POTENTIAL SOLUTIONS OF INSTRUMENT APPROACH PROCEDURES TO A SMALL AIRFIELD EMPLOYING SATELLITE NAVIGATION SYSTEMS

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This thesis discuss the problematics of the aplication and potential use of the procedures, which are given us by thw global navigation satellite systems and their augmentations, for small airports. In the first pharagraph characterizes and describes the sattelite navigational systems used in aviation and also discusses individual augmentations of GNSS systems used in the Europe and other parts of the world. Content of the second part assembles requirements for performing and constructing the instrument approaches. Characterizes the requirements of the international standards and assembles them to a whole. The next paragraph is aimed on the possibility of the application of the instrument GNSS approaches and their augmentations for small airports, for which theese systems are possible solution as an appropriate landing system. Thesis further describes differencies and advantages of the GNSS systems and their augmentations over the convetionald landing systems. Last paragraph of this thesis solves design of the intstrument arrival and approach for the small airport Svidník. It contains a evaluation of the operational procedures, rectrictions in vicinity of the airport and description of the designed instrument arrival and approach for the airport and includes also corresponding maps.

K e y w o r d s: GNSS, GBAS, SBAS, instrument approach, GLS approach, airport Svidník, aerodrome operatong minima

1 INTRODUCTION

Currently in the field of civil aviation receive current conventional navigation and landing systems into the position of providing services and operating costs can not compete with the modern system based on satellite navigation. Services provided global satellite navigation systems are now widely used in various industries . GPS services have become part of our lives as a reliable and easily accessible way navigation and positioning . Even in the field of civil aviation achieved substantial growth . Developed systems are extensions of basic GNSS receivers and thus achieve high accuracy and integrity of these systems . This enabled the creation of a new approach systems . These systems represent the future of navigation and positioning in civil as well as military aviation . In the first chapter of my thesis I will focus on the study of global navigation satellite systems and their extensions .

The problem is that there are actually complete instructions for the construction of these procedures and GBAS system, for example, use the techniques carried over from the ILS. In my work in the second and third chapter gather information necessary for the construction of approach using GBAS system to the airport, which currently does not have any other navigation respectively. landing systems. This information then will use and apply in creating the precision approach using satellite navigation systems with ground-based augmentation.

In the last chapter of my work will focus on issues and design solutions arrival process and an approach to a small airport. For this purpose I chose a small airport in Svidníku. It has reinforced resin track with suitable dimensions. One of the reasons why I opted for the proposal airport Svidník is the fact that as a pilot operating at this airport familiar with local operating conditions and limitations. In developing the draft instrument approach I will see to it that this particular process ensures clearance from obstacles, reliable guiding the aircraft to land and that are simple.

Process design approach and arrival airport Svidník can be applied in the future to service, thereby ensuring further development of the air and pushed the boundaries of the applicability of this small airport, for example. even in small regional aviation.

2 GLOBAL NAVIGATION SATELLITE SYSTEMS GNSS

A **satellite navigation** or **sat nav** system is a system of satellites that provide autonomous geo-spatial positioning with global coverage. It allows small electronic receivers to determine their location (longitude, latitude, and altitude) to high precision (within a few metres) using time signals transmitted along a line of sight by radio from satellites. The signals also allow the electronic receivers to calculate the current local time to high precision, which allows time synchronisation. A satellite navigation system with global coverage may be termed a **global navigation satellite system** or **GNSS**.

As of April 2013, only the United States NAVSTAR Global Positioning System (GPS) and the Russian GLONASS are global operational GNSSs. China is in the process of expanding its regional Beidou navigation systeminto the global Compass navigation system by 2020. The European Union's Galileo positioning system is a GNSS in initial deployment phase, scheduled to be fully operational by 2020 at the earliest.[2] France, India and Japan are in the process of developing regional navigation systems.

Global coverage for each system is generally achieved by a satellite constellation of 20–30 medium Earth orbit (MEO) satellites spread between several orbital planes. The actual systems vary, but use orbital inclinations of >50° and orbital periods of roughly twelve hours (at an altitude of about 20,000 kilometres (12,000 mi)).

