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TECHNOLOGY Horizons


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From human-machine interfaces of the future, to 3D printing and ultra-fast wireless communications, NAN MATTAI outlines Rockwell Collins' R&D path to innovation.

From the early days of flight to the connected sky of tomorrow, Rockwell Collins has a heritage of pioneering technologies in aerospace and defence. Our company is dedicated to serving our core markets through exceptional execution of current commitments while leveraging that performance to gain new business opportunities. Looking forward, accelerating growth is a top priority and we plan to do this by enhancing and expanding our addressed markets, growing our international business and maintaining our strong commitment to innovation.

Biggest challenges

Currently, there are two sets of challenges that stand out. The first is the tough economic environment and continuing budgetary pressures, primarily in the advanced economies. This has resulted in changing priorities and the pressing need to reduce total cost of ownership. The second challenge is maintaining an innovative edge in an increasingly competitive environment to provide our customers with the best capabilities to meet their mission and operational needs at an affordable cost.

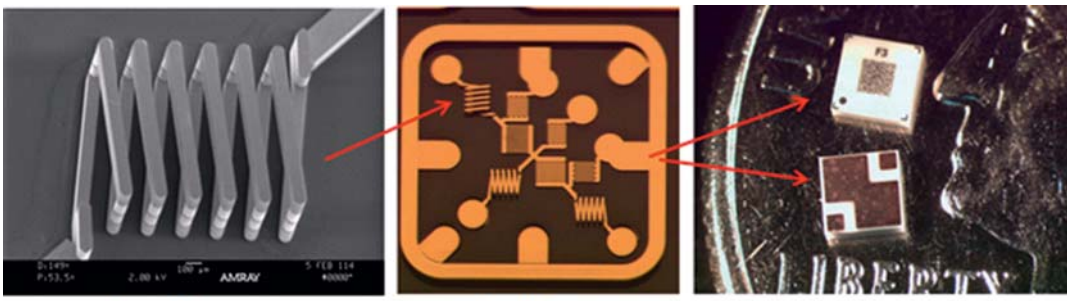
Innovation is at the heart of how we best serve our customers and, given fewer funds for next generation technologies, the intense global competition and the increased pace of technology change, it is a challenge for companies to raise the stakes and invest in the right areas to have the right solutions ready at the right time. We cannot afford to stand still, as there is always the risk of disruptive innovation and new players entering the market, displacing the incumbents. To stay ahead and differentiate in this challenging environment, Rockwell Collins invests between 18-20% of its annual revenue in research and development. These investments are targeted to high priority technologies that align with customers' needs and corporate strategic direction.

Future technologies

These are some of the future technologies we are most excited about:

Photonic communications — Radio frequency (RF) systems on the modern battlefield must cover many RF and microwave bands and deliver accurately processed information. Software-defined radios provide the capability for a single radio to generate multiple wave forms, allowing them to serve the functions of many different conventional radios. Photonic technology transmits information using light and has the potential to digitise signals at

Z-Fab brings 3D printing to the computer chip scale.



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18-20%
Revenue reinvested into R&D

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Rockwell Collins's HeliSure brings advanced situational awareness to the rotary-wing pilot.

higher frequencies and with more resolution than ever before. This technology can further enhance the capabilities of today's software-defined radios with direct conversion receiver capability. Silicon based photonics-integrated circuits enable high- speed, high-resolution analogue-to-digital converters, significantly reducing size, weight and power requirements while boosting performance of today's RF systems.

Information analytics and human machine interfaces — Rockwell Collins has pioneered information delivery and security for over 80 years. Today we are building on that experience to develop systems for the 21st century: information-rich flight decks, smart targeting systems, real time battle-space networks, and aviation information management solutions. The future lies in connecting everything, getting hardware functions into software applications that run on open architectures, proliferating sensors through aircraft and systems, and controlling where data goes, how it is distributed and analysed. We expect that the number of aircraft that are information-enabled — those featuring advanced avionics, connectivity and information services and applications — will increase significantly by 2030. The volume of data available to these systems will be much greater and more complex, requiring new technologies and tools to integrate and translate into meaningful, actionable information.

Given this more interconnected world, improving information analytics and human machine interface to provide the most efficient, secure and reliable real-time interconnectivity possible is foundational. A good example is air traffic management in the NextGen airspace. The backbone of this system is the new surveillance system, Automatic Dependent Surveillance — Broadcast or ADS-B. With the ADS-B Out mandate set to go into effect in 2020, aircraft will broadcast precise location and other information about the aircraft to ground stations and other aircraft equipped with ADS-B receive capability. Processing and presentation of this information will give air traffic controllers and pilots a better understanding of their environment.

Additive manufacturing /3D printing — The potential for this technology to be a game changer in aerospace manufacturing is out there with dramatic progress being made. Additive manufacturing builds objects by adding parts together in layers, rather than taking raw material and 'subtracting' excess material away from fitted moulds, as in traditional 'subtractive' manufacturing. Additive manufacturing isn't new but was typically used for small plastic prototypes of objects, aiding design tweaks.

