a cognitive walkthrough that will try to enact thoughts and actions of users when they use the interface to perform for the first time a task. For this purpose, we used a small prototype of the interface implemented through Figma, which allowed us to create an interactive wireframe. In addition to the interface reproduction prototype, we also need to imagine a persona who carries out a well defined task of which we already know the ideal sequence of steps. This is a task-specific approach to usability. In the following sections we will enrich the analysis with holistic usability inspection.

Task 1
Plan a route

User
Maria is an adult woman of 45 years of age. She is currently unemployed and is looking for a job in a different city from the one she lives in. For this reason, she's travelling to Bologna, where she has some interviews planned for the day. Of course, interviews are located throughout the city and she needs to understand how to reach the different locations. Thankfully, this is not the first time she had to come to Bologna, so she has already downloaded the Tper app, but she has just used it for checking general information about tickets and subscriptions. She didn't have time to check in advance the route and now she wants to use the planification option available on the app.

Happy path

1. Maria accesses the app from her phone. Having not logged out last time, she found herself already logged in, as she can see from the icon photograph in the upper right part of the main page of the application;
2. She immediately click on "Calcola il tuo percorso" from the same page;
3. She selects "La mia posizione" as the departure point of the route;
4. She confirms the position found with the GPS;
5. She knows that she needs to reach Bologna Fair so she selects the "Centri d'interesse" option and chooses it among the interesting places already selected;
6. She now has another opportunity in order to check her choice. She decides to go on;
7. Now she must select the starting time for the route. She's already in Bologna, so she selects the real time option "Adesso" which also shows the current timing and goes on;
8. Maria decides to check the one way option, cause after the first interview she must reach a different location from the one she's now;
9. All the info are correct so Maria clicks "Calcola" and waits for the results;
10. She can choose among many options. She doesn't want to walk a lot, so she prefers the second option which is a bit more long but surely more comfortable;
11. In the same page, she looks at the route in the map and clicks on "Usa opzione" in order to choose the selected travel option;
12. An overlay block shows her a recap of the information related to her route. Maria confirms her choice for the route;
13. Now Maria can choose among three options: saving the route, following the status of the lines she chose for her route or continuing with information about tickets. She chooses the latter;
14. The, she insert the number of passengers: X1;

15. The page now shows her the ticket she needs to buy in order to use the bus selected before and relative purchase options. She decides to buy it later on the bus because she has quite some currency with her. So she clicks on “Compra più tardi”;
16. Again, now Maria can choose among three options: saving the route, following the status of the lines she chose for her route or going back to the main page. She chooses the second option and clicks on “Segui stato”;
17. An overlay block confirms the successful outcome of the action;
18. Maria can now choose to close the overlay block or to go back to the planification. She chooses the first option and clicks on “Vedi stato”;
19. Now she is back on the home page and a new widget has appeared on top of all the other four options. Now that she has all the information she needs she makes her way to the bus stop and checks her phone for real-time updates about the bus she needs to take.

Task 2
Check stops and lines

User
Filippo is an adult man of 54 years of age. He’s staying in Bologna for a few months for a work project that will require him to live and stay there. He’s not planning a particular visit but he wants to know what are the most efficient ways to move from the place where he’s staying. A general overview of the lines, stops and timetables would do to his case. When he arrived, he saw a bus stop right on the street of his rented apartment. His son suggested to him to look for an official app of the public transport agency of the city. For this reason he decided to look for it on the browser application of his phone.

Happy path

1. Filippo is using the browser application on his phone. He found the Tper website and the first thing that he noticed was an overlay initial message telling him to download the official application;
2. Filippo downloads the application through the direct link found in the website;
3. After the download, he accesses the application;
4. Now he is on the welcome page. He has three options: logging in, register or access as a guest without an account. He chooses the last option and clicks on “Accedi come ospite”;
5. He clicks on a button in order to accept the terms and conditions;
6. Then, he is required to activate and give authorization for localization. He clicks on “Consenti quando utilizzi l’app” and then on the continue button;
7. The third and final page asks him if he wants to receive notifications. He denies and goes on;
8. Now he is on the main page of the application. From this page he selects “Linee e orari”;
9. In the first page of this section he’s asked to choose among three cities. He selects “Bologna” and the on the continue button;
10. Now he can switch between lines and bus stops. He wants to look for bus stops near his location, so he clicks on “Fermate;
11. Here he filters the results using the near me option called “Vicino a me”;
12. The he orders the results by distance from his position;
13. Out of curiosity, he decides to learn more about the nearest bus stop and clicks on the detail button;
14. In the next page, he can see all the available information about the bus stop: name, address, map, his position and distance from the stop, all the available busses and the current real-time busses that are arriving to the stop;
15. He wants to check the timetables for the next morning and insert a different time filter in the top right corner of the page;
16. The results are rearranged and now he selects the first result and checks for more details;

