IFIS SIIV
MONTRÉAL•2004

Enhanced Vision System (EVS) and Synthetic Vision System (SVS) for night Flight Inspection operations: a possible solution

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ABSTRACT

In the increasing complexity of air traffic management, Flight Inspection operations are mainly regarded as a disruption of the otherwise well organized flow of air traffic. The recent application of EVS (Enhanced Vision System) and SVS (Synthetic Vision System) for civil use can allow safe night Flight Inspection operations, thus alleviating congested airports and airspaces from the necessity of Flight Inspection during busy daylight times.

Technological as well as procedural implications are considered with the following main aims: safety of flight operations, quality of collected data and efficiency.

PURPOSE

To permit efficient use of resources for FI departments, reducing daytime flight activity at busy airports, with improved safety margins allowed by technological innovations. A by-product will be a reduced impact in commercial aircraft operations.

LIST OF ABBREVIATIONS

APU	Auxiliary Power Unit
ATC	Air Traffic Control
DOC8071	ICAO document 8071 Manual on Testing Radio Navigation Aids
DME	Distance Measuring Equipment
EFIS	Electronic Flight Information System
EFV	Enhanced Flight Visibility
EFVS	Enhanced Flight Vision System
EVS	Enhanced Vision System
FI	Flight Inspection
FLIR	Forward Looking InfraRed
GNSS	Global Navigation Satellite System
GS	Glide Slope
HAZOP	Hazard and Operability study
HUD	Head Up Display
IAP	Instrument Approach Procedures
ILS	Instrument Landing System
IR	InfraRed
IRU	Inertial Reference Unit (meaning both Gyro or Laser)
MLS	Microwave Landing System
Navaid(s)	Radio Aid to Navigation
NM	Nautical Mile
Ops., ops.	Operations
PIC	Pilot In Command
RADAR	Radio Detection and Ranging
SA	Situation Awareness
SIC	Second In Command
SOP(s)	Standard Operating Procedure(s)
SV	Synthetic Vision
SVS	Synthetic Vision System
TACAN	Tactical Air Navigation
UHF	Ultra High Frequency
USSFIM	United States Standard Flight Inspection Manual, FAA Order 8200.1A
US	United States (of America)
USD	United States Dollar(s)
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	Very High Frequency Omni directional Range

INTRODUCTION

Safety first! This is the main reasoning behind the idea of using EFVS (Enhanced Flight Vision System) and eventually SVS (Synthetic Vision System) for Flight Inspection night operations.

But first of all: why flight inspection night operations? Because at majors hubs and in many busy airports FI during daylight is a problem. It is a problem for all the involved parties: ATC, Airlines and other commercial operators, general aviation and, most of all, for the FI crew. Night FI ops are already considered in DOC8071 and USSFIM and recently (February) the FAA amended chapter I of CFR 14 to allow for the use of EFVS as an alternate method of satisfying visibility conditions under certain circumstances during straight in approaches and that is exactly the point: to supplement normal eye vision through enhancement using certified technology in order to provide a higher level of safety. The key to success is integrated technology: EFVS + HUD (Head Up Display) for real time awareness and SVS for navigation and positioning. Crew training and motivation will play an important role in the final equation, as well as business justification of investment for the manager of the FI dept.

Last but not least, the final variable of our equation: environment. Jet noise is not well accepted by airport neighbours during the day, much less during the night! Summarizing, we have to cope with four main goal: safety, technology, business justification and environment. Each point can be further divided into detailed objectives that we are going to analyse.

Furthermore, the feasibility of this kind of ops. is related directly to the type of navaid to be inspected due to propagation differences between day and night. To neglect this problem efforts should be concentrated on VHF/UHF navaids, such as VOR/TACAN, ILS, MLS and GNSS. In fact the real challenge is to calibrate approach navaids in congested airport. Enroute navaids can be calibrated during daylight as usual.

SAFETY

The use of EFVS may potentially offer a giant leap forward in SA, with a corresponding higher level of safety. There are many advantages in night flight and few disadvantages.

The main advantage is reduced air traffic. This is a big step in the direction of safety because of two reasons: lower workload in the cockpit and lower workload for ATC. This single point will improve efficiency probably by 30-40% (Italian traffic environment – see "business case" below). Night flight is usually less subject to turbulence due to the lack of thermodynamic effects.

