PHOTO: TIM MCGUIRE/D.J. & COMPANY

4p + 3c = Engineering Excellence

A conversation about leadership, vision and the future with Boeing's Chief Engineer

Dr. Greg Hyslop is Chief Engineer of The Boeing Company and executive vice president of Engineering, Test & Technology. Hyslop leads the Engineering function, including more than 50,000 engineers worldwide, and oversees technology vision, strategy and investment. His responsibilities also include oversight of all aspects of safety and technical integrity for Boeing products and services. Engineering, Test & Technology is an incubator for businesses that will define the future of urban, regional and global mobility, as well as those aimed at near-term opportunities.

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GREG HYSLOP, BOEING CHIEF ENGINEER

IQ: As Boeing’s Chief Engineer, what does leadership mean to you?

GH: Probably the most important characteristic of an engineering leader is curiosity, in all its dimensions. The best part of my graduate program at Washington University was working on my dissertation. The sense of discovery that came with seeing results that no one had seen before was tremendous. But it was work that was not solitary; it was done alongside my thesis adviser and another faculty member. I still remember the day when I made my breakthrough. I walked down the hall to review the result with my adviser; he shook my hand and said, “Congratulations! You got it.” And then he immediately gave me more work to do!

Modeling technical curiosity is critically important as an engineering leader. I must always be an engineer first, constantly learning and pushing myself into new areas of engineering or fields related to our industry. While I will not become an expert, I need to be informed so I can ask the right questions and assess the risks and opportunities.

But curiosity extends beyond technical fields to leading your team, especially when you are leading change. The higher you go in any organization, the more your job becomes identifying and leading change. But to effectively lead change, you have to know what your team is thinking at every level. This means being curious and seeking out their input. Have they heard the message? Is the message clear? Do they know what to do to implement this change? Do they understand why this change is necessary? Demonstrating this genuine curiosity is essential in leading change.

IQ: How does this play out in your role as Chief Engineer?

GH: Aerospace will always present some of the toughest engineering challenges. It was this way when our industry and company started, and it continues today. If the product can’t be built with first-time quality, it probably isn’t designed right. And if it can’t be operated or maintained in the field properly, it probably isn’t designed right. It all comes back to engineering.

This is why our values state right up front that we start with engineering excellence. We continue to strengthen and elevate engineering in our company. We recently unified all of engineering functionally and, two years ago, established four engineering priorities (the 4p):

- Safety Management System
- Design Practices
- Engineering Across the Value Stream
- Investing in and Empowering Our Team

All of these actions are designed to further strengthen our engineering, to continuously improve and act consistent with our values.

Our **Safety Management System** (SMS) will provide the framework and structure under which we can gather data from the operation and production of our products and the systems that design them. From that, we can identify risks and implement mitigation steps to avert incidents or accidents.

Our SMS has already led to significant changes and, in many respects, defines how we run the company now. SMS is how we work.

Our work on **Design Practices** is meant to capture the best of what we know from our history and to be the place to collect lessons learned from our SMS and our Quality Management System. Over the years, we've had a number of best practices and design guides across engineering, but in some cases, they weren't kept up to date and there was no uniformity in their format.

Our work now is to:

- Define a taxonomy for how we organize what we know.
- Establish an infrastructure and format for us to write it down.
- Create a means for peer review by our technical fellows.

I recall an early-career engineer described a design practice as the "journal of an engineering career."

When we talk about **Engineering Across the Value Stream**, there is a near-term and a long-term aspect. In the near term, we want engineers shipside in the factory, doing what they can to help stabilize our production system and achieve predictability. This means evaluating quality up close or perhaps identifying ergonomic concerns and then addressing issues by changing the design or modifying the work.

Longer term, this is about the digital transformation that is underway. When we're complete, we will apply the same level of rigor and modeling to our production system design as with the airplane itself. This will let us flatten the learning curve and bring our production system up to rate much faster.

As for **Investing in and Empowering Our Team**, this is how we recruit the best and brightest and how we retain the great talent we have and then provide training. We provide opportunities for growth, invest in continuing education, and offer a depth and breadth of experience that is unique to our industry. We want to provide the best environment for people to build a career in aerospace.

IQ: What behaviors or attributes do you look for in Boeing engineers?

GH: Not too long ago, a colleague sent me an image from a recruiting brochure from the late '80s. Yes, that's me in this photo!

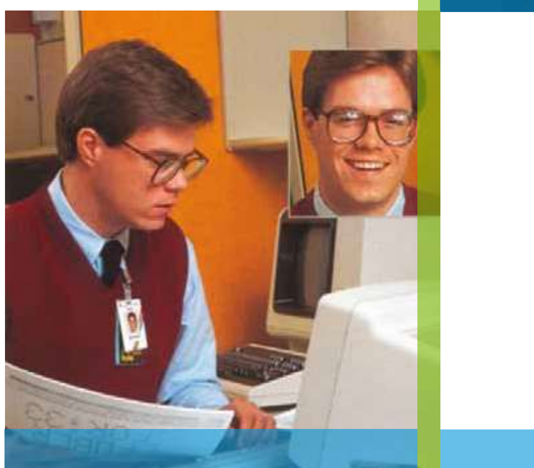

PHOTO: BOEING

It made me think back about what it was like for me as an early-career engineer. One of the biggest highlights during that period — apart from starting a family — was the publication of my first technical paper in a peer-reviewed journal. But professionally, I was even more excited by seeing algorithms I devised being implemented in our products.

