

Army/NASA Rotorcraft Division



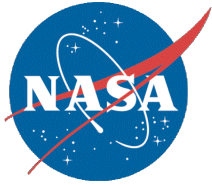
The Evolution of the Tiltrotor - From Dream to Reality

Daniel C. Dugan

NASA Ames Research Center

ICAS 24th Congress

September 1, 2004



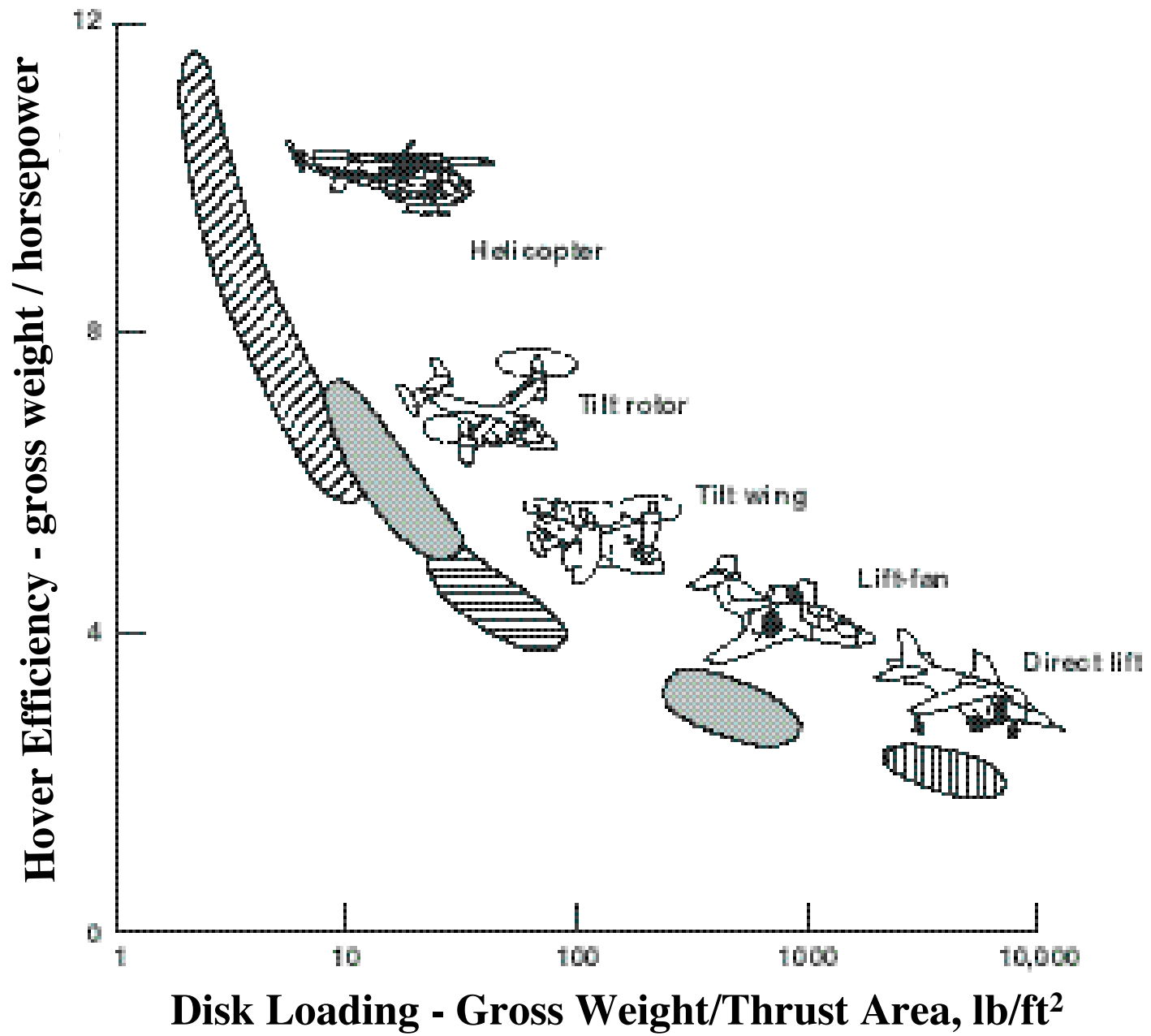
- **Concepts, Designs, and Early Developments**