Satellite navigation systems that provide enhanced accuracy and integrity monitoring usable for civil navigation are classified as follows:

- **GNSS-1** is the first generation system and is the combination of existing satellite navigation systems (GPS and GLONASS), with Satellite Based Augmentation Systems (SBAS) or Ground Based Augmentation Systems (GBAS). In the United States, the satellite based component is the Wide Area Augmentation System (WAAS), in Europe it is the European Geostationary Navigation Overlay Service (EGNOS), and in Japan it is the Multi-Functional Satellite Augmentation System (MSAS). Ground based augmentation is provided by systems like the Local Area Augmentation System (LAAS).
- **GNSS-2** is the second generation of systems that independently provides a full civilian satellite navigation system, exemplified by the European Galileo positioning system. These systems will provide the accuracy and integrity monitoring necessary for civil navigation; including aircraft. This system consists of L1 and L2 frequencies for civil use and L5 for system integrity. Development is also in progress to provide GPS with civil use L2 and L5 frequencies, making it a GNSS-2 system.
- Core Satellite navigation systems, currently GPS (United States), GLONASS (Russian Federation), Galileo (European Union) and Compass (China).
- Global Satellite Based Augmentation Systems (SBAS) such as Omnistar and StarFire.
- Regional SBAS including WAAS (US), EGNOS (EU), MSAS (Japan) and GAGAN (India).
- Regional Satellite Navigation Systems such as China's Beidou, India's yet-to-be-operational IRNSS, and Japan's proposed QZSS.
- Continental scale Ground Based Augmentation Systems (GBAS) for example the Australian GRAS and the US Department of Transportation National Differential GPS (DGPS) service.
- Regional scale GBAS such as CORS networks.
- Local GBAS typified by a single GPS reference station operating Real Time Kinematic (RTK) corrections.

3 EGNOS

Satellite-based augmentation systems (SBAS), such as EGNOS, complement existing global navigation satellite systems (GNSS). SBAS compensate for certain disadvantages of GNSS in terms of accuracy, integrity, continuity and availability.

For example, neither the USA's GPS nor Russia's GLONASS meet the operational requirements set by the International Civil Aviation Organisation (ICAO) for use during the most critical phases of aircraft flight, in particular landing. To solve it, ICAO decided to standardise several GNSS augmentation systems including SBAS.

The SBAS concept is based on the transmission of differential corrections and integrity messages for navigation satellites that are within sight of a network of reference stations deployed across an entire continent. SBAS messages are broadcast via geostationary satellites able to cover vast areas.

Several countries have implemented their own satellite-based augmentation system. Europe has the European Geostationary Navigation Overlay Service (EGNOS) which covers Western Europe and beyond. The USA has its Wide Area Augmentation System (WAAS). Japan is covered by its Multi-functional Satellite Augmentation System (MSAS). India has launched its own SBAS programme named GPS and GEO Augmented Navigation (GAGAN) to cover the Indian subcontinent.

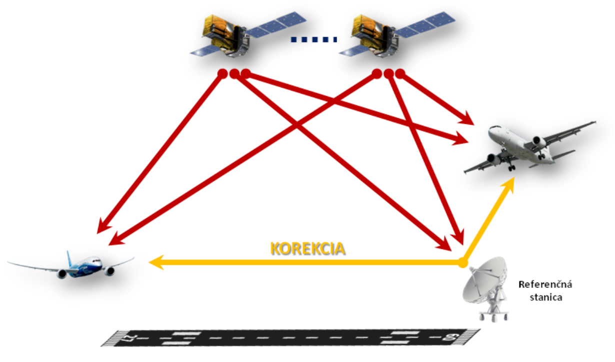
All of the systems comply with a common global standard and are therefore all compatible (do not interfere with each other) and interoperable (a user with a standard receiver can benefit from the same level of service and performance whether located in the EGNOS or WAAS coverage area).

In addition to their use in the aviation sector, SBAS systems are essential for applications where accuracy and integrity are critical. In particular, they are indispensable for all applications where people's lives are at stake or for which some form of legal or commercial guarantee is required.

For example, SBAS make it possible to improve and extend the scope of applications for GPS in areas such as precision farming, the guidance of agricultural machinery, on-road vehicle fleet management, oil exploration for the positioning of platforms at sea or for scientific applications such as geodesy.

4 GROUND-BASED AUGMENTATION SYSTEMS – GBAS

The **Local Area Augmentation System (LAAS)** is an all-weather aircraft landing system based on real-time differential correction of the GPS signal. Local reference receivers located around the airport send data to a central location at the airport. This data is used to formulate a correction message, which is then transmitted to users via a VHF Data Link. A receiver on an aircraft uses this information to correct GPS signals, which then provides a standard ILS-style display to use while flying a precision approach. The International Civil Aviation Organization (ICAO) calls this type of system a Ground Based Augmentation System (GBAS).



