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The Engineer's Guide to Design & Manufacturing Advances

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Overcome antenna crosstalk issues with simulation.

Visualization of the electric field norm and 3D far field due to a transmitting antenna. Antennas are intentionally large in this tutorial model.

Multiple antennas are needed to create more complex communication systems on airplanes. But this arrangement of transmitters and receivers can cause aircraft operation issues due to crosstalk, or cosite interference. Simulation helps you analyze the crosstalk effect on an aircraft and in turn find the best antenna placement.

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August 2018

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The Engineer's Guide to Design & Manufacturing Advances

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Optical Seeker for Munitions Systems

Designing a High-Speed Decoy Unmanned Aerial Vehicle (UAV)

In-Flight Real-Time Avionics Adaptation

Using Turbine Flow Meters for Aerospace Test and Measurement Applications

From the Publishers of TECH BRIEFS

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TECH BRIEFS

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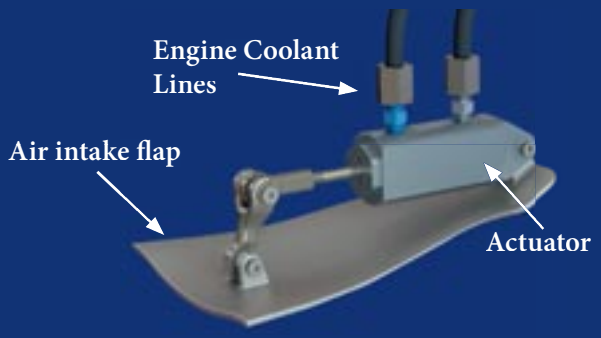
ON THE COVER

BAE Systems' cost-effective optical seeker for precision-guided munitions is designed to improve navigation, as well as automate target location and homing, for different types of munitions that are used in GPS-denied and other contested environments. To learn more, read the applications brief on page 52.

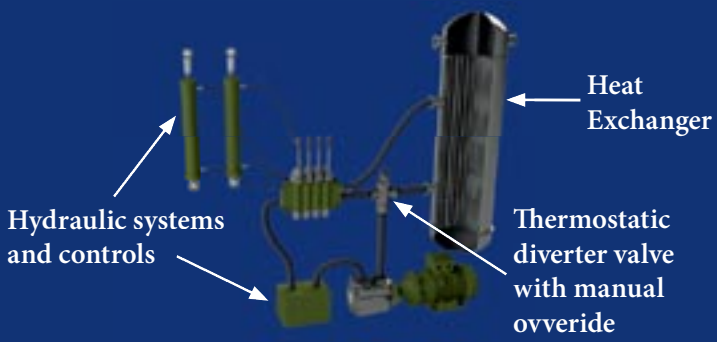
(Photo courtesy of BAE Systems)

Thermostatic Solutions for Your Temperature Control Applications

Airflow Control on Aircraft



Hydraulic Fluid Temperature Control



Freeze Protection for Naval Shipyards

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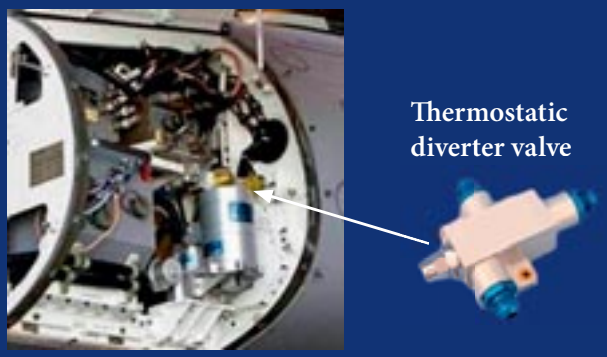

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Designing a High-Speed Decoy Unmanned Aerial Vehicle (UAV)

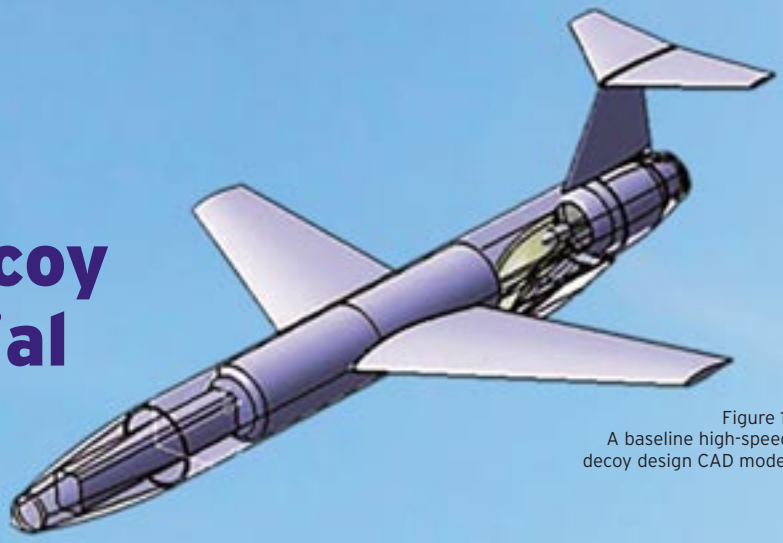

Figure 1.
A baseline high-speed decoy design CAD model

Drone aircraft and their uses have been evolving quickly, supported by a great deal of ongoing research. One area of increasing interest is the decoy drone, designed to mimic the radar and heat signature of an actual aircraft. These drones are intended to confuse or mislead anti-aircraft defense systems. If operating as designed, one or more drones are launched from an actual aircraft as it enters airspace monitored by anti-aircraft systems. The system picks up the signature of the drones and attacks them while the actual aircraft can be hidden with the swarm of drones.

In this study, computational fluid dynamics (CFD) embedded in CAD software was used to optimize the aircraft design and test the aircraft performance during different operations such as cruise, maneuverability, and maximum speed. The mission requirements for the high-speed decoy were a maximum altitude of 15,000 feet with maximum speed of 450 knots and an endurance of at least one hour.

The highly agile decoy UAV with high maneuverability capability was designed to launch from a pneumatic catapult and land via a parachute. This aircraft design had a 6-g sustained and 9-g instantaneous load factor. The required payload capacity was 22 lb, consisting of a smoke dispenser, a passive radar cross section augmenter (luneberg lens), a chaff and IR dispenser, and a miss distance indicator.

Wing Geometry

After considering the catapult, maneuver, and cruise constraints, the wing loading at takeoff condition was calculated as 23.209 lb/ft^2, which is the maximum that it should experience. From this, the advantages and disadvantages of high-wing, mid-wing, and low-wing configuration types were considered. The mid-wing configuration was selected because it had the properties of high- and low-wing; it also had the lowest drag from wing-body interference.

The wing incidence angle was 0 degrees for this decoy design because the wing incidence angle is generally set at 0 degrees for mid-wing jet fighter aircraft. The aspect ratio (AR) of the high-speed decoy wing was 5, and taper ratio value was 0.36 from other successful aerial target designs.

If an aircraft's maximum speed is less than 0.3 Mach, wing sweep is not recommended. However, wing sweep angle is used for high-speed aircraft. Wing sweep helps to protect from shock formation by increasing the critical Mach number. The leading-edge sweep angle value increases as the aircraft maximum speed increases. After considering the decoy's maximum speed requirement, leading edge sweep angle was chosen as 30 degrees.

Wing dihedral angle gives lateral stability to an aircraft; however, too much reduces rolling controllability. Wing sweep and high-wing configuration gives naturally positive dihedral, whereas, low wing gives naturally negative dihedral effect. Considering aircraft wing sweep selection, wing configuration and aerial target requirements of the dihedral angle was 0 degrees for this design.

Fuselage

For an initial guess, fuselage length was initially estimated by using the following formula assuming jet fighter coefficients:

$$l_{fuselage} = aW_0^c$$

where a is the speed of sound, and W_o is the maximum takeoff weight.

However, the actual length of the aerial targets is longer compared to the calculated values. Examining other aerial target designs, the average length difference was calculated as 26%. Therefore, for the calculated W_o, the aircraft length was calculated as approximately 9.03 ft.

Another important parameter for fuselage design is the slenderness ratio value (f). This is the ratio of fuselage length to the maximum diameter of fuselage:

$$f = \frac{l_{fuselage}}{d}$$

A slenderness value was chosen as 11 from previous successful aerial target designs with similar design requirements. Slenderness value of 11 is also close to jet fighter designs.

Tail Geometry

The tail has three main functions: stability, control, and trim. Trim refers to generation of the lift force; by acting through some tail moment arm about the center of gravity, it balances some other moment generated by aircraft. Different tail configurations were considered. The T-tail configuration was selected because of its simplicity. T-tail provides a wake-free horizontal tail and a heavy vertical tail structure to carry the horizontal tail.

A horizontal tail generates aerodynamic force to trim the aircraft longitudinally; in other words, it is responsible for balancing the moment by the wing. The horizontal tail chosen was a movable tail. Leading-edge sweep was 35 degrees, which was 5 degrees more than the wing sweep to ensure the critical Mach number would not lose elevator control from shock formation. The thickness ratio of the airfoil (t/c) section was thinner than the wing t/c to reduce the flow Mach number at the tail section. The aspect ratio (AR) of the horizontal tail was lower than the wing to improve the stall characteristics. Horizontal tail AR was estimated to be two thirds of the wing aspect ratio.

Background Image: mexrix/Shutterstock.com

Vertical tail generates aerodynamic force to trim the aircraft directionally. Rather than (yawing) directional stability, the rudder is a movable part of the vertical tail. Therefore, directional control and maneuvering of the aircraft is done by the vertical tail. The vertical tail and horizontal tail combination should be designed so that at least a third of the rudder should be out of the wake for spin recovery.

Like a horizontal tail, the vertical tail also should have a high sweep angle to increase Mcrit and avoid problems from shock formation. The vertical tail airfoil section t/c ratio was selected the same as the horizontal tail to reduce the vertical tail Mach number. A high lift curve slope airfoil was selected because the directional stability derivative is directly related to the lift curve slope of the airfoil of the vertical tail.

Airfoil affects the aircraft performance such as cruise speed, stall speed, handling qualities, and overall aerodynamic efficiency. The airfoil can be defined as the 2D profile of the wing. Optimum pressure distribution can be achieved on the upper and lower surfaces by choosing the right airfoil. The right airfoil can be chosen if the design lift coefficient Cl(ideal), Cl(max), operating Reynolds number (RE), and design Mach number, are known.

The NACA 63-412 airfoil was selected. NACA 63-412 airfoil has a maximum thickness at 34.9% of the chord and is 2.2% maximum camber at 50% of the chord. For the horizontal and vertical tail, a symmetric airfoil NACA 0009 smoothed was selected.

CFD Analysis

Because the aim of this study was to design an optimized high-speed decoy that surpasses its predecessors, the FloEFD CFD tool was used to achieve the high-speed decoy configuration that resulted in the best aerodynamic performance. Baseline design and other configurations were created according to their vertical wing and tail geometry designs. All models were created in a CAD environment and analyzed for different flow regimes and envelopes. Finally, configuration was selected based on various design and performance criteria.

Once the baseline design of the UAV was created in CAD, nine variations were generated with the different wing/tail design combinations as shown in Figure 2. CFD analyses of each of these combinations were executed to find the optimum combination that would best meet the mission requirements of the drone. Nine design variations were compared from three wing and three tail options. The following design aspects were considered in the analyses:

- Wing vertical location affects the performance directly; it alters the C.G. of the aircraft and therefore, the stability.
- Baseline high-speed decoy UAV was designed as mid-wing because of reasons stated previously.
- Low wing has less ground clearance and is not as laterally stable, but enables better lateral control. It also produces less lift and induced drag. It has less downwash on the tail, thereby making the tail more effective, and finally, it is structurally lighter than a high wing configuration.
- High wing has the most ground clearance and is the most stable laterally, though it has less lateral control. It also tends to produce more theoretical lift and, therefore, more induced drag. Plus, it is structurally the heaviest of all the designs.
- Mid-wing, as the name implies, is in between both the high and the low design with their associated characteristics.
- Conventional tail has a vertical tail that is the lightest structure of all three tail combinations because the vertical tail does not need to carry the horizontal tail. The wing wake can disturb the horizontal tail in this configuration, especially with the high wing combination.
- T-tail offers the advantage to have a wake-free horizontal tail because it is positioned the furthest distance vertically from the wing in any configuration. The downside is that it requires a

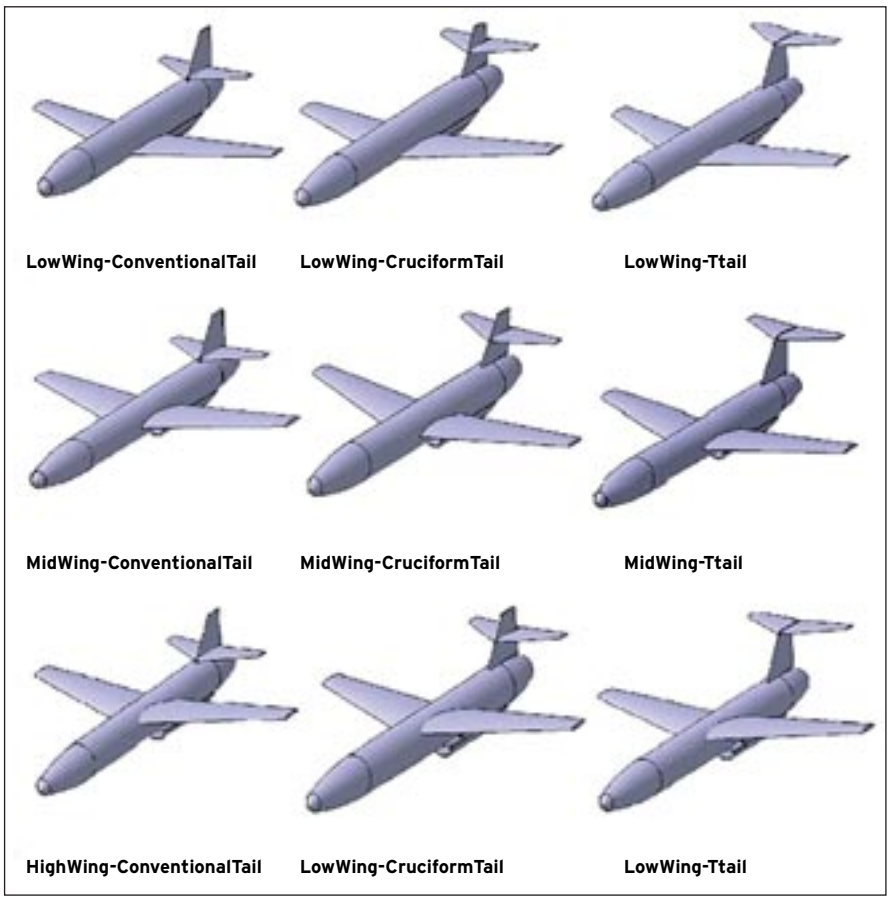

Figure 2. Drone test configurations

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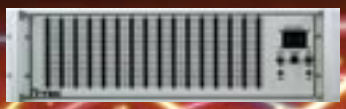

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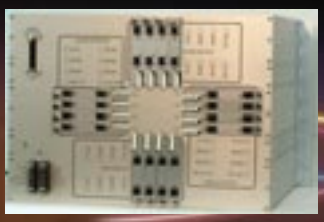

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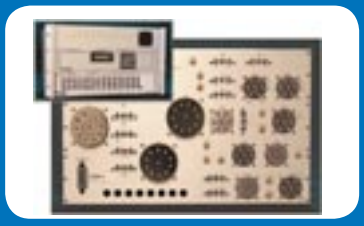

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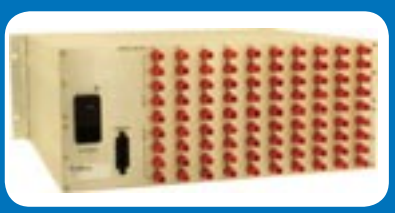

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heavy vertical tail structure to support the horizontal tail.

- Cruciform tail is the combination of the T-tail and the conventional tail. The cruciform tail enables a lighter vertical tail and helps prevent deep stall.

