Improving Aircraft Reliability with Focused EWIS Sustainment Assessment

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Foreword

This white paper is a case study on recent work performed for the US military to achieve EWIS sustainment of an aircraft fleet. This is a review of thousands of man-hours to provide clear data-based EWIS sustainment recommendations affecting more than 300 aircraft.

This white paper has been written for the purpose of helping system engineers and fleet managers in need of solutions to address their fleet sustainment needs. For the managers in the audience, we will keep the science and math to a minimum.

As you read through this, we ask that you consider the current condition of your fleet, how it is maintained, and how you plan to maintain or improve its reliability. Making good, data-backed engineering decisions through the sustainment process is the best way to ensure a reliable and safely operating wiring system.

- **Lectromec Editorial Team**

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Executive Summary

In this white paper, we discuss a recent successful implementation of Lectromec's Electrical Wire Interconnection System (EWIS) Service Life Extension Program (SLEP) process for the US Military. The work has provided the following clear-cut benefits for the US military:

- Identified the current health of the fleet's EWIS.
- Determined the need for EWIS component replacement and provided a **recommended replacement schedule**.
- Determined what can be done from a maintenance perspective to maintain the reliability of the aircraft and provided a **recommended inspection schedule**.

This focused EWIS assessment has made it possible for fleet maintainers to make informed data-based decisions on system sustainment activities.

Introduction

The longevity of aircraft performance is dependent on sustainment activities throughout the aircraft's life cycle. These sustainment activities may include routine maintenance inspections, life limiting parts, and/or proactive part replacement. Many aircraft components, particularly engines and structures, have guidelines on when parts should be inspected and/or replaced. As methods for aircraft sustainment have evolved, so has the guidance. For the military, the last several years have included significant improvements in the mechanical subsystems service integrity programs (or MECSIP) covered in MIL-STD-1798. This standard was improved in 2013 when the MECSIP community adopted EWIS sustainment into the latest revision to highlight the importance of EWIS in aircraft sustainment.

Managing a fleet of aircraft involves more than just sustainment of the engines and structures. At some point in the SLEP process, it becomes necessary to look at the wiring system.

In this white paper, we will go over recent work performed by Lectromec to support the US Military with a recent Service Life

If I am familiar with Lectromec's work, why should I read this?

This white paper includes discussion of significant improvements in Lectromec's EWIS life extension services.

In addition to several improvements in the process and background research, the process now shows alignment with the system sustainment requirements defined in MECSIP document MIL-STD-1798.

Lectromec's Previous Service Life Extension Services (1984 – 2014)

- Harness replacement recommendations based on field data and research
- Rudimentary description of results and impact on fleet.

Lectromec's New Service Life Extension Services (2014 – Present)

- Improved predictions of system performance (less conservative – more aligned with actual performance)
- Recommendation on harness replacement
- Recommendations on initiation of maintenance actions.
- Clear definition of result implications on the fleet.
- Aligns with existing SLEP MECSIP requirements

Assessment Program (SLAP)/SLEP effort. Please keep in mind that the technologies, methods, and research to make the assessments possible have been part Lectromec's ongoing effort to predict EWIS performance. Dozens of fleets have benefited from these assessments.

Established in 1984, Lectromec is an engineering firm specializing on aerospace wire system safety and sustainment.

We can help your organization ensure that your wires satisfy industry operating standards, meet regulatory safety standards, and are maintained efficiently and effectively.

The Beginning of Fleet Assessment

It was determined that, in order to meet force readiness levels, a US military aircraft fleet service life required a service life extension. Some of the aircraft in this fleet had already reached and exceeded the end of the originally designed service life. In addition to review of the structures, engines, and other system components, the EWIS was added to the list of systems in needed of assessment. In particular, their concerns were similar to those that many face when looking to extend the life of an aircraft beyond its original certified life.

The concerns could be summarized in the following three questions:

- What do I need to do to ensure the aircraft's EWIS is reliable for the next 10/15/20 years?
- Are we going to need to replace all/any of the wiring on the aircraft?
- How can I get the data to make an educated decision?

Lectromec's turn-key solutions for EWIS sustainment assessments make it possible to address these concerns in a timely and regimented fashion. The following sections will discuss the challenges faced by the US military in their fleet assessment and how they were addressed with Lectromec's EWIS SLEP services.

