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ACCESSIBILITY TO STUTTGART AIRPORT

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Analysis of the mulimodal mobility system in the local airport FUA

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1. Introduction

Stuttgart Airport plays an important role for the local economy and tourism. Many global players like Daimler, Porsche or Bosch have their headquarters in the functional urban area of Stuttgart. Their employees rely on a good connection into the world. Various projects around the airport will create an even more important European transport hub in the coming years. In addition to this infrastructure projects, there is another focus on reducing the environmental impact. One aim of the Stuttgart Airport company is to be carbon-neutral in 2050. The following report describes the transport systems of passengers and luggage on and around the airport.

2. Stuttgart Airport and the functional urban area (FUA)

2.1. General describtion

The Stuttgart Airport is located about 13 kilometres south of the city of Stuttgart and is on the edge between the nearby municipalities of Leinfelden-Echterdingen, Filderstadt and Stuttgart. Stuttgart is the capital city of the federal state of Baden-Württemberg. Vehicle design and production as well as engineering in general are a vital part of the region's economy. Besides its traditional strengths, the Stuttgart Region is also well known for its strong creative industries and its enthusiasm for research and development. All these factors make the Stuttgart Region one of the most dynamic and efficient regions in the world[1]. The city of Stuttgart has a population of approximately 610.000 inhabitants by 2018[2].

The functional urban area (FUA) of Stuttgart comprises 95 municipalities. The total population of the Stuttgart FUA (DE007) were 1.965.942 inhabitants in 2014.[3] Besides the FUA Stuttgart there are other FUA`s in the direct catchment area of the Stuttgart Airport:

- FUA Sindelfingen (DE068) as a medium-sized urban area with 306.122 inhabitants.
- FUA Reutlingen (DE537) as a medium-sized urban area with 235.737 inhabitants.
- FUA Tübingen (DE050) as a small urban area with 189.252 inhabitants.
- FUA Heilbronn (DE529) as a medium-sized urban area with 372.093 inhabitants.
- FUA Pforzheim (DE533) as a medium-sized urban area with 243.262 inhabitants.

[1] https://www.region-stuttgart.de/englisch/overview.html

[2] Statistisches Amt Stuttgart, https://www.stuttgart.de/item/show/55064, opened 06.03.2018

[3] Functional urban areas in OECD countries: Germany (June 2016)

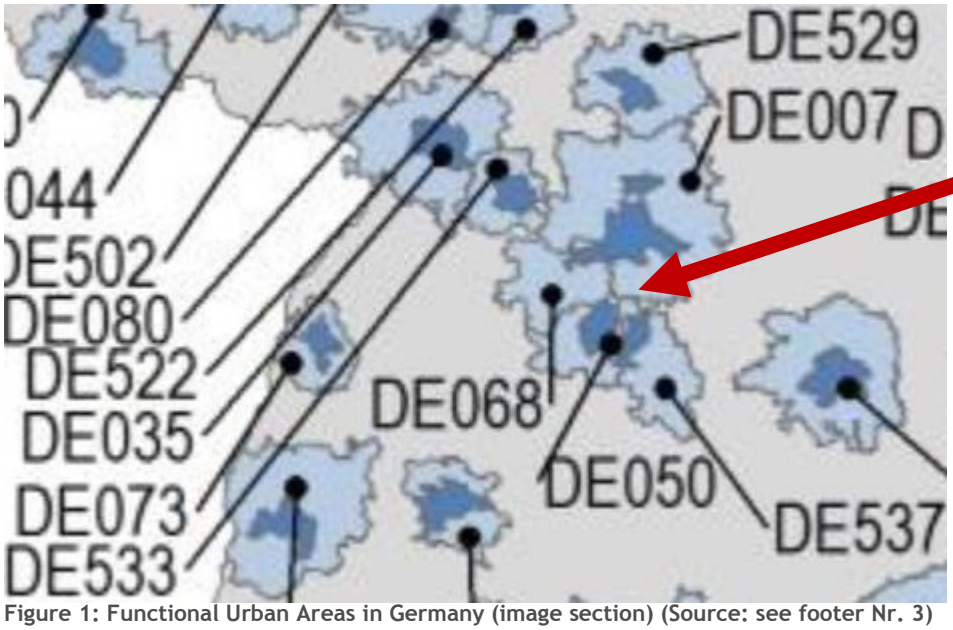

Figure 1: Functional Urban Areas in Germany (image section) (Source: see footer Nr. 3)

All these other FUAs are less than 60 minutes away from the Airport (by car). This five other FUAs combined with the FUA Stuttgart have a population of more than 3.3 million people.