17. Now he's redirected to the bus line page. Here he reads all the timetables related to his bus stop and to all the other stops related to the bus line;
18. He's very content about the results and does not want to lose all the information he found, especially for the next day. For this reason he selects the following status button;
19. An overlay block confirms the successful outcome of the action;
20. Filippo can now choose to close the overlay block or to go back to the planification.
21. He chooses the first option and clicks on "Vedi stato";
22. Now he is back on the main page and a new widget has appeared on top of all the other four options;
23. He closes the app, happy to know that the next morning he will just open it again and check for the real time updates about his chosen bus line.

Action analysis

We will now proceed with quantitative analysis of the specific sequence of actions that must be performed to complete a task. This type of study is called *action analysis* and it consists in an evaluation process that closely examines the sequence of actions for every task. In our case we will use an informal approach to the analysis, which consists in listing a natural series of actions and evaluating them globally, without taking in considerations micro-detail actions or specific timings. This is done to verify the concept that easier tasks (such as logging in or checking real-time updates) require fewer actions and less time then other more complex tasks (like planning an entire route). The opposite scenario would highlight a usability problem. Every task will be described generally by a performance outcome that will express the ratio between difficulty, number of actions and minimal time of usage, which means the minimum amount of time required to complete the task.

Task	**Actions**	**Minimal Use Timing**	**Outcome**
Log in	1. Click on "Accedi"; 2. Enter username; 3. Enter password; 4. Click on "Accedi"; 5. Agree on terms and conditions; 6. Click on "Iniziamo"; 7. Give authorization for localization; 8. Click on "Continua"; 9. Click on "Consenti".	00:28,17	Very simple task, which includes many pages. The timing is proportionate to the number of steps.
Log on	1. Click on "Accedi come ospite";	00:15,80	Very fast access point to the application. It should be even faster.

	2. Agree on terms and conditions; 3. Click on “Iniziamo”; 4. Give authorization for localization; 5. Click on “Continua”; 6. Click on “Consenti”.		
Sign in	1. Click on “Registrati subito”; 2. Choose a category; 3. Click on “Continua”; 4. Enter name; 5. Enter surname; 6. Enter date of birth; 7. Enter nationality; 8. Enter gender; 9. Enter fiscal code; 10. Click on “Continua”; 11. Enter email address; 12. Enter phone number; 13. Enter address; 14. Enter username; 15. Enter password; 16. Confirm password; 17. Click on “Accedi”; 18. Enter username; 19. Enter password; 20. Click on “Accedi”; 21. Agree on terms and conditions; 22. Click on “Iniziamo”; 23. Give authorization for localization; 24. Click on “Continua”; 25. Click on “Consenti”.	01:42,49	The task has a high level of predictability, so the timing respects proportionally the requirements of the task.

Plan route	1. Click on “Calcola il tuo percorso”; 2. Choose one option; 3. Select or enter one departure; 4. Confirm departure; 5. Choose one option; 6. Select or enter on arrival; 7. Confirm arrival; 8. Click on “Avanti”; 9. Enter time; 10. Click on “Avanti”; 11. Select one way/round way; 12. Click on “Calcola”; 13. Select one option; 14. Click on “Usa opzione”; 15. Confirm recap; 16. Click on “Biglietti”; 17. Enter number of passengers; 18. Click on “Calcola”; 19. Click on “Acquista”; 20. Select one purchase option; 21. Click on “Salva percorso”; 22. Choose one option; 23. Close overlay; 24. Click on “Segui stato”; 25. Click on “Vedi stato”;	01:29,96	The most complex task of the application, still the most sequentially based. Its sequenciality allows the timing to remain low, despite the high number of actions.
Check lines	1. Click on “Linee e orari”; 2. Select one city; 3. Click on “Continua”; 4. Enter the line; 5. Choose order; 6. Set filters; 7. Click on “Dettagli”;	00:30,32	The task is simple, timing is proportionate to the task. It may take longer if used dynamically and in parallel with other sections.

