AEROTECH RESEARCH (U.S.A.), INC.
Aerospace Engineering Consultants

Improving Airport Take-off and Landing Efficiency

"EDR" – a Key Component

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"EDR" – a Key Component

1 Purpose

The predicted growth in air travel over the next 10 years has government and industry very focused on optimizing the efficiency of airspace usage, as well as maximizing the throughput of arriving and departing aircraft at airports.

This White Paper will:

- Describe the need for improved awareness of a prevalent aviation hazard, which needs to be avoided in maximizing airport efficiency.
- Identify and describe a key piece of information needed for this improved awareness, as well as the difficulties in its measurement.
- Describe the way in which the accuracy of these data can be evaluated, thereby quantifying the uncertainty in the estimation procedure.
- Describe AeroTech's key role in developing and testing methods to gather this information, and the ability of AeroTech and partners to provide the information to government and industry.
- Identify how AeroTech's the technology and capabilities described herein are applicable in other aviation safety products being implemented by AeroTech and its partners.

AeroTech Research has played an important role in this process. AeroTech's efforts described in this White paper are directly applicable to the Next Generation Airspace development work being carried out under the Joint Planning Development Office (JPDO).

AeroTech's unique capabilities have established it as a leader in the airborne detection of aircraft hazards.

2 Background

2.1 The Operational Problem

FAA and international organizations are working on how to safely reduce aircraft spacing at airports to get the most traffic in and out of airports as quickly as possible,

thereby maximizing capacity. The question being addressed in these efforts is **"how close can the aircraft be spaced for safe operations?"**

All aircraft in flight leave behind them a pair of strongly spinning wakes from their wing tips. Following aircraft encountering these wakes can experience a loss of control. Therefore, for safety, aircraft are separated one behind the other, based on very specific FAA rules. If the spacing is too large, the throughput of the airport is reduced, thereby reducing the overall efficiency of the national airspace system. If the spacing is too small, safety may be compromised. The hazard from the wakes for a following aircraft is diminished when the wakes move out of the way or decay in strength. Aircraft must have enough distance between them and the aircraft ahead so that they will not encounter these wakes.

2.2 The Need for EDR Data

Wake behavior is a topic that has been studied since the 1960's. It has been found that the time it takes for a wake to move out of the way and decay depends on the conditions of the atmosphere. On a very calm day the wakes may remain in place for a while, and, in windy or unstable conditions, they will move or decay quickly, allowing aircraft to follow each other closer - and more aircraft will land or depart in a given period of time.

There is a critical need for accurate and reliable knowledge of the atmospheric conditions in order to quantify and track the wake hazards. There are many atmospheric parameters required for this knowledge– including an obscure but vital parameter, Eddy Dissipation Rate, or "**EDR"**. This parameter is important because it has been found that wakes decay and disappear quicker in a turbulent atmosphere than in a non-turbulent environment, and EDR is the parameter that quantifies how turbulent the atmosphere is. A large EDR indicates a turbulent atmosphere in which wakes will decay quicker.

3 The Need for Airborne EDR Estimates

One of the most important attributes of EDR is that it cannot be directly measured. Unlike distance or acceleration, which can be measured directly by a measuring tape or accelerometers (respectively), EDR must be diagnosed or estimated using other measured parameters in a formula based on fluid mechanic theory. For this reason the remainder of this White Paper refers to EDR ***"estimates"*** as opposed to "measurements".

The fundamental question arises: "how do you estimate EDR in a way that is useful for deciding how to space arriving and departing aircraft?" Some instruments – called profilers – are fixed on the ground at airports and "stare" straight up into the atmosphere trying to estimate the variations of EDR with height. The problem with the data from these instruments is that aircraft flying on approach or departure may be 5 or 10 miles from an airport when they encounter a wake. An EDR measurement at a far away airport is not useful in assessing what the wake from the aircraft ahead is going to do.

What is needed is the ability to estimate EDR on aircraft and track its variations as the aircraft climbs or descends. Commercial airliners are not designed to be weather stations. Many cannot measure some parameters accurately enough to make a good EDR estimation. There are several ways to estimate EDR and the best method to use depends on the aircraft platform itself – and its onboard sensor capabilities.

