V-280 VALOR
HARNESSING THE DIGITAL THREAD

With its cruise speed of 280 knots and a combat range of up to 800 nm, the Bell V-280 Valor tiltrotor has demonstrated its ability to revolutionize battlefield air assault as the U.S. Army seeks to take its rotary-wing force into a new era through its wide-ranging Future Vertical Lift programme. With speed and range performance broadly double that of today's rotorcraft, the V-280 offers truly game-changing attributes that could open up new realms of operational tactics supporting the Army's Multi-Domain Operations concept, while building on the success that Bell and partner Boeing have achieved with the V-22 Osprey tiltrotor in U.S. Marine Corps service.

In the past, the introduction of a platform that offers such a step-change in capability has typically come with a high price, not only for development and acquisition, but also in terms of through-life sustainment. However, the Future Vertical Lift (FVL) Capability 3 requirement – also known as Future Long-Range Assault Aircraft (FLRAA) – at which the V-280 is aimed envisages a fleet of more than 2,000 aircraft to replace the incumbent UH-60 Black Hawk, and there is a pressing need to keep costs down throughout the life-cycle.

In order to achieve high performance at low cost, Bell is employing the latest digital technologies, including a collaborative 3D digital product definition approach. By leveraging the power of this toolset, the cost and speed of engineering development can be kept down through the near-instant digital testing and fine-tuning of design elements, so that a more mature design is the one that is first to be committed to hardware.

Moreover, this engineering development technology – along with others such as health awareness and data analytics – can be re-purposed to significantly enhance sustainment activities throughout the platform's life-cycle. Harnessing the power of digital models, processing and analysis reduces maintenance and servicing requirements – and thus sustainment costs – by a significant amount.

To achieve this streamlining of sustainment activities, Bell has brought in emerging practices from the commercial world and is adapting them to military requirements, recognizing that the platform will have to serve for many years alongside the current generation of helicopters, and share the same logistic chains and maintenance infrastructure.

At the same time, stakeholders from the manufacturing and sustainment segments are included in the engineering development process from the start. Design inputs made during the 3D modeling process can have hugely beneficial effects on both the ease and speed of aircraft assembly and with which maintainers can perform their tasks during operations.

V-280 Valor – Transformational Sustainment

Around a decade ago Bell revamped its design/development systems and databases, including integration of the latest CATIA 3D computer-aided design (CAD) technology. With this toolset the design of the entire platform and all of its systems could be digitally modeled in great detail. It was first used in the company's Model 525 civilian helicopter.

Experience from that helped with the implementation of a completely digital development when Bell was selected to build what became the V-280, as part of the U.S. Army's Joint Multi-Role Technology Demonstrator (JMR TD) programme. The adoption of collaborative digital product definition permitted the company to move from contract award to a flying tiltrotor prototype in just four and a half years.

AIDING THE DESIGN PROCESS

Using a computer-based model – the 'digital thread' – for engineering development has numerous benefits, not least of which is the rapidity of development through the ability to make and test parts digitally rather than in hardware.

By the time that the CAD data for a part is issued to the shop floor for manufacture the design has been fine-tuned in both its individual form, and how it interacts with other parts around it. First-fit rates are significantly higher, resulting in speedier assembly times and reduced staffing requirements. The system also assists in the optimization of procurement and fabrication of parts and the overall assembly sequence.

Another benefit is the speed at which the precise engineering data itself can be generated. Bell cites an example of an assembly with around 1,000 parts: under the traditional method the engineering drawings would require around 900 hours of work to produce, whereas with CAD the process was completed in less than a week. This order-of-magnitude cost saving comes from the ability to expose information imbedded in the CAD models to automate part callouts and process requirements. Furthermore, the CAD model eliminates the need to create multiple static views to fully define the product. Both aspects of leveraging the CAD models have significant application for logistics tracking throughout the life-cycle.

The design itself can also be enhanced through the combination of CAD data and virtual reality systems. On the flight deck, for instance, pilots can use VR headsets to hone the cockpit layout to optimize its ergonomics to a high degree.

