2016 Statistical Analysis of EWIS Failures of the US Commercial Aircraft Fleet ... and How to Improve
Foreword

Aircraft that are more than 20 years old are twice as likely to have EWIS failures than newer platforms. Many of these failure events lead to emergency landings or grounding of the aircraft which cost airlines millions of dollars each year. This white paper is a review of FAA data for five major airlines to identify the scope of EWIS problems in the US commercial airline fleet.

As you read through this white paper, please think of how much of the EWIS has evolved over the last 20 years on aircraft and how the maintenance of your aircraft could be improved by directing maintenance to the correct locations and head off EWIS failures before grounding of your aircraft or create the need for emergency landing.

- Lectromec Editorial Team
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>3</td>
</tr>
<tr>
<td>EWIS as the Problem</td>
<td>4</td>
</tr>
<tr>
<td>Dealing with No Fault Found</td>
<td>4</td>
</tr>
<tr>
<td>Data Gathering and Evaluation</td>
<td>6</td>
</tr>
<tr>
<td>Results</td>
<td>7</td>
</tr>
<tr>
<td>What is the Cost?</td>
<td>8</td>
</tr>
<tr>
<td>Aircraft Age and EWIS Reliability</td>
<td>9</td>
</tr>
<tr>
<td>The Solution</td>
<td>10</td>
</tr>
</tbody>
</table>
Introduction

For both narrow body and widebody aircraft, the amount of wire and cable can range from tens to hundreds of miles. When all of the connections, clamps termination, splices, and other wiring system support equipment are considered, there are hundreds of thousands of electrical wiring interconnect system (EWIS) components on a modern aircraft.

Naturally, as these components support an ever-growing array of EWIS tasks, many of them become mission-critical. The frequency of component inspections must increase alongside improved assessment and analysis capabilities. This is the field where Lectromec excels.

Requirements, issued by the regulatory authorities, on EWIS specify the legal obligations of manufacturers and operators; but, regulations themselves cannot convey the importance of EWIS. To understand the importance of EWIS requires conveying the impact it has upon aircraft systems and fleet operation. The commercial aircraft service difficulty report data available from the FAA makes it possible to quantify the impact. Many of the in-services EWIS failure instances were reported with descriptions of smoke, fire, and emergency landings. Each one of these issues cost an airline in direct revenue and in public perception.

This white paper covers work and research done by Lectromec to determine the scale and the frequency of EWIS related failures among U.S. carriers in 2016. Lectromec’s intention with this white paper is not intended to scare the industry into action, but rather, to enlighten the industry as to the scale of the problem and recommend solutions to improve the aircraft reliability.
EWIS as the Problem

Why is it so hard to handle EWIS? Why has the wiring system been relegated in importance? The aerospace industry has done the tremendous job of addressing structure and engine problems and an incredible level of effort has gone into health utilization and monitoring of these systems. But with the wiring system, the problem is often hidden behind layers of maintenance data and in the failure modes of these components.

Dealing with No Fault Found

Lectromec has written frequently on the impact of No-Fault Found (NFF) cases in aircraft maintenance. When a system error occurs, the first maintenance action is to replace the device that reported the error in the hope the issue is resolved. Often, the device is inspected and tested without detecting any fault – thus No-Fault Found. The cycle repeats and can continue for many iterations before maintainers evaluate the true cause is the wiring system (Lectromec has a full article on NFF). When the U.S. Department of Defense reviewed the scale of the problem, they estimated that NFF cost the DoD $2 billion annually (Report here).

What could the scale of the problem be for commercial airlines?

The true problem with the NFF cycle is that it hides the scale of EWIS issues within a fleet. Multiple efforts combing through maintenance databases have found that many NFF events could be traced back to wiring issues. Further, issues involving wire system component failure are often associated with the system they support and not the EWIS. This increases the difficulty of bulk data searches as manual review and assessment is necessary to determine the problem origin.
What do you see when you look at this picture? Is it the pump? Or the hydraulic tubing?

What about the 11 electrical connectors, or the 27 wire clamps, or the 500 wires? What about the overloaded ground stud or the wire harness resting on a fuel line? What about the undersized bend radius for the wire harnesses?