For the initial analyses, high wing, mid wing and low wing configurations were compared with the tail configuration kept as T-tail. CFD analysis showed that the fuselage effect negatively affected the low wing and forced the flow to separate,

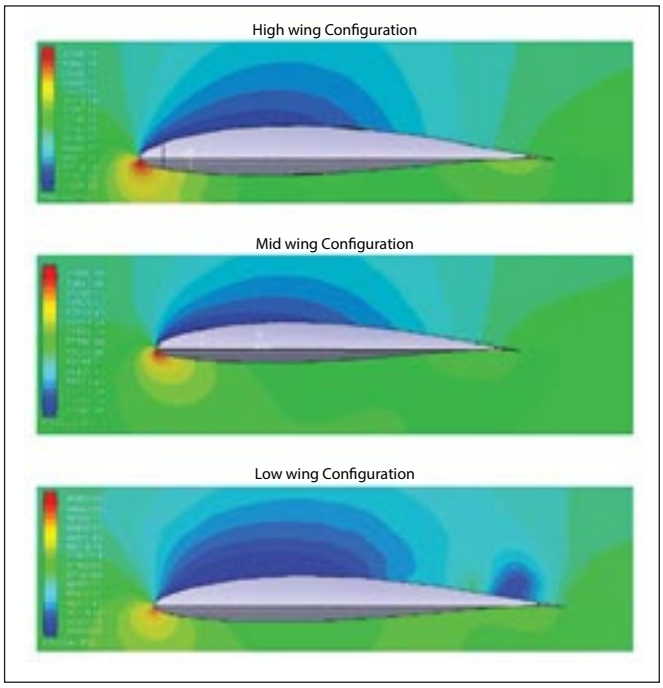

Figure 3. Pressure contours 0.13m from centerline for high wing, mid-wing and low wing angled at 6°

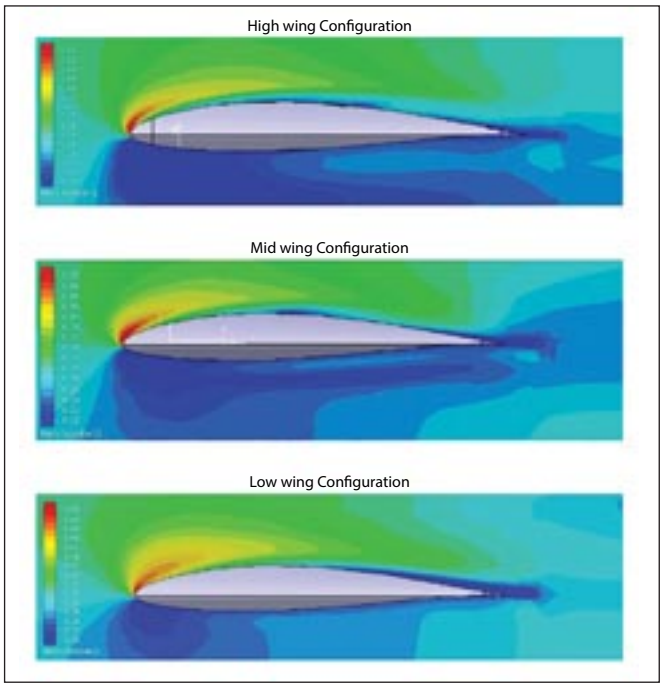

Figure 4. Mach number contours 0.13m from the centerline for high wing, mid-wing, and low wing angled at 14°

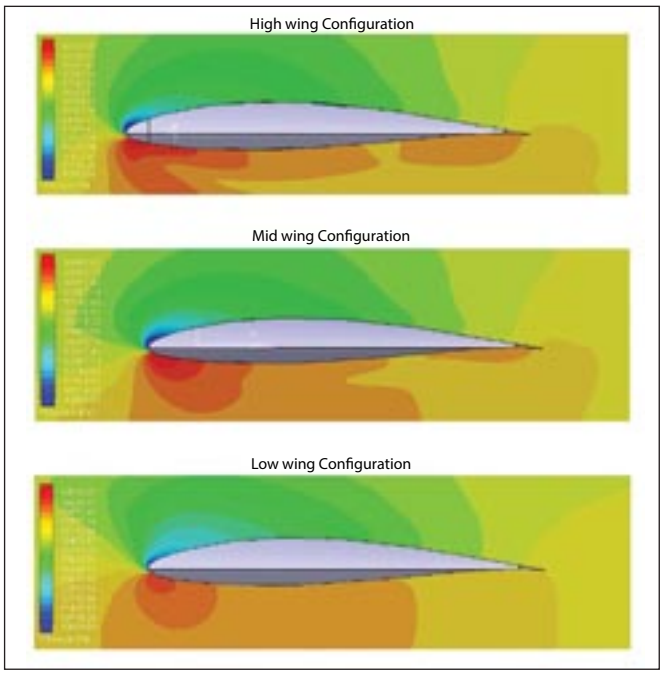

Figure 5. Pressure contours 0.13m from the centerline for high wing, mid-wing, and low wing angled at 14°

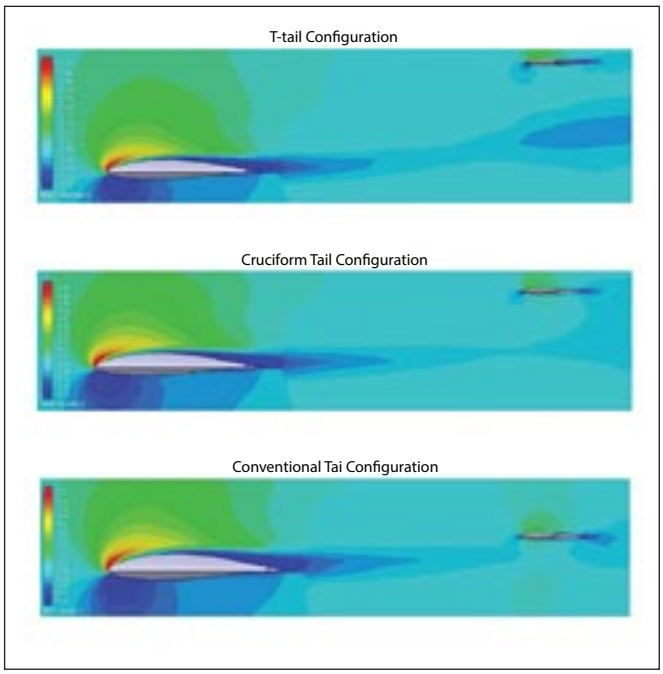

Figure 6. Mach number contour cut plots 0.231m from centerline of T-tail, cruciform tail, and conventional tail at a 14° angle

making the low wing prone to the stall and reducing its lift efficiency — the worst wing position among all configurations. High wing and mid-wing showed similar performance but the high wing was better for high angles of attack.

FloEFD revealed that for low angles of attack, the mid-wing configuration had lowest drag and highest lift-to-drag (L/D) values. Whereas for higher angles of attack, the high wing configuration yields the lowest drag coefficient, highest maximum lift coefficient, and gave highest L/D values. Unexpectedly, the high wing configuration model yielded the lowest drag at higher angles of attack compared to other configurations. Therefore, the high wing design was selected for the wing configuration.

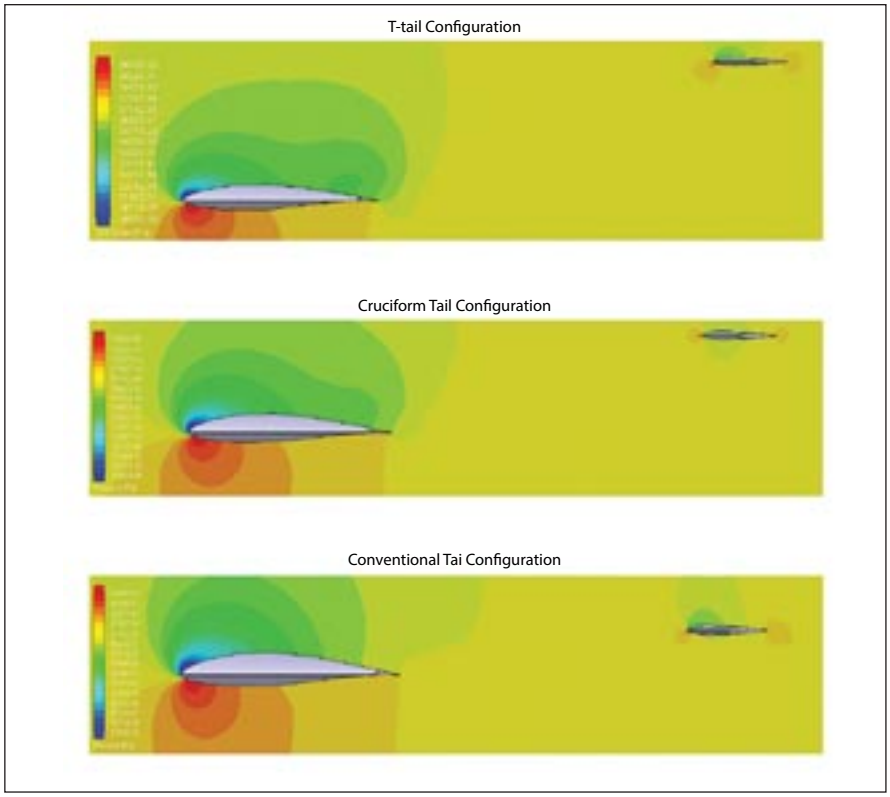

Figure 7. Pressure contour cut plots 0.231m from centerline of T-tail, cruciform tail, and conventional tail at a 16° angle

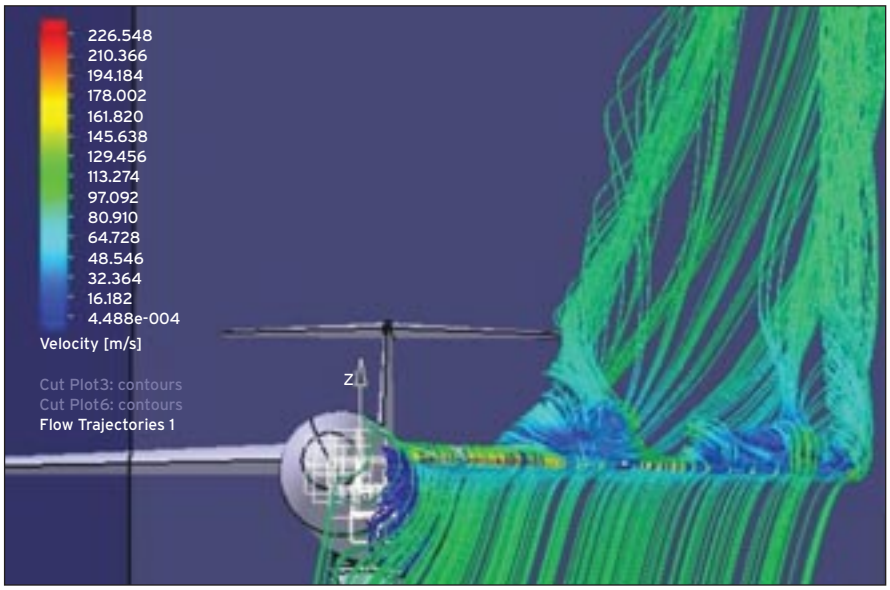

Figure 8. 3-D flow trajectories of the T-tail configuration at a 16° angle

Three different tail configurations were then analyzed while holding the high wing configuration constant. This showed that the T-tail seemed to be wing wake free and provided the most lift. Because deep stall is an important phenomena, the stall angle of 16° needed to be analyzed in more detail to prove that deep stall would not occur.

To see the occurrence of the stall phenomena completely, 3D flow trajectories were plotted; 200 pipe lines were used to show the flow trajectories through the wing. 3D flow trajectories confirm that the T-tail configuration's horizontal tail tips were not significantly affected by the stall wing wake.

Finally, the decoy UAV was tested with the CFD tool at maximum, corner, and cruise velocities. The results showed that the aircraft design would be able to fly at the required maximum velocity without a strong shock occurrence. Optimum cruise velocity was 0.38 M in the drag polar curves. Then, optimum corner velocity was found from the CFD result CL max. Wind tunnel testing is considered indispensable for getting the most accurate aerodynamic performance. However, creating prototypes of every configuration and testing them in a wind tunnel is too time consuming and expensive for a designer. The FloEFD CFD tool embedded in CATIA was helpful to reduce the number of prototypes.

This article was written by Umut Baycara, Aeronautical Safety Assistant Expert, Middle East Technical University (Ankara, Turkey) and Mike Croegaert, Senior Industry Manager of Military and Aerospace Technology, Mentor Simulation and Test Solutions (Wilsonville, OR). For more information, visit ***http://info.hotims.com/69509-503.***

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Using Thermoplastics in Aerospace Applications

In August 2017, Qantas Airlines laid down the challenge to both Boeing and Airbus to offer an aircraft that can cross one of aviation's "last frontiers." That "last frontier" was an aircraft capable of flying an economical passenger load non-stop for over 20 hours. This would allow Qantas to offer direct service from Sydney to London or New York. Weight reduction through the use of thermoplastics and other technologies would be the key to any chance of success in this endeavor.

Aluminum, steel, and titanium used to reign supreme in the world of aerospace manufacturing, taking up 70% of the average aircraft. Yet as demands for weight reduction and fuel efficiency increase, metals are losing ground to the new kid on the block – thermoplastic polymers and composites. You need only consider the latest generation of modern aircraft to see the impact these materials are having on aerospace manufacturing.

For example, look at the A350 XWB. Over 50% of this fuel-efficient aircraft is built from carbon-reinforced plastic composites, while its competitor, the Boeing 787, is also roughly 50% composite materials. Notably, this trend isn't limited to Airbus and Boeing; other companies such as Bombardier, BAE Systems, Raytheon, GE Aviation, and Lockheed Martin have also leaned into using thermoplastics and composites in their aircraft and defense related systems.

What is the reason behind this drastic shift from aluminum and steel to thermoplastics like PEEK, PPSU, PEI, and other polymer materials? As it turns out, there's more than one explanation.

Weight Reduction

With fuel costs representing the highest of all operating costs for aircraft, it's not surprising that the demand for lighter aircraft has risen with it. To put this in perspective, it is interesting to note that years ago MIT researchers estimated that for each passenger to carry a cell phone, it cost Southwest Airlines and additional $1.2m annually in fuel costs. If the passengers each carried a laptop then the cost jumped to $21.6m!

Polymer and composite materials meet the challenge of helping reduce aircraft weight by being up to ten times lighter than metal. This sharply lowers lifetime fuel costs, reduces emissions, and extends flight range. By and large, the most efficient airframes contain large amounts of carbon-fiber reinforced polymers and composites. These airframes and components can be responsible for reducing aircraft weight by as much as 20%.

For this reason, the market for machining components from lightweight, high-performance thermoplastics is growing, especially for aerostructure applications. Aerospace-grade polymers such as polyetheretherketone (PEEK), polyphenylsulfone (PPSU), polyetherimide (PEI), and polyetherketoneketone (PEKK) provide a reliable and cost-effective way to reduce weight. More importantly, they add value beyond weight reduction for many applications due to unique properties advantageous to metallic components where their superior corrosion and fatigue resistance, tensile strength, and durability can lead them to outperform metal.

Extreme Resistances

High-performance thermoplastics meet more stringent flame, smoke, and toxicity (FST) standards due to their inherent flame resistance or, in some cases, flame retardancy. A few standouts are PPSU (RADEL), PEI (ULTEM), PPS (RYTON), and PEEK (VICTREX 450G), which have UL94 V-0 flammability ratings without any flame-retardant additives.

It shouldn't be surprising then to know that thermoplastics can survive in extreme temperatures. Two striking examples are polyimide (PI) (VESPEL) and polybenzimidazole (PBI) (CELAZOLE), which can operate uninterrupted from cryogenic temperatures to over 550°F, with intermittent exposure to over 900°F. This, combined with resistance to high wear and friction, gives PI and PBI impressive longevity in hostile environments.

Hostile environments aren't always made so by temperature, though. Resistance is key for aerospace applications which involve exposure to harsh chemicals. The high chemical resistance of

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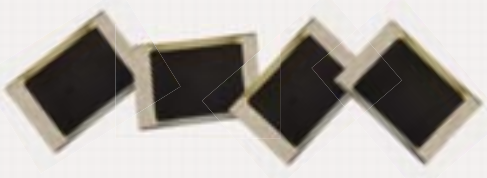

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Wing Flex on a Boeing 787 in Flight

thermoplastics like PPS means it can operate even when submerged in a severe chemical environment, where metals are prone to dissolving. PPS's dimensional and density stability has also made it a favorite for aircraft components, whether for interior, mechanical, or exterior.

Another crucial feature for aerospace is corrosion resistance. This is something that thermoplastics excel at, especially when compared to aluminum and steel. One of the primary causes of structural failure for aircraft is galvanic corrosion between dissimilar materials. As aerospace manufacturing leans towards using thermoplastic composite fuselages, metallic structural brackets and other associated causes of galvanic corrosion are being replaced, creating overall safer aircraft.

Both the Boeing 787 and Airbus A350 XWB offer composite fuselages which are able to operate at a higher-pressure differential, which in turn results in a cabin altitude lower than with previous aluminum fuselages. The composite materials allow for higher strength, lower fatigue and no corrosion, allowing for a lower cabin altitude with higher humidity resulting in a less fatigued passenger upon arrival.

Insulation and Radar-Absorption

While metallic components require extensive and costly secondary processing and coating to achieve their insulating properties, polymers and composites are inherently thermally and electrically insulating.

A perfect example of this is PEI, which has one of the highest dielectric strengths of any thermoplastic material. Its low rate of thermal conductivity makes it a frequent choice for aircraft galley equipment, while its UL94 V-O flame rating makes it ideal for aircraft interior components. In fact, ULTEM 2300 – a 30% glass-reinforced grade of ULTEM PEI – is often used as a direct replacement for aluminum due to its similar coefficient of thermal expansion to 6061-T6.

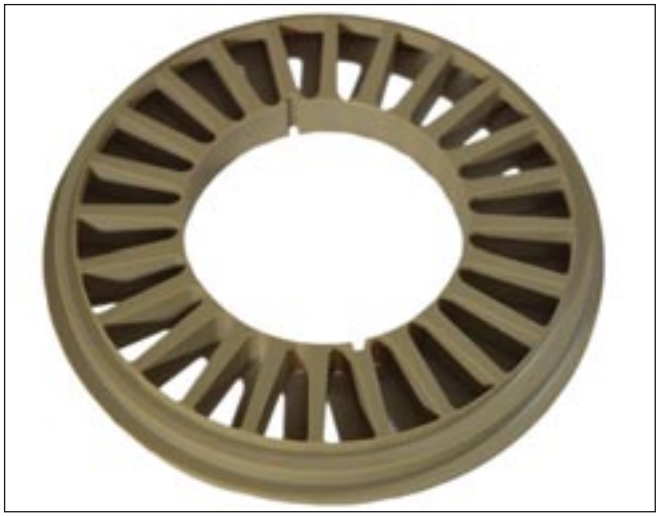
Along with their insulation properties, polymer components have the additional benefit of being radar-absorbent. This makes thermoplastics useful for stealth military aircraft applications, where evading radar detection is mission-critical. Metals, on the other hand, tend to be strong reflectors of electromagnetic waves, making them easy to detect by radar.