Flights are expected to be shorter than usual, thus reducing fatigue for the crew. Night shifts are normally enjoyed if they are not very close. Normally is easier to reach the workplace (road traffic is greatly reduced during the night) and to go back home (or to the hotel) after the mission. This will require a carefully planned crew rostering, otherwise the stress level will increase. Voluntary crew may be selected if this fit the needs of the FI department.

On the other side there are few disadvantages.
First of all night, from a physiological point of view, is intended for rest. This means that even if a person can get used to night shifts the organism is not in its best conditions. Fatigue is the most common symptom, with increase in stress level, reduction of attention, change in behaviour and so on. Again, a good crew rostering and a strict adherence to rest periods can reduce this disadvantage to the minimum. Stress and increased attention during night flying can be very subjective, but is indeed a disadvantage. Assessment is suggested on personal basis. A HAZOP/Human Factor case can provide interesting data on the matter(1).

In another correlated paper it is clearly shown that, contrary to the common thought, night flying is not the most stressful flight. Pilots interviewed reported higher stress level as a consequence of flying in congested areas. Nevertheless these comments may be very subjective and a company policy about night FI operations should be established by each FI service Provider.

This is a good starting point for a full spectrum evaluation, and if we put in the equation the EFVS and eventually SVS a great reduction in stress level is expected. One of the main reasons of stress during low level night flying is the fear to hit unseen obstacles. With a system giving the crew the possibility to see through darkness and bad weather is certainly a turning point in SA and obstacles avoidance. Strict rules should be applied to avoid overconfidence in the system, for the purpose of the use of new technology is to increase safety during normal operation (performed by night). For this reason no reduction in the minimum visibility for FI operations should be allowed.
VMC should always be used as a reference.

ENVIRONMENT

Environment impact is very favourable: less flight time means less pollution, but another problem must be faced, and its name is *noise*. Most airports are close to cities and are very sensitive to the noise issue.

For this reason night FI should be used only at major hubs and at the most congested airports, but its use cannot be widespread. Only turbofan equipped aircraft should be used and the concept of "flexible thrust" adopted for the go-around (ILS, MLS and IAP checks). This means that maximum thrust should be used only when absolutely necessary. Another step to reduce noise is to position the

FI aircraft at secondary airport if possible. This will reduce the number of take offs and landings (reverse thrust is very noisy) nearby sensitive communities.

REGULATORY BACKGROUND

Rules already in place coming from different sources, mainly ICAO and FAA, can be used satisfactorily to form the basement for a new set of FI procedures. At the moment of writing the JAA (EASA) has not yet produced final rules on the matter. It is opinion of the authors that special rules for FI ops. are not necessary, since to perform FI duties certain weather conditions must be met regardless of the time of the day and the technology used. The use of devices to enhance natural vision during marginal VMC or during night are considered a mean to reach greater safety, allowing routinely to perform FI during night or during condition of reduced visibility (reduced visibility is intended as "marginal VMC"). It is absolutely outside the purpose of this document to suggest a reduction to weather minima for FI ops. In fact the truth lies exactly in the opposite direction: given the already established weather minima the use of EFVS will improve SA, thus increasing the level of safety.

TECHNOLOGY

EFVS and HUD are common feature in most tactical aircraft. Military development of IR sensor begun in the fifties and operational system were available during the Viet-Nam era in most tactical and strategic aircraft. Further developments includes star light/low light intensifier and microwave radiometry and RADAR. Only recently EFVS technology has been made available on the civil market and now at least two systems are certified by the FAA (HUD has been in use in the civil sector since the mid-eighties, even if only in recent years it has become a common sight in business and commercial aircraft). The FAA was so foresighted to modify, effective 9 February 2004(2), the relevant chapters of 14CFR (part 1, 91, 121, 125 and 135) to reflect the implementation of the new available technology and its advantages, allowing equipped operators to legally benefit from the use the EFVS. The relevant definitions concerning EFV, EFVS, SV and SVS are reported below (from FAA document).

