

INNOVATORS OF AVIATION TECHNOLOGY

EXECUTIVE OVERVIEW

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METRO AEROSPACE OVERVIEW

WHO WE ARE

USA based -> delivers certified high-performance additively manufactured structural components for aerospace

Holds the perpetual exclusive license to globally manufacture Microvanes™

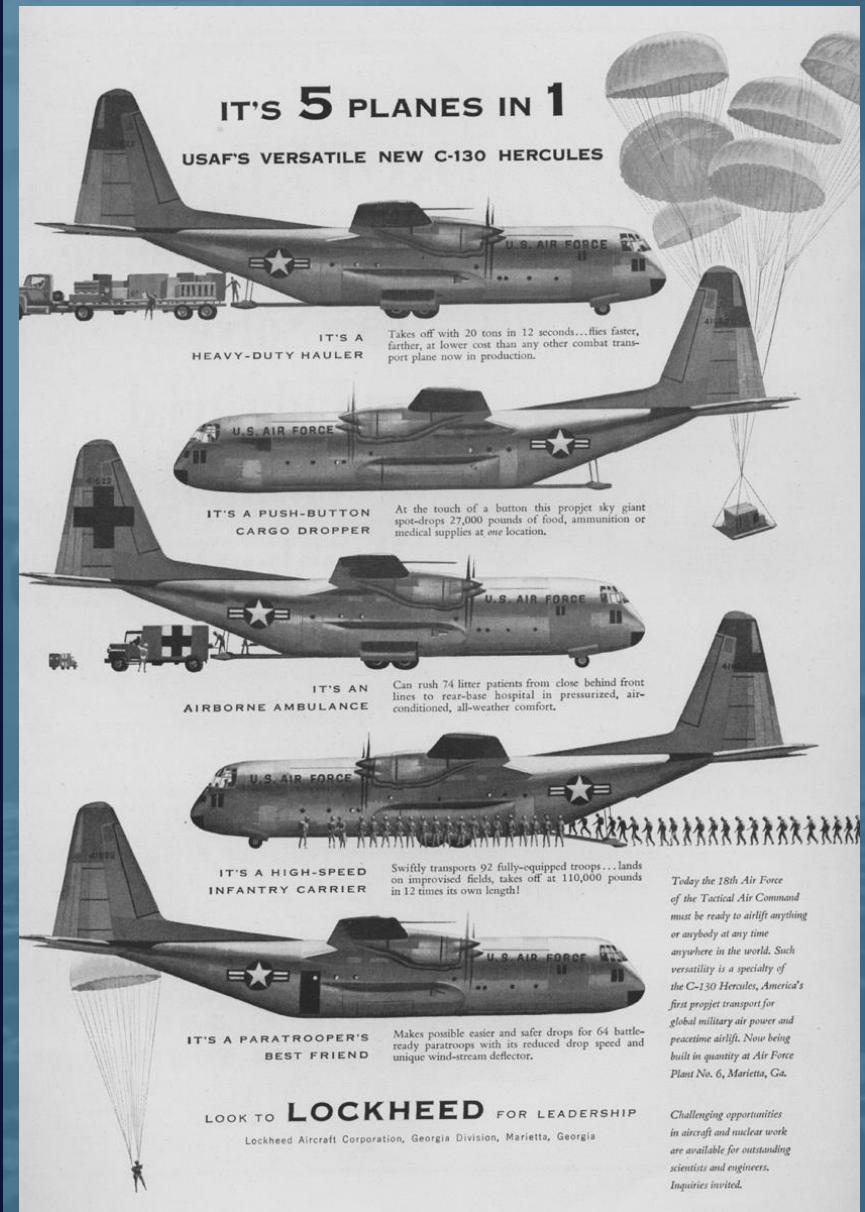
Microvanes bring performance enhancement and cost reduction to both military and commercial large rear cargo door aircraft



AVIATION FACES **THE CHALLENGE** TO REDUCE COST AND HARMFUL CO2 EMISSIONS

All while sustaining existing
fleets, some developed
over 60 years ago...

***The solution is easier
and more cost-effective
than imagined.***



IT'S 5 PLANES IN 1
USAF'S VERSATILE NEW C-130 HERCULES

IT'S A HEAVY-DUTY HAULER
Takes off with 20 tons in 12 seconds...flies faster, farther, at lower cost than any other combat transport plane now in production.

IT'S A PUSH-BUTTON CARGO DROPPER
At the touch of a button this project sky giant spot-drops 27,000 pounds of food, ammunition or medical supplies at one location.

