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CASE STUDY:
MITIGATING EMI TAKES MORE THAN *BLIND LUCK*

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If you're driving down the street and your car stalls out, what happens? You brake, the vehicle slows down, and eventually comes to a stop - no harm, no foul. In that same vehicle, if you can't use your phone, is your ability to drive compromised? While it's surely inconvenient, driving remains business as usual. But in an airplane? System failures, even on the smallest of scales, can have catastrophic results.

If not properly held in check, Electromagnetic Interference (EMI) can cause such system failures. If an errant signal causes the radio to cut out, the pilot can't communicate with ground control and the plane cannot safely land. If a bolt of lightning shorts out the navigation controls in the cockpit, the plane can't take off. With hundreds of electronic devices working together within the plane, potentially harmful signals are lurking behind every motherboard. Each device must be properly filtered to ensure Electromagnetic Compatibility (EMC).

"GROUND CONTROL, WE HAVE A PROBLEM"

Louis Gabriel is a pilot and the owner of *Blind Luck Racing*. Gabriel and his team race their Lancair 360 at several light-aircraft events across the country, but the Reno Air Races are their top priority.

After observing the Reno Races for the first time in 2006, Gabriel and his family fell in love – so much so that a major life change was about to occur.

"In 2009, we rented a house on the race course, and after seeing the Unlimited Class roar through pretty much the back yard, we all became Nevadans!" Gabriel explained.

Gabriel's Lancair 360 was purchased and *Blind Luck Racing* was formed in 2011. Gabriel's dream was being realized.

The team was excited to get going, but they knew that their aircraft wouldn't be competitive as it was. Later that year, the team decided that if they hoped to compete at a high level, they needed more horsepower. It was time to ditch the antiquated push-rod, carbureted, simple magneto ignition motor in favor of modern technology: electronic fuel-injection.

Quell Corporation is an EMI solutions provider.

Since 1994, they've been producing filter connector inserts to combat EMI, RFI, and transient emissions in high-value electronics. All solutions are custom-built to work in perfect harmony with the host connector.

The "massive engine rebuild," as Gabriel labeled it, took three and a half years. Not being able to race during that time was tough for the team – but a small step backward would propel the team many steps forward.

In 2014, the modifications were completed, and it was time for testing.

"We did a lot of ground-testing, a lot of ringing the thing out on the ground," Gabriel detailed. "We made sure we were getting the fuel we needed, the spark when we needed it - really spending a lot of time analyzing our design choices, and everything looked great!"

Since ground testing was a success, it was time for flight testing!

The test pilot "took the thing up for an hour," Gabriel recalled. "He's running the engine...taking off...landing... really tearing stuff apart, finding out how it lifts."

"He came back with a really detailed flight test report. Everything was preforming well - even faster than we expected except 'one small problem… when you key the mic to talk on the radio, the engine quits!'"

GROUNDED

The team was perplexed.

Gabriel's first thought: "What?!"

"We had tested everything we could think of. Everything worked great on the ground. But in flight, if you click the mic to speak on the radio, the engine quits."

Blind Luck Racing had a problem: when they used the radio in their aircraft, the engine would stall mid-flight! After months of testing and troubleshooting, they were no closer to finding a solution than they were on day one.

In the end, all it took was a simple phone call.

Quell Corporation is a manufacturer of an EMI filter insert called the EESeal. Designed to fit seamlessly into any host connector, the EESeal protects against EMI, RFI, and transient emissions.

After Louis Gabriel, owner of Blind Luck Racing, called Scott Lindberg from Quell Corporation, Lindberg and his team went to work developing a custom insert for Blind Luck's aircraft. An EESeal was manufactured and shipped, landing in Gabriel's hand the very next day!

The EESeal did the job, protecting the electronic fuel injector from errant radio signals. Safe for liftoff once again, Blind Luck Racing has soared to new heights with the help of Quell Corporation and the EESeal.

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With no clear diagnosis jumping off the page, *Blind Luck* had to circle back and reexamine the entire design.

"This launched us into a multi-month, multi-discipline troubleshooting tree to try to get to the bottom of this," Gabriel remembered. "We exhaustively went down every path we could take, and we could not duplicate [the problem] on the ground. We tried different radios, different antennas, external radios.