The EWIS SLEP Process

Maintaining aircraft systems has been part of the aerospace industry for decades, but the particular requirements for the wiring system are relatively new. It was not until 2011 that the United States Air Force (USAF) undertook an effort to establish guidance for EWIS Integrity Programs in the form of MIL-HDBK-525. This handbook provides a comprehensive method for assessing an aircraft's EWIS condition for service life extension and ensuring continued airworthiness. Before this guidance, there was not a consistent method by which maintainers would determine their platforms' EWIS system's health, leaving each group to develop their own means for assessment.

The EWIS Integrity Program strives to achieve consistency by providing the necessary guidance on how to utilize aircraft data (maintenance, data availability, financial constraints, etc.) to determine the most accurate EWIS component life span.

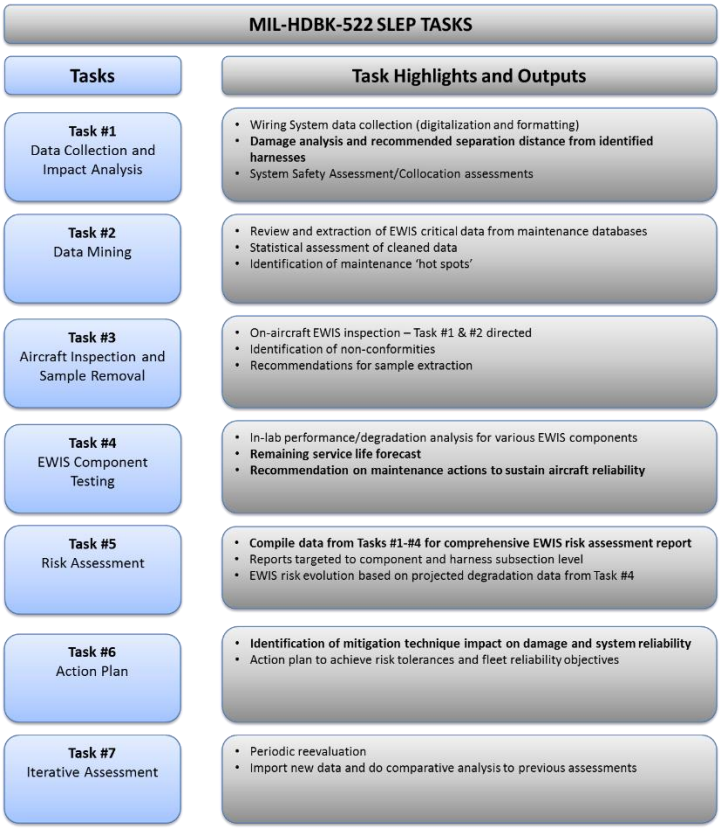
[Lectromec has a 13 minute video introduction to EWIS SLEP]

The key to defining any sustainment action is using the combination of probability of failure and failure severity to determine risk. The handbook provides details on a seven step process for identifying EWIS risk to a platform.

Each task generates information that can be directly beneficial for data-driven decisions. Although the process needs to be tailored to the needs of each fleet, it must be focused on supporting the end goal of maintaining or improving fleet reliability.

How Does EWIS Assessment fit into the SLAP/SLEP process?

Service Life assessment and Service Life extension are two parts of the same process. The Service Life assessment part looks to determine ***if*** *a fleet is viable* for continued service and what might be necessary in order to achieve that. The service life extension part determines ***how*** *to make a fleet viable* for the extended service life of the platform. The EWIS evaluation can occur at any point during the Service Life assessment process. Depending on where you are in this process, different levels and assessments can be done. If the EWIS assessments are performed late in the overall SLEP effort, then the evaluations and assessments can be tailored accordingly to generate information that can be used for data-driven decisions.



Proven Implementation

Starting in 2009, the US military knew they had to look at the wiring system and identify what they need to do to maintain an aircraft fleet. At that time, there was no process and no defined guidance for doing the type of EWIS assessment that was necessary to determine what should be done with the hundreds of aircraft in the fleet.