It is easy to miss EWIS issues, but they can be identified and resolved. Lectromec can help.
Data Gathering and Evaluation

For this effort, Lectromec used as a primary data source the Federal Aviation Administration’s (FAA) Service Difficulty Reporting system (SDR) database. The SDR database is a voluntary system that provides insight into the maintenance actions taken by airlines. Lectromec has a more comprehensive explanation system.

A key feature of the SDR database is the capability to search and filter. For this research, Lectromec chose the following data for review:

<table>
<thead>
<tr>
<th>Filter Topic</th>
<th>Criteria</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Types</td>
<td>Wire</td>
<td>Other EWIS components could have been added to the evaluation (see Lectromec’s article on FAA regulation <a href="#">25.1701</a>), but these were selected with the hope of identifying the bulk of EWIS failures.</td>
</tr>
<tr>
<td></td>
<td>Cable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Connectors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wire harness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Circuit Breakers</td>
<td></td>
</tr>
<tr>
<td>Time Period</td>
<td>Jan 1 – Dec 31, 2016</td>
<td>It can take more than 60 days for new entries to appear in the SDR database. Lectromec choose to limit the search to 2016 as all data should be available.</td>
</tr>
</tbody>
</table>

In a service difficulty report, there is a description of the problem, some descriptions are more verbose than others, and an explanation of what was repaired. Often, the problem description includes the means of how the fault was detected. During the review of this information, special care was taken to go through each problem description and identify issues that involved smoke or fire and those that required the aircraft to be grounded, diverted, and/or an emergency landing.

Any report where the issue could not be re-created or traced to a particular issue (such as NFF) was dropped from the overall data analysis.

An important challenge with the data review was the significant variability and terminology used between those that reported the issue. While many of the records
use a common vernacular and common spelling abbreviations, sufficient spelling variations and abbreviations required the need for records to be manually evaluated.

As an example: many of the events included emergency pathway or emergency lights; these need to be differentiated from actual in-flight emergencies or cases where the aircraft was grounded or diverted.

Results
The initial search using the parameters specified earlier identified more than 2,000 reports. After filtering out the non-applicable reports, 1,265 unique failure reports remained. The following reports are a sample of what was found during the evaluation. Changes to the problem report have been made for clarity.

<table>
<thead>
<tr>
<th>Incident Information</th>
<th>Problem Report</th>
</tr>
</thead>
</table>
| Aircraft: Bombardier 100  
Reported as: Windshield issue | While descending through fl180, the flight crew detected a strong odor, followed by smoke and fumes coming from the lower left side of the pilot’s wind screen. Crew donned their O2 masks and immediately turned off the windshield heat.  
An emergency was declared.  
The smoke eventually subsided and an uneventful landing was accomplished.  
Maintenance found several shorted/burnt wire terminal rings at the windshield heating element terminal block; cause unknown at this time. |
| Aircraft: BOEING 757  
Reported as: Wire Harness Issue | Aircraft was grounded. Emergency declared. During approach when flaps 5 degrees selected received EICAS message "TE FLAP ASYM " and flaps stopped at 2 degrees. Found damage to #7 skew harness at connector d8970.  
Repaired harness in accordance with standard procedures. System checks normal. |
| Aircraft: BOEING 737  
Reported as: Connector Issue | While performing standard maintenance, found NR 2 engine fault code 75-10802, t25 signal disagree, short term. Aircraft grounded.  
No longer present. Fault now shows fault code 75-30802 all flight legs.  
Accomplished alternate deactivation procedure, used in accordance with standard procedures.  
Accomplished wire checks from connectors DP909 and DP1010 to sensor T25 a & b channels all within limits.  
Removed connectors at T25 found connector for channel a, DP910, has evidence of moisture in connector.  
Cleaned connectors Also checked resistance of both channels and found to be within limits reconnected all connectors.  
Accomplished repair confirmation test, test passes. |
Further, it was necessary to review the records and differentiate actual events from those that could not generally identify the component. Many of the events were associated with smoke and fire as the means for detection of the failure event.

Of the failure events examined for the five major airlines reviewed in this effort, more than 21% of the incidents resulted in the grounding of the aircraft, an aborted takeoff, or required an emergency landing diversion.