There was no shortage of suggestions: Was it a spark-plug wire? Was it a grounding issue? The thought was 'OK, it's failing in flight. We can obviously duplicate that, but that's a risk that I'm not willing to take!' So we were in this catch-22 situation where we didn't know what we were going to do next."

One specific suggestion turned out to be very fruitful, though.

Fortunately for *Blind Luck*, one of the team members came from a racing family. He recalled that, at one point, his father had worked with Quell Corporation and they helped to solve his EMI problem. So Gabriel reached out.

"Louis called us," explained Scott Lindberg, the VP of Sales and Marketing for Quell, "and said 'when I use my communications device, my engine stops - and I find that to be a problem.' And we found it to be a problem too!"

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Lindberg asked Gabriel all about his engine rebuild. They discussed the new components being installed, frequencies, voltages, pin placement, and so on. Lindberg had placed his detective's cap on, trying to help Gabriel and *Blind Luck* to solve this problem.

"When someone calls us, they usually say 'hey, I've got an issue with X. We need to mitigate certain frequencies, from 50 – 200 MHz for instance. And we've got a peak outage that we need to mitigate of 15 dB at 150 MHz.' So they describe the problem to us and we ask, "what's the frequency outages you have? The connector part number? The voltages on each of the pins? What pins, if any, have any high-speed data? Are there any transient issues?"

But that wasn't the case with this particular challenge. Lindberg and his team had to analyze all the data, plus the components and connectors being used, to try and piece together a solution to a rather murky puzzle. When all things were considered, the Quell team came to a consensus, and the engineers went to work building a custom EESeal which would fit right into the host connectors of the aircraft.

Quell's EESeal is a filter insert made from silicone rubber packaging technology with embedded chip components. It provides EMI, RFI, transient, ESD, and grounding protections while also maintaining a rugged, durable environmental seal to the host. The EESeal slips directly over the pins and into a device's connector, ensuring no redesign is required and no extra space is forfeited.

As luck would have it, the Blind Luck team had finally figured out a way to reproduce the problem on the ground right around this time.

"With this new antenna, we could pass it over the airplane and cause the engine to stall on the ground," Gabriel recalled. "So now we had the ability to test on the ground. Meanwhile, Quell overnighted EESeals for the ESU connectors. I was [really eager] to see if they'd work, so we installed them in the connectors going to the engine control computers right away."

> ***"The EESeals worked,"*** *Gabriel reminisced.*
>
> *"Just over the phone, they identified what the problem was and made a solution for it. Quell was really incredible. Their expertise, their help, it was critical."*

"BLIND LUCK, YOU'RE CLEAR FOR TAKEOFF"

Tensions were running high during the ensuing testing.

"Honestly, we probably would have given up on the electronic engine control if the EESeal didn't work," Gabriel conceded. "We probably would have gone back to the old setup.

One of the core philosophies of our team is to mitigate risks wherever we can, so we probably we would have gone back to flight-proven stuff - something not electronic in nature."

With so much on the line, the team held their breath, but: "It worked!" Gabriel exclaimed.

With the EESeal installed in the ESU connectors going to and from the engine control computers, the electromagnetic compatibility issues between it and the radio frequency were seemingly gone. With a successful ground test, the team was much more comfortable with the idea of sending the test pilot back up into the air for another flight test. This time, the plane passed with flying colors.

Lindberg explained that, unfortunately, he's never sur-

prised when he receives a call like the one he got from Louis Gabriel. EMI issues, particularly on an airplane, stem from "the cross-talk between two different, or all the different, platforms on an aircraft." Quell's EESeal was able to mitigate the problem, putting *Blind Luck* back in the pilot's seat.

"The EESeals worked," Gabriel reminisced. "Just over the phone, they identified what the problem was and made a solution for it. "Quell was really incredible. Their expertise, their help, it was critical.

The EESeal enabled us to take the steps we needed to successfully compete in the races. We didn't fly that year (2014), but we did in fly in the Reno Races successfully in 2015. We placed second in one race and earned a bronze in another, so it was awesome. It was a great year!"

