

The Use of Video Cameras in In-Flight Entertainment Systems

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Abstract

Many Airlines are now considering the addition of Video Cameras to their passenger entertainment (IFE). CCD Camera technology has allowed the development of highly effective and reliable colour sensors, which when used correctly give excellent pictures of the aircraft, and terrain being overflown. These add to the passengers' flight experience, particularly for holiday flights to exotic locations. The prime locations for the cameras, across a wide range of aircraft types, is the Fin Tip, and Underbelly, where the cameras view both forward and aft.

Introduction

Historic Airline Differentiators

Airlines have for many years been trying to improve their passenger numbers by the provision of additional services in the cabin. Initially, these consisted of meals and drinks, of ever increasing quality. In the last few years, the differentials achievable using these staples of airline travel have diminished; no longer can an airline distinguish itself for providing the best food and wines as passengers expect all airlines to provide a high standard. Seeking more and more refinements, airlines have chosen In Flight Entertainment provisions to enhance their customer uptake.

The first movie shows on scheduled airlines date back to 1948, when Pan Am entertained their passengers with 16mm films from a standard projector

set up in an aisle. During the 1960's the Bell & Howell "Astrovision" system ran 16mm films threaded through a series of film monitors located throughout the aeroplane. The 300' length of active film meant that the first class passengers on the port side would see scenes and hear sound up to 7 1/2 minutes after the first class passengers on the starboard side! In the late 1970's video films began to replace tape movies, and around 1980 the first 2.5" personal liquid crystal display (LCD) was introduced to the seatback of a commercial aircraft. In the 1990's the top movies are shown on airlines, even before being available to the general public; moving map systems ("Airshow") enhance the passenger experience by allowing him or her greater access to flight information than ever before. The quality of these maps and the style and graphic presentation on some airlines is now very high, as is expected by the discerning passenger who is used to the quality of images presented to him by his home computer.

Interactive IFE

The most recent moves have been for "interactive IFE systems", whereby the passenger has greater freedom to choose the entertainment program he or she desires. These include up to 14 channels of movie entertainment, shopping, video games, gambling, etc., all down-loaded to the passenger seat, and viewable through the individual passenger seat back screen. It is here that the airlines have been badly let down by the IFE system manufacturers.

Promises of high levels of interactivity, coupled with high reliability and simple maintenance were made by companies largely coming from the video entertainment industries who understood little of the environmental and maintenance constraints of a working airliner. Even vendor companies which have worked with avionic systems for many years have been unable to succeed in putting together the complex network of parts which would be needed to give this sort of interactivity to, say, 400 seats on a Boeing 747.

A Simpler System

The airlines have, for the most part and for the time being, retreated from the large interactive systems, and are looking for simpler, more reliable IFE which will still serve for market differentiation without leaving the airline exposed to high maintenance charges.

The solution may be a system combining moving map, advertising and video cameras, shown through a distributed or selectable system, giving the passenger an interesting, varied and enjoyable co-ordinated entertainment experience. The system would be cheap to buy (probably less than \$100,000 installed), easy and inexpensive to maintain, and highly reliable, as there are so few complex avionic sub-systems.

Recent trials in the UK with a two camera system, the following results were obtained : 90.3% of passengers who responded to the questionnaire thought that the pictures were “Interesting”, 61.3% found them “Informative”, while only 2.5% reported the pictures “Unsettling”. Further passenger comments are included as Exhibit A to this paper.

Giving the Passenger a “Pilot’s Eye View”

There have been several suggestions over the last few years that Video Camera systems be used as part of a co-ordinated In Flight Entertainment presentation, containing Flight Safety information, Movie, Advertising and Moving Maps, as well as the views from external video cameras. This has culminated in installations by JAL, Emirates Airline, and two UK airlines (Airtours International Aviation Ltd and Air 2000) trialing the DM Aerospace FlightVu system, starting in April 1998. Other airlines throughout the world are now evaluating video cameras as part of their own passenger entertainment presentations. Early passenger feedback is almost totally positive and welcoming.

The systems give remarkable views from the aircraft, showing the beauty of the aircraft in flight, against a stunning backdrop of sky, clouds and sea.