Manufacturing and Design Flexibility

One reason aluminum had been so frequently used for aerospace is that it was considered easy to manufacture into aircraft components. A misconception is that thermoplastics don't share that quality. Advances in thermoplastic manufacturing and processing have allowed for great flexibility in both manufacturing and design. One major thermoplastic and composite manufacturing misconception is that plastic parts cannot be easily machined. On the contrary, thermoplastic components have been machined into geometrically complex mission critical components over the past few decades.

Thermoplastics can be machined to extremely tight tolerances up to 0.002mm, which can be critical for aerospace applications. Processes such as rapid thermoforming, autoclave processing, tape and fiber placement techniques and press forming are also all possible with thermoplastic polymers and composites.

Many thermoplastics also have better fatigue properties than metals do, and they tolerate larger deflections without



Polymer and composite materials help reduce aircraft weight by being up to ten times lighter than metal.

deforming. To prove this fact, just look at the wing flex on a Boeing 787 in flight as shown in the accompanying illustration.

PEEK is one thermoplastic that has fast become a popular replacement for metal in aerospace. It's a natural choice since PEEK's lightweight nature, mechanical strength, creep and fatigue resistance, and ease of processing all give it great versatility. PEEK's diversity of applications includes flight control, fuel systems, aircraft interiors, and engine and aerodynamic-related components.

Conclusion

There are numerous types of thermoplastics gaining ground in aerospace, many more than are named in this article. Yet it's important to remember that each thermoplastic, though sharing broad characteristics, has its own unique strengths that make it better suited for some applications over others. It's not unexpected that an aircraft engine has different needs than a RADEL aircraft galley bezel or a landing gear component.

When determining thermoplastic solutions, it's crucial to practice due diligence and partner with an experienced aerospace plastics manufacturer. They should be able to offer material consultancy as part of their expertise and discuss the pros and cons of each selection, as well as display experience in manufacturing it. Take a careful look at their industry standards and certifications, like the ISO9001:2015 AS9100D, to be sure that they understand the regulatory requirements for aerospace applications. Most importantly, look at the supplier's experience in manufacturing mission critical thermoplastic aerospace components, as many times the actual machining talent and experience is the difference between a failed or successful thermoplastic component.

In a field as mission-critical as aerospace, success often relies on choosing the material best suited for an application. Increasingly, that material is thermoplastic.

This article was written by John Macdonald, President, AIP Precision Machining (Daytona Beach, FL). For more information, visit ***http://info.hotims.com/69509-501****.*

In-Flight Real-Time Avionics Adaptation

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Avionics is a very restricting domain for obvious safety reasons. Along with miniaturization comes the idea of integration. More functionality on one spot requires a good management of privacy and congestion on shared platforms. This is why determinism is one of the keywords of avionics works. This led to protocols like ARINC653[1] assuring that multitask embedded programs respect a predictable policy applied by the operating system (OS). Another key protocol is ARINC664, which guarantees that multiple communicating systems efficiently share the network. These two protocols are pillars of the Integrated Modular Architecture (IMA) concept[2].

IMA concept consists of a multitask module hosting ARINC653 OS, interconnected with an ARINC664 data network. Compared to federated avionics architecture, it considerably reduces the overall weight and power consumption for aircraft. IMA also reduces the development expenses, the design cycle times and the maintenance costs. With the intention to step forward with this concept, the CORAC (The Council for Civil Aeronautics Research) has developed a technological demonstration platform (PDT) called Extended Modular Avionic (AME)[3]. This paper explains a project dedicated to monitoring the system.

Embedded Simulator

Methodology

Figure 1 presents the basic methodology. We consider an avionic architecture featuring core processing modules (CPM) implementing several applications and generating data traffic and avionics switch modules (ASM), which route data packets to their destination CPM.

As an example, CPM1 in Figure 1 features three partitions, each one hosting an application dedicated respectively to GPS, speed, and angle estimation. Through an ARINC664 communication End System, data generated by these applications are sent through several Virtual Links (VL) of the data network. While performing data traffic management, the ASM also implements a simulator that runs a timed model of the expected communication traffic, considering the OS and network parameters. The ASM is the privileged place to implement a simulator since its CPU only manages message traffic and has available time.

The simulator performs two types of verification: temporal consistency, which checks whether communication occurs at the expected time, according to the system scheduling, and data consistency, which analyzes N consecutive data values to determine if their evolution is coherent or if we can assume an error has occurred.

The simulator can also be used as an architecture exploration tool. It can model different application mappings on the system and test which one is the most efficient to handle specific scenarios. This could help the system to perform dynamic reconfiguration when it comes upon critical situations.

To achieve this goal, the SystemC[4] language was chosen as an appropriate candidate to model both software (application) and hardware system (processors and communication modules) under time constraints defined by ARINC653 and ARINC664.

SystemC

SystemC is a C++ class library based on an object-oriented design concept (OOD) providing common Hardware Description Language (HDL) features. As such, it allows hardware description

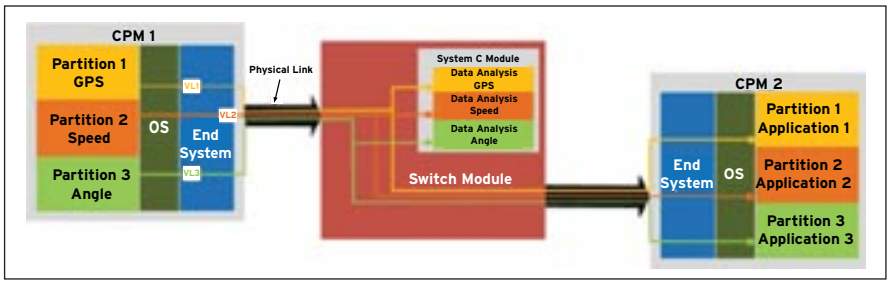

Figure 1. Embedded Simulation Methodology

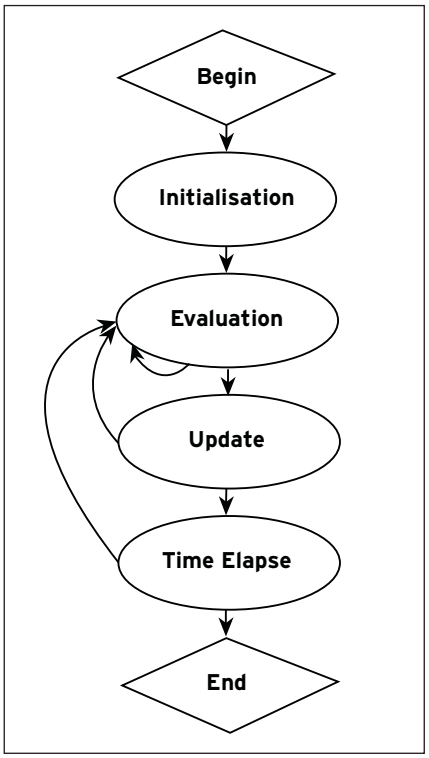

Figure 2. SystemC Flow

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along with software development. Hardware behavior concurrency is simulated by the way simulation time is being managed by the simulator.

Hardware components are modeled using the sc_module class and are interconnected to each other with sc_port class objects. Module internal registers are represented by sc_signals, and module behavior by processes, which can be described as functions triggered by the update of ports or signals that are registered in a sensitivity list. A SystemC program usually consists of an elaboration phase where all the elements of the described system are declared and assembled, and where all processes are listed. Then comes the simulation phase, which is initiated by the sc_start method, which is a function of the simulator. Finally, the cleanup phase ends simulation, by cleaning objects and structures.

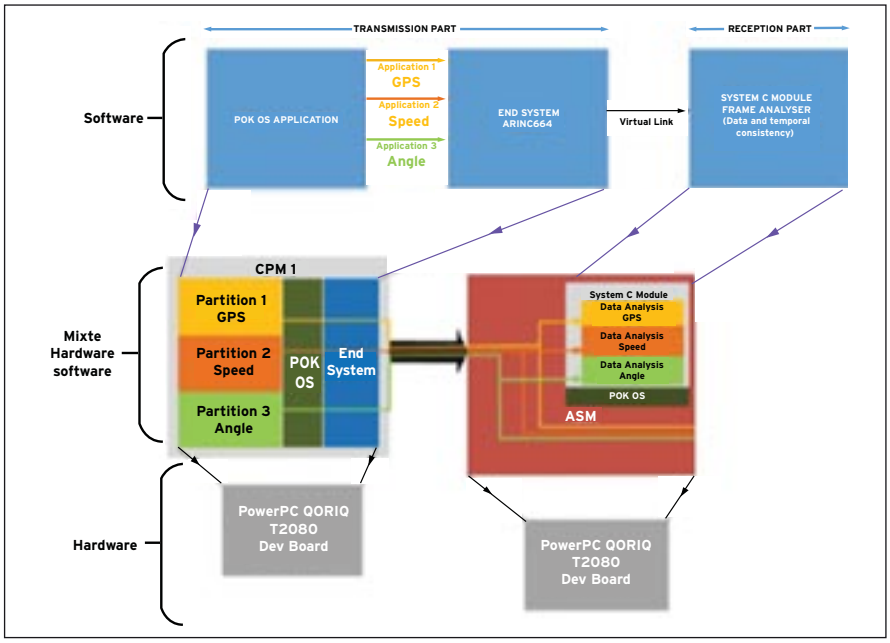

Figure 3. T2080 Demonstrator

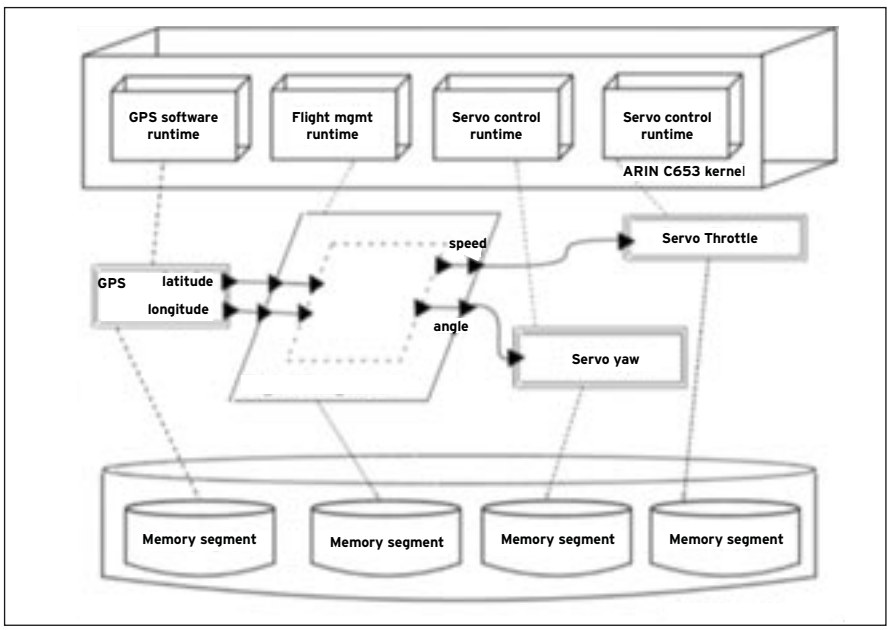

Figure 4. POK Flight Management Application

The role of a SystemC simulator is to manipulate the timestamp to simulate the concurrency of hardware behavior. It determines in which order processes must be executed, and when values of ports and signals must be updated. The Accelera Systems Initiative (ASI) provides an event driven simulator with the language library.

The simulation phase features three steps: *Evaluation*, in which the simulator checks which processes must be executed, according to their sensitivity list. The simulator then executes these processes. When this is done, the second step, *Update*, updates the values of ports/signals according to the previous execution of processes. If signal or ports updates trigger a process sensitivity list again, then we go back to the evaluation step. When no process is triggered anymore, the simulation timestamp is updated in the *Time Elapse* step (Figure 2).

The ASI simulator, as it is implemented, features memory dynamicity, which avionic constraints don't allow. Furthermore, process scheduling at each timestamp is dynamic and non- deterministic[5]. This doesn't affect the result of the simulation, but can be an issue in an avionic context, considering execution time.

SystemCASS

SystemCASS (SystemC Accurate System Simulator)[6] is a SystemC simulator that establishes a static scheduling of processes, which is made at the start of simulation. To do so, SystemCASS requires describing all component models as CFSM (Communicating Finite State Machine) using a CABA (Cycle Accurate Bit Accurate) abstraction level. Furthermore, a single clock must drive all modules. SystemCASS modules can include the following types of processes:

Transition: triggered by the clock rising edge, it sets the new values of registers, depending on their actual values and the input port values.

Moore/Mealy Generation: triggered by the clock falling edge, these processes set the new values of output

ports, depending on register values only (Moore) or register and input port values (Mealy).

When calling the sc_start method, SystemCASS creates depending graphs that generate the static scheduling of processes, which will be used throughout the simulation phase. This implementation ensures a deterministic behavior of the simulation.

As a result, SystemCASS is more suitable to avionic constraints than a dynamic event driven simulator. As we use gcc compiler, SystemCASS original implementation featured dynamic memory allocation during the creation of the depending graph after the elaboration phase, and right before the simulation phase. To remove these dynamic allocations, we first used a static version of gcc compiler and then identified in runtime all the encountered dynamic memory allocations and replaced it with static memory allocations.

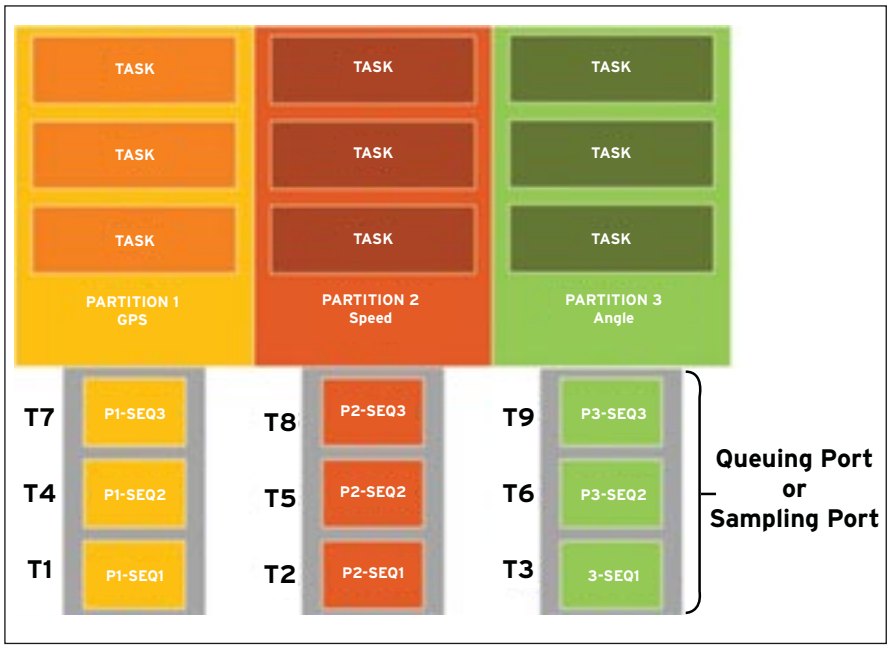

Figure 5. Data Generation and Space Partitionning

To identify dynamic allocation, we used gdb debug tool and a script that put breakpoints on malloc call. This script is:

```
set logging file trace.txt
set logging on
break malloc
Command
Bt
Continue
End
Break main
Command
Continue
End
Run
Set logging off
Quit
```

Implementation

To validate the system, a demonstrator was designed based on two QorIQ T2080 design boards, each featuring a PowerPC E6500 processor (Figure 3). The first board assumes the role of a CPM module, running test applications which are supposed to transmit data toother CPM modules. The second board assumes the role of an ASM module. It performs data reception and runs the embedded SystemCASS simulator.

Each QorIQ T2080 board hosts the PolyORB Kernel (POK) operating system. POK is a partitioned operating system compliant with ARINC653 avionic standard[7]. POK ensures enforcement of safety and security requirements at runtime. It also provides some example of avionics applications. One of these applications is Flight Management (Figure 4).

This application was run on the CPM QorIQ board. POK OS handles the flight management application (GPS, Speed and Angle) and at the same time handles the ARINC 664 End System module. On the ASM QorIQ board, POK handles the SystemCASS simulator to perform data monitoring or architecture exploration.

Use Cases

Data Monitoring

Considering the predictability and determinism of applications software ruled by the protocol ARINC653 and their windows of communication in ARINC664, one can predict part of the aircraft data traffic. Some verification within the communication protocol already exists concerning the integrity of the data transport, but none can analyze the content itself to determine whether one or another application is really supposed to send a value, or if a communication disappeared, or if a value is simply incoherent. Obviously, simulating the whole communication flow to determine if it is coherent would be too time-intensive. The idea is to target specific applications, or specific suspect behaviors (missing material, erroneous values) that could be monitored during the flight. We could then create a simplified functional timed model of applications as communication providers. On the basis of ARINC664 and ARINC653 configuration values (major frame, bandwidth allocation gap ...), we could predict communication by simulation and compare it with the real traffic to verify temporal and the data consistency.

The application is implemented as follows: on the CPM QorIQ board, POK runs the Flight Management application, which features three partitions (speed, angle and GPS) and generates the application data (Figure 5). POK's ARINC653 properties guarantee space partitioning (meaning that memory of partition is protected) and also guarantees time partitioning (meaning that only one partition at a time is executed).

