Analýza využití SBAS přiblížení pro malá mezinárodní letiště

Závěrečná zpráva SGS12

Využití moderních systémů a technologií v letectví má obrovský význam pro zvyšování jeho kvality a tedy bezpečnosti. Zároveň také umožňuje snižovat jeho časovou, ekologickou i finanční náročnost.

Jednou z těchto technologií může být satelitní navigace umožňující navigování bez jakýchkoliv jiných navigačních systémů postavených na povrchu země, přičemž čím více se satelitní segment využije, tak je na něj dáváno stále více požadavků. Z tohoto důvodu byly vymýšleny rozšiřovací systémy pro GPS, které dokáží znatelně zvýšit přesnost určování pozice.

Jedním z těchto systémů je i SBAS. Před jeho použitím je však potřeba vytvořit kompletní analýzu jeho využití napříč letectvím.

Seznam zkratek

DA	Decision altitude	Výška rozhodnutí
IAF	Initial approach fix	Počáteční bod přiblížení
MAPt	Missed Approach Point	Bod nezdařeného přiblížení
GA	General Aviation	Všeobecné letectví
SBAS	Space based Augmentation System	-
LPV	Localizer precision with vertical guidance	Minima u RNP APCH down to LPV
VMC	Visual meteorological conditions	Vizuální meteorologické podmínky
ATZ	Aerodrome traffic zone	Letištní provozní zóna
EGNOS	European Geostationary Navigation Overlay Service	Evropský SBAS
TIZ	Traffic information zone	-
WAAS	Wide Area Augmentation System	Severoamerický SBAS

1 Definice

1.1 Malé mezinárodní letiště

Malé mezinárodní letiště je letiště, které neposkytuje službu řízení letového provozu a leží v neřízeném vzdušném prostoru, přičemž mezinárodní je myšleno vzhledem ke státům v Evropské Unii, tedy letiště s vnitřní hranicí.

1.2 Přiblížení

Přiblížení (přiblížení na přistání) je závěrečná fáze letu mezi traťovým letem a přistáním, kdy je letadlo naváděno do prostoru letiště a směru dráhy (RWY), tak aby mohlo provést bezpečné přistání. Přiblížení začíná v bodě IAF (initial approach fix) a končí v bodě MAPt, či ve výšce rozhodnutí DA, kdy se pilot musí rozhodnout, zdali bude pokračovat na přistání (pokud vidí dráhu), nebo provede postup pro nezdařené přiblížení.

1.3 SBAS

SBAS (satellite based augmentation system) je rozšiřující systém pro družicovou navigaci GPS. GPS s SBAS dosahuje lepších hodnot přesnosti, kontinuity, dostupnosti a integrity. Evropský systém SBAS se nazývá EGNOS a jeho využití, stejně jako v případě GPS, není zpoplatněno.

1.4 RNP APCH

RNP APCH je zkratka RNP přiblížení, což je přiblížení využívající jako zdroj polohové informace satelitní navigaci.

Tabulka 1 – rozdělení RNP přiblížení [36]

PANS-OPS Terminology	PBN Terminology	Chart Minima	Minimum Sensor
NPA	RNP APCH down to	LNAV (MDA)	Basic GNSS[2]
APV Baro-VNAV	RNP APCH down to	LNAV/VNAV (DA)	Basic GNSS + Baro-VNAV
-No criteria available	RNP APCH down to	LP (MDA)	SBAS
APV SBAS	RNP APCH down to	LPV (DA)	SBAS

1.5 SBAS přiblížení (LPV)

SBAS přiblížení je přiblížení RNP APCH down to LPV (zkráceně LPV). Využívá tedy jak GPS signálu, tak i signálu SBAS. Díky tomu dosahuje podobných parametrů jako konvenční přiblížení ILS Cat I. Díky přesnosti zajištěné pomocí SBAS má toto přiblížení trajektorii definovanou jak v horizontální tak i vertikální rovině, a proto je také řazeno do kategorie přiblížení s vertikálním vedením.

2 AS-IS analýza využití SBAS

Signál EGNOS Safety of Life je k dispozici od března roku 2011 a ač zpočátku nebyl moc využíván, letiště se naučila vytvářet přiblížení s jeho využitím. Tomu jistě pomohlo i nařízení ICAO 37-11, které přikazuje mít na všech koncích přístrojových drah do roku 2016 publikování přiblížení RNP APCH, tedy přiblížení využívající satelitní navigaci.

Některá letiště v Evropě se rozhodla pro implementaci LPV přiblížení, avšak např. Německo zásadně upřednostnilo RNP APCH down to LNAV/VNAV, které pro navigování využívá základní GNSS spolu s barovýškoměrem. Pro malá letiště však žádné takovéto nařízení není a ani být nemůže. Všechna malá letiště v ČR jsou letišti VFR, tedy neřízená a provoz probíhá pouze za meteorologických podmínek VMC.

V polovině roku 2013 byla v ČR provedena změna předpisu L 11, kde přibyl dodatek S týkající se nové služby na malých letištích a tou je poskytování informací o známém provozu. Do té doby měla všechna neřízená letiště v ČR službu AFIS, která působila v prostoru ATZ. AFIS, který je specifikován v dodatku N předpisu L 11, doznal drobných změn z praktického hlediska, avšak z organizačního jsou na něj kladeny větší nároky a je třeba, aby byl certifikovaný ÚCL. Přínosem z této změny je možnost přístrojového přiblížení na takovéto letiště, i když se tam služba ATC neposkytuje.

Aktuální seznam letišť, která využívají SBAS je na http://www.essp-sas.eu/downloads/eqpnwor/aerodromes_procedures_actual.pdf

Obrázek 1 – LPV přiblížení v Evropě k 6.8.2013

Výsledek AS-IS analýzy byl zveřejněn v odborném periodiku Acta Avionica, který je v příloze 1.

(Kraus, J. - Duša, T.: Obstacles in the Implementation and Publication of RNP Approaches at European Airports. *Acta Avionica*. 2012, vol. 14, no. 23, p. 69-73. ISSN 1335-9479.)

2.1 Překážky v zavádění LPV

Při AS-IS analýze byly identifikovány hlavní obecné překážky, které brání rychlému rozšíření LPV přiblížení. Avšak během následujícího roku byla většina překonána a začaly se objevovat místní požadavky, které LPV nedokázalo splnit a bylo je tedy třeba vyřešit. Týkaly se hlavně následujících.

Tabulka 2 – Překážky v zavádění LPV

Překážky v zavádění LPV
Klasifikace vzdušného prostoru okolo letiště
IFR požadavky na letiště
IFR požadavky na dráhu – značení, světelné soustavy
Nutnost přítomnosti ATC
Pravomoci a zodpovědnost AFIS
Radarové pokrytí v okolí letiště
Vhodný systém (technologie) pro přiblížení
Postup přiblížení
Současná legislativa, podle které se letiště certifikují
Požadavky na vybavení letadel
Požadavky na výcvik pilotů

Tyto dílčí překážky zahrnovaly neshody mezi předpisem a požadavky provozovatelů, či pilotů. Jejich možné řešení bylo zveřejněno ve sborníku konference NT AD 2012 a je v příloze 2.

(Kraus, J. - Duša, T.: Increasing Safety at Uncontrolled Aerodromes in the Czech Republic - Introducing IFR Approach Procedures. In *New Trend in Aviation Development*. Košice: Faculty of Aeronautics Technical University Kosice, 2012, p. 1-5. ISBN 978-80-553-1083-1.)

2.2 Vytvoření přiblížení

Při snaze o vytvoření přiblížení je potřeba překonat velkou část identifikovaných překážek, avšak i po vytvoření je má konečné slovo ŘLP, které jako jediné může přiblížení schvalovat.

2.3 Letiště

Jako vhodná letiště byla vybrána ta, která mají asfaltovou, nebo betonovou dráhu. Jejich seznam je v tabulce níže, kde zelená znamená vysokou možnost zavedení, žlutá střední a bílá nízkou možnost. Viz příloha 2.

Tabulka 3 – Vhodná letiště pro LPV

Letiště	ICAO kód
České Budějovice	LKCS
Hořovice	LKHV
Hosín	LKHS
Hradec Králové	LKHK
Jindřichův Hradec	LKJH
Křiženec	LKKC
Mnichovo Hradiště	LKMH
Olomouc	LKOL
Otrokovice	LKOT
Panenský Týnec	LKPC
Plzeň – Líně	LKLN
Přerov	LKPO
Příbram	LKPM
Vysoké Mýto	LKVM

Vzhledem k vývoji se měnili priority a např. letiště Mnichovo Hradiště je v současnosti v zelené „zóně“ stejně jako travnaté letiště Benešov.

3 Identifikace potřebných změn

Identifikace potřebných změn vzešla z AS-IS analýzy, kde byly specifikovány hlavní překážky (tab. 1). Existuje však nutnost dvou nezávislých změna na převážně technických překážkách. Jsou jimi legislativní orgány a vnímání GA.

3.1 Legislativní orgány

Pozice státní správy z pohledu změny zákonů a předpisů je sice obtížná, ale přesto by mohla býti vidět větší aktivita. V současné době je však nejlepší postupovat, tak že v případě zamýšlené změny, subjekt, který ji požaduje, vytvoří kompletní analýzu, co by to znamenalo i s předložením úprav do dotčených zákonů a předpisů.

3.2 Vnímání GA

Pohled na GA je ze strany úřadů i letecké veřejnosti ne moc pozitivní ve smyslu vyhovění požadavkům. Všeobecné letectví je bráno jako zábava (kterou ve většině opravdu je), avšak právě toto GA nejvíce ubližuje. Proč by měl mít někdo, kdo si jen hraje přednost před velkým letectvím? Vzdušný prostor je ale potřeba řešit jako kompromis mezi všemi jeho účastníky.

Tento problém se týká také snahy o zavedení LPV na malých letištích, kterým se však právě nedostává takové podpory od ŘLP, ÚCL, či MDČR jako velkému letectví.

3.3 Vzdušný prostor a ATC

Třída vzdušného prostoru je zásadní změnou, kterou je nutné provést pro povolení IFR letů na neřízená letiště. Současná třída G je v českých předpisech definovaná pro lety VFR a IFR jsou v ní zakázány. Změna tohoto stavu není moc složitá a vede zavedením třídy F vzdušného prostoru v ČR.

Návrh zavedení vzdušného prostoru třídy F pro malá letiště v ČR byl popsán v článku zveřejněném na konferenci INAIR 2012 společně s potřebnými změnami předpisů a je v příloze 3.

(Kraus, J.: Analysis of Options and the proposal to Introduce the Class F Airspace in the Czech Republic. In *InAir 2012*. Žilina: EDIS, 2012, p. 57-60. ISBN 978-80-554-0574-2)

Druhou analyzovanou možností bylo využití prostoru třídy F společně s prostorem TIZ, který by odlišil klasické malé letiště s VFR letištěm od malého letiště s IFR provozem. Návrh tohoto řešení byl zveřejněn v odborném periodiku MAD – Magazine of Aviation Development a je v příloze 4.

(Kraus, J.: Implementation of Traffic Information Zone in Czech Republic. *MAD - Magazine of Aviation Development* [online]. 2013, vol. 1, no. 3, p. 19-22. Internet: http://www.mad.fd.cvut.cz/issues/3/04_Kraus.pdf. ISSN 1805-7578.)

Problematika nutnosti ATC na všech letištích, byla vyřešena koncem června 2013, kdy vznikl nový dodatek předpisu L 11. Výsledkem čehož je možnost IFR přiblížení i na letiště, která mají AFIS.

3.4 IFR požadavky na letiště a dráhu

Všechna letiště musejí odpovídat předpisu L 14, což je velmi zavazující. Pokud totiž uvažujeme o zavedení LPV přiblížení na dosud neřízené letiště, tak je nutné, aby byla vybudována infrastruktura, která umožní předpis L 14 splnit. Pokud by se však uvažovalo o komplexní analýze bezpečnosti přiblížení, tak je možné z tohoto přístupu odvodit rovnici:

$$Safety\ level\ of\ approach = safety\ of\ technology + procedure + aircraft + aerodrome \quad (1)$$

A tedy:

$$ILS\ Cat\ I + compatible\ aerodrome = LPV500 + compatible\ aerodrome \quad (2)$$

$$ILS\ Cat\ I + Annex\ 14\ Airport\ Infrastructure = LPV500 + Airport\ Infrastructure for\ this\ approach \quad (3)$$

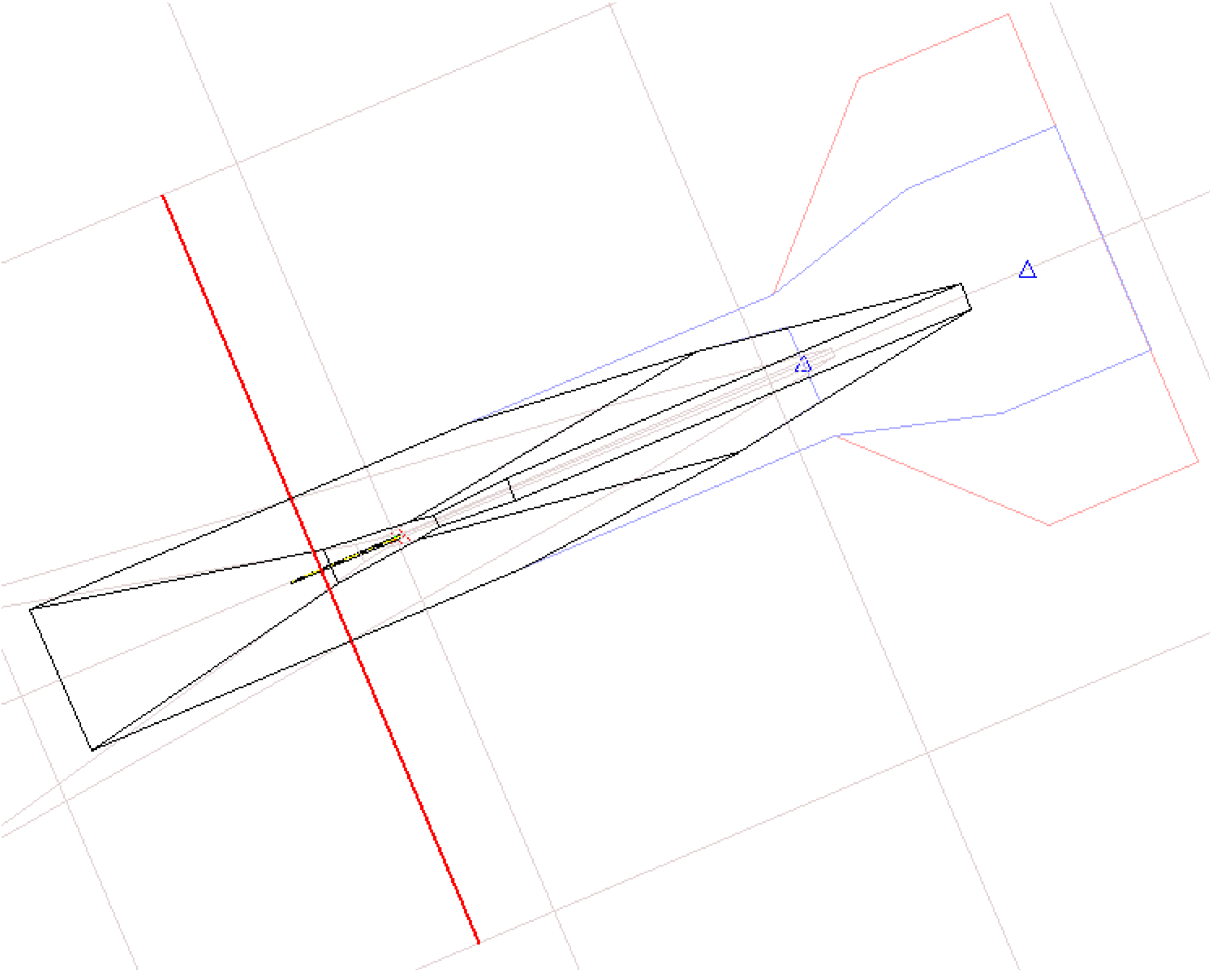
Tento přístup řízení bezpečnosti na stejnou úroveň danou předpisy by měl zajistit možné změny v požadavcích na infrastrukturu letišť.