Enhanced flight visibility (EFV) *means the average forward horizontal distance, from the cockpit of an aircraft in flight, which prominent topographical objects may be clearly distinguished and identified by day or night by a pilot using an enhanced flight vision system.*

Enhanced flight vision system (EFVS) *means an electronic means to provide a display of the forward external scene topography (the natural or manmade features of a place or region especially in a way to show their relative positions and elevation) through the use of imaging sensors, such as a forward looking infrared, millimeter wave radiometry, millimeter wave radar, low light level image intensifying.*

Synthetic vision *means a computer generated image of the external scene topography from the perspective of the flight deck that is derived from aircraft attitude, high-precision navigation solution, and database of terrain, obstacles and relevant cultural features.*

Synthetic vision system *means an electronic means to display a synthetic vision image of the external scene topography to the flight crew.*

The EFVS is a direct vision system, meaning that what the pilot sees is the real environment in real time, while SVS is a database and navigation sensors derived reconstruction of reality.

The EFVS can be used for FI approaches because of its peculiarities (real time, direct imaging), but the use of SVS should be limited to general navigation and repositioning after approaches have been flown. This is due to the dependence of the system from other navigation sensor to derive the position of the aircraft. An error/interference on a GNSS signal, for example, could lead to a displacement in position and thus a displacement in the presentation to the pilots of the "synthetic reality". Multiple navigation sensors (GNSS, DME-DME, IRU) should be used in hybrid mode to ensure the required accuracy.

Projection of EFVS data on HUD is absolutely mandatory. In a fully integrated system also FI parameters should be superimposed on HUD (for example the 150/180 $_{\mu A}$ trajectory below the GS should be presented on the HUD, to minimize the risk of being too low with reference to the intended trajectory).

The quality of the presentation (imaging) is of paramount importance and the existing technology is enough advanced to provide good results in this field. It is important to point out that the purpose of this document is to highlight the technological possibilities to solve the problem of FI at busy airport, using new hardware and procedures to fly FI mission at night with the same (or better) degree of safety obtained during daylight operations. In no case a reduction in established meteorological requirement (normally VMC are required) could be tolerated. The technology must be used to increase the SA and safety in general.

EFVS works using IR sensors located conveniently on the aircraft. The EFVS projects an image on any raster-capable Head-Up Display, providing the pilot with a forward-looking infrared (FLIR) picture overlaying the outside view in a conformal manner. The system allows the pilot to detect lights and ground features (runways, aircraft, mountains, buildings, etc.) at night and in low visibility conditions. The same image can be projected on the first officer head down EFIS display (normally only one HUD is installed on the Captain side).

The HUD is normally composed of 3 main elements:

- HUD computer, receiving and processing data coming from various aircraft sensors and generating the symbols to be projected on the combiner/display.
- Optical projector, containing a relay lens assembly, to project symbols generated by computer on a
- HUD combiner/display, normally an holographic optical element that collimates imaging (from EFVS, for example) and symbols in order to have correlation (perfect overlay) with the real world features.

The SVS provide a reconstructed digital image of reality based on database and precise positioning information. Database contains land features as well as buildings and other man made features. The information given to the crew are very useful for general navigation and also to perform approaches and even taxi to the ramp after landing or to the runway for departure, but the accuracy of the whole system depends entirely on the goodness of positioning data.

The integration of the three systems will provide the best combination possible for the FI needs:

- EFVS as a direct, real world, visibility enhancement system
- HUD, on which EFVS data are projected, for seamless transition from enhanced vision to natural vision, if required
- SVS (plus EFVS/HUD) for general navigation and repositioning in an efficient way for the next run

With the existing technology this is really the top.

PROCEDURES

The possibility to see through darkness in the night or trough weather is not new. The novelty is in the application of the existing technology, mainly from military origin, to the civil market.

From the point of view of the FI procedures it is important to highlight the concept of standard operating procedure(s), or SOP(s). It is a common acronym in the professional pilot community and the meaning is very simple: standardise procedures and train the crew to act in a certain way when a specific set of conditions apply. This is very easily done by the airline's crew and can be done, with some modifications to take care of the peculiarity of FI operations, in the cockpit of a FI aircraft.