	8. Set terminal; 9. Select days; 10. Scroll timetable; 11. Click on “Segui stato”; 12. Click on “Vedi stato”;		
Check bus stops	1. Click on “Linee e orari”; 2. Select one city; 3. Click on “Continua”; 4. Switch to “Fermate”; 5. Enter the line; 6. Choose order; 7. Set filters; 8. Click on “Dettagli”; 9. Set time; 10. Scroll timetable;	00:28,15	The task is simple, timing is proportionate to the task. It may take longer if used dynamically and in parallel with other sections.
Check prices	1. Click on “Promozioni e tariffe”; 2. Select one city; 3. Click on “Continua”; 4. Select one area; 5. Click on “Continua”; 6. Switch typology; 7. Choose order; 8. Set filters; 9. Scroll list;	00:17,57	The task is simple, timing is proportionate to the task.
Check real-time updates	1. Click on update widget;	00:05,12	Super fast and the simplest widget to use inside the application.

Heuristic analysis

The final part of our inspection is the heuristic analysis. This time, we will choose a different set of guidelines, against which we will evaluate the usability of our application, and that will allow us to detect problems that may have gone unnoticed during the inspection of the previous website. Re-using the same set of guidelines would in fact iterate over the same set of violations, which have been already solved. Subsequently, we chose to use Jakob Nielsen's heuristics, developed in 1996, which are considered the most used set of guidelines in the field.

The 10 heuristics of Jakob Nielsen (1996)

1. **Visibility of system status**:
   The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
2. **Match between system and the real world**:
   The system should speak the user's language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
3. **User control and freedom**:
   Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
4. **Consistency and standards**:
   Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
5. **Error prevention**:
   Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
6. **Recognition rather than recall**:
   Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
7. **Flexibility and efficiency of use**:
   Accelerators—unseen by the novice user—may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
8. **Aesthetic and minimalist design**:
   Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
9. **Help users recognize, diagnose, and recover from errors**:
   Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
10. **Help and documentation**:
    Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

Before proceeding with our heuristic analysis, we want to clarify that the wireframe does not implement all the possible paths that a user might want to explore for it being just a prototype of the final application.

We decided to implement the tasks that better represent the final goal of the general user, which is finding information about prices, bus lines and stops; and accordingly planning a route. Therefore, the final heuristic analysis takes in consideration only the main features implemented in the wireframes and does not consider other ancillary tasks. However, the behaviour of this less complex and satellite tasks would reuse all the usability choices used for the main functions of the design.

GUIDELINE	VIOLATION
1. Visibility of system status	/
2. Match between system and the real world	Tickets do not reproduce the real world shape of a real ticket. The general design should not be Skeuomorphic, but some elements should reproduce real life scenarios or iconic references.
3. User control and freedom	/
4. Consistency and standards	/
5. Error prevention	A confirmation message is missing when the user decides to interrupt the planification of the route. Being it a long task, it should be useful to prevent the resetting of the entered keys or chosen options.
6. Recognition rather than recall	/
7. Flexibility and efficiency of use	Favorites positions and geographical information are meant to be remembered. However, they will not be used automatically. Experienced and inexperienced users must go under the same steps.
8. Aesthetic and minimalist design	/
9. Help users recognize, diagnose, and recover from errors	
10. Help and documentation	Help button is present, however no documentation is provided.

During the inspection we understood that the design under consideration widely satisfied the requirements identified by the 10 Heuristics of Jakob Nielsen. It also helped us identify some issues that we hadn't taken into consideration before. Subsequently, we solved some of them. Now the design of tickets reproduce the shape of the actual paper cards used by Tper. Skeuomorphic choices have been taken into consideration, without compromising the minimalist aesthetic of the application. A confirmation message has been added when the user decides to interrupt the planification of the route. Violation of heuristic 7 and 10 have been considered superficial at the actual stage of design. They will be taken into consideration for further developments of the applications.

