GORE-FLIGHT®
Microwave Assemblies

# REDUCING LIFE CYCLE COSTS WITH RELIABLE AIRFRAME MICROWAVE ASSEMBLIES

White Paper

*Together, improving life*

# Abstract

Aircraft manufacturers can no longer afford the total costs associated with airframe microwave assemblies that fail because of rigorous installation and the extreme conditions of aerospace. W. L. Gore & Associates evaluated the performance of microwave airframe assemblies before and after installation. This testing showed that performance of many assemblies degrades significantly because they get damaged during installation, which results in increased costs, production delays, and additional testing to requalify system components. Selecting a durable cable assembly that has been tested to survive challenging aerospace applications is the key to reducing costs and ensuring reliability over time.


## Introduction

A recent study[1] conducted for the aerospace industry showed that 64 percent of respondents expect assemblies to fail before the end of the service life of the aircraft. Over time, manufacturers have just accepted the practice of replacing assemblies that fail frequently — causing additional retesting, delayed production schedules, increased maintenance and downtime, and cable replacement costs. In today's economy with cost pressures and tighter budgets, manufacturers can no longer afford the total costs associated with airframe microwave assemblies that do not withstand the installation process and the extreme conditions of flight. They need a low-risk solution that withstands the rigors of installation and reduces the total cost of ownership, so they can fit and forget.

W. L. Gore & Associates (Gore) evaluated the durability and performance of microwave airframe assemblies before and after installation. Using a cable installation simulator that they designed[2], Gore replicated the conditions an assembly experiences while being routed during installation in an aircraft to evaluate the stress on the assembly (see Appendix 1 for a description of the installation simulator).

Gore compared a leading alternative airframe assembly with GORE-FLIGHT® Microwave Assemblies, 6 Series, both with similar specifications. They tested the insertion loss and VSWR prior to installation to see how they performed when brand new (Figures 1 and 2). The results were recorded over the range of 0.0225 GHz to 18 GHz and served as a baseline to evaluate any performance change after being routed through the simulator.

**Figure 1: Insertion Loss of new cable assemblies before installation**

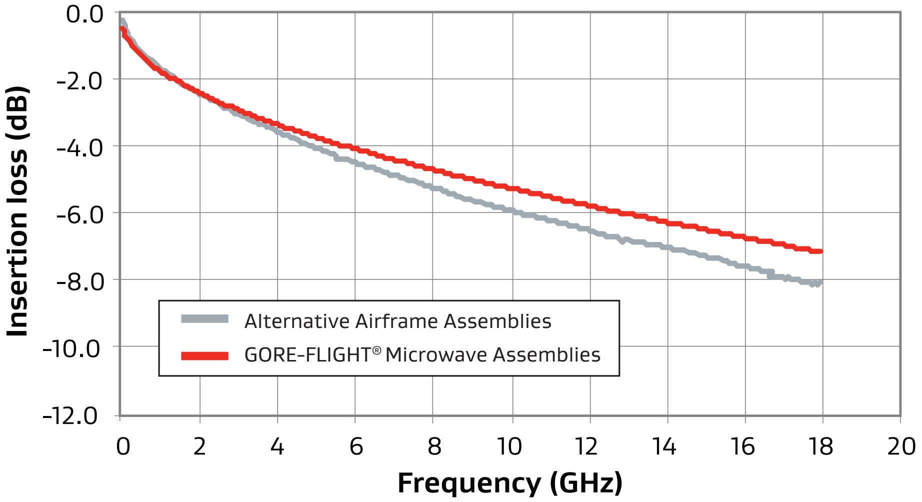
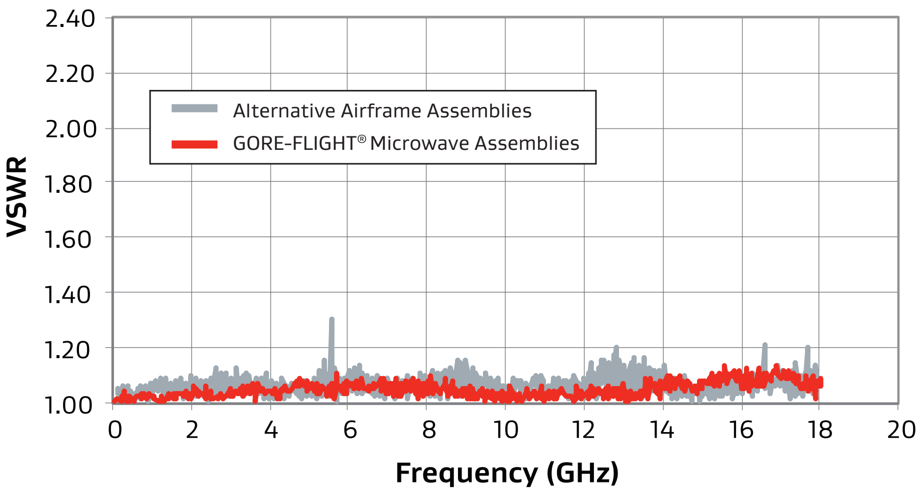


