Every minute a Pratt & Whitney engine powered aircraft takes off or lands at destinations all around the world. Founded in 1925 and holding a share of nearly 30% of the world’s commercial passenger aircraft engines, Pratt & Whitney (P&W) have a long history of innovative design and are not afraid to use new technologies to achieve greater efficiencies. The vice-president for technology and environment talks to us about the company’s key to success and tells us why engine development and pancakes have more in common than you might think.

Tell us a little bit about yourself, what motivated you to study Aeronautics & Astronautics at MIT? When I was growing up I thought aerospace was the most exiting thing on the planet, so of course I went into it. As a student at MIT I got a job working on the Apollo 11 landing which was exciting, especially when not everything went according to plan! It also gave me an opportunity to see how people behaved – who took responsibility and who didn’t. Then rather than find a real job I stayed at the university for another 30 years which I enjoyed greatly.

Can you tell us about your current job in the role of Vice-President for Environment and Technology? I almost have two different jobs. One is responsibility for advanced technology, and one is responsibility for the environment. They come together because a concern for the environment shapes our products. So rather than make them separate, P&W combined them. I’m concerned with the engines no one has heard of because they don’t exist yet. If a concept looks promising, it gets passed on to one of the other executives for development.

So do you get research and ideas from other places (for example universities), evaluate that and use it for your new designs? Well it’s more that we try to point the research in a certain direction. We partner with universities for basic research and sponsor university centres of excellence. Our parent corporation, United Technologies Corporation, has a central research lab where we hire PhDs to work on basic research. Once the basic research is ready, then the next step is to mature the technology to the point where it is ready for a product. So for example, in the aviation industry, for a new structure to go from a lab bench in a university to where I can safely put it into service on a new aero-plane could cost about one billion dollars and take about twenty years. People try to shorten this (because it’s not a fact of nature, just an empirical observation) but no one has yet. Past industry experience has shown the dangers of putting into service
a material that was not well characterised, so we are always very careful to minimize risk. Does that inhibit innovation? No, it may slow it down. But it is how you ensure the incredible safety record that we now enjoy.

**Have you enjoyed the transition from the academic to the corporate world?**
Yes, because it’s totally different. I really enjoyed working with my students, now I enjoy working with thousands of engineers. One thing I’ve learned is that what we teach in university is perhaps only 20-25% of what it takes to really build and maintain a state-of-the-art jet engine and rocket engine.

**What about the other 80% - what is it? And why isn’t it taught in university?**
What you are taught in engineering in universities - aside from the basics - is how to educate yourself, which is perhaps the most valuable lesson of all. Those who learn it then spend their entire careers continuing to learn, whether they stay in engineering or move on to other things.

Another very important aspect is ensuring high quality while at the same time co-ordinating the thousands of people who work here at P&W. There are very high quality standards on the engineering, the manufacturing and on the support in the field. And it’s not really something you can teach students – it’s more training than education really.

The other thing I wouldn’t tell students is how much of their career is spent writing amongst the team and with your management. Recently universities have begun to do a better job in teaching some of these skills, or at least informing the students of how important they are.

**What is the team structure like within P&W?**
The management has an engineering structure. If we are talking about actually executing a design i.e. making a new engine, there is a multifunctional team we call the CPT, Component Integrated Product Team, which is at its core about eight to twelve people, and the person who heads it is the key person. Our ability to design, make and manufacture engines depends upon that person and often it is a big career step about ten to twelve years. The CPT leader is the person who must ensure that all the requirements for a certain component like efficiency, cost and so on are met while staying on schedule. One change at P&W is that an increasing number of CPT leaders are women, whereas many years ago there were relatively few.

“**I’m really worried because we don’t have any problems! I’ve never worked on an engine before where at this stage we didn’t have major problems!**”

- because then they would go into English as opposed to engineering! There are two skills you need as an engineer: one is the actual engineering, doing calculations, design and getting the right technical answer. The other is communicating. There are lots of great engineers out there with great ideas, but they may not be very good at communicating what the idea is, or what the value behind the idea is. Engineering now is all about big teams, and you need to be able to communicate amongst the team and with your management. Recently universities have begun to do a better job in teaching some of these skills, or at least informing the students of how important they are.

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How risky is it for the company taking this new approach of a geared fan when developing a completely new engine? What kind of risk management is necessary to ensure success?

Risk management is about understanding and taking into account risks. It is critical as a new engine costs us about one billion dollars, and a new airplane depending on the size is five to ten billion dollars. We have seen large companies run into trouble recently by not managing risk. You need to ensure that your organisation is a learning organisation. Learning from your mistakes is the critical part.

So how does it work at Pratt & Whitney?

At P&W we have a very formal system where if mistakes are made, we try to learn from them and continuously improve the way we do things. We did something very different on the PurePower® PW1000G Geared Turbofan™ (GTF) that I have not seen done in the business, which is we invested considerable money - about one billion dollars - in technology before we started the programme. In the past, the way engine programmes ran: you developed technology in the middle of the programme. Because of the pre-investment, the GTF programme is going extremely well. It is going so well that a senior and experienced component engineer got up in a meeting and said “I’m really worried because we don’t have any problems! I’ve never worked on an engine before where at this stage we didn’t have major problems!” Then his boss said, “But you never had ten years to work on technology development before, did you? Think back to five years ago and the problems you were having then.” And that is the point, it wasn’t part of an engine programme when the problems were discovered - it was just technology development. This is technology readiness; a process that is rigorously enforced here at P&W that has made a big difference.