The execution of each partition is handled by a static scheduler (Figure 6) and is defined by the system integrator. Each partition (P1, P2 and P3) has a set of execution windows (T1, T2, T3) and this set of windows is repeated in time (T4, T5, T6 and so on...) and at the same order, which guarantees that each partition has access to the system resources once in a MAF (Major Frame).

Once that data is generated by POK, they are put in the Queuing Port or Sampling Port and are then sent to the End System with the order defined by the scheduler. Queuing Port can be seen as a buffer and the Sampling Port as a FIFO. The End System then encapsulates the data in an ARINC664 frame with the specification of the Virtual Link (BAG, Frame Size, Jitters) that has been defined by the

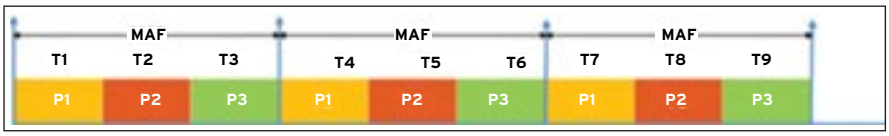

Figure 6. Partitionning Scheduling

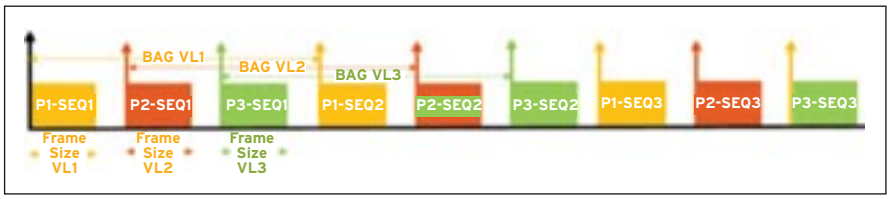

Figure 7. ARINC 664 Frame at the Output of the End System

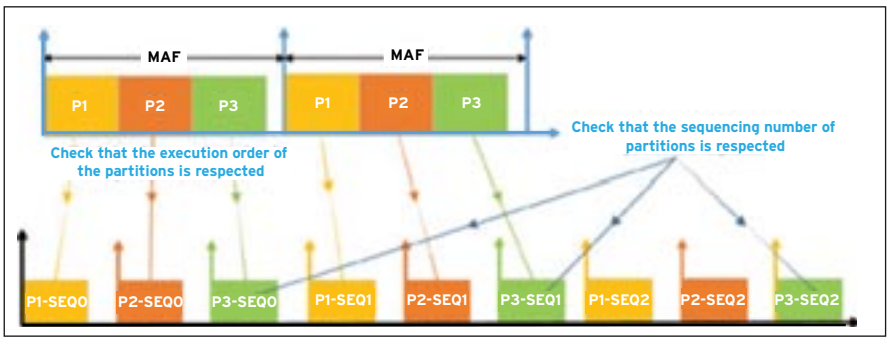

Figure 8. Temporal Consistency Verification

system integrator (Figure 7). A Virtual Link defines a unidirectional logical connection from one source End-system to one or several destination End-System(s). Each partition has a dedicated Virtual Link (VLi is dedicated to the data of the Partition i).

On the ASM QorIQ board, POK runs the embedded simulator. SystemCASS runs a SystemC module that analyzes the ARINC664 frames coming from the CPM board, performing data and temporal consistency.

Data consistency involves analyzing the payload of the ARINC664 frame that contains data for each application (GPS, speed, angle). In order to do so, a verification of the physical variation law between two data values T and T+1 for each application is performed.

On the other hand, temporal consistency involves verifying that the execution order of each partition is consistent with the scheduling defined by the transmitter part (Figure 8).

Architecture Exploration

Embedded simulation can also be used to help decide in real time how the system should be configured (i.e. what is the most efficient application mapping configuration) when critical situations occur and processing resources should only focus on the most essential applications.

To do so, a predefined set of application mapping configurations should be stored in a library. When the system detects some incoherent execution or some major misbehavior (based on the data monitoring simulation, or other verification mechanisms), a reconfiguration procedure can be started. The embedded simulator then runs the stored configurations to get performance profiles. A decision motor selects the most appropriate configuration (whether it's the one that reaches the best performance, or simply the first configuration that meets a predefined performance requirement). The system can then be dynamically reconfigured to remap the application according to the simulated scheme.

This article was adapted from SAE Technical Paper 2017-01-2169. To obtain the full technical paper and access more than 200,000 resources for the aereospace, automotive, and commercial vehicle industries, visit the SAE MOBILUS site at: ***http://saemobilus.sae.org****.*

References

1. Spitzer C. R., Ferrell U., Ferrell T., and Prisaznuk P. J., "ARINC Specification 653, Avionics Application Software Standard Interface," in *Digital Avionics Handbook, Third Edition*, CRC Press, 2014, pp. 625-632.
2. Paul J. P., "ARINC 653 role in integrated modular avionics (IMA)," in 27th Digital Avionics System Conference Proceedings, 2008, vol. 1.
3. "CORAC," *COnseil pour la Recherche Aéronautique Civile*. .
4. Initiative O. S., "IEEE standard SystemC language reference manual," *IEEE Comput*. Soc., pp. 1666-2005, 2006.
5. Schumacher C., Weinstock J. H., Leupers R., and Ascheid G., "SCandal: SystemC analysis for nondeterminism anomalies," in Specification and Design Languages (FDL), 2012 Forum on, 2012, pp. 112-119.
6. Buchmann R., Petrot F., and Greiner A., "Fast cycle accurate simulator to simulate event-driven behavior," in Electrical, Electronic and Computer Engineering, 2004. ICEEC'04. 2004 International Conference on, 2004, pp. 35-38.
7. Delange J. and Lec L., "POK, an ARINC653-compliant operating system released under the BSD license," in 13th Real- Time Linux Workshop, 2011, vol. 10.

Using Turbine Flow Meters for Aerospace Test and Measurement Applications

Turbine flow meters have long been a preferred technology for obtaining precise measurements of fluid flow in the aerospace industry. In addition to their high accuracy, they are recognized for exceptional turndown, repeatability and speed of response.

With recent design enhancements, instrumentation manufacturers have expanded the advantages turbine flow meters offer in a host of demanding aerospace applications. Indeed, the turbine remains one of the most accurate and reliable transducers for today's critical flow measurements.

In the aerospace and defense industry, testing of fuel system components is key to ensuring final vehicle or aircraft performance. By pairing a flow meter with a flow computer or smart transmitter, aerospace equipment manufacturers can perform precise metering of fuel flow in engine test cells.

Experience has shown that turbine flow meters are the sensor-of-choice for test and measurement applications requiring the best accuracy available with the benefits of high resolution, extended turndown across wide flow ranges, fast speed of response, proven reliability, and compact size. These meters also feature a small footprint for ease of installation on both fixed and portable test stands.

Turbine flow meters incorporate a time-tested measuring principle. They contain a freely suspended rotor, and the flow against its vanes causes the device to rotate at a rate proportional to flow velocity. A sensor/transmitter is used to detect the rotational rate of the rotor; when the fluid moves faster, more pulses are generated. The transmitter processes the pulse signal to determine the flow of the fluid in either forward or reverse direction.

Common Flow Applications

Available in compact and lightweight packages with rugged materials of construction, turbine flow meters are used to measure diverse fluids ranging from aircraft fuel to hydraulic fluid, lubricant, cryogenic fluid and coolant.

Common turbine meter applications include:

- Fuel management
- Fuel ballast
- Flight testing
- Hydraulic system verification
- Product R&D
- Qualification and acceptance testing
- Performance evaluation
- Maintenance, Repair, and Overhaul (MRO)

From monitoring the fuel consumption of rotary and fixed wing aircraft, missiles and drones, to evaluating the performance of hydraulic fluid and lubricants on test stands, aerospace applications place high demands on flow sensing.

Latest Technology Advancements

In recent years, instrumentation manufacturers have expanded the traditional advantages offered by turbine flow meter technology. Turbine meters now have unprecedented mechanical linearity, resulting in minimizing, or negating, temperature-induced viscosity influence. Meters equipped with sophisticated electronics also provide total compensation to enhance measurement accuracy, while extending linearity over their repeatable range.

The following improvements enable turbine meters to satisfy application requirements in ways once considered infeasible:

- Dual-rotor designs
- Hydraulically coupled rotors
- Helical rotors
- Embedded processors
- Ceramic bearings
- Secured internals

With the latest advancements in technology, turbine flow meter accuracy has improved. Increased sensitivity allows for the precise measurement of even extremely low flow rates in some models. Manufacturers also continue to develop blade and rotor materials that are highly sensitive, durable and less vulnerable to drag and other factors that have traditionally decreased accuracy.

Important Application Considerations

Today's versatile turbine flow meter systems can be configured to achieve the best solution to measure liquid or gas in the most challenging environments. For instance, flow meter suppliers provide an assortment of electri-

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cal pickoffs to meet temperature and signal transmission distance requirements, which are complemented by an assortment of electronic processors and indicators. And, selecting from either standard or custom end connection designs can optimize meter installation.

For users with demanding fuel system measurement requirements, the following application consideration guidelines will make turbine flow meter configuration simple, while presenting alternatives to maximize accuracy and minimize cost.

Fluid Parameters: Fluid properties vary from one flow measurement application to another and need to be defined in order to properly develop the correct meter configuration and calibration specification. Fluid parameters include:

1. Fluid Type
   - Affects the flow meter's wetted parts
   - Defines filtration requirements
   - Determines water, solvent or oil blending calibration
   - Provides fluid density information, required for inferred mass flow
2. Operating Fluid Temperature (minimum and maximum)
   - Defines fluid viscosity range
   - Identifies the number of calibrations required to develop a Universal Viscosity Curve (UVC) calibration
   - Required to select pickoff type (from cryogenic to high-temperature applications)
   - Determines if remote electronics are required
3. Static Line Pressure
   - Over 1000 psig changes viscosity and density properties
4. Flow Range
   - Determines the permissible range in combination with the pressure drop and UVC capability

Meter Type: There are different types of turbine flow meters, and some are more specialized to certain applications. Depending on the particular needs, one style of meter may be preferable to another. Users can choose from four basic configurations, depending on their requirements:

- Low-flow axial meters
- Precision single-rotor meters
- Dual-rotor meters
- Original Equipment Manufacturer (OEM) specialty meters

Electrical Pickoffs: Because test and measurement applications vary so greatly, most turbine flow meter manufacturers offer multiple electrical pickoff choices to meet specific end user requirements. A pickoff is mounted on the meter body and is used to take the output of the device.

When specifying a pickoff, there are many factors to consider. The following list outlines the consideration process:

1. RF carrier pickoff (requires carrier amplifier)
2. Magnetic pickoff (no power required)
3. Pickoff fluid temperature ranges
4. Embedded temperature sensor (RTD or Thermistor)
5. Transmission distance (when amplified)
6. High-vibration pickoff coils
7. FM, CSA, CE and ATEX approvals for EMI, explosion-proof and intrinsically safe applications

In some cases, an RTD thermowell temperature probe can be inserted into a flow straighetner to provide improved temperature monitoring in place of an embedded pickoff temperature sensor.

Turbine flow meters come in a variety of sizes and materials to handle different applications.

End Connections: End connections are determined by the pipeline size and pressure, ease of removal, and other specific application criteria. Equally as important is the adjoining pipe and end connection pressure rating. High temperature will reduce the pressure rating on all fittings.

Flow Straighteners: Flow straighteners are recommended on single-rotor turbine flow meters to negate swirl from influencing the accuracy of the meter. Some flow straighteners employ a bladed insert to prevent swirl and minimize pressure drop. In addition, they can be paired pressure and temperature taps.

When flow straighteners are impractical due to space limitations, a turbine meter can be calibrated in the same piping as found in the installation to compensate for fluid swirl. Generally, dual-rotor meters can be used without flow straighteners.

Packaging: Turbine flow meter packaging options are available to allow for integral or remote mounting. Remote mounting provides a solution when space is limited or when environmental temperatures are excessive. OEM meters are commonly designed with an embedded flow processor, allowing for complete interchangeability of the meter system.

Calibration: Turbine meters are highly repeatable, however, care must be taken to choose a calibration that will maximize their accuracy. The meters are viscosity-sensitive and may need a calibration that corrects for temperature/viscosity effects on the output. This type of calibration is accomplished by blending solvent and oil to simulate the

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kinematic viscosity of the fluid at a given temperature. Wide temperature variations might require multiple calibrations to develop a UVC. A flow processor uses this data to provide a fully temperature compensated precision flow output.

The quantity of calibration data points, over the usable flow range, will determine the resolution of the calibration curve. More data points result in a higher degree of accuracy. Because of the predictability of the turbine meter, 10 data points are generally sufficient. For master meters, 20 to 30 data points are recommended.

Service Provider: Since a turbine flow meter's performance is highly dependent on the quality of its calibration, it is wise to utilize primary standard liquid and gas calibrations performed by NVLAP-accredited calibration facilities. The calibration criteria at these sites are based on the ISO/IEC 17025 International Standard, which is used to evaluate the competence of calibration laboratories throughout the world. The standard specifically assesses factors relevant to the ability to produce precise and accurate calibration data including:

- Correct equipment – properly calibrated and maintained
- Adequate quality assurance procedures
- Proper correlation practices
- Appropriate testing methods
- Traceability of measurements to the National Institute of Standards and Technology (NIST)
- Accurate recording and reporting procedures
- Suitable testing facilities
- Technical competence of staff

Final Recommendations

Leading turbine flow meter manufacturers provide knowledgeable technical assistance for specifying the correct instrument and calibration for a given application. Their experience and know-how can guide users in selecting the proper meter electronics based on a wide range of power and output configurations.

In many cases, precision turbine flow meters are designed and manufactured to provide a building block approach to satisfy the most difficult applications requirements. This approach takes into consideration fluid temperature, environmental conditions, vibration, shock, bi-directional flow, and a host of tube and pipe connections, which solves a multitude of challenges.

This article was written by Mike McCoy, Technical Sales Manager, Badger Meter (Milwaukee, WI). For more information, visit ***http://info.hotims.com/69509-502.***

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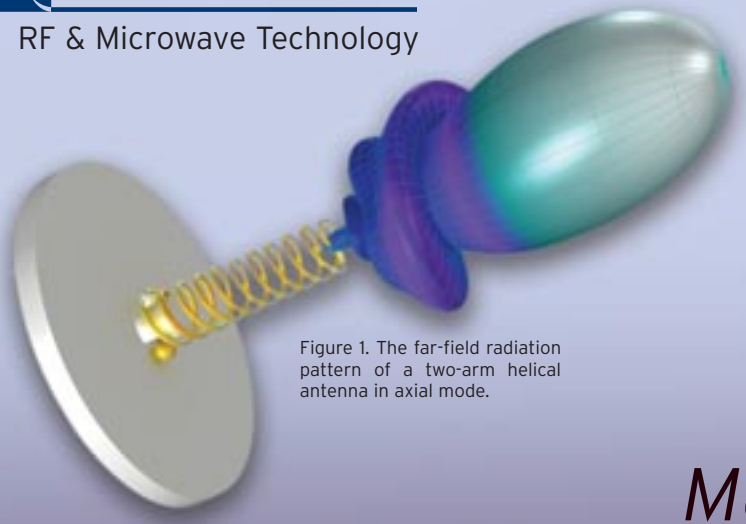


Figure 1. The far-field radiation pattern of a two-arm helical antenna in axial mode.

Communicating from Space: *The Front End of Multiscale Modeling*

As satellites and astronauts travel further out in space, the more communication challenges they face. NASA launched the InSight Mission on May 5, 2018 from Vandenberg Air Force Base, California. InSight was designed to collect data on Mars quakes and the processes that shaped the rocky planet to help us better understand how it formed. Getting the information back to the scientists here on Earth required a variety of antennas on the spacecraft.

The Helical Antenna: An Upward Spiral

Helical antennas have been deployed for communication with orbiters in applications such as global positioning systems (GPS) and NASA's InSight mission. Helical antennas are used to transfer data through the electromagnetic wave in the range of ultra-high frequency (UHF).

A helical antenna is known for its spiral geometry, which features one or more conducting wires wound in a helix. It is essentially a miniaturized monopole antenna with an input impedance mismatched to a typical reference impedance of 50 ohm. A helical antenna is much smaller than a traditional half-wave dipole and a quarter-wave monopole antenna. The smaller size of the antenna is achieved by turning the wire obliquely along the rotational axis, decreasing its input resistance. One way to compensate for the lowered resistance without adding a large matching network next to the antenna is by utilizing the folded dipole antenna design that has four times the resistance compared to that of a half-wave dipole antenna. The input impedance can then be enhanced by turning the single helical wire to a two arm-helical structure.

Figure 2. Helical and horn antennas are present on InSight for RISE. (NASA)

The helical antenna provides two resonant modes: normal and axial. In a normal-mode antenna, the radiation pattern resembles the far-field pattern of a monopole antenna that is omnidirectional around the azimuthal angle. The axial mode is the one used to reach the orbiters. When the antenna operates in an axial mode, it behaves like an end-fire ring array and generates a directional beam pattern, so the antenna gain is higher than that at the normal mode. With the higher-gain far-field radiation, the same limited amount of energy used in the normal mode can be transferred over a longer distance. Additionally, the antenna polarization becomes circular due to the nature of the geometry. Compared to the linear polarization, the circular polarization is less sensitive to the multipath fading effect, so it is less vulnerable to environmental fluctuations, making it an ideal candidate for space communication.