**Figure 2: VSWR performance of new cable assemblies before installation**

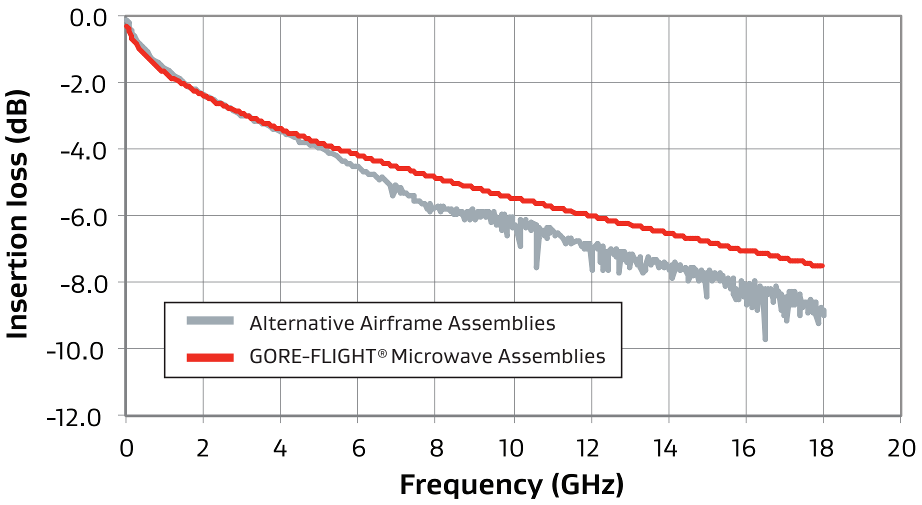



The assembly was routed through all the features of the simulator to mimic typical installation practices. The simulator has several features that replicate minimum bend radius conditions, routing guides to induce torque, and an abrasion bar to simulate routing across sharp edges and through access holes in the airframe structure. The assembly was then connected to a Vector Network Analyzer (VNA) to test the insertion loss and VSWR after installation[3].

## Insertion Loss after Installation

The results showed that after only two cycles, the insertion loss of the alternative airframe assembly changed significantly with higher frequencies, indicating unstable performance after installation (Figure 3). In comparison, GORE-FLIGHT® Microwave Assemblies, 6 Series maintained lower insertion loss after three cycles — providing stable and accurate system performance after installation.