A highlight of the airport is its proximity to the state´s exhibition centre and the airport city. The fair has a total exhibition area of 120,000 m^2, spread over 10 halls. In addition, a convention center called "ICS" with over 10,000 seats is available. In 2017 there were more than 1.2 million visitors at the fair.[4] Due to its proximity to the airport, the fair is used by an international audience. Fair and airport benefit from each other. Many companies use the proximity to the international airport and settle in Airport City. Stuttgart airport is developing a services and office location in the northern part of the airport, between the terminal facilities and the state's exhibition center. According to the airport company, about 170,000 m^2 of office space will be created over the next few years. The German headquarter of the consulting firm EY is already located in the newly built office complex called "Skyloop" with an office space of more than 33.000 m^2.

Looking at all this together, Stuttgart Airport is part of a strong economic sector in the middle of an international transport hub.

2.2. Airport facts and figures

The Stuttgart Airport spreads out over an area of 4 square kilometres in the south of the city of Stuttgart. With an annual passenger volume of 10.5 Mio, which consists of 28 % national and 71 % international flights, the airport is an essential factor for the economy of the federal state of Baden-Württemberg. Furthermore it provides jobs for more than 10 000 people in more than 300 companies, organizations and agencies. There are 39 shops and 21 restaurants, bars and cafés spread over all 4 terminals. Up to 400 flights with over 100 destinations and about 55 Airlines are landing and taking off daily on the runway.[5]

[4] http://www.messe-stuttgart.de/en/company/about-us/facts-figures/

[5] http://www.flughafen-stuttgart.de/unternehmen/zahlen-und-daten

Since 2014 the Stuttgart Airport is named after Manfred Rommel (*1928-†2013) who was Lord Mayor of Stuttgart and Chairman of the Supervisory Board for many years.

The Stuttgart Airport is managed by the Flughafen Stuttgart GmbH (FSG). The federal state Baden-Württemberg (65%) and the city of Stuttgart (35%) have a stake in the FSG. The FSG compromises the two business segments aviation and non-aviation. The first segment it is about air traffic planning and management, ground traffic service and passenger clearance. The business activities of the second segment are construction of the runway and the infrastructure, rental and leasing of restaurants, parking blocks and plots and supply services inclusive electric power, water, heating, cleaning, waste disposal, information- and communications technology. In 2016 the FSG had an turnover of 269,8 Mio Euros, 165,1 Mio Euros in the segment of aviation and 104,8 Mio Euros in the segment of non-aviation.

It is the aim of the FSG to be steady one of the most powerful and sustainable airports in Europe – the fairportSTR. All projects should be done in terms of the strategy of the fairportSTR. They should be economically successful though as well contain social responsibility and environmental compatibility.

2.3. Facts on enviromental and social engagement

Besides the economic success sustainability is the big aim of the FSG. They are committed to have a positive influence on the economy, society and the state of local and global environment. On that account they developed the fairport strategy, which is based on binding values and guidelines for all employees compiled in the fairport code. This code defines values and norms for the behaviour of all employees among each other as well as towards customers, competitors, business partners, public authorities and other stakeholder groups.