Veškeré změny požadované infrastruktury však budou muset být řešeny přes bezpečnostní analýzy a modelování procesů s vlivem na bezpečnost. Řešené v SGS13.

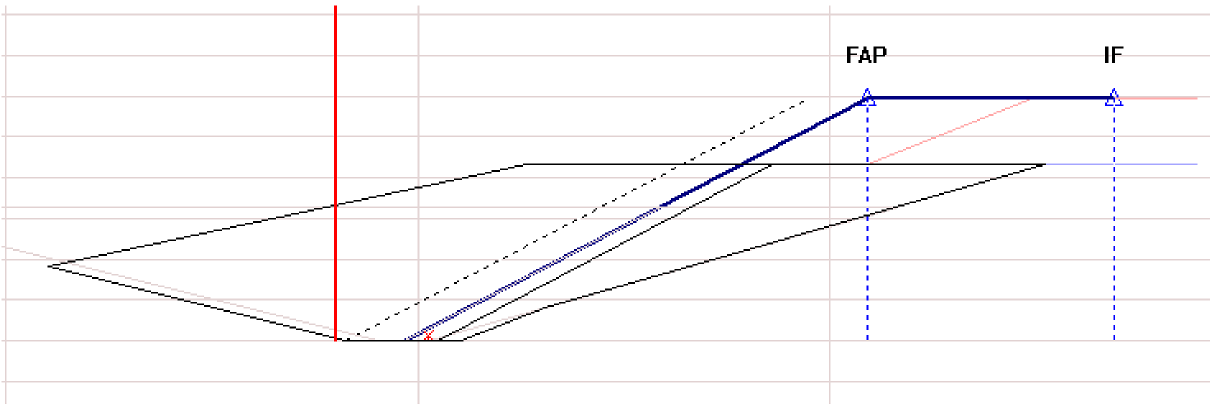
4 Geografická analýza

Pro geografickou analýzu byl využit program MET od společnosti EUROCONTROL, který dokáže vykreslit překážkové roviny pro nadefinované přiblížení (v našem případě LPV) a určit zdali dané roviny neprotíná nějaká překážka.

Program MET byl aplikován na vybraná letiště v České republice (tabulka 2) a neodhalil u nich žádnou vážnou překážku při jejich využití pro implementaci LPV.



Obrázek 2 – příklad rovin pro letiště Hořovice - plán



Obrázek 3 – příklad rovin pro letiště Hořovice - profil

5 Provozní analýza

Při řešení otázky výhodnosti využívání LPV přiblížení jsou důležité pouze tři věci. První je schopnost letiště implementovat toto přiblížení, druhou je schopnost letadla a pilota toto přiblížení zaletět a třetí vhodnost implementace LPV oproti jiným druhům přiblížení z pohledu jednoduchosti použití při přiblížení na přistání.

Schopnost letiště implementovat toto přiblížení závisí na předpisech v tu dobu platných. Dle naznačení problémů v legislativě zmíněných v předchozích kapitolách jsou aktuálně pouze dvě malá letiště v České republice, která jsou schopna využívat LPV. Jsou jimi LKHK a LKKU (které by však šlo zařadit mezi velká letiště, jelikož má v daný provozní čas i ATC Tower).

Předpisovou základnu je však potřeba změnit a i dotčené organizace jsou si toho vědomy. Díky těmto důvodům byla vypracována analýza českého malého letectví, konkrétně letadel GA a VFR letišť. Tato analýza se zaměřila na základní parametr, kterým je délka dráhy letišť a potřebná délka dráhy pro vzlet a přistání letadel. Vzhledem k předpokládaným změnám předpisů nebylo uvažováno LPV jako současné přístrojové přiblížení.

Při analýze bylo zjištěno, že většina GA letadel registrovaných v ČR by mohla přistát na většině letišť.

Tato analýza byla publikována na konferenci Increasing Safety and Quality in Civil and Military Air Transport a je obsahem přílohy 5.

(Kraus, J. - Soporský, T. - Jeřábek, K.: Analysis of Czech Aerodromes in Terms of the Introduction of an Instrument Approach. In Increasing Safety and Quality in Civil and Military Air Transport. Žilina: Žilinská univerzita v Žilině Fakulta prevádzky a ekonomiky dopravy a spojov, 2013, p. 59-62. ISBN 978-80-554-0665-7.)

Vzhledem k pozitivní situaci pro LPV vyplývající z výše zmíněné analýzy byl další krok směrem k definování vzdušného prostoru kolem malých letišť tak, aby byla zajištěna bezpečnost letadel používajících LPV přiblížení. Jako nejlepší možnost bylo identifikováno využití Traffic Information Zone (TIZ), tedy „norského stylu“. Proto byl vytvořen návrh využití a implementace TIZ pro Českou republiku, který byl publikován v odborném periodiku MAD – Magazine of Aviation Development a je v příloze 6.

(Kraus, J.: Implementation of Traffic Information Zone in Czech Republic. *MAD - Magazine of Aviation Development* [online]. 2013, vol. 1, no. 3, p. 19-22. Internet: http://www.mad.fd.cvut.cz/issues/3/04_Kraus.pdf. ISSN 1805-7578)

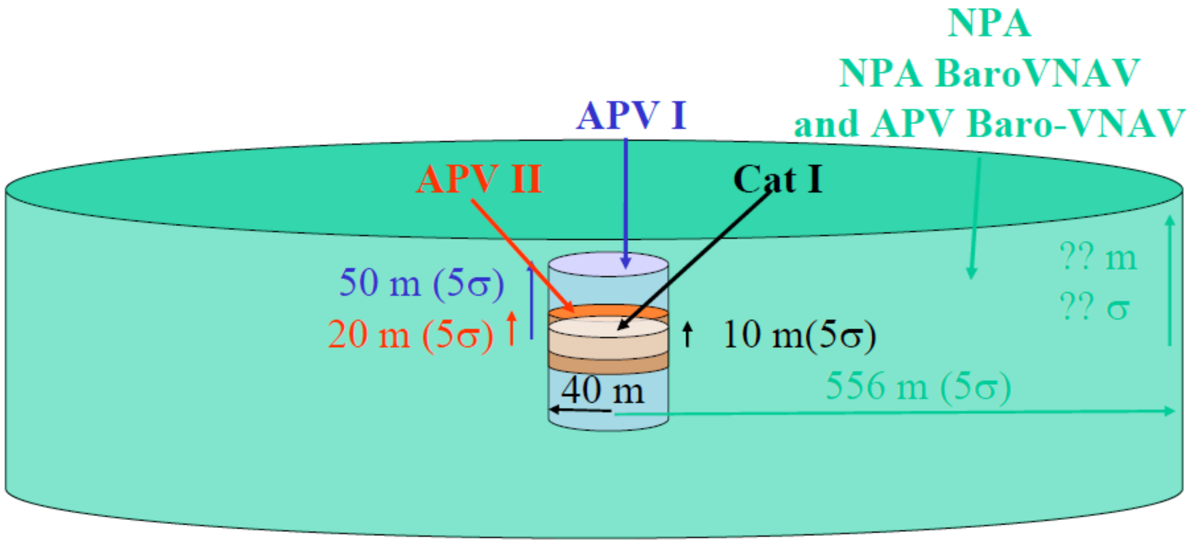
Pro změněné požadavky na letiště mající jako jediné přiblížení publikované LPV však bude v budoucnu potřeba vytvořit nový standard, ještě důležitější ale bude, aby prošel certifikací. Tento proces certifikace je značně nákladný a i časově náročný, avšak z některých jeho prvků lze odvodit požadovaný směr vývoje výzkumu LPV přiblížení. Kvůli tomuto tak byl zpracován postup certifikace přístrojového přiblížení, který je v současnosti jediný použitelný u LPV a i při očekávané změně předpisů bude sloužit jako základ pro vytvoření nového.

Postup certifikace byl analyzován a publikován v odborném časopise MAD – Magazine of Aviation Development a lze ho nalézt v příloze 7.

(Kraus, J. - Ninger, J. - Jeřábek, K.: Implementation and Certification of LPV Approach and Options for VFR Aerodromes. *MAD - Magazine of Aviation Development* [online]. 2013, vol. 1, no. 2, p. 3-6. ISSN 1805-7578)

6 Finanční analýza

Využívání SBAS, a tedy primárně LPV přiblížení, je z finančního hlediska nejlepší možnou volbou. LPV umožňuje jak horizontální, tak vertikální vedení po trati s vysokou přesností, která v kvalitě APV II přibližně odpovídá přiblížení ILS (viz obr. 4), přitom i APV I je daleko lepší než ostatní GNSS přiblížení.



Obrázek 4 – Porovnání přesnosti Navigačních systémů

To nejdůležitější je však, že navigační signál GPS, EGNOS a v budoucnu i Galileo jsou pro uživatele bezplatné, takže není potřeba stavět na letišti žádnou navigační infrastrukturu, což je oblast kde mohou letiště ušetřit velké částky (tabulka 4).

Tabulka 4 – Náklady na ILS

Kategorie ILS	Cena (€)
DME a ILS Cat I	336000
+ Roční provozní náklady	79000
DME a ILS Cat II	384000
+ Roční provozní náklady	95000

Kde je však potřeba investovat, je oblast IFR dráhy a certifikovaného AFIS. IFR dráha oproti VFR zahrnuje zvětšení pásů dráhy, což může být problém, kvůli majetkovým poměrům týkajících se pozemků kolem letiště. To nejdůležitější je však osvětlení dráhy a přibližovací světelná soustava, kde při cca 750 m dlouhé dráze budou stát světla kolem 300000 Kč a přibližovací světelná soustava stejnou částku (je vycházeno z cen návěstidel + zemních prací + kabelových rozvodů). Co se týče AFIS, tak to je nad rámec výzkumu tohoto grantu, ale rámcově lze jeho zavedení a certifikace odhadnout na 1000000 Kč s tím, že roční provozní náklady takovéhoto letiště se pohybují v jednotkách milionů korun na zabezpečení možnosti IFR letů.

Při uvažování celkové cost-benefit analýzy na transformaci letiště pro IFR provoz s LPV přiblížením je nutné vycházet z kompletních nákladů, které se pohybují v milionech pro zavedení (při pominutí problémů souvisejících se vzdušným prostorem, které možná vyřeší státní organizace zdarma) a následně další provozní náklady v milionech ročně. Z tohoto pohledu se jeví jako nereálné, aby byly tato finance vyváženy např. výnosy za přistávací poplatky GA, či za další služby poskytované na letišti. Proto je nutné tyto vstupní náklady považovat za dlouhodobou investici s možností přitáhnout větší provozovatele business aviation, či přímo velké dopravce. Jelikož by tato skutečnost měla pozitivní vliv na celý region, mělo by být snahou letiště získat alespoň nějakou část financí potřebnou na změnu od dotčených subjektů jako je město, či kraj. Taktéž je možné, že v budoucnu se budou roční náklady na takovéto letiště s LPV přiblížením snižovat z důvodu možných změn předpisů např. zalétávání světelných soustav, které se v současné době provádějí častěji než by bylo nezbytně nutné (v porovnání s okolními státy).

7 Avionika pro SBAS

Avionika pro využití v letadlech schopná přijímat SBAS signál se vyrábí již od zprovoznění SBAS signálu v oblasti Severní Ameriky v roce 2003. Severoamerický SBAS je pojmenován WAAS a v některých drobnostech se liší od evropského systému EGNOS. Osmiletý náskok Ameriky před Evropou ve využívání SBAS však způsobil pro rozšíření jeho využívání v Evropě pozitivní situaci, kdy výrobci jsou „naučeni“ SBAS do svých přístrojů zahrnovat. Se spuštění EGNOS se začala objevovat avionika schopná přijímat EGNOS, avšak která byla certifikovaná pouze pro WAAS.

Současný stav problému má pozitivní směr. Nejenže výrobci avioniky začleňují EGNOS již jako standard, ale neustále se sbližují předpisy definující WAAS a EGNOS, čímž se v dohledné době stanou certifikace na jeden, či druhý systém záměnné. Tento stav umožní další urychlení využívání EGNOS v ČR a v Evropě.

Tabulka 5 – výrobci avioniky podporující EGNOS

Výrobce	Model
Garmin	Aera range
Garmin	G1000 (with GIA63W unit)
Garmin	G600 (with 430W/530W units)
Garmin	G900X (with GIA63W unit)
Garmin	GNC 420W
Garmin	GNS 430W
Garmin	GNS 530W
Garmin	GPS 400W
Garmin	GPS 500W
Garmin	GPSMAP 196
Garmin	GPSMAP 296
Garmin	GPSMAP 396
Garmin	GPSMAP 495
Garmin	GPSMAP 496
Garmin	GPSMAP 695/696
Garmin	GPSMap 96
Garmin	GPSMap 96c
Garmin	GTN 625
Garmin	GTN 635
Garmin	GTN 650
Garmin	GTN 725
Garmin	GTN 750
Honeywell Bendix King	AV80R range
Honeywell Bendix King	KI 825 – New units, or in service upgrade
Honeywell Bendix King	KSN 770
Honeywell Bendix King	EASy II
Honeywell Bendix King	Primus Apex® Avionics System
Rockwell Collins	GPS-4000S Global Positioning System Sensor
Septentrio	AiRx OEM
Thales	Multi-Mode Receiver - MMR
Thales	TopDeck LPV
Thales	TopStar 200 GPS

Aktuální seznam zařízení certifikovaných pro příjem EGNOS lze nalézt na webové stránce GSA: http://egnos-portal.gsa.europa.eu/developer-platform/developer-toolkit/receiver-list

8 Školení pilotů

Přiblížení LPV, tedy RNP APCH down to LPV, je řazeno mezi přiblížení s vertikálním vedením a tedy přístrojové přiblížení. Z tohoto pohledu by měl i výcvik pilotů probíhat se zaměřením na GNSS využití. V současné době je však ve výcviku základ navigace založený na NDB a VOR, což je pro budoucnost téměř absolutně zbytečné. Výuka GNSS také probíhá avšak v osnovách je pouze na doporučené bázi.

Jelikož je GNSS budoucností navigace, i když s otazníky týkajících se zabezpečení a možných výpadků signálu, tak by bylo vhodné zavést povinnou část ve výcviku zabývající se GPS a SBAS a to jak v teoretické rovině, tak i v praktické.

Vzhledem k oblíbenosti a rozšířenosti všeobecného letectví v Severní Americe nebo např. ve Spojeném Království je možné čerpat inspiraci z jejich organizací dohlížejících na letectví, tedy FAA a CAA UK. Z dokumentu „CAP 773 Flying RNAV (GNSS) Non-Precision Approaches in Private and General Aviation Aircraft“ také vychází návrh osnovy pro výcvik pilotů na GNSS systémy.

Osnova by se měla skládat z osmi bodů

1. Seznámení s RNAV, PBN manuál – vysvětlení prostorové navigace a jejich kladů a záporů při používání při letu
2. Družicová navigace a její použití – základní princip a funkce GPS, augmentační systémy se zaměřením a SBAS, RAIM, chyby, přesnost
3. Instalace GNSS systému – typy přijímačů a jejich komponenty, komunikace GNSS jednotek s ostatní avionikou v letadle, certifikace
4. Lidský činitel – chyby obsluhy, monitorování systému
5. Předletová příprava – mapy, AUGUR, NOTAMy, kontrola funkčnosti, kontrola navigačních funkcí, tvoření vlastních navigačních bodů
6. Let – monitorování systému a systémových zpráv, využití GNSS pro traťovou navigaci, let SID a STAR, vyčkávání
7. Přiblížení – direct to IAF, IF, vektorování k FAF, monitorování postupu přiblížení, přechod na vizuál v minimech, přechod na nezdařené přiblížení
8. Další – postupy pro ztrátu družicové navigace, přechod na jiný druh navigace

Výzkum zaměřující se na výcvik pilotů a návrh osnovy pro školení byl publikován na Evropském dopravním kongresu 2013 a je přiložen v příloze 7.

