AEROSPACE SYSTEMS FOR MONITORING AND CONTROL

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CFIT PREVENTION WITH COMBINED ENHANCED FLIGHT VISION SYSTEM AND SYNTHETIC VISION SYSTEM

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Abstract

This paper aims to combine two vision systems as a new technology to suggest the improvement in the continuing problem of Controlled Flight into Terrain (CFIT) accidents. A combined enhanced flight vision system and synthetic vision system seems to hold the solution, while it unhesitatingly accommodated to the commercial and General aviation instrument environment if pilots are getting minimal instrument training. This research shows the benefit of combined enhanced flight vision and synthetic vision systems based on analysis of the accident that occurred in 2013 on approach at Birmingham-Shuttlesworth International Airport. It is shown that the use of a combined system, could have prevented this accident. The head-up display is taken to facilitate this technology to the pilot to be able to see and read accurately using sky lenses.

Keywords: CEFVS, SVS, CFIT, HUD, EVS, air navigation, flight safety

1. Introduction

Controlled Flight into Terrain (CFIT) is a primary cause of worldly general aviation fatal accidents. Unstable approaches are a key contributor to CFIT events [1]. When does CFIT occurs or expected to happen? Mostly when an airworthy aircraft is under the complete control of the pilot who is inadvertently flown into terrain, water, or an obstacle. The pilots are generally unaware of the danger until they have no time left.

Most CFIT accidents happen in the approach and landing phase of flight and are more often associated with approaches, (non-precision approach & Precision approach).

Despite continued Enhanced Ground Proximity Warning System (EGPWS) and Terrain Awareness warning system (TAWS) development, CFIT accidents still occur in all categories of aviation. To reduce and prevent these events, a synthetic vision system (SVS) combined with an Enhanced flight vision system (EFVS) should be used to improve the pilot's ability to detect and evade a potential CFIT differed to conventional flight instrument. That combination will be utilized efficiently to enhance the pilot's abilities to maintain situational awareness in all meteorological conditions and assisting them in making timely decisions to avoid CFIT. The research challenge is to combine and bank on those vision systems using the Head-up display (HUD) function.

2. Related study

A separate study was conducted to verify that a pilot demonstrates the ability to respond adequately to an EGPWS warning and properly interprets information emitted by an EGPWS warning and alert. The study was based on 51 accidents and incidents from 2008 through 2017 where GPWS/TAWS was found in their respective narratives [2].

The study revealed that about 39 percent of the incidents and accidents under review showed that pilots had the ability to properly respond to an EGPWS alert and warning. And that 47 percent (24 accidents/incidents) showed that pilots did not adequately respond (whether in a timely manner or have taken the correct action maneuver) to EGPWS warnings, and about 6 percent (3 events) show that the system did not emit a warning sound, means that EGPWS did not emit a warning due to being disabled [2].

In this research, one case study has been considered from CFIT accidents with intent to learn from the error that may have led to the accident and present the use of combined EFVS and SVS on HUD as a possible solution to that accident and then highlights the enhancement part for safety recommendations.

3. Heads Up display

The Heads Up Display (HUD) displays all necessary flight guidance and navigation data for the pilot on a combiner glass that is mounted in the pilot's normal field of view out of the forward windscreen (Fig. 1).

Fig. 1. HUD approach

This is done by projecting images from the overhead unit onto the combiner. The system is designed so that the display appears to be towards infinity, allowing the pilot to see the outside world as well as the information on the combiner without changing focus [6] thus it shows the pilot primary flight and navigation information and allows the pilot to transition from instruments to head-up flying during the critical phase of the takeoff or approach.

4. Enhanced Flight Vision System

Enhanced flight vision system (EFVS) is an airborne system that provides an image of the scene and displays it to the pilot [3] as shown in Fig. 2.

