

V-STAR™

Pocket Guide

VTOL-Swift Tactical Aerial Resource™



FRONTLINE AEROSPACE

Tactical UAVs have tremendous potential to transform the outcome on the battlefield. However, none until V-STAR™ has solved the long-standing challenges of critical logistics for troops at the frontline, as well as adapting to provide optional payloads including ISTAR, lethal and other missions.

V-STAR™ is a medium altitude, VTOL-capable, autonomous UAV solution for land and naval force commanders that outperforms helicopters and tilt-rotor UAV systems. The design provides tremendous payload flexibility—from traditional ISTAR roles to lethal weapons to logistical supply deliveries for combat troops. V-STAR's™ unique patented lift fans, diamond box wing and Rolls-Royce power plants create the core of this revolutionary UAV configuration.

V-STAR™ creates new logistical, intelligence, and weapons assets.

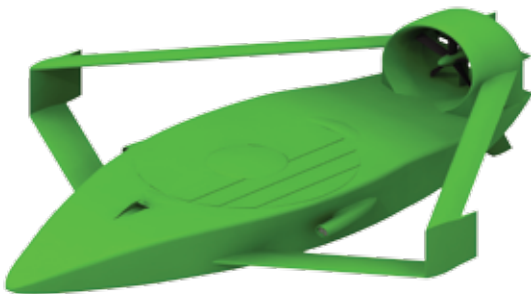


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Introduction

The development of V-STAR™ – Vertical Takeoff and Landing (VTOL) - Swift Tactical Aerial Resource) – represents a novel solution to the long-standing unmanned aerial vehicle (UAV) design challenges of the Front Line Delivery System (FLDS), as well as Multi-Role Endurance (MRE) and related missions. V-STAR™ radically exceeds the performance capabilities of other VTOL and tactical UAVs. This patent-pending breakthrough is achieved by the use of counter-rotating ducted ring-fans and a diamond box wing structure.

The core technology enables the V-STAR™ to provide superior speed, rate of climb, reliability, endurance, payload, and mission flexibility. For the first time there is a UAV that truly delivers key capabilities that military forces are looking for now and will demand in the future. V-STAR™ provides the operators with a single platform that:

- Conducts VTOL flight operations
- Operates 2-3 times faster than helicopters
- Provides tremendous payload flexibility (logistical, lethal and ISTAR)
- Delivers the first genuine solution to FLDS and MRE missions
- Eliminates exposed blades, using enclosed ducted fans for efficiency and safety
- Substantially improves noise stealth over helicopters

The Frontline Aerospace, Inc.'s patented V-STAR™ integrates the innovative aeronautical design of advanced ducted-fan lift technology with proven and reliable Rolls-Royce Model 250 turboshafts to maximize the utility of the UAV at low unit and maintenance costs.



In Theater FLDS Simulation

Frontline Aerospace, Inc. is a start-up company. It is a fusion of ingenious innovation and business acceleration. The V-STAR™ configuration stems from work commissioned by entrepreneur Ryan S. Wood representing a well-known and long-respected aerospace engineering legacy – including a family heritage of aeronautics and astronautics texts still used in universities worldwide and executive leadership at McDonnell Douglas Corporation. Detailed vehicle concepts have been honed by a retired Boeing technical fellow and early-stage design team. Lift fan configuration has been elaborated by a former NASA propulsion expert, and overall design has received advice from senior scientific talent at the Naval Research Laboratory, a world-class innovator in UAV design.

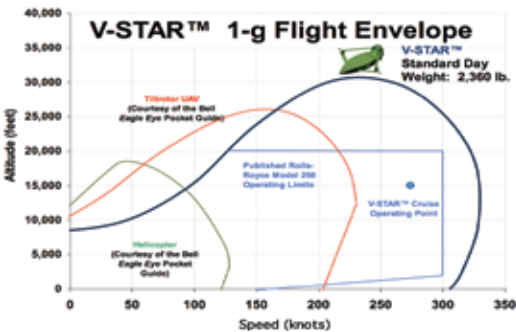
Lift Fan & Diamond Box Wing Advantages

The V-STAR's™ capability to take off and land vertically and then seamlessly transition to forward flight at a high speed (288 knots cruise) in the mode of fixed-wing aircraft provides military commanders with tactical advantages that no other UAV system can match.

Vertical launch and recovery operations eliminate the need for prepared runways, large areas of obstacle-free land, nets, parachutes or airbags. Precise navigation and system redundancy dramatically reduce the potential for damage to an air vehicle and mission payload.

The combination of the ducted lift fan and diamond box wing improves survivability because it is harder to shoot off the wings or degrade the air vehicle's ability to hover. The diamond box wing provides a high aspect ratio that improves lift and drag performance over helicopters, tilt-rotor and short take-off and landing aircraft.

The flight envelope comparison below shows that V-STAR's™ core enabling technologies outperform Helicopter, STOL Tilt Wing, and Tilt Rotor VTOL UAVs.



V-STAR™ Delivers Breakthrough Operational Performance

Front Line Delivery System Mission

Military success hinges on logistics, which plays a fundamental role in warfare. Today logistics is, in many ways, the weapon. It is the ability to move ammunition and critical supplies quickly and safely to troops



in combat. FLDS is a new method for resupplying ground forces in the heat of battle – overcoming risks from Improvised Explosive Devices (IED) and other critical delays. This can dramatically shift the “tooth-to-tail” ratio for frontline war fighters. The FLDS mission is to deliver from a VTOL air-

borne system 156 short tons of fuel, water, ammunition and other supplies daily, to an Objective Force Brigade (Future Combat System) via 624 deliveries of 500 lbs, to 105 delivery points spread across 1000 square miles. Today this often requires either slow, vulnerable, inefficient convoys of HUMVEEs or trucks, or expensive air missions.