A highly significant feature of the CAD digital thread is that it can be modified and updated at source, so that the new data is immediately available to everyone that has access to it. Engineering updates are applied only once, with all CAD by-products and technical publications that rely on the central model being updated accordingly and concurrently.

AIDING THE MAINTAINERS

Clearly the 3D CAD model – or enterprise digital mock-up – has revolutionized the way in which complex platforms such as the V-280 Valor are designed and productionized, but Bell has also recognized the benefits of harnessing the inherent capabilities to implement a step-change in sustainment and to re-purpose the 3D data to transform the work of maintainers in the field. With sustainment typically accounting for 60 to 70 percent of a platform's through-life costs, savings that can be made to in-service maintenance and servicing are of great value to the operator.

The process begins during design, with maintenance and sustainment representatives having their influence in the detail design. The arrangements in which certain parts are located can have considerable ramifications to the speed and ease with which they can be removed for maintenance when the platform reaches the front line. A simple rearrangement conducted in the digital mock-up, aided by the use of virtual reality, could improve accessibility to key parts and result in a meaningful cumulative saving in time and cost across the platform's life-cycle. The digital mock-up can even be programmed to simulate loads and forces, such as weights or the flexibility characteristics of cables, to further optimize design and accessibility.

A key feature of the digital thread is that it is available to all users at their point of need. It is also configurable to match their requirements. The full data-heavy 3D model can be filtered into lighter, more agile data loads that provide only the information that the user requires and which require far less computing power. Individual systems, such as hydraulics, fuel or wiring, can be presented in isolation, or selected areas of the platform, such as what might be located behind an access panel.

This data – in the form of the interactive electronic technical manual (IETM) – is presented to maintainers at the point of need on a laptop/tablet-type device, and the ability of the digital mock-up to provide an infinite number of views is a major advantage over typical technical publications that might show a small number of views from different perspectives.

Taking this 'any-angle' view capability one major step further, Bell is working on head-worn displays, such as those being used for the Army's Integrated Visual Augmentation System (IVAS), that provide an augmented reality overlay of the real scene. The ability to 'see' the model overlaid on the platform provides rapid parts identification. Both augmented and virtual reality products have significant benefits for both in-the-field maintenance and in the training of maintainers.

HEALTH AWARENESS

In recent years the advent of vehicle health-monitoring systems has begun to transform the servicing and maintenance of air platforms, and Bell has fully embraced this emerging technology in the design of the V-280. The use of more robust and mature monitoring systems that embrace an increasing range of information sources has raised their capability to what is now termed health awareness.

Combined with the IETM, these systems are resulting in a major change to how maintenance issues are handled and the time in which they can be rectified. The system permits more visual decision-making for both servicing and maintenance, including a so-called 'heat map' that can visually highlight the parts that are becoming due for scheduled replacement.

Troubleshooting is greatly assisted. Typically, when a technical issue arose in-flight, a crew chief would have to wait until the aircraft had landed and for a series of manual troubleshooting steps to be accomplished before a full diagnosis could be made. In the V-280, the crew chief can connect via a laptop into the tiltrotor's onboard health data server to review the system generated issue diagnosis. The system automatically links faults to the IETM served by the aircraft itself. In the case where troubleshooting is required, the aircraft provides bus monitoring capability that eliminates the need for a category of special test equipment. Embedded test capabilities are key to an expeditionary platform where daily unit moves are a part of the expected response to a peer-level threat. New parts can be ordered prior to the end of the mission, opening up options for maintenance. Moreover, the system generates a 3D animation of the process required to replace the defective part(s). In this manner, maintainers will know exactly what they have to do, and have the parts available, as soon as the aircraft lands, reducing the down-time for the platform by several hours. More efficient trouble-shooting through smarter diagnostics results in greater availability rates and a lower lifecycle cost.

Increased platform availability is a key requirement of the Future Vertical Lift programme, and the V-280's design reflects a strategy to move towards the condition-based maintenance that allows a graceful degradation and an extension of the period between scheduled overhauls.

