MITIGATING CFIT RISK WITH INNOVATIVE CONTROLLER RADAR DISPLAYS GRAPHICS WHICH ENHANCE SITUATIONAL AWARENESS

by Dr. A.O. Braseth

In this article, we present ongoing research into the mitigation of CFIT, which is part of a joint project between three Norwegian organisations, the Institute for Energy Technology, Edda Systems and ANSP Avinor.

CFIT is not the most common cause of aircraft accidents but it is still a significant one. It happens to modern aircraft flown by well-trained pilots - for example the 2012 accident involving a Norwegian Air Force C130J, which crashed in a mountainous region of Sweden with no survivors[1].

Pilots are responsible for the safety of their aircraft, completely so when outside controlled airspace such as that where the C130J crash occurred, but it may be that improved ATC situational awareness using more effective display graphics in radar displays based on human perception research can help. Let us start by taking a closer look at the CFIT situation itself.

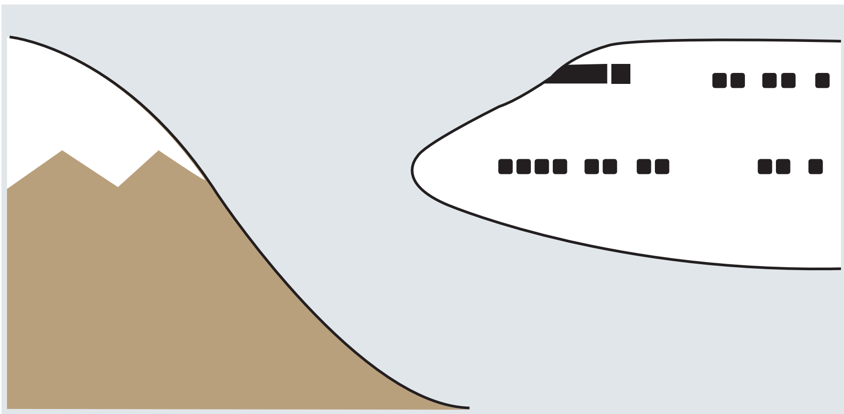
Explaining CFIT

CFIT occurs when a crew inadvertently fly their fully airworthy aircraft into terrain. This requires a complete loss of Situational Awareness (SA). Recognition by controllers that such SA has probably been lost can therefore be used to mitigate such accidents. The introduction of EGPWS dramatically reduced CFIT risk and the ground-based Minimum Safe Altitude Warning (MSAW) systems which warns controllers about aircraft proximity to obstacles and terrain has helped too.

One could argue that these technologies should be sufficient for preventing accidents. However not all aircraft are required to be fitted with EGPWS and Shorrock (2007) noted that controller radar displays are prone to errors in visual perception, which suggests that they can lead to the missing or even overlooking of MSAW activations. We have therefore sought a research-oriented foundation for more effective graphics which can help mitigate CFIT risk by first asking what information is required by controllers for rapid awareness of such situations?

Information for CFIT

SKYbrary (2014) explained how the direct cause of CFIT situations often involves loss of awareness of the aircraft position in the vertical plane in relation to surrounding terrain. The article describes further how many crash-sites are on the centreline of the landing runway and is often associated with non-precision approaches. IATA (2015) explained that the typical causes of CFIT accidents are "flight crew or human error, such as non-compliance with established procedures, inadequate



1- see http://www.skybrary.aero/index.php/C30J,_en-route,_northern_Sweden_2012

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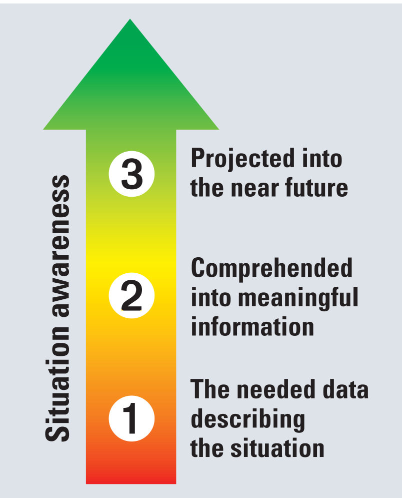
flight path management, lack of vertical and/or horizontal awareness in relation to terrain, unstable approaches, and failure to initiate a go-around when a go-around was necessary". Ladkin (1997) noted that these accidents often occur outside controlled airspace.

Based on this, we should visualise the aircraft position in relation to nearby terrain and controlled/uncontrolled airspace, paying particular attention to the vertical position. Now, as the purpose is to support a high level of SA, let us look at the definition of that concept. What does it mean for our accident category?

Situation awareness for CFIT

Endsley (2013) described how SA consists of three levels and that all three levels should be supported. We have adapted the material slightly, so encourage readers to visit Endsley´s original research material for a broader understanding of the concept.

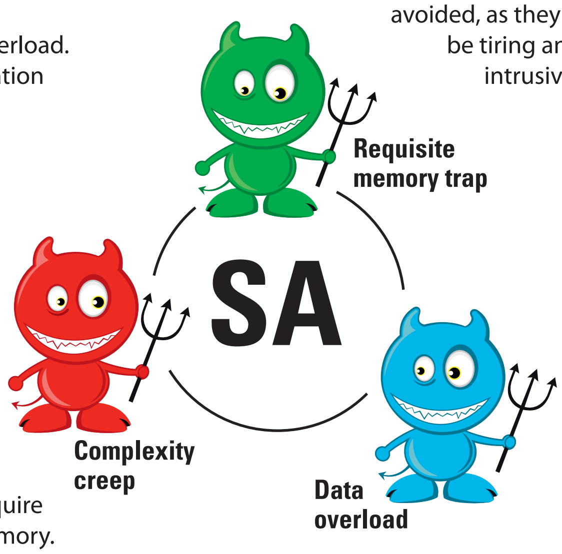


Level 1 raises the question: what are the relevant parameters, what data are needed to understand the situation? In our case, controllers must know which aircraft is involved and relevant data including its speed, flight level, and descent rate (typically found in the flight label). They must also be aware of the position of the flight in relation to uncontrolled airspace. Let us progress to SA level 2. It explains how the data in level 1 must be comprehended. Presentation in a meaningful way is essential - the information on the radar display must facilitate rapid visual perception of what is going on. To support SA level 3, a projection of the situation into the near future must be added - how is the situation expected to evolve in the next minute or so? Is the aircraft likely to enter uncontrolled airspace and where and when could a CFIT potentially occur?