(Kraus, J.: Extending the Use of GNSS in Aviation - Pilots Training. In Proceedings of the 11th European Transport Congress. Praha: České vysoké učení technické v Praze, Fakulta dopravní, 2013, p. 148-151. ISBN 978-80-01-05321-8.)

9 Shrnutí

V průběhu let 2012 a 2013 byla vytvořena komplexní analýza zabývající se využitím SBAS pro malá letiště. AS-IS analýza provedená v prvním roce řešení ukázala velký potenciál, který v sobě navigační infrastruktura placené z „evropských peněz“ skrývá. Taktéž ale ukázala velkou dynamiku rozvoje a nutnost neustálého zdokonalování techniky a technologií.

Při procházení legislativy týkající se využití SBAS bylo na začátku roku 2012 problematické vyhledávat správné části, jelikož se konkrétní nové odstavce zatím pouze připravovaly. Výhodou tohoto stavu byla možnost porovnání starých předpisů s novými se závěrem, který ukazuje na snahu úřadů rozšiřovat dostupné systémy.

Pro rapidní rozšíření SBAS v letectví jsou však nutné ještě větší změny, u kterých ale bude problém přesvědčit ÚCL a Ministerstvo Dopravy o jejich vhodnosti a nutnosti. V nejhorším případě bude nutné komunikovat přímo s mezinárodními organizacemi EASA a ICAO. Ve snaze o rozšíření využití SBAS pro letectví se skrývá velký výzkumný potenciál.

Analýza letadel a letišť v České republice přinesla očekávané závěry, avšak i zde leží potenciální výzkumný záměr, zjištění ceny za zabudování avioniky do současných letadel GA v ČR a zjištění zdali piloti chtějí mít možnost LPV přiblížení na větším množství letišť jako ukazují průzkumy EUROCONTROLu.

Při zpracování geografické a provozní části analýzy nebyly zjištěny žádné překážky pro implementaci SBAS, ale mnoho možných vstupů a metod, jak zajistit bezpečnost při jeho využívání.

Cost-benefit a finanční analýza naráží na problém se současným stavem předpisů, kdy zavedení LPV přiblížení na letiště obsahuje vysokou vstupní částku pro transformaci z VFR letiště na IFR. Tyto náklady se pohybují v desítkách miliónů Korun a pro většinu letišť jsou nepřekonatelným problémem. Změna předpisů by v tomto případě velmi pomohla, avšak pro změnu je nutné vytvořit provozně-bezpečnostní analýzu potvrzující zachování dostatečné úrovně bezpečnosti. Se snižováním požadavků na vybavení letišť tak bude CBA vycházet stále lépe. Za současného stavu se snaha o zavedení LPV přiblížení vyplatí pouze letištím s dobrým finančním zázemím a dobrým výhledem na rozvoj.

Výzkum v oblasti avioniky ukázal dostatečný potenciál soukromých subjektů zásobující celoevropský trh. V této části se jeví další výzkum jako možný pouze ve spolupráci s dalšími subjekty, např. FEL, FIT.

Přeškolování posádek na GNSS, a tedy i LPV, se v současnosti provádí pouze na dobrovolné bázi, avšak pro budoucí vývoj je nutné přidat GNSS do osnov základního výcviku. Spolupráce na tomto problému s piloty je možná.

10 Závěr

Na analýze využití SBAS přiblížení pro malá mezinárodní letiště jako části grantu SGS12 bylo pracováno po 2 roky a zapojilo se do ní kromě členů řešitelského týmu i 10 studentů bakalářského a magisterského studia. Byly splněny všechny nadefinované cíle a vznikl ucelený materiál o současné pozici SBAS v českém letectví a jeho budoucím směřování.

Během řešení grantu byly definovány další problematické oblasti vhodné pro řešení na ÚLD (bezpečnostní analýzy, úprava předpisů). Taktéž byla v této oblasti navázána spolupráce s Úřadem pro civilní letectví a s letištěm Hradec Králové (LKHK), které bude zastávat pozici pilotního projektu implementace LPV na malých letištích v České republice.

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Obsah

12 Seznam příloh

Příloha 1

V této příloze je citován celý článek, který byl publikován v odborném periodiku Acta Avionica.

(Kraus, J. - Duša, T.: Obstacles in the Implementation and Publication of RNP Approaches at European Airports. *Acta Avionica*. 2012, vol. 14, no. 23, p. 69-73. ISSN 1335-9479.)

Příloha 2

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(Kraus, J. - Duša, T.: Increasing Safety at Uncontrolled Aerodromes in the Czech Republic - Introducing IFR Approach Procedures. In *New Trend in Aviation Development*. Košice: Faculty of Aeronautics Technical University Kosice, 2012, p. 1-5. ISBN 978-80-553-1083-1.)

Příloha 3

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(Kraus, J.: Analysis of Options and the proposal to Introduce the Class F Airspace in the Czech Republic. In *InAir 2012*. Žilina: EDIS, 2012, p. 57-60. ISBN 978-80-554-0574-2)

Příloha 4

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Příloha 5

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Příloha 7

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(Kraus, J.: Extending the Use of GNSS in Aviation – Pilots Training. In Proceedings of the 11th European Transport Congress. Praha: České vysoké učení technické v Praze, Fakulta dopravní, 2013, p. 148-151. ISBN 978-80-01-05321-8.)

OBSTACLES IN THE IMPLEMENTATION AND PUBLICATION OF RNP APPROACHES AT EUROPEAN AIRPORTS

Jakub Kraus – Tomáš Duša

This article analyzes the problems in the implementation of RNP approaches in Europe in accordance with ICAO Resolution A37-11, which aim to increase the safety during approach and landing by publishing RNP approach according to PBN Manual. It also analyzes the trends in this area in the Czech Republic.

K e y w o r d s: APV SBAS, LPV, ICAO, RNP APCH, GNSS, approach with vertical guidance

1 INTRODUCTION

In an effort to improve air traffic we must always look for safety. Any system, which will be put into operation, must ensure that the current level of safety is maintained or, in better case, increased. Because the most dangerous part of flight is approach and landing, civil aviation organizations (ICAO and EASA in Europe) currently investigating the possibilities for increase safety in this phase of flight with using instrument approach procedures. They are divided into:

- precision approach and landing operations,
- approach and landing operations with vertical guidance and
- non-precision approach and landing operations.

Precision approach and landing operations currently uses mostly ILS system, which exhibits excellent precision guidance on the final approach with landing even in zero visibility. Non-precision approach and landing operations using systems NDB, VOR or LOC. The main problems of non-precision approach are less accurate signals NDB, VOR and the absence of a continuous guidance in the vertical direction. This led to using high MDA (Minimum Descend Altitude).

APV SBAS was renamed and according to a new agreement in PBN terminology it is named "RNP APCH down to LPV". This technology uses GPS SBAS corrected signal to increase the accuracy of positioning. The SBAS navigational signal is used for continuous guidance in the lateral and the vertical direction with the Signal in Space performance requirements 16 meters horizontally and 20m vertically [8].

It is obvious that this method of navigation is in many aspects superior to non-precision approach systems. Main and most important contributions of the approach with vertical guidance are safety, reduction crew's workload and reduction of CFIT (Controlled Flight into Terrain). Also improvements in availability of airport should not be ignored with respect to meteorological conditions and the consequent reduction in the number of failed approaches and diversions due to improvement in RVR and decision height minima.

Table 1 - Terminology - PANS-OPS vs. ICAO PBN Manual (Doc9613)

PANS-OPS Terminology	PBN Terminology	Chart Minima
NPA	RNP APCH down to	LNAV (MDA)
APV Baro-VNAV	RNP APCH down to	LNAV/VNAV (DA)
-	RNP APCH down to	LP (MDA)
APV SBAS	RNP APCH down to	LPV (DA)

2 PROBLEMS IN RNP APPROACH IMPLEMENTATION

In the effort of introduction the most accurate RNP Approach (LPV minima) there are some barriers, briefly described in this chapter.

2.1 Availability of signal

EGNOS Open Service, the European SBAS signal, used to improve the accuracy of GPS is available since 1 October 2009, but the EGNOS SoL (Safety of Life) service only since 2 March 2011 [5]. Nevertheless, it is the EGNOS SoL, which provides the necessary signal integrity essential for use in critical applications such as aircraft navigation.

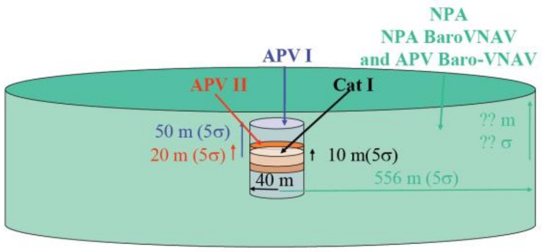

Figure 1 - ICAO GNSS signal performance requirements [4]

2.2. Avionics Certification

Because of the relative novelty of this solution there are just few regulations published so far. Especially in the Europe, while in USA approaches based on SBAS are in operation for 8 years.

Different dates of implementation of SBAS systems largely determine the different approaches to certification of aircraft using RNP approach. As the USA was the first in the World with SBAS system, they are focused on aircraft operators. Each operator can fit the necessary avionics in his aircraft and have it certified. The seven-year delay in Europe caused orientation towards manufacturer, who can certify his product - SBAS avionics and its installation into the aircraft. The advantage of this approach is that at the time of the certification process completion it will be automatically applicable to all aircraft of that type.

However, delay with EGNOS certification still persists. AMC 20-28 addressing the question of fulfilling the requirements for avionics certification for LP and LPV minima is still only at the design stage. For now, the certification is all in EASA authority, which should delegate these competences to the NAA (National Aviation Authorities).

2.3 Requirements for Airports

The ICAO resolution A37-11 [1] requires that 100% of instrument RWY ends have to have LNAV / VNAV or LPV minima RNP approach until the end of 2016 (with key milestones of 30% in 2010 and 70% in 2014). There is one exception - runway is allowed to have only LNAV minima if it is used by aircraft with MTOW equal or less than 5700 kg.

It is the delay in the implementation of SoL signal, which caused the impossibility of implementing LPV approach at European airports in the 30% of runways thresholds, as stated in the 2010 milestone. The only option at that time was the introduction of LNAV / VNAV minima (barometric vertical guidance). The regulations for this minima are already created and new major manufacturer's aircrafts (Airbus, Boeing) are LNAV / VNAV certified.

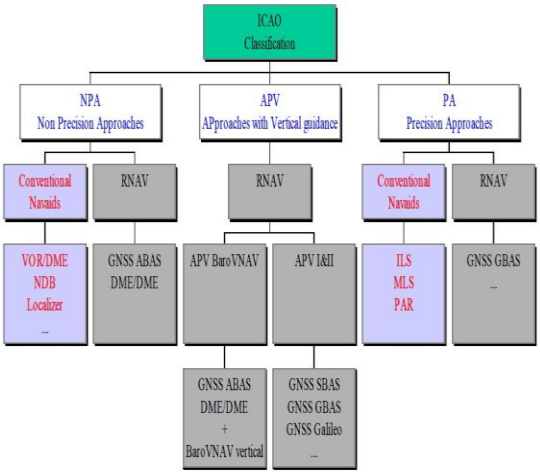

Figure 2 - ICAO approach classification and related systems [4]

Certification of airports is also not yet clarified. To avoid the need to create entirely new requirements for approach with vertical guidance (APV), the requirements are divided into two parts depending on decision height [2]:

- For DH (decision height) under 300 feet - the same requirements as for precision approach (PA) are applied, such as approach lighting system for Category I.
- For DH of 300 feet and above - the same requirements as for non-precision approach (NPA) are applied.

2.4 Costs associated with the introduction of RNP approaches at airports

In order to determine these costs, we have identified four different directions of the introduction of RNP approaches. They are distinguished by initial state of radio navigation equipment at the airport and the target RNP implementation for the airport project. These different directions are:

1. Airports that have ILS (precision approach) and introducing LPV because they want to attract smaller aircraft operators.
2. Airports that have NDB, VOR, LOC (non-precision approach), introducing LPV, which may allow them approaches to accuracy of Category I.
3. VFR airports, introducing LPV to allow growth and development of the airport.
4. Airports that have ILS, VOR, NDB, or LOC, introducing LNAV / VNAV, due to the simplicity of the solution and the possibility of immediate use.

Airports, which belong to the first group, have all necessary infrastructures and a change from precision approach to RNP approach is only about the creation and publication of the new approach procedures.

For smaller regional airports (group 2) is the situation more complex. Beside from issues mentioned above, one of the main obstacles is lack of funding for airport development. Airports do not have the resources to build ILS, which would enable them to ensure further development by allowing operation in low visibility conditions. Therefore, the transition from the NPA to RNP APCH appears to be a convenient alternative. At the same airport, operators can minimize the cost required, if they choose the correct decision height (see section 1.3), because they only need to design the new approach procedure and then certified it.

VFR airports are the most discriminated ones because of the necessity of changing the status from VFR to IFR and build eg approach lighting system. Still, there is no investment in the construction of radio navigation equipment, which suggests that RNP approaches are less financially demanding than approaches based on ILS or VOR. However, the ICAO resolution A37-11 does not take into account the VFR airports. This may change after 2016, but the current priority is IFR airports. Until then, the introduction of RNP approaches at VFR airports is up to operators decision.

Last but not least classifiable obstacle is potential competition between airports. Therefore, smaller airports must decide whether to enter the business among the big players to take the competitive advantage by using EGNOS signal years before big airports.

3 RNP APCH IMPLEMENTATION IN EUROPE

Since March 2011 so far, EGNOS signal has been used only at eight airports [7]. Most states within Europe have implemented LNAV / VNAV approach while it was the only possible solution to meet first ICAO milestone in 2010 (par. 2.3.). In Germany, they have introduced a nationwide LNAV / VNAV, which has similar signal accuracy like non-precision approach. On the other hand if they implement LPV, they would gain far more accurate signal than the baro-VNAV (vertical guidance based on barometric altitude measurements) and therefore benefit from lower DH.

Figure 3 - LPV procedures published in Europe in first year since EGNOS Sol introduction [7]

Within the already published LPV's we want to pinpoint two important things:

- The introduction has always been a joint effort of the aircraft operators, airports and ANSPs (Air Navigation Service Providers) - other airports should choose this direction too, because the costs arising from the introduction of this approach will start returning immediately.
- The LPV approach was implemented largely at regional airports - the reasons are that a large international airport, served by operators with large fleets of aircraft
  - have sufficient infrastructure consisting of ILS and prefer to introduce LNAV / VNAV, due to the simplicity and the possibility of immediate use by the aircraft operators and
  - LPV approach's main advantage of lower DH could not be applicable (is not needed) due to the presence of ILS - this reason may fade away over time with SBAS avionics extending into a large number of aircraft and with significant decreasing of ANSP' navigation costs.

4 RNP APCH IN THE CZECH REPUBLIC

In the Czech Republic, as in other parts of Europe, the RNP APPCH down to LNAV / VNAV has been implemented to meet the ICAO Resolution milestone for 2010. These were published at runways thresholds 06, 13, 24, 31 at Praha-Ruzyne airport (LKPR) and runways 10, 28 at Brno-Turany airport (LKTB) [3]. Currently impulses come for the introduction of LNAV / VNAV approach in Karlovy Vary.

Table 2 - RNP Approach implementation process in Czech Republic

Airport		THRs	ILS CAT/THR	LNAV/ VNAV THR		
LKTB		2	I / 1	2		
LKKB		2	I / 1	N/A		
LKKU		2	I / 1	N/A		
LKKV		2	N/A	N/A		
LKMT		2	II / 1	N/A		
LKPD		2	LOC / 1 II / 1	N/A		
LKPR		4	I / 3 IIIb / 1	4	ICAO resolution A37-11	
LKVO		2	LOC /1	N/A	2012	2014 – 70%
IFR	8	18		6	33,33%	12,6
In ČR	92				30% was enough	Will it be done?

5 CONCLUSION

EGNOS SoL signal is fully available to aviation and the availability of basic technology is not a limiting factor to the implementation of RNP approaches already for one year. During this period, however, only 8 airports used it.

