Rotary Wing DVE Solution Proof of Concept Live Demonstration

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ABSTRACT

This work will describe a proof of concept of a DVE solution that was developed, embedded and tested in the IAF.
The IAF's interest in DVE is broader than brownout. The main interest today is IMC (instrument meteorological conditions - fog/Cloud etc), since the force had suffered a loss of a CH53 in training in Romania several years ago, and had several near accidents with similar characteristics. Nevertheless, the force had lost several AC in B.O conditions and seeks a full DVE solution.
The IAF had decided to embark a technological/conceptual demonstration and to validate it in live conditions.

1.0 PROBLEM DEFINITION:

As mentioned in other papers, the problem of DVE in rotary wing is comprised of several and serial phenomena:

1.1 Loss of visual outside the window

1.1.1 This situation occours in several scenarios described by may prior workgroups. The loss of visual can be spontaneous, or planned.

1.1.2 It can be near the ground or high above

1.1.3 It can be for a short while or for a long flight

1.1.4 Examples for unexpected loss of visual:

1.1.4.1 Brown out (loosing visual due to self induced dust at landing) White out (same phenomena with snow) Spray out (same with hovering over water)

1.1.5 Examples for other types:

1.1.5.1 Fog, smog, clouds, haze, smoke, heavy rain, very dark night.

1.2 Loss of orientation

1.2.1.1 Loss of orientation is the situation where the pilot's natural orientation is not coherent with reality.

1.2.1.2 Orientation of the human is the way the brain interprets the body's 3 dimensional behaviour.

1.2.1.3 The natural sensors for the orientation are mainly the eyes, but also the ears (supplying 3D attitude) as well as gravity sensing.

1.2.1.4 When the brain is deprived of the visual information, it needs to rely on the other two. The other two do not perform well on an aerial platform and they tend to "drift" through time and environmental conditions. For example, the ears do not respond well to low rate of angular change but do respond to fast ones. If the aircraft is tilting slowly to the right, and the pilot notices that only through instruments, and corrects the attitude fast, without visual assistance (out the window), the brain would get an attitude signal of "left", because the tilt right was slow and was not discovered by the ears, but the correction was sensed. This is usually called "Vertigo".

1.2.1.5 Relying on gravity to defer "up" from "down" is not relevant in an aerial platform. When it is balanced, even when turning down would be to the floor of the aircraft. Even on a loop (on fighters), when AC is up, and pilot head is down, the gravity seems to feel towards the AC floor.

1.3 Mishandling of the platform

1.3.1.1 When the brain is deprived of visual, it will still act on other senses. There is no mechanism that is signalling to the brain that it is disoriented. Therefore when deprived of visual, it will keep on orientating and ordering other organs accordingly.

1.3.1.2 If the natural sensors are drifted, than this would end in mishandling of the AC.

1.4 SEVERE C.F.I.T

1.4.1.1 When the AC is mishandled it will often hit the ground.

1.4.1.2 When this occurs high and fast, (inadvertent IMC) use of instrumentation may help the pilot. There is more time and the AC acts as a regular fixed wing AC.

1.4.1.3 When this occurs in hovering it will often result with CFIT (controlled flight into terrain). Sometimes there will not be an impact because the touchdown will be within AC limitation, but when drifting sideways, this may result with an accident

2.0 THE HFM-162 R&T WORK GROUP AND ITS INFLUENCE ON THE DEVELOPMENT

The HFM 162 WG was assigned to deal with human factors. The work included a lot of human machine interactions:

2.1 Physiological and Perceptual Limitations

2.1.1 In the HFM 162 there was a lot of physiological and perceptual limitations that affect the human ability to handle information.

2.1.2 It was our understanding that un natural symbology would result in un natural feeling of the AC. As a result we looked for "natural" symbology systems.

2.2 Human Machine Interfaces

2.2.1 The interfaces took a lot of our attention. The idea to get "natural" cueing (visual aid) was a logical result, but not the only one. We also understood that the visual cannot be an HDD (Head Down

Display).

2.2.2 This is because of the problem of the brain to interpret scene that is not aligned with the head attitude.

2.2.3 It is possible to fly with HDD far enough from obstacles, but when real time fast reaction to AC is required this cannot be the solution. Therefore, we understood that HDD will not solve the brownout problem (but it can assist with other DVE challenges).