IT'S AN AIRBORNE AMBULANCE
Can rush 74 litter patients from close behind front lines to rear-base hospital in pressurized, air-conditioned, all-weather comfort.

IT'S A HIGH-SPEED INFANTRY CARRIER
Swiftly transports 92 fully-equipped troops...lands on improvised fields, takes off at 110,000 pounds in 12 times its own length!

IT'S A PARATROOPER'S BEST FRIEND
Makes possible easier and safer drops for 64 battle-ready paratroopers with its reduced drop speed and unique wind-stream deflector.

LOOK TO LOCKHEED FOR LEADERSHIP
Lockheed Aircraft Corporation, Georgia Division, Marietta, Georgia

Today the 18th Air Force of the Tactical Air Command must be ready to airlift anything or anybody at any time anywhere in the world. Such versatility is a specialty of the C-130 Hercules, America's first project transport for global military air power and peacetime airlift. Now being built in quantity at Air Force Plant No. 6, Marietta, Ga.

Challenging opportunities in aircraft and nuclear work are available for outstanding scientists and engineers. Inquiries invited.

Lockheed Martin C-130 advertisement circa 1955



INITIAL FOCUS: CARGO AND AERIAL REFUELERS

Large airframes with cargo ramps create a significant amount of drag due to the abrupt change in airflow from the sides to the ramp/door and steep aft tail section.



THE SOLUTION: MICROVANE TECHNOLOGY



Reduces C-130 fuel consumption 3%-6%

Microvanes are strategically surface-mounted on the aft body to reshape tail section airflow.

These small changes in redirection minimize drag; thereby, reducing fuel consumption, carbon emissions and engine wear.

ANNUALLY:
Microvanes reduce USA's fuel cost by \$63m and reduce CO2 emissions by 441m pounds... if installed on the C-130, C-17 and KC-135 fleets.



What are Microvanes?

Microvanes are small aerodynamic components that reshape the air flow around the aft cargo door, reducing the total drag on the aircraft, and in turn reducing fuel and thrust requirements.



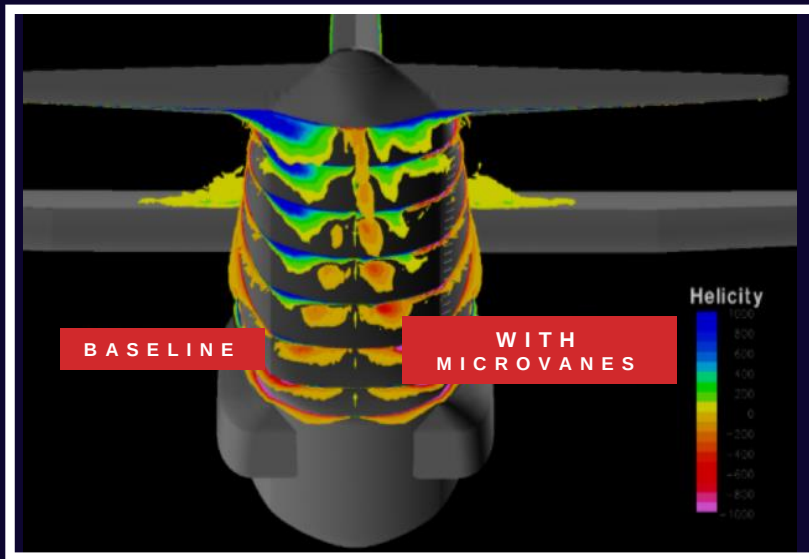
- Extremely lightweight, non-corrosive, polymer materials
- Engineered & proven not to interfere with cargo air drop or Para troop operations
- Easy to handle and install, strong yet flexible
- Engineered to last the lifetime of the aircraft – durable material
- Tested over **10 years** with USAF & US Coast Guard



PROVEN EFFECTIVE, TESTED FOR SAFETY

Extensive aerodynamic performance tests and conditions were evaluated with a focus on safety, drag reduction, optimization, and handling.

Less Blue = Less Drag



Approximately 300 CFDs generated
for drag reduction and handling
validation

- ✓ Range of flight conditions:
 - climb, cruise, descent, airdrop, traffic/approach...
 - wide range of weights, speeds and altitudes
- ✓ Propeller effects
- ✓ Stability and control impact
- ✓ Air drop and paratroop testing
- ✓ Material and adhesive testing
- ✓ Aerodynamic loads and structural analysis
- ✓ System safety assessment developed for flight handling (FHA)



Microvanes have been designed, tested and proven



- ✓ Reduce fuel consumption by 3-6%
- ✓ Reduce CO2 emissions
- ✓ Reduce engine wear with lower TIT
- ✓ Extend time on mission
- ✓ Increase range
- ✓ Increase payload capability
- ✓ Reduce refuelling
- ✓ Get on target faster w/o using additional fuel



