X-76: Redefining the Speed Limits of Vertical Flight

DARPA SPRINT Bell X-76 Artist Concept (Image provided by DARPA | Collie Wertz)

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For more than seven decades, vertical flight has been defined by a fundamental trade space. Aircraft capable of hovering and operating independently of runways have historically sacrificed speed, range and efficiency when compared to conventional fixed-wing aircraft. Conversely, aircraft optimized for high-speed cruise have required prepared runways and infrastructure, limiting operational flexibility.

The US Defense Advanced Research Projects Agency (DARPA), in partnership with US Special Operations Command (USSOCOM), is seeking to fundamentally reshape this trade space through the Speed and Runway Independent Technologies (SPRINT) program. The goal is ambitious: demonstrate an aircraft capable of cruising between 400 and 450 knots while retaining the ability to hover and operate from austere, unprepared locations.

The SPRINT X-plane, recently designated the X-76, is not intended as a production aircraft but rather as a proof-of-concept technology demonstrator designed to validate enabling technologies and integrated concepts that could scale across future generations of military aircraft. If successful, the X-76 could represent a transformational shift in how speed, survivability and operational flexibility are balanced in runway-independent aircraft design.

Like many transformational efforts in aerospace, SPRINT did not emerge in isolation. It is the latest chapter in a long lineage of DARPA-sponsored innovation.

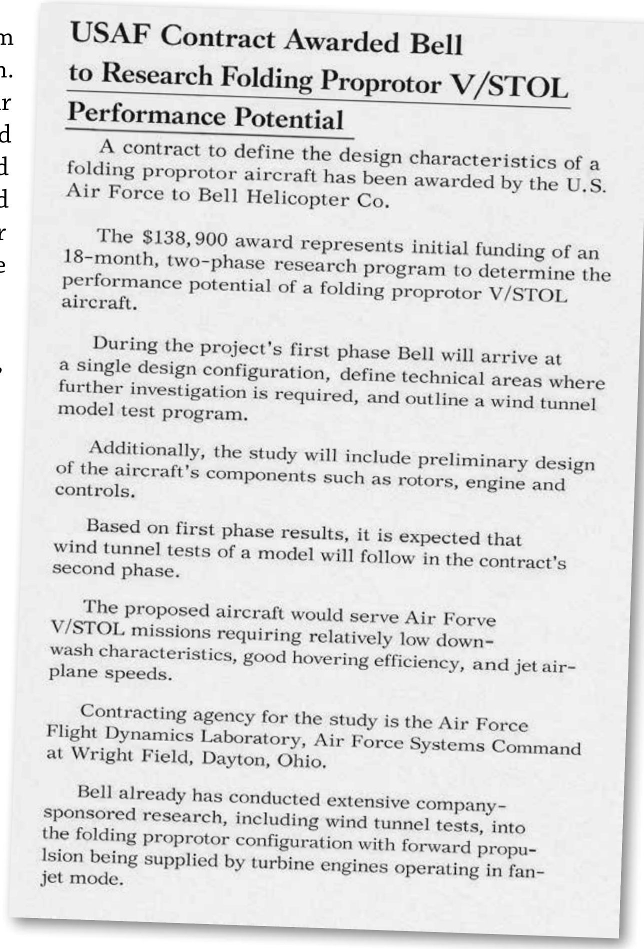
DARPA and the Pursuit of Transformational Vertical Lift

DARPA has played a defining role in advancing unconventional vertical flight concepts. Across several decades, the agency has repeatedly challenged industry and academia to rethink fundamental assumptions about aircraft configuration, propulsion integration, autonomy, and operational employment.

Programs such as the Unmanned Combat Armed Rotorcraft (UCAR), Boeing's A160 Hummingbird, the Heliplane, and more recent efforts including ARES, Tern, ALIAS, EVADE, and the VTOL X-Plane program have explored novel approaches to endurance, autonomy, deployability, and speed for runway independent aircraft. While not all resulted in operational systems, each contributed technological building blocks and lessons that shaped future programs.

SPRINT traces its origins to DARPA seedling efforts initiated by Tactical

Technology Office (TTO) Program Manager Dr. Xander Walan. Parallel efforts within the Air Force's AFWERX High-Speed VTOL Challenge in 2021 provided additional industry input and served as an informal request for information that helped shape the eventual program architecture.



USAF Contract Awarded Bell to Research Folding Proprotor V/STOL Performance Potential

A contract to define the design characteristics of a folding proprotor aircraft has been awarded by the U.S. Air Force to Bell Helicopter Co.

