Small Aircraft Transportation System

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The article presents ways of transportation system development which is possible to revolutionize personal air transport in the first half of the 21st century. Small Aircraft Transportation System – SATS uses small planes operating on the current aerodromic infrastructure. Aeroplanes operated by one pilot taking onboard up to 14 passengers should considerably speed up air transportation "from door to door" at the distance to 1500 kms. This aircraft should perform on airports with underdeveloped flight control systems, landing support systems or well developed infrastructure. The article comprises SATS system requirements on procedures, technologies and the modernization of flight control systems.

The nineteenth century, the age of steam and electricity, was an age when cars democratised travelling in the two-dimensional world. Travelling was no longer limited by the location of seaports, river harbours, or railway lines. The car dominated the world transport of the 20th century, making it possible for a wide range of people to realize their dreams, allowing free migration all over the world. The 21st century, the age of information, issues entirely new challenges before modern means of transport. The 19th and 20th centuries paradigms on transport, will not satisfy transportation needs of the new age. Since the very beginning of the aviation era, the aerospace became part of the national road-infrastructure, acting as the free three-dimensional expressway, where airfields are treated as loading platforms which make it possible for us to freely use this "highway in the sky".

1. INTRODUCTION

11 September 2001 diametrically changed the world of air transportation at the beginning of the 21st century. Air carriers worldwide had to increase drastically security measures in the air traffic, which in turn caused restrictions and difficulties in the passengers check-in, and longer flights, which indirectly led to the recession in the tourist trade.

Surprisingly enough, despite its considerable travelling speed, when compared with other means of transport, the air transport is only profitable with the distance between destinations of 600 - 800 km. The average travelling speed of a statistical passenger with large air carriers in '*door to door'* variant, with the distance between destinations of 800 - 1000 km, does not exceed 100 - 120 km/h *(Fig. 1)*.

One of the ingenious solutions to the problem above, intending to increase the average travelling speed, is the system of air traffic on short distances (to 1500 km) using small planes (*AirTaxi*).

Such a system has been introduced in the US and is called SATS (*Small Aircraft Transportation System.*

The US are one of the most "aeronautically urbanized" countries in the world. At present in the US, there are over 5400 airports and landing fields, with over 18 000 facilities of air infrastructure. Over 93% of the population live at a distance no greater than a 30 minute drive from each of them.

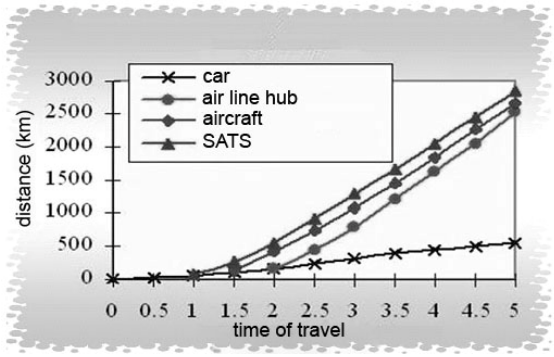

Figure 1. Average speed of travel for selected means of transport.
Source: Bruce J. Holmes & and Michael H. Durham - Small Aircraft Transportation System Concept and Technologies - JOURNAL OF AIRCRAFT Vol. 41, No. 1, January–February 2004.

In Europe there are 1270 airports and 1300 landing fields *(Fig. 2)*. There are 43 major airports *(large and medium Hubs)* and 450 domestic and regional airports *(commercial service airports)*. European airports have 1336 hardened lanes (concrete or tarmac) with 737 airports adapted to make IFR flights *(Instrumental Flight Rule)* – Instrument landing (IIIC category airports)[12].

Figure 2. Localization of airports and landings in Europe.
Source: [12][14][15].

The concept of Small Aircraft Transportation System emerged in the late 80s' of the 20th century, and was introduced in the paper *"The Role of Technology In Revitalizing the U.S. General Aviation Industry"* sponsored by AAIA, NASA, FAA. The term SATS was used for the first time in AGATE undertaking *(Advanced General Aviation Transport Experiments),* carried out by privately-owned enterprises in the US in the years 1994 - 2001. At present SATS project is being developed by consortium incorporating state and private enterprises as well as US organizations: NASA, FAA and NCAM *(The National Consortium for Aviation Mobility)*. The NCAM SATSLabs consortium comprises over 130 members [2].

Through a number of simplifications in the air traffic procedures, STMS system will increase the average travelling speed from "door to door", as well as efficaciousness and accessibility of transportation services [1].

STMS system enables:

- The use of small passenger planes *(Fig. 3)*;
- The use of the infrastructure of small, partially functioning airports, without well-developed ground support systems for take-off and landing;
- A wider choice of carrier services virtually to any part of the country or mainland – air TAXI;
- A relief of huge "traffic jams", becoming one of the biggest problems of modern civilization;
- Reduction of travelling time between two locations by 75% (2030 yr).