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Fig. 2. EFVS detection

EFVS is also known as enhanced vision (EV) which incorporates information from aircraft-based sensors to provide vision in limited visibility environments. It is indeed useful during approach and landing. A pilot on a stabilized approach is capable to recognize the runway environment (light, runway markings, etc) earlier in preparation for a touchdown, again the obstacles such as terrain, structures, and vehicles or another hazard on the runway that might not otherwise be seen, are clearly visible on the IR image [4].

5. Synthetic Vision System

A synthetic vision system (SVS) is an aircraft installation that combines three-dimensional data into intuitive displays to provide improved situational awareness to flight crews. This improved situational awareness can be expected from SVS regardless of weather or time of day. In addition, the system facilitates a reduced pilot workload during complex situations and operationally demanding phases of flight, e.g. on approach [5]. Fig. 3 presents the 3D image of SVS.

Fig 3. SVS 3D presentation

As it is shown in the figure 3, SVS offers enhanced terrain awareness throughout the flight operation by extended centerline symbology, threshold markings, and accurate visualization. SVS can be considered as a developed feature for improving aircrew situational awareness. In this paper, the combination of SVS and EFVS and their enhancement as a better solution for CFIT in any weather environment is considered on the given below example of CFIT event.

6. Event description

The accident event was considered and analyzed to propose possible ways to overcome future failures. Further, the benefits of the combined use of the systems (EFVS and SVS) will be discussed.

- The accident occurred in 2013 on approach, aircraft type A300-600.
- Crashed short of the runway during a localizer non-precision approach.
- The cargo flight was operating a scheduled domestic service.
- All the crew died.
- The weather was in Instrument Meteorological Conditions (IMC) at Night.

- The intended method of descent was a CDFA using a vertical profile generated by the flight management system (FMC) to provide guidance to the crew after leaving the final approach fix (FAF).
- With the autopilot engaged, the expected approach clearance to the runway was received.
- The FAF was crossed 200 feet above the published minimum of 2300 feet QNH.
- the AP did not follow the anticipated CDFA (Continue Descent Final Approach)
- The aircraft was configured for landing when the first TWAS aural alert, "sink rate", was issued 3.5 seconds later announced the runway was in sight.
- An EGPWS 'Too Low Terrain' Alert was annunciated and there were several additional impact noises until the recording ended.
- The crew had expected to become visual at about 1000 feet AGL (Above Ground Level) based on the weather reports but had only seen the runway about 5 seconds before contact with the trees.

