

LINEX

Long-line INsertion and EXtraction

Reach the ground without landing. A fixed-wing system for lowering and recovering personnel, mission equipment and critical supplies from a circling aircraft - while the platform remains at altitude and on speed.



3,000 ft

standoff altitude

450 lb

current design maximum

80-85 kt

typical operating speed

5/32 in

aramid-fiber line

ABSTRACT / INTRODUCTION

LINEX incorporates the equipment and flying techniques involved in lowering and raising personnel and supplies between a circling aircraft up to 3,000 feet and a point on the ground. The equipment includes an airplane-mounted winch assembly capable of lowering and raising weights of up to 450 pounds without the need to land or slow the aircraft below about 80 knots. Higher speeds are also acceptable. Typical airspeed is 80-85 knots.

LINEX was developed concurrently with the third-generation quiet ISR and special operations support airplane, the QS3 NightHawk (www.NightHawkAircraftLLC.com). The system may be installed on other fixed-wing aircraft such as the Cessna 208 Caravan, DeHavilland / Viking DHC-6 Twin Otter and Quest Kodiak. LINEX may also be installed on Group 4 (MQ-1, MQ-9 and similar) unmanned aircraft systems (UAS) without difficulty. Standoff altitudes above 3,000 feet AGL may be significantly increased, as well as maximum loads, with more robust components.

Built around the orbit.

The aircraft establishes a controlled circular flight path above the target area. The winch pays out up to 3,000 feet of high-strength line, allowing the working end to settle over a precise point below.

01 / LOWER

The aircraft maintains a typical 80-85-knot orbit as the line, personnel or payload descends. The aircraft does not need to land or slow below about 80 knots.

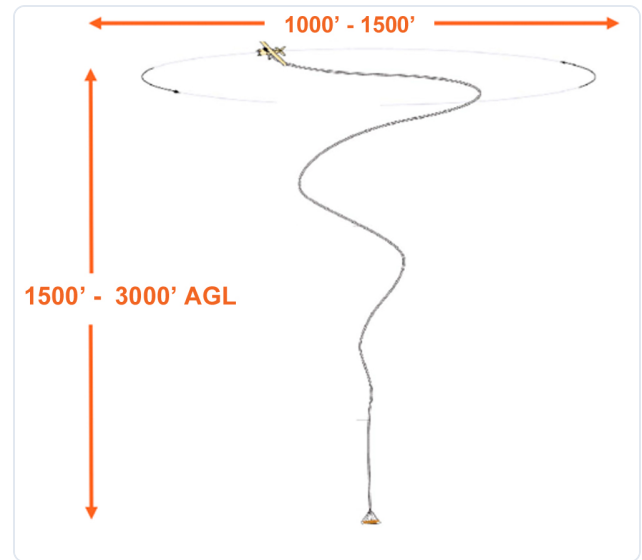
02 / PLACE

Crew coordination, position sensing and line-end controls support placement in confined or sensitive areas. Optional provisions include parachute pack, quick release, radio communications, GPS, LIDAR altimeter and remote control of winch operations.

03 / RECOVER

The aircraft climbs clear of nearby obstacles and transitions to egress while the load is winched aboard. Lifting a person or object from the ground into the airplane has far fewer safety or operational concerns than lowering.

Reference geometry at right: a 1,000-1,500 ft diameter orbit at 1,500-3,000 ft AGL. Nighttime, rough terrain and open-water operations are possible with additional training, excellent crew coordination and specialized equipment, including a precision-orbit autopilot.



Reference geometry: controlled orbit above a 1,500-3,000 ft line deployment. Line behaviour in the orbit is central to precise placement.

HISTORY

From bucket drop to LINEX.

LINEX traces its ancestry to a missionary bush pilot who developed the 'bucket drop and hoist' concept in the late-1940s from the necessity to deliver and retrieve small objects to and from colleagues working deep in Latin American forests and jungles where few landing fields were available at the time.

