Analysis of the Impact on the Safety and Sustainability of Vehicular Traffic in the Landside Area of Olbia - Costa Smeralda-Airport

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Abstract. The quality and efficiency of the landside area of an airport are strongly conditioned by the circulation of the internal mobility that must be efficient and safe at the same time. Key elements in this regard are: (1) the curbisde highway, (2) the roads that wind around the terminal area and (3) the parking areas.

The traffic on the roads serving the airport area is clearly distinguished from that on ordinary roads (urban and suburban) both because of the geometry, strongly conditioned by limited space, both for the different traffic composition and the expectations of their drivers. The concentration of a multitude of structures with different functionalities, located in relatively small areas, means that the signage are abundant and complex to code quickly, especially for those users who are unfamiliar with the infrastructure and who represent the dominant share of users. In addition, the latter live with regular users (mainly private transport operators) who have a casual drive.

This is the scenario that is the background to the study whose concrete case concerned the Airport of Olbia Costa Smeralda. In the Sardinian airport, in July 2019, some rental operators/ remote parking won the appeal to the Regional Administrative Court (TAR) for the annulment of the ENAC Order and in this case the section concerning the limitation of the free admission to only three entrances to the parking area in front of the terminal and called Short term parking.

The aim of the study is to analyze the traffic flows resulting from the application of this amendment and to assess its effects in terms of traffic efficiency and the safety of users.

Keywords: Airport terminal · landside areas · curbside highway · parking areas · pick-up areas · drop-off areas · safety

1 Introduction

Airports are strategic infrastructures of modern life and play a crucial role for transportation of passengers with different purposes, such as tourism and businesses. They become even more important in complex contexts such as islands where they are part of a complex transport system whose efficiency is vital for economic, social and territorial development [1–4].

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Airport planning is a complex process because an airport involves a wide variety of activities, with different and often contradictory requirements [5], which must be analyzed and solved separately but need integrated policies choices.

The overall level of service (LOS) of a terminal system depends on the LOS of individual components, such as check-in, departure lounges, landside, ect., as well as socio-economic variables [6, 7]. Parking is a integral part of the landside and its operation affects the level of service of an airport [8]. Anderson et. al. [9] show that curbside operations is one of the most significant factors affecting of the overall LOS of the airport terminal system.

So, the curb-side and the access roadway are two important segments of the terminal that needs in depth analysis in order to identify their operational characteristics [10]. The operational characteristics of the curbside terminal significantly differ from those of most other roads due to several reasons such as different traffic composition, passenger expectations and driver behavior, vehicle downtime and etc.. Moreover, the planning of future expansions of the terminal will have to be based on the analysis of the vehicular traffic, the choice of the mode of travel, the queues of the vehicles along the parking lanes, the times of permanence of the vehicles and the level of occupation of the passengers [11].

The regulation of accessibility to the airports landside areas arises from the need to guarantee a multiplicity of aspects. The most important is to organize and regulate, according to a hierarchy of priorities, the access of vehicles to the area in an orderly, safe and controlled manner.

It is quite clear that emergency vehicles, law enforcement and public security vehicles, airport inspection and maintenance vehicles as well as public vehicles should have absolute priority over other vehicles. The latter mainly include private vehicles, rental cars, on-demand and pre- reserved taxicabs, prearranged and on-demand limousines or Town Cars, door-to-door vans, courtesy vehicles, charter buses, scheduled buses, and service and delivery vehicles.

The Ordinance issued by the Italian Civil Aviation Authority (ENAC) [12], which governs the management of spaces (road network and parking) and regulates access, establishes that access to the "Short term parking" is free of charge for 15 min and for a maximum of 3 consecutive daily accesses. Beyond these, parking must be charged according to the airport's tariff scheme.

At Olbia "Costa Smeralda" airport, some operators appealed to the Regional Administrative Tribunal (TAR) to remove the limitation of the free allowance to only three accesses, winning the appeal. Hence, this study on the evaluation of the effects of this decision and the resulting set up on landside area traffic and security on operators and users was born.

Section 2 reports issues that specifically concern airport operations with particular reference to the definition of the internal road system and the physiological differences with the ordinary road system in urban and suburban areas. In Sect. 3 the case study will be presented and in Sect. 4 the conclusions.

2 Management Criteria for Airport Landside Operations

The quality and efficiency of the landside area of an airport are conditioned by the circulation of the internal road system, which must be both efficient and safe.

In literature there are two guidelines which analyze and evaluate the performance of the curbside and roadway operations of landside, 1. International Air Transport Association (IATA) Manual [13], which gives standard figures can be used in planning and design and 2. The methodology proposed in Airport Cooperative Research Program (ACRP) Report 40 [14].

