An Interview with Brian Billman, V.P. Product Development, at Isotropic Systems

The Isotropic Antenna: The Perfect Solution for Aero?

With the coming of LEOs and MEOs and the burgeoning demand for broadband on commercial aircraft, satellite antenna developers are racing to develop a suitable phased array antenna.

Despite multiple efforts and millions of dollars invested in development, success has remained elusive, and significant obstacles remain in place.

Typically, flat panel phased arrays use large numbers of beam forming ICs, a requirement dictating an extensive array of electronics that consumes vast amounts of power, generates excessive heat, and is expensive to manufacture.

Isotropic Systems, a London-based start-up, has designed, prototyped and tested a uniquely innovative antenna that breaks through these barriers. Using lenses that concentrate the RF signal, the antenna design significantly reduces the number of electronic components, resulting in a terminal that uses considerably less power, achieves true time delay, duplex operation, and can be produced at a relatively low cost.

To find out more about this unique product and its potential in aero markets, we met with Brian Billman, Isotropic System's V.P. of Product Management for Aero.

SMW: I understand that the Isotropic antenna has been in development for around three years. Is your first antenna Ku or Ka-Band, and how far have you come in the development? What is the initial target market, and when will the antennas be commercially available?

Brian Billman: Our optical beam forming antenna is a new technology. So, in the beginning, we didn’t have all the answers and have been learning along the way. Throughout the development process, we have been pushing the envelope in terms of the features we can offer.

At the same time, we have spoken with customers, been made aware of their challenges, and have sought out solutions. That’s why, over the last couple of years, we have refined our focus.

As to where we are in the development process, we have already fabricated and tested prototypes - a Ku-Band prototype in 2018, and a Ka-Band antenna is 2019. Those tests were successful for both Ku and Ka-Band antennas, proving the accuracy of our in-house simulation tools and the suitability of our materials for the manufacturing process.

At the end of 2019, using our Ka-band prototype and an Avanti satellite, we completed a full-duplex, over-the-air test. That was a major milestone because it proved the viability of our technology and enabled us to shift from technology development to product development. The science was behind us, and the next level of challenge was to integrate the technology into a saleable product.

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Our first product is the Ka-Band terminal. It will be a premium iteration of our design targeted to military applications and high-end enterprise and leisure craft such as yachts and super yachts, markets that value extremely high-performance combined with a low profile form factor.

The product will be available for test and certification by our partners in mid to late 2021, and a full production version will be ready for the market in 2022. While this is our first terminal, it will be followed by other iterations designed for specific markets.

Because we can easily optimize the antenna for different markets, we see a lot of interest and opportunity. For example, we can configure the antenna with either a symmetrical or asymmetrical bandwidth capability by varying the number of transmit and receive modules.

By slightly modifying the optical beam module, we can very easily create derivative products for markets such as buses and small fishing vessels. For land and maritime, we will sell a fully integrated terminal while for aero, we are pursuing a licensing approach.

We will be licensing our beam forming modules to aero integrators, including the lens, the feed, and all the circuitry on the PCB needed to do the beamforming. The integrators will use the technology to design and fabricate the rest of the system and handle the certification process for each type of aircraft.

SMW: I understand you have been speaking with some potential aero integrators. Without naming anyone in particular, can you give us an idea of the level of interest and how far you have come in the discussions? When might you conclude a technology licensing deal?

Brian Billman: Although we are involved in discussions with many integrators and providers, it's a bit early to go into detail.

Regarding the timing of our aero product release, we only announced the licensing opportunity a month ago at Satellite 2020. Since then, we have had an incredibly favorable response. I think that is because our unique benefits and features are closely aligned with the challenges faced by the aero connectivity market.

Of course, at this point, we are still in the preliminary stages of discussions. However, its important to remember that our aero product development is parallel to the development required for our initial maritime and land product.

So, the technology is essentially the same.

SMW: Currently, there are many flat-panel aero antennas in development. While their form factor is attractive, in GEO applications, they are very inefficient at high latitudes and low look angles. How does your antenna compare?

Brian Billman: Compared to a conventional flat panel antenna, we can reach a look angle of 20 degrees of elevation, vs. 30 degrees for the typical flat antenna. Since we use RF "lenses" that bend and focus the RF energy, we can achieve a very low look angle. Besides, the gain at those extreme angles is around 3 dB better than a standard flat panel ESA. Of course, that's in the case the antenna is mounted flat.

However, if we conform the antenna to a specific shape, whether it's the fuselage or the radome, that can push the scan range even farther beyond 70 degrees from boresight (below 20 degrees in elevation). In that case, you have modules that are pointing toward the horizon, resulting in increased gain. Because our modules are only six centimeters in diameter, it's quite easy to mount them in a conformable configuration.

SMW: In both GEO, LEO and MEO applications, flat panel ESAs have excessive power requirements and cooling requirements. How does the Isotropic antenna overcome these challenges?

Brian Billman: First of all, power consumption is a huge challenge for conventional flat panel phased array antennas, especially in aero. That is because airlines are demanding more bandwidth. To achieve high bandwidth capability, you need a large and power-hungry antenna. The isotropic antenna is different. Because we use lenses to concentrate and focus the RF energy, we need around 90 per-cent fewer beamformer ICs.

Instead of having to illuminate thousands of antenna elements all the time, we only have to illuminate one lens and feed to generate a beam. We then combine the beams from multiple "cells" to achieve the desired bandwidth, drastically reducing the power consumption. That means that we can offer digital beamforming and dynamic resource allocation.