The 'bucket drop' technique has been resurrected and renamed LINEX by Davis Aviation. New equipment has been designed, built and tested, and new and interesting applications are being explored - most for special operations, sensitive logistics applications and rescue scenarios.

DESCRIPTION

Purpose-built for long-line fixed-wing work.

The LINEX winch is custom designed and built to lower and lift humans and precious cargo to and from confined spaces with minimum fuss and danger from an aircraft circling as high as 3,000 feet above ground level. The normal expected load is about 250 pounds, with the current maximum of 450 pounds. The LINEX components have not been modified from any previously existing winch or lifting device.

MAJOR COMPONENTS

- + 48VDC power supply
- + Electric motor
- + Gearbox
- + Large spool with baler assembly
- + Up to 3,000 feet of high-strength, 5/32 in aramid-fiber line
- + Power electronics and control package
- + Two back-up braking systems to the standard electronic motor brake

SUSPENSION LINE

The preferred suspension line is Aracom Miniline, which combines a low helix angle core of aramid fiber with a very tightly woven over-braid of thin polyester. Aracom Miniline provides the maximum strength-to-weight ratio in a composite aramid polyester construction.

Design maximum - LINEX v.2: Today's equipment has been rigorously researched, designed, built, and tested to support loads weighing up to 450 pounds.

A system, not a repurposed hoist.



Purpose-built LINEX winch drum and line-management assembly. The large spool carries up to 3,000 ft of 5/32 in aramid-fiber line.

AT THE WORKING END

Safety features on the working end of the line may include a parachute pack, quick release, radio communications, GPS, LIDAR altimeter and remote control of the winch operations.

INSIDE THE AIRCRAFT

Features include the primary control box for the winch, hydraulic and self-deploying electro-mechanical brakes to back up the primary electronic winch motor braking, and a digital control screen and readout of the height of the end of the line above ground level.

An optional readout of a GPS sensor at the line end provides independent position and movement indications. In case of emergency, a line cutting device may be provided, and a parachute may deploy at the separated end of the line.

Layered safety: Electronic motor braking is backed by hydraulic and self-deploying electromechanical brakes. Allowing a qualified LINEX passenger to control the winch while in close proximity to the ground is also a risk-reduction technique.

The most likely threat to LINEX passengers or cargo is a failure of the flight crew to exercise precision airmanship - injuring a person on the end of a line while lowering that person onto the ground at a high rate of descent or excessive lateral movement. Precision flying is therefore part of the system, not an afterthought.

Designed with the QS3. Adaptable beyond it.

LINEX was developed alongside the NightHawk QS3, where the winch components are intended to mount within the airframe and left wing trailing-edge area near the aircraft's 44 in W x 45 in T cargo door.



QS3 reference integration. Aircraft-specific engineering, airworthiness review and testing are required for any installation.

NATIVE PLATFORM

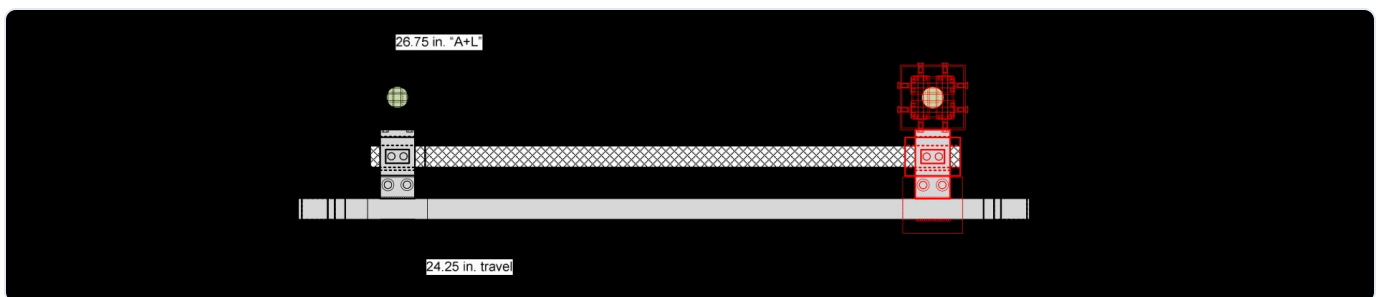
QS3 NightHawk - integrated low-signature insertion, extraction and mission-support configuration.