- **XV-3**

- **XV-15**

- **Applications**

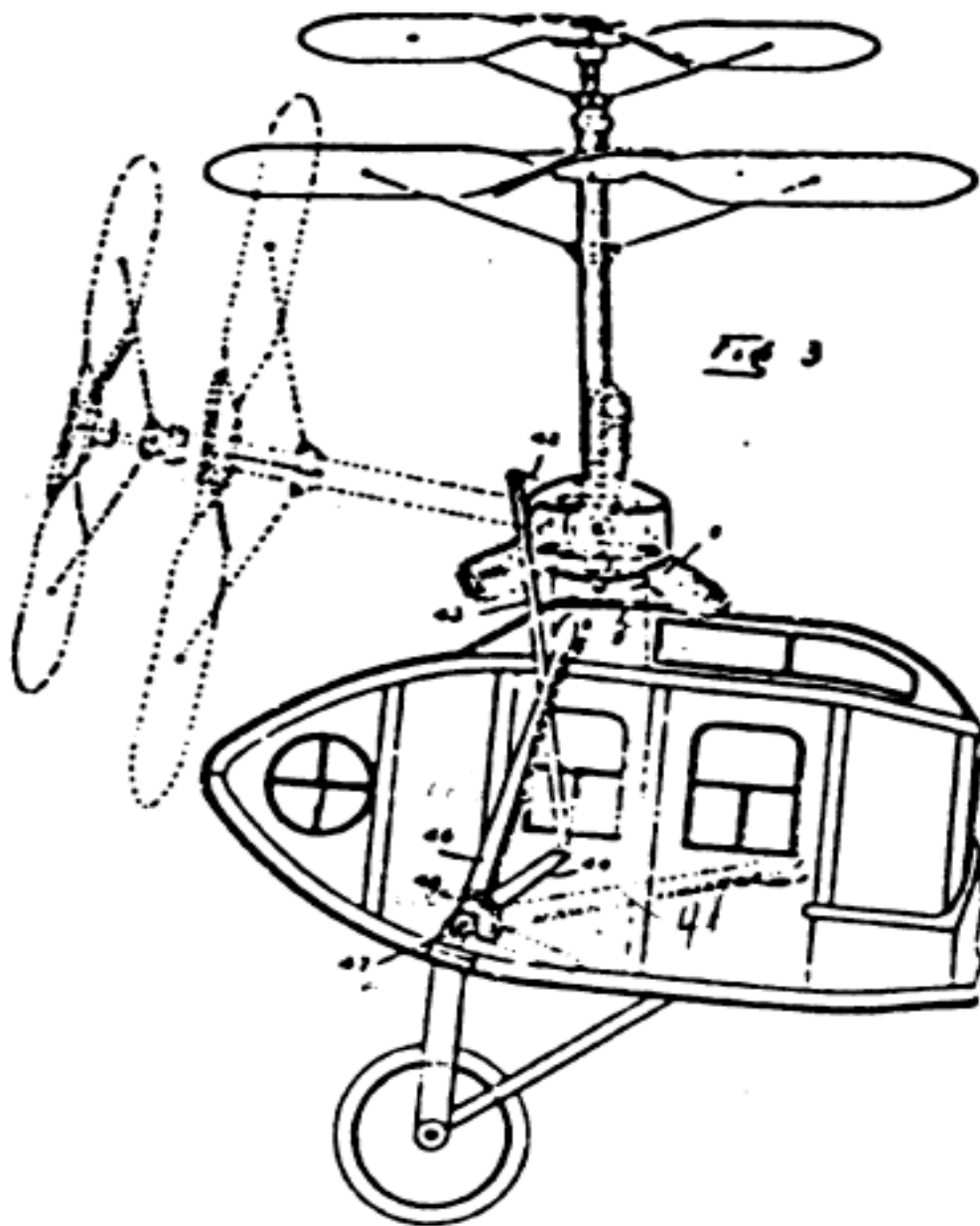




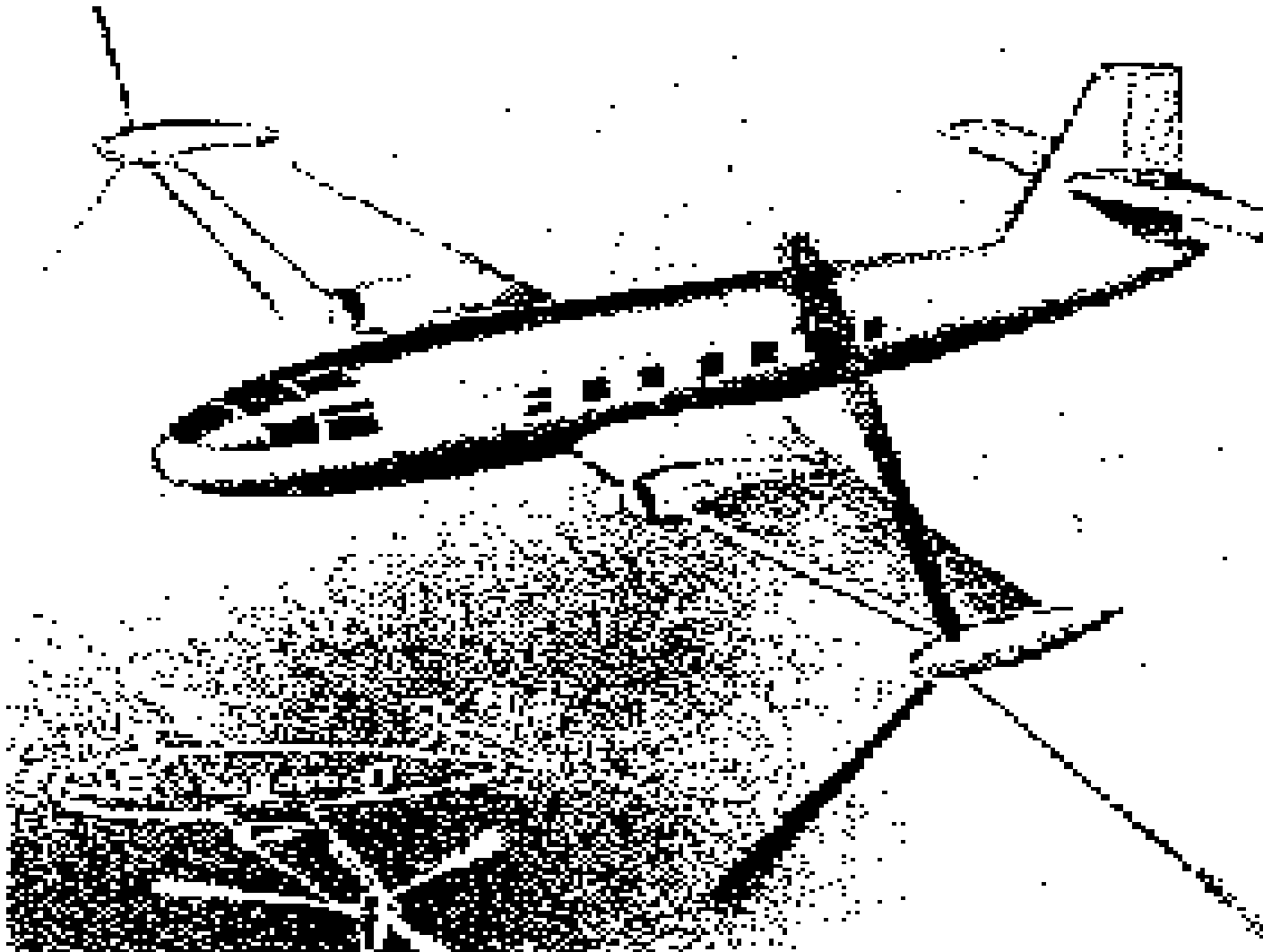
Henry Berliner's Tilt Prop Helo



George Lehberger's Flying Machine

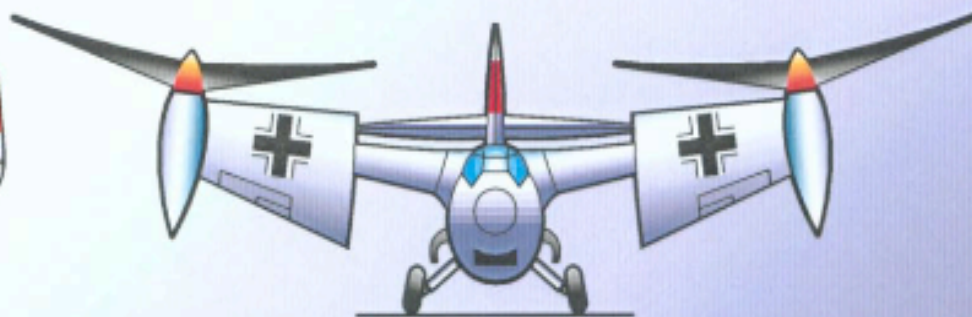
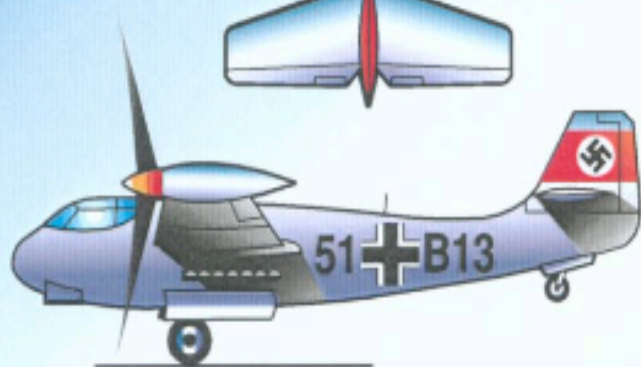
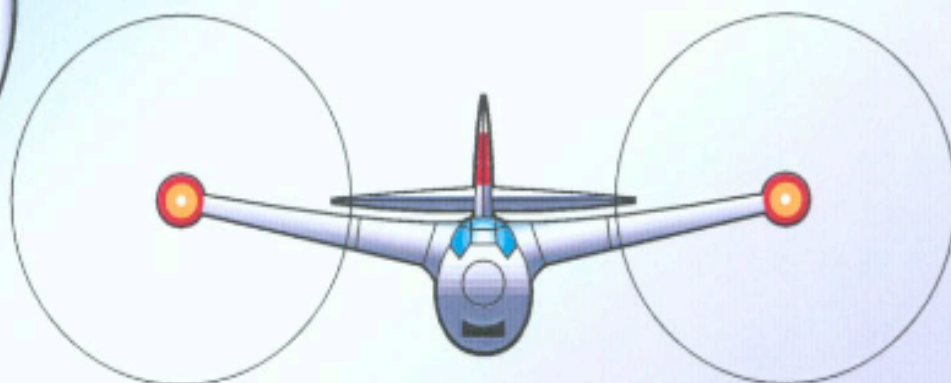
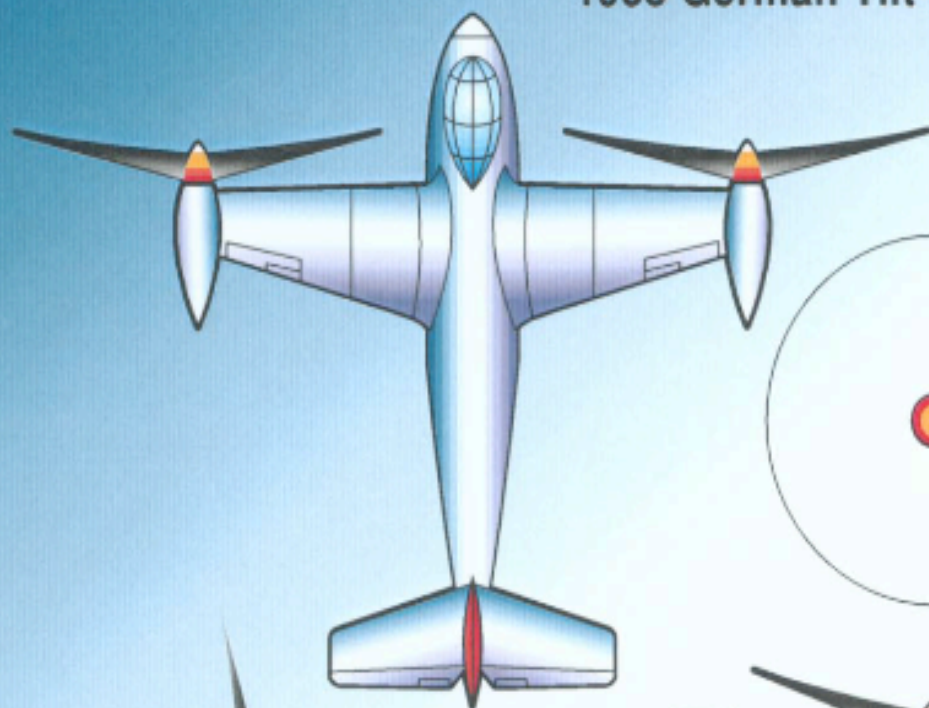