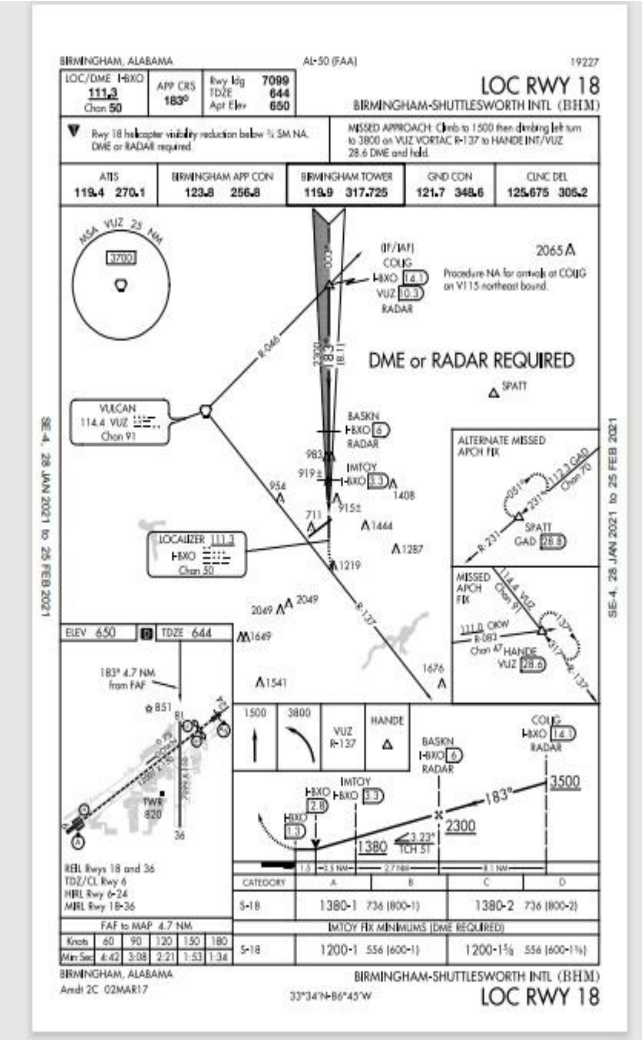

Fig. 4. Diagram of KBHM LOC RWY 18 [8]

7. Combination of the systems

EFSV (EVS) together with SVS is a modern and unique solution for aviation. Setting a new standard, the Combined Vision System (CVS) provides a good picture of the outside world even in a low visibility time. It helps the operator to clear sight the runway lights for the intended approach. This enhances the pilot's ability to execute approaches (precision & non-precision) and safely land, lessen the risks of CFIT accidents.

8. Analysis of the event and the combined system

The investigation did not find any technical issues by the aircraft that would have given rise to the accident, the analysis will focus on weather, pilot awareness, alternative when flying a non-precision approach.

The weather encountered at the final approach was not seen ahead due to inoperative system in displaying remarks published on the Meteorological aerodrome report (METAR), therefore, variable ceiling published at the destination was not acknowledged by the Pilot while flying IMC, if aware the pilot could have prevailed by the time, he and co-pilot made their approach.

There was a miscommunication between Pilot and Co-Pilot, whereby, all pilots did not monitor the rate of descent and the aircraft was flown with a vertical descent rate of 1500 fpm below 1000 ft AGL [10]. This was contrary to aircraft SOPS, again neither Pilot managed to sufficiently check the aircraft altitude during the approach and eventually allowed it to descend below minimum descent altitude (MDA) without visual reference. The pilot's poor performance and multiple errors which the co-pilot made during the flight were all the results of this accident.

Enhanced true CVS (Fig. 5) displayed on HUD would have been a better solution on reducing crew workload and achieving unmatched situation awareness and a cleared view at the final approach and warning to the low MDA.

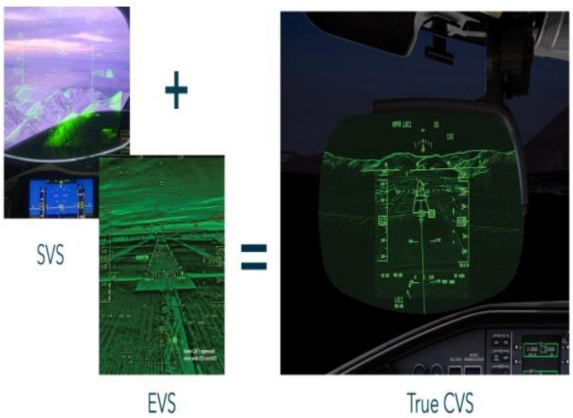

Fig. 5. True CVS

Clear Vision is absolute EFVS solution giving HUD capacity combined with EVS and synthetic 3D SVS. It features immense field of view, with the clear and highest resolution HUD for general Aviation in the market. Its indeed pilot friendly split screen display permits the pilot to change between the two different background imagery areas for premier control with CVS. Extreme weather conditions: it is seemed that low visibility will no longer be a problem if CVS will be in place to intuitive out of the window while flying.

The combination of SVS and EVS will benefit the approaches with or without vertical guidance as shown in the Fig.6. Having a low visibility on the previous data but being cleared after using the EFVS and provide better guidance to the Pilot and this will reduce the CFIT mostly caused by low visibility near the airfield.