HIGH-WING UTILITY

Cessna 208 Caravan, DHC-6 Twin Otter, Quest Kodiak - candidate aircraft with suitable cargo-door geometry. Modifications are relatively simple: floor mounting plates, hard points at or near the doors for pulleys, a short retractable arm, and power supply components.

UNCREWED

Group 4 UAS - MQ-1, MQ-9 and similar-size platforms. Standoff altitude and maximum load can be increased with more robust components.



Winch layout reference: 24.25 in travel. Installation details are aircraft-specific.

From logistics to remote sensing.

When installed on manned or unmanned platforms, one LINEX architecture supports a broad mission set:

Personnel delivery & extraction Low-signature delivery and extraction to and from confined or sensitive areas.	Critical resupply Clandestine, precision and long-range resupply to troops on the move, remote outposts, hide sites or battle locations.
Medevac Wounded, injured or stranded personnel from confined or sensitive areas, especially beyond helicopter range.	Rescue at sea Rescue of personnel at sea, particularly beyond helicopter range.
Sensor placement Low-signature, precision insertion and extraction of signal collection devices.	Prisoner transfer Rapid, low-profile prisoner transfer from remote locations.
Tethered sensing Chemical, biological, nuclear, SIGINT, SONAR / ASW sensors deployed below the aircraft.	Information operations Psychological / Information Warfare: clandestine radio and TV, leaflet, audio, DNA collection and other.
Object recovery Rapid, precision retrieval of objects at the ground or ocean surface, such as evidence.	ISR support Fixed-wing observation before, during and after a lift - the delivering aircraft remains a sensor platform.

The five scenarios that follow (pages 8-12) are the source document's 'Food for Thought' vignettes, reproduced in full. They are illustrative operating concepts, not certified procedures.

Precision flying is part of the system.

Daylight LINEX operations are straightforward, but require practice and precision flying abilities.

Nighttime, rough terrain, and open water operations are more difficult, but are possible with additional training, excellent crew coordination and specialized equipment.

One such piece of specialized equipment is an airplane autopilot, much like modern UAS autopilots, capable of performing very precise circling maneuvers over a LINEX 'landing zone' which will minimize aircraft flight path disturbances from winds, turbulence and imprecise pilot control inputs.

Sensor emplacement or employment at the end of a long line is generally straightforward.

ENVISIONED MILITARY PILOT PROGRAM

30 days

program duration

20-40 hr

flight training

Crew coordination focus: stable daylight orbits and cargo placement first, then line-end control near the surface, night and complex-terrain scenarios, and mission-specific procedures.

RISK NOTE FROM THE SOURCE DOCUMENT

The most likely threat to LINEX passengers or cargo will be a failure of the flight crew to exercise precision airmanship and injure a person on the end of a line while lowering that person onto the ground at a high rate of descent or excessive lateral movement. Training, autopilot assistance and line-end winch control by a qualified passenger are the stated mitigations.

Scenario 1: ISR, LINEX extraction

A small, special forces team at a distant operating location was able to make a low-profile capture of an important member of a wanted terrorist cell. The team has moved off some distance and desires a clandestine pick up of the subject, who does not appear to speak any languages the team can use to question him. An open area in a nearby valley has been selected as the extraction zone for the QS3 at 0300 local time. The team wants to continue its operations in the area without 'spooking' the locals, so a helicopter extraction is not possible. The QS3 is en route and will arrive in the vicinity at approximately 0230.

Approaching overhead, the aircraft crew will make radio and positive visual contact with the team prior to conducting a circular reconnaissance around the pick up site to help determine if a clandestine extraction by LINEX can be accomplished at 0300. Background noise from a river in the valley completely masks the NightHawk's very slight noise signature at 2,000 feet above ground level. In less than five minutes, the ground team captures the LINEX line end with attached restraint bag for the prisoner, places him inside and signals for the extraction. The circling aircraft climbs several hundred feet to lift the 'package' clear of any nearby obstacles. After a straight-line climb to 4,000 ft while winching up the prisoner and bringing him on board, the QS3's crew provides overwatch and reconnaissance for the SF team's movement to its daytime hide site.