To reach the aim to become one of the highest-performing and most sustainable airports in Europe they defined steps to achieve on the way to fairport Stuttgart. One of these steps is the environmental policy. Running an airport has an impact on the environment. The airport operator contributes to reducing noise, greenhouse gases, energy consumption and waste as well as to protecting surrounding waters and biodiversity. To reduce its environmental impact to a minimum the Stuttgart airport intends to half its greenhouse gas emissions by 2030 as compared to 1990. By 2050 the airports operations are to be entirely carbon-neutral. To realize this ambitious plan they started efficiency and reduction projects. This means that the electric fleet will have to be increased, more energy will have to be produced from alternative sources and energy storages will have to be massively expanded. Therefore the FSG counts on technological innovations to be introduced in the coming 30 years such as a more efficient energy production in solar plants and better storage facilities. On the compound already exist a surface of 15.000 qm solar plants. On third of the produced energy is used by the airport itself and the remaining is fed into the public power supply system. Energy that is not produced at the airport is purchased to 100 percent from renewable sources.

More and more diesel vehicles are replaced by electric vehicles. Since the year 2018 the passengers and the luggage is transported by electric vehicles. Due to that local emissions at the airport are reduced and less noise is caused. That has a positive effect on the environment and the conditions for the employees.

SCALE-UP! is a project that realises the aim to reduce the CO^2-emission of the fleet by 80 % until the year 2020 as compared to 2009. Electric vehicles are particularly suitable at airports. On the one hand because the distances are short and on the other hand the breaks are long enough to recharge the battery consistently. Furthermore SCALE-UP! links to the already concluded project e-fleet. Through the major number of vehicles a wide amount of data admits specific statements about ecological and economical effects by electro mobility used on airports. The results are supposed to be assigned to all airports worldwide.

The project efleet was the beginning of the electrification at the Stuttgart Airport in 2013. In a period of 3 years the electrical vehicles dragged 12.000 airplanes, transported 1.5 Mio items of luggage and carried 300.000 passengers. The result was that electric vehicles are really suitable at airports.

Concurrently proceeded a similar project which focused especially on decarbonised passenger transport at European airports, in order to prove if the entire passenger transport could be managed with electric buses. With the aid of the European Union fast chargers and an electrical infrastructure was built. As a result the electrical buses are as good as the diesel buses at passenger transport but with a 70 % higher energy efficiency.

From 2015 to 2017 they tested an alternative energy storage beside the established lead acid batteries. Therefore they extended the fleet by a lithium ion baggage tug. It was investigated if there are differences in durability and charge time. Additionally they developed a guideline to facilitate the conversion to electro mobility.

The Stuttgart Airport is also dedicated in economical waste management, water protection and the preservation of the biodiversity to reduce the ecological footprint.

As far as practicable they avoid waste. The waste that is not avoidable is recycled in a valuable system with a utilization rate of 99 %.

To protect the water they built a sophisticated dewatering system. For instance they use chemical de-icer not until then ice and snow cannot be removed mechanically.

The about 2 square kilometres big green area is a habitat for about 70 plant species and numerous animals. Studies have proven that the biodiversity on the compound of the Stuttgart airport is not burdened.

Besides the emissions noise is a burden for the environment too. Not only for the habitat but also for neighbours and employees the noise must be decreased. The average noise pollution has been decreased in Stuttgart in the last years since the FSG encourages the airlines to use quiet airplanes with prices depending on the noise. Further to avoid nightly noise between 11.30 pm and 6 am civil airplanes with a jet engine are not allowed to land. To ensure soundproofing for the adjacent residents the FSG pays for physical alteration.

The FSG schedules a conjunction to the Central European pipeline system in order to make the aerial refuelling safer and more environmentally friendly. Yet about 6.500 trucks carry above 270.000 cubic meters of kerosene on a distance of about 70 km each way. The construction shall be concluded in 2019.

