French Low-Speed V/STOL Concepts of the Twentieth Century

Thomas Müller
Salzmann Buchhandlung
Waltershausen, Germany

Michael J. Hirschberg
CENTRA Technology, Inc.
Arlington, Virginia

Alexis Rocher
Aviation Historian
Villiers Sur Marne, France

International V/STOL Historical Society (IVHS)
www.vstol.org
Background

- This paper is the fourth in an ongoing series that will form the basis for the V/STOL Encyclopedia

- **Vol 1: German V/STOL Concepts - publish in 2003**
  - German V/STOL Fighters - AIAA/AHS/SAE IPLC, Nov 2000 (65 concepts)
  - German V/STOL Rotorcraft and Propellercraft - AHS Forum 57, May 2001 (75 concepts)
  - German V/STOL Transports - SAE WAC, Sep 2001 (50 concepts)

- **Vol 2: French V/STOL Concepts**
  - French Low-Speed Concepts - AHS Forum 58, June 2002 (35 concepts)
  - French High-Speed Concepts - AIAA/AHS/SAE IPLC, November 2002

- Future volumes in the planning stages

- Check the web site for briefs from all of these papers:

  www.vstol.org
Overview

• Background
• Dawn of Vertical Flight
• Sud-Ouest Tip Jet Compounds
• Sud Aviation Compounds
• Nord Aviation Ducted Props
• Breguet & SNECMA Flying Jeeps
• Aerospatiale/Eurocopter Tiltrotors
• Summary
V/STOL Wheel of Mis-Fortune

Depicted here are the various types of Vertical and Short Take-Off and Landing (V/STOL) aircraft which have been tested over the past 45 years. All were built to be flown, but only three [shown in bold] have led to operational aircraft. In fact, the Harrier is the only V/STOL aircraft in service today.

The Joint Strike Fighter concept demonstrators (shown in blue), are scheduled to fly in 2000; one of these concepts will serve as the basis for development of an aircraft to replace the Harrier.
“The V/STOL Pyramid”

Operational V/STOL Systems:
- Harrier
- Forger

Flight Test:

Large-Scale Testing:

Design Concepts / Small-Scale Testing
The Dawn of Flight

Wright Brothers
Kitty Hawk, NC
December 17, 1903

Alberto Santos-Dumont
Paris, France
October 23, 1906

"The aeroplane won't amount to a damn thing until they get a machine that will act like a hummingbird. Go straight up, go forward, go backward, come straight down and light like a hummingbird."

- Thomas Edison, 1905
The Dawn of Vertical Flights
The first hops in France in 1907

Louis Breguet

- First vertical flight machine to leave the ground 24 Aug 1907
  - “tethered” by assistants
- 32 lifting surfaces
- Reached a height of 2 ft and endurance of 2 min
- No means of control
- No provision for lateral translation

Paul Cornu

- First true free flight 13 Nov 1907
- 300 test “flights” -- only 15 manned
- Reached a height of 5 ft for 20 sec
- Lateral motion via vanes in front and rear to deflect downwash
- Weak control power
Pre-Historic V/STOL Concepts

- 1908 Bertin & Boulline
  - compound helicopter ("flown")
- 1912 Viscount Decazes
  - compound helicopter (never flown)
- 1921 Toussant
  - quad propeller compound (flown?)
- 1922 Margoulis
  - tilt-propeller triplane (design)
Pre-Historic V/STOL Concepts

- 1922 Oemichen
  - five “rotors” + three propeller (flown!)
- 1922 Pescara
  - stoppable co-axial compound (design)
- 1927 Chauviere
  - compound helicopter (flown)
- 1935 Marmonier
  - dual tilt-propeller (design)
The First True Helicopter
Breguet-Dorand Gyroplane Laboratoire