It is of paramount importance that the established procedure in use in the FI department are not altered in order to perform night FI. Only minor adjustment are acceptable because it is not considered safe to modify a well established habit (coming from years of experience and training) when operating in a different and potentially hazardous environment.

To provide detailed procedures for night FI operations is outside the scope of this document, however it may be useful to outline the main areas of interest for future detailed development (and simulator/flight testing).

First of all a set of SOPs must be developed. SOPs should include notes highlighting differences between day and night operations (to be kept to a minimum). HUD is mandatory. Transition from enhanced vision to natural vision must be seamless.

SVS is highly recommended. This will give to the crew the best level of SA possible with regard of position and navigation. A SVS database should be developed and kept updated for every airport where night FI is expected and should include an area of at least 30 NM radius from the airport.

Emergency escape procedure must be established in case of loss of EFVS devices and must be specified and reviewed by the crew before every night flight. The escape procedure must be considered a "memory item", since there is no time to review check lists in this critical phase. In a general way the PIC should brief the rest of the crew before initiating the run about his/her intentions in case of loss of EFVS. In particularly good weather conditions the PIC may decide to continue the run. Anyway this is not considered to be a good practise and a go-around to safe altitude should be initiated immediately (this is particularly important when calibrating ILS, MLS and IAP in general). Failure of SVS is less dramatic, but potentially hazardous, so emergency procedure should be developed to take care of loss of SVS. Since SVS is not likely to be used for the final approach phase, but only for positioning and general navigational awareness the level of risk, in case of failure (software, hardware), is quite low. Multiple failure (EFVS and SVS) normally happens in case of widespread failures of the aircraft electrical system. In this case, even if it is an unlikely event in modern aircraft, manufacturer's emergency procedures apply to reduce electrical load (i.e. double generator failure and no APU). In most FI aircraft such an emergency triggers the automatic shut down of all FI equipment. An immediate return to a safe altitude and position (obstacles) from which a landing can be made is mandatory.

Particular attention should be given to training, both academic and practical (simulator). Some real night flying may be necessary before operations can be started. Currency and proficiency levels should be carefully monitored.

AIRCRAFT AVIONIC CONFIGURATION

Only state of the art avionic equipped aircraft are eligible for this kind of operation. SVS is mainly and head down system, but EFVS will require HUD. EFIS should be configured so that PIC (normally the HUD is placed only in front of the Captain, on the left side of the cockpit) will be able to use the HUD and fly the aircraft during the run (the readout of EVS is projected on the HUD, with superimposed flight data such as attitude, speed, altitude, rate of climb or descent, navigation) and the SIC will monitor the run on his/her EFIS (in the navigation display SVS and EFVS can be superimposed) and perform other FI duty as necessary.

CONSIDERATIONS ABOUT VHF/UHF PROPAGATION

Some considerations about radio frequency propagation are necessary to validate night FI data collection. Data compatibility between day and night FI should be evaluated. Propagation of radio frequencies on Earth involves two specific layers of the atmosphere filled with different gases: the Troposphere is filled mainly with air while the Ionosphere contains more ionized particles and plasma.

By approximation we can consider Troposphere, divided into several thin layers each with a different refractive index, hence due to this variation electromagnetic field bends when passing through each layer as described by *Snell's* formula for spherical dielectric medium, where n_p and n_{p+1} are different and both altitude dependent :

$$R_p n_p sin\alpha_p = R_{p+1} n_{p+1} sin\alpha_{p+1} \qquad n_p = f(h_p)$$

In the troposphere refractivity is a function of humidity, pressure and temperature (and thus altitude) and this is valid for all radio frequencies, an empirical formula is given by :

$$N = 77.6\frac{P}{T} + 3.73 \cdot 10^5 \frac{e}{T^2} \qquad N = (n-1) \cdot 10^6$$

The first term (called DRY) depends on absolute temperature (in Kelvin degrees) and pressure in hectopascals while the second term (called WET) depends on partial pressure of water vapour in hectopascals and temperature; N is relatively insensitive to variations of pressure but sensitive to changes in temperature and water vapour pressure.