Every Seat a Window Seat

Many passengers, even seasoned travellers and businessmen, state their preference for a window seat, just a look in a sparsely filled airliner will bear this out – see how many of the passengers choose aisle seats or central seats when given a free choice. This is especially during take off and landing, low level manoeuvre and approach, or when there is little cloud cover.

The majority of these passengers can see very little from their selected window seats. Many have “restricted views” downward due to the wings, and because of the seats not aligning with window locations. And yet the window seats are still the most popular on the aircraft.

The Integrated Passenger Presentation could be configured to give:

Ground	Passenger Greeting;
	Airline Messages
Taxi	Fin Camera; Safety Briefing
Take Off Roll	Fin Camera
Climb Out	Rear Looking Camera

Cruise	Cameras; Moving Map; Flight Information; Advertising
Descent	Rear Looking Camera; Advertising
Landing	Fin Camera

customers. Even so, with airlines constantly fighting to minimise costs and maximise revenue in all areas, seats are not necessarily aligned to windows, and the benefits to passengers are hence reduced.

Why aren't these systems in use right now?

The arguments against the systems are generally concerned with the effects on nervous passengers, concerns over increased anxieties caused by the camera systems should an airborne accident or incident take place, the use of the cameras after nightfall, and the objections of some ICAO countries to the placement of any photographic apparatus on aircraft when overflying their territory.

This paper will address each of these issues, give industry responses and proposed solutions.

Knowledge is Power

The modern world thrives on information and knowledge. The success of the Internet as an "Information Super-Highway" is just the latest example of this. Throughout history, man has sought knowledge and his curiosity is frustrated by closed doors and screened windows. The modern airliner is equipped, at very great cost, with windows at each seat row, even though the provision of an airframe discontinuity required by the window installation makes the airframe inherently weaker. The increased strength requirement, and the consequently heavier structure has a direct impact on the weight to be carried, and hence on operating cost. Why, then, do all aircraft manufacturers, without exception, dealing in one of the most cost conscious industries, provide passenger windows? Precisely because the idea of flying in an aircraft with no windows would be abhorrent to all of us, and would therefore be a serious deterrent to the aircraft manufacturer's

Nervous Passengers

Most major airlines today have "Nervous Passenger" schemes which serve to reassure passengers who would not otherwise fly, that they are perfectly safe in doing so. How do the airlines achieve this? Many airlines take the nervous passenger onto the flight-deck in order to reassure him, and allow him to see as the pilot sees. Would this "Pilots Eye" view from the passengers seat then cause him increased anxiety as some commentators have put forward? Or does research and psychological testing confirm that allowing the passenger to see the aircraft in flight and the ground being overflown will actually have a positive influence on the relief of the "Fear of Flying". To put the contrary point, if you were nervous in a car for instance, would being blindfolded calm you down? No, obviously the more clearly you can see, the safer you feel!

Incidents/Accidents

Pilots Views

In general the pilot community are quite unconcerned about the IFE program which is presented to their passengers. There is a body of feeling which is worried about the introduction of cameras to the passenger entertainment program. Of some concern is the objection where the pilot feels he is "performing" to his audience through a landing, but these fears can be allayed through training and familiarity with the system.

Similar systems can be made available to the pilot either on dedicated LCD monitors, or through is EFIS displays, and would allow him to examine his

undercarriage, engines and control surfaces during flight, and to check clearances and ground crew activity when on the ground.

Various pilot views elicited during a recent UK trail installation are included as Exhibit B of this paper.

Cameras After Dark

Video cameras are inherently optical sensors; most passengers accept that looking out of the window at night, they will see very little – why then should a camera enhancement of an IFE system be expected to perform better? In fact, the high sensitivity sensors available today will perform several times better than the eye, adapted as it is to the relatively bright conditions inside the cabin. Superb views of approaching cityscapes are available to the passenger, views far better than can be seen from the passenger windows especially during low level manoeuvre shortly prior to landing. These are among the most exciting views available to the passenger using a video IFE based system.