2.2.4 The solution is of course conformal HMD.

2.3 Technology: Sensors and Data Processing

2.3.1 The WG also studied most if not all sensors types.

2.3.1.1 Radar

2.3.1.2 Laser

2.3.1.3 Passive Electro-Optical

2.3.1.4 Visible Waveband or Low Light Level TV Cameras

2.3.1.5 Passive MMW Imaging Sensor

2.3.1.6 Thermal Imaging Sensor

2.3.2 It was our understanding that this issue is the most crucial for several reasons

2.3.2.1 Cost – no operator will develop or purchase all of the above

2.3.2.2 Weight (especially with CG problems)

2.3.2.3 Complexity – too much information will result with a problematic hard to maintain system

3.0 DEVELOPMENT OF THE DEMO

3.1 Development philosophy

3.1.1 With all that we have learned with the HFM 162, we have looked at two natural blindness phenomenons. The "blind man at home" situation, and the bat.

3.1.2 The blind man at home seems to manage all right. In his head there is a description of the world as he knows it. As long as his attitude is not disturbed, and no one changes the scene (move the table) he can walk freely in his house.

3.1.3 For us this resembles a mapping infrastructure as a 3D basis for orientation. As long as the navigation system was fine, and the scene was accurate enough it seemed to be a good solution.

3.1.4 The problem with this solution is that it is not enough to fly low in DVE. It is only good for 300 AGL and above, or brownout landing. If fly low is required than it is not enough.

3.1.5 The bat uses an external sensor (sonic sensor). It is sufficient for avoiding obstacles, but the problem is that the flight is hectic. Nevertheless, it seems that one sensor for all scenarios should be sufficient if combining it with the other method (the blind man).

3.1.6 As a result the solution would be comprised of an accurate 3D model, and a radar sensor, displayed on a conformal HMD (L.O.S dependent visor).

3.2 Simulations phases

3.2.1 The simulation phases aimed at describing the right characteristics for the sensor.

3.2.2 Over specifying is quite easy, and will result usually with too expensive/heavy device. It is easy to asses but rather hard to prove.

3.2.3 Under specifying may result with an affordable (price/weight) device that is not fit for the job.

3.2.4 The way to specify the sensor characteristic was to "fly" it in a lab:

3.2.4.1 A very detailed terrain database was created. It had planes, hills and mountains. On the terrain a large amount of objects were embedded, mainly trees and buildings.

3.2.4.2 The simulation had a trainee station (pilot – that flies the system) and an instructor – to observe the system and write results.

3.2.4.3 The data base was copied **<u>without the obstacles</u>** to the pilot station. The pilot could only see the terrain but the instructor could see the "reality" - terrain and obstacles.

3.2.4.4 The pilot would fly a mission with a virtual sensor. The virtual sensor had several configurable parameters – field of regard, range, latency, accuracy.

3.2.4.5 The pilot was instructed to stay at low altitude unless impossible. The pilot would get obstacles embedded on the visual as a result of the sensor characteristics and where the obstacles were.