Daily variation of refractive index is mainly due to temperature changes and thermodynamic effect upon low level atmosphere and in particular

- Turbulence: since turbulence can cause only instant changes in electromagnetic field propagation (atmospheric scintillation) we can consider this phenomenon as non influent for this paper's purposes
- Ground thermal inversion: this phenomenon causes the electromagnetic field to bend downward
- Air transparency

In case of areas subject severe pollution smog might concentrate near the ground in correspondence of a thermal inversion layer and a smooth attenuation of radio signal can occur.

Focusing on VHF/UHF the primary difference, with respect to lower frequencies, is to be found in Ionospheric propagation and its daily variation.

Ionosphere can be divided in four layers, called *regions*: *D, E, F1* and *F2*.

D region is the lowest layer, hence reactions are produced by the most penetrating ionizing radiation hitting the earth. Secondary sources for electrons are the visible and ultraviolet solar emissions, which can provide the energy necessary to release weakly held electrons from negative ions. This layer is present only during daytime and has a peak ionization density (10^{10} electrons /m^3) at around 90 km, which may drop down to around 60 km in case of enhanced solar X-ray flux.

Considerable attenuation of RF can occur in this layer, where collision of electrons with neutral particles are more common due to the higher density of neutral molecules when compared to the upper regions as *E* and *F* (the lower the frequency the greater the attenuation).

In ***E region*** the ionization of molecular species is dominant and electron-ion losses are solely due to dissociative recombination processes. This layer has peak density (10^{11} electrons /m^3) around 120 km and following sunset the electron density in this region decreases by a factor of 10 or more within a very short time.

In conjunction with solar spots and interaction between solar wind and Earth's magnetic field an higher increase in electronic density can be expected, localized in thin layers of *E region* (called *"sporadic-E"*), this phenomenon brings up the probability of VHF reflection (up to 200 MHz), but is a very rare one.

F region which is a combination of two different regions: *F1* and *F2*. *F1* region has a peak density ($2 \cdot 10^{11}$ electrons/m^3) at around 200 km and is more marked in summer or during high sunspots In *F2* region the altitude of the peak density (10^{12} electrons /m^3) occurs at 300 km during daytime and at higher altitude at night.

Shortly after sunset the absolute density near the peak of the *F region* often increase due to plasma transport processes, before decreasing to a nigh time value and drifting downwards.

In a first approximation ionized-gas refractive index (n) is:

$$n = \sqrt{1 - \frac{80.8 \cdot 10^{-5} N}{f^2}}$$

Other formulas can be used to determine critical and maximum usable frequencies:

$$f_c = 9 \cdot 10^{-3} \sqrt{N_{Max}}$$

$$MUF = \frac{f_c}{\sin \alpha_0}$$

Where:
N is the number of electrons/cm^3,
f_c is the critical frequency with respect to maximum density of electrons of the layer (N_{Max}) and
MUF is maximum usable frequency dependent on α_0 grazing angle.

We can observe that as frequency increase the reflective index decrease, meaning that a short wave is more likely to pass through ionosphere without being reflected.

If f is less than or equal to f_c, considering a zero angle of incidence, the wave will be reflected; hence the MUF gives the highest value of frequency usable in accordance to the angle of propagation and incidence on the first potential reflective layer of the ionosphere.

Usually only HF waves are subject to ionosphere reflection. In fact assuming that during night time *D* and *E* regions will disappear (except *sporadic-E* if present) shortly after sunset and the only active region is F (with a relative low electrons activity), for a wave with a frequency of 140Mhz to be reflected about $2.4 \cdot 10^{14}$ electrons/m^3 are needed, a far greater than normal value.

Fundamental physic consideration reveals that the worst situation for propagation anomaly is during daytime because of the strong thermodynamic effect of the sun upon both Troposphere and Ionosphere gases. Solar wind and free charged particles increase molecular reaction in the Ionosphere and consequently there is an increase in the electronic density of all layers.

Even if the conclusion is that there is no significant alteration of the signal in space in the lower levels of the Troposphere between day and night (if the frequencies considered are in the VHF/UHF range), a comparative flight test program (day-night) may provide statistical data and form the basis for filtering algorithms if required. From the formulas above a slightly better signal during night time can be expected.

