THE BENEFITS OF FLIGHT DATA ANIMATION:

AN AIRLINES PERSPECTIVE

Presented By

**AeroPerspectives**

and

HalldaleGroup

INTRODUCTION

One of the earliest examples of using a computer simulation to recreate an aircraft accident scenario was more than 30 years ago. Delta 191 was the first commercial flight with a second-generation flight data recorder (FDR) onboard to crash in a microburst. The US Justice Department used 40 different parameters from the FDR (acceleration, roll, pitch, heading, etc.) as well as audio from the cockpit voice recorder, ground radar images, weather reports, and statements from pilots of other aircraft to visually replicate the plane's final moments of flight.

You can view the animation at https://www.youtube.com/watch?v=HY7pH3fzsvY.
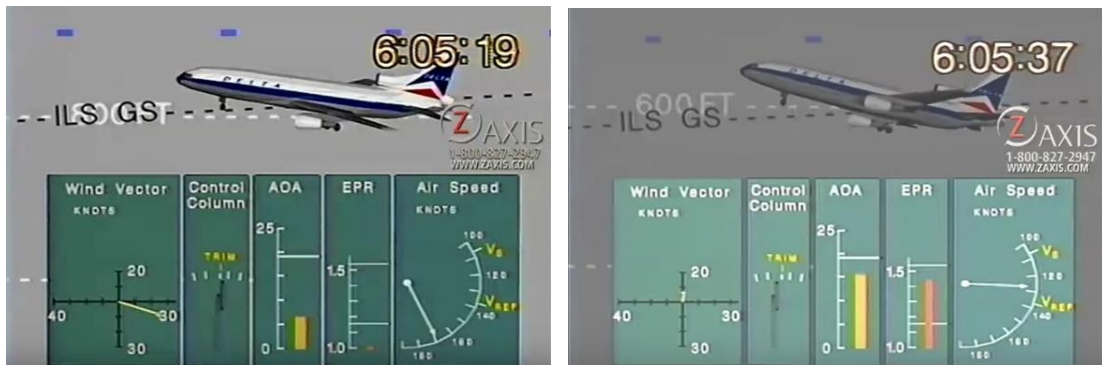
The laser disc video, produced by legal presentation specialists Z-Axis, looks crude by comparison with today's much more realistic animations. But it was effective. One of the Justice Department's lawyers in the case, Roy Krieger, called the animations "pivotal." The district judge ruled that the US Federal Aviation Administration (FAA) and the National Weather Service were not negligent in the windshear-induced accident.

With ever-increasing computing power, today's flight animation tools are used not only by accident investigators but also by hundreds of airlines to regularly analyse flight operations, non-standard incidents, and trends. Flight data animation is also increasingly used for pilot debriefing, training, and airport familiarisation. And it is sometimes employed to help airline senior management visualise significant incidents or accidents.

What is Flight Data Animation?

Flight data animation is a component of a Flight Operational Quality Assurance (FOQA) programme, previously known as Operational Flight Data Monitoring (OFDM), or simply FDM, or flight data analysis (FDA). FOQA is the proactive use of recorded flight data from routine operations to improve aviation safety. It was defined in a Flight Safety Foundation report as "a programme for obtaining and analysing data recorded in flight to improve flight crew performance, air carrier training programs and operating procedures, air traffic control procedures, airport maintenance and design, and aircraft operations and design."

In 2008, the International Civil Aviation Organization (ICAO) amended Annex 6 to the Chicago Convention to introduce requirements and recommendations related to the implementation of safety management and safety management systems by operators of commercial air transport aircraft and helicopters, including FDM. The FAA defined FOQA in its Advisory Circular #120-82, dated April 12, 2004. The European Aviation Safety Agency (EASA) requirement is defined in EU-OPS section 1.037.

Among the many flight safety and flight operations efficiency benefits of FOQA are:

- Providing data to help in the prevention of incidents and accidents.
- Providing the means to identify potential risks and to modify pilot training programmes.
- Identifying and improving aircraft standard operating procedure (SOP) issues by reviewing flight data in consultation with the manufacturer.
- Improved fuel consumption.
- Reduction in unnecessary maintenance and repairs.

The technologies available for flight data monitoring and analysis programmes are better than ever today and the costs lower. With the added safety benefits of FOQA, more operators are making use of data that is readily available to them.