The $138,900 award represents initial funding of an 18-month, two-phase research program to determine the performance potential of a folding proprotor V/STOL aircraft.

During the project's first phase Bell will arrive at a single design configuration, define technical areas where further investigation is required, and outline a wind tunnel model test program.

Additionally, the study will include preliminary design of the aircraft's components such as rotors, engine and controls.

Based on first phase results, it is expected that wind tunnel tests of a model will follow in the contract's second phase.

The proposed aircraft would serve Air Forve V/STOL missions requiring relatively low down-wash characteristics, good hovering efficiency, and jet air-plane speeds.

Contracting agency for the study is the Air Force Flight Dynamics Laboratory, Air Force Systems Command at Wright Field, Dayton, Ohio.

Bell already has conducted extensive company-sponsored research, including wind tunnel tests, into the folding proprotor configuration with forward propu-lsion being supplied by turbine engines operating in fan-jet mode.

The First Mention of the Folding Proprotor Research in the May 1969 Issue of Vertiflite

Following successful early studies, DARPA Director Dr. Stefanie Tompkins, in conjunction with SOCOM, approved the SPRINT program proposed by Dr. Andy Baker in late 2022. The program was publicly introduced by DARPA TTO Director Dr. Mike Leahy in January 2023 at the Vertical Flight Society's 10th Annual Electric VTOL Symposium during the Transformative Vertical Flight meeting. A formal Broad Agency Announcement followed on March 9, 2023, formally launching industry participation.

Early performers included Aurora Flight Sciences, Bell Textron, Northrop Grumman, and Piasecki Aircraft. The program entered Phase 1 on Nov. 1, 2023, with competing teams conducting preliminary design activities. In May 2024, Aurora Flight Sciences and Bell Textron advanced into Phase 1B, refining their concepts over approximately one year.

In June 2025, Bell Textron, Inc. was selected as the final performer and awarded contracts for Phases 2, which encompass detailed design, fabrication, and flight testing of the SPRINT X-plane demonstrator.

In April 2026, VFS recognized the Bell High-Speed VTOL Track Test Team with the Howard Hughes Award for outstanding improvement in fundamental vertical flight technology. The team achieved a first-of-its-kind "stop-fold" rotor demonstration, executing a powered transition from rotor-driven flight to jet propulsion — accelerating with a proprotor, transferring thrust to a turbofan, and stopping and folding the rotor in motion to enable high-speed flight. This breakthrough significantly reduced technical risk for DARPA's SPRINT program. Bell Textron will receive the Hughes Trophy at Forum 82.