How much better is difficult to say in quantitative form. However there is no physical reason to expect alterations, for example, in course alignment or GP angle under normal circumstances.

A different consideration should be made for GNSS signals, since in the evening (from sunset till about midnight) satellite signals are subject to ionospheric scintillation caused by electron density irregularities which manifest themselves as changes in the refractive index. It should be noted that the equatorial scintillation region can cover up to 50% of the earth. Ionospheric scintillation is more likely at night and in summer days according to solar activity and is stronger at low latitudes. In theory an interfered signal (increased noise level or, in extreme cases of solar activity, a total loss of signal) can be expected at night under the same conditions of satellite position in space. This should be taken into account. Furthermore a comparative flight test campaign (day and night flights on the same Navaid – see above) may provide interesting "real world" data used for evaluation of FI recordings. From a propagation point of view, the best time frame to perform FI starts at midnight and terminates at 3 o'clock (Human factor consideration, in this case).

BUSINESS JUSTIFICATION

It is now time to put in the equation some economical/commercial consideration. At first glance economic advantages are far greater then disadvantages. The following chapter should be considered an overview of this aspect, for more precise commercial and financial considerations are required. Nevertheless the result of this quick overview can form the basis for more in dept evaluation.

To proceed in a logic and simple manner a table has been drawn to include benefit and costs in a comparative view.

Some assumptions have been made:

- Labour cost at night +50%
- Duty time (night) 7 hours
- Flight time required for a given Navaid -30%*
- Crew composed by four people (Captain, First officer, FI Operator, Aircraft technician)

** A statistical evaluation has been made using data collected during years of operations in the ENAV FI Dept. Flight time used to perform ILS check at major hubs (Rome Fiumicino, Milan Malpensa) and other busy airports (Milan Linate, Catania, Palermo, Turin, Venice, Florence) was calculated and then compared with the flight time required to perform the same type of check at secondary airports. The difference vary between 20 and 55%, depending on the day of the week and* *the time of the day the FI mission was flown. The 30% value, chosen as mean value, is considered conservative in our environment. If there is no traffic at all (quite common after midnight) a better result in terms of reduction of flight time required to perform a given check is expected.*

Another assumption is that the baseline for flight time is 3 hours, and that means that a reduction in flight time for the given calibration flight is 54 minutes.

In many cases this is a conservative value but can be used as mean value. Every FI provider can do its own calculation, based on experience.

Item	Daylight ops.	Night ops.	Difference	
Flight time	3 Hours	2.1 Hours	0.9 Hours	+
Labour cost (1 man hour equal to one unit)	28	42	14	-
Other costs (hotel, transportation, etc.)	Standard	Standard	No difference	No difference
Aircraft Repositioning	Standard	Standard	No difference	No difference

In the following table the money value of Bonus/Malus is added where applicable. In this case the assumptions made are:

- Base rate for labour cost 1** per hour (1.5** night labour cost)
- Rate for flight hour set at 90** (includes base rate labour cost)

** This is a coefficient and not a specific currency value.

Item	Daylight ops.	Night ops.	Difference	Bonus/Malus
Flight time	3 Hours	2.1 Hours	0.9 Hours	81** Bonus
Labour cost (1 man hour equal to one unit)	28 Units	42 Units	14 Units	14** Malus
Other costs (hotel, crew transportation, etc.)	Standard	Standard	No difference	No difference
Aircraft Repositioning	Standard	Standard	No difference	No difference
TOTAL BONUS				67** Bonus

Such a saving on a single flight is a result worth consideration. This means the an investment in new technology worth hundreds of thousands USD (EFVS, SVS, HUD, exact costs will depend on aircraft type, avionic configuration, manufacturer, etc.) can potentially be recovered in 100/200 flights (or, to say better, night FI missions).

Calculation are based on estimates and may not match those of other Providers.

Depending on type of contract this translates directly into profit or in availability of flight time for other contractors. A commercial provider can be more competitive on the market, whereas a Government Agency can reduce costs and provide aircraft availability for other purposes.

If the maintenance structure of the FI provider is not able, or not organized to provide 24 hours service an increase in maintenance costs may occur. It can be offset by increased efficiency, in the form of aircraft availability for day and night mission in the same calendar day. Every Provider should evaluate costs Vs. benefit using data from real life ops., internal statistics and experience.