No negative effect on aircraft handling or flight envelope characteristics

Easy to install with 1-2 days aircraft downtime

No maintenance required after installation

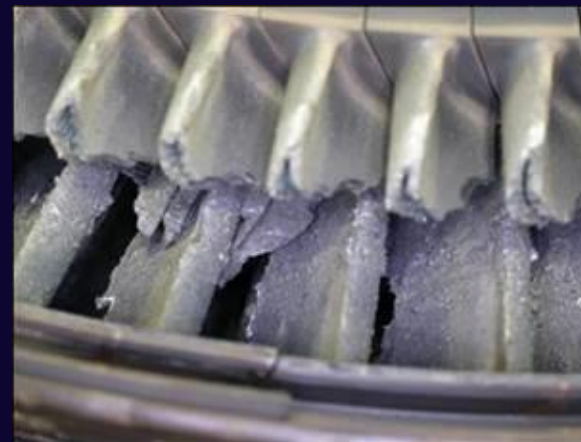
Pay back in a very short period



Engine Benefits

Drag reduction allows aircraft airspeed performance to be maintained at lower TIT settings.

Operating at lower TIT slows down the thermal damage to Hot-Section Turbine components, prolonging the operational life of the engine.



Reduced Temperature Cruise Savings

T56-A15, -16 / 501-D22A Lowering TIT from 1010° to

970°C Reduces fuel consumption 4%, reduces sulfidation factor 200%, increases thermocouple life, adds 3 minutes per flight hour.

*** 932°C** Reduces fuel consumption 8%, reduces sulfidation factor 400%, increases thermocouple life, adds 6 minutes per flight hour.

T56-A7B/501-D22 Lowering TIT from 932°C to

*** 850°C** Reduces fuel consumption 8%, reduces sulfidation factor 400%, increases thermocouple life, adds 6 minutes per flight hour.

*** Recommended for Cruise**

When operation of the aircraft can be accomplished with a lower TIT, the life of the turbine section is greatly increased.

...up to 20% reduction in hot section component wear



REDUCING FUEL CONSUMPTION AND CARBON EMISSIONS ON A GLOBAL SCALE



Example Fuel Savings

C130 Fuel Savings Calculation with Microvanes			
T-56 Engine Burns pounds per hour (4 engines):	1,494	5,976	Pounds
Gallons of Fuel Per hour Burned:	223	892	Gallons
6 Hour Flight will Burn:		35,858	Pounds
6 Hour Flight will Burn:		5,352	Gallons
Flight Hours Per Year/Per Aircraft:	500		
Total Fuel Used Per Year/Per Aircraft:		2,988,200	Pounds
Total Fuel Used Per Year/Per Aircraft:		446,000	Gallons
Microvane Fuel Savings Estimate Per Year/Per Aircraft:	4.0%	119,528	Pounds
Microvane Fuel Savings Estimate Per Year/Per Aircraft:	4.0%	17,840	Gallons
Fuel Cost Per Gallon	\$5.00		
Fuel Savings Per Year/Per Aircraft	\$89,200		
Extra Time on Station for 6 hour Flight (minutes)	14		
Extra Time on Station for 1 year (minutes)	1,200		
Extra Time on Station for 1 year (hours)	20.0		
Extra Range for 6 hour Flight (nautical miles)	87		
Extra Range for 1 year (nautical miles)	7,240		
Carbon Emissions Saved for 1 year (pounds)	374,640		
Carbon Emissions Saved (Percentage)	4.0%		
Total Annual Fleet Fuel Savings	\$1,070,400	12	Fleet Aircraft
Total fuel savings over # years with total a/c	\$5,352,000	5	Number of years in Service

*RAND Report 'Fuel Reduction for the Mobility Air Forces': "install Microvanes if total retrofit cost is less than \$618,000 per aircraft."

https://www.rand.org/content/dam/rand/pubs/research_reports/RR700/RR757z1/RAND_RR757z1.pdf