There must be published RNP approach to thirteen instrumental runways thresholds in the Czech Republic by 2014. Six of them have already introduced LNAV / VNAV. On seven remaining thresholds (i.e. a minimum of 4 airports) we suggest to implement LPV. This could be achieved with the first from four proposed directions of development applications (see Chap. 1.4) e.g. at the airport LKKU and LKMT or applications of the second direction at LKVO. Nowadays there is a strong demand from aircraft operators for application the 4th direction at LKKV. Just to be complete, we propose airports being able to fulfill the third direction: LKCS, LKHK, LKMH, LKLN, LKPO and LKPM.

It is pity that nobody has forced forward the question of LPV approach introduction in the Czech Republic for a long time and everyone (airports, ANSP, aircraft operators, Civil Aviation

Authority, the state) has been waited to see what happens. Nowadays, in this question, ŘLP (Czech ANSP) is the most active. However, other stakeholders must as soon as possible join to ensure that the Czech aviation would not "crawl far behind the rest of Europe."

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AUTHORS ADDRESSES

Ing. Jakub Kraus, Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University, Horská 3, Praha 2, 128 03, Czech Republic
e-mail: xkraus@fd.cvut.cz

Ing. Tomáš Duša, Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University, Horská 3, Praha 2, 128 03, Czech Republic
e-mail: t.dusa@sh.cvut.cz

INCREASING SAFETY AT UNCONTROLLED AERODROMES IN THE CZECH REPUBLIC – INTRODUCING IFR APPROACH PROCEDURES

Jakub Kraus, Tomáš Duša

This paper discusses improving air safety operations at uncontrolled aerodromes. It analyzes the possibility of instrument approach implementation on such aerodromes in the Czech Republic and identifies changes needed for effective use of satellite based augmentation system (SBAS) during approach. These changes should be applied in each aviation sector, beginning from aerodromes through the aircraft operators to Air Traffic Control and finally the Civil Aviation Authority.
K e y w o r d s: uncontrolled aerodrome, ATC, SBAS, IFR approach, LPV

1 INTRODUCTION

Let's imagine a beautiful summer sunny day. Those of us, the flying freaks, will immediately imagine spending it on the local airfield. What is a dream for pilots could be a nightmare for AFIS officer. Many planes taxing on the ground, many in the air, in between the pilot veterans mixed together with flight school cadets. Suddenly, the engine cut-off emergency occurs, the issue, which dramatically affects the safe operations in the area.

Using the SBAS technology during approach and landing, is the best way to implement instrument approach and thereby increase safety at small aerodromes without spending enormous amount of money for building expensive navigation infrastructure. SBAS is used in the most accurate version of the RNP APCH – the LPV (Localizer precision with vertical guidance). Since there is the appropriate SBAS avionics installed onboard, we have got very precise navigation feature, furthermore very convenient from the pilot's perspective. One could say: "Ready for flight".

However the biggest obstacle is still hiding on the ground, while according to the current regulations the presence of ATC at the IFR airport is mandatory and IFR certified airport is required for allowance the instrument approach procedures on the airport. This significantly reduces the possibility of introducing RNP approach. However, in some countries in Europe, it is possible to carry out instrument approach at uncontrolled aerodromes. These states could give us a clue how to adjust the current regulations in Czech Republic for establishing safe instrument approach procedures at uncontrolled aerodromes.

There are three basic enablers for increasing safety in general. The first, increasing safety by introducing new technologies, the second is improved staff training agenda, the last one hide in better standardization process. This paper deals with the first one.

2 WHAT PREVENTS THE INTRODUCTION OF AN INSTRUMENT APPROACH AT UNCONTROLLED AERODROMES?

Already mentioned was a requirement for the presence of ATC. This is the main obstacle, however not the only one.

According the Czech version of ICAO Annexes (so called "L" standards) there is a rule that IFR traffic must be operated only at controlled airports and in controlled airspace. In this article we would like to show the possibility of introduction IFR approach only.

Absolute safety in aviation is achieved by the aircraft at the aerodrome and firmly tied to the ground. This option is economically out of the question, so now the next problem for the safety is to get the aircraft on the ground without incident. Therefore it is necessary to allow IFR approaches at uncontrolled aerodromes.

The following table lists all the obstacles that prevent the introduction of an IFR approach.

Table 1. Obstacles in implementation of the IFR approach

Type of the airspace around aerodromes
IFR requirements for aerodrome
IFR requirements for the runway – marking, lighting system
Need for the presence of ATC
Competences and responsibilities of AFIS
Radar coverage in the vicinity of the aerodrome
Appropriate system (technology) for approach
Approach procedure
Current legislation for aerodrome certification
Requirements for aircraft equipment
Requirements for pilot training

All these criteria arise from current legislation. They have to be applied to all IFR approaches within the Czech Republic regardless of small, medium or huge international aerodrome. In order to introduce safe IFR approaches on small (VFR) aerodromes, modifications have to be done. Our suggestion of such modifications follows.

3 NECESSARY MODIFICATIONS AND ALTERNATIVE PROCEDURES

3.1 Aerodrome and instrument runway

Runway where we want to introduce an IFR approach must currently meet all the requirements for IFR operations eg horizontal markings, runway lights, glide slope lighting system and approach lighting system.

From our perspective, where we want to use the runway for IFR approach and landing at sudden weather conditions deterioration, it could lead in reduction of requirements for runway and runway equipment. The requirements for the minimal time margin before the sunset and after the sunrise are not affected. Naturally, we don’t want to land in night, we don’t want to land during the fog, we just want to stress down the pilot when the clouds are coming, to help him quickly find the direction to the aerodrome and lead him safely through the clouds below the cloud base. Cutting down the restrictive IFR requirements would lead to expansion of instrument approach to more aerodromes due to a reduction in costs.

Our demands to the aerodrome for IFR approaches are:

- Paved runway
- Taxiways may have a grass surface
- AFIS
- Runway marking
- PAPI slope system
- Runway center lights
- Simple approach lighting system is recommended

3.2 Airspace management and Air Traffic Control

From the perspective of ATC it is important to ensure that the two aircraft would not converge or even clash. The problem then is how to ensure the spacing between IFR flights. This can be solved in two ways, either by introducing activated F class airspace in the vicinity of the runway (German method), or creating new type of airspace the Traffic Information Zone around the aerodrome.

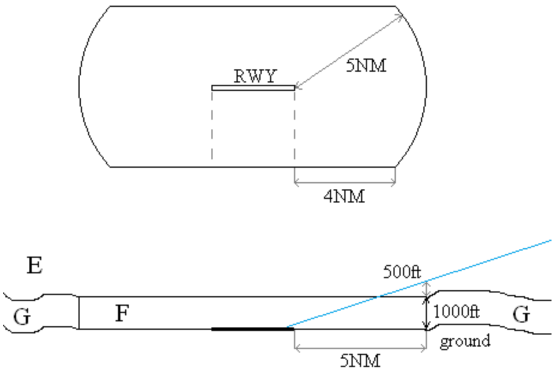
3.2.1 Activated class F airspace

The Czech Republic only uses following airspace classes: C, D, E and G. However, as can be seen in regulation L 11, all classes of airspace are incorporated from ICAO Annex 11 into Czech legislation, including the F class.

In Germany, the class F airspace is used for the protection of IFR flights in uncontrolled airspace and its size defines the space required for IFR flights.

This area is activated only during the approach and departure of IFR flight. It is activated by AFIS officer on the aerodrome frequency. After landing or leaving the area by the IFR flight the F class is deactivated.

In the class F airspace shall be mandatory to establish two-way communication between a pilot and AFIS officer.

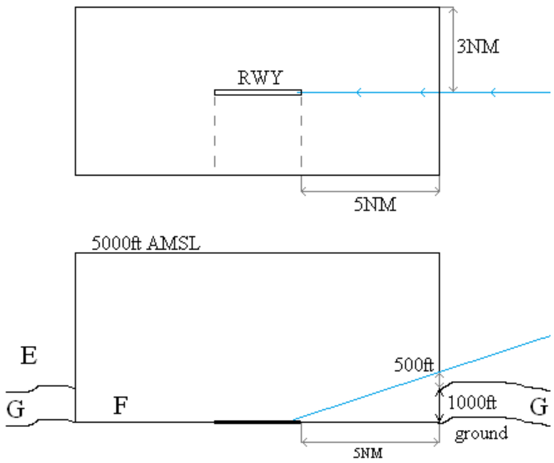


Source: Author

Figure 1. Proposed class F airspace for Czech Republic

3.2.2 Traffic Information Zone - TIZ

The second option is to introduce a new space called Traffic Information Zone, which would have at uncontrolled aerodromes similar function as the CTRs at controlled ones. TIZ differs from CTR by the airspace class and established communication. TIZ shall be class F or E with mandatory two-way communication between a pilot and AFIS (in CTR it is a pilot and ATC).



Source: Author

Figure 2. Traffic Information Zone

3.3 Clearance

The clearance to fly into the aerodrome area (class F airspace or Traffic Information Zone) would be issued by ATC before reaching the minimum radar vectoring altitude (MRVA). As a result, in the aerodrome area will be located always only one aircraft flying according IFR, and this will ensure IFR separation thus safety as well. After landing and leaving runway AFIS officer transmits the runway occupancy information to ATC.

3.4 AFIS

The requirements for certification of AFIS have changed this year. This change increases the requirements for the appropriate AFIS officer and is compatible with the necessary change in the airspace around the aerodrome and the need of communication between air traffic controllers and AFIS. AFIS officer should obtain various particular competencies, eg he should be able to prohibit aircraft landing.

3.5 Choice of system for precision approach at uncontrolled aerodromes

For the introduction of IFR approaches at uncontrolled aerodromes, it is best to use LPV minima. LPV is the highest type from RNP APCH category. There is a strong push to implement RNP APCH with LPV minima within the Europe, while it uses the EGNOS navigation signal which is available since March 2011. RNP APCH has also advantage over conventional approach systems (eg ILS, VOR), and GBAS while there is no need neither to build up radio navigational equipment nor any other facilities. It costs "only" design and publication procedures. However, this approach can achieve accuracies equal to ILS Cat I.

Table 2. Approach systems and their approximate cost

Radio Navigational AID	Approximate cost [USD]
By the ICAO [6]	
ILS CAT I	500 000
ILS CAT II	1 100 000
ILS CAT III	1 250 000
GBAS	850 000
VOR	135 000
DME	125 000
NDB	30 000
SBAS	0
By ŘLP, a.s. (Czech ANSP)	
ILS CAT I (in CR)	800 000
By [5]	
ILS CAT III	1 000 000
GBAS	1 000 000

3.5 Approach and landing procedure

Approach procedure would match the conventional IFR approach with some minor differences.

The first is the need to obtain clearance to enter the aerodrome area, which would be before IAF and above the minimum radar vectoring altitude. When the pilot obtains clearance for approach, he starts RNP approach. The next would be based on the runway lighting equipment. If there is no approach lighting system, it is necessary to increase the visibility minima. What is more, there is nobody, who could give landing clearance to the pilot. AFIS officer could only inform the pilot, that runway is free. This should be changed, as discussed in chapter 3.4

3.6 Aircraft operators and pilots

From the perspective of aircraft operators, there is no change. If they wish to fly IFR approach (in this case, RNP APCH LPV), they will have to be equipped with the necessary avionics. The avionics must be naturally certified.

Pilots must have the necessary training for IFR flying and has to be trained to use the RNP APCH, to understand differences in the use of the class F airspace, and / or TIZ and landing on a runway which does not have approach lighting system.

3.7 The proposed amendments to the regulations

Table 3. Changes in legislation and rules

AIP	Implementation class F or TIZ
L 2	Definition of airspace around aerodromes
L 11	Aerodrome Flight Information Service (AFIS)
L 14	Specification for uncontrolled LPV aerodromes
AIP	Specification of differences between ICAO Annexes and L standards
L 8186	Procedures for approach to uncontrolled aerodromes
	Update for pilots training

3.8 Civil Aviation Authority

Most important for any new system and procedure is approval. When introducing an IFR approach at uncontrolled aerodromes it is necessary that all changes in regulations is approved by the Civil Aviation Authority. Finally the CAA certifies aerodrome itself.

The certification procedures are based on international agreements and standards. However there is a chance to alter the standards to fit the national environment in each country. As it was stated in chapter 3.2, the Czech Republic accepted the respective international standards, but finally implemented just a part of it. There are many such an examples which should be changed one by another in the appropriate way to increase safety.

4 SELECTION OF AERODROMES FOR THE INTRODUCTION OF INSTRUMENT APPROACH

In the Czech Republic we have 14 uncontrolled aerodromes (Table 4) with paved runway of which four have very good infrastructure thus publishing IFR approach would be very easy there (marked green). Nine other also appear to be appropriate (marked yellow) due to still sufficient size of the runway (the smallest runway is 595x15m). Remaining one, in Olomouc has the major shortcoming in a short runway, which is with 425 meters not long enough even for some Cessna with propeller.

Table 4. List of possible aerodromes

Aerodrome	ICAO code
České Budějovice	LKCS
Hořovice	LKHV
Hosín	LKHS
Hradec Králové	LKHK
Jindřichův Hradec	LKJH
Kříženec	LKKC
Mnichovo Hradiště	LKMH
Olomouc	LKOL
Otrokovice	LKOT
Panenský Týnec	LKPC
Plzeň – Líně	LKLN
Přerov	LKPO
Příbram	LKPM
Vysoké Mýto	LKVM

5 CONCLUSION

We have shown the technology enabler could increase safety on uncontrolled aerodromes. Unfortunately, it is the common fact, especially in aviation, that the technology development overruns the legislation process. The Czech Republic's legislative environment is rigid as well.

We have shown some necessary modifications in aerodrome, it's runway, airspace management and air traffic control, ATC clearance, approach and landing procedures, operator's, pilot's and civil aviation authority workflow. All this lead to break the rigidness, thus enable new technologies being used to increase aviation safety. We realize there is still the long way ahead.

6 ACKNOWLEDGEMENTS

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AUTHORS ADDRESSES

Ing. Jakub Kraus, Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University, Horská 3, Praha 2, 128 03, Czech Republic
e-mail: krausjak@fd.cvut.cz

Ing. Tomáš Duša, Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University, Horská 3, Praha 2, 128 03, Czech Republic
e-mail: t.dusa@sh.cvut.cz

ANALYSIS OF OPTIONS AND THE PROPOSAL TO INTRODUCE THE CLASS F AIRSPACE IN THE CZECH REPUBLIC

Ing. Jakub Kraus
Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University, Czech Republic
krausjak@fd.cvut.cz

Abstract - This article focuses on the analysis of possibilities of currently unused class F airspace in the Czech Republic for a small uncontrolled airport. This airspace class will allow the introduction of IFR operations at those airports. Additionally, this article includes the necessary adjustments to the legislation and indicates possible obstacles in practical realization.

Key words – class F, IFR, airspace, safety

I. Introduction

Nowadays it is necessary to move aviation in the Czech Republic further. This can be achieved by increasing the number of quality airports, and quality can be obtained by introducing IFR traffic. This, however, brings many necessary changes either in legislation or regulations. The introduction of IFR traffic also increases safety.

Situation – we are flying VFR and weather can be described with the word CAVOK. Suddenly, clouds begin to form and weather conditions are rapidly deteriorating. We should land, but in the vicinity is not any airport. Then, in few more minutes the Earth is no more visible. What now? Emergency situation for the pilot, which could be easily solved by the introduction of instrument approaches at uncontrolled aerodromes, where he could change to IFR and land safely.

So, if we introduce IFR operations at uncontrolled aerodromes we increase safety and sudden weather deterioration will be no longer problem. But before this implementation we need to identify and apply the changes to the aviation industry. These relate mainly to processes and procedures at the airport and legislative framework.