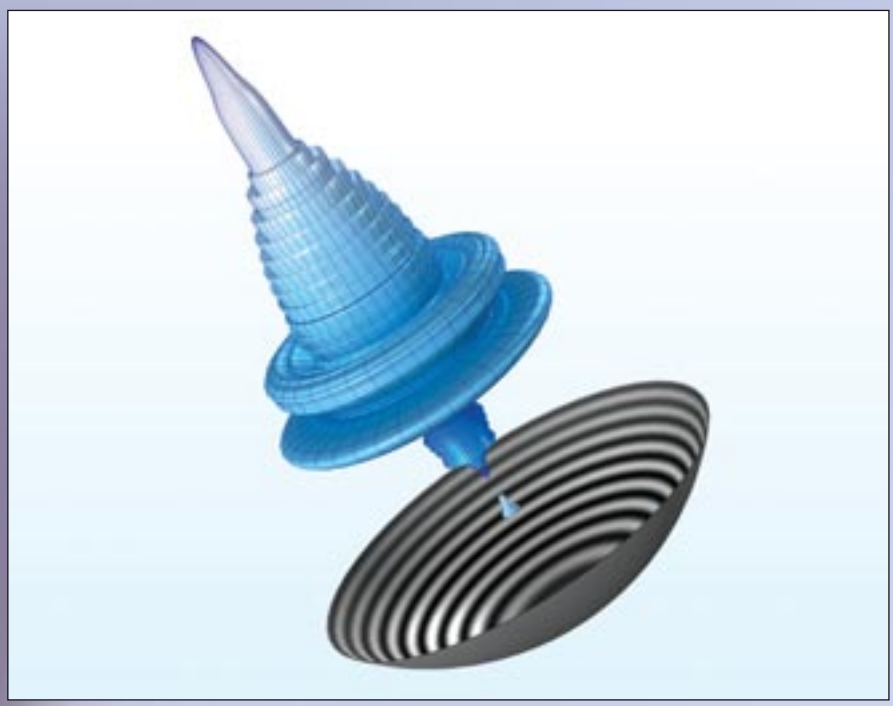


Figure 3. A dish reflector antenna with a feed horn and its far-field radiation pattern in dB scale.

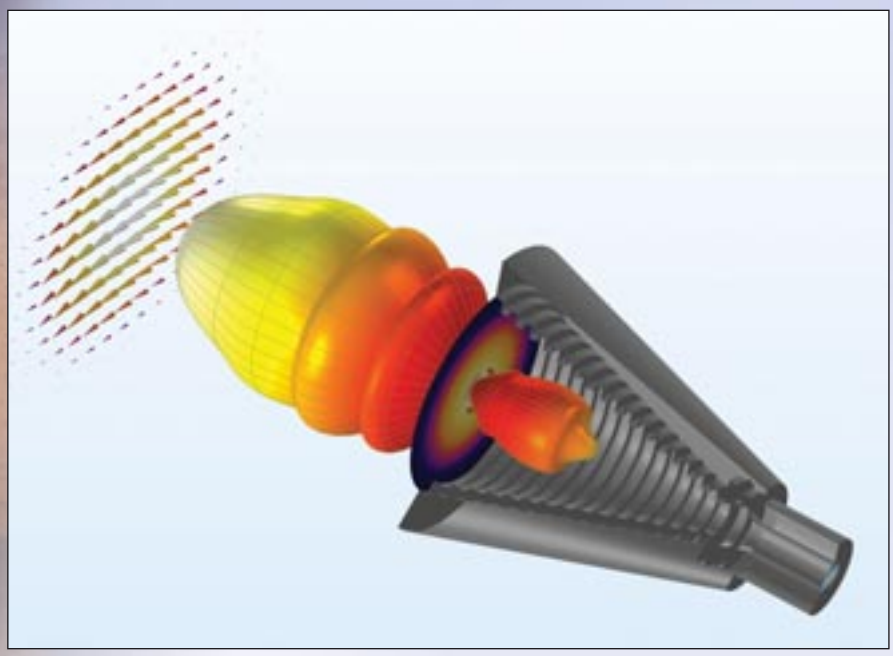


Figure 4. The far-field radiation pattern and aperture electric field results of a corrugated horn antenna.

From Helical to Horn Antennas

In conventional satellite communication applications, a large aperture or reflector antenna is preferred since it provides the high-gain output without building a complicated antenna structure. Medium-gain x-band horn antennas are also present on the InSight for Rotation and Interior Structure Experiment (RISE) to find the geometrical stability of the North Pole of Mars through the revolution that Mars makes around the Sun by tracking its location.

The geometry of a horn antenna is relatively simple; however, when it comes to simulating the electromagnetics, its computational cost can be expensive due to the large electrical size scaled by the operating wavelength. To address the increased computational costs when computing an electromagnetic (EM) wave propagation and resonance analysis, the horn antenna can be designed using 2D axisymmetric modeling that reduces the computation time by orders of magnitude.

A simulation of the x-band circular horn antenna deployed on the InSight spacecraft would benefit from the 2D axisymmetric modeling approach. When improving the performance of a circular horn antenna, a dielectric lens and corrugated antenna interior are used to enhance the radiation characteristic and refine the circular waveguide polarization to appear more linear by combining two waveguide modes. In Figure 4, a conical horn antenna is fed by a circular waveguide. And thanks to the corrugated surface throughout the cone, there is a lower cross-polarization at the aperture. Cross-polarization oc-

Figure 5. The user interface of the antenna array simulation app, built using the Application Builder within COMSOL Multiphysics, with an 8 x 8 virtual array, electric field distribution, and 3D far-field radiation pattern view.

curs when the electromagnetic fields are polarized opposite than what was intended; for example, if the fields from an antenna are meant to be horizontally polarized, the cross-polarization occurs vertically. If an antenna has a great degree of cross-polarization, the signal is likely to interfere with nearby channels, which is not a desired outcome.

Deploying High-Gain Antennas

The deployment of these high-gain antennas is sometimes quite limited due to their large size and weight or angularly restricted visibility from a sharp radiation pattern with a high directivity. Actively electronically scanned array (AESA) antennas offer not only a high-gain radiation pattern with a conformal shape of a smaller antenna, but also beam-steering capabilities so the shortcomings from a large dish reflector and aperture antennas won't be significant. These benefits come at a computational cost due to the large electrical wavelengths it produces.

The necessity of high-speed communication and beam-steering capability has grown with emerging trends such as the Internet of things (IoT), SatCom, and the Internet of Space (IoS). As such, the AESA has become more popular not only in traditional military applications, but also in consumer electronics. The antenna array size is often smaller than that found on reflector and aperture antennas; however, the design process of an antenna array could be memory-intensive because it remains electrically large in terms of wavelength.

The computational cost for simulation can be reduced by using efficient modeling techniques. An antenna array application available in the COMSOL Multiphysics RF module application library — the Slot-Coupled Microstrip Patch Antenna Array Synthesizer application — shows how the simulation can be compressed at the prototyping stage. It simulates an FEM model of a device that is fabricated on a multilayered, low-temperature, co-fired ceramic (LTCC) substrate, and extends the results to the user-specified array configuration.

Here we use the analysis of a single antenna to describe the behavior of the entire array. First, an accurate 3D full-wave simulation of a single microstrip patch antenna is performed. Then, user inputs such as array size, arithmetic phase progression, and angular resolution are taken into account to describe, for example, the 3D far-field of the entire array. The two-dimensional antenna array factor has been implemented to include the translational phase shifts and array element weighting coefficients needed to determine the radiation pattern of the entire array.

Fast and Accurate Results

Efficient modeling techniques with low computational cost and fast computational speed are critical for modern-day design and simulation engineers in the millimeter-wave industry. The purpose of simulation is to describe real-world devices and components as close as possible through mathematical representation. When simulating and analyzing axisymmetric objects such as spheres, conical dish antennas, and circular waveguides, the 2D axisymmetric modeling approach offers orders of magnitude faster computation time compared to a full 3D model.

Simulating a simple shape structure may appear to be easy and fast without considering the impact of the electrical size of the model in terms of wavelength. It is feasible to simplify the simulation process without losing accuracy with the support of the 2D axisymmetric modeling approach while sustaining the integrity required to analyze electrically large real-world components.

Summary

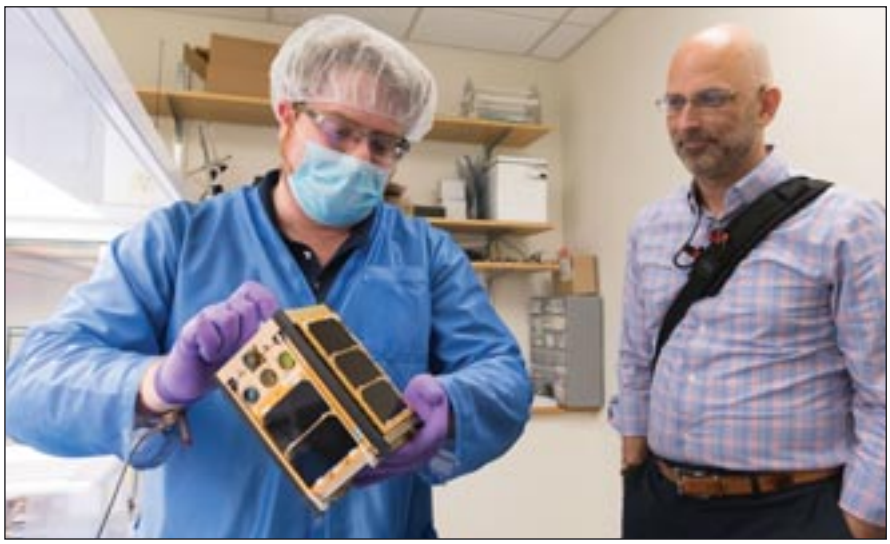
Using a variety of antennas, such as the InSight, is the most effective way to ensure that communication from space arrives back to Earth in a timely fashion. Making sure those antennas are ready for space travel requires multiphysics simulation that allows you to scale your model to ensure efficient use of computational resources while maintaining high accuracy.

This article was written by Jiyoun Munn, Technical Product Manager, RF, at COMSOL Inc., Burlington, MA. For more information, visit ***http://info.hotims.com/69509-541.***

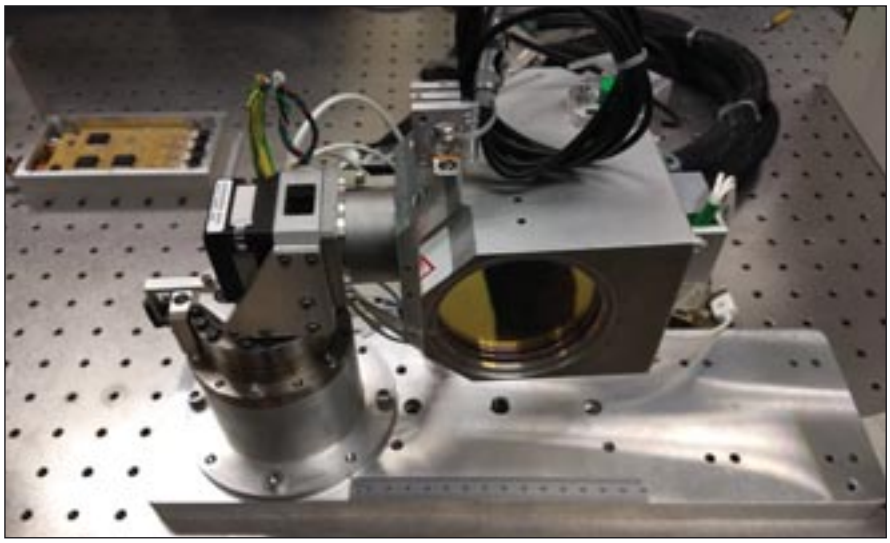
Laser-Based System Could Expand Space-to-Ground Communication

A new research project announced recently as a collaboration between the Georgia Institute of Technology and satellite communications provider Xenesis could help open the bottleneck that now limits the flow of data from Earth-orbiting satellites to ground stations.

The project will miniaturize, space-qualify, and test a laser communications transceiver that could dramatically expand the bandwidth available for downlinking information from the growing number of satellites — and future constellations of space vehicles — in low Earth orbit. Xenesis licensed the technology from NASA's Jet Propulsion Laboratory (JPL), and will work with Georgia Tech and JPL to mature it for use as a primary communication system for satellites as small as CubeSats.



Georgia Tech aerospace engineering graduate student Byron Davis (left) shows Xenesis CEO Mark LaPenna a RANGE CubeSat scheduled to go into orbit later this fall. (Allison Carter, Georgia Tech)



The compact, reduced-complexity, low-cost laser communications transceiver will enable down-linking of data from Earth-orbiting spacecraft, as well as point-to-point communications and private networking.

The NASA Technology

The JPL-developed system is a compact, low-cost laser communications transceiver that surpasses the severe spectrum-allocation and bandwidth limitations of conventional radio-frequency communication systems. The innovative design reduces complexity, size, mass, and cost by using readily available flight-grade parts for the compact optics assembly and high-capability electronics assembly. JPL's laser communications transceiver can uniquely and inexpensively satisfy the high-bandwidth communications needs of Earth-orbiting spacecraft.

The laser communications transceiver comprises two primary modules: an optics module and an electronics/laser module. The optics module includes a 5-cm-diameter telescope; a two-axis, coarse-pointing gimbal; monitoring sensors; and thermal control. The electronics module includes a transmitter, processor, controllers, and power conditioning.

Keeping optical uplink rate modest and emphasizing downlink, the high-bandwidth downlink transmitter uses coarse wavelength-division-multiplexing for operation at four 2.5-Gb/s channels (a total data rate of 10 Gb/s). Applying this technique enables the use of larger active-area photodetectors at the ground station, which reduces the atmospheric scintillation/turbulence effects on the received beam. These effects are further reduced with forward-error correction and deep-interleaver codes.

A compact laser communications transceiver with a single transmit/receive aperture has been built using components with traceability to flight qualification (i.e., a flight-qualified version is commercially available). The transmit downlink wavelengths fall within the standard C-band telecom grid of EDFA fiber amplifiers (1530 to 1560 nm).

Applications

Mark LaPenna, CEO of Xenesis, compared the benefits of the planned space-based network to the jump in performance from terrestrial dial-up connections of the 1990s to today's high-speed broadband services.

"Xenesis recognizes the need for a global communications revolution, and we plan to empower space with an optical product called XenHub," LaPenna said. "Through this architecture, any company, mission, or global operator on the ground or in space will be able to compete on a level playing field for the first time since Sputnik."

"We expect to significantly add to the total bandwidth of information that we can get down from space, and the more bandwidth we have, the more information we can exchange and the more value we can get from satellite networks," said Brian Gunter, an assistant professor in Georgia Tech's Daniel Guggenheim School of Aerospace Engineering, who will be leading the project.

Gunter's lab has experience with small satellites and will apply that expertise to the project with Xenesis, which signed a $1.2 million contract to support the work. Georgia Tech's contribution will be to miniaturize the original JPL technology, update the control software, space-qualify all the hardware, and test the improved system from space — likely from the International Space Station.

"With all of the satellites that are going into space, everything from CubeSats to major satellites, there is more information being generated than can ever be downloaded," said Dennis Poulos, chief technology officer at Xenesis. "Most of today's systems depend on radio frequency downlinks, and there is just a limited amount of bandwidth available for use."

Laser-based systems can expand that bandwidth to beyond 10 gigabits per second, Poulos said. In addition to boosting bandwidth, optical systems can use smaller antennas, use power more efficiently, and provide better data security.

Though it is subject to interference from clouds, the laser system will benefit from producing a narrow beam that can travel farther than comparable radio frequency transmissions at the same power level. The initial focus will be space-to-ground communication, though the system could also be used for cross-linking communication between satellites. The small antenna size is also more suitable to the small-form satellites envisioned for future constellations that may include thousands of spacecraft.

"Once we can show that this works from space to ground, that will demonstrate that the technology can survive the harsh environment of space and allow us continue the development of the transceiver for commercial use," Gunter added. "This has the potential to open up a range of new capabilities, including the ability to provide high-volume data services to anywhere in the world."

For more information, contact ***John Toon at jtoon@gatech.edu; 404-894-6986.***

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Company Description

Visualization of the electric field norm and 3D far field due to a transmitting antenna. Antennas are intentionally large in this tutorial model.

COMSOL is a global provider of simulation software for product design and research to technical enterprises, research labs, and universities. Its COMSOL Multiphysics® product is an integrated software environment for creating physics-based models and simulation apps. A particular strength is its ability to model multiphysics systems by accounting for different boundary conditions, material properties, and physics describing, for example, sensors and actuators found in aerospace and defense systems.

Electromagnetics, mechanical, acoustic, fluid flow, heat transfer, and chemical phenomena can be included to model antennas, microwave electronics, connectors, switches, mechanical components, and more. Interfacing tools enable the integration of COMSOL Multiphysics® simulations with all major technical computing and CAD tools. COMSOL users can convert their models into easy-to-use apps for their design teams, manufacturing departments, test laboratories, and customers throughout the world. Apps are deployed and accessed online through a local installation of the COMSOL Server™ product.

Target Markets

Technical enterprises, research labs, and universities.

Products/Services Offered

This simulation application runs in a web browser and allows users to optimize the design of a capacitive touchscreen.

Designing aerospace and defense systems is a company-wide effort. To foster collaboration COMSOL is providing engineers with the tools to optimize a design by taking into account all relevant physics and enable the input of experts from other departments such as design, manufacturing, and testing through the use of apps. COMSOL Multiphysics® is uniquely positioned to address the modeling of designs such as batteries, fuel cells, corrosion, thermal cooling, electrical sensors, piezoelectric devices, and more. The Application Builder in COMSOL Multiphysics® provides design teams with tools to turn detailed multiphysics models into easy-to-use apps. COMSOL Server™ allows worldwide publishing of these apps by hosting them locally and making them readily accessible through the web or COMSOL® Client for Windows®. The adoption of simulation apps makes the workflow streamlined and inclusive. With simulation apps, you do not have to be an expert in numerical simulation to analyze and optimize a design based on accurate multiphysics simulation results.