Without being able to identify the condition of a life-limited part, such as wiring, the overly conservative approach would have been to replace every harness. For many organizations, the time and financial impact of such an endeavor is cost prohibitive. Consequently – as it should have been – full harness replacement was seen as a last resort. So, rather than replace every harness on the aircraft, a more systematic approach was selected – one in which data-driven decisions would be made.

It is at this point that the US military contacted Lectromec to identify what could be done to maintain their fleet. After several discussions, Lectromec was able to identify the critical areas and factors that needed to be focused on during the EWIS assessment. This examination of critical areas started with an aircraft zonal evaluation identifying environmental, operational, and maintenance commonalities for locations within the aircraft and created subgroups with common attributes. The creation of these subgroups reduced the total number of compartments necessary to be opened for EWIS component extraction. Further, this meant there were fewer zones in need of laboratory degradation examination.

By reducing the number of aircraft locations that needed to be evaluated meant that the overall size and complexity of harness removal was significantly decreased. Requiring fewer doors to be opened meant that fewer components had to be removed for wire harness access and removal.

The next task was to determine how many aircraft will need to be evaluated. The service history and fleet utilization will have an impact on the total aircraft needed for degradation assessment. Typically, to get a good understanding of a fleet, 3-5% of the aircraft needed to be evaluated.

Once the aircraft have been selected and the components to be removed have been identified, an extraction team visits the aircraft. The locations are photographed pre and post extraction and reviewed for any concern areas. The samples are then boxed and shipped to Lectromec for in-lab testing and degradation evaluation. In the US Military case study, the aircraft chosen for sample extraction were selected by the US Military based on availability and aircraft age.

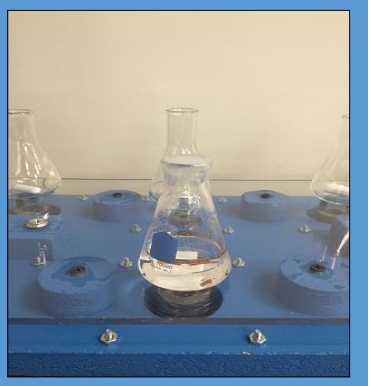
During the extraction, both US Military and Lectromec personnel were on-site for the wire harness removal. For the aircraft being tested, it was determined that it was easier to remove the entire harness for testing rather than individual wire segments (depending on your platform, it may be easier to pull individual wires).

Before and after harness removal, each location was inspected by Lectromec to identify and document areas of concern, uneven wear on components, chaffing, chemical exposure, heat damage, proximity to critical component (pipes, fuel tank), and violation of best wiring practices were identified. This was included in the after-extraction report.

ARE THERE CIRCUMSTANCES WHERE FULL HARNESS REPLACEMENT MIGHT BE WARRANTED?

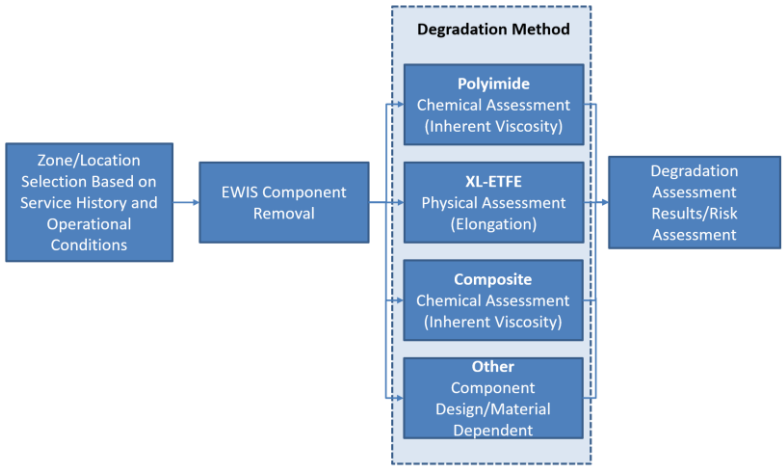
Yes. There have been some cases where the benefit of full wire harness replacement has been warranted. These were cases were older aircraft that have undergone dozens of mods added a lot of wire and also left a lot of wires unused after the original system they supported was replaced or upgraded.