An important note here is that not all failure events recorded in the SDR database included information about how the fault was detected. As such, Lectromec believes that the 21% figure stated above is underestimated and that a much greater frequency of the overall failure events could be attributed to the grounding of an aircraft.

**What is the Cost?**

An estimate, available online, suggests that for an Airbus A330, a monthly leasing price is roughly $500,000. Using this as a cost basis, and further assuming each aircraft requires at least one day for maintenance to troubleshoot the error, the 159 EWIS failures causing grounding and emergency landings contribute to a minimum of $3 million of idle equipment each year.

Furthermore, a total of 40 emergency landings, diversions, aborted takeoffs are part of this data set; assuming most airlines have roughly the same emergency failure rates pertaining to EWIS related issues, this could be roughly 70 incidents annually. A review of costs associated with emergency landings and diversions suggest a potential cost upon the airline to be between $10,000 and $200,000. If we assume $100,000 per aircraft diversion, EWIS failures cost an additional between $4 million and $7 million annually.

Yet the financial impact of emergency landings and grounded aircraft may not be the largest cost. If NFF scenarios occurred in as few as 10% of the ‘Other’ situations, NFF
could be the cause of **tens of millions of dollars of aviation hardware sitting idle**. This can truly be a significant hidden cost that EWIS failures impose upon the industry.

This figure shows the total number of EWIS related failures reported in 2016 among five major airlines. Note that these have not been normalized to the actual aircraft numbers used by these airlines or any effort to include leased aircraft. But for some fleets, it is nearly once a day that a maintenance issue is created attributed to EWIS component failure.

The unfortunate part is that the problem does not get easier with age. In fact, problems become more common.

**Aircraft Age and EWIS Reliability**

It is natural to assume that as a component ages, the reliability of a component decreases. Thirty years of Lectromec investigations, reports, and presentations on this topic have shown examples of degraded EWIS. This data set continues to support that conclusion.

First, the evaluation of the EWIS failure rates are based on the total aircraft time. Total aircraft time considers all the operation time of the aircraft without regard to its calendar age. The histogram below shows that EWIS failures are relatively random across the spectrum of reported failures with the exception of aircraft with 30-40k hours.
However, this does not tell the full story. Lectromec further evaluated these numbers and found a noticeable increase in EWIS failure rates as the planes aged. Lectromec’s analysis indicates that older aircraft (> 25 calendar years old) are almost twice as likely to experience EWIS failures than aircraft only 15 years old. With the introduction of more electric aircraft into commercial fleet, the potential cost of EWIS failures is only going to increase.

The Solution

Obviously not all risk can be avoided or mitigated, but steps can be taken to reduce the likelihood of failure. This can come in two parts: improvement in focused maintenance and identifying where EWIS components are most susceptible to failure.

Lectromec’s wire system evaluation techniques in identifying where the EWIS is most susceptible, to observe and measure degradation, have significantly evolved over the last 30 years. This evolution of technique and earned expertise make it possible to identify the remaining reliable service life of the EWIS. This method has been
used on numerous platforms, sometimes as part of supporting maintenance efforts, but frequently in support of thorough EWIS evaluations and service life extension programs.

The outputs from these efforts have been used to identify replacement of EWIS, augment maintenance procedures, and help with identifying the sun setting of aircraft.

For those looking to determine the business case and potential cost for extending the life of an aircraft, understanding the remaining EWIS service life is of critical importance, not only for its potential interruption to service, but the strain it will place on the supply chain for replacement components when dealing with incorrectly diagnosed faults.

Many of the procedures and techniques involved in Lectromec’s process are captured in the U.S. military’s handbook on service life extension and EWIS assessment. This process is now part of a standardized process for fleet sustainment where the procedures and techniques are well vetted and can be applied to any platform.

A reliable safe EWIS is possible. Lectromec’s team and methodical process is ready to help you improve your aircraft EWIS reliability. We have helped dozens of fleets identify the condition of their EWIS and help craft plans for long-term reliability. There is no reason why you should not take care of your fleets EWIS needs with the same dedication that the engines and structures receive.

ewisSolutions@lectromec.com

+1 (703) 263 - 7100

4230-K Lafayette Center Drive

Chantilly, VA 20171