Early Foundations in Stoppable-Rotor Research

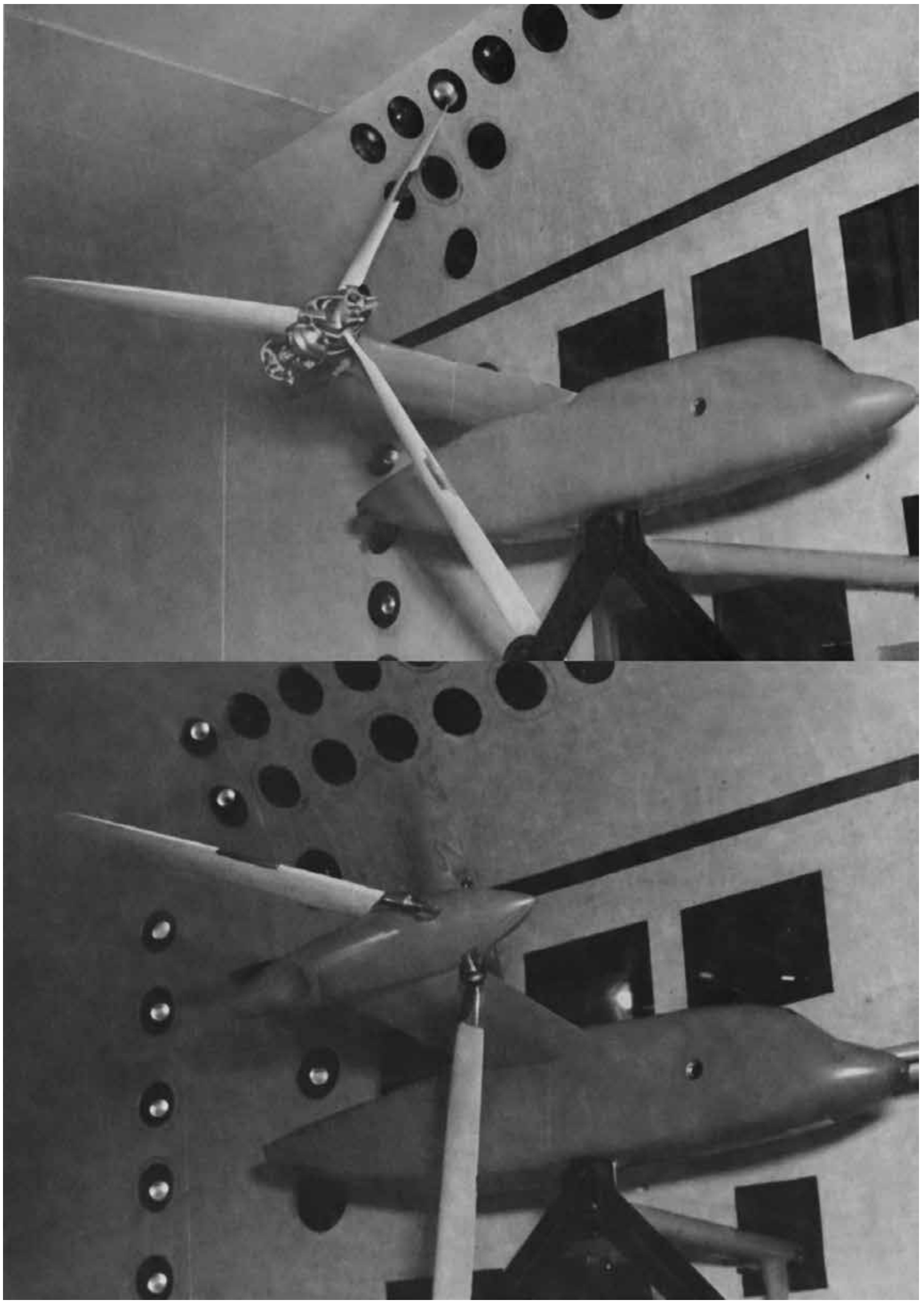
SPRINT represents a modern effort enabled by advances in materials, controls and propulsion integration. Many of its underlying concepts trace back decades. The technical foundations underpinning today's high-speed VTOL concepts extend back to pioneering work conducted in the late 1960s and early 1970s, when researchers began seriously exploring "stoppable-rotor" configurations as a pathway to combining vertical lift with efficient high-speed flight.

An active VFS member now in his eighties, Mr. John M. Davis, who worked in Bell's Stability and Control (S&C) Group from 1967 to 1976 and later supported the US Army's Aviation Applied Technology Directorate (AATD) and NASA Ames, recalls that parallel lines of research were underway during this formative period. In addition to the dynamic modeling efforts led by Dr. Jing Yen and documented in the 1971 technical report "Study of Folding Proprotor VTOL Aircraft Dynamics" (AFFDL-TR-71-7), along with subsequent NASA wind tunnel investigations under contract NAS 2-5461, established foundational understanding that would influence later high-speed VTOL concepts. Davis notes that his supervisor, Mr. Charles "Chuck" Livingston, led complementary work focused on predicting stability and control characteristics of stoppable-rotor aircraft.

As Davis explains, "The S&C work was done in the December 1968 to February 1970 timeframe, whereas the dynamics work was done from February 1969 to February 1971." Despite this overlap, he points out an interesting historical gap: "Although there appears to be overlap in the periods of performance, the 1971 report does not reference the 1969 stability and control work." The absence of cross-referencing between these closely related efforts highlights the fragmented nature of early exploratory research in this emerging field.

Davis also recalls early experimental efforts, including wind tunnel testing of a stoppable-rotor configuration at the LTV Low-Speed Wind Tunnel. He emphasizes that the testing likely involved a fixed airframe model for force and moment measurements, rather than a dynamically operating rotor system.

Dr. Jing G. Yen, a longtime member of the Vertical Flight Society (VFS) and a prolific donor to the Vertical Flight Foundation (VFF), recalls early work at Bell studying the dynamic behavior of



Wind Tunnel Model from AFFDL-TR-71-7 (VFS photo)

folding proprotors under US Air Force sponsorship. The work focused on dynamic stability and transient response during feathering and folding of rotor blades transitioning between helicopter and airplane modes.

In the feathering process, rotor blade pitch increases to reduce rotational speed to zero before indexing and folding the blades for cruise flight. Understanding the complex interactions among elastic rotor blades, wing structures and aerodynamic interference proved essential to making such concepts viable.