DOCUMENTED RESULTS

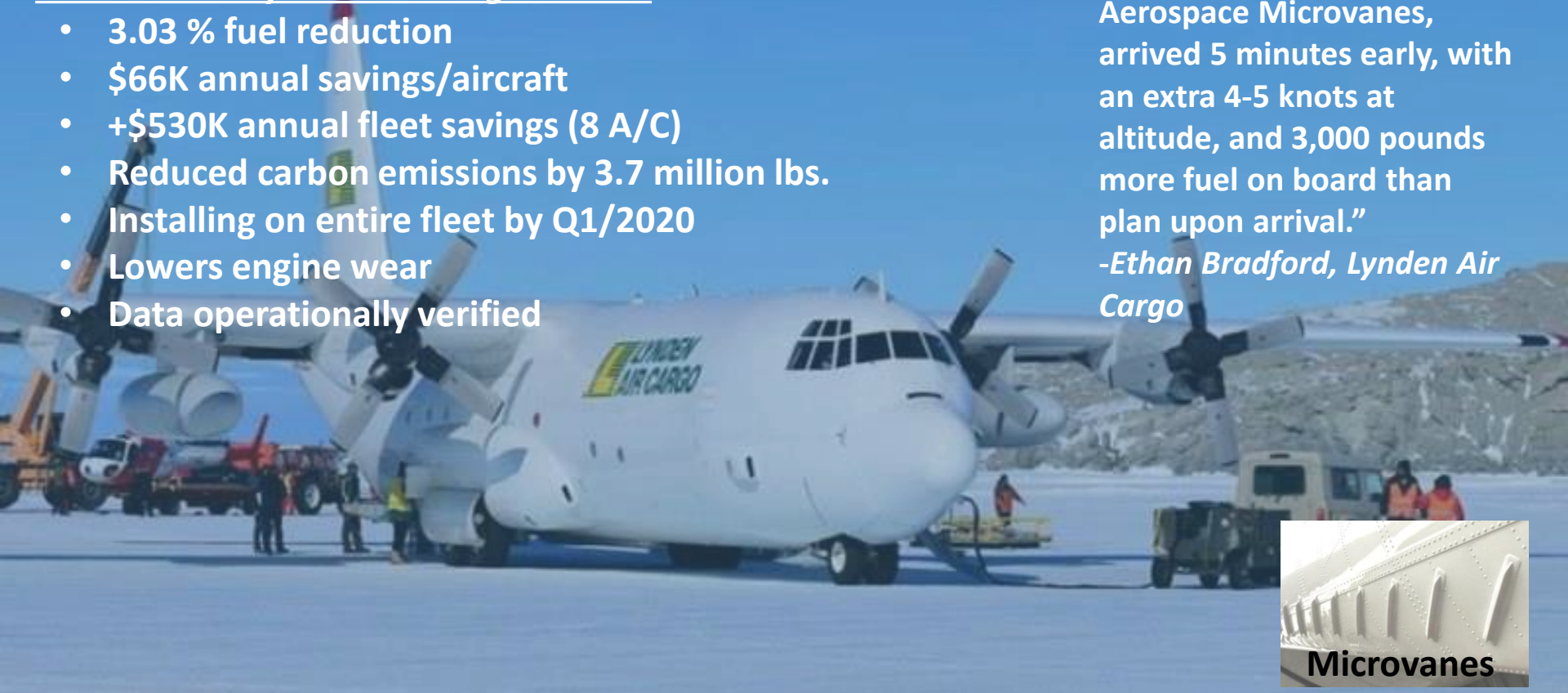


Documented Lynden Air Cargo Results

- 3.03 % fuel reduction
- \$66K annual savings/aircraft
- +\$530K annual fleet savings (8 A/C)
- Reduced carbon emissions by 3.7 million lbs.
- Installing on entire fleet by Q1/2020
- Lowers engine wear
- Data operationally verified

“The first flight since installation of Metro Aerospace Microvanes, arrived 5 minutes early, with an extra 4-5 knots at altitude, and 3,000 pounds more fuel on board than plan upon arrival.”

-Ethan Bradford, Lynden Air Cargo



Microvanes



US Coast Guard Test Aircraft

Installed on a C-130J Coast Guard aircraft in **2013**; no disbonds or Microvane failures have occurred. In 2018 the USCG stripped and repainted this aircraft without removing Microvanes as they are engineered to remain on the aircraft for the lifetime of service.



Engineered to last the lifetime of the aircraft.



PROVEN SUCCESS

GLOBAL PRESENCE

Microvanes are currently being utilized by military units and commercial operators around the world, operating in and out of 5 continents.

CERTIFIED

AS9100D with ISO9001:2015 manufacturing quality certifications

FAA Supplemental Type Certificate (STC) approval for L-100

Operational/certified on C-130J, C-130B-H, L-100, and C-17

INDUSTRY RECOGNITION

2018 Laureate Award Winner for Defense, Supplier Innovation

Featured in:

- Aviation Week
- MSC
- Forbes
- AdvancedManufacturing.org
- Dover.af.mil/News
- Robins.af.mil/News
- Rand Corporation



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