IN AEROSPACE, EMC IS A MATTER OF LIFE AND DEATH

EMI is especially dangerous in the aerospace industry, as even the most basic aircraft is littered with high-value electronics for mechanical function, control, navigation, and even basic human conveniences. Any such interference poses a serious danger to the pilot, the passengers, and even people on the ground.

"Our goal at Quell is to solve people's EMI and transient suppression issues," Lindberg explained. But the stakes are raised and space is more limited when you're talking about vehicles and equipment designed for aerospace.

Let's consider the amount of space in an airplane's cockpit. There's very little, if any, unutilized space – and the control panel is a cluster of computers, each of which has a motherboard behind it potentially causing EMI. The EESeal is perfect for overcoming issues in such tight spaces.

"Customers have told me, 'I want to design the EESeal into my products in advance because it'll reduce the size of my board. It's lightweight and takes no space,' Lindberg recalled. Additionally, "compared to a filtered connector solution, we typically save 20-50% in a production solution."

More importantly, though, "you need that plane to land, right?" Lindberg asked, rhetorically. "On a plane, there has to be a hundred – or hundreds – of computers. Every box that goes in there – from an altimeter to the coffeemaker – they all need to be electronically compatible with one another, protected against one another, and they all have to work together."

Lindberg explained that in the aerospace industry, protecting against EMI is about overcoming functionality challenges – "but it's also about saving (protecting) lives."

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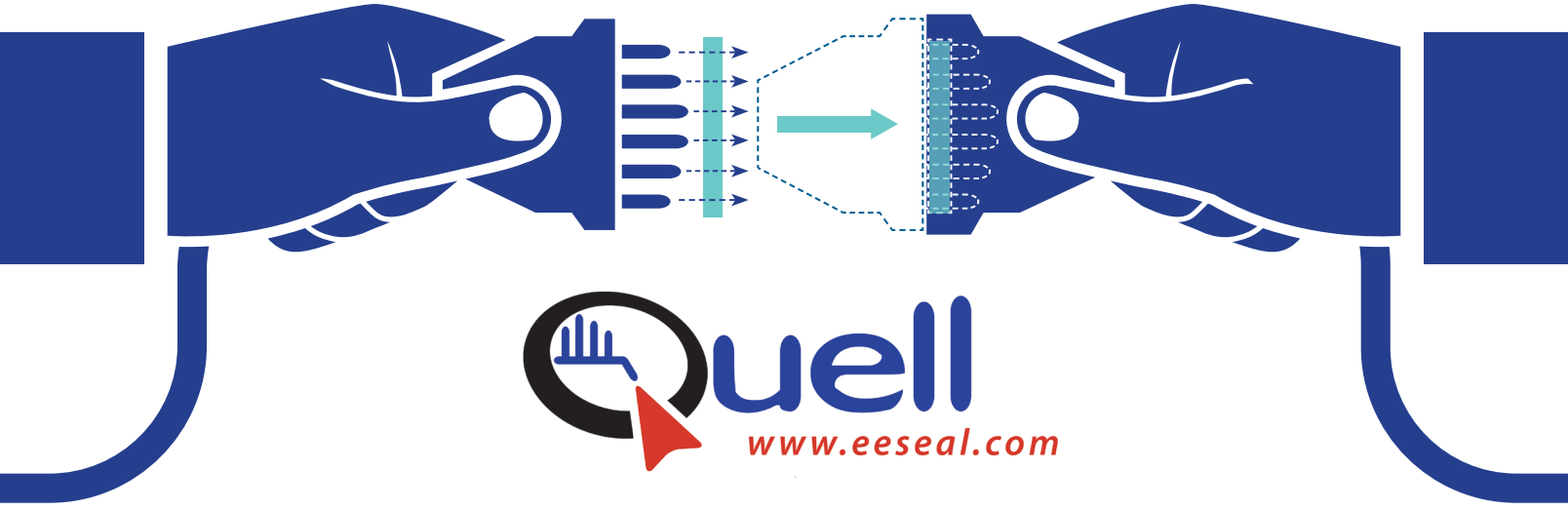

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