The steps of flight data analysis are relatively simple. Data can be taken from an aircraft's flight data recorder (FDR) or from a quick access recorder (QAR). This is normally done via a laptop computer, sometimes with special software and a special cable. Some QAR manufacturers also support wireless data transfer. The data file recovered from the aircraft is then processed through specialised software, identifying any predefined "events" or "exceedences." A flight data analyst then reviews the statistical information to identify any unsafe trends. The final step is to make actionable decisions based on that data to improve operations, training, and safety.

Flight data animation is often a component of flight data analysis. Animations are typically used to visualise an aircraft's flight profile, cockpit instrumentation, terrain, and scenario data. In effect, the FDR or QAR data is used to re-create a portion of the flight, usually the approach and landing or takeoff, similar to what the pilot may have observed in the cockpit. Graphic representations may include the control stick or yoke, throttles, tachometer, altimeter, horizontal situation indicator (HSI), airspeed indicator, electronic flight instrument system (EFIS), primary flight display (PFD), and electronic centralised aircraft monitor (ECAM).

Some flight data animation systems also depict cultural features such as terrain elevation data, runways, towers, navigation aids, ground vehicles and buildings, as well as environmental factors: visibility, cloud layers, illumination.

Image courtesy CEFA Aviation

Three-dimensional flight animation benefits include:
- Accident and incident investigation
- Crew self-assessment
- Flight training
- Airport familiarisation
- Operational procedures review
- Airline safety improvement
- Human factors studies

Flight data animation is an effective means of conveying the results of analyses to various end-users in a manner that is easily understood.

The benefits of animation, of course, are contingent on the fidelity and accuracy of the animation.

Why Airlines Use Flight Data Animation

In a survey of airlines, AeroPerspectives and Halldale Media researchers found that flight data animation tools were most used (by more than half the respondents) for accident / incident investigation. The second most frequent use is flight crew training, followed by management communication.

Survey respondents included Flight Data Management Analysts, Safety, Flight Operations, Flight Crew Training, and Executive/Senior Management personnel from international scheduled airlines, regional airlines, charter airlines, FOQA service providers, and national aeronautical accident investigation authorities. They represented the Africa, Asia Pacific, European, North American, and South American regions.

The airlines reported that, when applied to accident / incident investigation, flight data animation provided "more credible investigation" and that "it supports the investigator-in-charge in better identifying the aeronautical accident contributing factors." One operator said, "It helps the investigators in a better understanding of the Human-Environmental-Machine trinomial relationship."

The Manager Flight Safety, FOQA, for a North American airline said using flight data animation for accident / incident investigation "gives us a good representation of the aircraft state without using simulator time."

The Senior Flight Data Analyst for another North American carrier commented: "The flight data animation tool has allowed us to improve our internal investigations by visualising the data in an entirely different way. It allows us to look at the human factors to understand what the crew was experiencing."

Another noted a case in which "an investigation of complex avionics problems was made easier by using animation with engineers who do not fly the airplane, but could see what the airplane experienced."

For flight training, flight data animation provides "practical, real-world scenario-based training (not hypothetical or theoretical)," as well as "trends and lessons learned." Airlines like the "ability to produce 3D animation of a flight in order to debrief incidents to flight crews" and the "ability of a crew to see exactly what they did, often including elements they would have otherwise had no idea about." In cases "like tail touch, animation tools are very useful for analysis." Another cited "ILS instrument approaches from IAF to Threshold."

The Head of Flight Data Monitoring for a European airline said that "an unstabilized or rushed approach with late stabilization is a good candidate for a visualisation, where the crew can replay the approach and review it together with our flight data monitoring specialists."

Animation "allows our training department the capability to actually show a training scenario using real-world flight data in the classroom, instead of just showing a slide or discussing a training topic," said another.

One airline includes animations in their new iPad-based training, which they said reduces the effort needed by courseware developers.

A North American operator is applying flight data animation to new destinations, such as Cuba, "where there is no flight data available. We are able to fly the procedures in a simulator, record the animation, and release it to our pilot group via EFB (electronic flight bag). They are able to see the procedures visually before flying their first trip."

"The best scenario," said one operator, "is when the investigators need to explain to the authorities and disaster victims and their families" who are "often unfamiliar with the aeronautical terms and jargons."