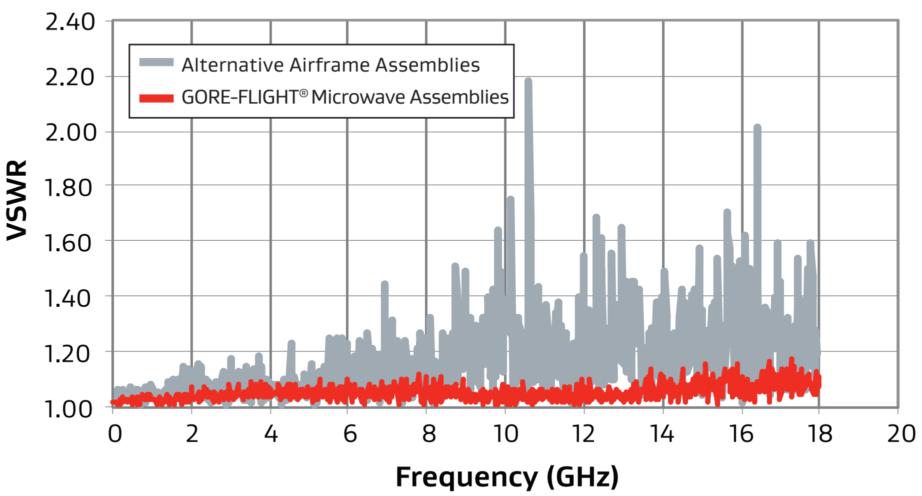
**Figure 3: Insertion loss of cable assemblies after installation**



## VSWR after Installation

Gore's test also showed that the alternative airframe assembly was compromised by the installation process and experienced significant changes in VSWR impedance uniformity (Figure 4). However, GORE-FLIGHT® Microwave Assemblies, 6 Series maintained more reliable VSWR with less change in impedance. The 6 Series maintains consistent impedance of 50±1 ohms during installation, providing no major deviations in broadband VSWR performance and improving overall system response, especially on cascaded cable runs.

**Figure 4: VSWR performance of cable assemblies after installation**




## Durability

Gore conducted a shake stability test, which is an excellent indicator of the overall performance and stability of an assembly. The assembly's insertion loss trace was normalized to 0 dB on the VNA, and then the assembly was forcefully shaken against a hard surface. GORE-FLIGHT® Microwave Assemblies, 6 Series achieved less than 0.02 dB of change through 18GHz, whereas the insertion loss of the alternative airframe assembly changed almost 0.25 dB through 18GHz (Figure 5). The results indicated that Gore's assemblies have a more durable construction, enabling them to withstand the rigors of installation (Figure 6).