The Marines, in particular, have critical need for safe delivery of supplies using an inexpensive Vertical Takeoff and Landing (VTOL) UAS that speeds water, food and ammunition to forward troops. V-STAR™ is also ideal for over-water/cross-beach operations, and the riverine variant with pontoons offers advantages in salt and fresh water picket operations. Tactical UAVs are intended to complement, not replace existing helicopter, fixed-wing and other assets. This synergy between manned and unmanned tactical assets significantly reduces overall engagement costs and increases mission effectiveness.

The V-STAR™ program will revolutionize battlefield air logistical support for combat teams, squads, platoons, companies and special operations units. V-STAR™ provides frontline commanders with embedded capability to resupply fast-moving tactical units in the heat of battle. Future scalability of the V-STAR™ design will offer a range of UAS flight missions – from military supply, tactical combat support, to manned troop insertion and rescue.

TUCAV Mission

Tactical Unmanned Combat Aerial Vehicles (TUCAV) will come in many sizes and shapes for the Future Combat System both fixed wing and VTOL. TUCAVs will range from the near-Mach 1, 50,000 ft ceiling, to low-observable configurations, with internal bomb bays and precision guided munitions. At the opposite end of the spectrum, the VTOL TUCAV's provide direct support of advancing troops. They will serve a unique role, different from an attack helicopter but nearly as deadly. This is a mission that V-STAR™ can help fill.

Besides the logistical re-supply role, V-STAR™ can transform into a powerful Tactical UCAV with a simple swap of the payload. This



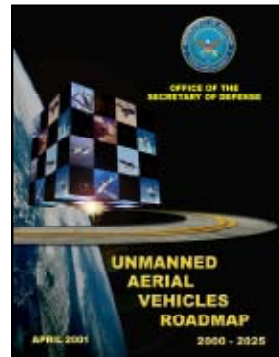
is due to a distinct design advantage, in which the V-STAR™ payload is always at the Center of Gravity, so can be rapidly changed without affecting vehicle balance. It can be loaded with powerful weapons systems, such as:

- Airborne M19 grenade launcher with 300 total rounds of ammunition that can be selectively fired based on the situation, including High Explosive, Fragmentation, Chemical, Incendiary, and the devastating Hellhound.
- M230 chain gun with 1,000 rounds.
- Thirty MK66 rockets as shown above
- Three Hellfire missiles.

These lethal weapons and other ISTAR options are discussed in later chapters.

Multi-Role Endurance Mission

The Multi Role Endurance (MRE) Unmanned Aerial Vehicle (UAV) is intended to perform medium and/or long-range endurance surveillance, reconnaissance, relay, targeting, and potentially attack (both lethal and non-lethal) against a wide variety of possible land and sea-based targets across the spectrum of conflict. This differs from a Unmanned Combat Aerial Vehicle (UCAV), which emphasizes lethality.



The MRE UAV provides a level of organic, survivable, interoperable reconnaissance, surveillance, targeting, and attack (RTSA) required by Naval forces in the 2010 to 2015 time frame. The MRE UAV should be capable of providing targeting data, conducting active and

passive electronic warfare (EW), and potentially employing lethal and non-lethal ordnance. A critical advantage of the V-STAR™ is that it's dual-engine design ensures the ability to generate high levels of electrical power until not possible except in large, cargo aircraft. It will be a flexible asset capable of many different missions, such as: ISR, Command, Control, Communications, Computers, and Intelligence (C4I), Suppression of Enemy Air Defenses (SEAD), and is potentially lethal. It's VTOL capability will be capable of operating from aircraft carriers (CV) amphibious assault ship (LHA), guided missile cruisers (CG), guided missile destroyers (DDG), and frigates (FFG).

Hunter-Killer Mission

With Presidential directives to provide new precision strike capabilities for the global war on terror and the Air Force's interest in reducing the kill chain, the Hunter-Killer UAS will be a key tool to achieve these goals.

Hunter-Killer UAV by most definitions designates an entirely new class of UAV, not a weaponized sensor platform but an aircraft designed from the beginning to seek out and strike targets. While the "baseline" V-STAR™ design has been designed for close combat logistics, embedded in V-STAR™ are the attributes to be a great Hunter-Killer UAV. By swapping payloads to a weapons system such as Hellfire missiles (\$25K-\$65K/each) or to the dramatically more cost-effective 40 mm grenades (\$5-\$40/each), V-STAR™ becomes a powerful Hunter-Killer UAV.

The hard part in the hunter-killer mission is the ISR effort at finding and fixing the enemy – doing the identification and then doing what the commander wants done. If you can find the enemy and track them, there are more options than to drop a bomb on them: you can follow them, capture them, and listen to them. Putting a bomb on the enemy may often be the last resort, only if you think you're going to lose them. In the end, the Hunter-Killer mission is still primarily a weaponized ISR platform—a hunter.

Sending a UAV deep into a threat environment calls for a decent magazine so it can take advantage of the hunter-killer aspect at any time throughout the mission without running out of ammunition. V-STAR™ has the flexibility to accommodate different profiles. By swapping payloads to Hellfire missiles, rockets, chain guns or grenade launchers all at the center of gravity, the mission commander can choose the tools he needs.