I was energized by knowing that the math was being put to work to control real systems. I felt that thrill of discovery that comes with solving a tough problem for the first time and was invigorated to have it validated by peers. It couldn't get much better for an early-career engineer. Even today, more than 30 years later, I still remember that feeling of amazement and accomplishment.

It's an experience that starts with being curious, creative and courageous (the 3c). These characteristics will manifest themselves in our team as we connect to our four priorities.

For example, we want our engineers not only to understand their design of a part but also to be **curious** about how the part is fabricated, how it is assembled into the system, and how the system is operated and maintained. A Design Practice will give any engineer a place to start with what we know works, but it is built upon years of experience and lessons learned, from which new **creative** designs will emerge.

Finally, **courage** will manifest itself within our SMS and as we Invest in and Empower Our Team. An empowered engineering team has the courage to speak up when it comes to any issue around product safety, but everyone needs support. This is why we've created a robust functional organization and design board structure rooted in our Boeing Technical Fellowship, so no engineer should ever feel alone when raising an issue.

IQ: As you look back at your career of 40 years, what changes or developments stand out?

GH: The most significant changes I've witnessed are:

- The advent of GPS.
- The first steps toward autonomous flight.
- The dramatic increase in computing power for flight systems.
- The advances in composite materials leading to the 787 and the success of the point-to-point model for air travel.

One of my first assignments was integration of GPS into a cruise missile guidance system. This was the first application of this technology for a weapon and led to the advent of precision munitions. But think about what being able to reliably answer the simple question "Where am I?" has unlocked. From precision approaches in aviation to ride-sharing apps, none would be possible without GPS.

One of the enablers for integration of GPS into guidance systems was the ever-increasing capability of onboard computer processors. In addition to navigation, this computing power is being used for more and more autonomy in flight.

COMPOSITIVELY SPEAKING

Soaring above Charleston, South Carolina, a 787-10 makes it first flight in 2017. The 787 is 50% composite by weight, which significantly reduces fuel consumption and maintenance costs.

PHOTO: BOEING

My first jobs were with autonomous weapons, but the autonomy there was restricted to navigation, guidance and control along preprogrammed routes. But it was the precursor to what we see today and continues to expand, not only capabilities for flight but also processing of inputs from various sensors.

As for materials, the widespread use of carbon-fiber composites in aerospace stands out. And beyond the materials themselves, their far-reaching impact on commercial aviation is remarkable. The big bet between Boeing and Airbus was whether passengers would continue to fly to hubs on jumbo jets and then connect to their final destination or would they prefer point-to-point travel on ultra-efficient jetliners. The 787 has shown that we were right, enabled by the efficiency provided by a composite airframe.

IQ: What near-term and longer-term technologies stand out as offering immense promise?

GH: What's next? The great challenges facing aerospace as we proceed through our second century will be sustainable aviation and the digital transformation of our industry with all of its implications. For sustainable aviation, there will be multiple solutions, depending on the range and payload required for the mission, but it's amazing to see how far we've already come.

Through our joint venture with Kitty Hawk Corp., Wisk is the first company in the U.S. to develop and successfully fly an autonomous, all-electric vertical takeoff and landing (eVTOL) aircraft. This two-passenger eVTOL air taxi has flown more than 1,500 successful test flights and is on track to be the first autonomous passenger-carrying vehicle to be certified in the United States.

EDITOR'S NOTE

For more on Wisk, see Page 90.

When we think about digital transformation, there is no better testament to the advances in computing and modeling than Boeing's T-7A. This advanced pilot training system is truly a modern marvel. It completed more than 300 flight-test hours in our two preproduction jets before a single piece of metal was assembled on the first production jet. And the results are:

- A **75% improvement** in first-time engineering quality.
- An **80% reduction** in assembly hours.
- A **50% reduction** in software development and verification time.

Once we are free from obsolete constraints, and quantum computing takes hold, even more complex optimization will be possible. We'll also see machine learning become a standard part of every engineer's toolkit, regardless of their specialty.

The use of models based on large datasets, when combined with traditional physics-based models, will yield even more creative solutions to the challenges of the industry's second century. This is an exciting time to be in aerospace! **IQ**

DIGITALLY DESIGNED

The T-7A Red Hawk will lead future U.S. Air Force fighter and bomber pilots in their training for decades to come.

PHOTO: DAVID TORRANCE/BOEING