For Dr. Yen, this effort represented his first major assignment after joining Bell in June 1968. The program encompassed methodology development, analytical predictions and an extensive series of wind tunnel tests. These included a 1/7th Froude-scale aeroelastic model tested at the LTV Low-Speed Wind Tunnel followed by testing at NASA Langley's 16-Foot Transonic Dynamics Tunnel, supported by Ray Katernik, and later, a half-span, full-scale test conducted at NASA Ames' 40- by 80-foot wind tunnel in 1972.

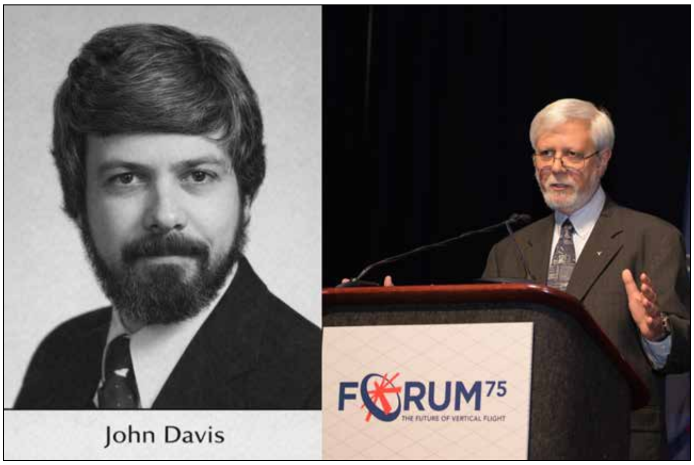
Reflecting on the work, Yen notes that "this report was the first aeroelastic rotor modeling using modal methods, as well as modeling of wing/rotor aerodynamic interference." These advances marked a significant step forward in understanding the coupled structural and aerodynamic behavior of convertible rotor systems.

The effort was led by project manager and famous VFS member Troy Gaffey, whom Yen credits as both a mentor and a guiding influence during the program. "He was a great mentor and 'dissertation adviser' to me," Yen recalls. Gaffey also found the solution to the "X-Mode" vibration problem that affected the XV-3, leading to success in the XV-15 and, ultimately, the V-22. Gaffey's legacy will be commemorated by his namesake Troy Gaffey VFF scholarship, which will be awarded to Jack Dooher, Texas A&M University at Forum 82.

Muneeb Safdar from the University of Maryland will receive the Dr. Jing Yen VFF Scholarship for Cost Awareness at Forum 82; $6,000 awarded to the top applicant with a focus on improving rotorcraft affordability. The Bell Textron Scholarship, for the highest-scoring applicant will be awarded to Hauke Till Bartzsch, Leibniz University Hannover.

Bell's SPRINT Concept

The wind tunnel test in 1972 went a long way to prove the basic concept, including demonstration of fold mechanisms and capture of full-scale stop-fold loads. In recent years, Bell has combined decades of tiltrotor experience with previous stop-fold efforts to develop a scalable, flight-representative folding proprotor design. Recent efforts have focused on four key enabling technology areas: a robust folding proprotor, multi-mode propulsion, automated transition control and a transonic proprotor air frame. The folding proprotor and multi-mode propulsion technologies were developed and tested initially in a laboratory benchtop environment with subsequent iterations of analysis, design



John Davis (VFS photo)

Dr. Jing Yen (VFS photo)

and test. Upon maturity, the folding proprotor and multi-mode propulsion elements were integrated with an automatic flight control system in a unique vehicle tested on the Holloman High Speed Test Track. That test demonstrated the first-known, powered, prop-to-jet and jet-to-prop transitions, establishing a significant milestone in runway-independent technology development. The DARPA SPRINT program progresses the technology to the next step by integrating rotor, propulsion and control technology elements into a transonic airframe with the objective of exceeding 400 KTAS at relevant altitudes and effective hover in austere environments.

The Bell SPRINT concept builds upon decades of experience in tiltrotor and advanced configuration development, combining lessons learned from operational systems and experimental programs alike. The resulting design seeks to balance aerodynamic efficiency in high-speed flight with controllability and stability during vertical operations.

Engineering Leadership and Program Execution

The SPRINT effort at Bell is led by a team deeply rooted in advanced vertical flight development. Among them is Jason Hurst, Executive Vice President of Engineering and current treasurer of the Vertical Flight Society; Zack Dailey, chief engineer; as well as the dedicated Advanced Programs team at Bell.

Jason Hurst leads Bell's engineering organization and oversees development of testing, talent, tools and technology across the company's military and commercial portfolios, including the DARPA SPRINT program. During his 23-year career at Bell, he has held leadership roles spanning innovation, advanced configurations, autonomy and propulsion integration.