II. The reasons for the Class F introduction

Currently, the Czech Republic airspace is up to 1000ft AGL classified as G. It is based on ICAO Annex 11 and transformed into Czech national standard L 11. However, in the Czech Republic airspace are the rules for using class G modified and IFR flights is banned in class G. Aerodrome traffic zones (ATZ) around Czech uncontrolled aerodromes are also class G and because of this it is impossible to introduce IFR traffic on them. Since the class G airspace is appropriate to preserve, as it is defined, it is necessary to create a new one. In ICAO airspace classifications is class F, which we can use to allow entry of aircraft flying under VFR and IFR conditions to some airspace.

Another reason for implementing the F airspace is increasing safety in General Aviation in the Czech Republic. The introduction of IFR operations at small airports will reduce risk of an accident, because the pilot will have an opportunity to land safely in the time of bad weather.

Class F airspace also enables implementing IFR operations at airports without the need to create ATC at the airport and CTR and TMA around it, which would all need to be done with the change from an uncontrolled aerodrome to a controlled one.

III. Definition of Class F airspace

Class F airspace is defined in standard L 11 and allows VFR and IFR flights, where for IFR is provided beyond flight information service also air traffic advisory service. For IFR flights is also a requirement for establishing permanent two-way radio communication. This definition is based on ICAO Annex 11. We have in the Czech Republic a small change, when air traffic advisory service is not applied.

IV. Requirements for airspace around uncontrolled IFR airports

For the introduction of IFR operations at uncontrolled airports is necessary to ensure safety. Uncontrolled airport means no ATC service and therefore the presence of Aerodrome Flight Information Service (AFIS) is essential at the aerodrome. It is also required to maintain constant two-way radio communications between a pilot and AFIS officer.

V. Options for introducing class F airspace

There are three ways to implement class F airspace and these are:

- Changing the class of ATZ airspace at the aerodrome, where we want introduce IFR operations.
- Creating activated class F airspace in close vicinity of the aerodrome.
- Introducing Traffic Information Zone (TIZ), classified with class F.

Changing the class of ATZ

Aerodrome traffic zone is in the Czech legislation defined as airspace with 3NM radius from the aerodrome reference point and reaching up to 4000ft AMSL. ATZ airspace class is G.

With the class change of the ATZ an interesting situation would have been created in the Czech Republic airspace. Here will be two types of ATZ, in maps indistinguishable, but with radically different style of operation. Therefore it would be appropriate to act together and introduce the class F airspace in all ATZ.

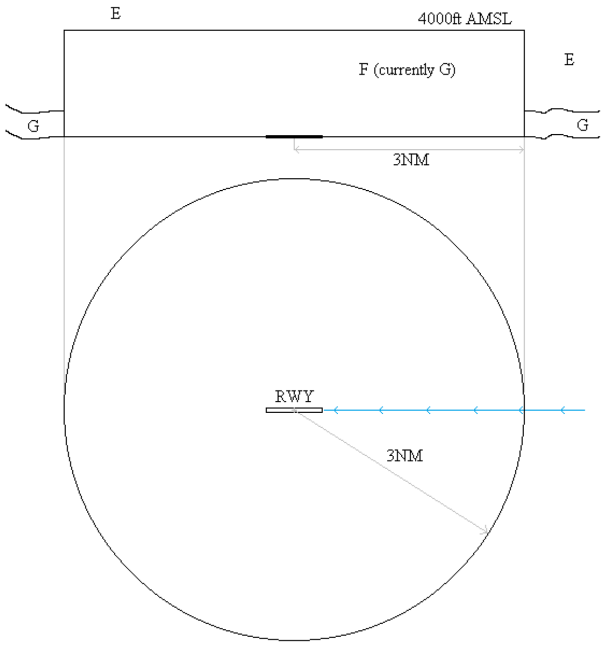

***Figure 1** – Aerodrome Traffic Zone*

The introduction of activated class F airspace

The second way to allow IFR operations at uncontrolled aerodromes is change the class of airspace around the airport from G to F. A model can be taken from the German airspace, where the class F airspace is used just to protect IFR operations at uncontrolled aerodromes and is activated only for IFR flights. If there is no aircraft flying under IFR, this class F airspace is deactivated and is replaced by class G.

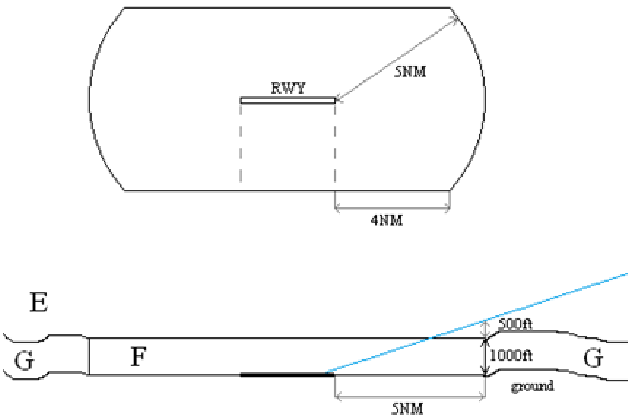

***Figure 2** – Proposed activated class F airspace*

Traffic Information Zone

Traffic Information Zone is a third option for the introduction of IFR operations at small airports. Based on the Scandinavian model it introduces at small airports airspace equivalent to CTR, where the size of TIZ area is based on the needs of IFR routes.

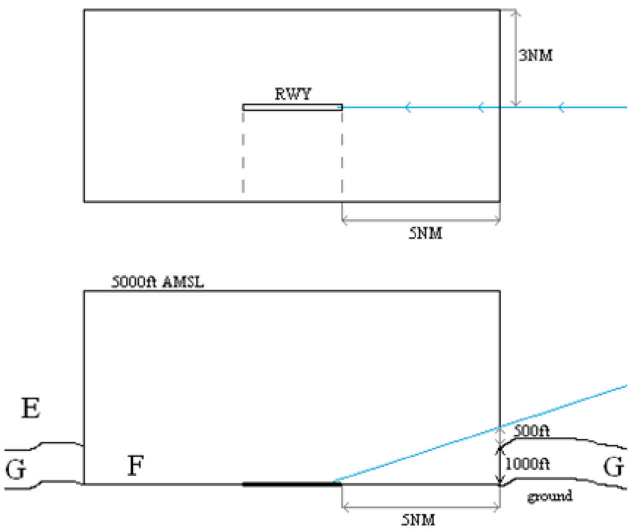

***Figure 3** – Example of Traffic Information Zone*

Selecting the option for class F introduction

Changing the class of ATZ faces two problems arising from the way of change to the class F airspace. If we change only some ATZ, under this abbreviation will be hiding two types of airspaces differing in classification and operating rules. There is the potential risk of confusion. The second option is to change every ATZ to class F, which is feasible, but not necessary, since IFR traffic cannot be introduced to all uncontrolled aerodromes. ATZ has one more drawback and that is the size of its radius. 3NM is not sufficient to descend 1000ft with standard 3° glideslope and therefore ATZ would need larger radius. For these reasons and in view of that ATZ is at Czech uncontrolled airports well established it is appropriate to leave it as is.

The possible introduction of class F airspace, activated only when there is need to protect IFR traffic (following the German model), is unsuitable for use in the Czech Republic due to boundary between class G and E airspaces, which is 1000ft AGL. This is very low and so it will be necessary to raise the upper limit, which already falls within the E and beyond the capabilities of simple changes classes of airspace.

The most appropriate type of airspace for the introduction of class F in the Czech Republic appears to be the Traffic Information Zone. This space would replace the ATZ at aerodromes, where the IFR operations will be introduced. Compared to ATZ and activated class F, TIZ has a larger size so it can absorb IFR operations with sufficient safety boundaries. The proposed dimensions of 5NM from the runway threshold and 3NM on each side of the runway centerline together with height 5000ft AMSL allow ATC to give approach clearance and maintain separation with procedural control.

VI. Barriers to implementation class F airspace

The only obstacle to the introduction of Class F airspace is the need to noticeably change the aviation regulations because class F is currently unused.

VII. The proposed amendments to the regulations for the implementation of the class F airspace

Table 1 *– Changes in legislation and rules*

L 2	Definition of TIZ, AFIS; Operations at the airport and in the vicinity
L 11	Appendix N – Aerodrome Flight Information Service (AFIS)
L 7030	Communications
AIP	Specification of differences between ICAO Annexes and L standards
AIP	Implementation of TIZ
	Update for pilots training

Main changes in L 2 standard

In Chapter 1 is needed to add a definition of TIZ: Traffic information zone (TIZ). An uncontrolled airspace of defined dimensions extending upwards from the surface of the earth to a specified upper limit within which two-way communications is required for all aircraft and flight information is provided by an ATS unit [4]. Furthermore it is necessary to change the definition of AFIS unit – the old formulation: “Aerodrome flight information service unit (AFIS unit). A unit established to provide flight information service and alerting service for aerodrome traffic at uncontrolled aerodrome and in ATZ” [5], and the new one: “Aerodrome flight information service unit (AFIS unit). A unit established to provide flight information service and alerting service for aerodrome traffic at uncontrolled aerodrome, in ATZ and in TIZ”.

In Chapter 3, section 3.2.5 it is necessary to add “TIZ” in all places where is mentioned “uncontrolled aerodrome” or “ATZ”. Example of change - the old formulation: “An aircraft operated on or in the vicinity of an aerodrome shall, whether or not within a control zone or ATZ: “[5], and the new one: “An aircraft operated on or in the vicinity of an aerodrome shall, whether or not within a control zone, ATZ or TIZ: “.

Similarly, it is necessary to add some variations resulting from the introduction of TIZ. Example of change - Aircraft shall report:

…
v) place of leaving the circuit;
vi) place of leaving ATZ;
vii) place of leaving TIZ;

Main changes in L 11 standard

In the standard L 11, changes concern Appendix N, namely:

In the paragraph 1.1 it is necessary to add a definition of TIZ: „1.1.4 Traffic information zone (TIZ). An uncontrolled airspace of defined dimensions extending upwards from the surface of the earth to a specified upper limit within which two-way communications is required for all aircraft and flight information is provided by an ATS unit.“ [4].

In the following paragraphs where ATZ is noted is needed to supplement the possibility of TIZ according to the following example: Paragraph 1.2 - the old formulation: “AFIS is provided to all known aircraft that are operating at the airport and in ATZ.” [5], and the new formulation: “AFIS is provided to all known aircraft that are operating at the airport and in ATZ/TIZ.”.

Main changes in L 7030 standard

In standard L 7030 there is the need of minor changes in the Communications part, where is required to maintain two way radio communication in uncontrolled airspace TIZ.

Main changes in AIP CR

One of the main changes is the need to update GEN 1.7 DIFFERENCES FROM ICAO STANDARDS, RECOMMENDED PRACTICES AND PROCEDURES and write down all above mentioned changes to it.

It is also necessary to modify formulation in the AIP for uncontrolled aerodromes to make it clear that Traffic Information Zone (TIZ) can exist around them.

In the ENR 1.1, “1.1.2.1.1.1 Aerodrome Flight Information Service (AFIS) is provided on an uncontrolled aerodromes published in AIP CR, Volume III and in Aerodrome Traffic Zone (ATZ) or in Traffic Information Zone (TIZ) of these aerodromes within aerodrome operational hours and encompasses the following information:

…
i) Relay of departure clearance“

and “1.1.2.1.1.2 Establishing of the radio contact with AFIS unit is compulsory for an aircraft equipped with radio set, operating on an uncontrolled aerodrome and/or within an ATZ/TIZ, when commencing taxiing and/or prior entering an ATZ/TIZ. Pilots shall transmit their reports whether or not an Aerodrome Flight Information Service (AFIS) is provided. To enter TIZ aircraft must be equipped with radio set."

In the ENR 1.4 is necessary to change the number of classes of airspace used in the Czech Republic: "1.4.1 Classification of airspace - The airspace is divided into five classifications C, D, E, F and G which equate with those recommended by ICAO. Airspace classified as C, D and E is controlled airspace. ", next describe the use of class F:
Class F airspace comprises:
– TIZ of all uncontrolled IFR aerodromes;
and change table of airspaces used in the Czech Republic, where the added class F will have the same parameters as the class G with one change in the column separation assurance, where will be inscribed "IFR from IFR".

In the ENR 6.1.1 – to the map mark the uncontrolled aerodromes with IFR operations and their TIZ.

In the AD part is necessary at every airport, where will be TIZ implemented, enter this airspace to the map.

VIII. Conclusion

This article shows three ways to implement class F airspace in the Czech Republic to increase airspace flexibility. Of these three options - ATZ, activated class F, TIZ - appears to be the best the last mentioned - Traffic Information Zone. With this type of airspace it is easy to implement protective area around the aerodromes, which is the first step to the implementation of IFR operations on uncontrolled airports.

Also shown here is one way how to modify the legislation in order to implement TIZ with class F airspace. When incorporated into Czech legislation, TIZ will allow new class of aerodrome to be born – uncontrolled IFR aerodrome.

Acknowledgments

This analysis was supported by the Grant Agency of the Czech Technical University in Prague, grant No. SGS12/165/OHK2/2T/16.

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Implementation of Traffic Information Zone in Czech Republic

Jakub Kraus
Department of Air Transport,
Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University
Horská 3, Praha 2, 128 03, Czech Republic
e-mail: kraus@fd.cvut.cz

Abstract – **This article focuses on the use of airspace, defined as traffic information zone for small aerodromes in the Czech Republic. This airspace should be around uncontrolled aerodromes introducing IFR operation to replace aerodrome traffic zone and to ensure the safe operation of aircraft flying by instruments.**

Keywords – Small Aerodromes, VFR, IFR traffic, AFIS, TIZ, Traffic Information Zone, EGNOS

I. Introduction

Improving the quality of anything is a good input for economic growth. That is true of course also for aviation, which is constantly evolving industry. Despite the increasing quality of the techniques, however, it is not expected a rapid change in the volume of air traffic. Commercial air transport market is saturated and the current carriers can basically only fighting over passengers. Change in this case can come in rapidly developing countries such as India or China. In Europe, growth prospects are very limited and the growth is estimated to around 3 % per year.

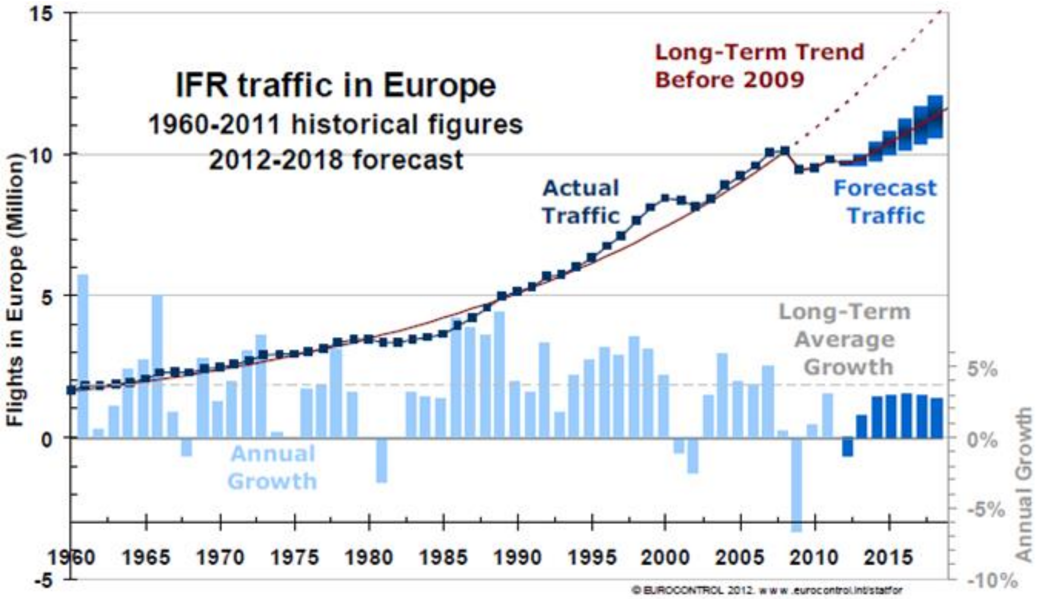

Figure 1. Eurocontrol IFR traffic forecast [14]

Therefore it would be appropriate to insert into the European air transport some momentum that would allow faster growth. The challenge, however, is to determine the correct part of aviation that still has enough options. This area could be general aviation with a clearer focus on larger GA aircrafts that have the avionics for IFR flying but they are struggling with a small number of IFR airports.