5.2 User testing

In order to evaluate our design, inspection needed to be completed with an evaluation able to involve reactions and opinions of real users. In providing them, we have conducted user tests on the app design.

Test protocol

Test Type	Discount usability test. It is an informal and intuitive test that allows to reach good results in a cheaper way than the deluxe one, due to the reason it involves only 3-4- users with no specialist in user testing. Also, it has the great advantage of being sequential, and thus allows to evaluate and solve inputs from each test before starting with a new one. As the test is sequential, it allows to accelerate the identification of errors cycle: the first participant finds a considerable percentage of catastrophic errors (even 80%). They are evaluated and resolved then the second participants find some remaining errors (few catastrophic and many serious). They are evaluated and resolved. Then the third participants find some remaining errors (none catastrophic and some serious errors and some cosmetics). Etc. Normally, after 5 iterations 100% of catastrophic errors, 80% of serious ones, and 50% of cosmetic ones were found.
Test methodology	Thinking aloud
Test purpose	Formative test to discover which problems in order to solve them as soon as possible
Test phase	The test is run at the end of the prototype development, in order to understand if the design choices made are correct
List of tasks to be tested	1) Understand the bus line 2) Check the timings 3) Check the ticket rate
Number of tests	3 + 1 (pilot)
Number of users	3 + 1 (pilot tester)
Choice of users	Users have been chosen to be most suitable as possible with the profile of our target user. All their profiles are anonimously described in the section 'Tests'.
Error classification	• Catastrophic (the user does not complete the task) • Serious (the user finishes the task with significant slowdowns and / or with considerable compromise on quality output)

	• Cosmetic (the user identifies light slowdowns or annoyances in the performance of one or more task)
Final assessment questionnaire	System Usability Scale (SUS)

Test outcomes

Quantitative

- Time/Task: The amount of time it takes the participant to complete the task.
- Success of the task completion: Each user is provided with a scenario that requires the participant to obtain specific data that would be used in a typical task. The scenario is successfully completed when the participant indicates they have found the answer or completed the task goal.
- Errors:
    - Critical Errors: Critical errors are deviations at completion from the targets of the scenario. Essentially the participant will not be able to finish the task. Participants may or may not be aware that the task goal is incorrect or incomplete.
    - Non-Critical Errors: Non-critical errors are errors that are recovered by the participant and do not result in the participant's ability to successfully complete the task. These errors result in the task being completed less efficiently.

Qualitative

- Satisfaction
- Opinions
- Suggestions

Tests

As we specified in the definition of testing protocol, we carried out the testings on four target users based on three tasks (on-street parking payment, extend the parking session and stop it before the expected end) according to the testing methodology Think Aloud. The tests were carried out sequentially and after each the expert team gathered to discuss the emerging usability issues of the prototype and solved them before proceeding with the following test, this was in accordance to our test type and also to make sure that in the subsequent test, the user could interact with an improved version and help us find other and new issues. At the end of this section we reported for each user the related SUS scores for each task and a general one on the application. Every test is described in detail below.

The three subjects we have asked to test our prototype are here describe anonymously:

User 1	a 24 year old girl who lived in Bologna for 5 years and is now resident in a different city within Emilia-Romagna. She is currently employed as art gallerist assistant, a work that requires a constant use of the Internet and the computer. When she lived in Bologna she used to take the bus, but she never used the Tper website.
User 2	
User 3	

Disclaimer:
As previously outlined, user testing as well needed to deal with the fact that the prototype has been implemented only with regard to certain options and actions. Thus, the user is not completely free of moving within the application, but their actions are restricted to the implemented options. For this reason, the test has focused on the capability of the user of understanding and describing, through the methodology of the thinking aloud, the expected role and the predictable consequences of the elements displayed, the reasons why they would click on an element rather than another one, and finally eventual personal opinions and suggestions about the design itself.

