Freewing

Briefing Slides

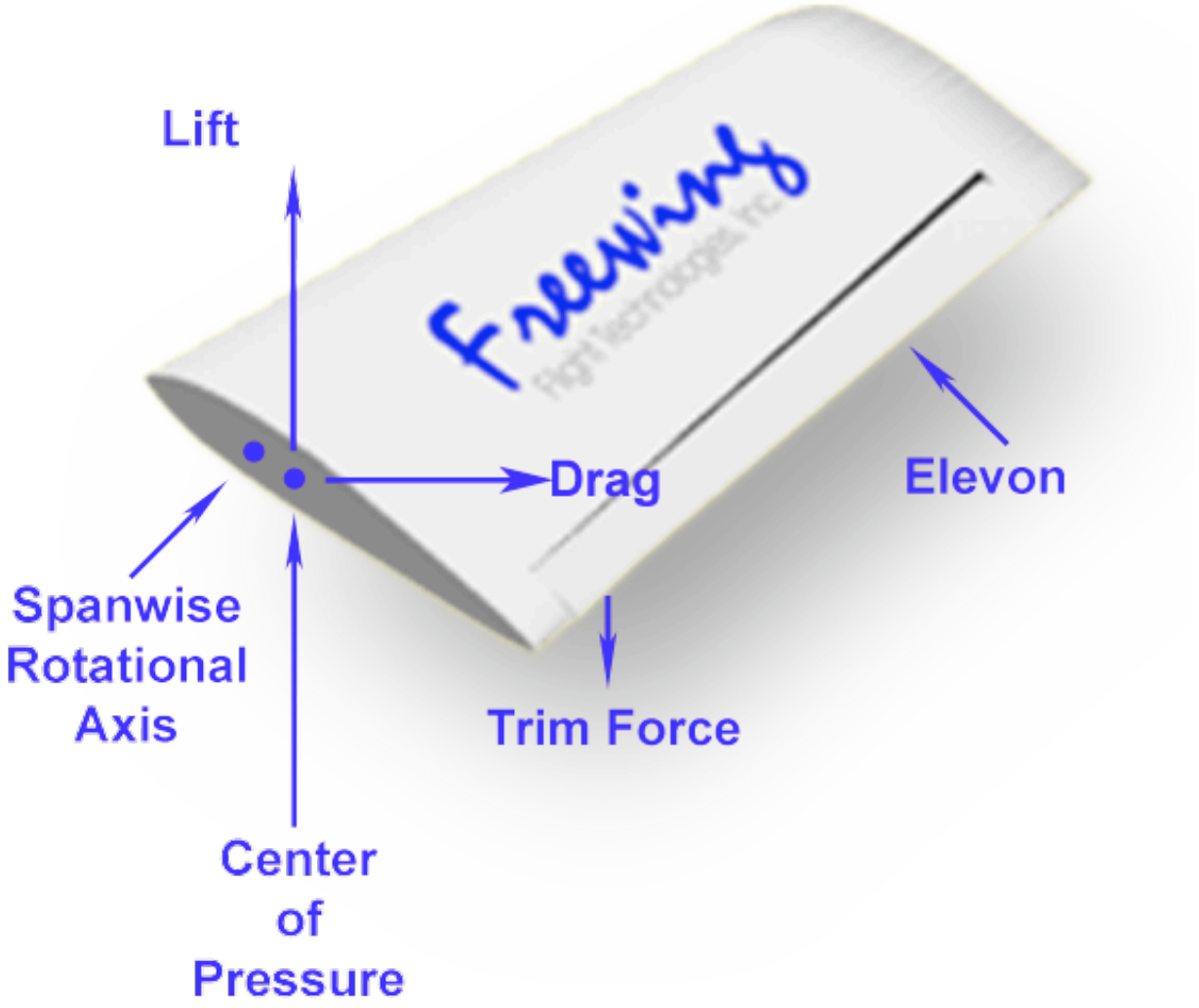
(use the controller on the bottom of this frame to control the briefing)

Note that start of presentation may be delayed while file downloads. Please be patient.

HOW A FREEWING WORKS

- **Hinged along a span-wise axis**
- **Floats freely in pitch**
- **Blends with changes in relative wind**
- **Simple, passive system -- based on "new" aerodynamic principles**