II. Arguments for Increasing the Number of IFR Aerodromes

This finding of a small number of IFR airports is based on a study carried out by Eurocontrol, which interviewed IFR pilots who are aware of the SBAS. This questionnaire was completed by 254 pilots, which is not sufficient for clear identification of possible causes of SBAS little usage in Europe, but some conclusions can be drawn from the results.

One of them is the fact that almost 48% of the people surveyed fly in machines with SBAS capable avionics, although not all of them could be used for APV approach.

However, the most important outcome is identifying of the two main barriers to the use of procedures requiring SBAS. The first one is the cost (either for certification, avionics acquisition, installation) and the second one is an insufficient number of publicated procedures. They were identified as a major cause in 30% responces.

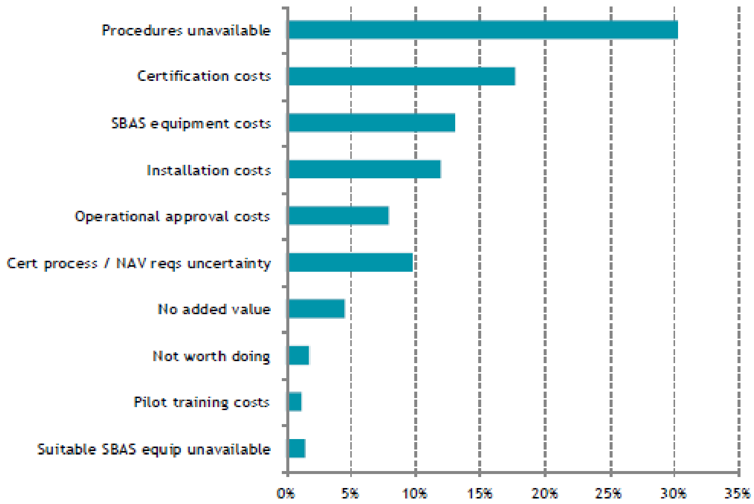

Figure 2. Obstacles to the use of SBAS / EGNOS [15]

Removal of the main obstacles, lack of procedures, is the best option for extending the use of EGNOS in Europe. Currently, approaches utilizing satellite augmentation are implemented only at 84 airports in Europe, from which only 46 are RNP APCH down to LPV.

In all 6500 airports in Europe are 84 procedures noticeably small number. It should be noted that RNP APCH down to the LPV is ranked as instrument approach and therefore it is possible to implement it only at IFR airports. These, however, are only a fraction of the total number, which is why some states are trying to allow IFR traffic at VFR aerodromes. Examples might be Germany, the United Kingdom, and Norway, Sweden and Denmark.

If we focus only on the Czech Republic, then from a total of 92 aerodromes are only 8 instrument ones that is only 7 %. To encourage aviation, it is therefore necessary choose other airports that allow instrument approaches.

III. TIZ

The main obstacle to the introduction of IFR operations at the VFR aerodrome is maintaining the level of safety: to ensure separation between aircraft and to enable landing at aerodromes, which do not meet the conditions for IFR operations.

The airspace around uncontrolled aerodromes in Europe is generally classified as ATZ with dimensions of 3 NM radius and height of 4000 ft AMSL. This size is insufficient for IFR operations and for this reason it is necessary to either enlarge the size of ATZ or introduce other airspace for VFR aerodromes with IFR traffic.

This option may be an area called the Traffic Information Zone (TIZ), which is mentioned in the Eurocontrol AFIS manual. The definition of TIZ is: An uncontrolled airspace of defined dimensions extending upwards from the surface of the earth to a specified upper limit within which two-way communications is required for all aircraft and flight information is provided by an ATS unit. TIZ basically provides same function for uncontrolled aerodromes as the CTR for controlled ones.

A. The Norwegian example

Among the European countries using TIZ is Norway. This airspace was introduced in order to allow flights at uncontrolled aerodromes in meteorological conditions which do not meet the VMC minima. In traffic information zone is provided AFIS and mandatory two-way radio communication ensures that AFIS officer may transmit information to all aircraft about all traffic located in TIZ.

Pilots are still responsible for maintaining separation, which may be in IMC quite a challenge. Therefore AFIS tend to have available output from surveillance systems for the accurate location information of other traffic. In some cases the number of aircraft that can move in TIZ the same time is also limited.

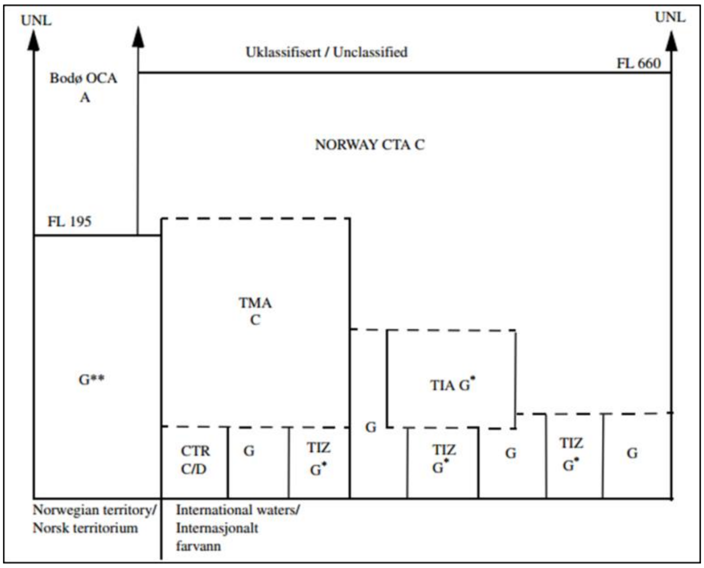

Figure 3. Norway airspace [2]

Figure 3 shows the location of the various TIZ areas, classified airspace class G*. This means ICAO Class G with mandatory two-way radio communications.

TIZ important feature is that the regulations do not strictly defined its dimensions and therefore it is always possible to establish the best airspace for each aerodrome, which it is not possible when using ATZ.

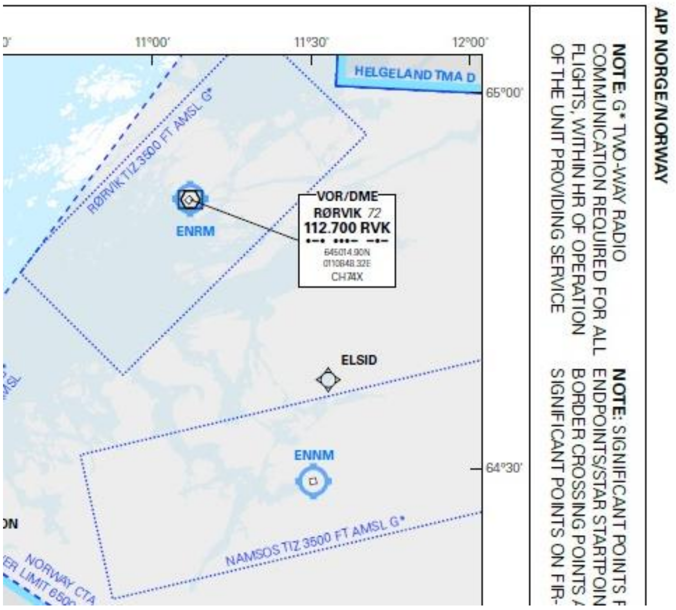

Figure 4. Part of Norway area map showing TIZs [2]

IV. The Use of TIZ in the Czech Republic

According to the above information, it is clear that TIZ should be implemented in the Czech Republic at selected uncontrolled aerodromes. However, to simplify the implementation this airspace could have defined dimensions, ensuring smooth operation of the IFR.

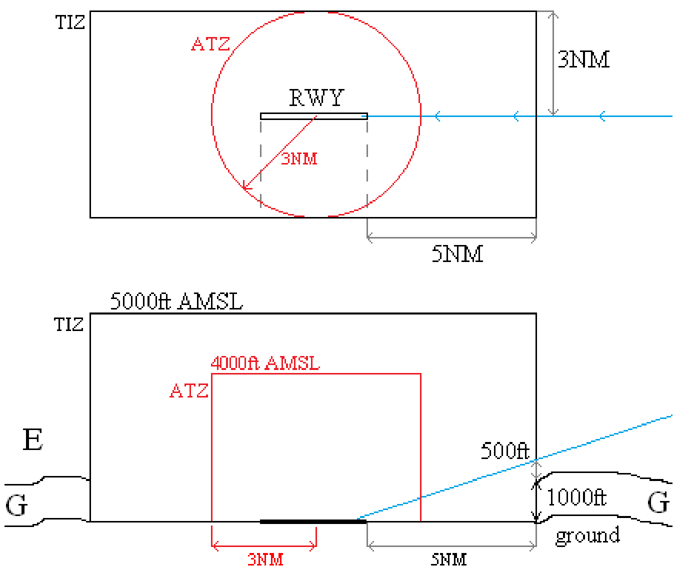

Figure 5. Proposed TIZ for Czech Republic

Figure 5 shows a comparison of proposed TIZ and present ATZ. The biggest obstacle of ATZ is the horizontal size of this airspace, which does not allow the creation of a direct approach route that would not missed class G airspace. In Czech Republic is this airspace defined as uncontrolled where IFR flights are not allowed. TIZ would have to be classified with modified class G (as has Norway), or there is the possibility to use class F. The F class is defined in L regulations, but it is unused in the airspace of the Czech Republic.

In the dimensions of TIZ, 5 NM from the runway threshold, 3 NM from the runway centre line and height of 5000 ft AMSL could be radar vectored aircraft by the ACC controller with subsequent use of RNP APCH down to LPV. Spacing would be ensured procedurally that the controller will give approach clearance only to one aircraft at one time. Another aircrafts would have to wait until ATC get the information about flight cancelation. With the coordination of ATC and AFIS would be also protected the departing aircrafts.

As mentioned, although the pilot is still responsible for the spacing from other traffic, by using a procedural control and mandatory two-way radio communication possibility of conflict would be greatly reduced in TIZ. In VMC is the traffic seen and in IMC cannot be present VFR flights, because of IMC, and IFR flights because of procedural control.

A. VFR aerodromes for IFR traffic

This airspace could be used for larger VFR aerodromes in the Czech Republic, such as České Budějovice, Hradec Králové, and also Benešov.

Table I. Czech Aerodromes Capable for TIZ Implementation

Aerodrome	ICAO code	Surface
České Budějovice	LKCS	Asphalt/concrete
Hořovice	LKHV	Asphalt/concrete
Hosín	LKHS	Asphalt/concrete
Hradec Králové	LKHK	Asphalt/concrete
Jindřichův Hradec	LKJH	Asphalt/concrete
Křížence	LKKC	Asphalt/concrete
Mnichovo Hradiště	LKMH	Asphalt/concrete
Otrokovice	LKOT	Asphalt/concrete
Panenský Týnec	LKPC	Asphalt/concrete
Plzeň – Líně	LKLN	Asphalt/concrete
Přerov	LKPO	Asphalt/concrete
Příbram	LKPM	Asphalt/concrete
Vysoké Mýto	LKVM	Asphalt/concrete
Benešov	LKBE	Grass

B. Needed regulation changes

The introduction of TIZ into Czech legislation would not be very difficult step and will significantly affect mainly the regulations L 2, L 11, L 7030 and AIP. The actual implementation would, however, require safety analysis to confirm that the introduction of TIZ is not more dangerous than the status quo. The safety analysis must be based on the risks caused by processes during approach and landing. Here arises a suitable comparison between the precision approach to airport and proposed approach to an uncontrolled aerodrome.

V. Conclusion

Traffic Information Zone is a simple tool which can improve the quality of air traffic in the Czech Republic. Thanks considered changes in the ways in providing AFIS, which must be certified, it would be possible to ensure safe operation of the instrument flights at aerodromes that do not have an air traffic control.

Although it is clear that the introduction of IFR operations at most of the aerodromes in the Czech Republic would increase the possibilities for air traffic, to quantify the contribution of this step in relation to the expended effort is difficult. Thanks to the experience and activities of other European countries, however, this seems like the right direction for development. From an economic point of view, the state funds given in the transformation of airspace change, thus in transport infrastructure, will return several times in economic growth.

From the safety perspective would TIZ request an operational and safety analysis to identify the limits of characteristics which could be used for TIZ implementation and other subsequent changes.

VI. Acknowledgements

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ANALYSIS OF CZECH AERODROMES IN TERMS OF THE INTRODUCTION OF AN INSTRUMENT APPROACH

Ing. Jakub Kraus
Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University, Czech Republic
kraus@fd.cvut.cz

Bc. Tomáš Soporský
Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University, Czech Republic
soportom@fd.cvut.cz

doc. Ing. Karel Jeřábek, CSc.
Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University, Czech Republic

Abstract – This article contains an analysis of aerodromes in the Czech Republic in terms of suitability for the introduction of an instrument approach. There are many barriers to the introduction of an instrument approach at VFR aerodrome at present, but the main important thing is the runway length. In this article is a comparison of Czech aerodromes with aircraft in aircraft register of the Czech Republic and the result of this analysis.

Key words – VFR, IFR, aerodrome, approach, general aviation

I. INTRODUCTION

Aviation, albeit still expanding and improving technical sector, has certain issues that would be good to remove. First of all, the attention of the general and professional public mainly focuses on the "big" civil aviation even though the beginnings date back to general aviation, which is today barely developed.

Such impulse for the development of GA in the Czech Republic and other European countries could be the introduction of IFR approaches at small aerodromes. This approach, however, has clear rules, and most of them put the GA aerodromes in a position unsuitable. With experience and operations from other parts of the world could be developed minor changes in the current regulations to change this position. However, it is necessary to select suitable aerodromes and outcomes of this selection are in this article.

The procedure was simple. The main requirement for any airport is sufficient runway length for landing. Therefore, we compared runways length of VFR aerodromes in the Czech Republic with the required runway length for the aircrafts.

II. VFR AERODROMES IN CZECH REPUBLIC

In the Czech Republic, the majority of aerodromes are in the category of aerodromes with VFR traffic. There are a total of 84, which is figure showing the tradition of flying, but if it were to be an attempt to improve the conditions of aviation, it is necessary to take a big step towards the possible transfer of some aerodromes to IFR category.

Table I. VFR aerodromes in Czech Republic [1]

Aerodrome	ICAO code	RWY length [m]
Benešov	LKBE	750
Bohuňovice	LKBO	830
Broumov	LKBR	920
Břeclav	LKBA	740
Bubovice	LKBU	730
Česká Lípa	LKCE	700
České Budějovice	LKCS	2500
Dvůr Králové	LKDK	860
Erpužice	LKER	860
Frýdlant	LKFR	770
Havlíčkův Brod	LKHB	1000
Hodkovice	LKHD	1000
Hořice	LKHC	740
Hořovice	LKHV	1170
Hosín	LKHS	800
Hradec Králové	LKHK	2400
Hranice	LKHN	735
Cheb	LKCB	1000
Chomutov	LKCH	1200
Chotěboř	LKCT	1010
Chrudim	LKCR	980
Jaroměř	LKJA	940
Jičín	LKJC	1000
Jihlava	LKJI	920
Jindřichův Hradec	LKJH	760 (700)
Kladno	LKKL	980
Klatovy	LKKT	820
Kolín	LKKO	900
Krnov	LKKR	750
Kroměříž	LKKM	770

Křižanov	LKKA	700
Kříženec	LKKC	595
Kyjov	LKKY	1000
Letkov	LKPL	700
Letňany	LKLN	860
Liberec	LKLB	1050
Mariánské Lázně	LKMR	1035
Medlánky	LKMC	890
Mikulovice	LKMI	1000
Mladá Boleslav	LKMB	900
Mnichovo Hradiště	LKMH	1550
Moravská Třebová	LKMK	720
Most	LKMO	1130
Nové Město	LKNM	930
Olomouc	LKOL	760 (420)
Otrokovice	LKOT	650
Panenský Týnec	LKPC	2505
Plasy	LKPS	840
Plzeň/Líně	LKLN	1450
Podhořany	LKPN	730
Polička	LKPA	1500
Prostějov	LKPJ	1000
Přerov	LKPO	2500
Příbram	LKPM	1450
Přibyslav	LKPI	765
Rakovník	LKRK	935
Raná	LKRA	850
Rokycany	LKRY	850
Roudnice	LKRO	1400
Sazená	LKSZ	1315
Skuteč	LKSK	875
Slaný	LKSN	760
Soběslav	LKSO	740
Staňkov	LKSA	660
Stichovice	LKSB	880
Strakonice	LKST	900
Strunkovice	LKSR	900
Šumperk	LKSU	700
Tábor	LKTA	1100
Tachov	LKTD	1100
Točná	LKTC	870
Toužim	LKTO	1290
Ústí nad Labem	LKUL	780
Ústí nad Orlicí	LKUO	887
Velké Poříčí	KVP	760
Vlašim	LKVL	750
Vrchlabí	LKVR	840
Vysoké Mýto	LKVM	1200 (600)
Vyškov	LKVY	1280
Zábřeh	LKZA	900 (1950)
Zbraslavice	LKZB	780
Znojmo	LKZN	860
Žamberk	LKZM	725
Žatec/Macerka	LKZD	1120

III. Aircraft fleet of the Czech Republic

The following table shows the number of aircraft registered in Aircraft register of the Czech Republic and their characteristics. For some aircraft was not possible to obtain the necessary information because of lack of sources or their credibility.