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Company Description

Crystal Group Inc., a technology leader in rugged computer hardware, specializes in the design and manufacture of custom rugged servers, embedded computing, networking devices, displays, power supplies, and data storage for high reliability in harsh environments. An employee-owned small business founded in 1987, Crystal Group provides defense, autonomous, and industrial markets with in-house customization, engineering, integration, configuration management, product lifecycle planning, warranty, and support services.

Crystal Group products utilize COTS (customer off the shelf) components and meet or exceed IEEE, IEC, and military standards (MIL-STD-810, 167-1, 461, MIL-S-901). All products are backed by a 5+ year warranty with in-house or on-site support and are manufactured in the company's NIST compliant Hiawatha, Iowa, USA, facilities with end-to-end U.S. supply chain of custody. Certified to AS9100D Aerospace quality management standards. For more information visit crystalrugged.com.

Target Markets

- Military & government
- Autonomous
- Oil & Gas
- Power Distribution
- Communications
- Mining
- Railway, Transit
- Weather Radar

Products/Services Offered

Crystal Group provides a three-point advantage: proven products, dependable support, and end-to-end services.

PRODUCTS – DESIGNED FOR MISSION CRITICAL APPLICATIONS
- Rugged servers
- Rugged embedded computers
- Rugged networking (switches, routers, firewalls)
- Rugged displays
- Rugged data storage
- Rugged power supplies

SERVICES
- Custom Design & Development
- Mechanical & Electrical Engineering
- Rugged Product Manufacturing & Testing
- AS9100C:2009 and ISO 9001:2008 Certified QMS
- Systems Engineering
- Custom Integration
- Transit Case Integration
- Configuration Management
- Product Life-Cycle Planning
- 24/7 In-House and On-Location Technical Support
- 5+ year warranties
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International Manufacturing Services, Inc. (IMS)
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Company Description

IMS is an industry leader in design, development and production of passive electronic components including thick and thin film resistors, attenuators, couplers, thermal management devices and other RF microwave components. Founded in 1974, IMS is a privately held, AS9100D and ISO 9001:2015 certified company supplying resistive products to industries such as aerospace, defense, communications, instrumentation, medical and RF microwave applications. IMS' Rhode Island headquarters combines the corporate offices and manufacturing facility, enabling IMS to provide excellent customer relations with a solutions-oriented approach. Over the past 40 years, IMS has garnered the reputation of producing quality products with the shortest lead times in the industry. They continue to grow through product innovation and meeting the demands of advanced technologies.

Products/Services Offered

- Thin and Thick Film Chip Resistors
- Chip Attenuators
- Thermal Management Devices
- Temperature Variable Chip Attenuators
- Chip Terminations
- Resistive Power Splitters
- Resistive Couplers and Lossless Dividers

IMS offers a full range of products to meet the specific needs of the electronic design community. Thick and thin film resistors, attenuators, splitter, couples and thermal management devices are available in a wide range of tolerances and sizes. Customers looking for precision, quality, non-ferroresonant, RoHS compliant, high power and small size will find a full complement of resistor and attenuator solutions for applications. Not only does IMS offer short lead times on catalog items, some products are even available for same day shipping. IMS originated the ThermaBridge™, a thermal transfer device designed to transport heat from one location to another, for which they won the EN-Genius Network Product of the Year Award in 2008. If the standard offerings do not match the intended specifications, IMS employs a highly qualified engineering staff that will work with customer requirements to develop a custom solution. Staying on the forefront of product design is what IMS does best and they are prepared to meet the challenges coming from advanced technologies and future innovation in the electronics design industry.

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Company Description

MW Aerospace Solutions designs and manufactures springs, fasteners, and related products for a wide range of aerospace applications, including components for engines, flight controls, propulsion, landing gear, interiors, avionics, and the most advanced space exploration vehicles. The brands comprising this group include Atlantic Spring, Accurate Screw Machine, BellowsTech, Helical Products and Servometer, - specializing in springs, stampings, fasteners, couplings, flexures, machined springs, edge-welded and electrodeposited bellows and assemblies.

"With ISO9001 and AS9100 certification and compliancy, MW Aerospace Solutions offers core aerospace capabilities and experience with our advanced manufacturing techniques and processes that yield unrivaled innovations. Our market basket of products and our custom solutions are specifically designed and manufactured for the aerospace industry. Our mission is to enable our OEM and manufacturing partners to bring products to market more quickly and cost-effectively.

Target Markets

Military/Defense
AUVSI
Commercial
Aerospace
Transportation

Products/Services Offered

The MW Aerospace Solutions consist of the following brands:

Atlantic Spring, Flemington, NJ has become a full-range manufacturer of custom springs, clock springs, flat springs, shaped wire springs, wire forms and assemblies.

BellowsTech, Ormond Beach, FL specializes in edge welded metal bellows with over a hundred die sizes and a wide variety of material choices from Titanium to exotic alloys.

Servometer, Cedar Grove, NJ uses a unique and proprietary manufacturing process is able to produce flexible, lightweight and extremely rugged bellows, couplings, electrical contacts and rigid electroforms in miniature sizes.

Helical Products, Santa Maria, CA proprietary process creates a flexure for couplings, machined springs and one piece custom solutions that integrates attachments, simplifies assembly and can be accomplished in a wide range of exotic materials.

Accurate Screw Machine (ASM), Fairfield, NJ is a manufacturer of custom and stock electronic hardware, fasteners, and precision machined components.

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RAD® TORQUE SYSTEMS

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Company Description

RAD Torque Systems creates extreme-duty torque wrenches for heavy-duty applications. Recognized worldwide as leaders in safety, efficiency, power and reliability in the torque industry, the RAD team is driven to constantly evolve; incorporating and creating their own technological advancements to improve their products and keep their customers at the forefront of their industries.

Innovation within RAD's tech department means they have the capability to supply the aerospace industry with lighter, faster, battery-powered and electric tools, complete with data collection capabilities to improve efficiency, cut costs and improve safety wherever they are used.

Target Markets

North America, Asia, Australia, Europe.

Products/Services Offered

RAD Torque Systems has worked with major players in the aerospace industry – including aircraft manufacturers and airlines – for more than two decades. Working directly with engineers to design and manufacture high-torque wrenches, offsets, multipliers and reaction arms, the RAD team creates custom solutions to solve problems unique to the aerospace industry.

The E-RAD Blu series is considered industry changing. With torque ranges of 100-11,000 ft. lbs. (135-15,000 Nm) the Torque Multiplier is credited with taking just an hour to complete a job that previously required three men working all day.

With a digital display, the portable B-RAD Select battery series is able to adjust the torque value by two simple buttons. Suitable for pre-torque and service jobs where electricity or compressed air are not available.

For applications where tool access to the bolt is limited, the RAD SDM Low Profile series multipliers can provide a solution. Based on RAD's long experience with planetary gear reduction technology, the SDM Low Profile gearbox was designed for confined applications in multiple industries including aerospace. The RAD SDM Multipliers are to be combined with your chosen nut runner.

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Company Description

TECA Corporation developed the first commercially available thermoelectric enclosure cooler in 1978. A privately held company since 1984, TECA remains the market innovator of thermoelectric thermal management products for industry, military, and laboratories. We manufacture a range of thermoelectric products for climate and process control. We serve all environments: NEMA-12/4/4X, Shock & Vibration, CID2, and CID1. Our products are built in our Chicago factory and ship directly to our customers worldwide. We adhere to strict consistency in the factory and transparency with our customers.

Target Markets

TECA Corporation serves a broad range of industries by providing best-in-class thermoelectric cooling/heating devices. Our enclosure air conditioners lead the market and include the only collection of large-capacity thermoelectric air conditioners ranging 3,200-6,000 BTU/HR. Our premium components and finely honed American manufacturing practices are required by demanding environments within industries such as aerospace, military, automation, and satellite communications. Contact TECA and let our experience and quality serve your unique climate control needs.

Products/Services Offered

The fundamental purpose of TECA is to serve its customers by providing world-class products of the best possible quality. Without sacrificing health, safety, or the environment in which we live, we prioritize our efforts to ensure product quality and customer service. We are committed to using premium components from original source manufacturers and their certified distributors. Suppliers are a crucial factor of TECA quality. Their performance is measured and controlled to ensure on-time, acceptable deliveries.

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MICHIGAN ECONOMIC DEVELOPMENT CORPORATION

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https://www.michiganbusiness.org/about-medc/contact-medc/
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Company Description

The Michigan Economic Development Corporation assists companies in their expansion strategies and fosters growth of a vibrant aerospace industry. The foundation of this success is found in 9 of the 10 largest aerospace/defense R&D firms with a presence in Michigan; a top 10 ranking for aerospace supply chain expansion; and, a talent pipeline that includes the highest concentration of mechanical, industrial, and aerospace engineers of any state, the No. 2 ranked undergraduate aerospace engineering program in the country (UofM) and 17 universities and technical schools with dedicated curriculum for the aerospace and aviation industry.

The MEDC also supports key industry initiatives, including two lightweight materials institutes: the Lightweight Innovations for Tomorrow (LIFT), and the Institute for Advanced Composite Manufacturing Innovation (IACMI) in the state. Work being done at these facilities will help create lighter, better materials for the next generation of aircrafts.

Target Markets

Aerospace companies that are interested in growing their business within a manufacturing-rich state.

Products/Services Offered

The state that revolutionized the automotive industry is now one of the top places in the country for aerospace business. Michigan offers a strong business climate, competitive tax structure and significant shared synergies and capabilities between the automotive, defense and aerospace industries.

Services offered/benefits include:

- Comprehensive aerospace ecosystem (ranked No. 2 in the nation by PwC).
- Talent pipeline including electrical and mechanical engineers and industrial designers.
- Financing opportunities including incentives, grants and loans.
- Site location assistance.
- Procurement and networking opportunities.

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GRAS Sound & vibration

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www.gras.us

Company Description

GRAS is a leading global provider of high quality, durable and reliable test microphones and is dedicated to finding new and better ways to measure acoustics. We design and manufacture state-of-the-art sensors for industries where accurately measuring acoustics is critical in R&D, QA and production.

At GRAS, we have developed a wide range of acoustic sensors and rugged measurement microphones designed to help our customers obtain reliable data the first time, and every time. Our world-class equipment is suitable in all types of aerospace applications, including in-flight measurements, fly-overs, propulsion, launch vehicles/payload, wind tunnels, UAV/eVTOL.

Products/Services Offered

Traditional approaches to acoustic testing often involve significant costs in both capital equipment and labor. And with the aerospace industry moving toward returning to supersonic commercial flight, you need even more accuracy and flexibility in your test equipment. Only GRAS can offer you the right acoustic sensors so you can collect high quality data while reducing test labor costs.

Shorter time-to-market requirements, new and complex technologies, and more pressure to "get it right the first time" in the testing phase, only makes your selection of acoustic sensors even that much more important. From standard microphones, customized sensors, flyover arrays or microphones for extreme sound pressures, GRAS has the right acoustic sensors to help you develop tomorrow's flying machines today.

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GAGE BILT
RIVET & LOCKBOLT TOOLS

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Fax: 586-226-1505
E-mail: solutions@gagebilt.com
www.gagebilt.com

Company Description

Gage Bilt, located in Clinton Township, MI, has been manufacturing a full range of Commercial and Aerospace blind rivet and lockbolt tools since 1956. We have a complete fastener installation product line that is interchangeable and equivalent with the competition. Our product line includes: Tools, Nose Assemblies, Power Units, Accessories and Spare parts. Gage Bilt is committed to manufacturing innovative and robust, standard and custom products, providing you with quality solutions at competitive prices and best in class lead-times. Our technical support and customer service teams will help you pick the best product for your needs.

Products/Services Offered

Gage Bilt's continued dedication to create innovative designs focused on safety, productivity, ergonomic and FOD control has led to a wide range of products. We have improved upon and developed new technologies from lockbolt collar feeders to automated riveting systems, high-production power units to specialized noses. We take pride in working closely with our customers to find solutions for special applications, such as tight clearances, faster cycles, and FOD control. These, and many other innovative products, have proven invaluable to our customers.

www.gagebilt.com

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Company Description

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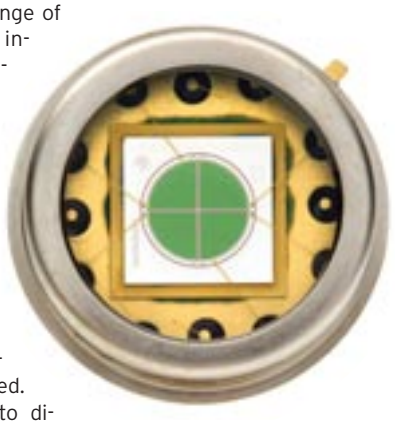
Products/Services Offered



We offer a broad range of technologies which include thick-film technology as well as all microelectronic packaging technologies from the processing of bare dice, mounting of active or passive electronic components up to the encapsulation and sealing in hermetic housings. EN 9100 certified. Products include photo diodes, pressure sensors and inertial sensors.

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Target Markets

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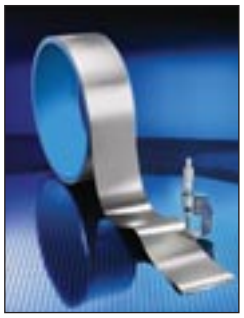
Products/Services Offered



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Company Description

Magnet Applications, Inc. offers customers turnkey solutions for magnetic assemblies, each designed and built around our core magnets. Magnet Applications, Inc. is the only North American manufacturer of compression bonded, injection molded and hybrid magnets. Our plant is ISO 9001:2008 certified and ITAR registered.

Target Markets

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Industrial and Commercial
Medical Equipment
Military & Aerospace
Sensors
Permanent Magnetic Motors

Products/Services Offered

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Target Markets

Aircraft/ Aerospace
Medical
Electronics
Communications
Defense
Energy
Agriculture
Automotive
Machinery & Process Equipment
Distribution

Products/Services Offered

Seastrom manufactures high precision hardware with precision stamping, CNC machining, screw machining, four-slide, waterjet and laser part marking capabilities in metallic, non-metallic and exotic materials. All backed up with an engineering and tool & die departments. Seastrom also is one of the premier stocking manufacturers of washers of all types including round flat washers, spring washers, shoulder washers, spherical washers and lock washers. Assembly hardware, including spring clips, spacers, clamps, brackets, expansion plugs and flexible grounding straps, as well as, AN, MS and NAS military hardware are available on our website. Seastrom has a 90 year tradition of producing quality precision products.

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Company Description

Hoffer Flow Controls has been designing and manufacturing quality turbine flowmeters and accompanying electronics for forty-nine years and is located in Elizabeth City, NC. Hoffer sells its flow products in more than 60 countries worldwide. Hoffer also performs flowmeter calibration and recalibration services on varying styles and sizes of flowmeters.

Target Markets

Hoffer's key markets include custody transfer of cryogenics via truck mounted systems as well as industrial plant cryogenic flow applications. Key markets also include industrial flow measurement in oil and gas, subsea, power generation, aerospace, government and military, pharmaceutical, food and beverage.

Products/Services Offered

Hoffer designs turbine flowmeters and electronics for the measurement of clean liquid and gas applications. Hoffer is noted for its ability to provide customers with highly engineered solutions which has led the company into many new markets and applications in its history. Hoffer's applications are many but include industrial flow for oil and gas, subsea, aerospace, government and military, power generation, pharmaceutical, food and beverage and cryogenic truck mounted systems. Hoffer also performs flowmeter calibration and recalibration services on varying styles and sizes of flowmeters including field calibrations for cryogenic customers.

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Hydraulic Testing of Polymer Matrix Composite 102mm Tube Section

Research could lead to development of a composite material that can be processed at a low temperature and still be used at 1000°F.

Armament Research, Development and Engineering Center, Watervliet, New York

The objective of this research was to hydraulically pressurize the internal diameter of one 102mm Polymer Matrix Composite (PMC) over-wrapped cylinder up to 25,000 pounds per square inch (psi) and during pressurization, in real time, collect and store pressure and strain data simultaneously. Strain data must be captured from the inside diameter of the oil filled metallic cylinder and from the outside diameter of the composite over-wrap material.

To do this, the test specimen was machined to a 15" height with seal pockets on each end. The seal pockets house the top and bottom enclosures. A 12" undercut was machined on the outside diameter for PMC over-wrapping. The test specimen evaluated had an average OD of 5.1366" which resulted in a nominal composite wall thickness of 0.2183".

Four strain gages were placed 90 degrees apart from each other on the test specimen bore to measure strain in the hoop direction. Axial location of the interior strain gages was in the center of the test specimen. On the exterior surface of the test specimen, four rosette strain gages were placed in the same radial and axial location on the outside PMC material.

Each interior hoop direction strain gage contained a three-wire set-up for ease of balancing the bridge. Each internal strain gage wiring system was insulated from the test specimen due to grounding loops, which cause noise in the test data. Polyethylethylketone (PEEK) material was utilized for this purpose.

1080 series steel piano wire of 0.040" in diameter was silver soldered to cylindrical 4340 steel connector pin housings. Harris brand "Stay-Clean" liquid flux and "Stay-Brite" silver solder was used by bringing the wire and pin housing to 500°F and soldering the two together. The silver soldered sub-assembly was placed inside the cylindrical shaped PEEK insulating seal.