At any given time, we only turn the resources required, depending on the link characteristics and the purpose of that specific beam. That's very different from a traditional flat panel in which you need to keep all of the elements illuminated all the time.

Another advantage of our design is that we can vary the number of feeds under each lens, which allows us to tailor the product to a specific application.

For example, in cellular backhaul, you are dealing with a fixed site. So, by only populating a single line of feeds, and tilting the terminal towards the GEO/MEO arcs, we can offer a reduced cost terminal that can still communicate with multiple GEO or MEO satellites simultaneously.

SMW: Traditional flat panel antennas solve the time delay problem by using phase shifters, digitizing the signal (Satixfy antenna), or, in the case of the Thinkom antenna, employ a slotted, rotating disk. How does the Isotropic antenna resolve this issue?

Brian Billman: We have no moving parts in our Aero modules. To shift the phase of the signal, we amplify the signal and digitize it.

Digital time delay is far superior to hardware phase shifters because hardware phase shifters are set to an average frequency value and the beam actually points in different directions over frequency (beam squint), thereby increasing side lobes and limiting instantaneous bandwidth.

In true time delay, the beam pointing direction is constant over the full range of frequencies, thereby maximizing available bandwidth and improving sidelobe compliance. However, the digital approach typically requires high power consumption. That's where the reduction in power consumption from the lens design gives us a significant advantage over a flat panel.

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Because we only use around 10% of the beamformer ICs, in a flat panel ESA, much less power is required. So, we don't need the heat sinks characteristic of a typical beamforming array, further reducing costs.

SMW: Interference is another problem with traditional phased array design limiting performance at low look angles and making it nearly impossible to do simultaneous transmit and receive. How does the isotropic antenna deal with these issues?

Brian Billman: In a traditional flat panel design, the patch antennas are placed in a tightly spaced matrix across the circuit board. Because the chips are close together, the lower the look angle, the greater the interference, causing a loss of efficiency and making it very challenging to do simultaneous transmit and receive on the same board.

Our use of individual cells, essentially dedicated send or receive modules, separates the patch antenna elements, thereby eliminating the interference and allowing full-duplex, simultaneous Tx and Rx, the "Holy Grail" in phased array design.

SMW: Weight and drag are also key elements in the design of an aero antenna. How does the Isotropic antenna compare in terms of weight and drag vs. existing gimbaled antennas and the Thinkom VICTS antenna, the most widely deployed phased array antenna in the market today?

Brian Billman: We can accommodate our antenna under radomes similar to those employed with other flat panel antennas. The optical beamforming modules we use are only 5 cm tall, and that includes the lens, the feeds, and the printed circuit boards with the amplification and digital beamforming circuitry and functionality all self-contained. That is a low enough form factor to allow for minimization of drag.

In terms of weight, the fact that we use a much smaller number of chips eliminates the need for heat sinks, which add a great deal of weight. The “lenses” we use are also very lightweight.

SMW: Do you have any estimates on the comparative cost of the Isotropic antenna vs. conventional flat panel aero antennas?

Brian Billman: Since we use only a tiny fraction of the number of beamformers required in a flat panel phased array, we are very cost efficient.

While we are not offering specific pricing at this time due to the variability of features and designs under consideration, I can definitely say that we will be competitively priced with far superior performance. If you think of the cost in relation to the number of full power beams available, the terminal is an outstanding value.

SMW: While nearly all flat panel ESAs are aimed primarily at the commercial jet market, mid and small-sized business jets are unable to access satellite broadband and must depend on ATG and L-Band services. Due to power limitations a satellite antenna would have to consume less than 300 watts and be small and lightweight. Could the Isotropic antenna be developed to compete in this unfilled market niche?

Brian Billman: Every terminal we are offering is based on the same flexible and modular building block design, basically a honeycomb of optical beamforming cells. That means we can optimize the design for each use case, a size requirement or a performance requirement. For a smaller business jet, we get all the benefits we discussed earlier, relating to our ability to configure the antenna under a radome and maximize the fill area and antenna gain. Of course, our lower power requirement is also advantageous, enabling us to meet the 300 Watt and under power requirement for a small business jet. Given our unique advantages vs. a conventional flat-panel, the small business jet market, it's definitely a market sector for us.

SMW: The ITU and WRC, have recently awakened to the interference threats posed by aircraft operating broadband services via NGSOs to satellites in the GSO arc as well as to 5G terrestrial networks employing the same shared frequencies on the ground. Specifically, the ITU specifies that terminals operating on NGSO satellites must limit their emissions in the direction of GSO satellites. Does the Isotropic antenna meet these requirements?

Brian Billman: Interference avoidance is one of the primary reasons we settled on the multi-lens, multi-cell design. As you know, controlling the shape of the "side lobes" is a critical element in interference avoidance. Our in-house custom-designed tools were very accurate in predicting the side lobe configuration, and we were able to prove the accuracy through extensive testing. In terms of GEO interference, we demonstrated compliance with both FCC and ITU regulations.

About Brian Billman

Brian joined Isotropic Systems in its early days in 2017 and as, V.P. of Product Development, currently leads the Product team .

His expertise in the design and development of mmWave communication, radar, and electronic warfare systems, cultivated during his years at Northrop Grumman, has helped Isotropic push the envelope in solving their customers' most