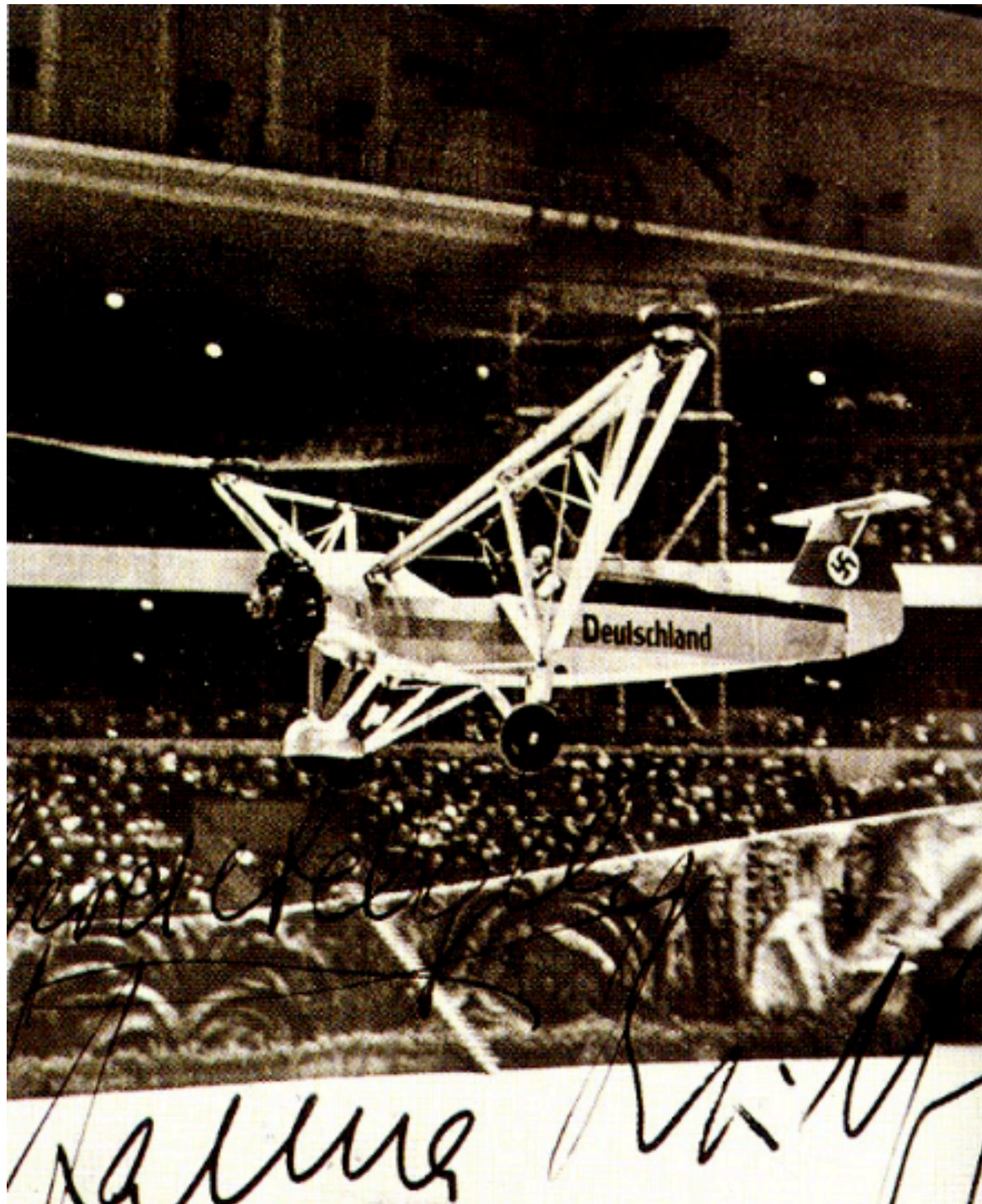
Baynes Heliplane



Weserflug P.1003

1938 German Tilt-Rotor Aircraft

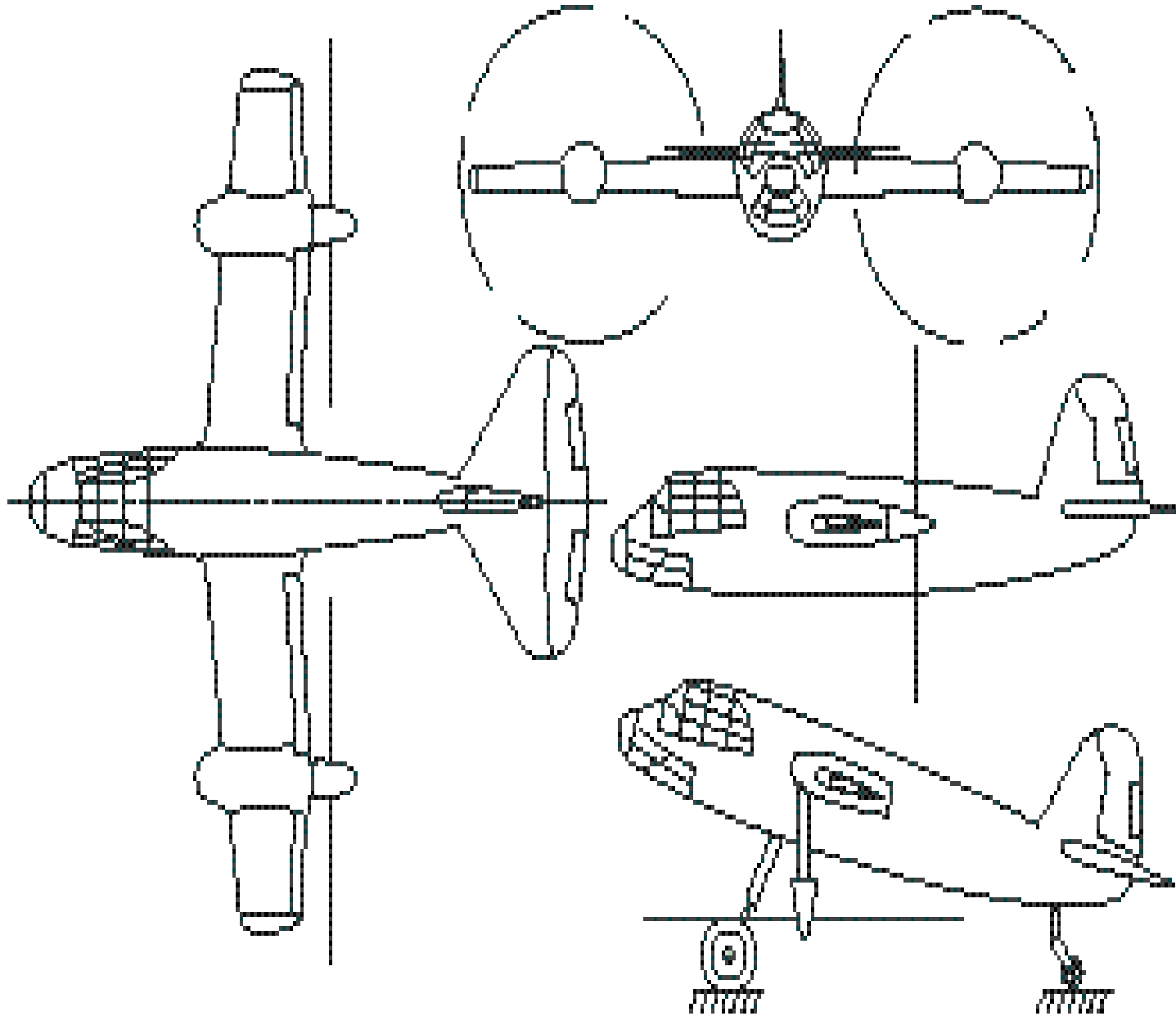




Platt LePage XR-1A, 1941



Focke-Achgelis FA-269, 1942



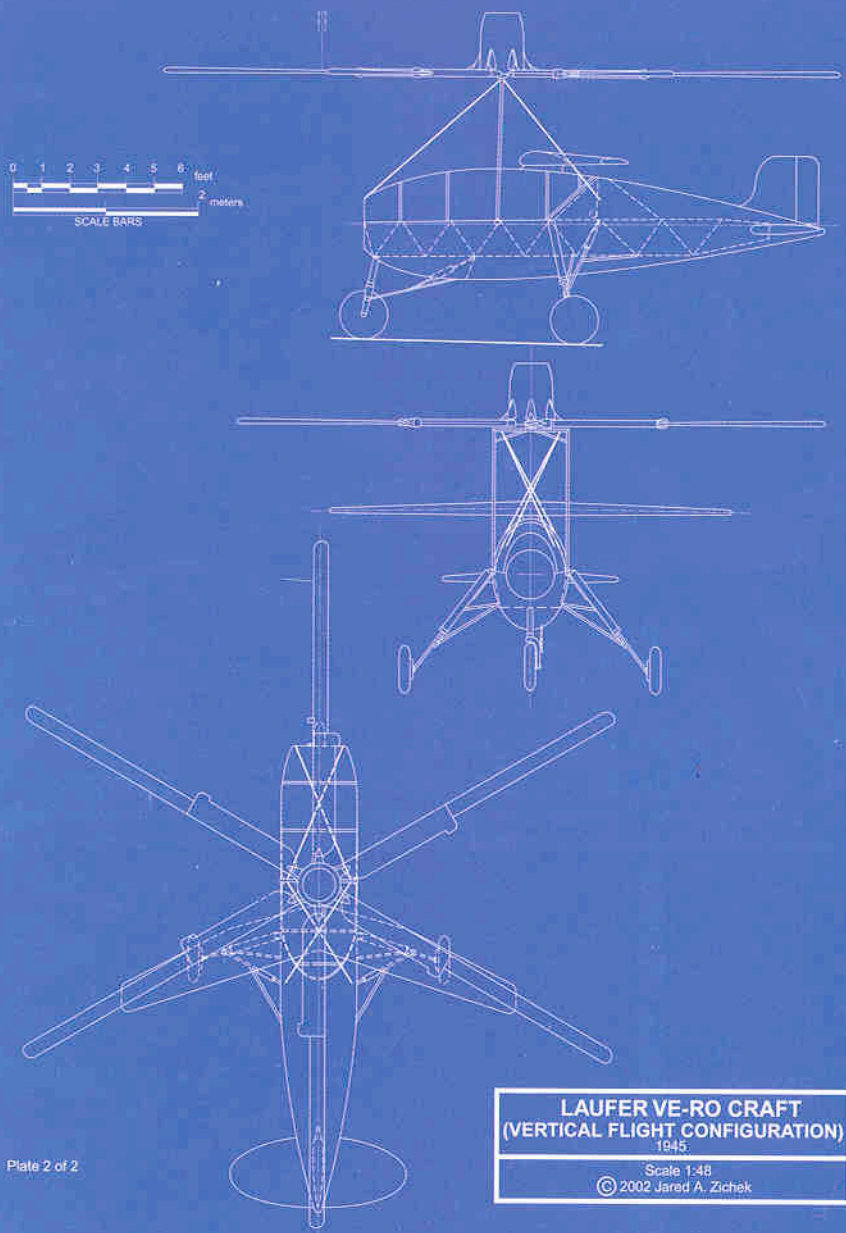


Plate 2 of 2

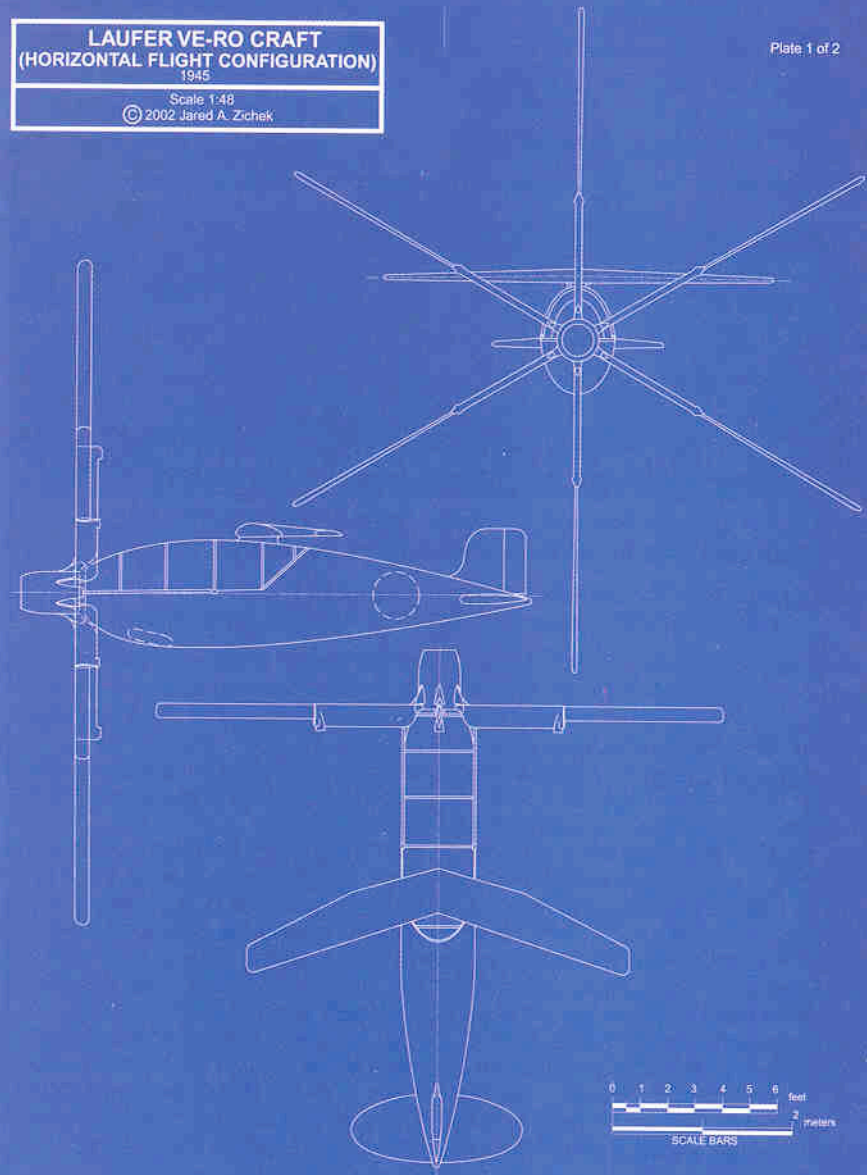
LAUFER VE-RO CRAFT
(VERTICAL FLIGHT CONFIGURATION)
1945
Scale 1:48
© 2002 Jared A. Zichek