Report 40 emphasizes that key elements are the lanes and curbside highway, where travelers with their luggage enter and leave the terminal, the roads in the terminal area travelled by private and commercial vehicles accessing the arrivals and departures area, and the parking area.

The maintenance of safety and efficiency standards must be ensured even with increasing traffic volumes (seasonal or annual growth), but often, the geometry of the lanes is constrained by the presence of terminal buildings and the proximity of other infrastructures serving the airport. So, their size, and therefore capacity, cannot always be modulated and aligned with traffic increases.

Traffic on airport roads differs significantly from that on ordinary roads (urban and rural) due to the highly restricted geometry, the different traffic composition, and the travelers' expectations. Unaccustomed drivers - unfamiliar with the area - mingle with a significant number of airport service operators and professionals who, driving vans, buses, and shuttles, due to their natural knowledge of the routes drive at operating speeds far above those of unaccustomed users.

Furthermore, there is a difference between traffic conditions within the same landside. The access and transit road network is characterized by traffic flows with driving styles typical of rural areas, while the road network of the landside areas is more akin to that of urban areas, both in terms of low travel speeds and the mix of traffic composition (private cars/pedestrians/buses and shuttles) and the multitude of manoeuvres permitted.

Figure 1 describes airport road network and its hierarchy by type.

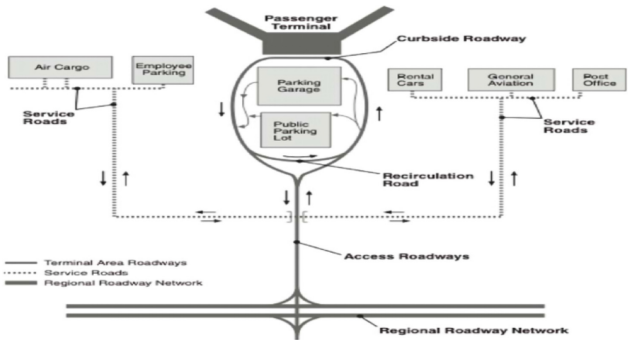

Fig. 1. Landside Hierarchy [14]

Roads are divided into:

Access Roadway: are roads that connect the regional road and motorway network with the terminal and other areas of the airport. They attract large volumes of traffic and generally have a limited number of decision points (i.e. entrances or exits).

Curbside Roadways: are one-way roadways which are placed directly in front of the terminal buildings where vehicles stop to pick up and drop off airline/non-airline passengers and their bags. Generally, curb side roadways consist of following road categories. (1) Inner lanes where vehicles stop or stand in a nose-to- tail manner while passengers loading and unloading. (2) Adjacent manoeuvring lane which is used to approach the inner lane. (3) Through or bypass lanes, which are used to move the vehicles through the facility without stopping. [11]. Depending on the configuration of the terminals, these roadways may be on staggered levels. In airports with a two-level Curbside Roadway, the area on the upper level serves the Departures area (i.e. ticketing and check-in). Those on the lower level are on the same level as the Arrivals (baggage claim and passengers).

Recirculation Roads: provide a variety of routes for the movement of vehicles between terminals, car parks and rental car facilities. Compared to access roads, Recirculation Roads generally serve a smaller volume of traffic, are less direct, operate at a lower speed and have more singular points (intersections with other roads, intersections between vehicle streams, etc.).

2.1 Aspects that Make Operating on Airport Roads Unique

The operational characteristics of airport roads and in particular of Curbside Roadways differ from other types of roads due to the peculiarities of the traffic and users they serve [15]. They can be summarized as follows:

1. Numerous and complex directional signs;
2. High percentage of large vehicles;
3. High percentage of unfamiliar drivers;
4. Mix of familiar and unfamiliar drivers;
5. Traffic circulation;
6. Presence of pedestrian flows;
7. Drivers often under stress.

Numerous and Complex Directional Signs. Airport directional signs often provide more information, that is more lines of text in the same sign, than the one on public roads, because of multiple and concentrated areas and services to reach. Signals often include colors, characters, symbols and messages not used on other public road signs. Due to the number, size and complexity of the signals, motorists may in some cases not notice regulatory signals and/or restrictions, thus contravening one regulation rather than another or due to information overload, slow down the gear to acquire all the necessary information causing slowdowns. Research suggests that drivers take at least 0.5s to read every word on signage and 1s to symbols [16].

High Percentage of Large Vehicles. More than 10 types of ground transport services operate on airport roads. The characteristics of each service, the needs of customers who use them and the operational characteristics of the vehicles used must be considered

when drawing up operational plans for the roads located within the airport area and, in particular, the terminal area.