3. Characterisation of the mobility system

3.1. Airport access to Stuttgart and the FUA

In the next years the Stuttgart Airport will experience many changes in terms of mobility systems, especially the connection to the railway system. The German railway company “Deutsche Bahn” runs a railway and urban development project in Stuttgart, called “Stuttgart 21” or “Bahnprojekt Stuttgart-Ulm” with an investment volume of more than 8 billion Euro. One part of this project is the connection of the Stuttgart Airport to the ICE high-speed track between Stuttgart and Ulm. For these ICE Trains and for other regional trains a new station called “Filderbahnhof” will be built in the next years. The airport company supports this project with 359 million Euro, because this project will increase the airport´s catchment area and improve the accessibility. Also there will be a final destination of the streetcar “U6” at the airport/fair. Together with the existing city train station and the bus terminal between airport and fair, there will be an important interchange of the public transport, connecting air, rail and road. Stuttgart Airport sees as its task to link the land and air traffic in a way that the people in the region are

optimally connected. In addition, the improved accessibility of the airport also ensures that the regional economy is boosted. With these improvements, the operator expects up to 1,2 million additional passengers per year and at the same time reduced CO2 emissions.[6]

For FSG employees, there are benefits and subsidies for the use of public transport. In cooperation with Stuttgarter Straßenbahnen AG (SSB), the airport offers the company ticket, from which other companies based at the airport can benefit as well. The employees receive an annual subsidy of up to € 500.

The following chapter will examine characteristics of the existing mobility system in which the Stuttgart Airport is embedded.

3.1.1. Characterisation of road network and services

The airport and its FUA are connected via the motorway "A8" and the national road "B27". The city centre of Stuttgart can be reached within 15-20 Minutes by car in case of normal traffic. But often a longer ride must be assumed, especially in the rush hours. The motorway A8 runs from Luxembourg at Schengen via Karlsruhe, Stuttgart, Ulm, Augsburg and Munich to Austrian border near Salzburg. Travellers from Ulm (FUA DE532) need approximately 60 minutes (with good traffic conditions) to the airport. Taking the car from Karlsruhe (FUA DE035) takes the same time. The national road "B27" connects the FUA Stuttgart with the airport. To the south the "B27" connects the FUA Tübingen (DE050) and FUA Reutlingen (DE537) to the airport in less than 30 minutes by car (with good traffic conditions).

In the point of traffic density the region around Stuttgart is highly fraught. Often, especially to the rush hour traffic, it's faster to take public transport instead of the own car. Caused by the high traffic density and the location of Stuttgart there is a massive issue with air pollution. At some days, the air is so polluted that the city calls out an alert named "Feinstaubalarm" due to the high pollution of fine particles. At these days travellers and commuters can take the public transport for reduced prizes.

Via road, private or rented cars, taxis and busses can access the airport. The following chart shows the approximately traveling times of the surrounding FUAs (with good traffic conditions) to the airport by car:

CITY	TRAVELLING TIME	DISTANCE
STUTTGART	20 minutes	13 kilometres
SINDELFINGEN	20 minutes	17 kilometres
TÜBINGEN	25 minutes	33 kilometres
REUTLINGEN	20 minutes	28 kilometres
HEILBRONN	50 minutes	70 kilometres
PFORZHEIM	35 minutes	48 kilometres
KARLSRUHE	50 minutes	77 kilometres
ULM	60 minutes	79 kilometres

Table 1: Approximate travelling times to Stuttgart Airport by car, according to Google Maps

For about eight million people, Stuttgart Airport can be reached within 90 minutes by car, according to the company.[7]

[6] Flughafen Stuttgart GmbH – Bericht 2016 (annual report of the airport company), page 33

At the airport up to 11.000 parking lots are offered. There are also special parking spaces (extra wide parking bays) and space for guests with handicap. For electric vehicles in the public area, 48 electric charging points are offered.[8] All parking lots are fee required. The price range is between 23 and 35 euros per day and between 53 and 125 euros for the first week.[9]

The Stuttgart Airport Busterminal (SAB) is located in front of Terminal 4 of Stuttgart Airport. The three lanes include a total of 18 bus platforms, with platforms 1 to 3 serving regional transport. National and international long-distance bus services leave from platforms 4 to 18.

Several local bus lines are leading to Stuttgart Airport. From the South the Line 828 called "Airport Sprinter" connects Tübingen and other municipalities on the track to the airport. Depending on the travelling route, the traveling time is between 50 and 60 minutes from End to End. The bus line 828 operates from Monday to Friday between 4 am and 12 pm twice an hour, except between 4 to 5 am and 10 and 12 pm with only one bus per hour in every direction. On weekend there is a reduced schedule. The ticket costs up to € 6,20 for an adult.