Comparisons to a Helicopter

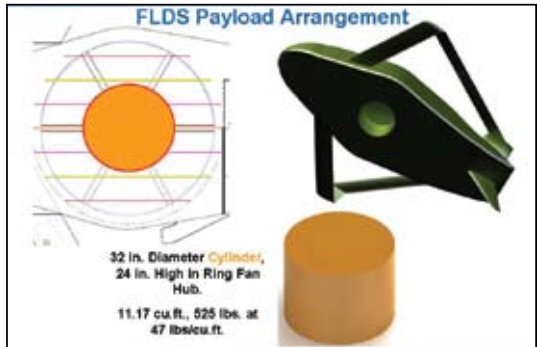
Below are eleven key reasons why V-STAR™ is superior to helicopter performance.

1. **It is Safer.** With the VTOL lift blades enclosed, the aircraft has more survivability, can land in tighter spaces and people can quickly get right up to unload even in rough terrain without fear of being hit by a blades.
2. **It has Instant Multi-Role Capability.** By picking up a different modular payload the craft instantly converts from a supply and logistics UAV to an Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISR) role or to a powerful weapons system capable of carrying a M203 chain gun, Hellfire missiles and M19 grenade launchers. V-STAR™ has superior capabilities for powering EW and related missions, and future larger-scale versions will be able to insert an able soldier or extract the wounded.
3. **It is Faster.** Two to three times faster than any current or anticipated helicopter, due to the unique diamond box wing in level flight, means the payload gets to the customer more quickly and can return home faster too. This allows more sorties per day and reduces exposure to enemy fire.
4. **It is Unmanned.** No need to pay the pilots, or give them breaks, or track their hours. It does not get tired or need extra oxygen at altitude. It can climb faster, descend faster and take sharper turns all beyond normal pilot comfort – making the aircraft more efficient getting to and from the target.
5. **It Delivers More Cargo Per Day.** With V-STAR's™ speed, unmanned and autonomous agility, the craft makes more sorties per day. It can achieve 10-14 full-range sorties per day depending on conditions, delivering 5,000 – 7,000 lbs of supplies daily for about \$1/lb in direct costs (fuel and maintenance).

Specific Payload Applications

The payload section of the “baseline” configuration V-STAR™ is a cylinder, 32 inches in diameter and 24 inches high, as depicted below, with a payload capacity of 400 lbs and 11.2 cubic feet.

6. **It Has Signature Shaping.** Acoustic noise is minimized via ducted lift and pusher fans into narrow sound cones. Infrared signature is reduced via the patent-pending MicroFire™ gas turbine recuperator.
7. **It Flies Farther.** With the diamond box wing and its high aspect ratio the V-STAR™ can go farther more efficiently, increasing both loiter time and sorties per day. This allows access and support to areas that were unreachable before.
8. **It Flies Higher.** With an airframe ceiling of 31,000 ft and cruise at 15,000 ft V-STAR™ can service mountain locations that other helicopters cannot.
9. **It Climbs Faster.** Typically V-STAR™ climbs 100% faster than a helicopter; this means it can get off the landing zone quicker and is less vulnerable to enemy fire.
10. **It is Cost Effective.** The number of lifetime missions is at the core of cost-effectiveness along with maintenance and survivability. V-STAR™ is designed to achieve over 500 lifetime missions. It has low operating costs given its proven power plant, fuel efficiency and superior design.
11. **It has Endurance.** In a standard configuration, with a small 30 lb payload V-STAR™ can stay aloft for 13 hours with a range of 1,950 nautical miles. V-STAR™ also offers another unique design advantage – the first practical “morphing wing.” With augmented wings (V-STAR™-Endurance) it can stay aloft for more than 24hrs, providing commanders with increased ISR, bomb damage assessment (BDA) and target analysis flexibility.



The FLDS logistical support mission for combat troops will deliver a payload primarily consisting of water, fuel, ammunition, medicine and other critical supplies, yet has the flexibility to insert weapons systems and intelligence-gathering systems.

Non-Lethal applications include:

- Logistical front line deliveries
 - making V-STAR™ the “HUMVEE of the Air”™
- ISR
- Target acquisition and designation for both land and sea weapons assets
- Real-time situational awareness for tactical forces
- Nuclear, Biological, Chemical (NBC) sensors in contaminated-area operations



General Characteristics

- Anti-submarine warfare: delivery of sonobuoys, or surface dipping sonar and magnetic anomaly detection (MAD)
- Airborne tactical datalink and beyond line-of-sight tactical communications relay (BTCR)
- Solider insertion
- Border patrol
- Pollution, atmospheric, oceanographic monitoring
- Power and pipeline monitoring
- Fisheries protection & fish spotting
- Fire detection
- Direct fire fighting, retardant, hose etc.
- Counterterrorism surveillance
- Casualty extraction – air ambulance
- Disaster relief – supply deliveries
- Search and Rescue
- Emergency Services support

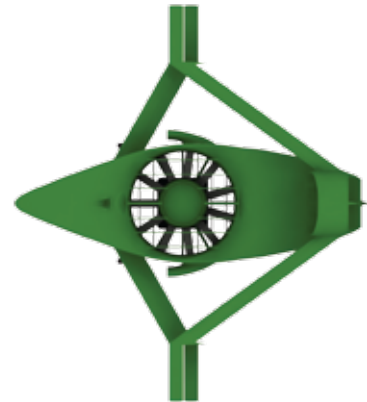


The V-STAR™ design is unique blend of several (BDA) aircraft technologies, combined with a highly innovative, breakthrough configuration. Experienced aeronautics experts reaffirm that V-STAR™ stands out as an innovation in aircraft design, solving stability, performance and flexibility problems that have long stymied earlier designs. VTOL lift is provided by counter-rotating ducted ring-fans, while forward flight is implemented with a rear ducted pusher fan. This ensures no exposed blades that can interfere with tight-quarters tactical missions both on land and ships. The diamond box wing eliminates the fountain effect in close hover and delivers a high aspect ratio configuration with superior lift/drag. Wing moment arms and innovative controls address classic stability challenges. Dual Rolls-Royce Model 250 turboshaft engines drive the lift fan during VTOL while just a single turbine drives the pusher fan in cruise. This makes exceptional power available for electrical generation when needed. A dash mode is available with both engines at nearly 400 knots, with cruise at 288 knots.