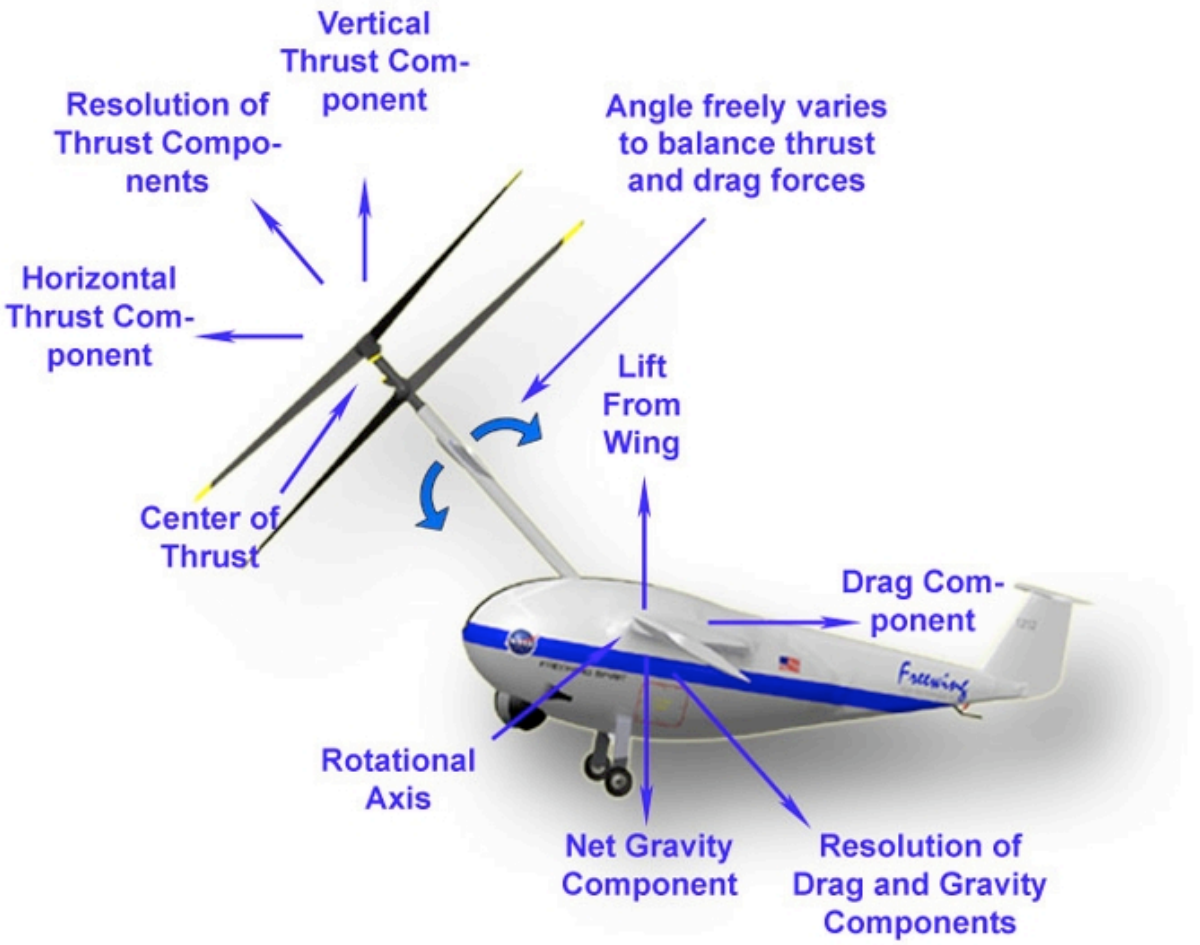
FREEWING CROSS SECTION



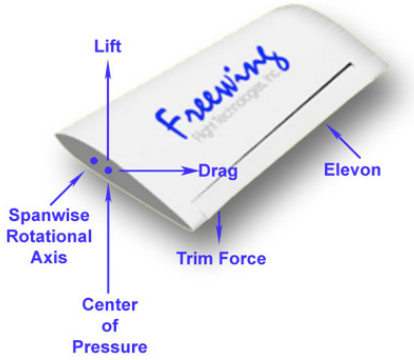
HOW A FREE LEVER WORKS

- **Thrust and Drag Forces act upon each end of the lever**
- **Pivots freely to balance forces**
- **Gravity/Drag Pendulums interact**
- **Simple, inherently stable system**

FREELEVER CROSS SECTION



Spirit technology is a Double Invention



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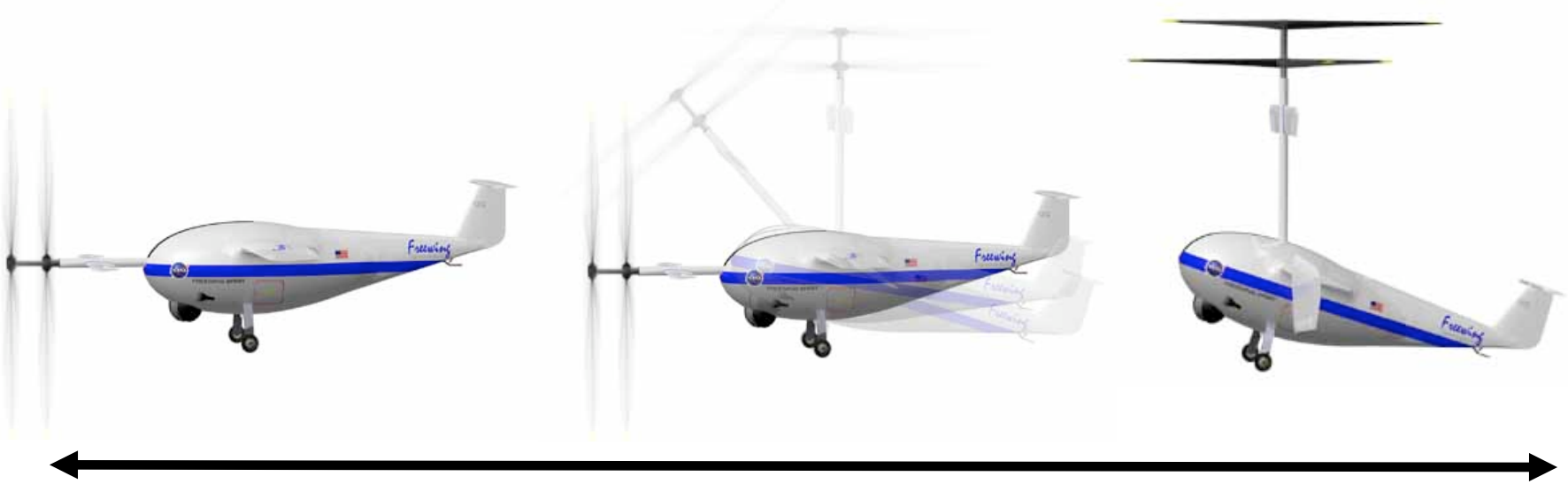
Spirit

Easy Transitions with Spirit



Freewings and boom self-adjust throughout transition :

- **Automatically**
- **Passively**
- **Neutralizing turbulence throughout process**

The Spirit UAV
Model 20-200

Freewing
Flight Technologies, Inc.

Maximum Speed @ Sea Level : 120 mph, 104 kts
Maximum Speed @ 15,000 ft : 145 mph, 126 knots
Optimum Loiter Speed : 75 mph, 65 kts
Maximum Endurance: 5.6 hours
Service Ceiling : 20,000 ft
Max Climb @ Sea Level : 3,680 fpm
Powerplant : Aerrow A200B (20 hp)
Fuselage Height : 26 in
Fuselage Length : 84 in
Overall Height (Boom Up) : 76 in
Overall Length (Boom Down) : 113 in
Wingspan : 96 in
System Weights
- Empty Weight : 100.8 lbs
- Flight Control Electronics : 10 lbs
- Gross Weight : 150 lbs

Rotor Diameter : 6 ft
Disc Swept Area : 28.3 ft²
Rotor Blade Composition : Carbon Fiber
Rotor RPM : Up to 1500 (5.4 gear ratio)
Fuel Type : Avgas (heavy fuel planned)
Fuel Consumption : 2.3 gph @ 100% power
0.9 gph @ 20% power

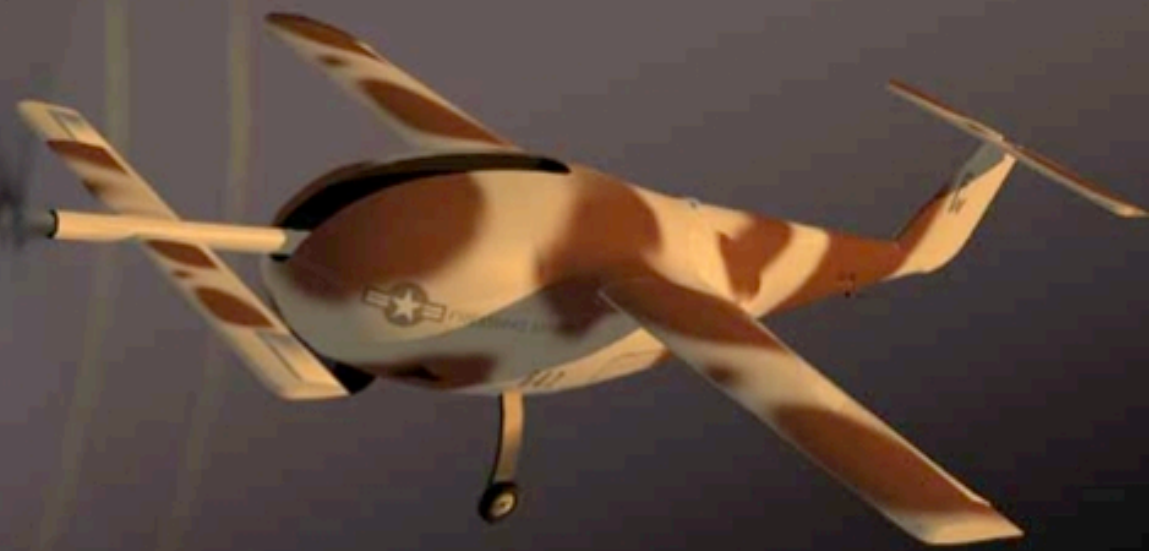
Fuel Payload (gals/lbs.)	Endurance (hours)	Mission Payload (lbs.)
5.0/30.5	5.6	18.7
3.5/21.4	3.9	27.9
2.0/12.2	2.2	37.0

The Spirit UAV
Model 100-800

Freewing
Flight Technologies, Inc.