Figure 3. A project whitin STMS planes programme.
[http://lisar.larc.nasa.gov/IMAGES/MEDIUM /EL-2000-00005.jpeg]

Maximum distance between European airports and landing fields is observed for the distance of about 1000 km, while a small number of possible connections exceeds the distance of 2000 km.

For Polish airports the maximum distance appears at approx. 300 km. Assuming that with distances to 250 km in Polish conditions the air transport is not in a position to compete effectively with other kinds of transport, for the cost and the lead time, it is possible on the basis of the schedule (Fig. 4) to define the range of the distance of potential connections and distances on which exercising STMS flights is the greatest.

The use of airports with no take-off and landing support systems (the aerodromic radar, the instrument landing system, MLS, the control system of the air traffic) partly constrains the operativeness of the system only for flights in good weather conditions. Because of the lack of the ground control equipment, such airports are able to direct simultaneously only one plane. This limits the number of planes being directed to approx. 3 – 4 per hour.

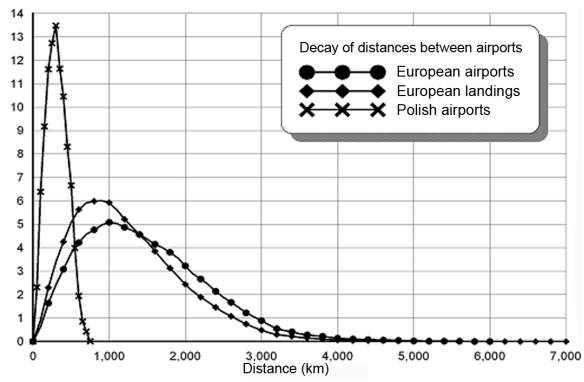

Figure 4. Decay of distances between European and Polish airports and landings.
Source: [12].

The growth of the air traffic within the framework of SATS project entails additional threats concerning flight safety. Despite the statistics informing that the flight by plane with a large carrier is four times safer than travelling by car, the situation with air taxis looks totally different. In 2004, the National Transportation Safety Board (USA) recorded 3464 accidents and incidents with air taxis, of which 1285 resulted in death. Statistical data point out that approximately 50% of air accidents happen during landing approach or while landing, whereas 20% are connected with take-off procedures [12]. Therefore one of the basic requirements that such planes are obliged to comply is increased safety along with the simplicity of pilotage which is associated with a range of investments in air traffic control systems both "on the ground" and "in the air". The development of control systems is heading towards the unification of ground control centers with deck navigation systems on planes in STMS system via digital data transfer connection.

The navigation system of the plane supported with systems of satellite navigation, transfers data of its own spatial position and flight parameters, to the ground control centres, and through a dual carrier channel receives instructions from the air traffic controller, navigational guidance, weather data as well as the information on air traffic over a particular area. Both the flight crew and the air traffic controller are informed real-time about the aerial conditions in a defined airspace.

2. THE AIR TRANSPORT IN POLAND

Poland has an underdeveloped road network, motorway system, railways and airlines. Because of their dismemberment, motorway stretches do not ensure long-distance connection between various regions of the country *(Fig. 5)*. The Ministry of Infrastructure has worked out a Plan for the Development of the Infrastructure of Transport in Poland, which implies constructing motorway network of a total length of 2085 km by the year 2013 (by the end of 2008 there had been laid barely 756.3 km of motorways) [12].

Poland is one of the European countries of the highest airport concentration in relation to unit area. In the state territory there are 118 airports and landing fields of which only 38 possess concrete or tarmac runways *(Fig. 6 – numbering accordant with [13])*. It means that approx. 70 % of people live within a 30min drive to the nearest airport *(USA approx. 93%)*. 11 international and national airports are adapted to perform IFR flights. On the remaining local airports landing is possible in VFR conditions *(Visual Flight Rulet)*. The last group comprises around 60 flying club, private and other air fields, with sod surface, useless at their present stage for the requirements of STMS standards [13].

