As a mechanical engineer and licensed pilot, Bill Bihlman found the perfect first job at Beech Aircraft after graduate school. “My passion was always aviation,” he says. “My work gave me access to time in the air.”

Yet he soon realized that although he liked engineering, he wanted to expand his horizons further. “Engineering is the quarterback of the field, but there’re other elements that make for smart business strategy and a sound product,” he points out. “So I went back to business school, worked for several firms, then went into consulting—where I combine engineering insight and acumen with business principles.”

Bihlman formed his own company, Aerolytics, LLC, in 2012, to help aerospace companies with decisions that impact design, material selection and supply chain structure. Advising clients about different production processes, he has gained significant perspective about the potential—and the challenges—of additive manufacturing (AM). He is also currently honing his expertise by working on a Ph.D. in industrial engineering. A panelist and speaker at the AM Symposium at the 2017 Science in the Age of Experience conference, he has big-picture opinions about the future of the technology as well as realistic insights into its plusses and minuses.

“We’re over the early hype about additive now and people are cautiously optimistic,” he says. “Like any new technology there’s a certain paradigm and anybody with a strong tech background is going to be a bit skeptical. Additive still has to mature more—and I believe it is doing so.”

The use of additive manufacturing in aviation began a couple decades ago, with laser cladding employed by government and commercial aviation for turbine blade-tip repair. Early adopters then began using it for tooling, where there was less emphasis on precision and integrity. “Of course those issues become much more important when you start talking about production parts and flight-critical components,” Bihlman points out.

The breakthrough moment for industrial AM was considered by many to be GE’s announcement several years ago about the Leap Engine fuel nozzle—the first additively manufactured component cleared by the FAA to fly in an aircraft. “That was absolutely pivotal because it legitimized additive and showcased the adaptiveness of the technology,” Bihlman agrees. “It was a big bet on the part of GE. This is a reminder to suppliers that to remain competitive they needed to be aware of technological advancements, not just price.”

“Given Dassault Systèmes’ position in connecting the digital thread from functional generative design to process planning and simulation on the 3DEXPERIENCE platform, they look to be one of the leaders in this space for years to come.”

—Bill Bihlman, President, Aerolytics, LLC
With metal additive manufacturing machines running in the neighborhood of $600,000 to $1 million apiece, not to mention the expense of advanced alloy powders of titanium and aluminum, unit cost is important to evaluate, notes Bihlman. “Whatever your production methodology, you need to amortize that over a certain number of units. Now when you’re talking about cost/benefit of additive, the ability to customize is a big plus. But in aerospace we’re not as interested in customization, with the exception of cabin interiors. We’re looking for repeatability and predictability of mechanical properties.”

So particularly in the case of flight-critical, load-bearing aircraft components, additive won’t be competing with closed-die forging for large, simple aircraft parts any time soon, Bihlman feels. “We won’t get away from the 50,000-ton press in the near future,” he predicts. “However, the design flexibility that is the genius of additive will support complex structures with hollow geometries, made out of exotic alloys such as titanium aluminate. And that makes additive’s powder-bed fusion technology more competitive against investment casting for things like engine turbine blades—something we’re already beginning to see with GE/Avio. Part-count reduction is another area in which additive offers benefits that can go far beyond traditional design thought.”

While wire-fed AM is also being used in aerospace, powder-bed RM will continue to dominate the field of research and development, Bihlman feels. Of course, any additive technology brings with it the attendant challenges of microstructure quality and process repeatability. And in powder-bed, sphericity, size and particle distribution are additional critical variables. So the ability to precisely predict and control material behavior is the goal of every AM technology.

This is where simulation enters the equation. But it’s no easy task. “Metal AM involves extremely complex physics,” says Bihlman. “You start with either a solid (wire) or powder, superheat it, essentially melt it into a liquid, and then let it cool back to a solid. It’s basically a controlled explosion, an incredible process involving extreme temperatures at a rate of heating and cooling on the order of tens of thousands of degrees per second. So it’s very complex to model properly.”

Simulation is coming along, Bihlman notes. “I know Abaqus is one of the more powerful tools and that’s an area that continues to improve. We’ve got the computational power to be able to do very fine, intricate meshes for microstructure prediction as well as part- or build-tray level part distortion and residual stress prediction, so it’s just a matter of time to where we can discretize the whole AM process and map it all the way through, and then include post-processing factors. Given Dassault Systèmes’ position in connecting the digital thread from functional generative design to process planning and simulation on the 3DEXPERIENCE platform, they look to be one of the leaders in this space for years to come.”

The reduction in experimental time and testing costs that simulation provides is well understood in aerospace, says Bihlman. “As confidence with AM modeling grows in this industry, we’ll be able to reduce our certification costs as well; the FAA has long since recognized instances where testing can be supplanted by analysis.” And as AM matures, this will become increasingly more common because of the prohibitive costs of full-scale and component-level testing.

With manufacturing of all kinds becoming increasingly automated (as underscored by the ubiquitous concept of “Industry 4.0”), maintaining the digital thread that tracks part pedigree all the way from early design through supply chain logistics is particularly critical in the case of additive, Bihlman feels. The complexity of AM demands mastery over a lot of data: there are well over 100 known characteristics that can affect the integrity of a final part—including machine settings, laser intensity, sweep pattern, particle distribution and many more. “Perhaps 20 percent of those characteristics account for 80 percent of the final part’s mechanical properties,” he points out. “But there’s so much hard science that remains in terms of build modification that we’re still learning and trying to tweak it.”

Learning-curve lessons, discovery and intellectual property are being kept close to the vest by many equipment manufacturers at this point in time. “Competition is understandable, due to the right to primacy,” Bihlman says. “But it’s unfortunate that we don’t really have an open forum through which the information is fed back properly so everyone can learn from it.” He describes the experience of a small, tier 3 parts manufacturer that spent months figuring out the optimum configuration of settings for their new AM machine. “When they fed that information back to the AM machine provider, telling them exactly what control settings and processes were required to produce the desired result, the provider said, ‘Well, that’s what GE told us!’”

Progress is being made. U.S. government labs and universities are working to provide publicly available data about AM, and the SME and the ASME have set up standardization committees. “We all need to agree on what to define in terms of critical path and share that information so that people can commercialize additive based on proper nomenclature and fundamental characteristics,” says Bihlman. “That is absolutely essential, not just to generate standards but to take a lead in public research as well.”