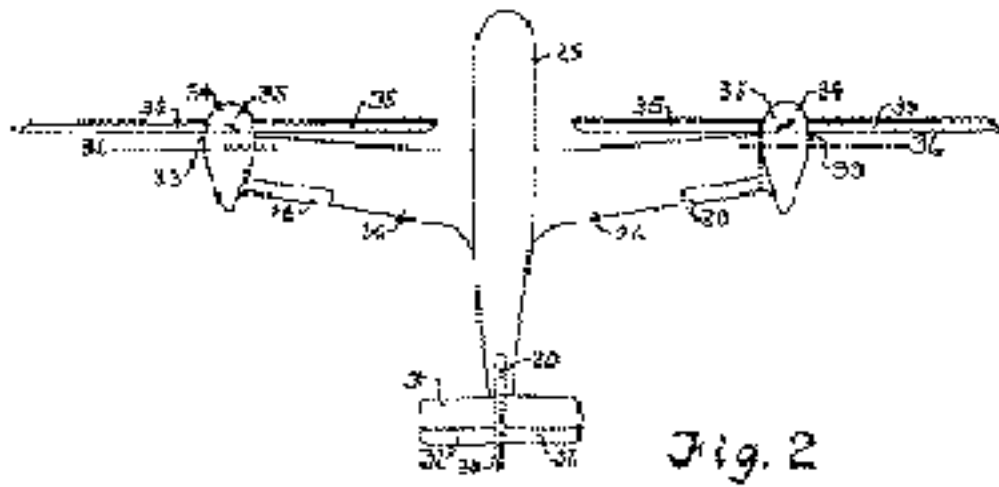
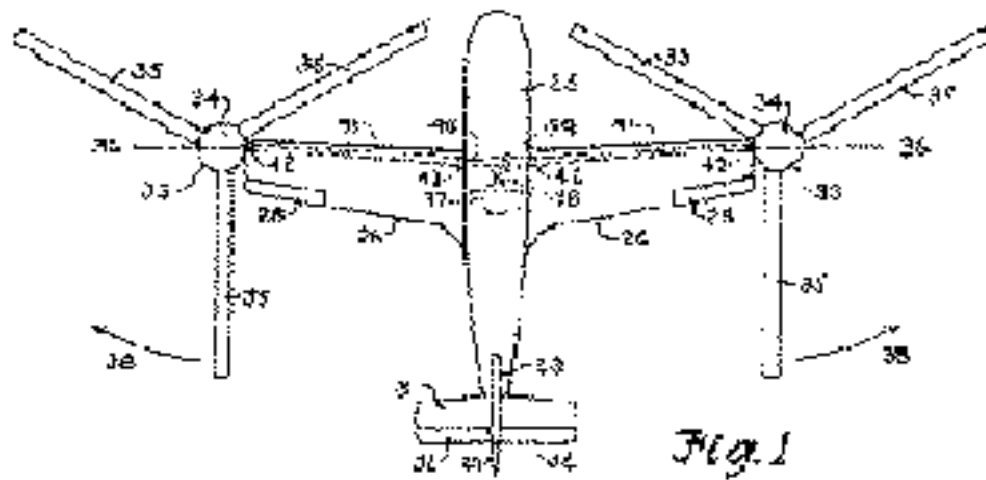
**LAUFER VE-RO CRAFT
(HORIZONTAL FLIGHT CONFIGURATION)**

1945

Scale 1:48
© 2002 Jared A. Zichek

Plate 1 of 2





INVENTOR
 HARRISON H. HART
 BY *Lawrence C. Hilditch*
 ATTORNEY

Transcendental Model 1-G, 1954



Model 1-G



Transcendental Model 2, 1956



York Convertiplane, 1956



Bell XV-3, 1955 (Model 200)