Another bus line from the south is the "eXpresso X3" which operates between Reutlingen and the airport in a travelling time of 50 minutes. The bus line operates from Monday to Friday between 4 am and 12 pm once an hour. On weekend the schedule is reduced. One ticket for an adult costs € 5,95. During the night between 0 am and 4 am there is no connection to the airport.

Another provider, the "VVS – Verkehrs- und Tarifverbund Stuttgart" operates with several bus lines. Most of the city trains called "S-Bahn" are aligned to Stuttgart's main station as centre of the FUA. The "Relex" buses "X10" and "X60" operate tangential between bigger Cities and other important destinations like the university or airport and fair. Thus, these bus lines create direct connections, without going via the main station. The bus lines 122 and 806 operate between the airport and surrounding municipalities.

Besides the local bus transport, also long-distance bus services are connected to the Stuttgart Airport. Providers like Flixbus, Eurolines, ÖBB-Postbus, Deinbus and 60 other companies connect the airport with destinations all over Germany and Europe. There are around 20 domestic destinations and 50 destinations in other European countries offered.

The airport campus with 400 hectares is a large operating area. That's why it makes sense that the employees use bikes for on-site routes. There is a good parking space infrastructure. In total, employees and airport visitors have around 280 m^2 of parking space in car parks and in front of buildings. Nevertheless, only a few employees use the bicycle as a vehicle for the trip to work - this is due to the location of the airport.

3.1.2. Characterisation of rail network and services

Currently the airport isn´t yet connected directly to regional- and long-distance traffic by train. As mentioned, in the near future there will be a train station at the airport called "Filderbahnhof". With the high-speed track it will be possible to reach the main station in 8 minutes or Ulm in 29 minutes.[10] Also there will be a station of the streetcar "U6".

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[7] https://fairport-stuttgart-airport.com/

[8] https://ecomento.de/2018/01/10/stuttgarter-flughafen-jetzt-mit-48-elektroauto-ladepunkten/

[9] http://www.flughafen-stuttgart.de/an-abreise-und-parken/parken/parkplatz-buchen

[10] http://www.bahnprojekt-stuttgart-ulm.de/mediathek/detail/media/reisezeiten-regionalverkehr-und-fernverkehr/mediaParameter/show/Medium/

At the moment there is a city train station of the "S-Bahn" in the underground with direct access to the entrance hall of the airport. The city train lines "S2" and "S3" are operating the whole week between 5 am and 1 am of the next day with four drives per hour. On Saturdays and Sundays also at night (1am - 5am) with one drive per hour. The city train needs 27 minutes to/from Stuttgart main station. A one-way ticket costs € 4,20 for an adult.[11] At the main station there is a large offer of city trains, which connect the municipalities of the FUA, regional trains with destinations all over Baden-Württemberg and the long-distance traffic. A few destinations of the long-distance trains are:

CITY	TRAVELLING TIME	OPERATOR
PARIS	3 hours	TGV by SNCF
ZURICH	3 hours	SBB/DB
GRAZ	8 hours	EC by DB/ÖBB
BERLIN	5 hours 30 minutes	ICE by DB
FRANKFURT (MAIN)	1 hour 30 minutes	ICE by DB
MUNICH	2 hours 15 minutes	ICE by DB
ULM	1 hour	ICE by DB

Table 2: Travelling times by train (fastest connection). Data by bahn.de

3.2. On demand mobility services

In addition to the mobility offers already described, there are also on-demand mobility services available at the airport. There are car-/ ride-sharing initiatives, taxis and other shuttle services.