ICAO Overflying Regulations

ICAO Article 36 refers to “Photographic Apparatus”, and states that “Each contracting State may prohibit or regulate the use of photographic apparatus in aircraft over its territory.”

Some countries will undoubtedly interpret video cameras as “Photographic Apparatus”, and will object to video cameras being fitted, under the above regulation, However, the cameras proposed are wide angle, focussed on the airframe itself, and cannot be used as “spy” cameras. The equivalent is for a passenger looking out of the window – the resolution and field of view not being dissimilar. This should put the minds of the international community at ease. While a change to ICAO Article 36 is unlikely to be

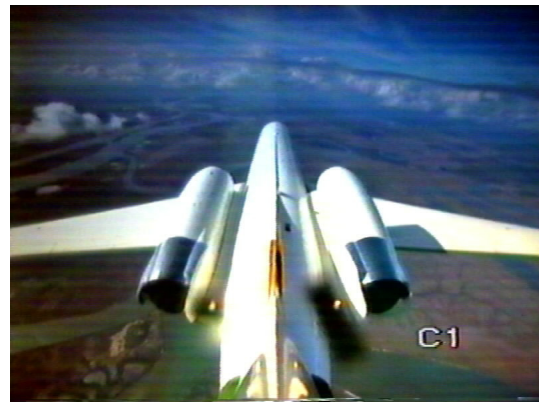
entertained to allow wide angle video cameras to be installed in an uncontrolled manner, manufacturers are suggesting that individual systems are approved for overflight on an exemption basis.

Even if this proves impossible, then the combination of the video camera system with a moving map display (such as Airshow, CD-2000 or Flightmaster), having the full FMS data available to it, would allow the system to be inhibited when crossing into prohibited territory.

Installation

Fin Camera

Undoubtedly the best view for In Flight Entertainment is from the tip (or as far up as practical) of the tail fin. The wide angle view, giving passengers a view of the upper surfaces of the aircraft as far out as the wing-tips, the horizon before them and the ground far below past the aircraft, is truly memorable. The wide angle view is such that this is also the best view to be presented on take off



roll and on landing, as the fin is “far from the action” and the world appears to be moving slowly past the stable aircraft. This is the most relaxing view for the nervous passenger and does not allow the experienced passenger to assess the performance of the pilot by giving too detailed a view of the landing.

Underbelly Forward Panoramic Cameras

The Underbelly Forward Camera will provide exciting dynamic views of the aircraft during landing operations. It may be too exciting for some passengers as the camera is positioned fairly close



to the ground, and care should be taken in deciding the appropriate flight phases to show this to the cabin. Once in cruise, the downward tilt of the camera gives exceptional unhindered views of the ground being overflown. Dynamic pictures of clouds, against an attractive horizon, give continually changing scenery throughout the flight. The camera view should be adjusted on installation in order that some of the airframe, or failing that, the horizon, is included in the picture as this serves to reassure and orientate the passengers. Systems have previously been fitted to the nose gear, such that they are only available when the gear is down. This allows use of the system for take off roll and landing, but much of the potential of the system is wasted.

Underbelly Rearward Panoramic Cameras

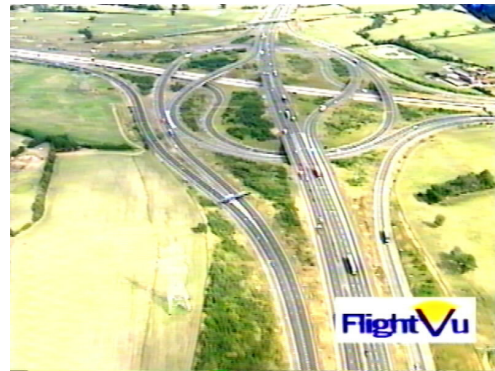
The Underbelly Rearward Camera will provide excellent views of the departing airport during climb out. During landing and flare, the camera becomes very close to the ground, and this, coupled with the disorientating effect looking backwards, makes this camera unsuitable for use during these phases of flight. Once in cruise, the downward



tilt of the camera again gives excellent unhindered views of the ground being overflown. As with the Underbelly Forward view above, the camera view should be adjusted on installation such that some of the airframe, or failing that the horizon, is included in the view as this serves to reassure and orientate the passengers' view.