To permit this without any effect on safety requires an advanced health awareness system. That system also feeds information to a global support network that can mine data on a fleet-wide basis to identify key areas that may require longer-term fixes. The growing amount of input from health awareness systems also provides a growing database for the application of prognostic maintenance and servicing processes. Long term gearbox health management for instance is enhanced by the joining of (1) chip detection information, (2) vibration health, (3) aircraft usage, (4) configuration data, and (5) trending information gained from the Army's Oil Analysis Program (AOAP) offboard.

V-280 Valor – Transformational Performance

In partnership with Boeing, Bell developed the V-22 Osprey in the 1980s to be the world's first operational tiltrotor aircraft. The type entered service with the U.S. Marine Corps in 2007, and subsequently the Air Force and Navy.

The full wealth of experience from having pioneered the tiltrotor as a military assault platform was brought to bear in answering the U.S. Army's Joint Multi-Role Technology Demonstrator requirement that is ultimately to lead to an aircraft that will perform a range of vertical lift missions for the U.S. Army, including air assault and medical evacuation. In configuration terms a significant difference between the V-280 and the V-22 is that the Valor's engines are non-rotating, with only the rotors tilting rather than the whole nacelle. As with the Osprey, the V-280 has a driveshaft running through the wing so that both rotors can be driven from a single engine.

Bell was selected to participate in JMR TD with its V-280 Valor design in June 2013, and was down-selected as one of two projects to proceed in 2014. Thanks to the rapid prototyping processes made possible by CAD design, the prototype made its first flight at Amarillo, Texas, on 18 December 2017.

Design goals for the V-280 centered around a two-fold increase in speed and range over the existing helicopter performing the mission, along with improved agility. By April 2018 the tiltrotor had performed its first transition between helicopter and airplane modes, and maximum speed was progressively increased, reaching its design cruise speed of 280 knots in January 2019. The prototype has since achieved a cruise speed of more than 300 knots.

These figures broadly mirror those of the V-22 and, more importantly, are well beyond those of the UH-60 Black Hawk, as set out in the original concept. Additionally, the V-280 has demonstrated a rate of climb that far exceeds the UH-60, and banked turns near 60°. The V-280's demonstrated range continues to grow towards the estimated combat capability of 500 to 800 nm, depending on load.

In operational terms the extra speed significantly reduces transit and reaction times, while its extra range doubles its reach and increases area coverage nearly five-fold. The type is efficient at long range, capable of meeting the Army self deployment requirements and it can be refueled in-flight. Fly-by-wire flight controls and increased rotor flapping capability improve low-speed agility, which have been proven to meet the U.S. Army's rigorous Level 1 handling qualities requirements in a demonstration conducted ahead of schedule.

The V-280's cabin has been designed for versatility with large side doors that speed ingress and egress, as well as accelerating the process of loading casualties. The Valor is capable of being armed with a variety of weapons located in bays on either side of the forward fuselage. The aircraft is fitted to provide for underslung loads such as the widely fielded M777 howitzer.

Extensive use of composites keeps the V-280's structural weight down, and the construction has been simplified in terms of components to reduce costs. Commercial practices have been adopted in the Valor's maintenance to greatly extend time between inspections. The Bell V-280 Valor continues to perform beyond expectations and recently completed flight demonstrations of all the key performance parameters (KPP) as part of the JMR TD program. In more than 120 hours of flight testing, the team has proven the V-280's agility at high and low speed, its speed for cruise and long-range travel, ability to accelerate and decelerate, fast-rope operations, a quick rate of climb, and the ability to integrate mission equipment systems such as the Lockheed Martin furnished Pilotage Distributed Aperture Sensor (PDAS) system.

The next steps for this aircraft will include more operational focused demonstrations including a fast-rope system, additional mission equipment package integrations and more.

Bell clearly understands though, that designing, building, and fielding aircraft are only part of the equation for a successful program of record. Sustainment plays a vital role as well. The V-280 Valor was designed to deliver exceptional operational capabilities at affordable procurement and sustainment costs.

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