How big is the share of space propulsion systems among P&W’s products and how do you think this will change in the coming years?

It’s an exciting business, but it is only a very small fraction of the overall revenue even though we make most of the large liquid rocket motors in the US. The cost of getting things into orbit is still very high.

Why do you think that is?

One major reason is that there are so few launches. Just as we need an army of engineers here to make aviation safe, we need the same thing for space. Even though there are only ten or twenty launches a year, you still need all the quality and safety people, which makes it very expensive.

P&W engines are now being used for UAVs. How do you see this market changing in the coming years?

I think that it will continue to grow in market share. At the moment UAVs tend to be low cost airplanes made in small quantities. This means that the people making them don’t want to pay for new engine developments; they just want engines off the shelf adapted at low costs to their application. We are the largest maker of small engines (below ten thousand pounds of thrust). We see a lot of activity but there isn’t much business compared to large commercial aviation which needs thousands of engines a year.

You have a long history in developing engines for military applications - are you allowed to move that technology towards commercial engines?

We develop the technologies in parallel and if you look back, sometimes commercial engines are more advanced, sometimes it is the military engines. They have different uses, so specific technologies have different values. We can use technologies originally developed for military engines for commercial engines with government permission. But in general, there is a bit less transfer today than years ago. In the past, military engines typically employed the most advanced technologies. Today some of the most advanced engines in the world are the commercial engines.

You collaborate with other companies, for example you recently came to an agreement with Rolls Royce to develop new engines and to do future research. How do such collaborations work?

The easiest way is to explain what we do now. No one country makes commercial engines any more – they are all made in partnerships. For example, for the Geared Turbofan™ engine we have two major partners: MTU Aero-Engines in Germany and JAEC (Japanese Aero-Engines Company) which is in itself a co-operative venture of several companies. So as an example, a certain engine programme might have MTU making the low pressure turbine and half of the compressor for an engine. But we do not buy anything from MTU, and we also do not send them our blueprints to have them make parts from. They are a partner; they design with their technology, they build test turbines with their technology, then they send them to us to be integrated into the engine. They then manufacture the low pressure turbine and send it to us. The technology and
manufacturing costs belong to MTU. We have only negotiated what fraction of the total engine value these parts are worth. So if it is X% they get X% of the revenue. All engines are made like that these days, even if the name on the engine only says GE or Rolls Royce.

You also develop industrial gas turbines at P&W. What do you think is going to change there from an environmental perspective?

That’s one of the key areas for the future. P&W makes peaking units which are derivatives of the aviation units, and they produce about 25MW of power. We also make windturbines and are the biggest manufacturer of geothermal power systems. The peaking units are very good compliment to solar and wind power, and they are all powered by natural gas, which is a big step in moving away from coal.

How much of a role do you think environmental and societal factors will play in the development of the aero industry in the future?

As the world becomes more responsible in terms of climate change it means companies must do a better job. For us, what is important - is reducing fuel burn and CO₂ emissions by about 25-30% compared to current engines. We know that we have to reduce noise to improve quality of life around the airport and in order to increase capacity. Thermodynamics are not negotiable (although some people may think they are) so I know I have to increase the thermodynamic efficiency somehow.

In a big company like P&W there are always people - usually old guys like me - who tell young engineers why they can’t do something. But what they really mean is we tried a long time ago and it didn’t work for us. But things are new, there are new materials, new computational techniques, even new ideas - and there’s a new imperative. Twenty years ago, jet fuel was sixty cents a gallon, now it’s three dollars a gallon. People didn’t care about climate change twenty years ago, we care very much now. So being responsive to our customers and society generates new requirements and new challenges. It will be difficult, but I think we can make as much, or more progress in the next thirty years improving the efficiency of aero-engines as we made in the last thirty years. This is an industry built on some of the best engineers the world has ever seen and if we get the same quality of people to come into aviation with the same level of passion, we can continue to make progress.

What do you see in terms of future engines - which direction do you think they are going?

The engines will get bigger and bigger in diameter as the bypass ratio increases to improve propulsive efficiency. They will start to get shorter as well, and begin to look like pancakes! The gas producer inside that produces the power to turn the fan will shrink because we need higher pressure to get higher thermodynamic efficiency. So all the components will get smaller. I think there is about one more generation of low engine, low wing airplane and after that the engines will be too big to fit under a low wing airplane. That will be another motivation for people to explore airplanes that don’t look like descendants of the Boeing707.

How do you see the overall shape of the wing and fuselage changing?

I think the blended wing body is a very plausible, low fuel burn, low noise configuration. However, a new airplane is about a fifteen billion dollar investment on part of the airframe manufacturer. The question is: when is the uncertainty driven down to a point that the director of a large company would risk their future on that design? If what we need is something radically different then perhaps one way to achieve this would be through a government-private partnership. To produce a reasonable prototype to demonstrate advanced technologies, it needs to be quite big - it can’t be a model airplane. It has to be about the size of an Airbus A320 to really prove itself. I would like to see other ideas though, and different designs, because I don’t know what the right one is. So maybe this is something we will see more of as economies begin to recover. It will probably take about five to eight years to execute such a design, but once it is ready, we would certainly be more than pleased to be part of that with advanced new turbofans.