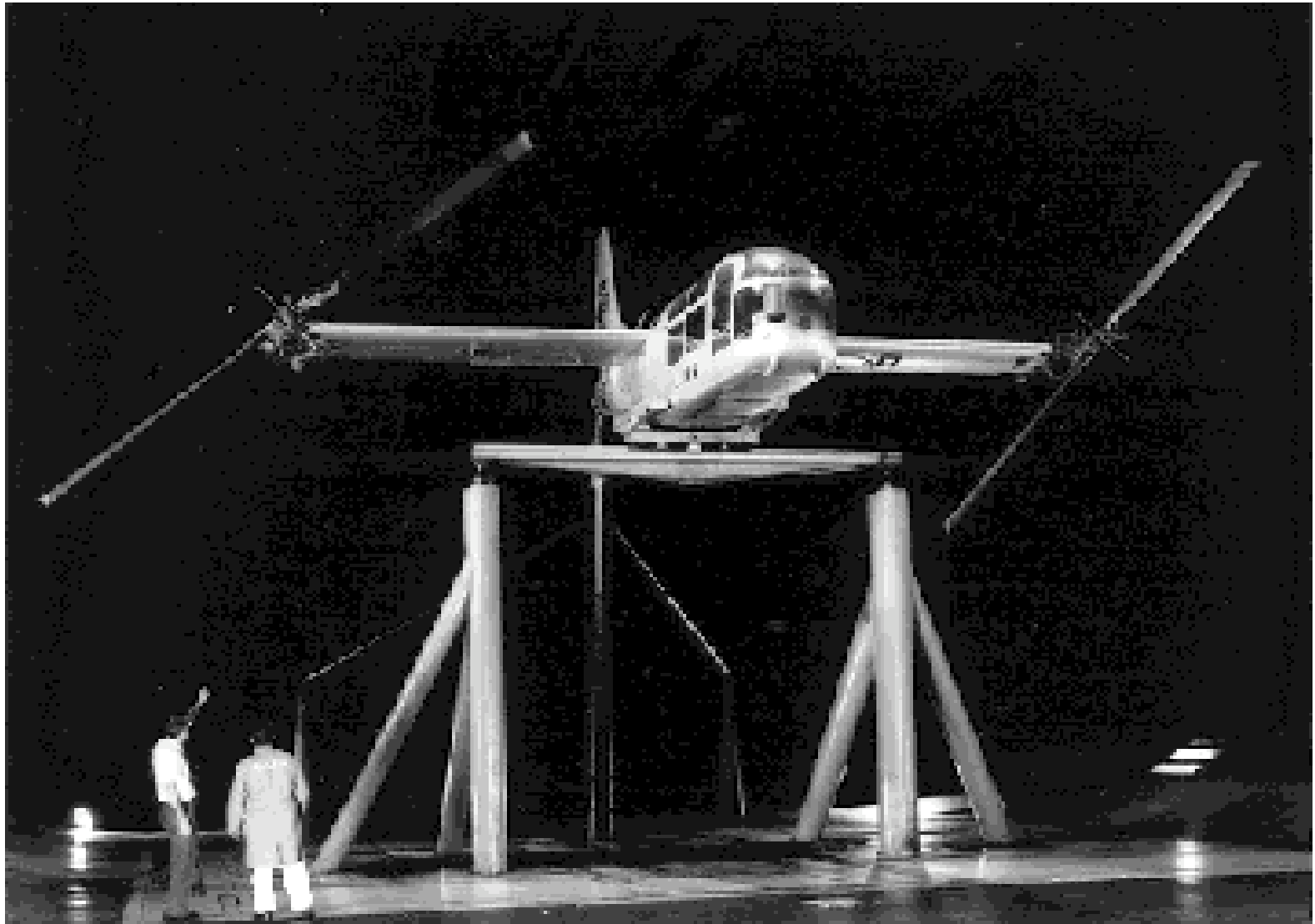




Came A Cropper, 1956









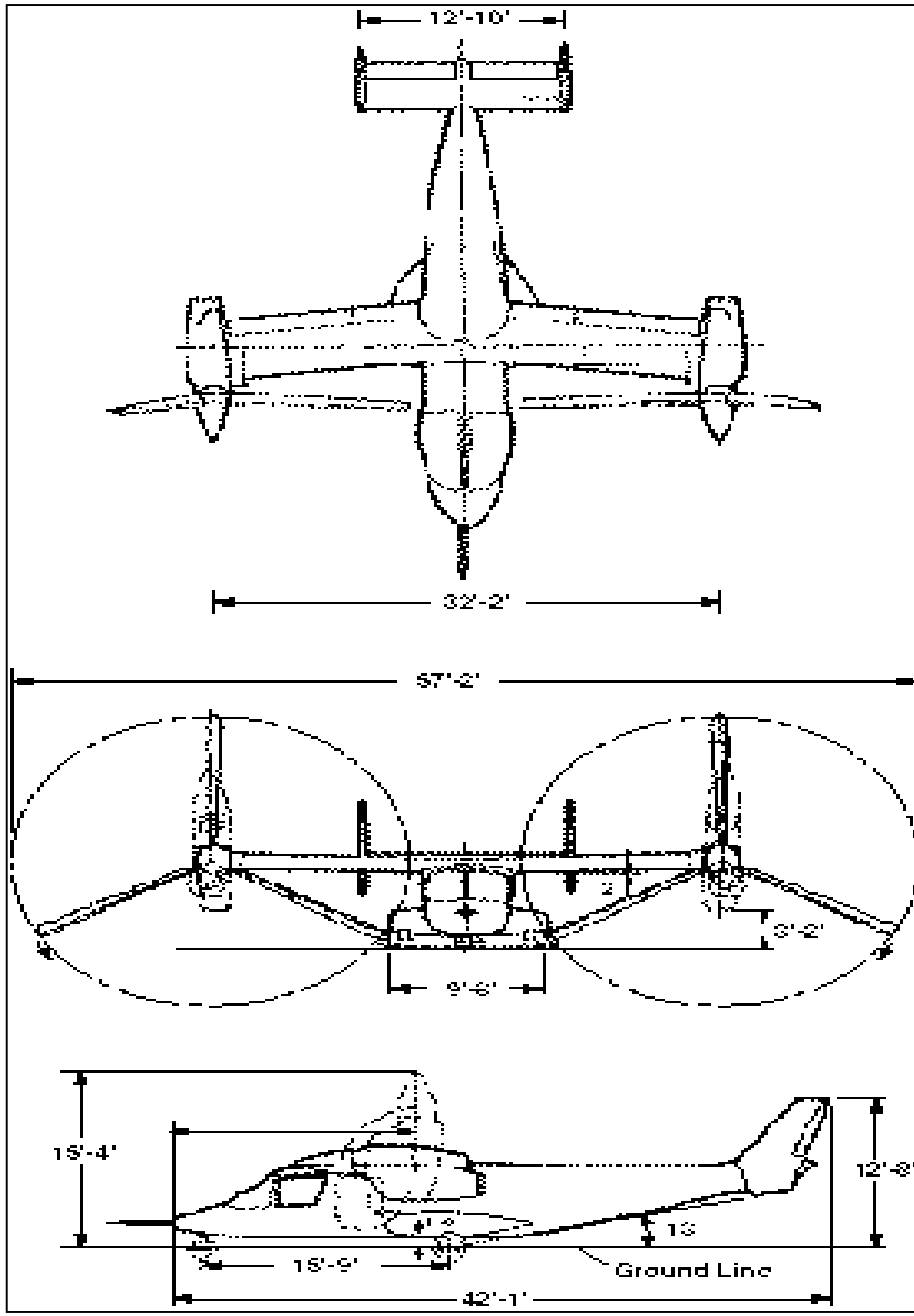
MI-30/31/32 Hxx* TILTROTORS

Designation	Mi-30	Mi-31	Mi-32
Crew	2	2 - 3	3
Weight	Unknown	9-tons	18-tons
Engines	2 turboprops	2 turboprops	2 turboprops
Speed	Unknown	550 km/h	550-650 km/h
Endurance	Unknown	3.5 hrs	3 - 6 hrs
Weapons	Heavy	Capable	Limited types
Troop capacity	Unknown	15	30
Mission 1	Attack	Air Assault	Air Assault
Mission 2	Air Assault	Troop transport	Troop transport
Mission 3	Anti-helicopter	?	Special Operations
Mission 4	Troop Transport	?	Electronic Warfare
Mission 5	Forward Air Control	?	?
Mission 6	Special Operations	?	?
Mission 7	Electronic Warfare	?	?

All figures are approximate.