Local reference receivers are located around an airport at precisely surveyed locations. The signal received from the GPS constellation is used to calculate the position of the LAAS ground station, which is then compared to its precisely surveyed position. This data is used to formulate a correction message which is transmitted to users via a VHF data link. A receiver on the aircraft uses this information to correct the GPS signals it receives. This information is used to create an ILS-type display for aircraft approach and landing purposes. Honeywell’s CAT I system provides precision approach service within a radius of 23 NM surrounding a single airport. LAAS mitigates GPS threats in the Local Area to a much greater accuracy than WAAS and therefore provides a higher level of service not attainable by WAAS. LAAS's VHF uplink signal is currently slated to share the frequency band from 108 MHz to 118 MHz with existing ILS localizer and VOR navigational aids. LAAS utilizes a Time Division Multiple Access (TDMA) technology in servicing the entire airport with a single frequency allocation. With future replacement of ILS, LAAS will reduce the congested VHF NAV band.

The current Category-1 (GAST-C) GBAS achieves a Category I Precision Approach accuracy of 16 m laterally and 4 m vertically. The goal of a to-be developed GAST-D GBAS is to provide Category III Precision Approach capability. The minimum accuracy for lateral and vertical errors of a Category III system are specified in RTCA DO-245A, *Minimum Aviation System Performance Standards for Local Area Augmentation System (LAAS)*. The GAST-D GBAS will allow aircraft to land with zero visibility using 'autoland' systems.

One of the primary benefits of LAAS is that a single installation at a major airport can be used for multiple precision approaches within the local area. For example, if Chicago O'Hare has twelve runway ends, each with a separate ILS, all twelve ILS facilities can be replaced with a single LAAS system. This represents a significant cost savings in maintenance and upkeep of the existing ILS equipment.

Another benefit is the potential for approaches that are not straight- in. Aircraft equipped with LAAS technology can utilize curved or complex approaches such that they could be flown on to avoid obstacles or to decrease noise levels in areas surrounding an airport. This technology shares similar characteristics with the older Microwave Landing System (MLS) Approaches, commonly seen in Europe. Both systems allow lower visibility requirements on complex approaches that traditional Wide Area Augmentation Systems (WAAS)and Instrument Landing Systems (ILS) could not allow.

The FAA also contends that only a single set of navigational equipment will be needed on an aircraft for both LAAS and WAAS capability. This lowers initial cost and maintenance per aircraft since only one receiver is required instead of multiple receivers for NDB's,DME, VOR, ILS, MLS and GPS. The FAA hopes this will result in decreased cost to the airlines and passengers as well as general aviation.

5 INSTRIMENT APPROACH PROCEDURES

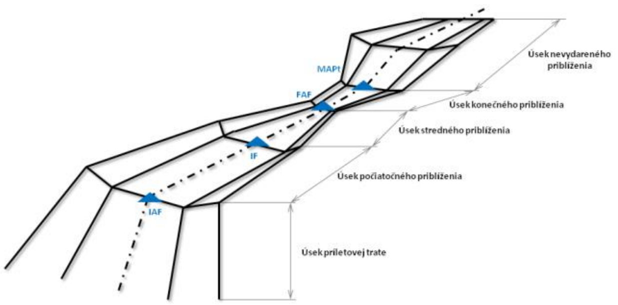
For the aircraft operating under instrument flight rules (IFR), an **instrument approach** or **instrument approach procedure** (IAP) is a series of predetermined maneuvers for the orderly transfer of an aircraft under instrument meteorological conditions (IMC) from the beginning of the initial approach to a landing, or to a point from which a landing may be made visually.

Instrument approaches are generally designed such that a pilot of an aircraft in IMC, by the means of radio, GPS, or INS navigation with no assistance from air traffic control, can navigate to the airport, hold in the vicinity of the airport if required, then fly to a position from which he or she can either obtain sufficient visual reference of the runway to make a safe landing, or execute a missed approach if the visibility is below the minimums required to execute a safe landing. The whole approach is defined and published in this way so that aircraft can land if they suffer from radio failure; it also allows instrument approaches to be made procedurally at airports where air traffic control does not use radar or in the case of radar failure.