Maximum Speed @ Sea Level : 160 mph, 139 kts
Maximum Speed @ 15,000 ft : 200 mph, 174 kts
Optimum Loiter Speed : 75 mph, 65 kts
Maximum Endurance: 15 hours
Service Ceiling : 25,000 ft
Max Climb @ Sea Level : 4,300 fpm
Powerplant : Rotax 912 ULS (100 hp)
Fuselage Height : 4.3 ft
Fuselage Length : 14.1 ft
Overall Height (Boom Up) : 10.8 ft
Overall Length (Boom Down) : 17.5 ft
Wingspan : 15. ft
System Weights
- Empty Weight : 497 lbs
- Flight Control Electronics : 20 lbs
- Gross Weight : 750 lbs

Rotor Diameter : 13 ft
Disc Swept Area : 132.7 ft²
Rotor Blade : Carbon fiber, variable pitch
Rotor RPM : Up to 800 (7.25 gear ratio)
Fuel Type : Avgas (heavy fuel planned)
Fuel Consumption : 7 gph @ 100% power
2 gph @ 50% power



Fuel Payload (gals/lbs.)	Endurance (hours)	Mission Payload (lbs.)
30.0/183.0	15.0	70.0
10.0/61.0	5.0	192.0
5.0/30.5	2.5	222.5

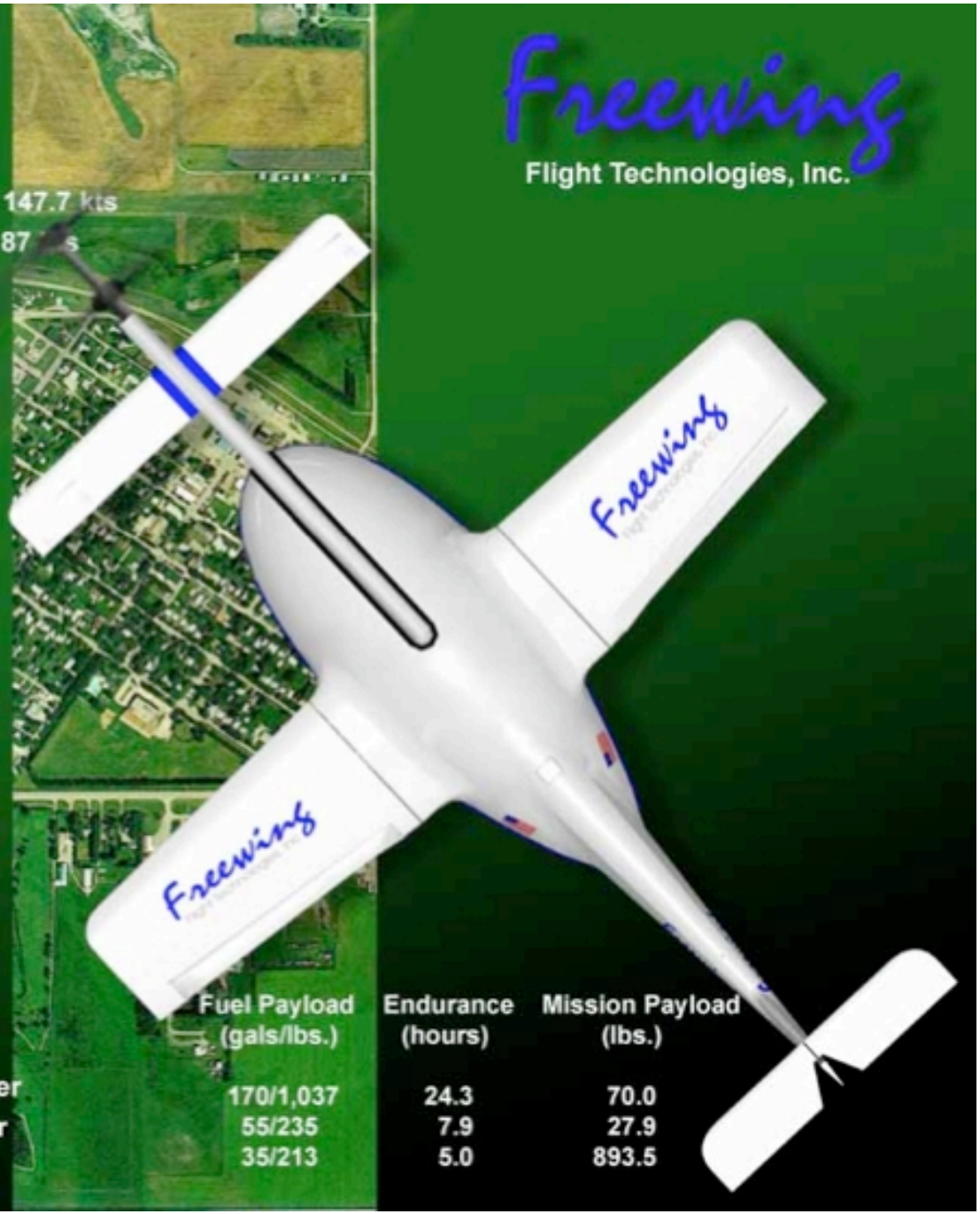
The Spirit UAV

Model 400-3000

Freewing

Flight Technologies, Inc.

Maximum Speed @ Sea Level : 170 mph, 147.7 kts
Maximum Speed @ 15,000 ft : 215 mph, 187 kts
Optimum Loiter Speed : 80 mph, 69 kts
Maximum Endurance: 24.3 hours
Service Ceiling : 25,000 ft
Max Climb @ Sea Level : 4,700 fpm
Powerplant : Two Lycoming IO360
(200 HP each)
Fuselage Height : 8 ft
Fuselage Length : 25 ft
Overall Height (Boom Up) : 20 ft
Overall Length (Boom Down) : 35 ft
Wingspan : 30 ft
System Weights
Empty Weight : 1,928 lbs
Flight Control Electronics : 20 lbs
Gross Weight : 3,035 lbs
Rotor Diameter : 26 ft
Disc Swept Area : 530.9 ft^2
Rotor Blade : Carbon fiber, variable pitch
Rotor RPM : Up to 400 (6.875 gear ratio)
Fuel Type : Avgas (heavy fuel planned)
Fuel Consumption : 29 gph @ 100% power
7 gph @ 35% power



Fuel Payload (gals/lbs.)	Endurance (hours)	Mission Payload (lbs.)
170/1,037	24.3	70.0
55/235	7.9	27.9
35/213	5.0	893.5

Common Avionics Suite

Special Features:

- Software-driven generic design
- Real-time in-flight control loop tuning
- Light weight & miniature design
- Low cost
- High MTBF
- Full sensor package
- Full peripheral capability
- INS / GPS inside

Portable Version of MCS

Airborne MIAS Functions:

Typically, in the UAV role, the MIAS performs the following functions:

Flight control and stabilization.

Navigation and Mission Control.

Payload / warhead control

Datalink management.

System logic.

Vehicle system monitoring and BIT.

External access for tuning.