Mass production of metallic objects for commercial and industrial use, built up layer-by-layer and modelled through software, has sparked excitement in manufacturing. Rockwell Collins has developed a game-changing additive manufacturing technology at the microelectronic device scale called Z-Fab. Z-Fab is used to create 3D radio frequency (RF) components that reduce size and cost of radio systems while improving performance and increasing functionality. The Z-Fab design process utilises the latest in 3D parametric design tightly coupled with high fidelity co-simulation methods (electrical, thermal, and mechanical). This technology is quickly growing to include active integrated circuits, greater functionality, higher power and frequency, and further reductions in size and cost.

R&D investment

Meanwhile we are investing in R&D to create the technologies of tomorrow:

Adaptation of commercial-off-the-shelf (COTS) technologies — With defence budgets tightening, the days of defence programmes spending billions of dollars developing new technologies are gone. Actually, defence programmes are placing greater emphasis on open architectures and affordable mature technologies (high technology readiness levels) that are ready to be introduced onto programmes to reduce program uncertainty and technical risk.

Given the investments being made in the consumer industry in technologies such as connectivity, computing, high-speed networking, graphics, displays, augmented reality and 3D printing we are working to rapidly adopt and adapt these COTS technologies for the unique commercial and military applications.

> THE KEY TO INNOVATION SUCCESS IS SOLVING PROBLEMS CUSTOMERS CARE ABOUT, ALIGNMENT WITH BUSINESS GROWTH STRATEGIES AND MARKET TIMING

Rockwell Collins' Venue cabin management system. The company predicts information-enabled aircraft will increase significantly by 2030.

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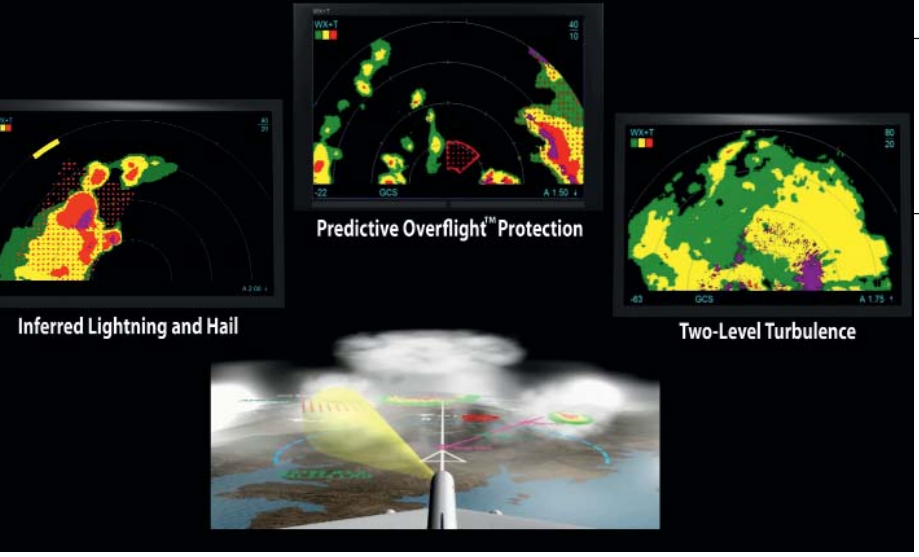

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Sophisticated algorithms in Rockwell Collins ThreatTrack weather simulate the build-up of thunderstorms.

Cockpit of the Future (2020 and beyond) — The cockpit of the future (2020 and beyond) must be ready to meet the requirements of global air traffic modernisation initiatives such as NextGen and Single European Sky. The future flight deck will be an intelligent cockpit that forms an integral and interactive part of the airspace eco-system, aware of the aircraft and the environment around it with an unprecedented amount of information available from advanced sensors, databases and connectivity channels.

Rockwell Collins is focusing its research and development efforts to provide greater safety, security and efficiency through enhanced situational awareness, improving human-automation interaction and efficiency in operations. Sensing and other technologies are creating the ability to see weather and terrain outside the specified flight path, as well as other aircraft, allowing the pilot to make real-time decisions to benefit the passenger or mission, while improving operational efficiency. We are developing next generation large format display, sensor and data fusion and intuitive human machine technologies to provide pilots a heads-up, eyes forward capability for operations in challenging low-visibility conditions.

Adaptive Networked Communications — Rockwell Collins has been pioneering airborne and surface communication capabilities for military customers for more than 80 years. We provide solutions that offer high throughout, spectrum-efficient, *ad-hoc* networking capabilities that address tactical operations requirements. The future battlespace is becoming even more complex, contested and highly congested. Assured secure communications regardless of the electromagnetic environment is critical to mission effectiveness. Therefore, the need for jam-resistant communications and difficult-to-detect communications technology to keep battlefield networks functioning amid a variety of spectrum-warfare threats is a top priority and aligns well with our capabilities and strengths.

Unmanned vehicles in civil airspace — Integrating unmanned aerial systems (UAS) into the national airspace will require advanced technology to ensure that flight safety is maintained. Capabilities and technologies such as collision avoidance, sense and avoid, auto takeoff and landing, failure tolerance and redundant avionics systems will enhance UAS safety and reliability for use in any airspace.

