Application Note
#6
The Engine Problem That Wasn't

One of the most frustrating events in a propulsion engineers life is troubleshooting an engine vib problem that isn't. Man-hours, equipment, and operations are all adversely effected by a reported engine problem that isn't an engine problem. The questions and doubt will also create credibility problems within and between groups in the airline. Pilots, ground maintenance, operations, propulsion engineering and many other groups suffer from these nuisance problems that occasionally take place. These problems are not high tech or technology extreme issues; they are the routine mundane issues that will very often wreak havoc. The simple problems whose solutions are typically less than a thousand dollars in actual cost end up sometimes costing an organization or support organizations tens of thousands of dollars. Very often these problems that are once solved, are quickly forgotten – and one should not do that.

A good propulsion engineer will remember these "little" things and use them in the future. This is the good news out of a bad situation – build upon experience and use these life experiences in the future. If this is done, then the propulsion engineer becomes the all-knowing guru. A good propulsion engineer will ask questions and examine the reports of the problems, and above all, remember the past experiences where he has been burned by "wrong calls."

This short application note will point out just one occasion where tens of thousands of dollars were spent chasing a problem and will document the problem so that the ramifications to the organization can be fully understood. Please keep in mind that what is said here is helped along by studying the situation in hindsight, but it is the type of problem that happens to everyone at one point in time or another. Nevertheless, the data presented here is kept generic so that no one's feelings are hurt.

At the time the problem existed, there was no chronological forensic analysis of what was happening. In other words, throughout the process the system failed. In this case, the system included the equipment, the people, and the communications between people and groups. In essence, the system collectively was "crying wolf." Everyone immediately jumped to the more common yet costly solution rather than suspect the actual inexpensive fault.

An aircraft started to get squawked for vibration intermittently. Ground maintenance personnel checked and cleared the squawk on a couple of occasions. The end result was no problem found. They had checked the Engine Vibration Monitoring equipment. The squawks continued. One flight crew would squawk the aircraft while others would not. What was not paid attention to was the method the crews used to report the squawk. One crew used the cockpit readout (the source of the squawk) while the other non-complaining flight crew used the seat of their pants, paying little attention to the instrumentation. The flight crew that reported the squawk of vibration never mentioned that they did not "feel" the vibration. They only documented the squawk with the cockpit readouts, nor did they mention that the readout was intermittent. There was no mention of the fact that the high vibration came and went frequently and, when the reported vibration level was low, it was very low.

As time went on, the squawks continued intermittently. The engine was balanced two or three times, as the recommendation was made to do so. Indeed the engine was running smooth; the balance solution on each occasion was an insignificant solution. On one occasion and obviously the last time a balance session was scheduled, the weight solution was not put in the engine. The reason for this move was the size of the weight and its location. The size and weight was totally out of line with the prior work performed. At this point a propulsion engineer was requested to personally investigate, rather than just phone contact with ground maintenance personnel.

The propulsion engineer that traveled to inspect the aircraft was a very experienced guy and was taxi and ground run qualified. This as it turns out was the downfall of the mission. The high vibes that were taking place took place more frequently during a taxi evolution (big hint) than at any other time. Since the propulsion engineer had the qualifications, he handled the ground run himself. The cockpit readout showed high vib most frequently during taxi evolutions and went undetected as the propulsion engineer had his attention elsewhere and totally missed the intermittent readings in the cockpit.

The good news out of this mission was the fact that he was the first to take note of the vibration levels as reported by both sensors. He thought that it was extremely curious that the forward sensor on the engine reported extremely low vibration while the aft sensor reported better than normal vibration but yet significantly more than the forward sensor. Based on this information, he deduced that perhaps an aft plane or maybe a dual plane balance solution was called for. Perhaps the aft plane in certain profiles was causing the engine to be squawked by flight crews that were more sensitive to this. Not having the tools or equipment available to perform an LPT or dual balance the mission ended with a reschedule.