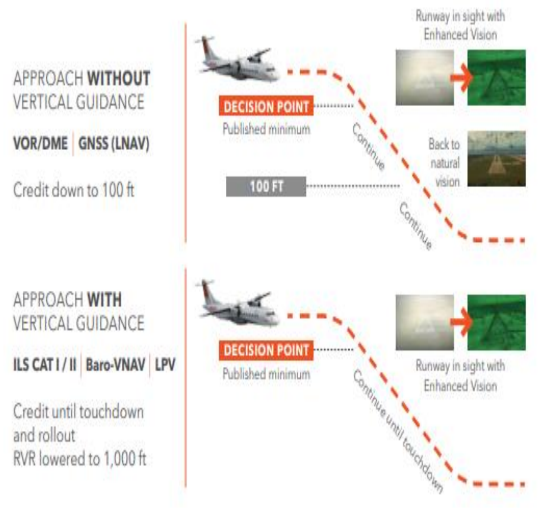

Fig. 6. CVS on approach

Therefore, by the use of Sky lenses and special training, the pilot should be aware of a circumstance ahead and mitigate it at the best of time. The sky lenses can be connected to help and improve focus and visibility in any type of weather and features a large field-of-view. There are several benefits of using this new technology. As it is shown in Fig.7 there is a huge difference on take-off and landings and loss of control situation where by with HUD the situations are more controllable than without.

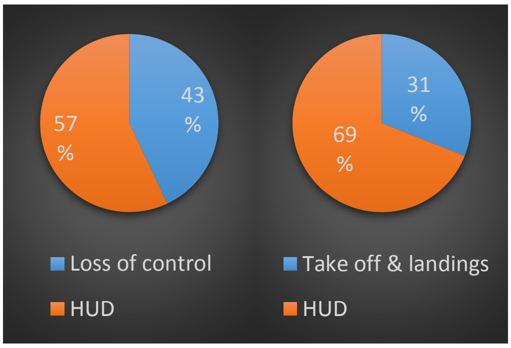

Fig. 7. Safety benefit of HUD

As the Civil Aviation Authorities allow exclusive operations for HUD and all the CVS the following will be improved for safety (Table):

Table

Benefit of HUD and flight phases

Flight Phase	**Runway / ILS**	**Airport visibility**	**Aircraft without HUD**	**Aircraft with HUD**
Landing	CAT I	600m	Can Land	Can Land
Landing	CAT I	350m	Cannot Land	Can Land
Takeoff	CAT I	200m	Cannot Takeoff	Can Takeoff

Using the HUD, the flights are disrupted, resulting in lower fuel costs,few delays and concellationsthat lead to the increased customer loyalty revenue [11].

SVS on HUD – the Pilot will have the below perspective, normally SVS consister or 3 layers: Terrain, Obstacles and airports & runways. With HUD all will be cleared as shown in Fig.8.

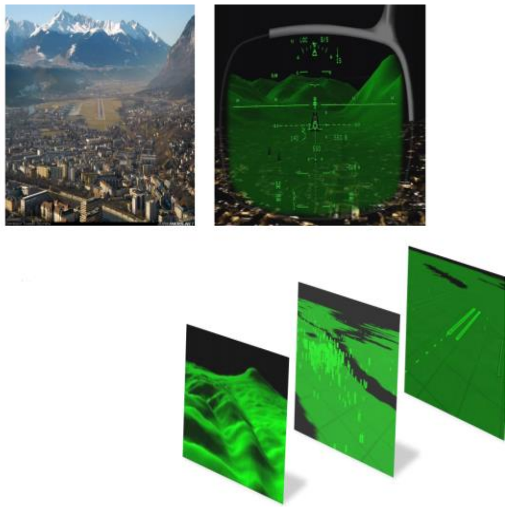

Fig. 8. Synthetic Vision system (SVS) on HUD

9. Recommendations

Air cargo crash has been finalized as a case of Controlled Flight into Terrain (CFIT). Failed Pilot awareness and miscommunication in an unsafe environment and hitting the true few miles to the runway was analyzed. As a result of the analysis the next basic recommendations can be done:
- all crew members should be re-brief on CFIT;
- all crew members should be trained on CEFVS;
- this should be implemented in all general aviation aircraft for safety procedures;
- implementation of an effective crew resource management (CRM) program is required;
- effective crew resource management (CRM) program should be reviewed in line with international standards;

- additional weather skills and the reading of METARs and Terminal aerodrome forecast (TAF) should be emphasized.