Ground control station

Typically, in the UAV role, the ground part of MIAS performs the following functions:

Real time controller for datalink and MCS management

UAV flight control and management

Pilot machine interface

Payload control and observation

Mission planning on a digital map

Special manus for UAV calibration and autopilot tuning

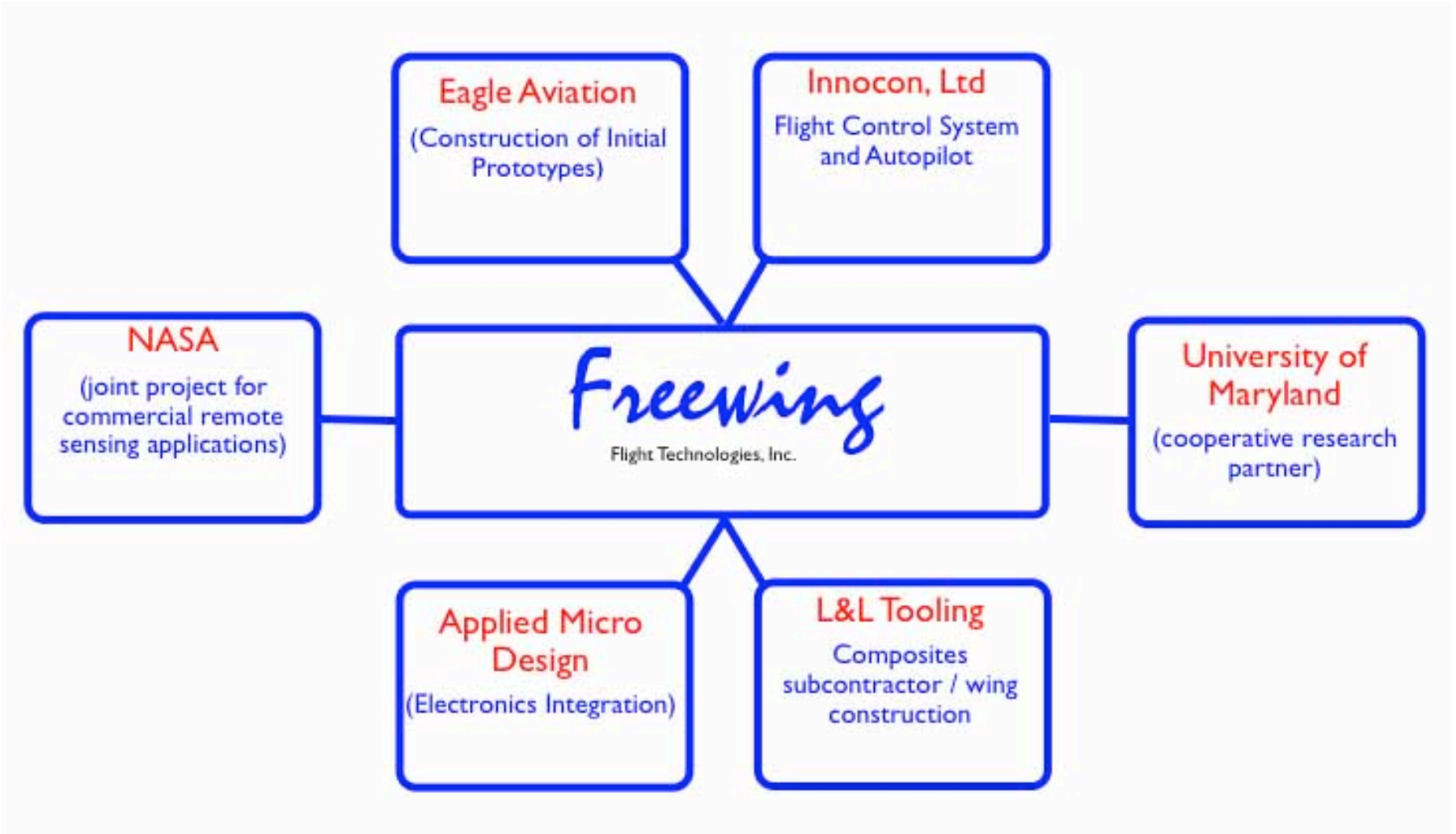
Flight recording and playback

Data link and directional antenna tracking management

Spirit v. Tilt-Rotor

- Wing structure- lighter, simpler
  - No mechanical mechanisms to induce movement
- Vertical to Horizontal Thrust transition much simpler
  - No gearboxes to force transition
- Inherently Stable in all Flight Modes
- More fuel-efficient due to "reverse snowball" effect in design; Payload/Range expanded
- Increased safety: fewer moving parts = reduced likelihood of catastrophic failure

TEAMING PARTNERS



Developed in a predecessor company

1983 - 1992

1992 - 1999

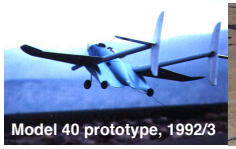
Freewing

Manned Freewings

Freebird MK-1, 1983-5

Freebird MK-2, 1989

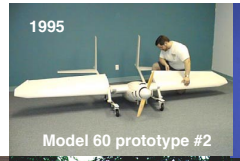
Early Freewing Thrust-Vectored Prototypes

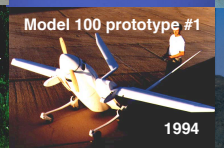


Scorpion Configuration

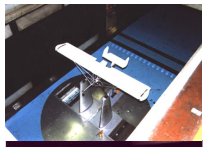
Freewing Thrust-Vectored Air Vehicles

(near-VTOL)





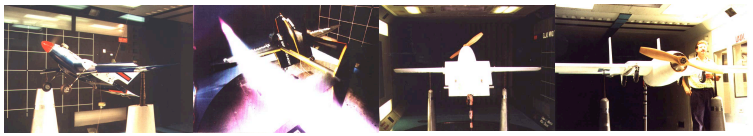
Wind Tunnel Models



Manta Configuration

Freewing Thrust-Vectored Air Vehicles

(full-VTOL)



Freewing Wind Tunnel Models (570 hours - 1990-97)