Lethal weapons applications include:



- M19 Grenade Launcher
- M230 Chain Gun
- M200 Rocket Pods with MK-66 rockets
- AMG-114 Hellfire missiles (pictured below)



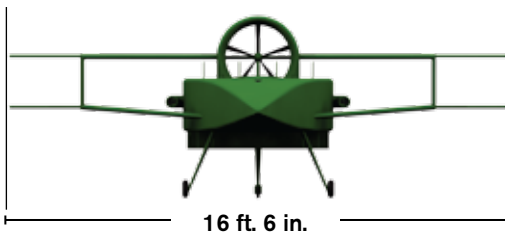
V-STAR™ UAV Top View



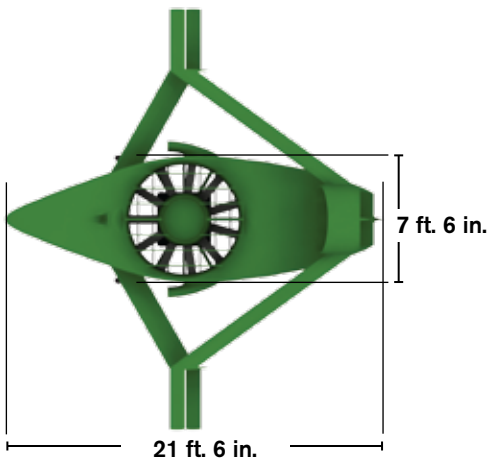
Front and Side View

External Dimensions

The V-STAR™ air vehicle provides VTOL operations and high speed flight without compromising transportability. The aircraft can be transported via truck, rail, ship, and transport aircraft including: C-130, C-17 and C-5. At 2,600 lbs gross weight it can also be slung beneath suitably equipped vertical lift aircraft. Additionally, the wings can be readily removed to further compact the volume for efficient transport.



V-STAR™ UAV Front View



V-STAR™ UAV Top View

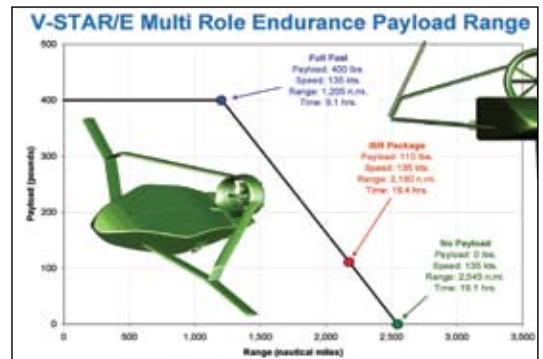
V-STAR™/E (Endurance)

The key change in the endurance version of the V-STAR™ product family is the addition of 5 ft detachable and folding wings. This upgrade provides a significant improvement in overall aircraft endurance and maneuverability. This helps with the all core missions, but particularly the Hunter-Killer and Multi-Role Endurance missions.



V-STAR™/E has the performance to provide commanders with significant flexibility to respond to varying logistical and combat needs.

V-STAR™ also as the option of adding a patent-pending MicroFire™ gas turbine engine recuperator that improves specific fuel consumption (SFC) by about 40% further extending the performance of the “E” model to over 24 hours with a 110lb ISR package.



V-STAR™ Mission Adaptive Planform (MAP)

Wing morphing is one the cutting edge areas of aeronautical engineering today. It's the ability to change the shape, sweep and length of the wing to optimally match the aircraft speed, lift/drag and mission requirements. The V-STAR's™ Mission-Adaptive Planform (MAP) creates a low cost and highly effective way of wing morphing.

In short, a morphed wing can do a low speed energy-saving loiter, then morph and perform a high-speed maneuver. A recent study in Nature, April 2007 proves that swifts can improve flight performance by up to three-fold via wing morphing.



Several companies and government agencies have pursued wing morphing, yet none have succeeded commercial or practically. The weight, complexity and reliability penalties associated with morphing a wing have limited success to date. However, because of V-STAR's™ patent-pending diamond box wing and mission adaptive planform the addition of folding wings creates a morphed wing that can improve aircraft and wing efficiency – enabling energy-efficient loitering as well as high-speed dashes.



Extended wings and folded for dash

V-STAR's™ patent-pending mission adaptive planform delivers the advantages of wing morphing today while others are still on the drawing board.

Operational Characteristics

V-STAR™ provides performance that cannot be found anywhere else in the UAV industry. The key advantages of the patent-pending ducted lift fan and diamond box wing configuration create breakthrough advances for the operator. These advances improve the overall mission effectiveness without increasing maintenance or operations costs.

Speed – V-STAR™ cruises at 288 knots on a single engine, with a dash speed of nearly 400 knots with both engines. This allows rapid transit over areas of interest.







Range – V-STAR™ (depending on which configuration) can fly over 3000 nautical miles with a small 30 lb ISR payload. More typically in the FLDS mission it can fly 425 miles delivering a 400 lb payload in 95 minutes.

Altitude – V-STAR™ is designed for an altitude of 0-31,000 ft, with typical cruise at 17,000 ft. The cruise altitude is an optimal blend of fuel savings, operational capability and survivability. The Rolls-Royce Model 250-C20 engines that powers V-STAR™ has over 160 million flight hours, worldwide service and an extensive military history as a reliable power plant.