If there is no way to get a direct EDR measurement – or "truth" – in order to assess how well the onboard systems are doing, the question now arises: ***"how accurate are the EDR estimates produced?"***

The answer to this question is simple to state but complex in practice. The accuracy of EDR estimates is assessed by using them for specific functions – to help in predicting the decay time of a wake - which is something that can be measured with current laser systems. In fact, NASA and FAA have research programs to do just that. The process is then to use the aircraft derived EDR (and other parameters) in the wake prediction models and compare the outputs with the measurements as part of a well defined and manageable process.

4 The Solution – AeroTech Provides the EDR Data

AeroTech has spent over 13 years testing EDR estimation techniques on research aircraft and commercial aircraft to refine several techniques. In the process, AeroTech has developed unique capabilities in the estimation of EDR on multiple aircraft platform types. The following table lists AeroTech's cooperation with NASA and FAA on several key EDR efforts:

AeroTech Cooperation with NASA and FAA

Dates	AeroTech's Responsibilities
1997 – 2001	AeroTech selected by FAA to correct and optimize EDR algorithms installed on United Airlines aircraft.
1998 – 2001	AeroTech selected by NASA to test multiple different EDR algorithms on NASA B-757 research aircraft.
2003	AeroTech selected by FAA to process EDR data from commercial aircraft at Juneau, Alaska.
2003 – 2004	AeroTech selected by NASA to process commercial aircraft flight data into vertical profiles for NASA's Wake Vortex Advisory System program.
2008 – Present	AeroTech selected by NASA to develop a real-time wake vortex encounter detection reporting system, including AeroTech's EDR profile generation algorithms.

2009 – Present	AeroTech selected by FAA to identify and quantify wake vortex encounters from flight data. This is the precursor to further analysis of events including EDR estimation to verify FAA/NASA wake prediction algorithms.

Over the years, AeroTech has processed flight data from several airlines (both directly and through its clients), including:

- ✓ United Airlines
- ✓ Alaska Airlines
- ✓ UPS
- ✓ Delta Air Lines
- ✓ Frontier Airlines
- ✓ US Airways
- ✓ Cathay Pacific
- ✓ EVA Air

There are other applications for reliable EDR data, in particular from aircraft operating at cruise altitude (or "en route"). Unexpected turbulence encounters are the leading cause of injuries in the aviation industry today, and to address this problem, AeroTech developed the Turbulence Auto-PIREP System (TAPS®), which automatically reports turbulence encounters from aircraft in real-time and disseminates the information to airlines. TAPS® was developed by AeroTech with NASA and is currently on 180 airliners with more coming online. Recognizing the importance of EDR to the forecast community, AeroTech added EDR to the TAPS® data stream in 2005. EDR from TAPS® can be used for forecasting regions of turbulence that may affect flight. Comparing the forecast turbulence to the real-time reports of turbulence severity can result in much better forecasts as well as better avoidance of the severe turbulence – and fewer injuries.

Clearly EDR is an important parameter for a number of uses, and AeroTech has established and demonstrated unique capabilities in:

a) Real-time estimation and reporting of EDR and other turbulence data on aircraft,

b) The processing, evaluation, and dissemination of this information to meet a variety of users' needs, and

c) The integration of the data with other systems and data sources.

Incorporating these capabilities in its products has established AeroTech as a leader in the airborne detection of aircraft hazards. AeroTech, and its partners, have the expertise and infrastructure to be able to provide these data to government and industry as a reliable data source.

5 Summary

- EDR is an important constituent in characterizing turbulence in the atmosphere and AeroTech has unique capabilities to estimate EDR on aircraft.

- NASA and FAA have selected AeroTech in the past to provide the capability of EDR estimations on commercial and research aircraft.
- AeroTech and its partners have the capability to make this estimate on aircraft and to assess its effectiveness for wake vortex and flight safety applications.
- Both NASA and FAA have been, and continue to be, supportive of AeroTech's efforts, which also support several JPDO goals.
- Reliable EDR data is important for both aircraft spacing on take-off and landing (*airport capacity*), as well as for forecasting regions of hazardous turbulence en route (*aviation safety*). AeroTech has developed solutions for both applications.
- It is AeroTech's goal to provide reliable and consistent data for multiple users.
- AeroTech is a leader in the field of EDR estimation for multiple uses.

6 About AeroTech Research

AeroTech Research has been a leader in the field of atmospheric hazard detection and avoidance since 1994. AeroTech's mature technologies detect and report wind shear and turbulence hazards. AeroTech's proprietary technologies are protected by patents and patents pending.

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