3.2.1. Car-sharing

Besides the travellers, car sharing is an interesting alternative for those who can´t buy their own car or don´t want to have an own car, in order to save the environment. The principle of car sharing is simple: You reserve a car of your choice by phone, by app or on the Internet, pick it up at a certain place, drive it and return it to a nearby parking space. It is usually billed by the kilometre travelled. In Stuttgart there are four providers: car2go, Flinkster, Stadtmobil carsharing and drivy, a platform where car owners can let their vehicle for a certain time. Only car2go offers its cars at the airport. This provider offers them according to the free-floating principle, means that the car is where the last customer turned it off. That is the main difference to the three other providers, where the car has to be picked up and taken back there. With a total of 550 electric vehicles of the brands smart (500 cars) and Mercedes-Benz B-Class Electric Drive (50 cars), car2go operates the largest fully electric, free-floating car sharing fleet in the world.[12] But this service is only provided between the "home area Stuttgart" (operating area of car2go) and the airport area.

[11] VVS online: www.vvs.de

[12] https://www.stuttgart.de/car2go

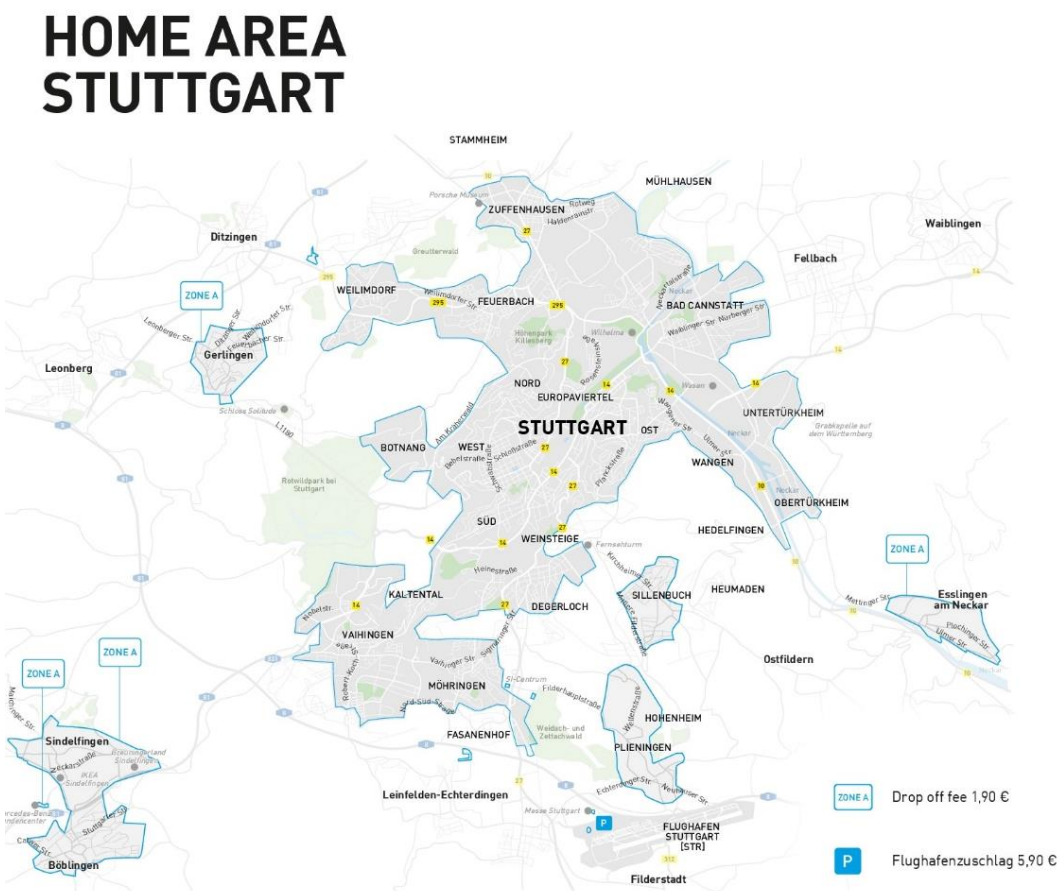

Figure 2: Home Area Stuttgart, https://www.car2go.com/DE/en/stuttgart/where

As shown on the figure, the operating area of car2go is limited mainly to the central city. This makes it interesting only for a limited clientele. Due to its sophisticated registration process, it seems that car2go isn´t an offer for tourists. It is more suitable for townspeople and business travellers.