Table II. Aircraft fleet of the Czech Republic [3]

Type	Needed Runway Length (m)	Corrected Runway Length (m)	Number (pcs)
A319-100	-	-	9
A320-200	-	-	10
AE 145	-	-	2
AE 45	-	-	1
AERO C-104 S	-	-	1
AN 2	500	675	35
ATR 42	1050	1307,5	5
ATR 72	1200	1480	2
Ae 270	550	732,5	3
B 737	1400	1710	20
BEECH 200	350	502,5	3
BEECH 300	400	560	3
BEECH 400	-	-	2
BEECH 58	450	617,5	2
BEECH C-90	350	502,5	3
Bellanca 8KCAB	300	445	1
Cessna 172	250	387,5	87
Cessna 152	250	387,5	24
Cessna 177 RG	200	330	1
Cessna 182	300	445	13
Cessna 206	300	445	4
Cessna 208	300	445	1
Cessna 210	-	-	6
Cessna 340	-	-	1
Cessna 400	300	445	1
Cessna 402	300	445	2
Cessna 414	250	387,5	4
Cessna 421	200	330	4
Cessna 510	700	905	6
Cessna 525	900	1135	6
Cessna 550	750	962,5	1
Cessna 560	900	1135	4
Cessna 680	800	1020	3
Cessna F 150	250	387,5	5
Cessna F 152	250	387,5	6

Cessna F 172	250	387,5	12
Cessna F 177	300	445	2
Cessna FR 172	250	387,5	6
Cessna FR 182	250	387,5	2
Cessna R 172	250	387,5	1
Cessna T 206	250	387,5	3
Cessna T 207	250	387,5	1
Cessna T 303	250	387,5	3
Cessna TU206E	250	387,5	1
Commander 112	200	330	1
Commander TCA	200	330	1
Corvus 1F	-	-	1
CTLS LSA	-	-	1
Cessna 207	250	387,5	1
Cessna 150	250	387,5	12
DA 40	350	502,5	6
DA 42 NG	-	-	2
DA 20	250	387,5	5
JAK11	500	675	1
JODEL F11	-	-	1
L 11	-	-	1
L 200	-	-	27
L 29	-	-	2
L 40	-	-	20
L 410	500	675	22
L 60	-	-	18
MAULE	-	-	6
M20J	300	445	2
MS 890	-	-	1
MU-2B	-	-	1
P.180 Avanti II	900	1135	1
PAC 750 XL	300	445	1
PIPER PA23	300	445	2
PIPER PA28	300	445	21
PIPER PA31	350	502,5	1
PIPER PA32	250	387,5	9
PIPER PA34	250	387,5	11
PIPER PA38	250	387,5	1
PIPER PA42	350	502,5	3
PIPER PA44	250	387,5	1
PIPER PA46	300	445	9
PITTS S-2B	300	445	1
PS-28 Cruiser	200	330	5
Pilatus PC-12	300	445	3
Rallye 100	-	-	1
SAAB 340	1050	1307,5	5
SR20	300	445	5
SR22	300	445	14
SU-29	350	502,5	3
Sokol M I	-	-	1
SportCruiser	250	387,5	5
SportStar MAX	250	387,5	1
SU-31M	-	-	2
Tecnam P2002-JR	150	272,5	3
Tecnam P2006T	200	330	1
T-131.PA Jungmann	-	-	2
T67	300	445	1
TATRA T-101	-	-	1
Tecnam P 92-JS	100	215	9
VUT 100	-	-	3
WT9 Dynamic LSA	-	-	1
Z 37	70	180,5	281
Z 42	-	-	16
Z 43	-	-	50
Z 50	-	-	12
Z 526	400	560	24
Z 226	-	-	75
Z 242	250	387,5	1
Z 326	-	-	9
Z 126	-	-	25
Z 137 T	150	272,5	5
Z 142	300	445	74
Z 143	300	445	8

IV. COMPARISON OF AIRCRAFTS AND AERODROMES IN TERMS OF RUNWAY LENGTH

From Table II. can be observed numbers of aircraft and their required runway length. When determining required runway length it is necessary to consider the safety margin, for this purpose 15%. Due to the formulation of this condition, for minimal runway length are considered values 1.15 times higher than the landing distance required and this values are increased by the safety distance for which is chosen value of 100 m. For example, Cessna 142 has the reported value of required runway length 231 meters. When multiplied by 1.15, plus 100 meters, the minimum length of runway for this aircraft will be 366 meters.

Table II. therefore indicates the number of aircraft capable of landing on the runway with a maximum length of 750 m, this number exceeds 700 aircrafts, and it will be certainly much higher, because aircraft Zlín and Morava will probably be in this category also.

Table I. shows that the 69 "small" aerodromes in the Czech Republic has a runway length of 750 m and more and only 15 aerodromes has shorter runway.

The result of this comparison is that the majority of GA aircraft in the Czech Republic is able to land on most VFR aerodromes, which is very important information for possible growth of general aviation.

V. Requirements for aerodrome with instrument approach

Non-instrument and instrument aerodromes have significant differences in the requirements which have to be met in order to be used. While aerodromes have non-instrument requirement basically only one, and that the presence of AFIS, the instrument ones must be controlled and located in controlled airspace (additional requirements are listed in Table III.). Most requirements can be seen as obstacles to the development of uncontrolled aerodromes.

Table III. Obstacles in implementation of the IFR approach

Type of the airspace around aerodromes
IFR requirements for aerodrome
IFR requirements for the runway – marking, lighting system
Need for the presence of ATC
Competences and responsibilities of AFIS
Radar coverage in the vicinity of the aerodrome
Appropriate system (technology) for approach
Approach procedure
Current legislation for aerodrome certification
Requirements for aircraft equipment
Requirements for pilot training

All these criteria arise from current legislation. They have to be applied to all instrument approaches within the Czech Republic regardless of small, medium or huge international aerodrome. In order to introduce safe IFR approaches on small (VFR) aerodromes, modifications have to be done.

Requirements for IFR aerodromes are exaggerated in terms of general aviation, because what works for Boeing 737, may not be best for Cessna 172.

VI. Future – SFR Aerodromes?

The best way to improve general aviation and increase safety in time of deteriorating weather conditions would be to introduce a new category of flight rules.

This category would be based on IFR, but should remove some of the requirements. The major change would be in no need for the presence of ATC at the aerodrome and associated controlled airspace around the aerodrome would also become uncontrolled. Such a principle already works, for example in Germany, and Norway, where it is possible to use instrument approach at uncontrolled aerodrome in uncontrolled airspace. Thanks to no ATC service the implementation costs would decrease. The meteorological station would, however, need to be maintained, and the information would have been broadcast on demand by AFIS officer, or via ATIS.

It is also necessary to select the right type of approach procedure and technology. Because of the costs reasons, RNP APCH down to LPV is the best solution. Avionics needed for instrument approach with the use of SBAS is for the aircraft relatively simple. It is basically only one part and that is a suitable model of GPS devices, allowing the approach to be flown. An example is Garmin, which states that all of their GPS G Series models from 420W above are compatible with SBAS. This fact makes the RNP APCH down to LPV interesting for general aviation, because according to simple device can be performed instrument approach.

VII. Conclusion

The analysis in this article shows that room for improvement in terms of general aviation is still here. It just needs a little tweak in the rules and GA would get an unprecedented impulse for development, which is today missing, and this change of the rules is the simplest step which would change something that exists "from the time being" and thus does not respond to current techniques and technology.

Comparison of Czech aircrafts and aerodromes shows that the development would not have to affect only some of them, but could focus on nationwide development. According to the analysis it could affect the implementation of IFR approach up to 69 VFR aerodromes, which would dismissed the biggest GA obstacle, lack of published instrument procedures.

Acknowledgments

This analysis was supported by the Grant Agency of the Czech Technical University in Prague, grant No. SGS12/165/OHK2/2T/16.

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Implementation and certification of LPV approach and options for VFR aerodromes

Jakub Kraus
Department of Air Transport,
Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University
Horská 3, Praha 2, 128 03, Czech Republic
e-mail: krausjak@fd.cvut.cz

Jakub Ninger
Department of Air Transport,
Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University
Horská 3, Praha 2, 128 03, Czech Republic
e-mail: ningejak@fd.cvut.cz

Karel Jeřábek
Department of Air Transport,
Department of Air Transport, Faculty of Transportation Sciences, Czech Technical University
Horská 3, Praha 2, 128 03, Czech Republic

Abstract – **This article focuses on general LPV approach certification for aerodromes. It also indicates the problematic parts of the current certification process and shows the direction for possible certification of instrument approaches at uncontrolled aerodromes.**

Keywords – instrument approach, LPV, IFR, aerodrome, VFR

I. Introduction

The introduction of RNP approaches is a complex process consisting of many stages, which require the cooperation of all participating organizations. This process should be in accordance with the recommendations and standards of ICAO, which issued Doc 9849 - GNSS Manual for that purpose. Another key document for the implementation and certification of all types of approaches is ICAO Doc 8168 - PANS-OPS Vol. II.

II. Planning

The first and one of the most important stages of the implementation is the selection of aerodromes at which will be the GNSS approach published. The planning should be approached from the perspective of the entire region. In Europe, this is stated in document called Navigation Strategy for ECAC issued by EUROCONTROL and in the conditions of the Czech Republic, planning and introduction of new approaches is currently managed by the Concept of development of navigation in the Czech Republic until 2020. This concept suggests the implementation of RNP approaches (mainly LNAV/VNAV (APV Baro) and LPV minima (APV SBAS)) - they must be implemented on all IFR runways in 2016.

General rules where it is advantageous to introduce the APV approach are:

- Aerodromes near areas with dense population - a continuous descent approach reduces noise pollution
- Aerodromes with meteorological conditions don't requiring frequent operation in LVP
- Aerodrome, where there may be interference with signal of ground navigation equipment
- Aerodrome, where it is not possible to install a ground navigation equipment (e.g. due to unfavourable terrain)
- Aerodromes without precision approach
- Aerodromes handling regularly aircrafts heavier than 5700 kg

It is recommended to establish implementation team, which includes representatives of all participating organizations - the aerodrome operator, CAA, air traffic management experts, air traffic control agents, security experts, specialists in the creation of approaches and, ultimately, pilots and environmental movement representatives. The team collects the following information about the aerodrome:

- Runways equipment
- Meteorological data (statistic information about wind, visibility, cloud base, ...) - this data can be used to determine the most suitable approach solution
- GNSS Infrastructure - all APV approaches are subject to sufficient availability of EGNOS
- Other infrastructure - meteorological instruments (options for measuring RVR, wind, pressure, ... - for aerodromes with already published instrument approach should be this equipment already available), existing terrestrial radionavigation devices can also be used, for example, for construction of the missed approach procedure

The implementation team should also assess the condition of traffic in the airspace around the aerodrome and to assess the impact of the introduction of RNP approach. Another important element in the introduction is communication with aircraft operators at aerodromes and to assess whether is their airborne equipment adequate for the proposed type of approach.

A. Requirements for aerodrome equipment

ICAO Annex 14 or any other international standards still doesn't specify aerodrome facilities specifically for RNP approach. In all international standards and within Europe it is considered to introduce RNP approach only on instrument runways for the time being. The general requirements are:

- Sufficient length and width of the runways
- Obstacles in the approach area
- The availability of meteorological information
- Adequate lighting equipment and signs
- Appropriate system of taxiways

LPV approach is based on the evaluation of aircraft position from global positioning systems advanced with SBAS, which doesn't requires any ground radio navigation aids.

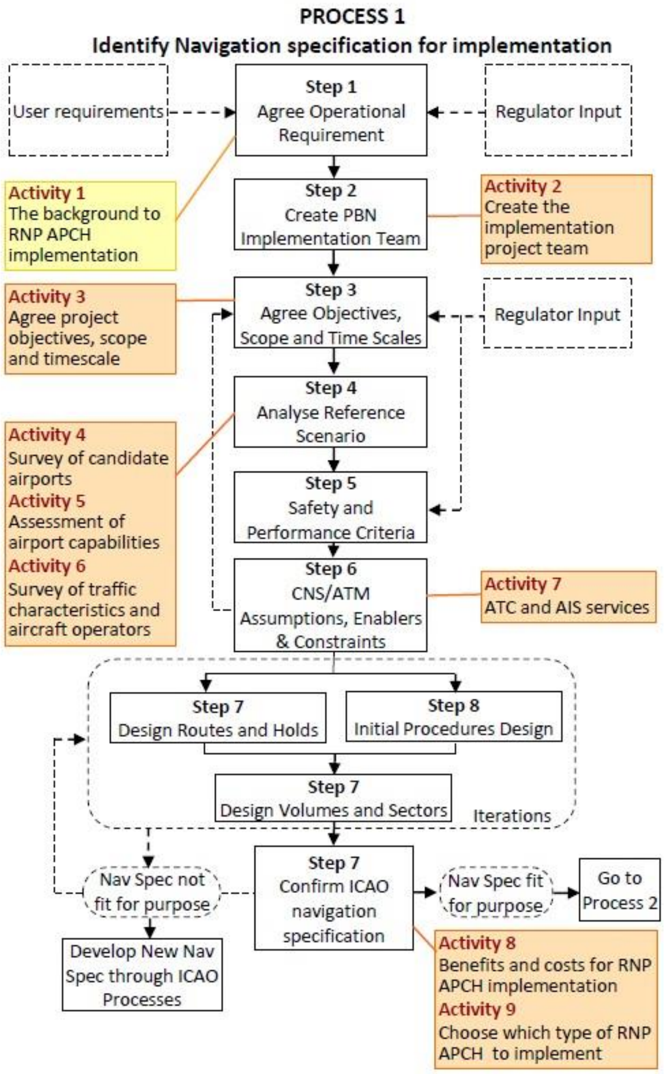

Figure 1. Planning and construction of approach procedures[14]

B. Effect on LPV landing minima by aerodromes surrounding

LPV approach Decision Height is influenced by many factors. These include (6):

- Obstacle Free Zones
- Glidepath Qualification Surface (GQS)
- Runway Lighting and Markings
- Taxiway Considerations
- Airport Surveys
- Runway Protection Zone

III. Validation - Certification

Validation is the final step in implementing the new procedures. Its aim is to verify quality and safety parameters of approach - including obstacles, terrain in the approach area and navigation data and includes also an assessment, if the approach could be flown in practice. Validation must be conducted by an independent organization. The procedure is set out in the following documents:

- ICAO PANS-OPS Doc 8168
- ICAO Doc 8071
- ICAO Doc 9906 Vol. 5 - Validation of instrument flight procedures

Validation itself has two parts - ground and flight.

A. Ground validation

Ground validation is mandatory for all new approaches. Its aim is to collect all data (namely the obstacle limitation surfaces and the related height clearances) and to check their required accuracy.