• Counter-rotating co-axial metal rotors with articulating blades
• First Flight: June 26, 1935
• FAI records:
  – December 22, 1935: speed of 67 mph (108 km/h)
  – September 26, 1936: altitude of 517 ft (157 m)
  – November 24, 1936: closed circuit course distance of 27.4 miles (44 km); 63 min endurance
French Aerospace Consolidation

- **Sud-Oest**
- **Sud-Est**
- **Nord**

1957: **Sud**

1970: **Aerospatiale**

1992: **Eurocopter**

**MBB**
Sud-Ouest Tip-Jet Compounds

Sud-Ouest SO 1100 Ariel

- After WWII, Sud-Ouest considered tip-jets for powered take-off autogyros
- Some technical assistance from Doblhoff’s WNF 342
- Propulsion scheme
  - Burned fuel/air in the blades
  - Ducted propeller for forward thrust
  - Rudder for yaw control
- Not very successful
  - Tested as pure helicopter
  - Ariel II and III were tip-jet helicopters (not compounds) but very high fuel consumption

Sud-Ouest SO 1100 Ariel

Rotor: 9.75 m 32 ft
Wt empty: 650 kg 1433 lb
Engine: 175 hp piston
First flight: 14 May 1947 (tethered)
Sud-Ouest Tip-Jet Compounds

Sud-Ouest SO 1310 Farfadet

• Propulsion scheme
  – Tip jets used for vertical flight/hover
  – Autorotating for forward flight
  – Compressor engine exhaust for yaw

• Testing
  – First flight without propeller engine
  – First conversion 2 Dec 1953
  – Difficulties with prototype Turboméca engines
  – Stable, controllable, pleasant to fly
  – Max speed 265 km/hr (143 kt)
  – Both engine failed catastrophically

• Program End
  – 2nd prototype with larger compressor that also failed, crippling aircraft
  – Further research terminated
  – Djinns bought for war in Algeria

Sud-Ouest SO 1310 Farfadet

Rotor: 11.2 m 36.7 ft
Wt empty: 1000 kg 2200 lb
Engines: 250 hp turbine
                      250 hp compressor
First flight: 29 April 1953
Sud Aviation Compounds

1966 - jet compound

1966 - retractable rotors

1967 - 50 pax compound
Sud Aviation Compounds

1969 - SA 350 Rotojet

1969 - 30-36 pax Rotojet compound

1969 - 40 pax stowed rotor
Nord Aviation Ducted Propellers

- Concept originated with Jean Bertin at SNECMA in early 1950s
- Work with Nord in early 1960s
- Numerous design studies conducted
- 2 1/2 Nord 500 prototypes + mock-up built
- Tethered hover achieved in July 1968
- Program (and derivatives) cancelled in 1969
Nord Aviation Ducted Propellers

Nord 500 Cadet

• 2 seat prototype
• 1250 kg (2,750 lb) empty
• 5 ft propellers in 7 ft ducts
• 2 Allison 250 engines (317 shp)
• 120 kg (265 lb) payload

• 4 seat operational concept
• 1000 kg (2,200 lb) empty
• 5 ft propellers in 7 ft ducts
• 2 Oredon 111 engines (350 shp)
• 850 kg (1900 lb) payload
Nord Aviation Ducted Propellers

Nord 500 Cadet

• First prototype used for static tests beginning in Apr 1967
• Diamond shaped control vanes

• Second prototype began ground testing in Feb 1968
• Tethered hover Jul 1968
• 1 m and less than 20 sec
• Unstable and difficult to control
Nord Aviation Ducted Propellers

Nord 501 Attack Aircraft

- Response to a 1966/67 study on a military application of Nord 500
- Attack, helicopter escort, heli-hunter, ASW
- 2 Lycoming T55 engines (2100 hp)
- Retractable skid
- Chin turret