The consumer pays 29 cents (smart) or 34 cents (B-class) for every minute using the car. Using it to and from the airport requires an additional fee of €5,90.

3.2.2. Ride-sharing

In and around Stuttgart there are many different ride-sharing providers available. With apps like blablacar.de or flinc you can search for journeys offered by private drivers. Many of this journeys are leading via the airport. But there is, unlike the public transport, no schedule. As a flight passenger you may have luck in finding an appropriate drive. Most of the offered journeys are leading to destinations in cities outside the FUA. A single drive costs about €5 to €10.

Since 2014 the airport operator offers a free ridesharing center for its employees. Since 2016 this service is provided for the employees of the subsidiaries as well. The platform TwoGo is developed by SAP and the employees can communicate a drive simply via an app or in Outlook.

3.2.3. Other on-demand services

At the end let´s take a quick look on the taxis (and other shuttle services) and the rental cars. On the airports homepage only one taxi provider is shown exclusively. The company “Hoffmann Taxi+Bus” offers

besides the taxis, mini busses, busses, limousine services and VIP-services. But in Stuttgart there are obviously many other taxi providers. At the homepage there is the contact of “Taxiservice Stuttgart”, a taxi-car office in Stuttgart with more than 700 cabs shown. The taxis are available in front of the terminals 1-3. In Germany you need a special taxi-driver license and a permission to run taxi business, therefore private taxi services like “Uber” are not available. Besides the other providers, Stuttgart Airport runs a VIP-service on its own.

Also 9 international car-rental services like “Avis”, “Europcar” or “Hertz” have a subsidiary at the airport.

4. Mobility information systems

4.1. Describtion of existing mobility information systems

In the first part there will be a short description of “offline” mobility systems. These systems fit especially for those travellers, who don’t have a fitting mobility app or no access to an internet connection. After that, some chosen apps will be described.

The first place to go for incoming passengers is the "Tourist Information Center Stuttgart". It´s an information point with different kinds of services like hotel reservations, ticket sales (regional tickets of the FUA, tickets for the FUAs in the south and long-distance tickets), souvenirs or city tours/walks. The info point is located in Terminal 3 at the arrival´s level. In addition to this, digital schedules of the next trains and busses are placed at the arrival hall. Taking the bus, it is possible to buy a ticket from the bus driver. Moving down to the city train station, there are ticket machines with menus in different languages. The provided languages are: English, French, Italian, Spanish and Turkish. Also there are route maps and printed timetables. In the city train, the next station is normally announced only in German. But for the main station and the airport/fair there is a call in English too.

In the functional urban area of Stuttgart different public transport apps exist. Some of them can be used all over Germany and some of them only in the region.