Endurance – V-STAR™ is primarily designed for repeated short-haul sorties; however, if the payload is converted to fuel, a small 30 lb ISR package can be flown for 17 hours at an average speed of 157 knots.

Extended Endurance – By adding 5 foot wings to V-STAR™/E, V-STAR™ provides a true MRE platform that is capable of +24 hour endurance. Specifically, with the patent-pending MicroFire™ recuperator the VSTAR/E can go 2,700 miles with a 110 lb payload.

Competitive Positioning

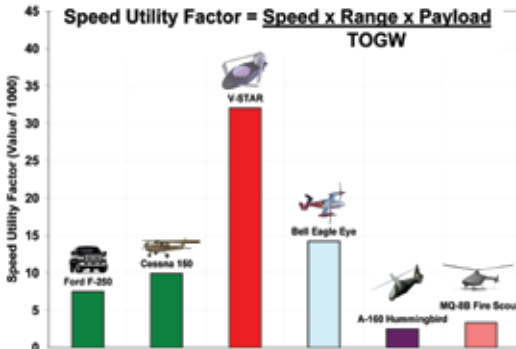
Attribute	Fire Scout	Bell Eagle Eye	A-160 Hummingbird	LittleBird	V-STAR™	V-STAR™/ER
June 2008 Data						
Designer / Manufacturer	Northrop Grumman- Ryan Aeronautical	Bell Helicopters / Textron	Frontier Systems / Boeing	MD Helicopters / Boeing	Frontline Aerospace / Major Partner	Frontline Aerospace / Major Partner
Cruise Speed	?	160 knots	100? knots	135 knots	288 knots	145 knots
Top Speed	> 125 knots	200 knots	140 knots	152 knots	400 knots	400 knots
Range	300nm	1,200 nm	Up to 1,700 nm	300 nm	Up to 2,650 nm	Up to 3,400 nm
Radius of Operation	150 nm	110 nm	850 nm	150 nm	1,325 nm	1,700
Payload Volume			110 ft^3	~50 ft^3 to 200 sling load	11.2 ft^3	11.2 ft^3
Payload Weight	Up to 600 lbs	Up to 200 lbs	Up to 1,000 lbs	1,200 lbs	Up to 400 lbs	Up to 400 lbs
UCAV mission	Partial	NO	Partial	Yes	YES	YES
Weapons Options	MK-66 rockets	None	Being evaluated	Hellfire, Mk66	Hellfire, M230, M19, MK66	Hellfire, M230, M19, MK66

Attribute	Fire Scout	Bell Eagle Eye	A-160 Hummingbird	LittleBird	V-STAR™	V-STAR™/ER
Noise	High	High	High	High	Low	Low
Rate of Climb	?	?	1500?	1500 fpm?	2,900 fpm	2,900 fpm
Cruise Altitude	?	14,600 ft		4000 ft	16,000 ft	16,000 ft
Ceiling	20,000 ft	20,000 ft	28,000 ft	20,000 ft	32,500 ft	35,000 ft
Engine(s)	RR Allison C20W	PW200/55	Turbine powered	RR 250 C30R/3	Twin RR Allison 250C20W	Twin RR Allison 250C20W
Power @ sea level	480 hp	641	390 hp	650 hp	425-850 hp	425-850 hp
Time-between Overall	3,000 hrs	3,000 hrs	~2,000 hrs	3000 hrs	3,000 hrs	3,000 hrs
Empty weight	1,862 lbs	1,300 lbs	1900 lbs	1591 lbs	1580 lbs	1680 lbs
Fuel weight	1,288 lbs	750 lbs	2,500 lbs	403 lbs	380 - 755 lbs	380-755 lbs
TOGW	3,150 lbs	2,250 lbs	4,300 lbs	3,100 lbs	2,360	2,460
Length x Width	23 ft x 27.6 ft	17.9 ft x 15.2 ft	35 ft x 36 ft	32.6 x 27.4 ft	21.5 ft x 16.5 ft	21.5 ft x 24.5 ft
Endurance	Up to 8 hrs	Up to 8 hrs	Up to 20 hrs	10 hrs @ 300lbs	Up to 15 hrs	Up to 24 hrs
Enclosed Blades	NO	NO	NO	NO	YES	YES
Operating \$/hr	~\$500 /hr	~\$1,000 /hr	\$1,500 /hr	\$600 /hr	~\$600 /hr	~\$500 /hr
Production Price Estimate*	\$5.2 Million	\$4.1 million	\$6.8 million	\$2.5 million	\$3.6 million	\$3.8 million

*Technomics Inc.-Average of UANS Cost Estimating Methodology Developed for US Army

Speed Utility Vehicle Comparison

The speed-utility factor multiplies (vehicle speed) x (range) x (payload) divided by TOGW x 1000 in order to derive a “figure of merit” relative to how effectively and efficiently a vehicle can deliver real payload. The results are plotted below for a Ford F-250 pick-up, Cessna 150, Bell Eagle Eye, A160 Hummingbird, Firescout and V-STAR™.



V-STAR™ creates a new class of UAV capability

V-STAR™ is twice as effective as the nearest competitor (Eagle Eye) and four times more effective than the A-160 Hummingbird. Overall, the conclusion is very clear – V-STAR™ creates a new class of logistical, intelligence, and weapons assets.

Signature Shaping

Helicopters are noisy. Their overhead beating rotors propagate sound in all directions announcing the aircraft's presence, typically 100-110 db at 100 ft. They can be even noisier upon landing and takeoff. V-STAR's™ ducted lift fan changes that.