Spirit Model 400

Payload: up to 890 lbs

Spirit Model 100

Payload: up to 220 lbs

Spirit Model 20

Payload: up to 20 lbs

Common Avionics

Advantages of Spirit Concept

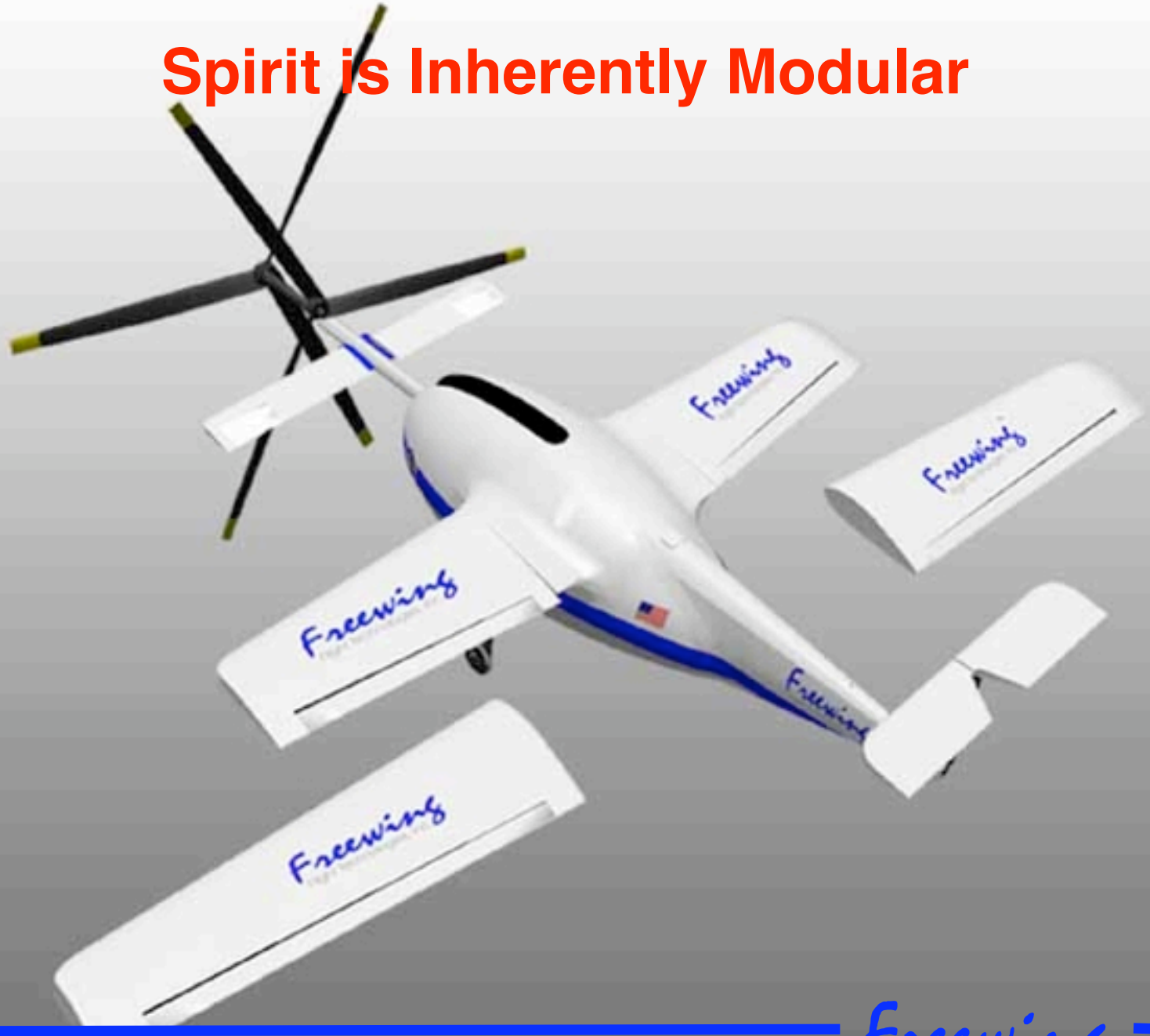
- Can fly at a hover or at dash speeds
- Or sustained at any speed in between
- Each possible speed is inherently stable
- Fuselage can be pointed independently of flight path
  - Allows gross sensor vectoring
    * Normal look-down sensor can also view forward
    * Increase in effective scan area of sensor

Advantages of Spirit Concept (cont.)

- **Expanded Mission Capability:**
  - **V/STOL performance and endurance of a fixed wing**
  - **System Flexibility:**
    - **Larger Flight Envelope**
    - **Inherent Stability**
    - **Increased Transportability**
    - **No External Launch & Recovery**

- **Spirit Freewing concept is inherently modular**

Spirit is Inherently Modular



OPPOSING THEORIES: CONVENTIONAL WING vs. FREEWING

- Angle of incidence - relation of wing to fuselage
- Angle of attack - relation of wing to relative wind

CONVENTIONAL WING :	FREEWING:
Angle of incidence is constant	Angle of incidence is variable
Angle of attack is variable	Angle of attack is constant

Advantages of Spirit Concept (cont.)

- Gust-induced vertical displacement from flight path on final approach is significantly reduced. Final approach is smoothed.

- Easy to transit through "burble" from ship superstructure

- No longer need to slow down in turbulent air; turbulence neutralization is so efficient V_{NE} occurs before V_{MO}

Advantages of Spirit Concept (cont.)

- Significantly more stable sensor platform = better image
  - Valuable trait for E/O sensor missions
  - Invaluable for target designation missions

- Airframe/system degradation from turbulence reduced

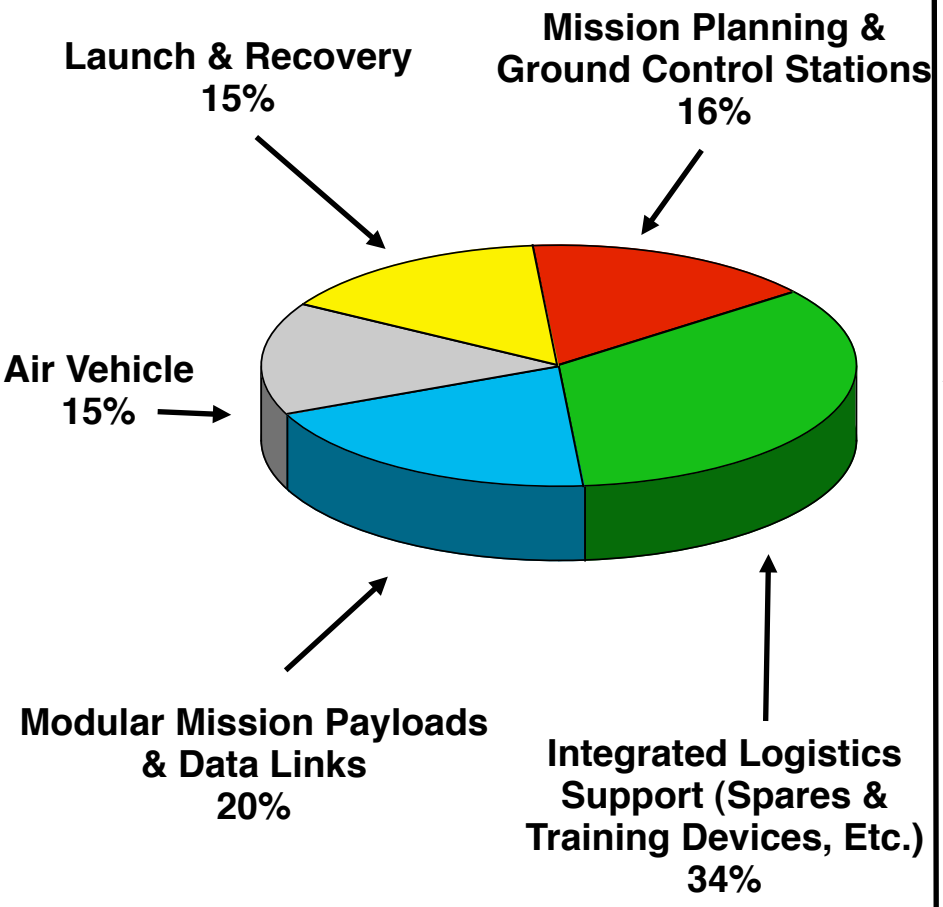
- Freewing insensitive to changes in fuselage dynamics (can survive loss of tail surfaces and continue mission)

Advantages of Spirit Concept (cont.)