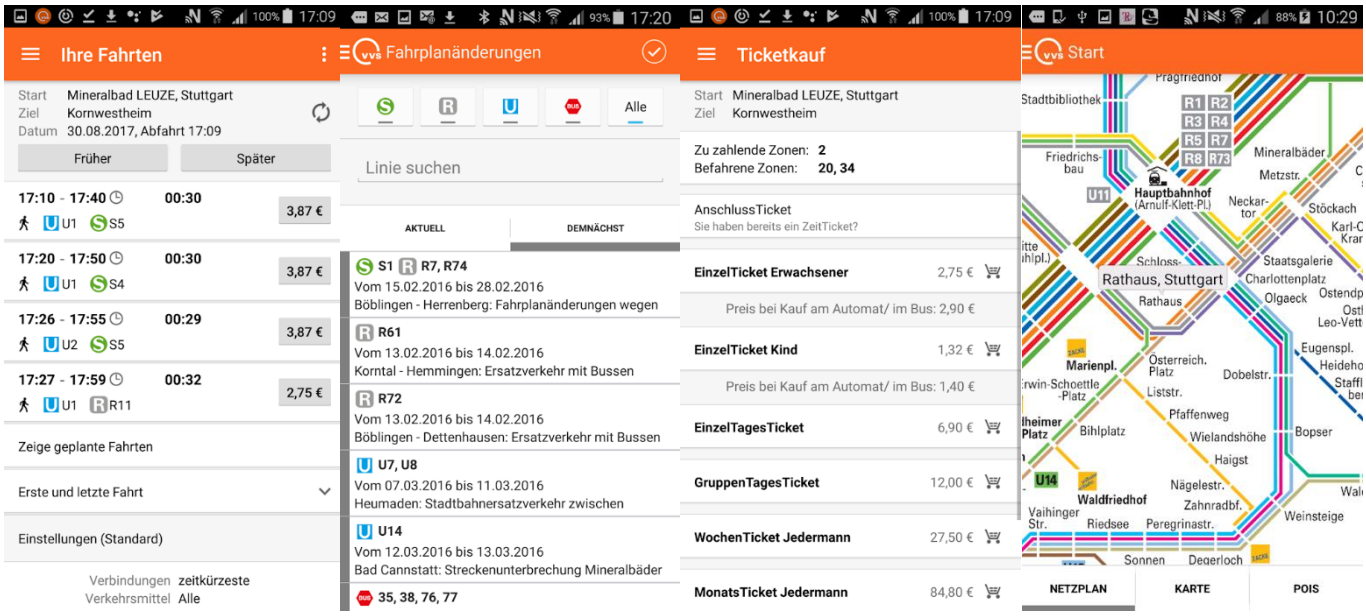

Figure 3: Screenshots VVS mobil App, Source: https://play.google.com/store/apps/details?id=com.mdv.VVSMobil

The “VVS mobil-App” is a system restricted to the region of Stuttgart. This is the operating area of VVS (Verkehrs- und Tarifverbund Stuttgart), the local public transport provider. VVS is running the city train called “S-Bahn”, the streetcars, busses and other mobility services. The app provides all information about the public transport in the region. You can plan and book your travel via the app. The app plans your travel to the exact address, means it shows also the way to walk on a map. Also you can get live information about single connections like the delay time or cancelled rides. If you book your travel via the app, you get a reduced ticket price. Once you have bought a ticket, it appears as a QR-Code in the app.

The application “DB Navigator” is similar to the “VVS mobil-APP” but on a national level. It already offers a variety of different services around rail travel, like mobile booking, real time information with current departure and arrival times or the opportunity to set a delay alert. Every day about 4 Mio. travel information is provided and in 2017 15 Mio. tickets were sold via the application. The “DB Navigator” provides also regional offers. The route planner shows the navigation for footways as well as lines of S-Bahn and underground, trams and busses. Meanwhile it is one of the most used applications in Germany.

Many people also use Google Maps. It shows the shortest way to the destination including footways and the route of the train. It shows different possibilities and as soon you have chosen one it also shows the link to the homepages of the mobility provider to get detailed information. An advantage is, that almost every traveller has access to Google. You can´t pay directly on Google Maps, but the user gets redirected to the purchasing site.

4.2. Potentials and gaps of mobility information services

The following aspects might be present gaps, but they can also be potentials for the future:

- There are many mobility apps on the market, but every app has its pros and cons. For example, the app of “Deutsche Bahn” (german railway company) works in whole Germany, but if you want to buy a ticket, only connections with trains runned by DB can be booked. What is missing is a unified solution.
- To increase the attractivity of public transport a reward program could be evolved, e.g. bonus miles for using public transport like frequent flier miles.
- On possible potential for the future could be an on-flight information panel, where you can look for connections at the plane.
- Lack of availability of public transport during the night times for those employees who begin to work at night time (0 am to 4 am).
- Long travelling times into southern FUAs (will get better in future).
- Car-sharing isn´t yet available for every user group (due to its sophisticated registration process)

5. Conclusion

The airport of Stuttgart is well accessible by road and rail. But not every part of the fua is connected equally has the others. To change this several projects have been started. They all follow the aim to expand the accessibility to the airport. Further the FSG wants to be carbon-neutral in 2050 meaning sustainability is a big aim too.

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