At one airline, flight data animation was particularly useful for "management review of a steep bank event at low altitude. The visual really made it 'hit home.'"

How Some Airlines Apply Flight Data Animation

Researchers also spoke at length with individual operators who are currently using flight data animation.

The Flight Data Animation Manager for a major European air carrier group said, "Flight data analysis is a more scientific approach than just quality assurance. We are using animation for event review for cases where we see something interesting has happened and we'd like to get a better understanding. The big advantage is that you can recognise a lot more information in a very short time. If you're just looking at a graph, you often miss something that you didn't think about. When you see a flight deck animation you get most of what the pilots would have seen."

He said flight data animation is used by the airline every day. There are 300-400 events per year "where we see something in the flight data that we'd like to better understand."

The FDA Manager said his department often receives requests from pilots "that they had a special event and they would like to see the data to get a better understanding, to re-live the whole event and talk about open items or CRM (crew resource management) issues." One example event is a go-around. "In the crew debriefing afterward there is discussion whether it was necessary and whether it was even a good idea at all. The pilots can exchange their positions and find how they got to different conclusions and resolve that issue between the pilots."

"We usually show the event once in real-time and then get into the discussion and go to slow-motion or frame-by-frame. And then maybe show it again in real-time to look at a certain part. That's a very effective tool."

The airline also recently used flight data animation to create a training programme for pilots who make maintenance flights. Line pilots flew demonstration flights to capture the flight data, from which an animation video was produced for training purposes.

Flight data animation is also used for training familiarisation of airports. "In Eastern Europe and the Med, there are a lot of circling approaches which require a good mental picture. We do a prepared flight and create an animation video from that."

In North America, Denver is an example airport with unique characteristics. "When you arrive at the airport from the north, you don't see it on the map but there is significantly rising terrain. You think it is flat but effectively there's a big difference in the elevation. The airport is 600 feet higher than the elevation at 10 miles out. You don't notice any elevation or any hills or anything there. One pilot might have the impression that it's flat terrain and he's referring to the radio altimeter when to expect flaps and gear down, for example. The other pilot's referring to the threshold elevation, which would be correct in that case. So there are different mental images of when would be the right time to do something."

The FDA Manager said one animation feature that is extremely helpful, in the cockpit perspective, "gives you a halfway transparent window frame and the frame is moving according to the accelerations that are sensed and recorded. So you get a better idea of what the crew's perception was."

He explained that with some earlier-generation animations, "you just have time points of up to one second between recordings and positions. So it's very much smoothed out; you don't see peaks of certain dynamic values like speed fluctuations or accelerations. This feature of the cockpit window moving like the head would move, it's like you were sitting in there and shaking with the turbulence and get an impression of the acceleration. It's a very good tool." He said that merely applying an acceleration arrow above the animated aircraft is not as effective to get the perception of the crew.

The most complex part of creating flight data animations is trajectory. The problem is not with the animation tools but rather the flight data recorders of older technology aircraft such as the Boeing 747-400 or older model Airbus A320s. "They have a small dataframe, recording for example a GPS (global positioning satellite) position in a very low resolution. You have to use quite complex algorithms to cover all the artifacts to compensate for certain errors in the data from an older dataframe. We're still using the most time in animation to get the trajectory right. It's the all-time number one challenge."