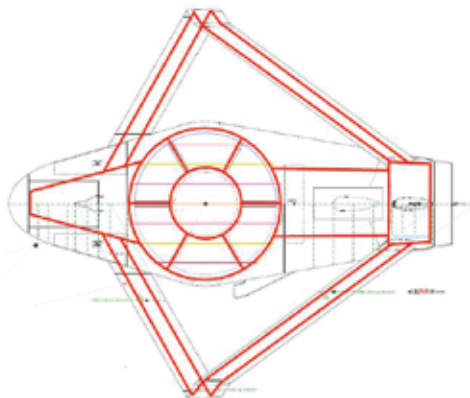
V-STAR™ with its ducted lift fan creates a directional beam of sound both upward and downward at a higher frequency that reduces the vehicle's acoustic signature. Additionally, as the V-STAR™ transitions into forward flight the rear shrouded pusher fan propagates sound both forward over the top of the fuselage, and rearward in a directional cone – which reduces ground noise.

Engine, transmission and exhaust noise are also sources of vehicle acoustic signature, yet the good news is that the Rolls Royce Model 250 engines are buried within the fuselage; the exhaust can be ducted upward and the gearbox is on the top of the vehicle above the payload, thus radiating noise upward. All these factors improve V-STAR's™ acoustic signature as heard on the ground.

With Frontline Aerospace's patent-pending MicroFire™ gas turbine recuperator, exhaust temperatures are dramatically lowered providing a smaller thermal signature.

Airframe

The airframe consists of the forward fuselage, ducted lift fan and payload, rear fuselage with ducted pusher prop/tail and wings, wing extensions and control surfaces. See the top view below of the primary load path diagram of the airframe structure.



Forward Fuselage—The forward fuselage assembly is designed to hold one of the two engines and dual fuel tanks. Access is via a topside panel.

Lift Fan & Payload—Since the payload at center of gravity (CG) is in the middle of the counter-rotating lift ring-fans, particular attention has been paid to forces and torques in this critical area.

Aft Fuselage—This area contains a small fuel store and the second Rolls-Royce Model 250-C20W engine which drives the airplane during cruise via a shaft to the ducted pusher prop. The ring-fan and downward tail provide both horizontal and vertical stabilization. Access to the engine is via top panels.

Box Wings & Extensions—These greatly improve the structural loading and stability of the aircraft. They are designed to reduce torque stress at the payload and the lift-fan center fuselage area. The wing structure is mostly composite, with forward and aft spar, upper and lower laminate.

Engines

A pair of Rolls-Royce Model 250 Series II C20B Turboshaft engines powers the V-STAR™. The model 250 is the leading power plant in its class worldwide. Virtually every turbine-powered light helicopter manufacturer offers a model 250 version. This fleet has accrued in excess of 160 million flight hours on some 29,000 engines delivered. It has the capability of Full Authority Digital Engine Control (FADEC), allowing for torque matching, automatic start, and auto-relight all helping to reduce maintenance costs.

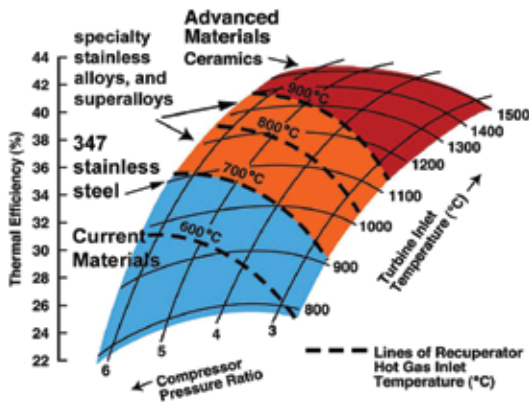


Model 250 Series II C20B with FADEC

The Model 250 also has several power options ranging from 420 shaft horse power to 715 shp. This allows for scaling the design to a larger or faster air vehicle.

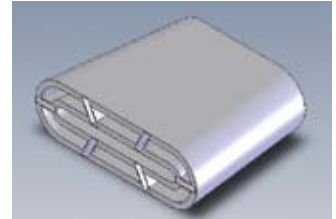
MicroFire™ Recuperators

A “recuperator” is a special-purpose high-temperature counter-flow heat exchanger that extracts heat from the hot engine exhaust and transfers it to the compressed engine air before combustion. Depending on the specific implementation, this can sometimes double the overall thermal efficiency of the engine. The historical challenge with recuperators in aircraft applications centers around three key aspects – low-weight materials that can withstand the pressure, thermal shock and heat-transfer efficiency.



The graph above shows the tremendous improvement in thermal efficiency that is possible with recuperators, but also the traditional problem with heavy, high-volume materials that are required in conventional designs to date.

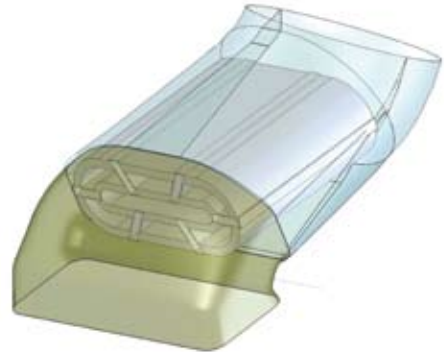
The V-STAR UAS has a patent-pending recuperator option that improves specific fuel consumption by as much as 40% with very low pressure drop and power loss. Power loss at take-off is estimated to be less than 1% when the recuperator is bypassed and power loss at cruise about 4% when the recuperator is engaged all for about 50



Mircofire™ Recuperator

pounds for the Rolls-Royce C20B engine. Other more powerful engines in the Rolls-Royce family can also benefit from Frontline’s MicroFire recuperator.

This is a key enabling technology to dramatically increase the range, endurance and in essence—fuel mileage.



Mircofire™ Recuperator in engine exhaust duct.