This helped to make the aircraft lighter, ease maintenance actions (as there were fewer unused wires hanging around), and improved routing by providing additional space to reduce chaffing hazards.



Wire Assessment

Lectromec has and continues to perform degradation research on most wire types found on aircraft. The particular assessment method varies from insulation type to insulation type, but each insulation type has an associated degradation model. As such, regardless of the material type, it is possible to forecast EWIS component reliability up to 20 years in the future.



Outputs from the Fleet Assessment

Upon completion of the harness evaluation, three areas are covered in the final report: aircraft current condition, replacement prediction, and maintenance prediction. Each area provides insights into the fleet's EWIS condition and guidance on actions necessary for aircraft sustainment including recommended inspection and replacement schedules to provide the best return on investment for maintenance actions.

Further, the assessment can be used to make immediate data-driven decisions based on current harness condition and fleet needs, providing direction on where maintenance actions can be allocated to improve EWIS performance.

Replacement Prediction

Replacement Prediction allows us to see the potential degradation of the EWIS components over the next 20 years. The benefit is that you can see how your system will perform as it ages and have enough time to plan, prioritize and budget for replacement actions.

HOW GOOD ARE THE PREDICTIONS?

Using the degradation projections from the US Military fleet provided an estimated number of wires that would be at or near insulation failure condition.

For several of the harnesses tested, they were also evaluated via Lectromec's DelTest method. This DelTest method is able to identify insulation breaches of any wire in a harness (best performed in lab conditions).

The number of insulation failures found in the harness was a direct match to the number of failures estimated by the degradation model.

Across the ten harnesses tested, the results were accurate to within 5%.

Maintenance Prediction

This is an analysis Lectromec has been working on further developing since 2014 and is excited to apply to more systems. Using the same test data gathered for replacement prediction as a basis, Lectromec's research, and historical data, paired with statistical analysis, we are able to see when age-related failures will start to appear. For example, we can look at a harness that has 100 wires and be able to answer whether this harness needs to be replaced when only one wire reaches its 'end of life' or when the harness reaches a point where it is unlikely to prevent a significant event before the next maintenance cycle.

	Years	Zone #1	Zone #2	Zone #3	Zone #4
Best Case Condition	0	71%	64%	61%	86%
	5	67%	60%	56%	83%
	10	64%	56%	52%	81%
	15	61%	52%	48%	79%
	20	58%	49%	44%	77%
Worst Case Condition	0	68%	61%	58%	82%
	5	64%	57%	53%	80%
	10	61%	53%	49%	78%
	15	58%	49%	45%	76%
	20	55%	46%	42%	75%
Years Until Recommended Replacement (Best Case)		>20	18	12	>20
Years Until Recommended Replacement (Worst Case)		>20	14	9	>20
Years Until Recommended Inspection (Best Case)		9	0	0	>20
Years Until Recommended Inspection (Worst Case)		4	0	0	>20

Thus, the value of performing scenario analysis on harness maintenance, is that you can see what the impact will be on aircraft reliability depending on the condition of the aircraft. In turn, allowing managers to make data-driven decisions.

This data will then be combined with other data gathered during the SLEP process. For more information about the implementation of the MESCIP MIL-STD-1798 requirements for EWIS (fully described in MIL-HDBK-525), Lectromec has an eight-part series of articles.

Matching the Results

Projections are great, but they are useless without matching with actual data. To verify the recommendations, the same harnesses extracted for degradation testing were also examined for existing insulation breaches. When averaged within each aircraft zone examined, the actual number of wire insulation failures closely tracked with the predicted number of breaches.

Impact

With the data gathered from testing and analysis, the US Military has been able to develop a data-based plan of action for fleet sustainment. Of particular benefit to the fleet, the assessment identified only a limited group of aircraft zones where replacement would be necessary in the coming years. Additionally, the recommended maintenance actions and inspection intervals make it possible to have a data-based action plan to maintain the aircraft reliability until replacement is needed.

Get Started

EWIS sustainment is a complex process that can be simplified through a focused effort that can deliver real value to fleet managers and maintainers. Regardless of where you are in the SLAP/SLEP process, consider augmenting your existing processes with EWIS assessment.

To get started, contact Lectromec to find out more about our fleet sustainment technologies.

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