The entire assembly was placed inside a counterbore in the top and bottom enclosures. Located at the bottom of the counterbores was a disc of PEEK material separating the silver soldered assembly from the enclosure. O-ring seals were used between the connector pin and the inside diameter of the PEEK material. Another o-ring was used for sealing pressure between the outside diameter of the PEEK material and the counterbore in the top and bottom enclosure.

Composite Cylinder Testing Conducted in 2004

All wires for the respective internal strain gages were connected to piano wires. As a result, there were six wires running through the top and bottom end closures in order to successfully read the four internal strain gages. Placed over the top and bottom end closures were cover plates, which accept and protect the strain gage wires. The set-up enables the wires to be connected to the computerized data acquisition system, located outside the test cell.

For testing conducted in 2005 for similar composite cylinders, strain data was successfully collected on the interior strain gages and correlated well with the exterior gages. This test was conducted several times around the 2002 - 2005 timeframe as a screening test for different polymer composite overwrapped cylinders, but the data was never published. The goal of the test was to see if there was a lag between the internal and external strain gages.

Any lag between the gages would indicate that there was a gap between the steel substrate and the composite overwrap.

The cylinder under study this time was produced under the Phase I of the "Low-Cost Low Temperature Processed Polyorganosiloxane Armament Composites with High Temperature Durability" SBIR, the goal of which is to develop a composite material that can be processed at a low temperature and still be used at 1000°F. Normally a composite cannot be used above its cure / melt temperature. This causes issues as thermoset composites become soft during cure and don't assume their final shape until after cure and they have a very low coefficient of thermal expansion (CTE) compared to metals. So, during cure of a thermoset composite over a steel substrate, the steel would expand as the temperature increased, the composite would soften allowing the expansion, and then set its final shape at the cure temperature. As the steel cools it shrinks, but the composite doesn't, forming a gap. The material developed under this ILIR can be moisture cured at room temperature so the difference in CTE between the steel and composite should not result in a gap forming after cure.

This work was done by Lucas B. Smith and Andrew G. Littlefield for the Armament Research, Development and Engineering Center. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Test & Measurement category.*** *ARDEC-0002*

Permeation Tests on Polypropylene Fiber Materials

Study attempts to determine if polypropylene nanofiber materials can be used in air filtration systems to remove toxic vapors.

Naval Research Laboratory, Washington, DC

The Toxic Industrial Chemical/Toxic Industrial Material (TIC/TIM) Task Force MFR#1 published in February 2009 focuses on inhalation hazards in an operational environment and provides a list of compounds prioritized based on toxic hazard and the likelihood of an encounter. With these types of vapor threats, cartridge-based air purifying respirators are used to protect the warfighter against chemical exposure. Traditional air purification materials often rely on porous carbons such as activated carbon or activated charcoal. Ongoing efforts seek to improve the performance of carbon materials in air purification applications as well as provide alternative materials.

For this study, polypropylene nanofiber materials provided by Apollo NanoTech Inc were evaluated for their potential use in removing vapor phase targets. A Thermolyne

Images of as received nanofiber materials: hydrophilic (A), hydrophobic (B), and sheet type (C) variations.

incubator (Compact Series 5000) was modified to conduct water vapor transport studies based on guidance provided by the ASTM E 96 protocol. Water vapor transport through a material is determined by measuring the rate of water loss through the material over a period of time.

A scintillation vial (20 mL) was filled with 16.9 mL deionized water (± 0.1 mL) over which the sample material was sealed with parafilm (water 1.27 cm from sample surface). The sample was weighed and placed in the incubator. Drierite was used to lower the humidity in the incubator and a dry nitrogen stream was flowed across the surface of the sample (250 sccm). Weight measurements were collected at 30 to 45 min intervals using an analytical balance. The temperature of the incubator was 25°C (±1°C). This instrument was used to evaluate permeation of water through the various functionalized fabrics.

The temperature in the custom environmental chamber was controlled using a probe inside the chamber that adjusts an Air-Therm ATX heater. Mass flow controllers, regulated by an inline Vaisala humidity probe, governed the ratio of humid to dry air entering the chamber. An Aerosol Vapor Liquid As-

sessment Group (AVLAG) test cell was used for these evaluations.

The AVLAG cell was set up for single flow diffusive penetration testing using a single air or nitrogen stream. The "headspace" above the swatch was stagnant, and the differential pressure above and below the swatch was zero. A sample (2.54 × 2.54 cm) was sandwiched between two supports with 0.64 cm^2 circular openings. The sample assembly was placed in the AVLAG cell and equilibrated to the desired humidity for 2h. Target was introduced by placing liquid drops on top of glass wool using a repeating dispenser. Challenge was applied to the surface of the sample in the static region of the AVLAG cell; therefore, evaporation was not a significant consideration. A direct line from the permeation cell to a dedicated FID allowed for continuous monitoring of target concentrations. The FID used Peak Simple, six-channel data acquisition software (SRI) for signal capture and peak integration. Excess flow from the direct line (above 50 mL/min) was filtered through a carbon scrubber.

Microwave modification of fabrics was used for modification of the polypropylene sheets. The initiation solution was prepared by mixing 5 mL ammonium hydroxide (28 – 30%) with 92 mL of isopropanol. To this solution, 3 mL tetraethyl orthosilicate (TEOS) was added to the ammonium hydroxide solution. The fabric substrate was fully submerged in the TEOS mixture and removed to a glass, microwave safe dish. The sample was microwaved using 1,200W for 30s. This process was repeated for a total of three cycles. Treated fabric was dried at 100°C for 30 min.

To prepare the sol, 1.9g Pluronic P123, 0.5g mesitylene, and 2.12g 1,2-bis (trimethyoxysilyl)ethane (BTE) were mixed with 16g ethanol at room temperature with a magnetic stir bar in a sealed container. At this point, 6.07g 0.1 M HNO_3 was added dropwise, and stirring continued for 6h. The TEOS treated fabric was dipped into the prepared sol at a rate of 270 mm/min. The sample was hung to dry in a 60°C oven for 24h followed by drying in a vacuum oven at 60°C for an additional 24h. The fabric sample was then immersed in ethanol at 60°C for 48h to extract surfactant.

The sample was rinsed with additional ethanol and dried overnight at 60 – 65°C. To functionalize the sorbent material with primary amine groups, the fabric was submerged in a solution of 3-aminopropyltriethoxy silane (APS) in toluene at 0.5% volume/volume for 1h. Samples were then rinsed thoroughly with toluene and dried at

100°C. The porphyrin was added to this sample by submerging in a solution of 0.6 mg/mL porphyrin in 0.1 M 2-(N-morpholino) ethansulfonic acid (MES) buffer pH 5.5 with 5 mg 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide (EDC). Samples were incubated overnight before rinsing thoroughly with water and drying at 100°C overnight.

Samples were evaluated using the permeation system with 2-chloroethyl ethyl sulfide (half mustard; CEES), dimethyl methylphosphonate (DMMP), and methyl salicylate (MES) as the targets. Evaluations used 1 µL of the targets. The total exposed area in the AVLAG system was 0.64 cm^2 providing surface exposure concentrations of 16.7 g/m^2 for CEES; 18.0 g/m^2 for DMMP; and 18.3 g/m^2 for MES.

This work was done by Brandy J. White, Martin H. Moore, and Brian J. Melde for the Naval Research Laboratory. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Test & Measurement category.*** *NRL-0074*

Inter-Laboratory Combat Helmet Blunt Impact Test Method Comparison

Ensuring consistent test methods could reduce the risk of head injuries.

Natick Soldier Research, Development and Engineering Center, Natick, Massachusetts

As the medical community learns more about brain injury, the importance of blunt impact mitigation becomes more apparent. As such, it is critical to make sure that research labs are not only capable of performing testing in this field, but also show inter–laboratory consistency and reproducibility. This study is a comparison between the two validated blunt impact testing labs (Aberdeen Test Center (ATC) and National Technical Systems (NTS) Chesapeake Testing Services (CTS)), and Natick Soldier Research Development and Engineering Center (NSRDEC).

NSRDEC has acquired new blunt impact test equipment including the Cadex uniaxial monorail drop tower, which has become the unofficial standard for military blunt impact testing. The primary objectives of this study were to validate and verify that NSRDEC's new equipment and personnel are conforming to the current standard operating procedure and to ensure that inter laboratory data are similar.

Each laboratory was provided with 8 Advanced Combat Helmets (ACHs) of each size (small, medium, large and X large) for a total of 32 helmets. This provided each test laboratory with the six required helmets of each size for the test and two contingency helmets of each size.

The purchase description CO/PD 05 04 for the ACH specifies the use of DOT FMVS218 with some exceptions. This

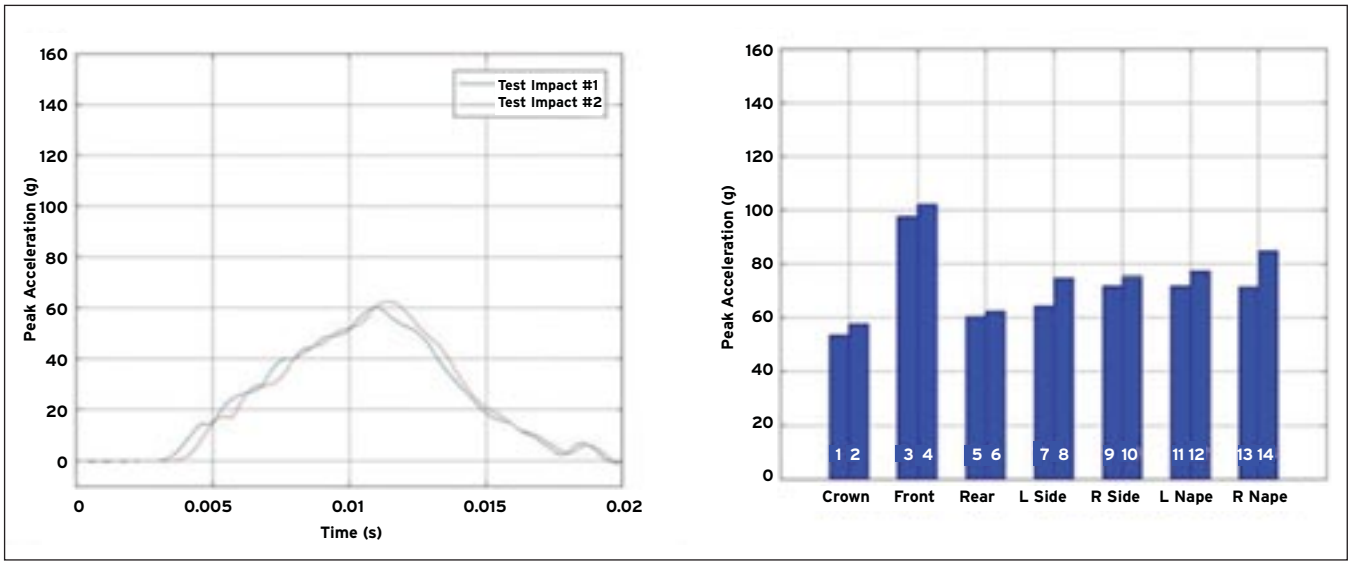

Figure on the left depicts a typical acceleration response. A first and second impact can be seen on the rear location of a hot conditioned ACH. Most impact locations result in a single, mostly parabolic, response as shown. Variations from impact to impact are seen due to geometry and pad interaction dependent on the impact location. Figure on the right depicts a complete data set of peak accelerations for a single "hot conditioned" ACH in the test method. The column on the left denotes the first impact at each impact location and the column on the right of each impact location denotes the second impact, tested 60 to 120s later. The second impact generally results in a higher peak acceleration.

test method leaves a lot of room for interpretation and the variation in test results can be seen in historical data. The recently developed Internal Operating Procedure (IOP) from ATC incorporates all requirements from the ACH purchase description, while removing a significant amount of user interpretation from the test method. This effectively improves the reproducibility of the procedure. All tests and collected data for this effort complied with ATC's IOP.

Head form acceleration and drop velocity data were collected for each impact. Velocity immediately preceding impact is collected as a single data point through a laser time gate while acceleration is collected continuously throughout the event. The Cadex data acquisition system collects data at a frequency of 33 kHz and filters the data through the CFC 1000 filter. The CFC 1000 is a 4 pole 1650 Hz low pass Butterworth filter specified for head impact acceleration data by Instrumentation for Impact Test, SAE standard J211-1. Although the entire curve is collected, the interest for this project lies solely in the peak or maximum acceleration the head form experiences during impact. The Test Laboratories followed the official test

procedure (ATC-MMTB-IOP-029-Blunt Impact Testing).

Six helmets of each size were prepared prior to testing. The helmets had to be weighed, labeled and the Team Wendy pads had to be placed into their corresponding locations as specified in the procedure. Two of each size helmet had to be placed into a cold (10 ± 3 °C) environmental chamber and two of each size helmet had to be placed into a hot (54.4 ± 3 °C) environmental chamber for at least 12 hours. The last two helmets had to be conditioned at ambient (21 ± 10 °C) for at least 12 hours.

On test day, just prior to the test, the Cadex drop tower was verified by using a calibration check procedure. The Cadex software was programmed for the test plan with correctly identified test sample nomenclature.

The helmets were tested in groups by size. Each helmet was impacted in seven different locations, twice. The helmets impact a hemispherical anvil, apex to apex. The seven locations were impacted in order as follows: crown, front, rear, left side, right side, left nape, and right nape. The second impact occurred between 60 and 120 seconds after the first.

The helmet was fitted onto its corresponding Department of Transportation (DOT) head form incorporating a foam chin. The front straps were tightened halfway and the back straps were tightened until the helmet was snug. The helmet was positioned to what is known as Helmet Position Index (HPI), a measured distance between the brim of the helmet and the first line on the DOT head form. The hot and cold conditioned helmets shall not be left outside their respective environmental chambers for more than 5 minutes. Any helmet that is left out for more than 5 minutes must undergo the full conditioning process again prior to continuing the test.

All impacts were conducted at a velocity of 10 ft/s (3.048 m/s) with a tolerance of ±0.3 ft/s (±0.091 m/s). A laser gate velocity detector was used to record the velocity at every impact and a uniaxial accelerometer (vertically located at the head form's center of gravity) was used to record acceleration during impact. Only the peak acceleration was evaluated.

This work was done by Tony J. Kayhart, Charles A. Hewitt, and Jonathan Cyganik for the Natick Soldier Research, Development and Engineering Center. ***For more information, download the Technical Support Package (free white paper) at www.aerodefensetech.com/tsp under the Test & Measurement category.*** *ARL-0213*

Maritime Unmanned Aircraft System

AeroVironment, Inc.
Monrovia, CA
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AeroVironment, Inc., a specialist in unmanned aircraft systems (UAS) for both defense and commercial applications, and ESG Elektroniksystem- und Logistik-GmbH, a system and software house in Germany for development and service, recently announced that the German Navy has acquired the AeroVironment Puma™ maritime unmanned aircraft system. The Puma systems will include the Mantis i45 sensor and pocket Remote Video Terminal (p/RVT). AeroVironment partnered with ESG to satisfy the requirement of the Bundesamt fur Ausrustung, Informationstechnik und Nutzung der Bundeswehr (BAAINBw) for an urgent operational requirement.

AeroVironment originally developed the Puma system to win a 2008 United States Special Operations Command (USSOCOM) competitive program of record and subsequently supplied the system to the U.S. Navy Expeditionary Combat Command Coastal Riverine Forces, the U.S. Army for convoy and ground troop support and the U.S. Marine Corps. Capable of both ground and water landings, Puma AE's innovative fuselage provides an operational flexibility never before available in the small UAS class.

Equipped with both an electro-optical (EO) and infrared (IR) camera and illuminator, Puma AE keeps the operator's "eyes on target" while the precision navigation system with secondary GPS insures positional accuracy up to its 20 km range. The Mantis i45 gimbal is backward compatible, fully waterproof and provides nighttime and low light capabilities ranging from Near-Infrared (NIR) to Long Wave Infrared (LWIR) imagery. During flight operations, the i45 gimbal provides full lower hemisphere coverage, continuous pan and is packaged to provide reliable operation in extreme environments.

An optional under-wing transit bay easily integrates third-party payloads such as communication relay, geo-location, or laser marker. Operated from AeroVironment's battle-proven ground control station (GCS), the GCS allows the operator to control the aircraft manually or program it for GPS-based autonomous navigation. Puma AE can deliver 3.5+ hours of flight endurance while versatile smart battery options support diverse mission requirements. A plug-and-play power adapter also makes for easy integration of extended endurance options such as solar wings.

The Navy procured Puma AE systems for use aboard Patrol Craft and also deployed them on a U.S. Navy Expeditionary Fast Transport (T-EPF) ship in support of counter organized crime operations in the Caribbean. The Puma system is also being deployed by multiple international partners. German Navy adoption of the Puma system marks another step in the growing need for and fielding of UAS for the international surface combatant and coastal craft market.

The United States Department of Defense established the designation RQ-20B for the block 2 Puma AE small UAS. The block 2 Puma AE system includes a more powerful and lighter propulsion system, lighter and stronger airframe, long-endurance battery, precision inertial navigation system and an improved user interface. The all-environment Mantis i45 gimbal sensor suite for Puma AE delivers a dramatic leap in small UAS image resolution and ISR capability.

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Optical Seeker for Munitions Systems

BAE Systems
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The U.S. Defense Advanced Research Projects Agency (DARPA), through the U.S. Air Force Research Laboratory, has awarded BAE Systems a $13.1 million contract to demonstrate a new, cost-effective optical seeker for precision-guided munitions. The seeker is designed to improve navigation, as well as automate target location and homing, for different types of munitions that are used in GPS-denied and other contested environments.