Underbelly 'Landscape' Cameras

Much has been made of the so called 'Landscape' systems which use a camera viewing directly downwards. While useful in the Cruise as an



adjunct to the Moving Map system, showing what can actually be seen from the air, and giving superb views for instance flying over cities on a clear night, the camera location is of no use in low altitude flight descent or take off phases, when it should be inhibited. Also, as no orientation can be given to the passenger as no airframe or horizon can be shown in picture, the psychological effect on the passenger can be that of being suspended in the air without any visible means of support –

not the pleasant experience that the airline is trying to give.

'Pilots Eye View'

Systems are regularly fitted to executive jet aircraft giving a "Pilots Eye" view to the executive in the cabin. These are mainly cameras fitted to the glareshield forward of the co-pilot position, and just out of his field of view from the normal "Design Eye" position. This is a fairly simple system to install as all parts of the system are internal to the aircraft, however the optical quality is invariably poor, as compromises are being made in looking through a sharply curved piece of the windscreen normally paid little attention. "Veiling Glare", caused by lights from the cockpit reflecting off the glass surfaces of the windscreen and spilling across the camera lens, can also be a problem reducing the contrast and quality of the pictures produced. This camera cannot be as wide angle as the external cameras, or cockpit structure will be visible, and this leads to an increased perception of speed, and therefore danger, to the passengers.

A variation of this is the camera fitted towards the rear of the cockpit, viewing past the pilots and through the windscreen. This was tried by American Airlines at one time. This gives the "worst of all worlds" with the drawbacks detailed above, plus the addition of objections by the pilots to the passengers watching them at work. Neither of the "Pilots Eye" views are recommended to be considered.

'The Human Face' Camera

There is considerable interest from airlines in enhancing the appeal of the Flight Safety Briefing, normally ignored by most of the passengers. Delta Airlines, for example, now carries out its briefings on video, using artistically enhanced photographs to add some interest to the film. Several airlines have expressed their interest in a camera mounted in the cockpit to allow live

"broadcast" pictures of the pilot, introducing the briefing, and adding further information during the flight. The pilots are understandably concerned about this move, and while the "Human Face" camera has some merit

Camera Technology

The Video Camera.

The worldwide use of video cameras for entertainment purposes is now well established, with "hidden camera" and "home video" shows being amongst the most popular shows on TV. This mature technology is now leading to highly reliable solid state CCD camera sensors, at ever cheaper prices and in ever smaller physical sizes.

Field of View. Undoubtedly, the most important parameter to define when considering an IFE camera system is the location of the camera, and its field of view. These, combined, define the composition of the shot, and therefore the ultimate passenger experience.

The wider angle the camera is, the slower the perception of speed, that is the slower things appear to happen. Therefore, for relaxing views of the landscape, and approaching scenery, the widest possible camera angles should be selected. To cater for this requirement, the FlightVu system extends to 104 degrees horizontal. This allows for a Fin mounted Camera to have an overall view of the aircraft, and still see past the aircraft to the ground below – see Picture 1. Note that the centre of the picture is aligned to the front of the visible aircraft, which gives the best composition of view from this position. For a more exciting view, giving an impression of speed at landing for example, a narrower field of view should be selected, perhaps 40 degrees horizontal.

Resolution. One of the major parameters to be considered in the choice of video camera is the required resolution of the recorded image.

For In Flight Entertainment, the detail of the picture is less important than the overall clarity, selection of view, and composition of picture and noise immunity. Most available cameras are sufficient to satisfy these requirements, although with the wide angle views which are recommended by this paper, the quality of the optics to minimise distortions, or to ensure that the distortions enhance the picture is of the greatest importance.

Colour. Despite the considerably lower resolution of colour sensors, as compared with monochrome sensors, and their reduced light sensitivity, colour sensors are necessary for In Flight Entertainment camera systems, as this is how the passenger sees his world, and what he expects from his home camcorder TV system.