Due to other logistics problems, the same propulsion engineer was not able to perform the aft or dual plane balance session. Another propulsion engineer was sent with the tools to meet with the plane and do the trim balance. The GSE balance equipment was connected up to the EVM system and the aircraft was taxied out to the run-up pad. On the way out, the new propulsion engineer made note of the cockpit readout. The vibration levels on the forward sensor were jumping very erratically from low to high. Once out at the run-up pad, the engine was run up and down several times. The high vib never manifested itself again. Extremely low vibration on the front sensor and somewhat lower than normal on the aft sensor.

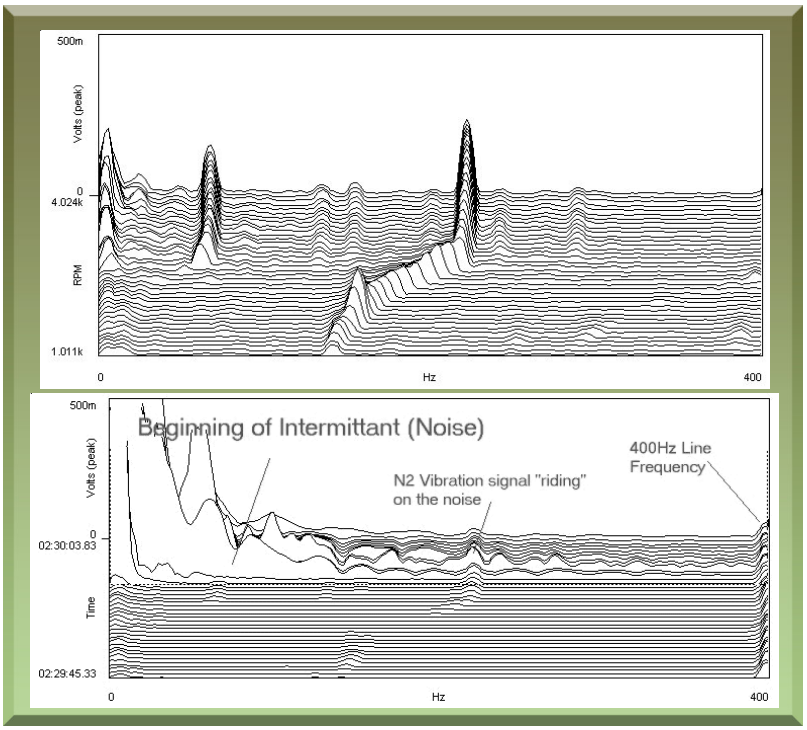
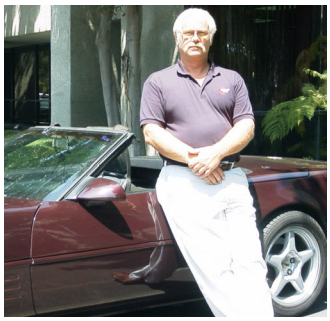


Figure 1. Connector Problem Revealed

The GSE equipment for balancing was turned on and the engine was observed. After examining the data, it was determined that the balance session was not required as they were dealing with a potentially failed forward sensor. Although the symptoms did not quite match, there were extremely low amplitude numbers while the phase data seemed consistent and appropriate to the previously performed balance sessions. Nevertheless, the decision was made to go back to the maintenance hanger and investigate the potentially failed sensor. It was during the departure from the run-up pad that the real problem finally revealed itself.

The two data traces taken from the GSE are shown in Figure 1. The data represents the engine spooling up from idle at the run-up pad and the start of the aircraft taxi away from the pad and back towards the maintenance hanger. Note on the top trace, the data from the aft sensor appears normal. However, on the forward sensor only faint traces of real engine data can be seen. More significantly, there is a huge jump in vibration level that takes place suddenly and only in the lower section of the vibration spectrum. Also, seen as the highest real signal in the data from this sensor is the presence of a 400 Hz signal that does not change with engine speed. This is an electrical signal that is somehow being detected by the EVM wiring harness. This is something that should not take place.

Armed with these revealing data plots, the correct diagnosis of the problem was made. The forward sensor was fine and in good working order. The EVM was also in good working condition, and properly reporting the apparent vibration levels that it was "seeing." What had failed was the cable system that was in between the sensor and the EVM system. As it turns out, it was a contaminated connection point. All the symptoms match and are in perfect agreement for a relatively inexpensive repair.



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