Courtesy vehicles, door-to-door vans, buses and other large vehicles may account for 10 to 20% of the traffic volume. On public roads, the presence of these types of vehicles is less than 10%. The consequence of this, and at the same time a critical issue, is that the presence of large vehicles can obstruct drivers' view of signs and interfere with the movement of passing vehicles.

High Percentage of Unfamiliar Drivers. Most airport passengers are not frequent users and likewise the accompanying persons are often unfamiliar with the airport and consequently with the access roads. The mental workload of the occasional driver is higher as there are multiple facilities to be reached, arrival/departure terminal areas, time differentiated parking areas, transport service areas etc. Simplifying maneuvers, he often must find the correct entrance to the desired terminal road, a place to stop to accompany or pick up a passenger, he must pay attention to the maneuvers of other vehicles and pedestrian crossings. Finally, in these areas confusion and thus discomfort can be fuelled given the short distances available, the complexity of maneuvers, the limited lines of sight and the large amount of signage that must be coded in a reasonably short time [15].

All of these elements make travelling within the terminal area challenging, stressful and characterized by low speeds that for this category of users.

Mix of Familiar and Unfamiliar Drivers. Although most drivers of private vehicles rarely use an airport, 20% to 30% of the vehicles on airport roads (taxis, courtesy vehicles and limousines) are driven by professionals. These, like commuters and regular users, are familiar with airport roads and therefore have a more casual driving style than unfamiliar users since they know how to get to the various areas and therefore do not need to dwell on reading directional signs, which is required for the other category of users.

Traffic circulation. Entering and exiting the innermost lanes of the Curbside Roadway generate potentially dangerous conflict points due to sudden lane changes. In addition, it often happens that motorists, if they cannot find a space to stop and are waiting for an oncoming passenger, are forced to exit the terminal area. These recirculating vehicles contribute to road congestion and represent unnecessary traffic volumes (passive traffic).

Presence of Pedestrian Flows. The presence of large numbers of pedestrians, crossing either at zebra crossings or without rules and/or attention to traffic, constitutes an additional element of risk for traffic safety on this type of infrastructure.

Drivers Often Under Stress. The mental workload faced by a motorist travelling on airport roads, by the very nature of the facility, is a risk factor. It is further aggravated by the presence of conflict points, i.e. intersections between vehicle flows that perform constant lane-change manoeuvres, and by the presence of heavy pedestrian traffic, characterized by a higher crossing density than that normally found on urban roads.

The stressful condition stems from the knowledge that small delays or wrong turns can cause delays that can affect the rest of the travel chain up to the loss of the flight in extreme cases.

Airport travel includes intermodal actions and/or connections: car - plane, car - bus, car - train, searching for a rest area or parking space; in addition, there is the action of

finding a passenger, the correct place to drop off or pick up a passenger, locating a taxi, courtesy vehicle or city bus stop, and so on. Each action is therefore part of a chain of events, so it is clear that if just one element goes wrong, it can interrupt or delay a holiday, business meeting or other important event.

2.2 Airport Policies to Improve the Functionality of Roads Adjacent to Terminals

The airport management companies regulate the airport grounds by requiring commercial vehicle operators interacting with passengers to comply with the rules and regulations they prescribe:

1. The roads that each operator may use;
2. The parking areas where they may drop off or pick up passengers;
3. The maximum permitted parking times;
4. The speed limits and other restrictions with which they must comply;
5. The fees they must pay to operate at the airport.

Airport operators may charge commercial ground transport operators fees to recover costs or manage demand. These fees include those charged per company or per vehicle and cost recovery charges generally calculated based on the transport operator's vehicle trip volume or the volume of airport-related business.

Demand management fees may also include penalties for operators who fail to comply with airport regulations such as, for example, staying in the parking area beyond a set maximum time, exceeding the daily or monthly limit on the number of allowed passages, and violating the minimum time intervals established between successive courtesy vehicles. Airport operators can use these charges to improve traffic operations along curbside roadways, discourage unnecessary trips, reduce vehicle emissions, and improve air quality by incentivizing the use of alternative fuel vehicles or consolidated shuttle vehicles using concessionary charges.

Among the airports examined in Report 40 [14], the best airport with best Curbside Roadways arrangements are those airports that (a) physically separate private vehicles from commercial vehicles through the use of multi-level infrastructure or dedicated zones or areas, (b) provide good signage, and (c) provide a traffic direction that is easily readable by drivers.

The curbside roadway and the designated parking area are important components of the airport facilities on the ground [10]. As mentioned in the previous section, the operational characteristics of Curbside Roadways differ significantly from those of most other ordinary roads in terms of: vehicle dwell time, continuous lane changes and demand fluctuation. Therefore, operation and intervention plans must take into account in addition to the analysis of vehicular traffic, travel mode choices and vehicle queues along the Curbside Roadways, vehicle dwell times, passenger occupancy time at the platforms, etc.