- **Inherently Stall Proof, Spin Proof**

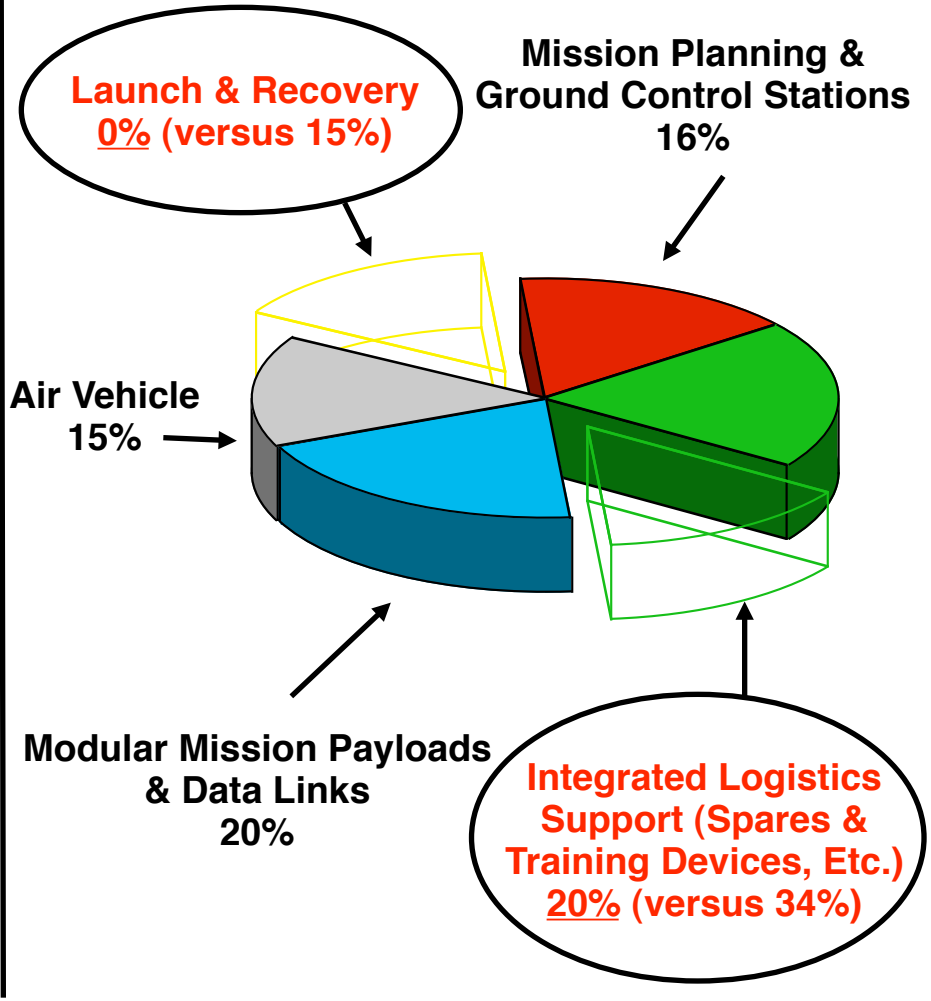
- **Up to 4-to-1 Reduction in Vertical Gust Sensitivity ("effective wing-loading" increased dramatically)**

UAV Program Cost Breakout *

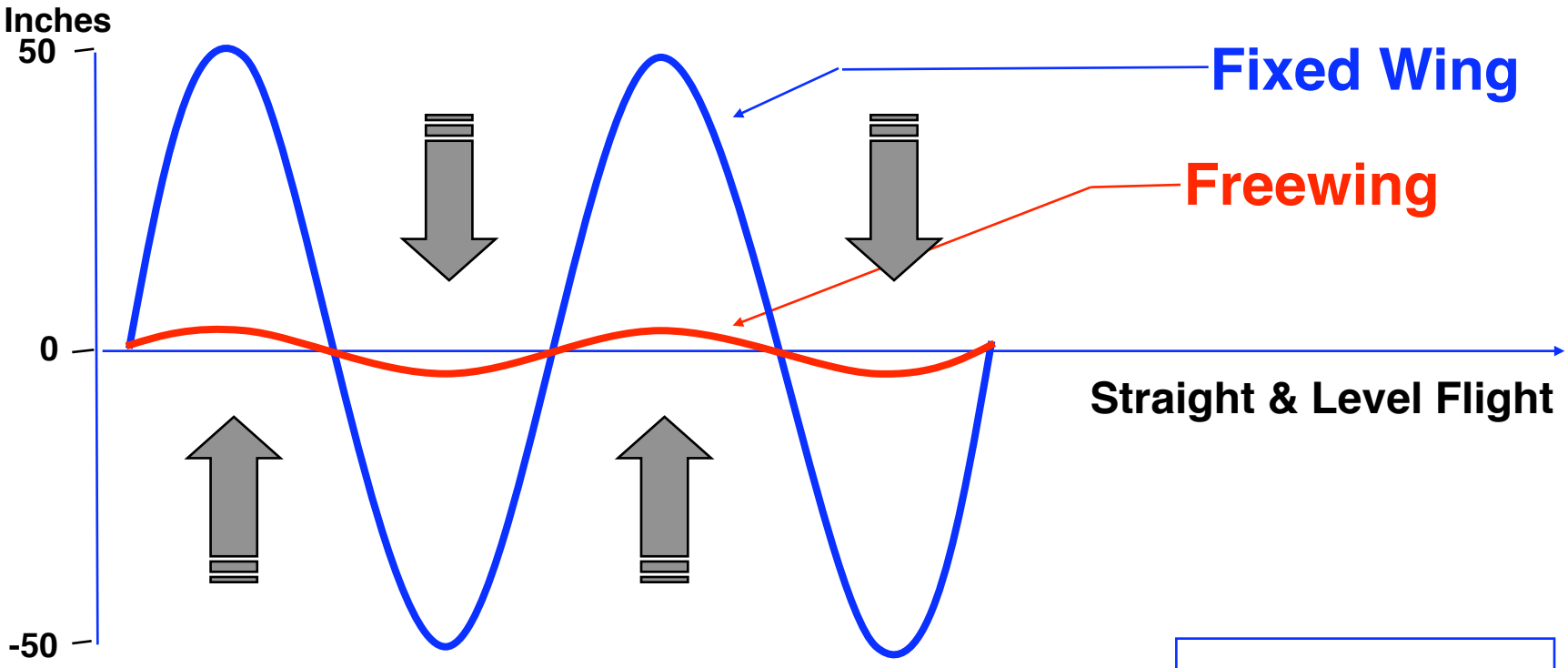


* Source: DoD UAV Joint Project Office 1993 Master Plan

Spirit Freewing Effect on UAV Program Costs

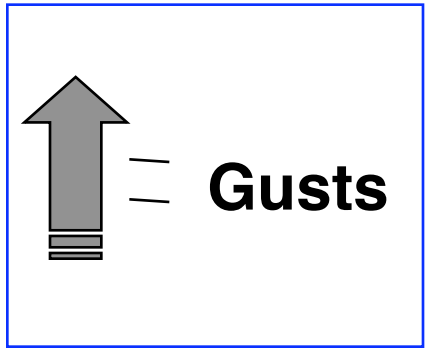


Relative displacement from flight path:

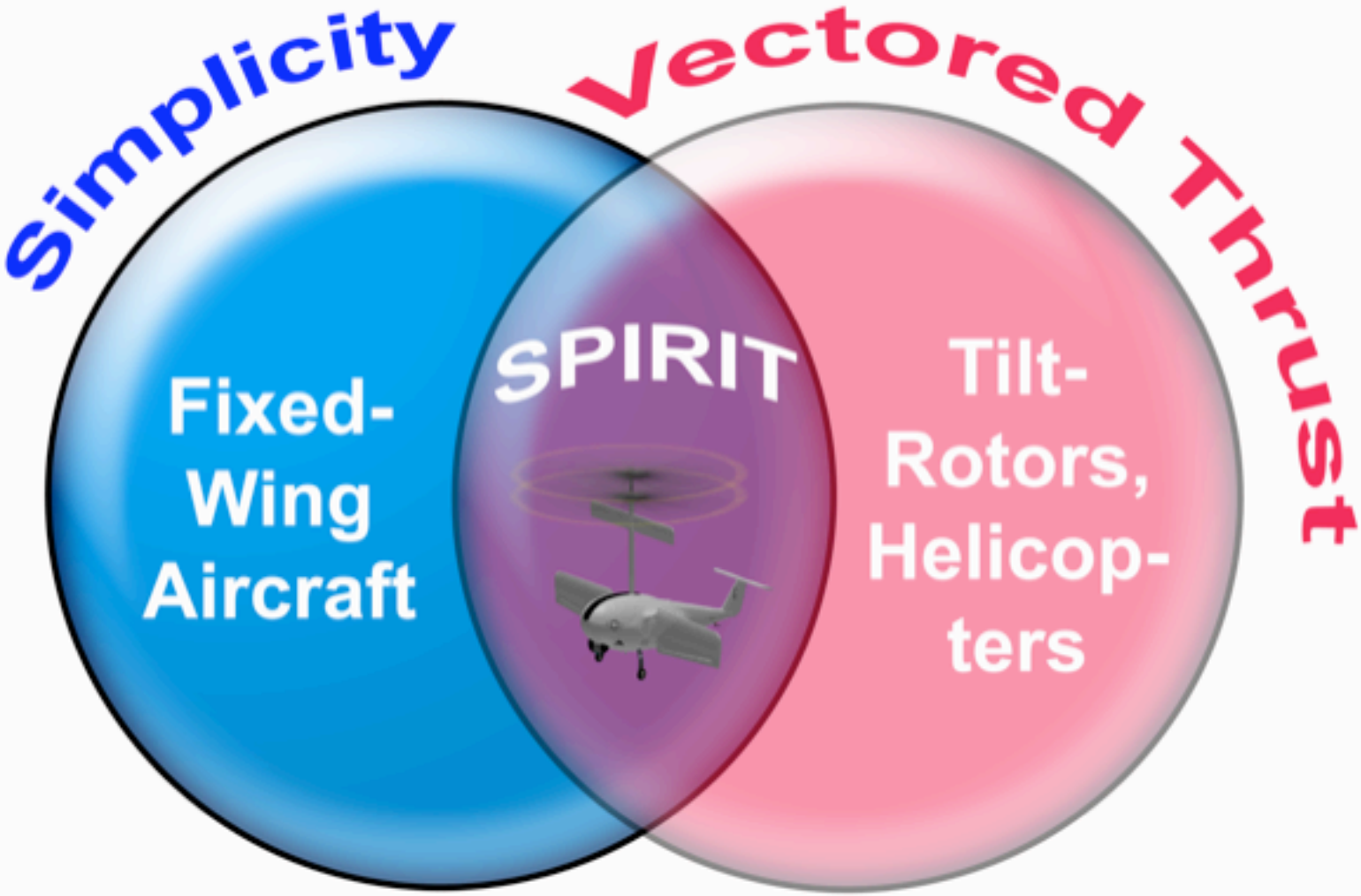


- "Displacement by turbulence is more than an order of magnitude less for the freewing case."