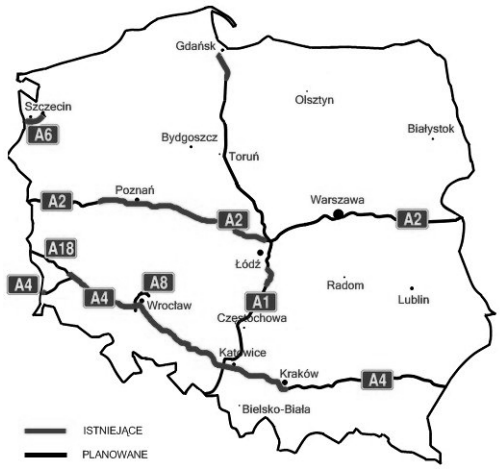

Figure 5. Arrangement of highways in Poland.
Source: http://automoc.ovh.org/autostrady111111.jpg

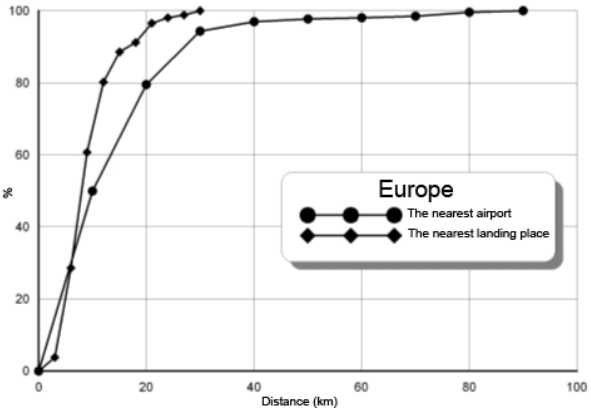

Figure 7. Decay of distances from cities to closest landing or airport.
Sources: [12][16].

Figure 6. Arrangement of airports and landings in Poland.
Source: http://www.jetforyou.pl/img/mapa-lotnisk-polska.jpg

3. ACCESSIBILITY OF AIRPORTS IN POLAND

It is worth noticing that besides the airport Warsaw – Okecie, whose capacity was depleted in 1998, and whose margin runway capacity will have been reached by the year 2020, the remaining airports do not fully use their capacity [12]. The above-mentioned state of national airports is insufficient in comparison with. In Poland there are 3.2mln citizens on average to one airport, whereas in the countries of West Europe it is approximately 0.46 mln citizens.

The result is that in some parts of the country passengers have to travel over 150 kms to reach the nearest airport (e.g. Bogatynia – Wrocław about 160 kms) [12][16]. Figure 7 depicts distribution function of the distance from various European cities (population size over 50 thousand citizens) to the nearest airport or landing ground. For 80 % of European cities the nearest landing field is located no farther than 12 – 15 km, while the closest airport is 20 km. Such a short distance allowing passengers to travel fast between cities and airports (landing grounds), proves their high accessibility in Europe.

The development of small airports network taking planes which use STMS system, will be observed in Poland in extension and modernization of existing civil airports as well as in utilizing and adaptation of former military air bases and sports – services air grounds. Any decision to build new airports will only be made after the capabilities of extension and modernization of existing airports have depleted.

With reference to developmental project of STMS airport network, the following actions must be taken into consideration [12][13][16]:

- modernization and development of the infrastructure of Polish airports, as well as simultaneous improvement of the accessibility to the air transportation, and eradication of regions isolation;
- improvement of regional and local accessibility to airports, with particular regard for conurbation;

- adjusting airport network to a domestic and EU network of intermodule transportation;
- active development of regional airports through the modification and improvement of certain Polish air regulations to fit STMS standards;
- problem solution of airport management shared by military services and civil aviation, through the setting of priorities in accordance with the country's defenses interest and regional development.

The problem in chosing the right location for a new airport is most often associated with the clash of interests of the local community. In creating selection criteria, the public interest must be taken into account, as well as the fact that there will always be certain objections to the construction of a new airport, irrespective of whether the location is perfectly convenient for air transportation, or if it is an indirect solution, using already existing infrastructure:

- Criterion of communicational accessibility for a particular localisation of the airport. The relations between the airport and other means of transport e.g. motor traffic and railway service. Minimizing the driving time to the airport parallel to "distancing" the airport from the city centre.
- Criterion of the lay of the land, with regard to already established building complex. In view of safe and effective air operations at the airport area, it is necessary to see to required space free of natural obstacles.
- Criterion of environment protection. The main threats to the natural environment are noise and pollution.
- Criterion of possible future development and mutual relation between airports. The assumed localization and the possibility of airport development are considered substantial for the next 60 years.
- Criterion of activity initiation time.

4. THE DEVELOPMENT OF STMS AIRCRAFT

On the turn of the 80s' and 90s' of the 20th century many aviation companies began scientific and design work aiming at creating new generation, prospective aircraft of STMS system, enabling passenger transport (from 2 to 14 people), carrying loads, patroling and protecting of forests, medical service, airmail etc. [12].

STMS project stipulates a range of changes in air transport techniques which can be expressed in the following four points:

- The ability to perform a flight between airports without the necessity of air traffic control tower support and airborne radar;
- Safe landing in all weather conditions;
- Full integration of STMS project with the present airport infrastructure;
- Thorough control over the course and safety of the flight by a single pilot.