Therefore, airport terminal curbsides are critical infrastructures, and their correct design is a crucial step for achieving positive passenger experiences avoiding long pedestrian paths, lack of information or long waiting time for transportation [17].

As airport passenger traffic increases, curbside roadway congestion is a growing problem. The capacity of a curbside is influenced by long dwell times of pickup vehicles at the curb, double parking, excessive queue lengths for taxi and limousines, and shortages of taxis and limousines. Congestion can be prevented through efficient curbside design and effective curbside management policies. Many airports accommodate the increase in passenger traffic by relying on policy and design measures to alleviate congestion and optimize operations [18].

Report 40 [14] provides a comprehensive summary of measures for improving curbside operations. The measures can be physical improvements and operational measures. Physical improvements, such as widening or lengthening the roadway, providing alternative pickup/drop-off areas, and constructing additional curbside levels, require substantial financial investment and space. Operational measures manage demand at the curbside by improving the public transit mode share, developing offsite facilities and rearranging curbside spaces. Wong and Baker [19] focus on rail transportation as a means to reduce curbside congestion and emissions and consider policies of US airports which promote the public transportation mode share.

3 Real Work – Aeroporto di Olbia Costa Smeralda

Olbia Costa Smeralda Airport is the second largest in Sardinia in terms of importance and number of passengers handled (3.2 mln in 2022 [20]).

As a result of the Ordinance issued by Enac [12] that regulates for each airport the management of spaces and regulates access, access to the parking area intended for short stay, enjoys a 15' free allowance valid for three daily entries. In the face of this, some operators appealed to the Regional Administrative Tribunal (TAR) for the removal of the free allowance limitation to only three accesses, winning the appeal. Hence the analysis of the effects of the measure.

3.1 ENAC Ordinance

Enac Ordinance [12] of March 2019 regulates vehicular movement on the state-owned area of Olbia Airport open to public use. It contains 20 articles of which the ones of interest and concerning the regulation of parking areas and the management of spaces for NCCs are Art.ii 8 and 13, respectively, which are given below.

As regulated by ENAC [12], parking spaces for NCCs, as just anticipated, are regulated by Art.13 which in summary:

- It identifies two areas where passenger loading and unloading can take place depending on the size of the buses:
  - o NCC1: vehicles with capacity over 7 seats, within the BUS area;
  - o NCC2: vehicles with capacity up to 7 seats, within the short-term parking area.

Both "*may only stay within the parking areas for the period of time necessary to drop off/pick up customers. Stops in excess of 30 min are not permitted*."

According to the regulations of the ENAC ordinance in Art. 8, "*In consideration of the safety needs of vehicular and pedestrian transit and the characteristics of vehicular*

flows in the vicinity of the air terminal, entrance with free allowance is permitted up to a cumulative maximum of 3 (three) accesses per day by the same vehicle. Accesses after the third will be charged according to the rules for the area concerned without any allowance."

In the face of this, a remote parking company filed an appeal against ENAC and the Airport Management Company for the annulment of the ENAC order [12] and in this case on the daily limitation of the free allowance to only 3 daily passes per car. On the face of this, the TAR for Sardinia ruled that the appeal was well-founded.

The grounds for the merits of the appeal, as justified by the TAR are: on the unlawfulness of the measure because the safety protection justifications were not found to be objective, as it concludes that: "*[…] Collective transportation, whether public or private, abates traffic and does not increase it*." The statement that logically "*Collective transportation, breaks down traffic*" recalled in the judgment deserves further study.

In some cases, it is evident that collective transport can reduce the vehicular traffic circulating on ordinary roads, but - on the other hand - it significantly increases pedestrian flows and conflicts between pedestrians and vehicles. Moreover, the peculiarity of this type of transportation (remote parking buses/shuttles) does not reduce the flow of cars at all but rather increases it. In fact, they themselves generate a continuous flow in the short-term parching area to accompany their customers/passengers who if they had gone independently to the airport would certainly not have transited in the short-term parching but at the long-term parching.

The critical issues of the Olbia airport are common to most airports and depend on the operations that characterize the road system in front of the terminal, which, it is worth reiterating, is characterized by vehicles that often stop in areas not allowed, maneuver and transit in a disorderly and unregulated manner in areas of limited size, which is precisely the part in front of the terminal. During the seasonal peak of the summer months, the promiscuity and number of vehicles in this area means that transit times, maneuvering spaces, and accessibility are severely affected.

In addition, the conspicuous presence of large vehicles limits visibility and all maneuvers are longer, uncertain, and unsafe. Still the presence of large flows of pedestrians, which in the peak season period reaches 20,000 passengers/day, pouring into the area in front of the air terminal, has important repercussions on the safety and service level of landside crossing operations.