"It's very different if you have a high-resolution FMC (flight management computer) or GPS position or both, like in a newer aircraft. With newer aircraft, better sensors, better data, it's much easier."
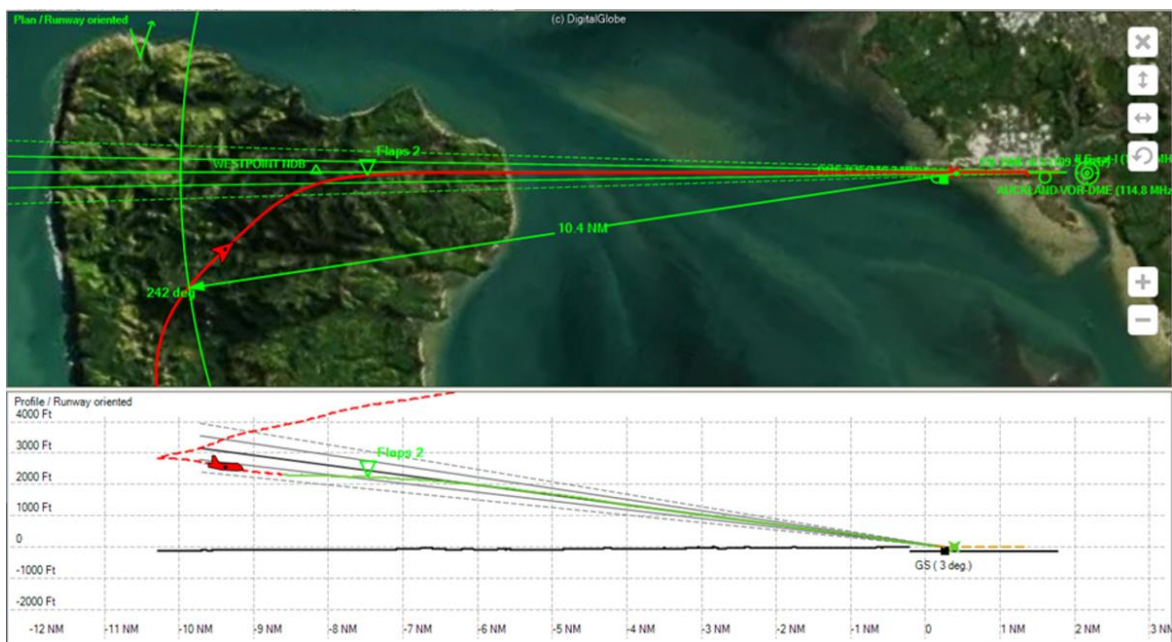

Image courtesy CEFA Aviation

A Flight Data Analyst in Africa with a mixed fleet of jets, turboprops, and helicopters, said, "We analyse our flights every day. When the aircraft comes back, they transmit the data here to our service. This is decoded by the flight data analysis tool with triggers for certain specific events – let's say high-speed approach. And when we see certain specific events we send the data to the flight animation system to give us a better view and a better understanding of what really happened. The 3D is easier to understand than tabular data and graphs. You have the cockpit in front of you; you know what the crew did."

"Not only the cockpit display and main instruments, the animation gives you a 3D aircraft and you have information such as wind magnitude. We can also overlay approach charts and get the meteo. And the animation draws a track so you can compare it with what was calculated, the distance of the aircraft to this point; it gives you the track of the aircraft in Google Earth with terrain information."

"At one glance you have all the information. It's the single tool that brings all the necessary information in front of you."

The airline typically animates one in 10 flights a day, starting from a point about one minute before the aircraft touches down.

"When we see a specific event that we think maybe we should talk to the crew," he explained, "we call in other colleagues who are pilots and they take a view. The head of corporate safety sometimes. We will call in the crew for their views on what happened, how such a situation could have been prevented, what other procedures they could have used to avoid such an event."

On a recent flight into Johannesburg, "We had a windshear warning. It is much better when looking at the animation because you can integrate the cockpit and the weather. You see the wind, how it is changing. You can see the reference to the aircraft."

"In certain cases, we also make an animation video and send it the pilots involved for their viewing and for other crews to use for training."

The Analyst said, "We have queries from engineering and from the air sections who ask us for information. Sometimes a crew comes to us and say we want to review our flight, what happened at this point in time, this approach, this airport. The animation comes in handy."

During regular meetings with the flight training department, "we give information about current trends we have observed over a period of time. Let's say we have noticed something on the approach. They will specifically address this aspect in their recurrent training. For these we also make animation movies and these are provided to the whole community of the crews."

Animations are also shown in the air safety review board attended by the various department heads of the airline. "We showed them an incident we had recently on a particular flight that caused a disruption and delays. We were able to show them what really happened on that day and what was done by the crew to try to avoid the situation."

He said the airline's pilots like the animation tool. "They are astonished what the tool can do, what is recorded, how it is replayed, how it represents the real cockpit, and what happened. They really appreciate the tool."