Lighting. Modern colour CCD cameras are capable of operating from twilight (1 lux) to full sunlight (100,000 lux), by automatic electronic shuttering, which makes them ideal for use in In Flight Entertainment Systems, as this is similar to the acceptable range of the human (non dark adapted) eye. Passengers will expect good pictures from the system when they can still see clearly out of the window, but will accept that when it is dark outside, the cameras will show a dark scene. As they react to the average light level across the scene, they may be affected adversely when the sun is directly in the field of view. Careful setting of the fixed iris, to define the range of light levels valid for the particular location on the aircraft is necessary. For example, an underbelly mounted camera receives less direct view of the sun, and therefore the fixed iris can be slightly more open than a Fin Camera, giving it better maximum

sensitivity for “evening” viewing. This is a minor optimisation, and will still allow spares holding to be minimised, with “standard” un-optimised cameras.

Housing

The problems inherent with the use of optics and video systems in as harsh an environment as commercial aerospace should not be underestimated.

Until recently, State of the Art video cameras employed balanced galvanometric iris's; before that the majority of cameras comprised photosensitively coated TV tubes. Both these technologies effectively precluded the use of video cameras in any harsh environment. The development of Charged Coupled Device cameras in the 1980's and the developments to high speed shuttering as a method of light control, have both contributed to the current State of the Art which uses fully solid state sensors and small robust lenses with no moving parts. Further protection is added by housing the camera in a benign Dry Nitrogen filled environment within a hermetically sealed housing, and heating the optics using a thermostatically controlled heater circuit. This does not allow any moisture to cloud the internal lenses. Finally an anti-icing heater attached to the inside surface of the glass protective window ensures that the glassware remains above 0°C even under the harshest of icing conditions.

Conclusion

This paper has shown the use of Video Cameras as part of an Integrated Passenger presentation, which is particularly applicable to smaller airlines.

The technical difficulties can be overcome through good engineering practice; and the passengers and airlines currently using systems report very favourably on them.

All indications point to Video Cameras having a large part to play in future IFE systems for Commercial Airlines.

Biography

Mike Horne BEng CEng MIEE is Managing Director of DM Aerospace Ltd. After qualifying from the University of Bradford, and a Student Apprenticeship with Marconi Avionics in 1983, he has worked extensively in video camera systems for a wide variety of purposes from missile guidance and fire control, to pipe inspection and commercial security. His work has included image intensified and thermal imaging systems. In 1995 he joined DM to form DM Aerospace

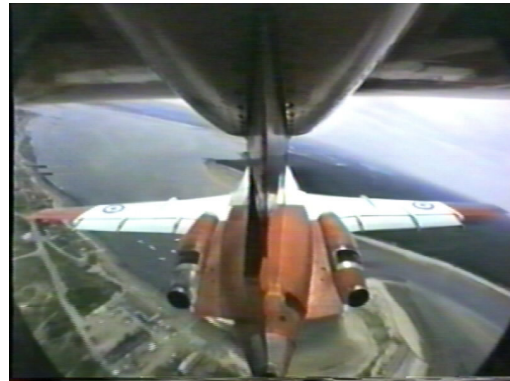


Exhibit A

Airline Passengers

Response to Questionnaire

“Very interesting, actually made me feel less nervous, enjoyed watching the plane take off”

“Its good if you don’t have a window seat because it means you can follow what’s happening outside”

“Very interesting and innovative. Gave a new aspect to flying”

“A great new idea – original and exciting – well done!”

“Makes the journey more interesting”

“Gives a new perspective to the air travel especially if not sitting by a window”

“We think this is a brilliant idea. Great!”

“A welcome addition to keep the passenger informed on different aspects of the flight”

“Amazing – it made me feel at ease”

“My son (14) liked the concept. My wife thinks it is advantageous for the people without a window seat. Good idea. I’d rather have more leg room. The lack of space is serious.”

“Allowed those of us with limited access to a cabin window a clear view. Enhanced the view even from the window, as the plane climbed giving an informative view of the ground receding. Night view could be really great!”

“Excellent idea. The pictures on take off were informative and interesting. We think it should be included in all aircraft.”

“This could be useful for people who are scared of flying they can see just what is going on. Great stuff!!”