His prior responsibilities included oversight of advanced research programs such as Nexus, Autonomous Pod Transport (APT) and numerous advanced concepts. Hurst also served as program manager for the V-247 Vigilant unmanned system and previously led the experimental V-22 program, supporting rapid testing of upgrades including inlet barrier filters, aerial refueling capability and live-fire testing.

Zack Dailey is currently the chief engineer of Bell's Advanced Program team responsible for exploring and developing new technologies and novel applications in order to radically redefine vertical lift.

Jason Hurst, EVP Engineering, Bell Textron

Dailey has been with Bell for 20 years serving in a variety of engineering roles. Prior to joining the Advanced Programs team, he served as the chief engineer for the Bell 505 and Bell 429. His background includes propulsion system design, rotor system design and experimental engineering contributing to many of Bell's commercial and military products, including the Bell Boeing V-22, Bell H-1 line, Firescout, Bell 429, Bell 505 and Bell 525.

The DARPA Team

The SPRINT program at DARPA is led by Cmdr. Ian Higgins, US Navy, who joined the TTO in June 2023 as a program manager.

Zack Dailey, Chief Engineer, Bell Textron

Bell Textron's High-Speed VTOL Track Test (photo: Bell)

Higgins brings extensive developmental and operational flight test experience to the role. Prior to DARPA, he served as a chief developmental test pilot for the US Navy, conducting testing involving mission-systems integration, loads envelope expansion, ordnance separation, air-to-air refueling, flying qualities evaluation, and carrier suitability testing for the F/A-18 and EA-18G aircraft. Operationally, he completed a carrier-based deployment flying the F/A-18.

The SPRINT program at its core is not simply a research effort, it is an X-plane initiative with a clear purpose: demonstrating capabilities for application by the Department of War. The objective is not just to explore what is possible, but to validate technologies that can transition into future operational systems.

As Cmdr. Higgins emphasizes, the program is designed to "challenge the current paradigm" of vertical flight by combining jet-like speeds with true runway independence, unlocking new operational concepts across a wide range of mission areas.

SPRINT is inherently a joint effort. Led by DARPA in close partnership with USSOCOM, the program actively engages the Navy, Air Force, and Army. These partners are not passive stakeholders—they are integral members of the team, embedded in technical reviews, continuous feedback loops, and ongoing collaboration. Their direct involvement informs the technologies under development, aligning X-76 capabilities with future warfighter needs. This level of joint integration ensures SPRINT is leveraged by the next generation of programs of record..

Behind the program's execution is a team structure that reflects how DARPA operates at speed. In addition to government civilian experts from across the services, SPRINT leverages Systems Engineering and Technical Assistance (SETA) personnel. These individuals serve as the engine of DARPA programs, executing across technical, programmatic, and administrative domains, and enabling rapid progress on complex challenges. As Higgins notes, these are leading subject matter experts working together to solve problems at a pace and level of complexity rarely seen in traditional acquisition programs.

That pace is a defining feature. X-plane programs compress years, often decades, of development into just a few years, moving rapidly from digital design to flight test. This creates a unique environment where decisions, lessons learned and technical breakthroughs occur in rapid succession, accelerating both innovation and experience.

The operational implications are significant. A platform capable of combining high-speed cruise with runway independence offers what Higgins describes as an "asymmetric advantage," enabling new approaches to logistics, special operations, combat search and rescue and distributed operations in contested environments.

Equally important is the human dimension. Programs like SPRINT serve as both proving grounds and inspiration for the next generation of engineers and technologists. By exposing emerging talent to real-world, high-consequence development efforts, DARPA is actively cultivating the workforce that will carry these concepts forward.

In that sense, SPRINT is more than an X-plane program; it is both a technological leap and an investment in the future of vertical flight.

Looking Ahead

As the SPRINT program progresses into fabrication and flight-testing phases, the emphasis will shift from concept validation to demonstrating integrated system performance. Success will ultimately be measured not only by achieved speed or hover capability but also by the ability to transition reliably between flight regimes and validate scalable technologies applicable to future operational aircraft.

Regardless of the final configuration, SPRINT continues DARPA's long-standing role as a catalyst for innovation in vertical flight. The program reflects a recurring theme in aerospace history: Transformational advances emerge when operational need, technological maturity and institutional willingness to accept risk converge.

For the vertical flight community, the X-76 represents more than a single experimental aircraft. It is a continuation of a decades-long pursuit to expand the boundaries of what vertical flight can achieve.