Image courtesy CEFA Aviation

The Flight Data Manager for a major Asia Pacific airline said, "The animations are quite helpful to the investigators if they are trying to understand the sequence of events. The animation shows the sequence and timing of how things went. It has great value rather than looking at a whole spreadsheet of data; even if you can picture in your head what went on, you have no idea how long that lasted. The animation tool shows you something has changed. It's not easy to find that in a CSV file. For an unstable approach, for example, fleet managers ask us to animate it from the start to find out where the flight could possibly have started to go wrong, when they decided to abort, or what they could have done to improve the situation. "It's so much easier to see it from their point of view from the flight deck."

The airline captures data from about 12,000 flights a month. Of those, perhaps 10 to 15 per month are selected for animation. "We do quite a lot of the Airbus ones because the fleet manager is quite keen to animate."

A 20-year veteran of flight data analysis, the Manager explained that 10-15 years ago, "we would spend about four hours to get a decent animation." Twenty years ago, "there was no animation and a maximum of 12 parameters. We analysed things manually and typed our reports. Now there's an now unlimited number of parameters."

Image courtesy CEFA Aviation

The FDM Specialist for a South American airline processes flight data from about 800 flights a day and produces about 10 animations daily. "If we find something wrong, an error or a violation, we have a gatekeeper who is responsible to contact the pilots. The gatekeeper analyses all flights that we validated and they use the flight data animation to check everything they are seeing and provide feedback and debriefings to the pilots."

Depending on the event, "we send them a print screen of the animation by email to the pilots. They really like the feedback because they can see exactly what happened."

The airline is conducting a study aimed at reducing the number of events related to energy management. A flight data animation is created for each flight with an energy management-related event "so they can realize what went wrong and why they had that problem."

The Specialist said current flight data animation software is "way better than it used to be more. It's more user friendly, and now we don't have to align the flight to the runway every single time. The quality of the animation is better too."

Image courtesy CEFA Aviation

The FDM Safety Officer for a European regional airline opined that, "It's magnificent; visualisation is a much better way to present flights to the crews and to our management."

Most animations are by crew request, although high-risk flights and special events will be animated for management viewing. "We mainly use the tool for situations onboard the aircraft such as a difficult landing."

For training, "we have some special airports rated as CAT B with difficult approaches. To brief the crews in the best way, our training chiefs make several approaches to the airport, and we take the best data and make a video with everything in it, including the charts. It helps a lot."

Excerpts from "Guidance on the establishment of a Flight Data Analysis Program (FDAP) – Safety Management Systems (SMS)"
Australian Civil Aviation Safety Authority (CASA)

Today it is realised by aviation agencies and airlines alike that the practice of routinely analysing recorded data from routine operations is a cornerstone in support of their accident prevention programs. Rather than reacting to serious incidents, operators have a very useful tool to proactively identify safety hazards and mitigate the risks.

FDAP is very useful in identifying exceedences of flight parameters that either indicate an underlying systemic issue or improper operating technique.

Excerpts from a British Airways (BA) industry conference presentation

Operational Flight Data Monitoring, known more recently as Flight Operational Quality Assurance (FOQA), is probably the most important safety tool available to aviation.

Some event types detected by BA's programme:

- Abandoned takeoff
- Altitude deviation
- Abnormal pitch landing (high)
- Approach speed high within 90 secs of touch down
- Climb out speed low 400 ft to 1500 ft AAL
- High rate of descent below 2000 ft AGL
- Land flap not in position below 500 ft AAL
- Deviation above glidepath below 600 ft AAL
- Pitch rate high on takeoff
- Excessive bank above 500 ft AAL
- Excessive pitch attitude
- Stick shake
- Go around from below 1000 ft
- Tail strike GPWS windshear warning

For the more serious events a subset of the data is archived to allow simulation of flight deck instruments and graphic reproduction of flight path. In these cases, detailed feedback is sent to the crew in the form of a few minutes of relevant data and an animation programme for replay on a computer. We are keen to understand why events occur and the crew's honest and detailed account is valuable in helping others to avoid the same event.

Pilots in airlines without FOQA programmes often express concern that the data may contradict their version of the event. However, the opposite is nearly always true.

AeroPerspectives is a communications consultancy based in Geneva, Switzerland and Argèles-sur-mer, France. AeroPerspectives is led by Rick Adams, one of the foremost communications authorities on aviation training, simulation, and safety, and Donna-Lane Nelson, a leading communicator in microfinance. (www.aeroperspectives.com).

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