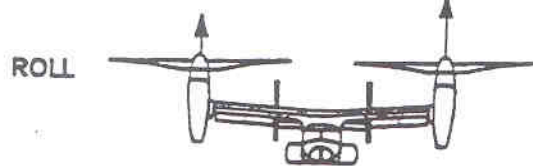
Figure 1

**Mil (Mikhail Mil) Design Bureau*



HELICOPTER

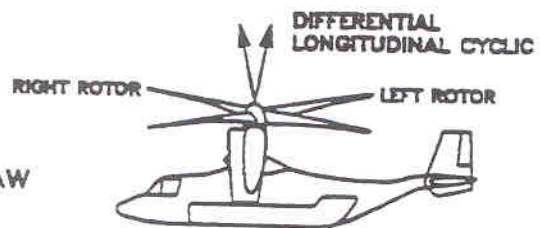
DIFFERENTIAL COLLECTIVE PITCH



LATERAL TRANSLATION MODE



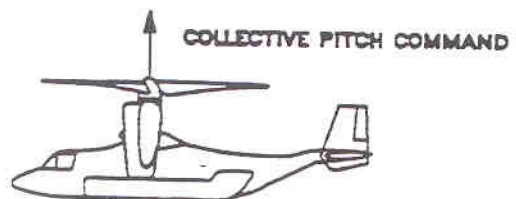
YAW



PITCH

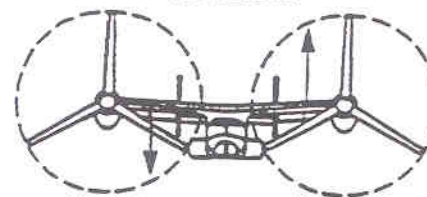


THRUST

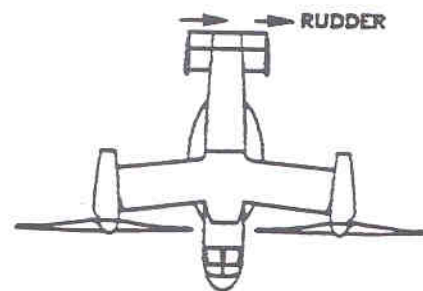


AIRPLANE

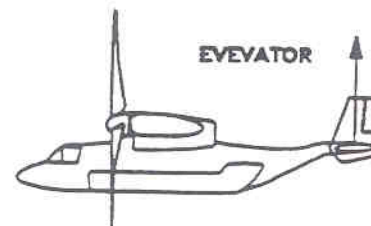
FLAPERONS