3.2 Analysis of Passenger Traffic and Vehicular Transits

Olbia Costa Smeralda Airport serves a commercial passenger traffic of about 2.9 million (pre-pandemic data (2019)), of which 47% belongs to the Domestic segment and 53% to the International segment. Looking at the data for the first 6 months of 2022 (green), it can be seen that the traffic trend follows that prior to the downturn due to the pandemic years (2019 - blue), which suggests that the alignment will continue for the following months as well.

However, the aspect to be highlighted is the airport's tourist vocation, which serves traffic purely belonging to the leisure segment, which characterizes its marked seasonality. In fact, 78% of traffic (about 2.3 million) is handled in the 5 months between May

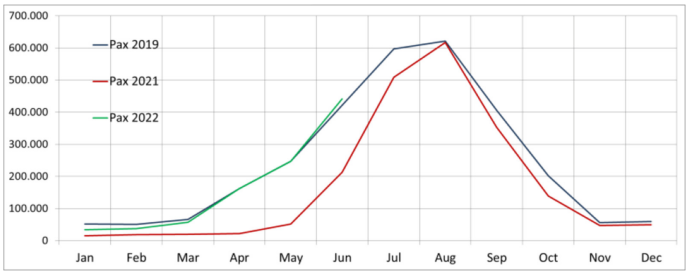

Fig. 2. Commercial passenger traffic (2019/2021/2022) (Data processing [20])

and September, months in which traffic exceeds the average monthly value (about 245 thousand pax) (Fig. 3).

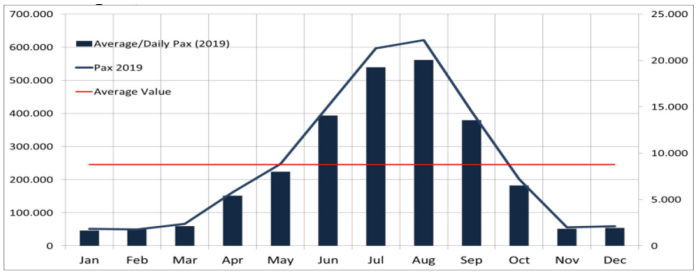

Fig. 3. Monthly passenger traffic trends (total and average daily), Year 2019

Staying on average values, an average of about 15,000 passengers pass through each day in the peak months with peaks of 20,000 passengers/day in August.

Such fluctuations inevitably spill over to the landside as well. In this regard, going into the specifics of the study, see the data on vehicular transit in the short-term parking area (Table 1).

Table 1. Number of transits with short stop tickets - historical series 2018–2022–

Year	Jan	Feb	Mar	Apr	*May*	*Jun*	*Jul*	*Aug*	*Sep*	Oct	Nov	Dic	**Tot**
2018	21.851	20.082	27.932	34.973	*44.917*	*67.176*	*104.338*	*116.209*	*65.169*	39.837	23.888	27.897	**594.269**
2019	21.407	20.201	24.283	39.470	*42.197*	*63.607*	*99.987*	*109.994*	*59.847*	36.769	22.001	26.260	**566.023**
2020	21.637	1.576	0	0	1	*15.475*	*65.471*	*101.897*	*41.791*	17.806	6.821	9.882	**282.357**
2021	8.040	8.498	10.103	10.710	*19.055*	*51.656*	*112.234*	*145.055*	*65.978*	26.745	18.267	21.178	**497.519**
2022	14.608	14.261	20.131	40.010	*49.130*	*81.086*							**219.226**

Until the date of the issuance of the Ordinance [12], a number of operators specialized in the business of remote parking and remote car rental operated within the airport grounds, and they managed their operations by benefiting from the time allowance within

the short-stay to carry out loading and unloading operations. Some of them, as a result of the Ordinance [12], which let us recall limits the maximum number of free daily passes to three and obliges commercial operators entering the short stop to agree with the Manager on the time and manner of their operations, have:

- Negotiated and found an agreement, signing an ad hoc sub-concession contract (3 operators). A specific area has been dedicated to them for this purpose to serve the loading/unloading activities, inside the main park that guarantees full security of operations;
- Relocated their headquarters within the rent-a-car area (1 operator);
- Stopped operating (2 operators).

Ultimately, remote parking and car rental operators agreed to two important conditions:

1. To be subject to a fee, recognizing that their business is related to and in absolute interdependence with the airport development activities of the operator,
2. To carry out service not at the short-term parking, but within the main park/rent-a-car area, safeguarding congestion and ensuring proper usability of the thoroughfares in the short-term parking area often subjected to slowdowns and blockages of both vehicular and pedestrian traffic.