Enemies of Situational Awareness

However, we must also consider the enemies of SA, which Endsley (2013) described as "demons". We will consider three "demons" relevant to the designing of CFIT-sensitive graphics.

The first of these is data overload. To avoid this, the CFIT situation should be presented using only essential data. The second "demon" is complexity creep. To avoid this, visually simple graphical components should be used. The third is the requisite memory trap. This can be avoided by designing visually explicit graphics for the CFIT situation so that their interpretation does not require avoidable use of visual memory.



Rapid perception graphics

The display graphics must be intuitive and effective, "grabbing" the attention of the controller. We will not go into detail here, but display graphics designed for these purposes must be designed to support rapid visual perception. It is therefore appropriate to take account of research into visual perception and computer graphics. Key researchers in this field include C. Ware, C.G. Healey, and J.T. Enns.

Designing visual presentations to optimise CFIT risk detection

Based on the knowledge about CFIT, SA, SA demons and rapid perception graphics, we propose the following design principles:

- The graphics should catch the attention of the controller through strong visual effects. Animated graphics are suitable. Blinking and flashing objects should be avoided, as they can be tiring and intrusive.
- The situation where CFIT risk exists must be easily perceivable and information must be given the highest visual priority. A projection into the near future must be presented.
- The design should focus on simplicity for optimal performance. Graphic objects should not burden controller visual memory, but instead offer explicit visual perception of the situation.
- The design should use visually layered graphics without ornaments or chart-junk, forming whole visual objects rather than multiple standalone elements. This facilitates rapid pattern matching abilities. The graphics should use familiar symbols (natural metaphors) to achieve an intuitive design.

Some examples of CFIT-focused graphics

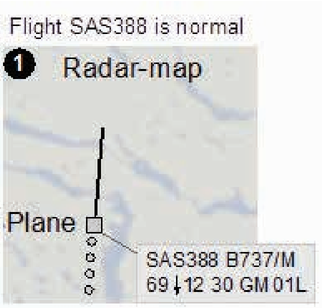
Based on these design principles, we have developed some initial prototypes that we are keen to share with you. However, we should warn that this is based on on-going research, where the design is currently being implemented on our full-scope simulator provided by Edda Systems. Controllers from Avinor will provide feedback through a trial during the spring and summer 2016 which will be used to improve the design. The small samples are for illustrative purposes and representing a small region of a radar displays.

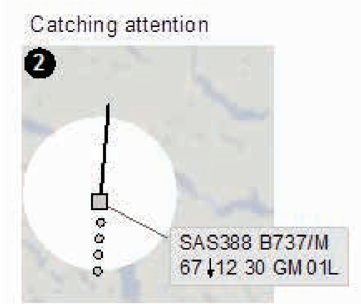
First up is a large white circle, which shrinks rapidly in order to catch the controller´s attention: "look here, something is going on, an aircraft is entering uncontrolled airspace in 60 seconds". A timer provides a countdown; this is a projection into the near future (figures 1-3).

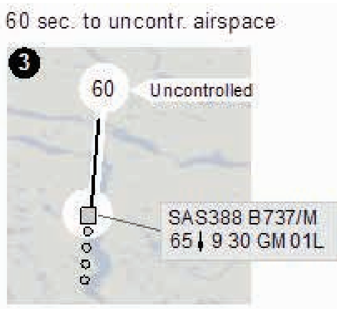
In this example, the flight continues on its path toward uncontrolled airspace (figures 4-5). A new, large white circle quickly catches the controller´s attention and a well-known "crash" symbol identifies the possible CFIT crash site. Again a timer counts down, representing a projection into the near future.

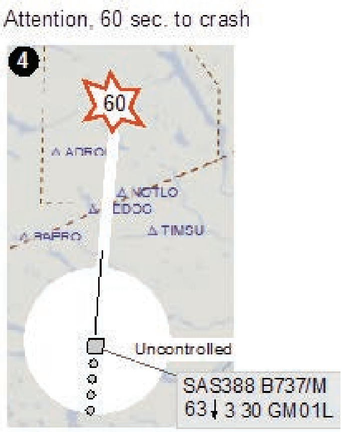
Although the radar coverage can be lost after the aircraft has entered uncontrolled airspace, radio communication may still be available. The last known position of the aircraft is therefore present on the map, together with the timer and potential crash site. This information might still be useful for avoiding a CFIT situation.

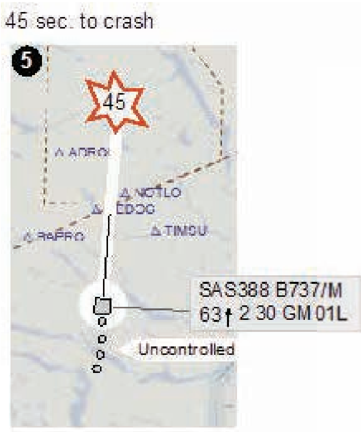
Our consideration of CFIT and SA has lead to design principles and a prototype design. It should be noted that final design must be harmonised with existing technologies and actual radar display design.











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