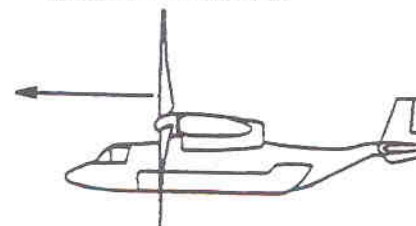
RUDDER



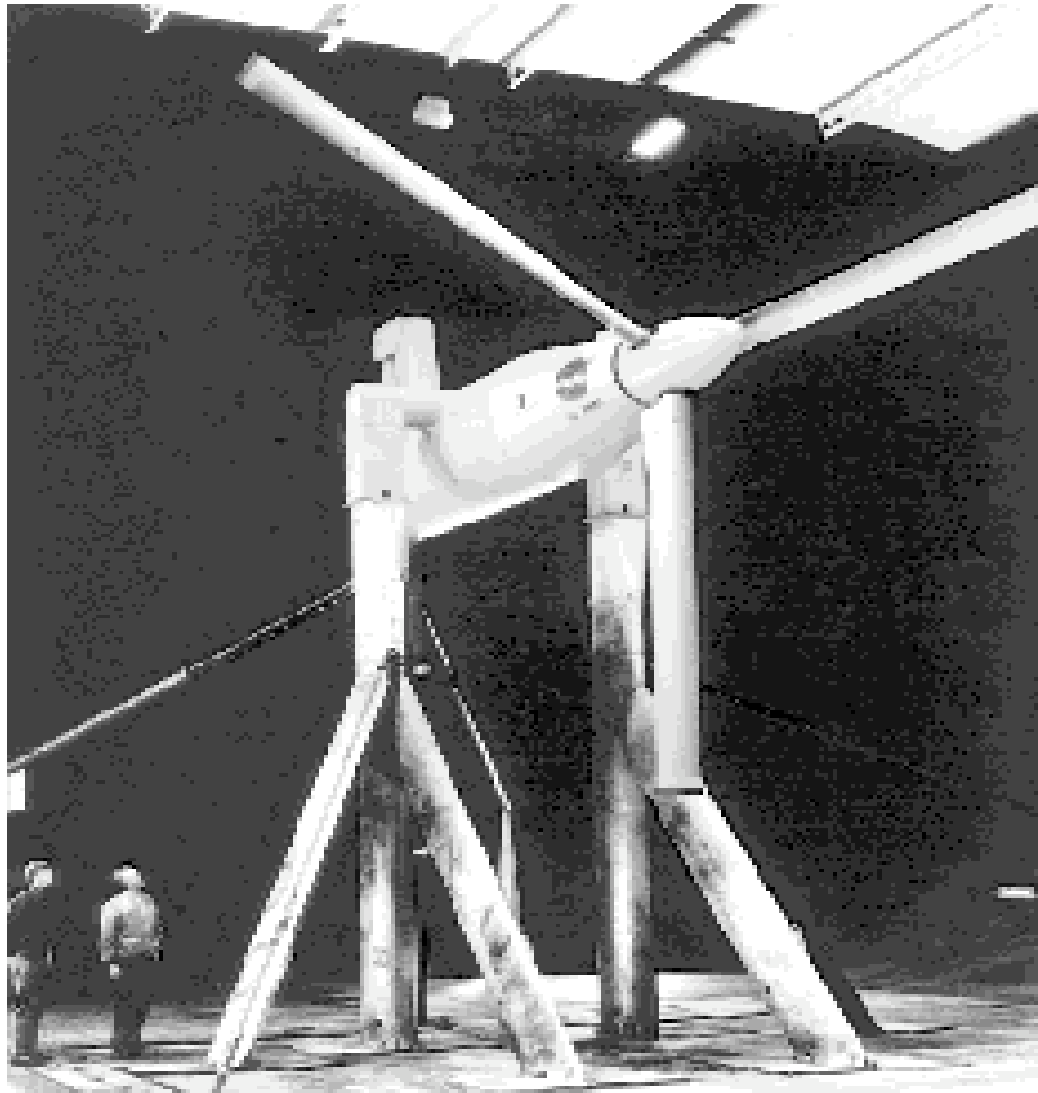
ELEVATOR



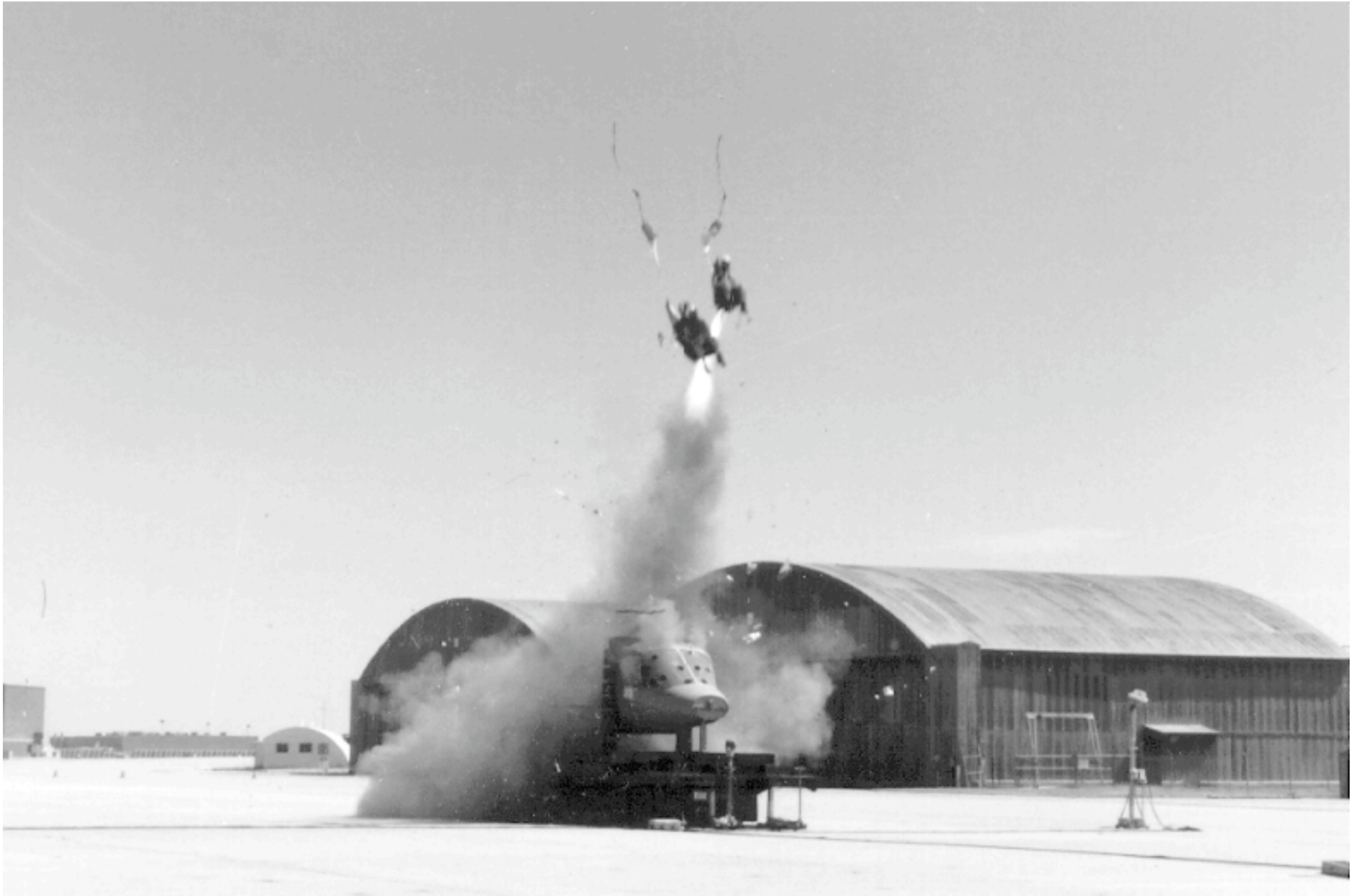
THROTTLE COMMAND



XV-15 Proprotor, Ames 40x80, 1969



Ejection Seat Test, Tulsa, OK



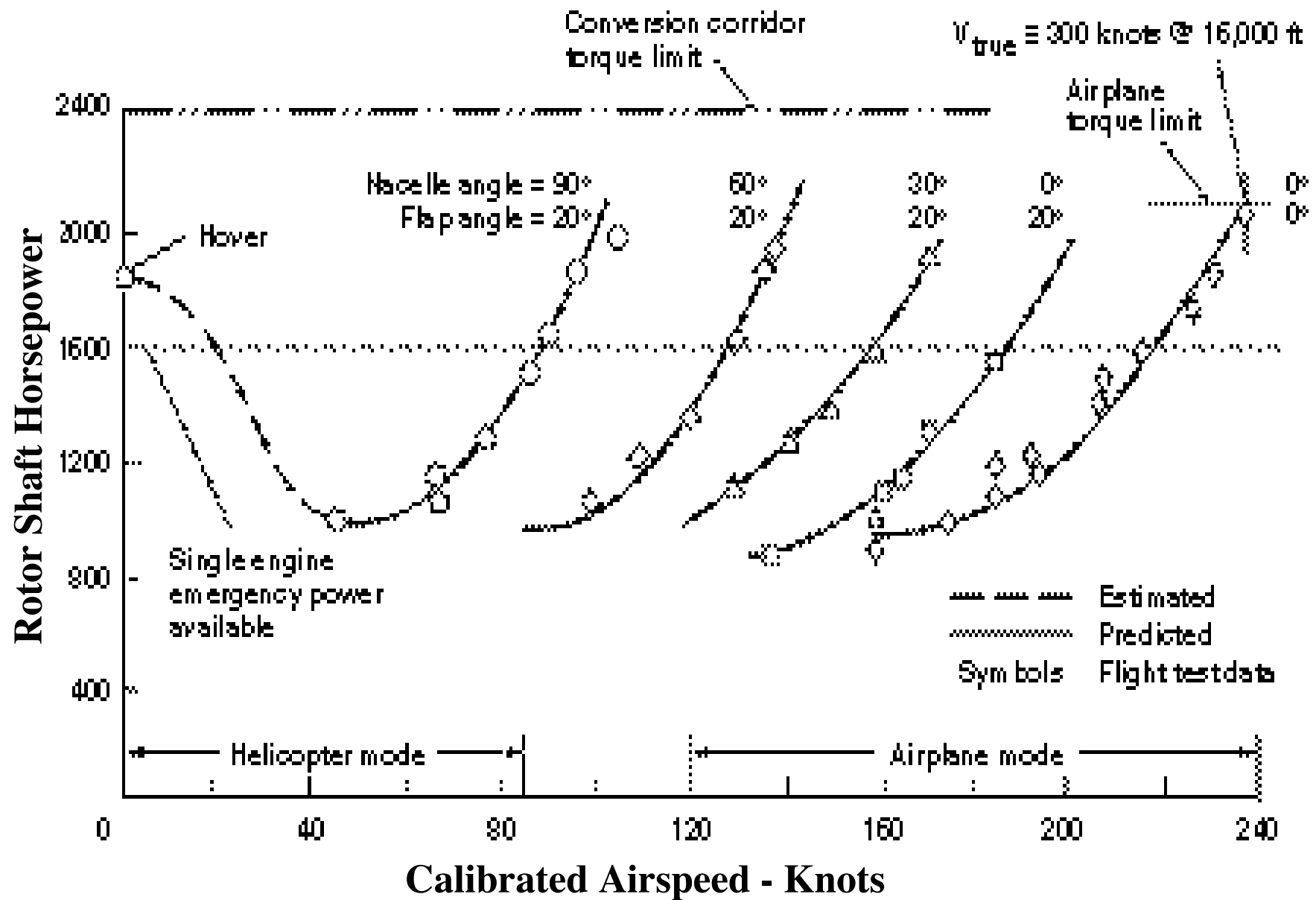


On the Rig, Bell 1977



40x80 Tunnel, Ames 1978





Government Acceptance, 1980



Cannon, Erhart, Dugan, Gerdes

Dryden at EDW, 1981





The “Fountain”