An instrument approach procedure may contain up to five separate segments (some of which are mandatory). These segments are:

- **Arrival segment**: The segment from where the aircraft leaves an en-route airway to the initial approach fix (IAF).
- **Initial approach**: The segment from the initial approach fix (IAF) to either the intermediate fix (IF) or the point where the aircraft is established on the intermediate or final approach course.
- **Intermediate approach**: The segment from the IF or point, to the final approach fix (FAF).

- **Final approach**: The segment from the FAF or point, to the runway, airport, or missed approach point (MAP).
- **Missed approach**: The segment from the MAP to the missed approach fix at the prescribed altitude.



When an aircraft is under radar control, air traffic control (ATC) may replace some or all of these phases of the approach with radar vectors (the provision of headings on which the controller expects the pilot to navigate his aircraft) to allow traffic levels to be increased over that which is possible when following the full procedures. It is very common for ATC to vector aircraft to intercept the final approach navaid's course, e.g., the ILS, which is then used for the final approach. In case of the rarely used ground-controlled approach(GCA), the instrumentation (normally Precision Approach Radar) is on the ground and monitored by a controller, who then relays precise instructions for adjustment of heading and altitude to the pilot in the approaching aircraft.

5 BENEFITS OF GBAS

GBAS is a 21st-century solution to replace or supplement Instrument Landing Systems (ILS). GBAS will overcome many ILS technical and operational limitations which currently constrain flight path flexibility and airport throughput.

GBAS can provide significant safety capacity, efficiency and environmental benefits for airlines, airports and air navigation service providers.

For airlines it delivers:

- less flight disruptions and associated cost caused by ILS interference
- minimal pilot training.

Airports benefit from:

- improved airport capacity from accurately guided, simultaneous operations to parallel runways and reduced runway exit times
- flexibility in GBAS station location, unlock valuable airport land and alleviate traffic restrictions which are otherwise required to protect ILS signals from interference sources
- improved airport access, even where ILS cannot be installed for terrain or economic reasons.

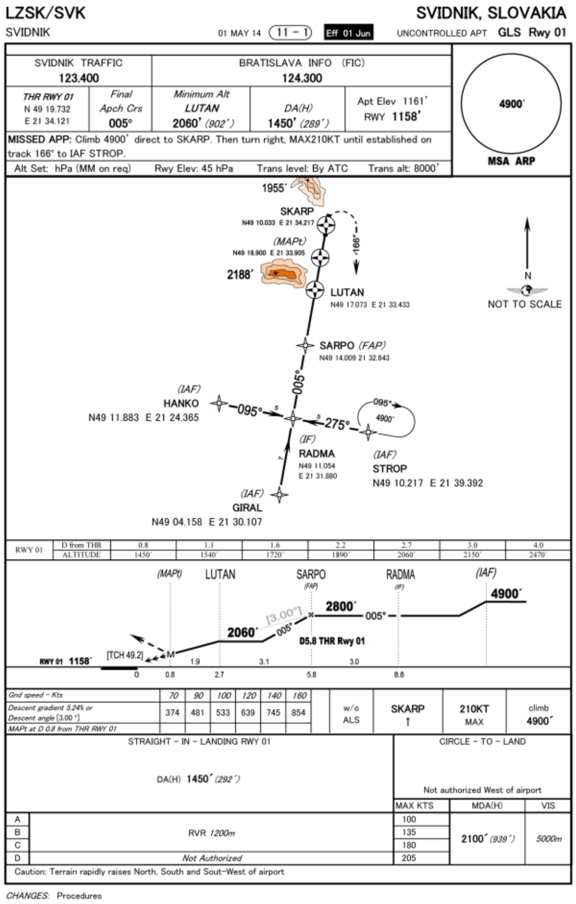
Air navigation service providers can obtain:

- reduced traffic delays and congestion as a result of more efficient and predictable approaches
- reduced capital investment cost and lower ongoing maintenance, as one GBAS covers all runways at an airport compared to one ILS installation required per one runway end
- easier and less frequent flight calibration inspections than ILS
- continued operations even during routine flight inspection or airport works.

5 GLS APPROACH – AIRPORT SVIDNÍK

I decided to construct a proposal for a precision approach procedures using GBAS systems for Category I (CAT I GLS) on runway 01

Since I used the approach for the design concept of the direct approach tees, constructed for this purpose I have three points of the initial approach IAF – HANKO, GIRAL and STROP.



On this picture is map of GLS precision instrument approach CAT I to RWY 01 of airtport Svidník.

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