The effects of the aforementioned ordinance can be seen by comparing the data of accesses to the short-term parking area in the pre-ordinance period: May - September (2018) with the same period in 2019 (Fig. 4).

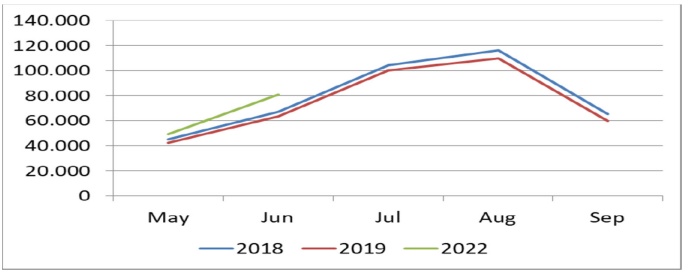

Fig. 4. Short-term parking area access comparison - Period May - September 2018/2019 - May - June 2022

The average seasonal change recorded between 2019 and 2018 is worth about -6%. Contributing to this decline is undoubtedly the transfer of 4 of the 6 remote rental operators from the short-term parking area to the long-term parking area and the discontinuation of 2 operators. Inserting the data for May-June 2022 (in green) into the analysis, on the other hand, shows a clear reversal of the trend compared to 2019, with an average increase in the two months of reference of about 7%, a value that is not supported by the traffic trend, which grows by an average of 1% during the same period (Fig. 2).

Downstream of the analysis just conducted and with regard to the passages recorded in the short-term parking area, it can certainly be concluded that the opposite trends

recorded at the turn of the pandemic period, i.e., the 2019/2018 traffic inflection (-6%) and the 2022/2019 increase (+7%) are the direct consequences, the former of the ENAC regulation of the airport's road system and airport grounds spaces, the latter of the decay of the same following the Sardinia TAR ruling.

Delving deeper into the issue of multiple passages, the following graphs show the processing of data referring to the transits in the short-term parking area and extracted on the day of 24/07/2022. Since the license plate of the car is recorded at each passage, the data processing made it possible to identify the number of passages made by each vehicle.

A total of 4.272 vehicles passed through the area for a total number of passages of 5.232. Of these 3.710 transited only once while 562 cars (13%) transited several times, from 2 to 14 times, generating 1.522 (29%) additional transits (Fig. 5).



Fig. 5. Distribution of access time on the day of July 22, 2022

Limiting the analysis to vehicles that have accessed more than three times, they in absolute value are 84 (2%) which translated into transits are worth 484 transits or 12% of the total daily transits (Fig. 6).

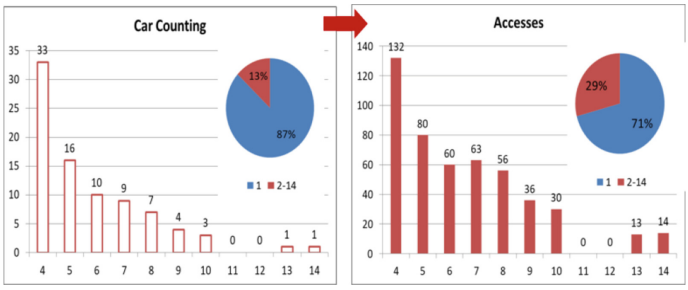

Fig. 6. Distribution of the number of vehicles with access greater than 4 and their number of transits

These multiple passes ranging from 4 (for 33 vehicles) up to a maximum of 13 and 14 for two individual operators respectively, are made throughout the day which confirms the operation of private collective transport services.

3.3 Parking Areas

The parking lots at Olbia Costa Smeralda Airport are located frontally and at a maximum distance from the Terminal entrance of about 140m. There are over 1.100 parking spaces available and they are divided into 3 sectors (Fig. 7).



Fig. 7. Aero photogrammetry landside Parking Area Olbia Airport

The small distances mean that they are absolutely walkable to such an extent that the airport, among the domestic ones, is the one with the greatest proximity of the parking area from the air terminal (Table 2).

Table 2. Distances parking areas at major national airports

National Airports	short-term parking Distance	Long-term parking Distance
Pisa	50 m ÷ 100 m	110 m ÷ 300 m
Bologna	40 m ÷ 125 m	250 m ÷ 460 m
Cagliari	28 m ÷ 45 m	80 m ÷ 210 m
Olbia	23 m ÷ 33 m	44 m ÷ 144 m
Milano - Linate	200 m ÷ 320 m	360 m ÷ 660 m
Alghero	60 m ÷ 170 m	120 m ÷ 330 m
Genova	45 m ÷ 85 m	85 m ÷ 220 m
Trieste	145 m ÷ 250 m	145 m ÷ 250 m
Bergamo	45 m ÷ 200 m	190 m ÷ 710 m
Bari	45 m ÷ 130 m	170 m ÷ 300 m
Palermo	28 m ÷ 110 m	300 m ÷ 700 m

Access to Sector C is through the gate located in the west area, in which there are 4 lanes (Fig. 8).