Drive System

Frontline Aerospace has designed the V-STAR™ drive system to provide high reliability and ease of maintenance to reduce overall life-cycle costs. The use of belts and multiple drive shafts – so that either engine can power both the lift fans and pusher fan – improves survivability in hostile environments. The drive system consists of the following components:

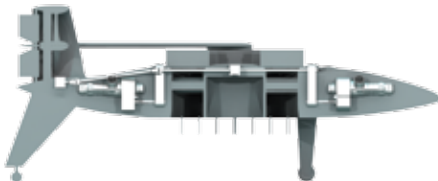


- Input drive shafts and fan belt couplings to the primary VTOL lift fans through reduction gearboxes
- A shaft from the rear engine to the ducted pusher fan
- Oil cooling for the reduction gearboxes

Lift and Cruise Fans

Central to the both VTOL performance and air vehicle speed are the enclosed counter-rotating ring-fans. Driven at takeoff by two Rolls Royce Model 250 engines it achieves a sea level thrust of 3,120 lbs, while the cruise fan provides 1,000 lbs of thrust.

Item	Units	Lift Fan	Cruise Fan
Diameter: Tip	in.	72.00	36.00
Diameter: Hub	in.	36.00	5.75
Number of Blades		11	5
Required Input Horsepower	HP	849	246
Thrust: Sea Level Static	#	3,120	1,000
Thrust: Cruise	#	–	400
Propeller Solidity		0.370	0.248



Safety Considerations

Engine failure has claimed 24% of all historical UAV crashes, and since V-STAR™ has two of the most reliable Rolls-Royce engines ever flown – either of which can safely land the air vehicle – the chance of engine failure is dramatically reduced. Furthermore, the glide ratio of the airplane is 12 to 1 allowing for a wider selection of possible emergency landing zones.

The dual batteries and ram-air turbine combine to maintain power to avionics and control surfaces. This allows for control and guidance in the rare event that there is a dual engine loss. Additionally, there are redundant fuel lines and generators. The ducted fan provides a shielding lift capability that increases aircraft safety and survivability from enemy fire. Upgraded versions of V-STAR™ can easily incorporate state-of-the-art light armor as needed for specialized missions.

In case of a landing emergency, the engines can be over-driven to land. With an engine in-flight restart capability this improves safety and eliminates the need for on-ground starters.

Fuel System

The V-STAR™ fuel system is a dual redundant design. This ensures that fuel is always available to the engines throughout the aircraft operating envelope. There are no wing fuel tanks – which makes it all the easier to attach and detach the wings – there are three fuselage tanks, two forward and one aft.

The system is designed for operation down to -40°F. A military standard, three-inch gravity refuel cap and adapter is provided, along with a single-point defuel valve to meet gravity-fill and defuel requirements. Safety and survivability is further enhanced with fire extinguishers on both engines.

Avionics

The design of the Avionics system onboard the V-STAR™ reflects Frontline Aerospace's intense focus on providing a safe and reliable air vehicle.

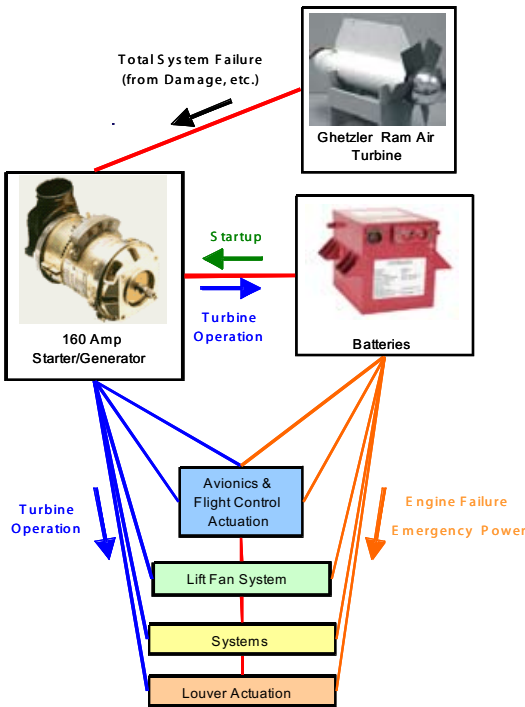
The system includes the following elements:

- Flight Control System (FCS)
- Flight Control Computer (FCC)/Actuator Drive Unit (ADU)
- Navigation Sensor (dual embedded GPS/INS)
- Air Data Computer (ADC)
- Radar Altimeter
- IFF Transponder
- All-weather capability, de-icing system
- Communication system (VHF/UHF Radio)
- Engine and transmission sensors
- Fuel sensors
- Electrical power system
- Wiring and equipment installation
- Airborne Data Link Terminal
- UCARS Transponder
- Payload interfaces

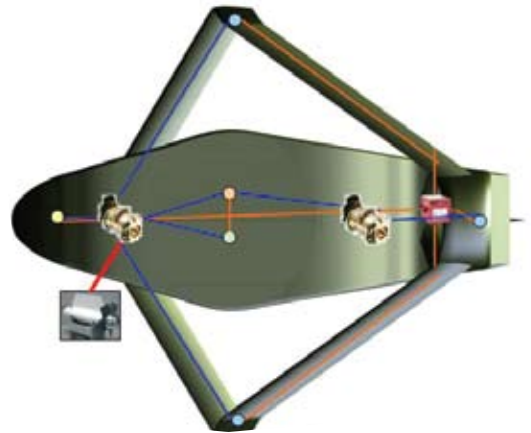
The fully integrated, dual redundant flight control system includes redundant sensors, processing elements, drive electronics, monitoring, wiring, actuator motors and data links. The system also includes built-in Fault Detection Logic and automatic reconfiguration following most failures. This approach provides a cost effective increase in reliability.