BAE Systems tested the seeker during the first phase of DARPA's Seeker Cost Transformation (SECTR) program. The SECTR seeker integrates with a wide range of weapon platforms that use munitions and can operate in day or night. It enables autonomous precision guidance via passive electro-optical and infrared sensors in environments where GPS navigation is unavailable or unreliable.

The seeker's open architecture enables highly accurate, competitive, low-cost munitions to be capable of navigating and locating targets in limited-access and denied environments. It provides these munitions with quick-reaction capabilities while meeting stringent cost, size, weight, and power requirements. The open architecture also enables rapid seeker integration into current and new weapon systems.

BAE Systems' cost-effective optical seeker for precision-guided munitions is designed to improve navigation, as well as automate target location and homing, for different types of munitions that are used in GPS-denied and other contested environments.

BAE Systems has extensive experience in developing precision guidance systems for munitions. Their APKWS® laser-guided rocket is a mid-body guidance section that transforms a standard unguided 70 mm rocket into a precision laser-guided rocket. Their Long Range Anti-Ship Missile (LRASM) seeker technology is capable of autonomously detecting and identifying targets. The M982 Excalibur GPS-guided, 155 mm artillery shell can defeat threats at ranges up to 60 kilometers, impacting at a radial miss distance of less than 2 meters from the target. And their Silver Bullet Precision Guidance Kit can transform a standard artillery shell into a precision-guided munition.

This phase of the DARPA program will conclude in July 2019 with multiple test firings on several precision-guided munition platforms.

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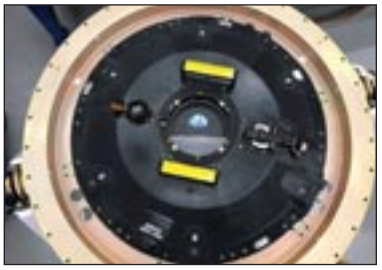

The Orion spacecraft leverages a variant of new Stratasys Antero 800NA to build an intricately-connected 3D printed docking hatch door.

Stratasys Ltd., a company that specializes in applied additive technology solutions, and Phoenix Analysis & Design Technologies, Inc. (PADT) have teamed up with Lockheed Martin Space to deliver next-generation 3D printed parts for NASA's Orion deep-space spacecraft. Key to the project are Stratasys advanced materials – including an ESD variant of the new Antero™ 800NA, a PEKK-based thermoplastic offering high performance mechanical, chemical, and thermal properties.

Orion is NASA's spacecraft that will send astronauts to the Moon and beyond. Orion's next test flight, dubbed Exploration Mission-1 (EM-1), will be the first integration mission with the world's most powerful rocket, the Space Launch System, where an un-crewed Orion will fly thousands of miles beyond the Moon during an approximately three-week mission.

The following flight, EM-2, will also go near the Moon, but with astronauts on-board, a first since 1972. That mission will enable NASA to prepare for increasingly complex missions in deep space. The mission will use more than one hundred 3D printed production parts on-board, engineered in conjunction with Lockheed Martin, Stratasys and PADT.

The production-grade, thermoplastic 3D printed parts for NASA's Orion vehicle are produced at the Additive Manufacturing Lab at Lockheed Martin in conjunction with PADT, which now employs the latest in Stratasys 3D printers and materials. Using advanced materials such as ULTEM 9085™ resin and the new Antero material incorporating critical electro-static dissipative (ESD) functionality, NASA could meet key requirements for 3D printed parts to perform in the extremes of deep space. Antero is ideally suited to meet NASA's requirements for heat and chemical resistance, along with the ability to withstand high mechanical loads.

The Lockheed Martin, Stratasys and PADT-engineered collaboration is differentiated by an ability to create consistency and repeatability in mass scale across the entire additive manufacturing part production process. Lockheed Martin is also one of the first customers leveraging Stratasys' Antero, using the new thermoplastic for a critical part situated just outside of Orion's docking hatch. The complex part consists of six individual 3D printed components locked together to form a ring on the craft's exterior.

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Artist's concept of a Lockheed Martin Multi-Mission Surface Combatant similar to the type that will be used by the Royal Saudi Navy. (US Navy)

Fairbanks Morse - an EnPro Industries company - has been awarded a contract to deliver eight FM | Colt-Pielstick diesel engines to power four frigates for the Royal Saudi Navy. The purchase is a part of the Saudi Naval Expansion Program II which has been in the works for over a decade with a cost of about $20 billion.

The frigates that the engines will be powering are based on the Freedom-class Littoral Combat Ship (LCS) used by the U.S. Navy. The two 16-cylinder FM | Colt-Pielstick PA6B STC diesel engines per ship will deliver over 12 MW of propulsion power and are among the largest medium speed diesel engines manufactured in the United States. The engines will begin to be manufactured in early 2019 with delivery scheduled for September 2020.

The 16-cylinder FM | Colt-Pielstick PA6B STC is a 20.32L, 4-stroke diesel with a 280 mm cylinder bore and 330 mm piston stroke. It produces 6,840 kWm at 1,050 rpm. To date there are more than 840 engines in operation throughout the world.

"The proposed sale will provide Saudi Arabia with an increased ability to meet current and future maritime threats from enemy weapon systems. The Multi-Mission Surface Combatant ships will provide protection-in-depth for critical industrial infrastructure and for the sea lines of communication," reads a U.S. State Department notification.

Each engine will be built at the Fairbanks Morse manufacturing facility in Beloit, Wisconsin. The company has a long history of designing and building maritime powerplants. For over 70 years they've been supplying the U.S. Navy and Coast Guard with diesel engines for marine propulsion and ship service systems. Fairbanks Morse, in fact, is the leading provider of propulsion diesel engines to the U.S. Navy.

Fairbanks Morse also announced today a multi-year $17.3 million contract to provide services to the U.S. Navy's Military Sealift Command (MSC) which will service military ships at sea and create jobs at their U.S.-based service centers.

For Free Info Visit ***http://info.hotims.com/69509-552***

Barometric Pressure Sensor

Bosch Sensortec (Reutlingen, Germany) has introduced a new high performance barometric pressure MEMS sensor, the BMP388. The BMP388 delivers outstanding altitude stabilization in drones, where accurate measurement of barometric pressure provides the essential altitude data for improving flight stability and landing accuracy. The new barometric pressure sensor is part of Bosch Sensortec's comprehensive sensor solution for drones, which includes the BMI088 Inertial Measurement Unit (IMU) for accurate steering and the BMM150 geomagnetic sensor for the provision of heading data.

The BMI088 is a 6-axis IMU, consisting of a triaxial 16-bit acceleration sensor and a triaxial automotive-proven 16-bit gyroscope. The BMM150 is a low power and low noise triaxial digital geomagnetic sensor designed for compass applications. Due to its stable performance over a wide temperature range, this geomagnetic sensor is especially suited for determining accurate heading for drones.

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3U VPX I/O Boards

The first two products in Concurrent Technologies' (Johnstown, PA) new range of 3U VPX™ I/O boards include a multi-channel serial board and a multi-channel Gigabit Ethernet board. Both boards require a single 3U VPX™ slot and are available for both air and conduction-cooled applications.

BA 2TR/501 supports up to eight serial communications ports for applications that require multiple serial ports within a single slot. Up to five ports are available on the VPX connector for rear communication and three are available on the front panel in the air-cooled variants along with optional cables (with screw locking connectors). The serial ports can be configured to support RS232, RS422 or RS485 standard interfaces.

BA 2TR/502 supports a quad-port Gigabit Ethernet controller for applications that require additional network interfaces within a single VPX slot. Up to four Gigabit Ethernet ports are available on the VPX connector for rear communication; alternatively the four ports can be routed to the front panel via standard RJ45 connectors for use in air-cooled applications. Both BA 2TR/501 and BA 2TR/502 link to a host processor board via PCI Express.

For Free Info Visit http://info.hotims.com/69509-526

Memory and Data Exchange System

The Memory Division of Kaman Precision Products, Inc. (Middletown, CT) recently announced the AMADEUS – the Advanced Memory and Data Exchange Universal System. The AMADEUS includes the Model 9740 Multi-Port® data transfer unit which includes four removable memory cards (RMC) and a mini-Ground Station Adapter (GSA). The Model 9740 provides simultaneous data interface over 10GB Ethernet, Mil-Std 1553, RS-232/422 as well as options to record multiple SMPTE 292 and NTSC (RS-170) video/audio channels.

Each Kaman RMC boasts a capacity of 2TB with AES 256 encrypted data-at-rest. This small card is packaged in rugged and hermetically sealed stainless steel. The pocket-sized GSA facilitates expeditionary operations and enables the operator to connect with virtually any computer via USB 3.0. AMADEUS is engineered to align with Future Airborne Capability Environment (FACE™) and flawlessly perform in the harshest military, aerospace, and industrial environments.

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Digital Oscilloscope

RIGOL Technologies (Beaverton, OR) has announced a significant addition to its oscilloscope portfolio with the introduction of the New 7000 Series Digital Oscilloscope. With 10 GSa/sec sample rate and up to 500M record length, the 7000 Series can deliver 20X oversampling on a 500 MHz signal providing unmatched signal resolution while still capturing a full 50 ms.

The core of the 7000 Series Oscilloscope is RIGOL's new UltraVision II architecture and its Phoenix chip-set. Two custom ASICs provide analog front end and signal processing performance. These chips are surrounded by a high-performance hardware design including Xilinx Zync-7000 SoC, Dual Core Arm-9 Processors, Linux +Qt Operating System, High Speed DDR System Memory and QDRII Display memory. This architecture enables a high waveform capture rate of 600,000 wfms/sec, color graded intensity display, and outstanding time-base accuracy and jitter performance.

The 7000 Series comes with a next generation user interface giving the customer five unique ways to interact with their instrument. A vivid 10.1" (1024 × 600) display supports a responsive and intuitive touch navigation. The 7000 Series is available in 8 Models (100MHz, 200MHz, 350MHz, and 500Mhz) with or without the Logic Analyzer (MSO).

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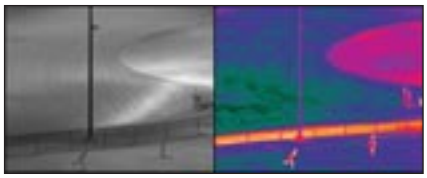

IR Camera Core

Lockheed Martin's (Orlando, FL) new µLAD SW/MW IR camera core brings big-sensor cooled performance to tiny platforms. Powered by Lockheed Martin Santa Barbara Focalplane's large format, small pixel nBn detector technology, µLAD runs at high operating temperatures, resulting in a compact package ideally suited for applications such as missile seekers, weapon sights, remote weapon stations, small gimbal or gimbal-less (e-stab) platforms, and tactical air and land sensor systems for OEM and military unmanned aerial vehicles (UAVs).

Lockheed Martin's dual-band µLAD camera core delivers high-definition SW/MW IR imagery at 1280-by-1024 pixels (1.3 megapixels) with the same high-speed digital output (up to 10 Gbps) as a single-band MWIR offering. Pixel pitch is 8 µm. Integration time is <0.1 µs to 200s. F# is 2.3. Input voltage is 5V and 12V, 12W steady state. The camera features a Stirling split linear closed-cycle cooler, and command and control is via an RS-422 serial interface over camera link.

For Free Info Visit http://info.hotims.com/69509-510

High Voltage Power Supplies

TDK Corporation (Neptune, NJ) has introduced the FLX-HV Series of high voltage programmable AC to DC power supplies with standard features including USB/LAN digital interfaces and active power factor correction. The FLX-HV Series covers output voltages of 10,000, 30,000 and 50,000 volts, at power levels of 200, 500 and 1,000 watts. The unit is housed in a compact, lightweight 2U rack-mount package that incorporates front to back cooling with a variable speed fan for quiet operation.

Standard features include a user-friendly multi-function display with coarse and fine output voltage and current controls and integrated LAN and USB digital interfaces. All models (and power levels) include active power factor correction with wide range 110-230 VAC input and a power factor better than 0.95 and high efficiency greater than 85 percent. Low output ripple of 0.1 percent peak to peak. Digital interfaces include resettable arc count functionality, programmable fine/coarse control steps, 16-bit ADC-DAC resolution, detailed unit status outputs and many other commands and features.

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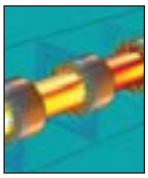

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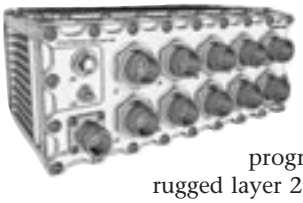

Rugged Ethernet Switch and Router

OnTime Networks (Oslo, Norway) is supplying its fully rugged military grade CR-6224F4-MIL series Gigabit/10 Gigabit Ethernet switch and router solution for use in a new wheeled (8x8) ground combat vehicle program. The Cloudberry CR-6224F4-MIL version is a fully rugged layer 2/3 switch combined with a router and an accurate network time server (IEEE 1588 PTP, NTP, IRIG, 1PPS) for military land, sea and air applications. The integrated GbE/10GbE switch provides a total of 24 Ethernet ports, of which 20 ports are 10/100/1000 BASE-T ports and 4 ports are 10/100/1000 BASE-SR. The CR-6224F4-MIL enables secure managed network routing and GbE switching capabilities for the vehicle's onboard communications and computing subsystems.

The CR-6200 Series router implementation is based on a separate router board with an Intel Atom processor and can either be equipped with the OnTime Networks router package providing routing speeds of up to 800 Mbps or with the Cisco® 5921 Embedded Services Router (ESR) Advanced Enterprise router package, providing up to 500 Mbps of routing speed. Its modular rugged design, enclosed in a completely sealed housing against dust and water ingress (IP68), requires no active cooling and provides MIL-DTL-38999 connectors.

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PXI, LXI Switching Solutions

BRIC™ Ultra-High-Density PXI Matrix Modules (model 40-559) from Pickering Interfaces (Clacton-on-Sea, UK) are robust 1Amp/20W switching modules, with up to 4,096 crosspoints. Constructed with Pickering Electronics' new miniature 4 mm × 4 mm reed relays, these new 1 Amp matrices have similar switch densities compared to 0.25 Amp, 0.3 Amp or 0.5 Amp high-density matrix solutions on the market, providing far more robust and reliable switching in the same footprint. The matrices are available in 2, 4, or 8-slot PXI sizes and are designed for high-performance matrix requirements. With their high level of switching density, these PXI matrices allow a complete Functional ATE system to be housed in a single 3U PXI chassis and allow the use of much lower cost 8 or 14 slot PXI chassis.

Pickering's High-Density Scalable LXI Ethernet Reed Relay Matrix Solution (model 60-2xx) combines their latest LXI Chassis with their new plug-in matrices. The range comprises four models covering matrices of up to 1,536 × 4 in increments of 128, 768 × 8 in increments of 64, 384 × 16 in increments of 32, and 192 × 32 in increments of 32.

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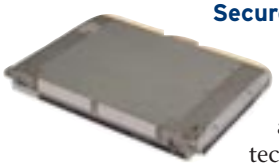
Secure Intel Xeon-based VME Single Board Computer



Mercury Systems, Inc. (Andover, MA) announced the planned availability of the Ensemble® 4000 Series SBC4510 VME single board computer (SBC) module with an Intel® Xeon® E3 v6 processor. The new SBC will enable technology insertion of modern high performance and system security engineering solutions into existing VME-based sensor processing systems.

Based on an open systems architecture and targeted for applications supplying 50W or less, the single-slot SBC is designed to be compatible with all legacy VME64 systems. Together with support for both Linux and VxWorks, an available secure hypervisor further enables legacy applications to run in their own container independent of the underlying system software and hardware. Multiple applications can run in a virtualized environment to take advantage of the increase in performance of the Intel Xeon processor. The Ensemble Series SBC4510 VME SBC features a PMC/XMC mezzanine site for I/O expansion and will be available in air-cooled or conduction cooled versions at various levels of ruggedization.

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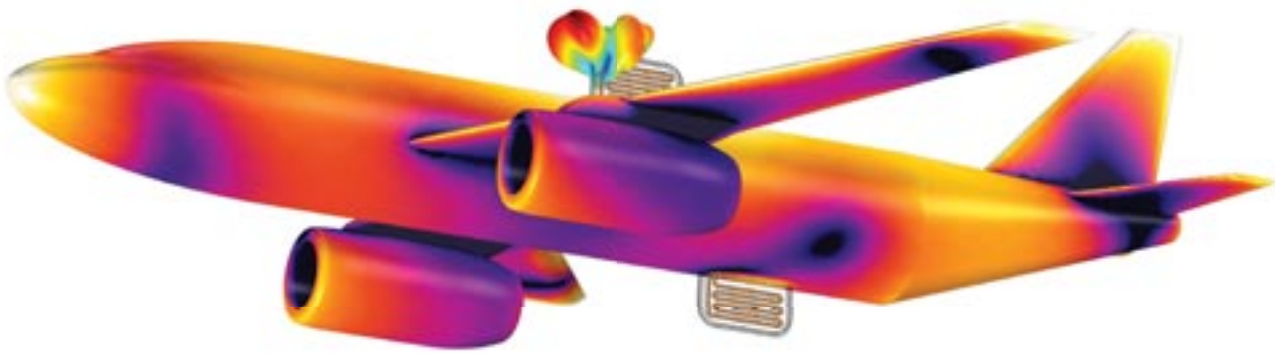
Overcome antenna crosstalk issues with simulation.



Visualization of the electric field norm and 3D far field due to a transmitting antenna. Antennas are intentionally large in this tutorial model.

Multiple antennas are needed to create more complex communication systems on airplanes. But this arrangement of transmitters and receivers can cause aircraft operation issues due to crosstalk, or cosite interference. Simulation helps you analyze the crosstalk effect on an aircraft and in turn find the best antenna placement.

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