Starting from the right, the First is intended for access for the parking of State and relief agencies, vehicles for unloading goods for the air terminal, cabs and for the transit of vehicles designed to the bus parking lot previously authorized [12].



Fig. 8. Sector C gate

The Second (Commercial Aviation) is an access lane in which no stopping is allowed. In this lane, as indicated in the road markings, only the loading and unloading of passengers is allowed, a maneuver that must be carried out without the car driver getting out of the car. Access is allowed by collecting a ticket at the gate, which allows to cross the area for a time equal to 10', after which the short-term parking tariff will be applied [12].

Finally, the last two lanes provide access to the short-term parking area where incoming vehicles can stop for a time of 15' free of charge.

Once through the gate, the lane reserved for State Bodies/Taxi/Buses is protected and no longer accessible from the others (Fig. 9).



Fig. 9. Sector C gate - Lane division.

The distance between the air terminal and the Short Stop and Long Stop areas is 23 m and 44 m, respectively. The inconvenience generated to passengers in reaching the Long Stop compared to the Short Stop is insignificant, i.e. 21 m more, compared to the aggravation of traffic and safety conditions in the area in front of the air terminal. Wanting to quantify numerically the time loss of a passenger, assuming an average walking speed of 1 m/s [21] it is about 21 s. Conversely, the times for the parking maneuver are about 18 s (entry/exit), so a total of 36 s[22]. However, the times given are standard average values for passenger cars, under average traffic conditions and road sections. In the reference context, which is characterized by mixed vehicular currents (pedestrians - NCC - BUS) and operations different from ordinary roads, as described in Sect. 2.1, the times are longer. From a survey conducted by the Manager, the average times to make a parking space within the short stop area were found to be no less than 90 s.

However, if the benefit of 21 s saved per passenger are for the benefit of the individual, the 90s are for the benefit of all vehicles passing during that period. Referring to the data on transits at the short-term parking on July 22, reviewed in the previous section, there were 5.232 vehicle transits on that day, of which 381 were in the rush hour and in minutes 6,35 vehicles per minute. Translating the figure into time loss to vehicular traffic, for each individual passage, both have a cumulative time loss of 572 s. In summary, the advantage of a single passenger in saving 21 s translates into overall collective time loss of 572 s.

Regarding safety conditions, a rigorous and timely analysis on pedestrian and vehicular flows would be necessary, however, the current unavailability of data postpones the analysis to future research developments. Nevertheless, it is sufficient to observe that the conflict points between pedestrian (P) and vehicular (V) flow is proportional to the product of the two flows (P x V) resulting from the 4 areas: Long-term parking, short-term parking, Loading/Unloading, Bus/Taxi.

Each vehicle operating in the long-term parking will see its passengers crossing vehicular flows V_l, V_b, $V_{c/s}$ and $V_{b/t}$, vehicles transiting in the long-term parking, short-term parking, Loading/Unloading, and Bus/Taxi, respectively, with $V = V_l + V_b + V_{c/s} + V_{b/t}$. Conflict points with pedestrians transiting in the Long Stop area (P_l) should be added to these conflict points.

In this case, the total conflict points for each passenger will be:

$$V_l + V_b + V_{c/s} + V_{b/t} + P_l \tag{1}$$

Similarly, each vehicle operating in the short-term parking will see its passengers crossing the V_b, $V_{c/s}$ and $V_{b/t}$ vehicular flows. To these conflict points should be added the pedestrian flow conflict points of the two areas: Long Stop (P_l) and Short Stop (P_b).

In this case total conflict points for each passenger will be:

$$V_b + V_{c/s} + V_{b/t} + P_l + P_b \tag{2}$$

Whence the difference between (1) and (2):

$$V_l - P_b \tag{3}$$

Substituting the symbols for the numbers gives: (i) the vehicular flows at the long-term parking (V_l) gate are of the same order of magnitude as those transited in the short-term parking (about 5.000/day); (ii) the pedestrian flow was calculated assuming a certain rate of use of the area by passengers. In this regard, considering the average daily passenger figure for the month of July (19.000), conservatively assuming a utilization coefficient of the short-term parking area of 15%, the (3) returns 2.150 additional conflict points. This value certainly constitutes a high risk factor such that encouraging the presence of vehicles in the short-term parking area, without any restrictions, generates an increased probability of risks on pedestrians.

The following images show the irregular use of the parking area by remote parking/rental operators and or by unauthorized operators.