Scenario 2: UAV-assisted Downed Airman Recovery

PART 1 - DEPLOYMENT

Several MQ-9 Reaper aircraft that are a lightly-, but defensively-armed, variant for unmanned SAR operations are deployed coincident with offensive air operations in sparsely populated terrain. In case of friendly aircraft failures or downing due to enemy action, the MQ-9 SAR birds are within easy distance and short ferry times of most ingress and egress routes used by US and coalition aircraft. Each MQ-9 is armed with several weapons capable of providing some protection to downed aircrew in case of intervention by small armed groups prior to or during a rescue lift. The Reaper's armament is also available to destroy the remnants of friendly aircraft once survivors are clear.

The SAR package on board the UAV includes several stock sensors and data transmission equipment in addition to a 'rescue pod' and the LINEX suite of components specifically engineered to permit the remotely-controlled rescue of an airman that is not seriously injured and has at least some mobility.

SCENARIO 2 - CONTINUED

Recovery and egress

On determining an aircraft has gone down and the crew has ejected and landed safely, two of the several available MQ-9 SAR aircraft are flown to the scene. One aircraft descends to 5,000 ft AGL in the immediate vicinity of the downed airman, while spooling out the LINEX recovery line package containing an aerodynamic rescue pod with incorporated parachute and an electronics package including comms and position sensors. Once ID validation and visual confirmation are complete, the Reaper descends further while circling to about 2,000-2,500 feet above ground level, making appropriate small adjustments in order to 'land' the rescue pod alongside the airman. Overwatch is provided by the second MQ-9 in a larger orbit several thousand feet above the first, unless and until it is needed elsewhere.

Comms with the downed airman via the rescue package electronics will assist in expeditiously preparing the airman for the lift and his incorporation into the rescue pod aboard the Reaper. When ready, the airman is lifted gently but quickly off the ground and clear of any obstacles in the immediate area. As little as ten minutes may have elapsed since the aircraft began orbiting the location of the downed airman. When the airman is well clear of all terrain and obstacles, the aircraft will cease circling and begin its egress to safety. Typically, the winching in of the aircrew will take approximately eight to ten minutes, and the aircraft will limit its airspeed to well below 100 knots (it may be as little as 70 knots) while continuing to climb to an appropriate altitude.

A relatively slow speed and level or climbing flight will be maintained until the airman has been brought up to and secured to the pod dock located on the belly of the aircraft. The pod accommodates the airman in a reclined position in an area that is climate controlled, lighted, comfortable and will allow him some movement and access to water and oxygen. Voice and video communications will be available to the rescued airman. The pod's incorporated parachute, oxygen and communications will remain functional even in the event of a life-threatening emergency aboard the Reaper during which the pod must be jettisoned.

Once the pod is secured to the Reaper's belly station, the aircraft will increase speed and climb to appropriate altitudes and continue the egress plan to the nearest safe facility. If the MQ-9 has any difficulty or is rendered unflyable due to enemy action, the pod with the rescued airman may have to parachute to the ground. Otherwise, the aircraft will land at the receiving location and taxi to parking where the airman will be removed and taken to medical facilities per SOP. The second MQ-9 SAR aircraft will be reassigned depending on circumstances after its duties as overwatch or escort are no longer needed.

MQ-9 Reaper maximum flight endurance is 14 hours. These SAR operations can occur in darkness and in time of low or no visibility provided winds and turbulence are not significant relative to safe operation of the UAV or the LINEX equipment.