**Figure 5: Shake stability results of cable assemblies**

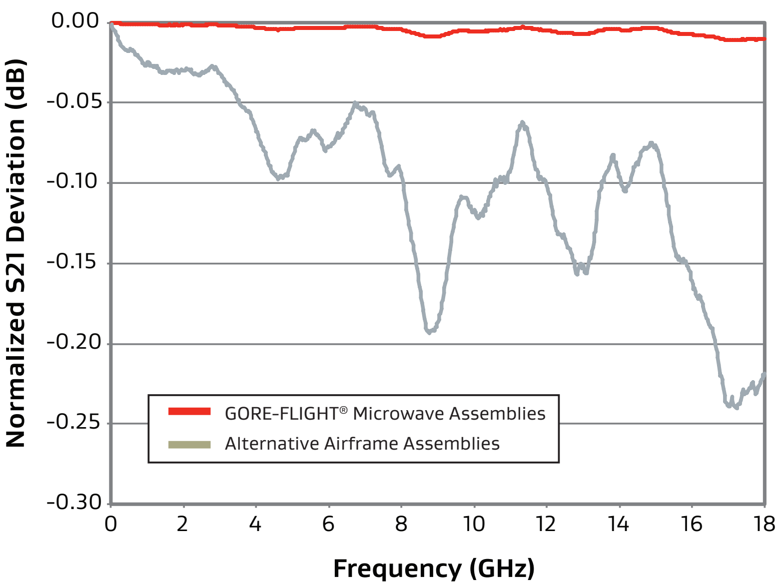
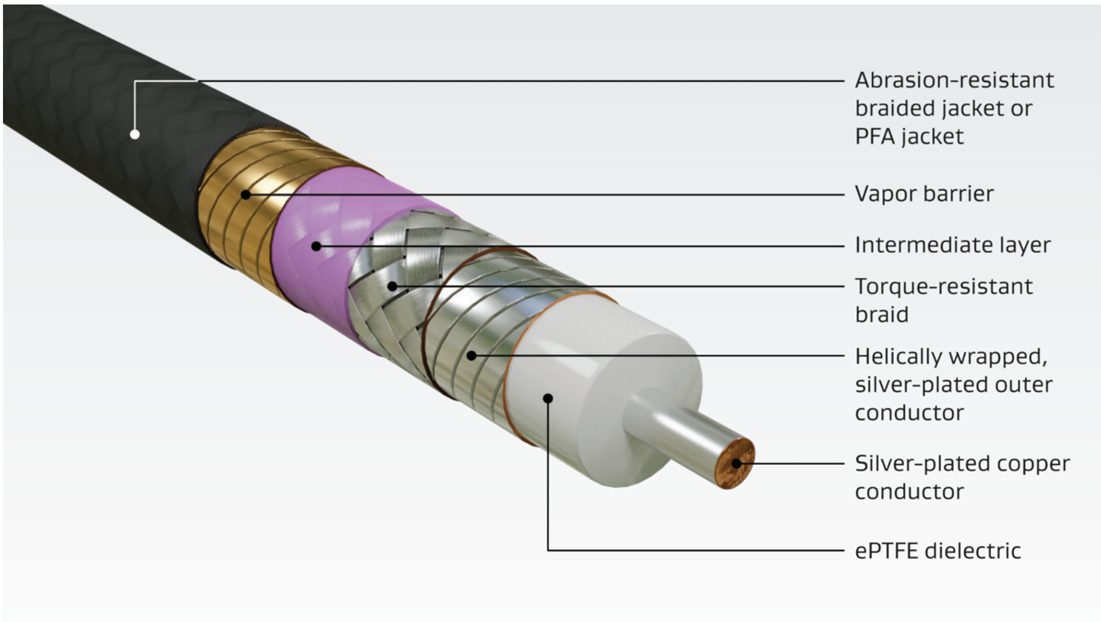


**Figure 6: Cable Construction**




## Total Costs after Installation

Using a real-world example, the average cost of assemblies is between $750 and $3,000. According to the survey results, 29 percent of assemblies fail during installation. Also, maintenance and downtime can often last between one to three days to identify the point of failure, remove the defective assemblies, install the replacement assemblies, and then retest and requalify each component. Therefore, you could spend between $44,950 and $156,600 to replace the assemblies (Table 1).

**Table 1: Total cost of cable replacement after installation**

| | Airframe Microwave Assemblies |
|---|---|
| Average cost per assemblies | $750 – $3,000 |
| Total vapor-sealed assemblies in aircraft | 100 |
| Total assemblies replaced in aircraft | 29 |
| Direct cost of replacement assemblies | $21,750 - $87,000 |
| Downtime of aircraft | 1 – 3 days |
| Maintenance/labor<br>($100 rate x 8–24 hours x 29 cables) | $23,200 - $69,600 |
| **TOTAL COST** | **$44,950 - $156,600** |

Replacing airframe assemblies that fail during installation is a complex process. However, if defective assemblies are not identified during installation or they fail during the aircraft's service life, the potential impact to the success of the mission and ultimately the safety of the crew in hostile environments is even more serious. The total costs for your application will vary; therefore, you should complete a similar cost analysis to consider the full impact of cable failure and replacement before selecting your airframe microwave assemblies.

## Conclusion

Even though new assemblies are compliant to industry standards, many of them on the market today fail frequently during installation. Gore developed the cable installation simulator to show the importance of testing assemblies in real-world conditions. Their testing showed that performance of many assemblies degrades significantly because they get damaged during installation, causing frequent replacement. Therefore, any savings gained from a lower purchase price are quickly lost when these assemblies have to be replaced. Also, manufacturers will experience an even greater increase in costs from delayed production schedules, compromised system performance, maintenance and downtime, and additional retesting to requalify and recertify every component — not to mention the safety issues associated with cable failure.