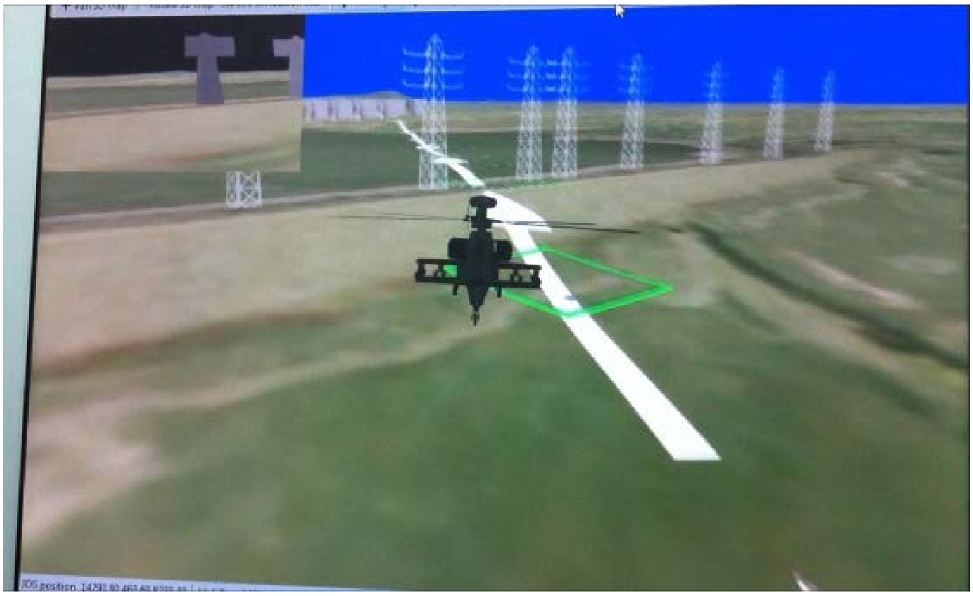
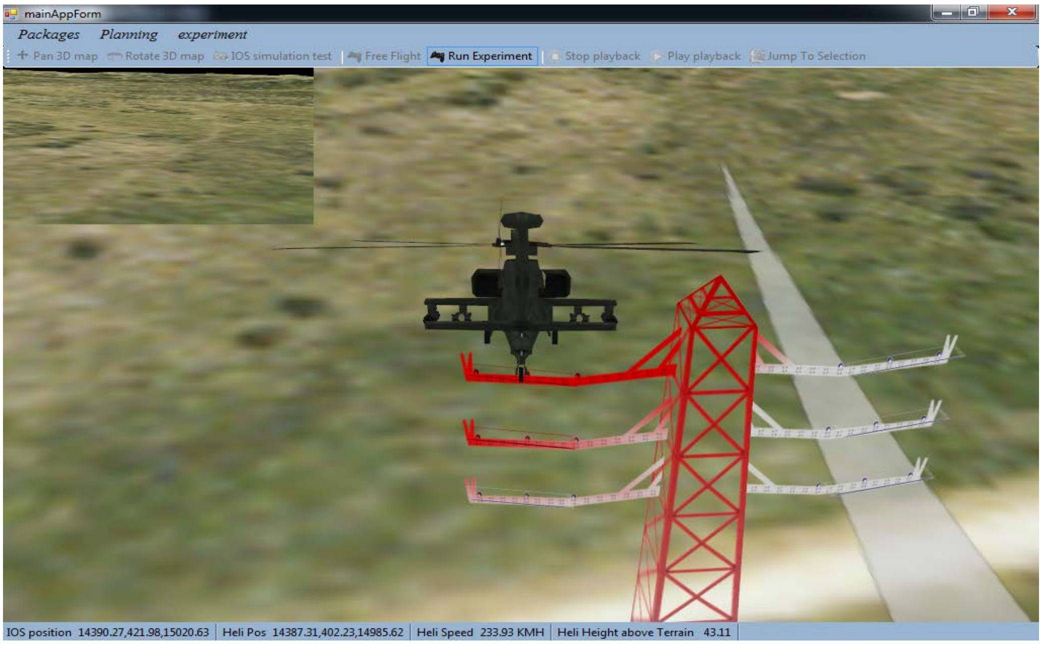


Figure 1: instructor view. Top left is pilot view as seen in the instructor station.

3.2.4.6 Whenever the AC passed an obstacle less than IAF safety clearance (50 feet) the Log would be filled with a CFIT event.



IOS position 14390.27,421.98,15020.63 | Heli Pos 14387.31,402.23,14985.62 | Heli Speed 233.93 KMH | Heli Height above Terrain 43.11

Figure 2: an incident as seen in instructor station.

3.2.4.7 The simulation was flown over 170 sorties in a variety of terrain scenes, and with a representing pilot population (AH64, AH1, UH60, CH53, Bell 206), and a variety of sensors.

3.3 The live demo

3.3.1 The live demo was only with a 3d model. The aim of the demo was to reduce risk and prove with low cost that the concept is valid. The demo used an AH64 A model aircraft.

3.3.2 The integration to the helicopter was minimal. A rugged computer was installed with NOVA software (NO Visual App). A video converter card was added to the package to convert VGA signal to rs343 of the AC.

3.3.3 The demo was flown by I.A.F test centre some 10 flights (shakedown until full operational mission profile) with a careful build-up method

3.3.4 The flight was flown by a the back sit pilot, the cockpit was covered as in BAG training, so the pilot could only see through the IHADDS. The front sit was occupied by another test pilot serving as a safety pilot.

3.3.5 The results were good, test centre declared that the system (as is – a demo only) is qualified to fly at 100' AGL.