Complete development of STMS program is possible not only through the modernization of the present aerodromic infrastructure but also through complete technological changes of existing and designed aircraft. The main modifications are based on:

- Integration of current on-board systems with data display system, allowing the creation of *Highway In the Sky (HITS)*. The flight route in its graphic form is displayed on Head Up Display (HUD), creating the impression of three-dimensionality *(3-D Flight Display)*. The necessary pilotage - navigational information as well as that on the functioning of on-deck instruments and on-board systems, are displayed on MFDs *(Multifunction Displays)* placed on the instrument panel *(Fig. 8)*.

Figure 8. HITS – Highway to heaven.
Source: http://ultimateroute.com/gpsnotes.htm.

- The flight route is generated on the basis of navigational information received by on-board, ground and satellite systems, and also

basing on the images of the environment from deck cameras operating in Low Light TV *(LLTV)* and infrared *(FLIR – Forward Looking InfraRed)*.

- Modernization of propulsion systems comprising the use of new, cheaper and more efficient fuel, constructing new and more cost-effective propelling systems based on polymers, ceramic materials, the use of electric propulsion systems powered by fuel cells, attempts to reduce noise and the use of new (turboprop aircraft) *(Fig. 9)*.

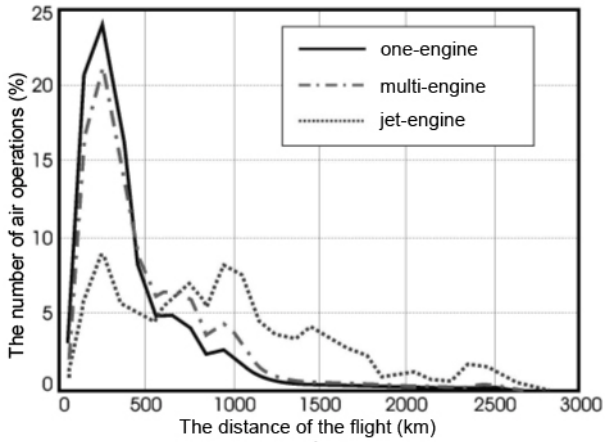

Figure 9. The choise of plane propeller as a function of the number and scope of air operations.
Source: [12][16].

- Modernization of on-board deicing systems allowing flights in all weather conditions
- Construction of high-tech flight training simulators reducing training costs and increasing the efficiency of trainings in pilotage – navigational equipment of pilots

5. FINAL CONCLUSIONS

STMS system will allow people to travel "on demand" on any flightpath, in any place and at any time, not limited by flight schedules and timeconsuming airport procedures. The main reason for the development of STMS is four times faster travelling time "from door to door", in comparison with the average speed of travelling by car. The system should take control of the majority of flights between places distanced from each other from 250 to 1500 kms [12]. STMS system should become open for general use, safe, cheap and fail-safe, and it should fulfil a number of requirements:

- High operativeness;
- Lowering the direct operating cost and increasing of the user's profitability*(Fig. 10);*
- The possibility to use airports with no aerodromic infrastructure (landing ground);
- Minimal requirements concerning the use of airport space;
- Full integrity with the current infrastructure and flight control procedures;
- Simplification of aircraft manufacture and reducing its costs for STMS system;
- Improvement of flight control and pilotage, influencing flights safety;
- Increasing aircraft endurance and indefectibility;
- Pilotage performed by only one pilot.

STMS system preliminary assessments state that approx. 20 - 40% of citizens should have access to the system, whereas transportation costs should not exceed 15 – 20% with comparable costs of car transport.

STMS system will create new communicational possibilities, new enterprise zones, and a new way of transportation, alternative and more flexible than before.

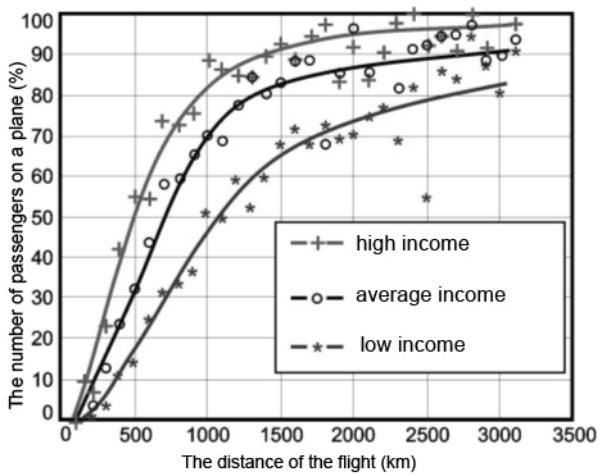

Figure 10. The influence of income and travelling distance on the number of passengers.
Source: [15].

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