Pilot test – Tester 0

Before starting with the actual user tests, a pilot test has been conducted in order to evaluate the testing protocol and the chosen testing method. The pilot test was elaborated by two members of the team and performed by the other one. The test was useful to make sure that questions were consistent, the team was prepared and the duration of the test was reasonable.

Quantitative results

	Success of task completion	Time on task	Catastrophic errors	Serious errors	Cosmetic errors
Task 1	X	39.23	no	no	CO1
Task 2	X	09.61	no	SE1 SE2	CO2
Task 3	X	10.61	no	no	no

Each spotted error has been provided with an ID (the acronym CE for catastrophic errors, SE for serious errors and CO for cosmetic errors, numbered in ascending order) and is described with the solution we have found to it in the table below.

Error ID	Error description	Solution
CO1	Missing map in ‘Use your position’	Adding map in ‘Use your position’ to make the page coherent with the app layout
SE1	After having planned the destination and the timing, if the user click on ‘Segui stato’, then on ‘Vedi stato’ and finally exit the status, they are not able to return to the last part of the planning task.	Adding the possibility to save the information at the middle of a task so that they can be recovered after having exit the section.
SE2	When clicking on the back arrow in the bus status page, the prototype sends in a different page than expected	Modify the link in the prototype
CO2	A fixed ‘1’ as the first cipher of the Time in ‘Orario’	Eliminating every cipher in the Time

Qualitative results

The opinion about the application is generally very positive. The only complaint is about the feeling of disorientation related to some problems with the connections of the prototype. Once solved, the application will improve in clarity and feeling of control.

User 1

User 1 has tested the prototype directly on her smartphone, an iPhone 10.

Task 1

The user decided to plan her route by accessing the 'Calcola il tuo percorso' section. She has had no problem in inputting a starting and arrival point, but she then found a little bit difficult to understand the indication of the two arrows for switching the start with the destination. Having understood their meaning, she has suggested us to put them in between the two options, in a way that more intuitively indicates the possibility to exchange the information. She then continued with the task and successfully managed to understand the line she needed.

Task 2

The understanding of timings was not a problem at all, as it was included in the planning phase. So the user has been required to access them by the 'Linee and Orari' section. She returned to the home and entered the required section, then she typed the line she previously computed and, clicking on 'details', she got the timings she needed.

Task 3

The user has no problem in understanding which ticket rate she needed. Anyway, when clicking on 'Acquista', she was disappointed by discovering that she cannot actually buy a ticket from the application. The only indications she has found were about other applications from which buying the tickets and other selling points. Particularly, she said that knowing that other applications give the possibility of buying a ticket, she would probably use them instead of this one.

Quantitative results

	Success of task completion	Time on task	Catastrophic errors	Serious errors	Cosmetic errors
Task 1	X	00:45.32	no	no	CO2
Task 2	X	08.51	no	no	CO3
Task 3	X	15.33	CE1	no	no

Error ID	Error description	Solution

CO2	Switching button in the wrong position	Replacing the switching button in between the two options
CO3	A ‘e’ missing in the sentence ‘Da adesso potrai seguire lo stato del bus in tempo reale [...]’	Fixing the error
CE1	Misunderstanding the button ‘Acquista’ and being disappointed by the impossibility to buy a ticket from the app	Modify the name of the button in ‘Dove acquistare’

Qualitative results

User 1's opinion on the possibility of purchasing tickets through other applications was very strong and raises a real problem within the design of the site. Nevertheless, our redesign represents the current policy of the Tper company which, not having its own official application, freely releases the data as available to all those who want to use it, including developers of competing applications. Obviously this is an improvement that we would like to make to the application in the future, but it will only be possible when Tper itself decides to invest in an application and provide the possibility to buy tickets through it too. Until then, we limit ourselves to providing, like the site itself, information on where to buy tickets, even if competing apps are among these.

User 2

User 2 has tested the prototype directly on her smartphone, an Iphone 11.

Task 1

The user decided to plan her route by accessing the 'Calcola il percorso' section. She had no problem entering a start and end point, selecting the centre of interest from which to start and then her own location. She completed the route without any particular difficulty but reported that once a phase was completed, it was not possible to click on the previous phase to review the choices made. She pointed out this limitation, also due to the limited number of actions in the prototype.