The Battery, NYC

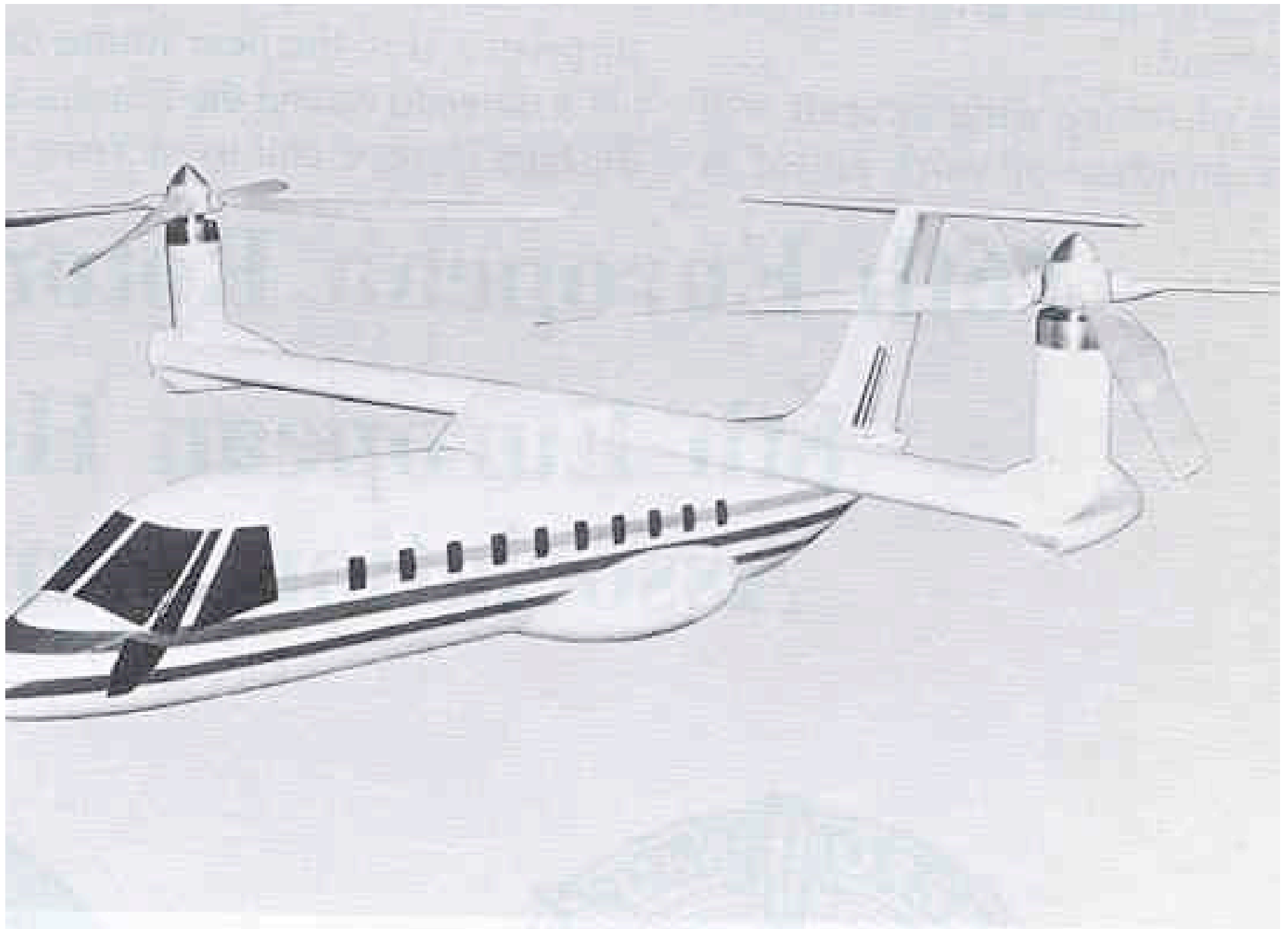




Acoustics Tests



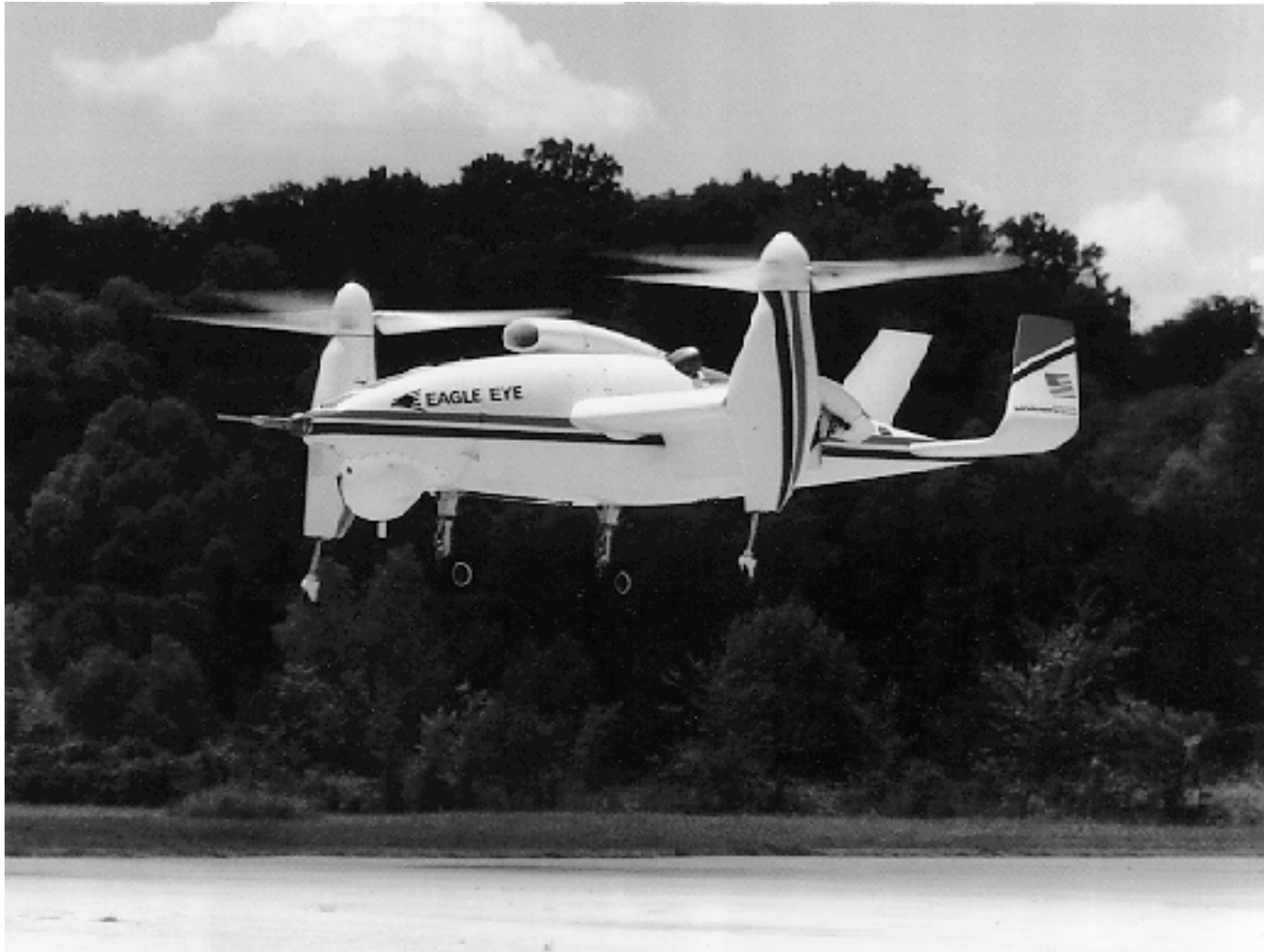




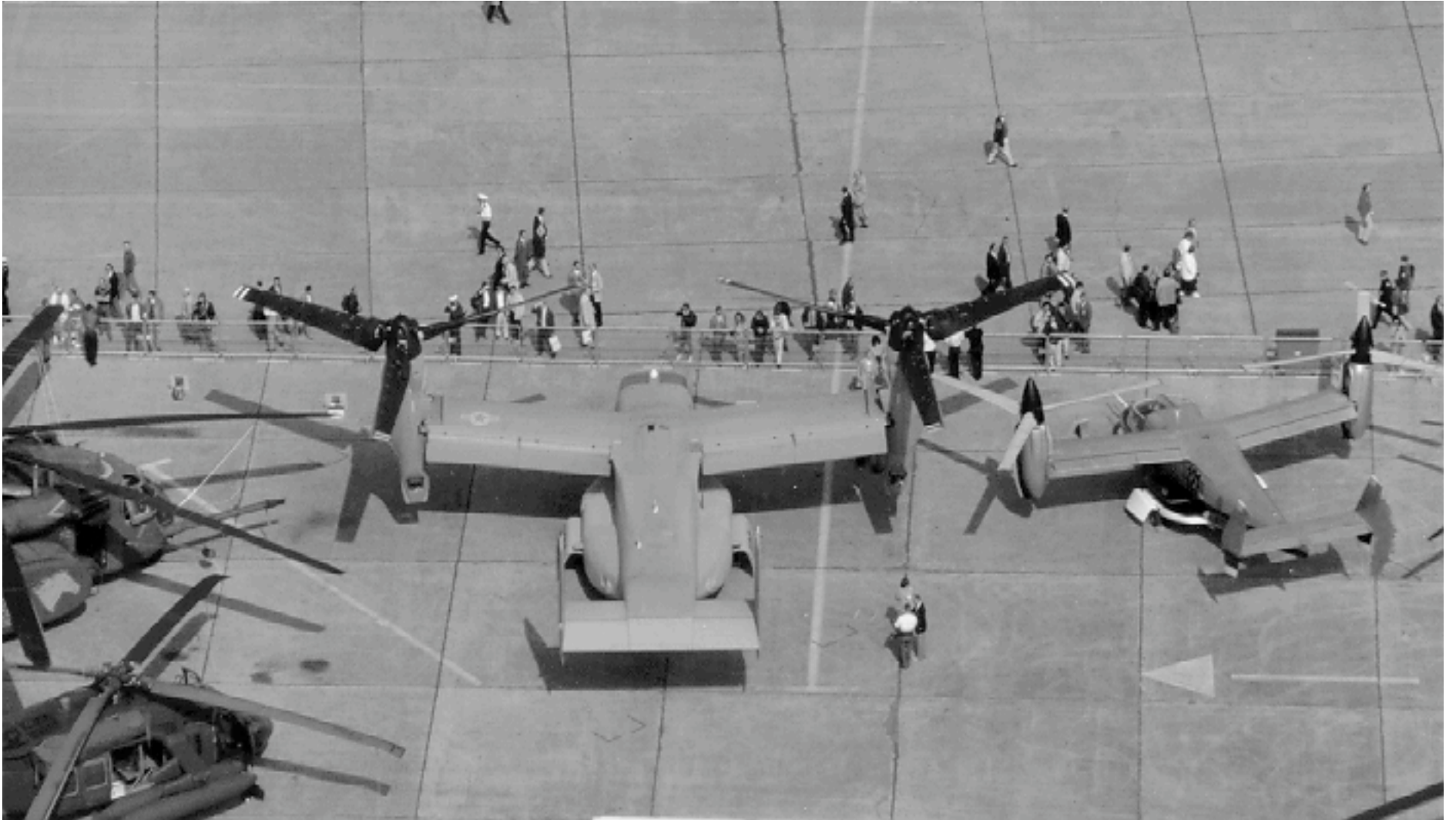
TEAR tiltrotor aircraft design





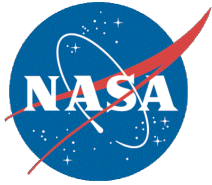


Paris Again, 1995









- **Early days - Basic Tiltrotor Concept Elusive but Pursued**
- **XV-3 Verified that the Concept was Sound**
- **XV-15 Successful Solutions to Tiltrotor Aeroelastics and Proof of Concept**
- **Production Initiated -- V-22 for Military, BA 609 Development Proceeding for Civil Market**
- **Potential for Introduction Into the National Airspace System Continues Under Development by the Army, NASA Ames, and FAA**