“Brilliant idea. Very informative. Better than watching the film. Well done!!!”

“Excellent for children – nervous passengers may find it disconcerting – I chose not to look at it on take off – but I will on landing as I enjoy that part of the flight.”

“Hope your cameras are always working. Really enjoyed it. Brill on the take off and also when in the air.”

“Although I liked the camera it might not be to everyone’s liking. But of course they don’t have to look.”

“Brilliant idea. I was smiling like a Cheshire Cat as we were taking off. I fly a great deal and this was definitely something different. It was interesting that the camera could switch views – from front to rear – would have been fun to capture the next aeroplane taking off behind us if that was possible. Looking forward to telling my daughter about it – hope she gets the opportunity to see it herself soon. Thanks Wendy.”

“It was better than a ride at Blackpool, even the ‘Big One’! Excellent Idea!!!”

Fab, Super, Smashing, Great, Excellent, Brill, Cool, Mad for it

Should be fitted on board more planes. Made take off more interesting and relaxing.

Should be 360 degree coverage with zoom facility for interesting landmarks!

If all aircraft were fitted with cameras. Very interesting to watch your journey on TV. I liked it very much. I have not travelled a lot by air but I found the journey the most interesting on board of all. Hope to travel again with you.

My husband and I were thoroughly delighted by the installation of the on board camera. It was particularly interesting to watch the take off and I look forward to seeing the landing at close range. I think all aircraft should be installed with similar cameras.

“It enables passengers to view and observe the scenery underneath the aircraft. It also must be beneficial to the security of the aircraft.”

“Would have liked to have seen Alps when passing over, “

“The children enjoyed watching it”

“It was great to know exactly where we were during the flight”

“Take off and landing shots would be very good”

“It was very interesting to see below from such a great height; the children were very impressed with the pictures.”

“Can’t wait to do it again”

“Great idea, Birds eye view!”

“Very good idea, should be on every plane”

“Very useful for easing the tension of take off and landing”

“Good idea, especially when your arriving over the Greek Islands, but we don’t want to see them coming back.”

“Having flown several times in the last few years this was our first trip on an (*airline*) flight. We both found the onboard camera to be fascinating and the Captain’s talks during the flight about route etc. to be very informative.”

“It was disappointing when it was switched off. Why not show take off and landing?”

“Very interesting, can we have a forward facing camera for landing?”

“I would think it’s a good distraction for nervous passengers and fun for children to watch. Also it’s good to be kept informed of what’s going on”

“It took my mind off being nervous – fascinating to watch”

“A great idea, please have this as a permanent feature. This feature would increase the likelihood of my choosing (*the airline*) in future”

“After your safety videos I think you should have the camera on all the time”

“I am unhappy about flying and the camera settled me”

“Effect spoiled to a degree by clouds on take off”

“Very interesting, could possibly help people who are afraid of flying”

“We all enjoyed this facility”

Exhibit B

Flight Crew Comments

“Today the pictures were available in the cabin and the pax were pleased and complimentary!”

“I find the flight deck monitor to be especially useful – checking the gear is lowered in flight – also on ground checking movement around the aircraft (a wheel change a few days ago could have been critical for a slot but was able to monitor progress and leave as planned) – the rear facing camera appears to be useful in looking behind especially at stations where push back is given “at Captains discretion”.”

“Apart from the passenger benefits I think the safety benefits to the flightdeck are worth consideration.”

“It will be of great benefit in helping Captains to decide if to call for an evacuation. It will also help with gear problems.”

“My guess is that “educated passengers” would enjoy the facility”

“The ability to observe gear/tyre condition could enhance safety in the event of a tyre burst”

“The flightdeck monitor should not provide a source of undue distraction”

“I have no objection to displaying live external images to the cabin in normal situations.”

“There are many benefits that could be derived from a cockpit display of the aircraft flying controls and engines when an emergency arises and so from a Flight Safety point of view this can only be a good thing.”

“One of the hardest things to judge when downroute is how long the baggage loading is going to take after the aircraft doors have been closed.”

“...the keen aviation enthusiast would find it wonderful but the nervous flyer may find it quite upsetting”