The use of multiple technologies and systems to seamlessly connect and communicate, to detect other aircraft and avoid collision by 'plugging into' national and international air traffic management systems, whether an aircraft is a manned platform, an optionally piloted aircraft or an unmanned aircraft is required. One of the critical enabling technologies is the command and control data link. We are collaborating with NASA on its UAS certifiable non-payload command-and-control data link programme, which will define the requirements for future command and control in the National Airspace System for control of small and large unmanned aircraft

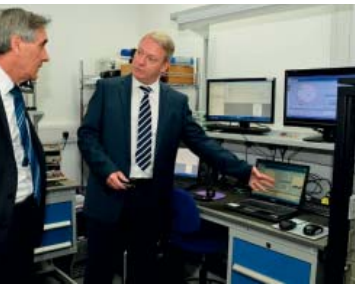
Radical breakthroughs

But we are always on the lookout for radical ideas that could create breakthroughs in our industry:

Terahertz communications — Today's radio bands are heavily allocated, data rate limited and near saturation. One of the avenues of research that is being explored to address this problem is terahertz communication. The challenges of working in the THz regime are balanced by the massive potential to unlock very high data rates for end-users in a large new carrier frequency space for wireless communications. The terahertz frequency range from 100 GHz to 10 THz, lies in the frequency gap between infrared and microwave wavelengths.

The properties and propagation characteristics of THz waves are shorter wavelengths, wide bandwidth and high directivity. Several research groups around the world have reported impressive results in THz communications but the key issue that remains in achieving robust THz links is obtaining long-term error-free performance which is required for real-time applications like video streaming. The realisation of THz communications

This year saw Rockwell Collins break ground on a new 40,000ft² R&D facility in Reading, UK, set to open in 2015.



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Brazil's new Embraer KC-390 airlifter will be equipped with Rockwell Collins' Pro Line Fusion flightdeck.

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NASA

relies on stable, robust THz emission chips, including power amplifiers at emission and low noise amplifiers at reception. THz communications with achievable data rates of 50 gigabits per second and more could be a game changer for many applications, such as machine-to-machine interfaces or transferring massive amounts of data. One application would be to eliminate many of the thousands of feet of electrical cable in an aircraft, thus saving hundreds of pounds of weight and freeing up space for other applications.

Formal methods for cyber-physical systems — model-based engineering — The development of modern embedded systems is becoming increasingly difficult and challenging because of their overall system complexity, tighter and cross-functional integration, the increasing requirements concerning safety and real-time behavior, and the need to reduce development and operational costs. Formal methods are mathematical techniques for the specification, development and verification of software aspects of digital systems.

The mathematical basis of formal methods consists of formal logic, discrete mathematics and computer-readable languages. The use of formal methods is motivated by the expectation that, as in other engineering disciplines, performing appropriate mathematical analyses can contribute to establishing the correctness and robustness of a design. Implementing a formal methods-based approach to the development of large complex systems can provide the highest levels of dependability and resiliency. Formal methods also have the potential of reducing DO-178c certification costs and improving test coverage.

Formal analysis can be applied to architectural models before the system is built, allowing 'virtual integration' and allows finding problems before going to the integration rig. Formal methods tools are also being developed on the Defense Advanced Research Projects Agency (DARPA) High Assurance Security Program (HACMS). This project involves developing formal methods tools to analyse UAVs for cybersecurity vulnerabilities.

Which technology to pursue?

There are often more ideas than investment dollars which requires us to make consumption choices and place technology bets. This is not a process to be taken lightly, making the down-selection process a complex, rigorous task that involves a wide range of parameters and stakeholders. The key to innovation success is solving problems customers care about, alignment with business growth strategies and market timing. To ensure that we are solving the right problems, we engage with our customers early and often, seeking their feedback during the development of new technologies.

Through the engagement with advanced research labs, such as DARPA, the DoD Service Labs, NASA, FAA, regulatory agencies and original equipment manufacturers (OEMs), we gain awareness of emerging customer needs. At the same time, we stay aware of emerging technologies through universities, academic studies, trade shows and media reports. By bringing together the base of technology know-how with emerging customer needs, we are able to identify where the big opportunities might exist in our markets and the technology and product strategy needed to make it happen. In partnership with business leaders within our company, an assessment of the market and strategic fit is made resulting in a prioritisation of the technology thrusts and initiatives.

To mitigate the risk and exposure, we engage with our customers through technology demonstrations and in-house customer immersion labs so that they can see the prototype and experience what value it brings. Having done all that, we have to remain flexible and be prepared to terminate a project if the market need or customer strategies change. At the end of the day, having a differentiating competitive solution that delivers a powerful convincing value proposition to the customer is what it takes to win.

Rockwell Collins is working with NASA to investigate UAS in civil airspace challenges using this S-3 Viking testbed.

> ACHIEVABLE DATA RATES OF 50 GIGABITS PER SECOND AND MORE COULD BE A GAME-CHANGER FOR MANY APPLICATIONS