Part of the validation is to create a package that includes:

- Map of all obstacles in the approach area
- Complete documentation describing the obstacles and terrain, including obstacle planes
- Detailed description of the procedure segment by segment
- Map and vertical profile of the procedure
- Data of all points and holding patterns in the procedure
- Confirmation that the coverage of navigation equipment is sufficient
- The design approach map for flight validation aircraft crew

If there is during ground validation founded that some data needs to be verified in flight, then flight validation must follow. The reason for the execution of the flight validation may be a failure to comply with international standards, the speed limit in one segment, inadequate segment lengths, steep descent gradient, or a lot of obstacles in the surrounding area.

B. Flight validation

Flight validation may be required to verify the adequate functioning of all navigation systems, on which is the procedure based. It must be made by qualified inspector with sufficiently equipped aircraft. Specific procedures of flight validation are defined in ICAO Doc 8071 or in related national regulations and directives. The aim is to prove fly-ability, exploring, for example, crew workload in its various stages, readability and clarity of procedure documentation (maps ...), verifying the accuracy of new navigational database (points, distance ...) and also verifying the obstacles.

Finally, in the flight validation of the procedure, the inspector shall state of one of the following classifications:

- Procedure without restrictions
- Procedure with restrictions – does not meet the requirements of the regulations entirely, it is not dangerous for air traffic
- The procedure is inapplicable - does not meet all regulatory requirements, it may be dangerous

C. Certification of LPV approach

Certification of LPV approach should follow the recommendations and standards of ICAO, in this case, the Doc 8071 - Manual on Testing of Radio Navigation Aids Vol. II Testing of Satellite-based radio navigation systems. This document is not freely available and by the latest information chapter 3 describing SBAS systems is not yet finalized.

After its completion and approval of this document it will, beyond description of systems and individual types of approach (Chapter 1), accurately describe the requirements necessary for certification of LPV approach:

- Ground validation - requirements for aerodrome surveillance equipment, testing interferences of GNSS systems, ...
- Flight validation - pre-flight testing, test flight procedures, forms and standards for writing final reports, a description of the test equipment of the airplane ...

Flight validation for LPV approach certification is required at all times (including modifications of established approach) and for each and every type of approach separately (if it is introduced more types simultaneously).

In Europe, several projects such as project ACCEPTA (Accelerating EGNOS Adoption in Aviation) or GIANT (GNSS Introduction in the Aviation Sector) deals with implementation and certification of RNAV (primarily avionics and equipment on board aircraft).

Since there have not yet been established international standards on APV, the certification of these approaches runs under existing standards for precision and non-precision approaches and according to national regulations and directives. Certification of these approach do not require any testing of ground radio navigation equipment (when it is not use for missed approach), but compared to the classical approach it is necessary to focus on monitoring and documentation of GNSS and SBAS availability and signal quality.

D. Certification Authorities

Within the European Union, for certification and the providing of air navigation services, is responsible each Member State. In the case of the Czech Republic, the authority responsible for the administration of civil aviation under section 5 § 3 of regulation No. 49/1997 (Civil Aviation Law) is Civil Aviation Authority Czech Republic. Under CAA falls the competence to determine the aerodromes suitability. The certification procedure must be in accordance with all applicable regulations and documents and is also controlled by internal directives.

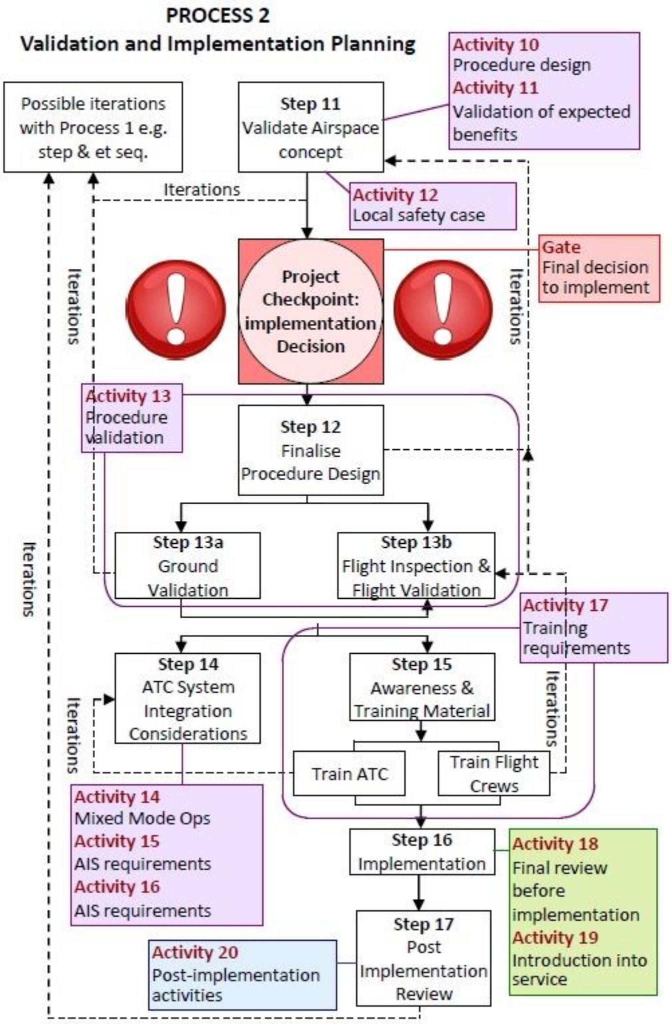

Figure 2. Validation and implementation of the procedure [14]

IV. Certification at uncontrolled aerodromes

Uncontrolled aerodromes have currently a unique opportunity for development, since, as mentioned above, all regulations for LPV approach certification are still not created. However, efforts on the introduction and subsequent certification of LPV approaches at uncontrolled aerodromes are prevented by several obstacles, which could be fortunately easily removed. The problem is to ensure compatibility with already applicable regulations.

The best choice is an introduction of LPV approaches across an entire region. Because of this there will be possible to adjust base rules for a larger number of VFR aerodromes, thereby eliminating a large number of obstacles, among which may be included the technical equipment of the aerodromes and uncontrolled airspace. In fact, it could mean the creation of an instrument approach to the aerodrome, which has only a grass runway, centerline lights, no air traffic control service and is located in uncontrolled airspace.

V. Conclusion

This article describes the process of implementation and certification of LPV approach how it should look according to currently available rules. Such a process is very complicated, because it's basically a pre-operational safety improvement that cannot be underestimated. Unfortunately, incomplete safety regulations do not help, but on the other hand allow a new perspective on the situation in process of their creation. This could be essential for the development in general aviation.

It would be also useful to consider and determine whether it is possible to reduce the requirements for the introduction of instrument approach at aerodromes, or in extreme case, to create a subgroup, respectively even a new group of rules of the air. This could start rapid development in air transport and, ultimately, increased accessibility and availability of the Czech Republic by air.

VI. Acknowledgements

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Extending the use of GNSS in aviation – Pilots training

Jakub Kraus [a]*

[a] *Czech Technical University, Faculty of Transportation Sciences, Department of Air Transport, Horska 3, Praue 2, Czech Republic, kraus@fd.cvut.cz*

Abstract

This article focuses on the need to extend the use of GNSS navigation in aviation. With the constantly improved GNSS signal, it will become the primary form of navigation for general aviation and therefore there is necessary to accelerate its implementation in the aviation industry. The first step may be educating pilots in this area.

Keywords: GNSS, IFR, VFR, RNP APCH, LPV, pilot

1. INTRODUCTION

Currently, GNSS receivers are standard equipment in IFR general aviation aircraft and this provides the opportunity to use all the functions hidden in them. Whether it is a mere en route or approach to landing, satellite navigation presents a wide range of applications. Spreading this knowledge is a long term activity and should be started as soon as possible: to teach of what GNSS "is able to do" to professional aviation community and especially to the pilots, who are the end users of the technology.

The advancing BC speeds up the whole development and currently is valid one ICAO regulation which orders to implement GNSS enabled approach at all instrument runway ends by 2016 [1]. Given the small number of airports with instrument runways in the Czech Republic or Europe, relative to the total number of aerodromes, it will be appropriate to extended GNSS approach to other aerodromes too.

Table 1. RNP approach [4]

PANS-OPS Terminology	PBN Terminology	Chart Minima	Minimum Sensor
NPA	RNP APCH down to	LNAV (MDA)	Basic GNSS[2]
APV Baro-VNAV	RNP APCH down to	LNAV/VNAV (DA)	Basic GNSS + Baro-VNAV
-No criteria available	RNP APCH down to	LP (MDA)	SBAS
APV SBAS	RNP APCH down to	LPV (DA)	SBAS

The best system for approach is RNP APCH down the LPV, which has very good precision and use only the GNSS receiver. (Table 1)

The implementation of GNSS in flight procedures is, in terms of en route navigation and navigation during approach, partially dealt with, but basically, it is still a vicious circle consisting of pilots and aircraft, avionics manufacturers, airports and procedures. (Fig. 1) The challenge is to find starting point.

* Corresponding author.

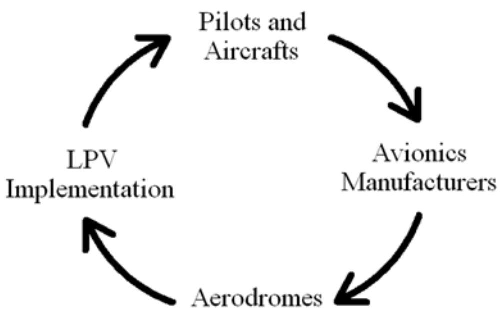

Fig. 1. GNSS Implementation cycle

2. AVIONICS MANUFACTURERS

Due to the 8-year lead in the implementation of approach using SBAS in the U.S., avionics manufacturers have easier job to make adjustment from WAAS (North American SBAS) to EGNOS (European SBAS). This process is further supported with efforts to unify technical requirements, from which should come interchange ability of SBAS receivers in the future, where the certification for one SBAS will mean automatic certification for the other.

For EGNOS, there are already available 33 receivers from six manufacturers that are certified. (Table 2)

Table 2. Avionics with EGNOS for aviation [5]

Manufacturer	Model
Garmin	Aera range
Garmin	G1000 (with GIA63W unit)
Garmin	G600 (with 430W/530W units)
Garmin	G900X (with GIA63W unit)
Garmin	GNC 420W
Garmin	GNS 430W
Garmin	GNS 530W
Garmin	GPS 400W
Garmin	GPS 500W
Garmin	GPSMAP 196
Garmin	GPSMAP 296
Garmin	GPSMAP 396
Garmin	GPSMAP 495
Garmin	GPSMAP 496
Garmin	GPSMAP 695/696
Garmin	GPSMap 96
Garmin	GPSMap 96c
Garmin	GTN 625
Garmin	GTN 635
Garmin	GTN 650
Garmin	GTN 725
Garmin	GTN 750
Honeywell Bendix King	AV80R range
Honeywell Bendix King	KI 825 – New units, or in service upgrade
Honeywell Bendix King	KSN 770
Honeywell Bendix King	EASy II
Honeywell Bendix King	Primus Apex® Avionics System
Rockwell Collins	GPS-4000S Global Positioning System Sensor
Septentrio	AiRx OEM
Thales	Multi-Mode Receiver - MMR
Thales	TopDeck LPV
Thales	TopStar 200 GPS

3. AERODROMES AND PROCEDURES

As written in the introduction, there is a mandate from the ICAO, which ensures the implementation of RNP approach to the instrument airports. This allows considering aerodromes as primary direction to start with GNSS implementation. ICAO, however, focuses primarily on large airports for airliners and does not solve general aviation. Because of this some of the airports implemented RNP APCH down to LNAV / VNAV for which there is no need of SBAS and glide path is controlled by barometric altimeter. For general aviation is more appropriate LPV approach, which only needs a GNSS receiver with SBAS: one piece of avionics.

Czech ratio of controlled and uncontrolled aerodromes is 8:84, so there is room for GA aerodromes to use SBAS approach requiring no ground radio navigation infrastructure and therefore saving finances. Nevertheless, it is necessary to change the aerodrome from VFR to IFR and that is unaffordable for most of them. Only change of the rules could help this situation.

4. PILOTS

From the GNSS implementation cycle and above mentioned follows that one way to start developing and expanding the use of GNSS is through pilot training. Dealing with satellite navigation is not included in current training structure as mandatory, but for example training the NDB is. By the look at the planned navigation infrastructure development for the decade (fig. 2) it is clear that new pilots, who just start training, should not come across with NDB in service, when they get pilot licence. It is necessary to count with some delay in the transition from terrestrial radio navigation infrastructure (NDB, VOR) to satellite systems, but the GNSS procedures are already in operation, and their number will increase. Pilots in IFR training should have in the course structure practicing the GNSS, which is drafted in chapter 5.

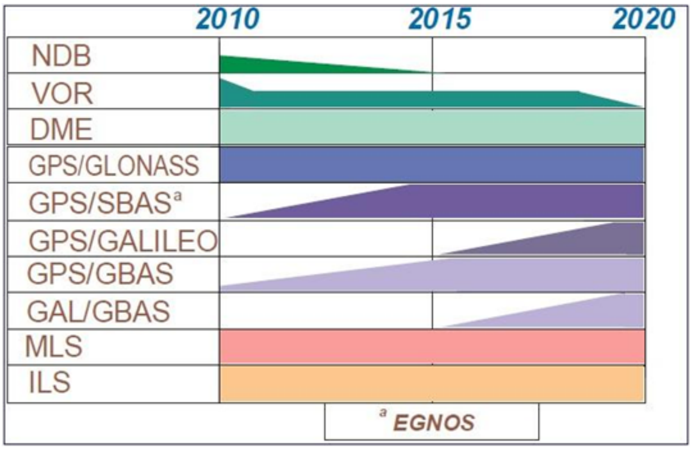

Fig. 2. Expected development of navigation infrastructure to 2020 (adjusted by author) [2]

When changes in IFR training are made, it would be appropriate to tweak those for VFR too, because the GNSS receivers are used also in aircrafts for VFR flights and pilots rely on them in certain situations. Although this requirement may seem totally unnecessary, because the use of GNSS is situated under IFR, in emergency situations (such as loss of position, sudden weather deterioration, or prevented view thought windscreen) even the most basic knowledge of navigation and GNSS receivers can prevent an accident.

5. IFR GNSS COURSE STRUCTURE DRAFT

Course structure should consist of eight points:

1. Introduction to the RNAV and PBN Manual – explanation of the area navigation and their pros and cons for use in flight
2. Satellite navigation and its use – the basic principle and function of GPS, augmentation systems focused at SBAS, RAIM, errors, accuracy
3. Installation of GNSS system – types of receivers and their components, communication of GNSS avionics with other units in aircraft, certification

4. The human factor – operator error, system monitoring
5. Pre-flight – maps, AUGUR, NOTAMs, functionality check, navigation functions check, creating own waypoints
6. Flight – the monitoring and reporting system, the use of GNSS for en-route navigation, flying SID and STAR, holding
7. Approach – direct to IAF and IF, vectoring to FAF, monitoring approach, transition to visual flight at minima, transition to missed approach
8. Emergency situation – procedures for loss of satellite navigation, change of navigation type

Despite the fact that requirements for IFR and VFR training are vastly different, it is possible to use this structure with small changes in the training of GNSS VFR. It would be basically a deletion of point 1. and reduction in points 2., 3. and 5.

6. CONCLUSION

In this paper is described the GNSS implementation cycle and indicated one direction where it can be accessed. This path leads through pilot education in GNSS. Today pilots do not have mandatory training for GNSS in their training course despite its expanding use, which is unsustainable state and the organizations creating legislation must change it. Training IFR pilots will not be expanded with the introduction of GNSS part, because satellite navigation could replace outgoing NDB and partially even VOR.

An important aspect of course structure is also VFR pilots training as they for their flight using GNSS equipment to a large extent, although officially it is only for support. General introduction of satellite navigation and area navigation to them would be beneficial to air traffic safety and larger interest in instrument rating for pilot can be expected as well.

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