-- NASA CR-1513, Sept. 1970

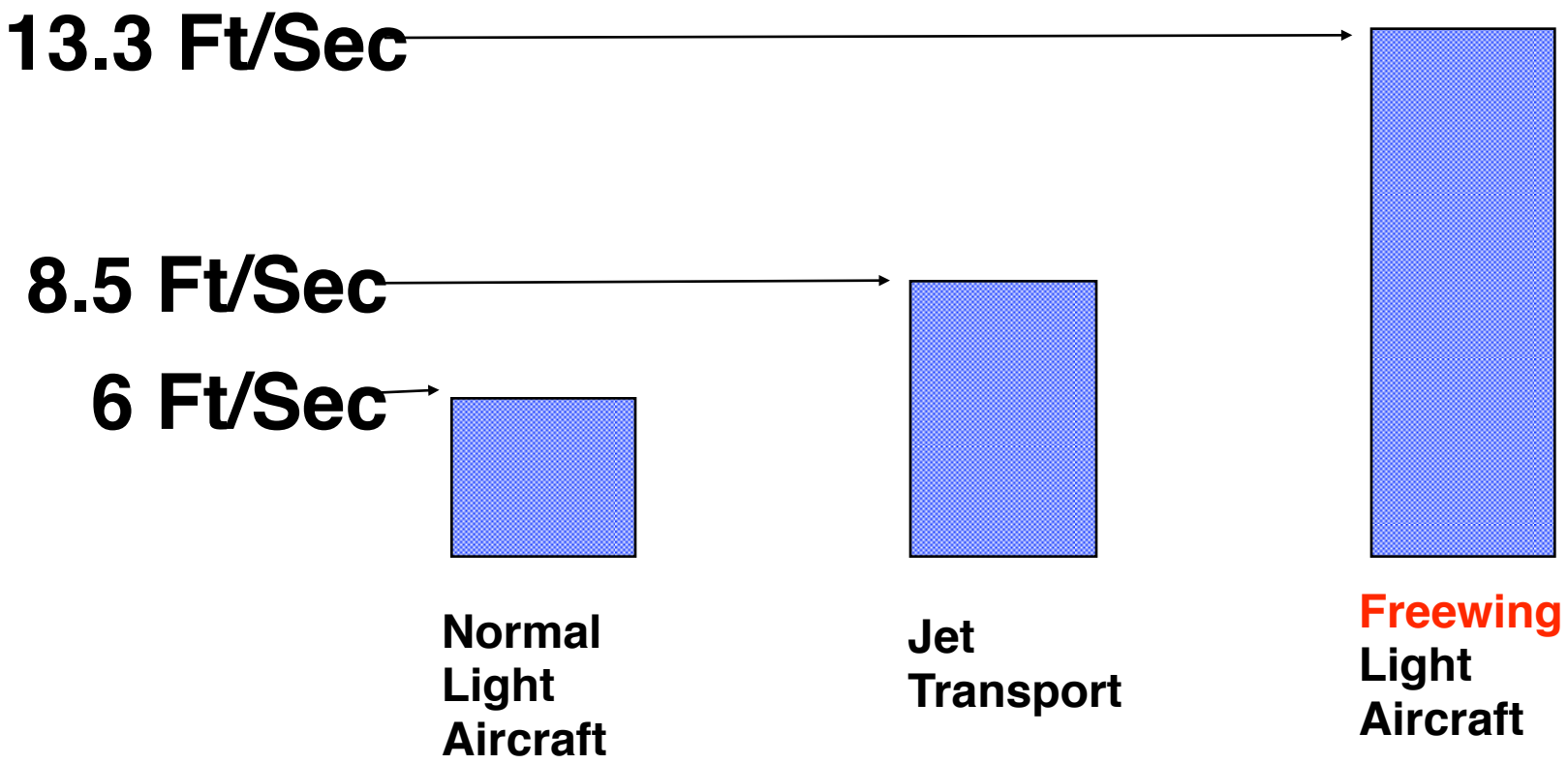


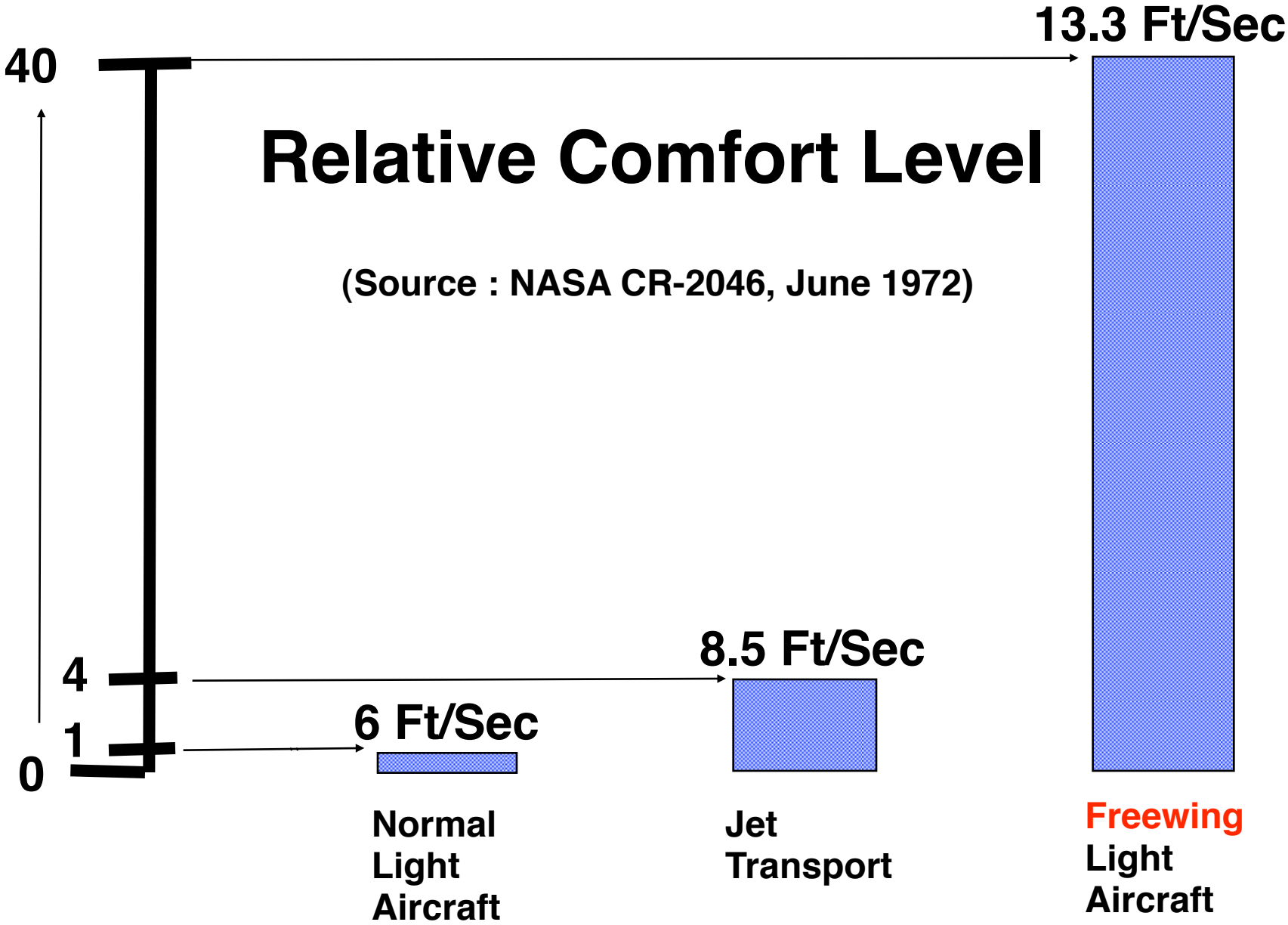
Unmatched Performance



GUST LEVEL REQUIRED TO EXCEED "COMFORT INDEX"

(Source : NASA CR-1523, April 1970)



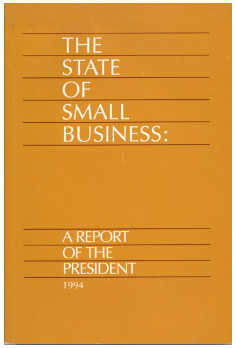

13.3 Ft/Sec
40
Relative Comfort Level
(Source : NASA CR-2046, June 1972)
8.5 Ft/Sec
4
6 Ft/Sec
1
0
Normal
Light
Aircraft
Jet
Transport
Freewing
Light
Aircraft

Honors & Technology Awards

Selected by the editors of *R&D Magazine* for their 1996 *R&D 100 Award* recognizing the 100 most technologically significant products developed over the past year.

FROST & SULLIVAN

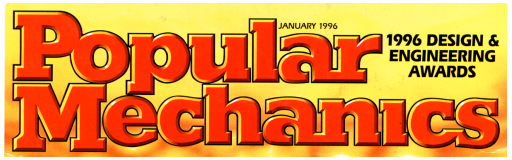
1998 Market Engineering Entrepreneurial Company Award, presented to Freewing by this preeminent int'l market analysis firm. *"This award is given each year to a small company that has demonstrated entrepreneurial leadership and drive. [Freewing] is working harder, faster, and more efficiently than its more established competitors and is making solid inroads in the market despite the limitations of a small company."*



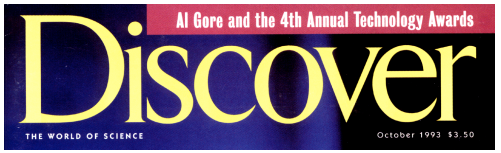
Added in 1994 to the US Small Business Admin. list of *top innovations of the 20th century* by small firms in the US, joining, *inter alia*, the integrated circuit, the helicopter, the Wright Brothers' airplane and air conditioning.

1994 Grand Prize Winner, *Excellence in Design*, *Design News magazine*, recognizing the breakthrough technology of the Freewing Tilt-Body™ invention.

Experimental Aircraft Association gave Freewing in 1992 a special *Award for Technological Innovation*, in recognition of the advanced safety and comfort of the Company's technology.



Selected by the editors of *Popular Mechanics* for their 1996 *Design & Engineering Award*. (Rockwell with its X-31 hyper-maneuverable jet fighter was the other aerospace winner.)



1993 Discover Award for Technological Innovation, selected from thousands of candidates, including the McDonnell Douglas MD90 and NASA entries. Judges included astronauts Scott Carpenter, Buzz Aldrin and Wally Schirra.

Selected by the editors of *Chief Executive* magazine for their first annual 1996 *Best New Products* list compiling the best product innovations released during the past eighteen months.

Commercial communications and military reconnaissance systems

Freewing
Aerial Robotics