10. Conclusions

In this paper, the benefits of the combination of two vision systems as new technology to prevent the problem of accidents connected with Controlled Flight into Terrain (CFIT) is considered and discussed on the example of an accident event.

In future work it will be reasonable to analyze CFIT as the world's second leading cause of General fatalities after Loss of control in-flight (LOC-I) [11], considering strategies and approaches that are being taken to clear up this problem in the aviation industry. Also, it would be important to identify the relevance of Pilot and ATC performance towards these accidents.

References

[1] 2021 Aircraft Owners and Pilots Association "CFIT avoidance strategies: avoiding unnecessary groundbreakings" 421 Aviation Way Frederick, MD, 21701.

[2] 2018 edition "IATA Controlled Flight into Terrain Accident Analysis Report 2008-2017 Data".

[3] 31 October 2020 Enhanced Flight Vision System, Wikipedia.

[4] 21 September 2020 Enhanced Vision System Sky Library.

[5] 4 February 2018 Synthetic Vision Systems (SVS)-Skybrary Aviation Safety.

[6] Gulfstream G450 Aircraft Operating Manual, Revision 35, April 30, 2013. Heads Up Display (code7700.com).

[7] 6 December 2018 A306, vicinity Birmingham AL USA, 2013 - SKYbrary Aviation Safety.

[8] KBHM LOC RWY 18 (IAP) - FlightAware

[9] Clear Vision. Available at: www.uasc.com.

[10] UPS Airbus A300-600, N155UP, Freight Flight 5X-1354: Accident Occurred August 14,2013 in Birmingham, Alabama.

[11] Head-up Guidance & Vision Technologies Enabling Safer and More Efficient Airline Operations March, Rockwell collins, 2017.

[12] Flight safety foundation Controlled Flight Into Terrain (CFIT). Available at: https://flightsafety.org/

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Запобігання зіткнення з землею при контрольованому польоті за допомогою комбінованого використання систем SVS та EFVS

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У статті аналізуються можливості поєднання двох систем SVS та EFVS для попередження зіткнень літаків за умови контрольованого польоту. Показано, що сумісна комбінована та вдосконалена система краще підтримує прийняття рішення пілотом у випадку регулярного проходження пілотами підготовки з польотів за приладами. Дослідження та аналіз доводять переваги використання комбінованої системи для попередження зіткнень літаків з землею на базі SVS та EFVS. Аналіз проводився на основі інциденту який стався у 2013 році на заході літака до Бірмінгемського аеропорту Шаттсворт. Показано, що використання комбінованої системи могло запобігти цій аварії.

Ключові слова: аеронавігація, безпека польотів, система зорового польоту, система синтетичного зору, контрольований політ на місцевість, прозорий дисплей

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Предотвращения столкновения с землей при контролируемом полете с помощью комбинированного использования систем SVS и EFVS

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В статье анализируются возможности сочетания двух систем SVS и EFVS для предупреждения столкновений самолетов при контролируемого полета. Показано, что совместное комбинированная и усовершенствованная система лучше поддерживает принятие решения пилотом в случае регулярного прохождения пилотами подготовки по полетам по приборам. Исследования и анализ доказывают преимущества использования комбинированной системы для предупреждения столкновений самолетов с землей на базе SVS и EFVS. Анализ проводился на основе инцидента произошедшего в 2013 году на западе самолета в Бирмингемского аэропорта Шаттсворт. Показано, что использование комбинированной системы могло предотвратить эту аварию.

Ключые слова: аэронавигация, безопасность полётов, система улучшенного видения, система синтезированного видения, столкновение с землёй в управляемом полёте, прозрачный дисплей

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