Selecting an assembly with a durable construction that has been tested to survive real-world conditions is the key to ensuring reliability after installation and reducing replacement costs. GORE-FLIGHT® Microwave Assemblies, 6 Series are lightweight cable solutions that deliver the lowest insertion loss before and after installation, ensuring reliable performance for the life of the system. The robust construction of these assemblies reduces total costs by withstanding the challenges of installation, reducing costly production delays, field service frequency, and the need for purchasing replacement assemblies. In addition, the 6 Series are lighter weight, which improves fuel efficiency and increases payload.

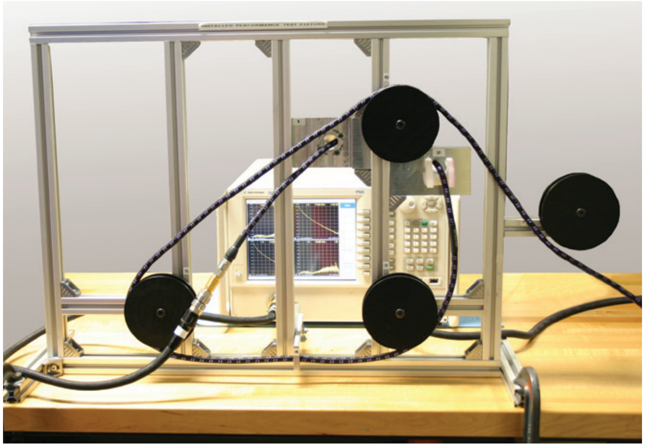
Manufacturers no longer have to accept the practice of replacing assemblies that fail after installation, because a fit-and-forget solution is now a reality. Choosing GORE-FLIGHT® Microwave Assemblies, 6 Series results in lower total costs and longer service life.

## Appendix A: Installation Simulator

Gore designed a simulator to replicate the conditions an assembly experiences while being routed during installation in an aircraft (Figure 7). The simulator has three main features:

- Mandrels with a diameter compliant to the claimed minimum bend radius (MBR) for the cable assembly to be tested
- Plastic and metal routing guides
- Abrasion bar

**Figure 7: Installation Simulator**



Gore uses four mandrels to simulate routing an assembly around the internal structure of an airframe (Figure 8). The mandrels replicate MBR conditions that the assembly will encounter in an aircraft. This ensures the assembly is being evaluated under the worst-case scenario.

Several routing guides are used to induce torque as the assembly is pulled through the simulator (Figure 9). Next, the assembly is pulled through an abrasion bar to simulate routing across sharp edges or through access holes in the airframe structure (Figure 10).

A tensile force of 20 to 40 pounds is required to pull the assembly through all the simulator features that mimic typical installation practices. The assembly is connected to a digital force gauge to measure the force applied.

Then the assembly is ready for testing. The assembly is connected to a Vector Network Analyzer (VNA) to test the insertion loss and VSWR. The results are compared to the baseline results of the assembly tested prior to installation. Depending on the results of the test, the assembly may be routed through the simulator multiple times and retested to verify its durability.

**Figure 8: Mandrel**

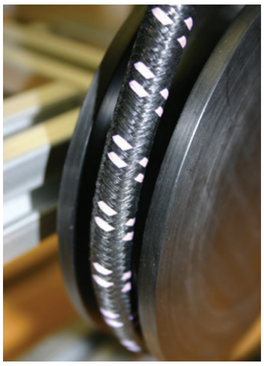


**Figure 9: Routing Guides**

**Figure 10: Abrasion Bar**

## References

1. This study was compiled and published by the Penton Design Engineering & Sourcing Group.

2. For more information, download the white paper Proving Installed Performance of Airframe Microwave Assemblies at gore.com/simulator.

3. For more information, watch the Installation Simulator video at gore.com/simulator.



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