Electrical Systems and Battery

The air vehicle primary electrical system is a 28 volt, 160 amp DC system comprised of two starter/generators, two 42 amp-hour batteries and optional ram air turbine (RAT) to power the system during engine failure along with an electronically controlled cyclic and collective blade-pitch system. Below is a block diagram of the system.



During normal operating conditions the generator is driven by the power turbine side of the engine and provides all system power. In the event that unit fails, the starter/generator (which is powered by the engine gas producer turbine) will pick up the bus and is capable of supporting all system loads while maintaining safe flight operations. The batteries are connected to the main bus during all normal operations to improve power quality and to maintain charge. Although external power is normally utilized for maintenance, the battery may be used for short-term system checks.



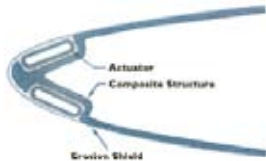
The standard 28 VDC military receptacle is located on the side of the fuselage and provides power for ground operation and engine starting. It supplies all electrical loads until the generator is placed on-line, at which time it is automatically disconnected from the main bus. Once the engine is started and the generator is on-line, the ground crew can remove the external power cable by pulling the release on the remote external power disconnect. This allows the ground crew to stay a safe distance away from the air vehicle.

All Weather Capability

For the first time in a UAV of this size, all-weather capability is a viable option, primarily because V-STAR™ has the extra power to easily heat the aircraft zones to prevent the formation of rime ice. V-STAR™ uses an embedded electrothermal heating system manufactured by Cox & Company. It is the same core technology as used on the wings of the Boeing 787 Dreamliner and V-22 Osprey engine inlets.

This is an important technology because it combines simplicity, versatility and ruggedness in an elegant solution that allows electrothermal heater mats to be easily embedded into the composite structure of the wings, inlets, ducts and fuselage areas as needed.

An electronic controller monitors each individual surface zone (wings, ducts, inlets) individually to minimize power usage and ensure that no rime is forming that would decrease lift and aircraft performance.



Decklock Arrest System

Decklocks are a critical part of the system for securing and maneuvering shipboard UAVs during operation from smaller ships such as Frigates or Coast Guard Cutters. V-STAR™ can be equipped with a decklock arrest system that is placed at the rear edge of the lift fan forward of the rear engine. The system is electronically actuated upon touchdown and extends below the aircraft to quickly secure the vehicle to a NATO-standard grid on board the ship.

The deck arrest systems includes an electromechanical active hook assembly that is attached to the end of a screw shaft mounted within the aircraft. When the system is actuated, the shaft lowers the assembly beneath the aircraft to latch onto the intersection of two holes within the NATO-standard grid. In the event of a miss, the gimballed system can quickly retract and re-extend to capture another grid point. The all-electric version was developed for VTUAV (Vertical Take-off Unmanned Air Vehicle) operation.



Decklock Arrest System

Ground Control Station / Datalink

Frontline Aerospace's focus on satisfying mission requirements is evident in the incorporation of mature command and control software and dual redundant architecture that can be integrated into existing or new land or sea-based ground control stations.

Frontline Aerospace understands ground control stations and the need to provide a low workload and an intuitive environment for the air vehicle and payload operators.



V-STAR™ Data Link System

The reconnaissance mission for the V-STAR™ UAV demands a high-bandwidth, reliable data link system capable of operating at ranges of 1000 nm or more in all weather conditions where the V-STAR™ mission is planned. An L-3 Communications dual UAV data link system provides redundant command and control links for extremely safe UAV operation. Both links deliver jam-resistant linkage to a ground, satellite or shipboard surface terminal while providing greater than 95% availability in most regions of the world.

Internal Datalink Components



The V-STAR's™ primary link system utilizes Tactical Common Data Link (TCDL) technology, which maximizes interoperability with hundreds of other TCDL and CDL deployments world-wide. The return link, equivalent to 6.5 T-1 cable connections, is currently used for transmitting real-time color video, radar, and voice data.

V-STAR™ Data Link System

Net-Centric Warfare



The future of the V-STAR™ is a network-centric, multi-session asset providing C4ISR capabilities during joint operations. The V-STAR™ data link system is already responsive to the need for networked information sharing, greater connectivity, high fidelity video imagery, efficient use of bandwidth, and assured access and control. It is also the correct baseline for growth in every one of those areas.

Frontline Aerospace stands ready to tailor the selection of specific datalinks as desired by the customer. Frontline Aerospace's system is TCDL compliant and can be adapted to meet the requirements of another standard if desired by the customer.

Deployability

The V-STAR™ is transportable by air, sea, rail and highway modes. It is C-5, C-17 and C-130 transportable with roll-on/roll-off. It can be carried on maritime pre-positioned ships, break bulk, roll-on/roll-off, barge carrying, container ships, and on all vessels of the Army, Navy and Marine Corps strategic tactical sea-lift fleet. It meets highway transportation policies. The system takes less than 20 minutes for transport preparation and can be operational within 30 minutes of removal from the transport aircraft. The V-STAR™ can be airlifted by rotorcraft using hard attachment points on each side of the airframe.

The entire V-STAR™ system can be loaded into a single C-130 for transport. The system is capable of being secured to the floor or deck of transport craft with integrated, permanently marked, tie-down systems.





Contact Information

Ryan S. Wood

President & CEO

14004 Quail Ridge Drive,
Broomfield, Colorado 80020

Phone: 720-887-8171

Fax: 720-887-8239

Email: ryan.wood@frontlineaerospace.com

www.frontlineaerospace.com



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