The images highlight the incompatibility of this service with the area under consideration, both in terms of the size of the vehicles, for which those over 9 seats, exceeding



Fig. 10. Use of the short-term parking by remote parking and rental operators

the size of the regulatory stalls, encroach on the traffic lanes, limiting transit and traffic capacity, and the way passenger loading and unloading operations are carried out, often inside the lanes and/or in areas that are not allowed, with what follows in terms of safety and traffic fluidity of private users.

The additional 21 m route to the long-term parking is indicated by a pedestrian segment protected by canopies (Fig. 11). It not only provides protection to pedestrians in case of rain and sunshine in warmer months, but also ensures excellent visibility of the pedestrian route to guarantee their safety, unlike the random crossing of the individual pedestrian.



Fig. 11. Covered shelters connecting the long-term and short-term parking and Sector C - short-term parking and Loading/Unloading Stalls

In fact, passengers of NCCs, remote parking shuttles, i.e., the authorized and non-authorized operators who benefit from the multiple accesses, if they went to the airport independently, would at most use the long-term parking and not the short-term parking. It emerged from the data analysis reported in the previous section, that there were 562 multiple passes on the sample day. Of these, 84 vehicles accessed the short-term parking area more than 3 times, generating 484 transits. It is reasonable to assume that these transits were made by commercial operators and not private individuals.

Hence the consideration that the annulment of the [12] ordinance has in fact transferred a collective benefit i.e. safety, good organization of the areas and thus their orderliness in favor of only the users of the commercial operators (private parties).

Added to this is the irregular activity of those who, in order to evade the payment of parking fees, wait for incoming flights in unregulated outdoor areas (e.g., at the traffic circle, traffic island divider beds, and at prohibited parking), creating situations of disorder, danger, and not least congestion. It is common and observed practice for passengers arriving and leaving the terminal to contact their pickups who move in platoons accessing the loading/unloading area and/or Short Stopover (Ref. Fig. 10) creating de facto congestion.

4 Conclusions

The study highlighted how the operation of roads within the airport grounds differ from ordinary roads. They are characterized by: (1) complex traffic flow with rapid lane changes, (2) a high percentage of buses/shuttles whose size may interfere with the lines of visibility of signs (articulated and complex) by motorists, (3) high percentage of unaccustomed drivers who perceive the complexity of the system and therefore have a mental workload that causes stress resulting in uncertain and unsafe driving different from users/operators who are familiar with the infrastructure and therefore adopt agile driving, and finally (4) high percentage of pedestrians with luggage in tow. It is evident from the above that although the road system in general, at whatever level one reasons, must be appropriately regulated in the pursuit of high standards of operation and safety, this applies even more so within the airport grounds.

Hence the analysis of Olbia airport, which in 2019 saw the cancellation of the ENAC Order [12] and in this case the daily limitation of the free allowance to only 3 daily passes per car. The analysis conducted in Sect. 3 highlighted how remote parking/rental operators and passenger shuttles are the only ones to benefit from this measure, allowing them free access to the Stopover/Breakdown area to carry out loading and unloading of their passengers. On a typical day in July, 4.272 vehicles passed through. Of these, 3.710 passed only once while 562 cars (13%) passed several times, from 2 to 14 times, generating 1.522 (29%) additional transits. It is evident how this results in worsening traffic conditions (queues, waits, congestion) and safety (significant increase in conflict points). At the same time, phenomena of irregular parking, the presence of unauthorized parties, conflicts and disorder not compatible with the orderly processing and routing of passengers are encouraged in a sensitive area facing the terminal.

At the conclusion of the study, it was found that the annulment of Article 8 of the [12] actually created a worsening of the situation, primarily by causing multiple passages with inevitable repercussions on security. In summary, it was observed:

- Creation of parasitic traffic in the landside road system;
- Continuous rotation of parking payment evaders creates additional use of the infrastructure by accelerating wear and tear on the roadway and the automated access system;
- There is objective confusion between licensed and unlicensed operators, with diversion of road space and capacity to the detriment of licensed operators;

- The management company loses control and the ability to regulate the most sensitive areas of the part facing the air terminal;
- The management company has a commercial detriment from the transit of squatter business operators without the necessary agreement with the Managing Company.

Hence the need for a more effective and efficient regulation that would remark the destination areas of operators' flows by reintroducing the limitation of multiple accesses to three. This regulation, benefiting from a reduction of transits in a parking area adjacent to the terminal and as such characterized by the different components of traffic, vehicular and pedestrian, deserves and needs to be regulated more effectively.

This does not mean taking away operating space from remote parking and rental operators, who would operate in areas dedicated to them, with the consequent benefit of harmonizing the entire landside area.

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