Scenario 3: Firefight resupply, ISR, LINEX, medevac

A QS3 NightHawk is performing night reconnaissance duties in the vicinity and is called to assist in supporting friendly troops in an extended firefight at a secluded outpost. The besieged unit is running low on small arms ammunition. The NightHawk proceeds to the nearest support base where ammunition is available and being prepared for transport. The aircraft's crew use the LINEX system to hoist the 300-pound munitions package up and into the airplane while circling the support base at 1500' to 3000'AGL. They then proceed to the location of the firefight and lower the package to the ground within the confines of the base. The NightHawk then climbs up to 3000 feet to assist with surveillance of enemy forces. After locating the main force and coordinating with friendlies, the NightHawk crew drops a firefight simulator behind the enemy's position, purposely adding to the confusion of battle, while a small team from the base maneuvers for advantage to nearby open high ground. The enemy soon disengages and moves away, infiltrating back into a local village. The QS3 observes and records all, including hide sites for weapons near the village, as well as specific houses where enemy combatants appear to reside. Finally, a wounded friendly who received initial treatment at the outpost is lifted by LINEX in a 'medevac bag' up to the circling aircraft and delivered to an ambulance crew on the flight line of a major airport 200 nautical miles away, one hour and thirty minutes after extraction.

Scenario 4: Sensor emplacement via LINEX

A new and growing camp of suspected AQ is being built up in Pakistan near the border of Afghanistan. Entities within the US Government want to emplace a sensor on a nearby mountainside to monitor signals from the camp. An aerial drop won't work due to unpredictable winds and the chances of compromising the site. Clandestine emplacement via ground infiltration by special forces is not allowed by USG territorial integrity agreements with the Government of Pakistan. A QS3 NightHawk can accomplish the mission in one of two ways:

- **Technician delivery:** Lower a technician with the package on the end of a LINEX line to the hillside and allow him to emplace, conceal and test the sensor package without ever unhooking from his harness and line. When reception is confirmed within minutes via SATCOM, the technician is extracted and winched back aboard.
- **Package-only delivery:** Lower the sensor package to the mountainside and confirm satisfactory emplacement (with EO/IR gimbal) and functioning (from receiving stations) prior to remote release from the LINEX cable. When testing is complete, the NightHawk climbs silently away and reels in the line.

Scenario 5: Dipping Sonar via LINEX

Well-funded cocaine trafficking cartels began using small, purpose-built submarines to carry up to ten-ton loads from South America to Central America and Mexico for onward shipment to the United States. More than one-third of all cocaine and other serious drugs reaching the US is believed to be transported over at least part of its journey by semi-submersibles or submarines.

From Der Spiegel: The Colombian drug mafia has had hundreds of similar boats built in the last few years. The police have only managed to capture 53 of them, 20 in the last year alone. It costs about \$500,000 to build a submersible, but the market value of the cargo can be more than 100 times that. The drug smugglers often sink their boats once delivery has been made.

SCENARIO 5 - CONTINUED

Counter-trafficking sonar operations

A LINEX-equipped NightHawk was deployed to the source region to conduct dipping sonar operations inshore and offshore up to 500 miles. Based on limited intelligence and a thorough study of the cartels' likely submarine employment operations, the NightHawk spent several weeks of intense sonar surveillance along the Colombian coast without being detected. During the study period, the operation developed significant new intelligence related to sonar signatures, routes, sailing techniques, sources, communications, construction locations, drug delivery mechanisms and disposition of the vessels.



Captured semi-submersible - reference image from source document.



Transport routes of the drug submarines (Der Spiegel, via source document).

NIGHTHAWK PERFORMANCE CITED IN SCENARIO 5

The NightHawk has a low-power (85-95 knots) unrefueled range of nearly 2,500 nautical miles on its 118-gallon internal tank with endurance of 25 hours. A cruise speed of 160+ knots is possible for more than 12 hours, resulting in a 2,000 nautical mile 'dash' range. It can loiter and conduct LINEX sonar operations at 75 knots at 16 locations, each 30 nautical miles apart, over an eight-hour period.

Program conversation

NightHawk Aircraft LLC, Wilmington, Delaware, can discuss LINEX integration concepts, platform compatibility and mission-driven development priorities. Platform integration and operational approval are aircraft- and mission-specific.

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