Task 2

Even for this user, understanding the timetables was no problem at all. So the user was asked to access them from the 'Lines and Schedules' section. She returned to the home page and entered the required section, then typed in the line she wanted to know the timetable for and, by clicking on 'details', got the timetable she needed.

Task 3

The user has no problem in understanding which ticket rate she needed. She didn't need to buy it or download one of the recommended applications to buy the ticket because she didn't want to buy it in advance.

Quantitative results

	Success of task completion	Time on task	Catastrophic errors	Serious errors	Cosmetic errors
Task 1	X	03.35	no	no	CO4
Task 2	X	02:40	no	no	no
Task 3	X	05:20	no	no	no

Error ID	Error description	Solution
CO4	Unable to click on previous steps to review the choices made	Make previous steps clickable

Qualitative results

User 2 found the application very usable and easy to understand. The options and navigation of the sections is clear and the information is comprehensive. She only points out that, when saving the bus status, if the user decides to save the status of a line and another status was previously saved, a warning reminding the user that there is a status already saved and confirmation to replace the new status with the previous one would be useful.

User 3

User 3 has tested the prototype directly on her smartphone, an Iphone 8.

Task 1

Route planning through the "Calcola il percorso" section is successful and the user does not report any problems.

Task 2

The timetable consultation and subsequent selection of the preferred line was also completed successfully, and the user reported no difficulties.

Task 3

The user has no problem in understanding which ticket rate she needed. She was not aware of the existence of apps to buy tickets from and seeing them recommended in this section was very helpful.

Quantitative results

	Success of task completion	Time on task	Catastrophic errors	Serious errors	Cosmetic errors
Task 1	X	06.13	no	no	no
Task 2	X	04.20	no	no	no
Task 3	X	05.44	no	no	no

Qualitative results

User 3 found the application well designed; the information contained is useful and the sections cover different needs. She said he would use it daily to move around Bologna.

Post testing phase

SUS score

As previously mentioned, the users have been required to complete a SUS evaluation similarly as conducted in the User research phase. The final SUS score as computed on the results tested on the app prototype is 85,83: a highly satisfactory result that proves the usability of our design.

6. Final recommendations

This report documents all the steps carried out by our team to redesign the user experience of tasks that Tper website already offered and that we considered and proved to be difficult to complete because of their complexity, incoherence, and fallacy. The goal of the current project was to provide guidance and explanations for simplifying decision making strategies and navigation patterns of these tasks. The application does not simply contain a list of instructions or suggestions, but it makes things easier for the user by means of interaction, context dependency and sequenciality.

The audience that the organization already reached and addressed satisfactorily is not impacted nor harmed in any way at all by the new application, for it being a separate tool to be used only in specific scenarios by a well identified type of user, a side initiative that will not disrupt the main informative core of the website. This is also proven true if we consider the fact that our intake only rearranges what was already present on the website, giving it a new life and making it usable.

In addition, we believe that both the application and the website could be further expanded with other tools, which would give a significant competitive advantage on the digital services market in question. From our user research, it emerged an interest towards the possibility of using a single app for getting reliable information about public transportation and at the same time, and most urgently, for buying tickets. Since online payments are already possible for renewing subscriptions and since online tickets are already used on the Tper busses, we believe that this should be the next logical step in the development of a well-integrated system. Users would benefit from a system that will be complete and fully circular, allowing to proceed from informative content to active services, without having to download multiple apps created by different providers.

Many other tools could be implemented, expanding, and reaching the full potential of communication between applications: synchronizing calendar events, highlighting real time bus crowding information, using offline maps, sharing favorites and routes among friends, creating a comment section for suggestions and updates on bus stops and human interaction among real users, synchronizing your data through external services which allow backup for small dimensions and so on. These are just some of the countless possibilities that would exponentially improve the quality of the service offered. All these options could be also easily integrated.

Finally, from a usability perspective, it would be interesting to see how the old tasks and new features would come together, potentially allowing the final achievement of creating two heterogeneous areas of action, the general informative website and the practical service-oriented app, that would fully complement each other and satisfy a high number of users.

Usability & User Experience design project

TPER APPLICATION

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