It is outside the scope of this paper to provide exact calculation on the business side of the problem. The only relevant thing is that indications are present to confirm potential benefits and increased efficiency.

Invaluable is the investment in EFVS and HUD technology from a safety point of view. It can not be said in numbers, but it is import to remember that FI crew flies most of the time in the so-called "safety window" (un-safety window it should be read), a portion of airspace surrounding the airport in which most of the accidents occurs. If technology can be of help to increase safety the FI Providers should do their best to acquire it, install it and train the crew to take advantage of it. Safety is not cheap, but an accident is orders of magnitude more expensive, in terms of human lives (invaluable), loss of properties and goods, loss of credibility (this can drive a previously solid business out of the market in a blink of an eye).

HANDS ON EXPERIENCE

Experiments will be conducted to verify the feasibility of this type of operations. According to manufacturers data, press releases and flight test report published on major aviation magazines, the technology is well developed and really useful in reduced visibility/night conditions. Comments ranges from enthusiasm to amazement, but FI is a peculiar activity and a more technical evaluation is required, with specific profiles that needs to be flown before issuing a final comment. Nevertheless indicators shows that a positive final result is very likely.

Manufacturers scheduling constrains prevented flight test data to be inserted at present time. Test report and final considerations will be provided in the final release of this document.

CONCLUSIONS

Innovation is sometime difficult to handle. The EFVS, SVS and HUD are relatively newcomers in the civil market, even if they are based on consolidated military technology. Most of the times new technology means a change in the way things are done, and in some cases the way we do things is no longer the right way. It is of paramount importance for all the people involved, from the decision making process (management) to the flight crew who will use the new "black boxes" to understand the reason for changing habits.

Safety, efficiency, Human Resource Management, technical, commercial and financial considerations are all part of the same body: everything must work in harmony, otherwise the body will become rapidly sick. This means that in some specific occasion night FI may become necessary. In a not so far away future the air traffic will increase dramatically. Just to give an idea there are estimates (EUROCONTROL) for an increase of flights over Europe from the actual 27.000 per day to 100.000 per day by the year 2020. It is clear that FI at night will shortly be considered as an interesting option. It is an efficient solution for all the three main actors: airlines, ATC and FI service Providers. When there is a common intent between all the involved parties it is clear that is only a matter of time before the night FI will be considered as a feasible option. And since is only matters of time we should not be caught by surprise when the moment will come. Technology is available now, the system (EFVS, HUD and SVS) are certified (at least in the US) and a research and development program should start now if we want to build the required experience to cope with the future requirements in this very specific field of operations. This is a new world and everything is to be done from scratch, from procedures development to flight crew duty time requirements, from training to evaluation of collected data. Managers as well as pilots and technicians are required to work together in a team to reach the target: safety, efficiency, quality.

To obtain the intended result nothing should be neglected, instead everything should be considered in the right perspective. The main points of interest are:

- Safety
- Procedures
- Efficiency
- Quality
- Human Resource Management (rostering, duty time, etc.)
- Industrial relation (labour dispute)

Every main point should be carefully evaluated.

This paper should be considered a proposal to study in much more detail the problem of night FI, with all its implications, including human factors, technology, procedures, commercial considerations and industrial relations.

REFERENCE MATERIAL

[1] Robert K. Bullard (FAA) "Night Flight Inspection Considerations", paper presented in Rome, 12th IFIS, 2002.

[2] Docket No. FAA–2003–14449; Amendment Nos. 1–52; 91–281; 121–303; 125–45; 135–93 RIN 2120–AH78 "Enhanced Flight Vision Systems".

Other documents used during research were:

- ICAO Annex 10
- ICAO Doc 8071
- FAA USSFIM (FAA order 8200 1A)

Informations were also obtained on the following web sites:

- www.gulfstream.com
- www.max-viz.com
- http://avnwww.jccbi.gov/icasc/
- www.faa.gov

ACKNOWLEDEGMENTS

Research about propagation of radio frequencies were made by Elvis Bergero (ATCO, ENAV, last year undergraduate, Physics, University of Turin, Italy).