- Length: 8 m (26 ft)
- Wingspan: 4.50 m (14.8 ft)
- Inner duct diameter: 1.34 m (4.4 ft)
- Empty weight: 2,100 kg (4,630 lb)
- Useful payload: 1,900 kg (4,190 lb)
- VTO weight: 4,000 kg (8,820 lb)
- Max speed: 600 km/hr (325 kt)
- Endurance: 1 hr 20 min
• Design for a pressurized civil or military transport
• 2 crew + 8 pax
• 2 T55 turboshfts (2650 shp)

• Length: 10.3 m (33.7 ft)
• Wingspan: 5.7 m (18.6 ft)
• Empty wt: 2,100 kg (4,630 lb)
• VTO wt: 4,625 kg (10,200 lb)
• Max speed 328 kt
Nord Aviation Ducted Propellers

Nord Estocade
Nord Aviation Ducted Propellers
Nord Rocade

- Design for a pressurized civil or military 40 pax transport
- 4 Turboméca Turmo-IIIC engines (1100 shp)
- Counter-rotating propellers
- Prototype construction begun

- Length: 18.4 m (60.3 ft)
- Wingspan: 19.5 m (64 ft)
- Duct outer diameter: 5.5 m (20 ft)
- Empty wt: 9,450 kg (20,800 lb)
- VTO wt: 15,700 kg (34,650 lb)
- Max speed: 540 km/hr (300 kt)
• Numerous jet-powered V/STOL projects studied at Breguet (subject of the next paper!)
• Two ducted propeller concepts considered for French Army (troop transport, assault, reconnaissance) in 1959
• Twin propeller/twin engine had a pusher propeller
• four propeller had a single engine and tilted for forward thrust
• Four seats, gross weight ~1800 kg (4000 lb);
• max speed 72-90 km/hr (40-50 kt); altitude 1200 m (3900 ft)
• 1 hr endurance
• Numerous jet-powered V/STOL projects studied at SNECMA (subject of the next paper!)
• In 1963, apparently also considered for French army application
• Two 530 shp turbines for 3 m propellers + 48 hp engine for wheels
• Control in flight via individual propeller pitch control
Aérospatiale Tiltrotor
Aérospatiale X 910

- Circa 1970, studied tilt rotor for emerging commuter requirements
  - Approximately 2/3 size of the Bell XV-15
  - Engines in the fuselage, rotors cross shafted
  - Able to land with rotors horizontal

- Wind tunnel tests
  - 1974 1/5 scale model at Marignagne
  - 1975/76 full scale tilt rotor system tested in S1 tunnel at ONERA

- Project continued to 1977
- First flight planned for 1981
Aérospatiale Tiltrotor

Aérospatiale X 910

- Arriel I turboshaft: 650 hp
- Rotor diameter: 5 m (16.4 ft)
- Length: 6.7 m (22 ft)
- VTO wt: 1,640 kg (3,615 lb)
- Operational weight: 2,560 kg (5,645 lb)
- Prototype weight: 2,455 kg (5,412 lb)
- Max speed: 517 km/hr (279 kt)
- Range w/ 4 pax: 800 km (432 kt)
- Range w/ 6 pax: 450 km (243 kt)
Eurocopter Tilt Rotors

EUROFAR

- 1987 started European Future Advanced Rotorcraft (Eurofar)
- 30 pax, 14 ton commuter tiltrotor
- Rotor tested in ONERA S1 wind tunnel in early 1990s
Eurocopter Tilt Rotors

Eurotilt and 2GETHER

- **Eurotilt**
  - 12-19 seat executive transport, SAR, offshore
  - 10 tons, 330+ kt, 750 nm range

- **2GETHER (Eurocopter together with Agusta)**
  - 2nd Generation European Tilting Highly Efficient Rotorcraft
  - Proposed in 2001 for €50M, but also rejected for funding
  - €3.7M project, studying tiltrotor interactional aerodynamics was approved
Summary

- About 35 different French V/STOL Rotorcraft and Propellercraft documented
- Most were design studies only
- Some achieved significant component testing
- Several conducted limited V/STOL flight testing
- None were tested extensively or reached production

Operational V/STOL Systems:

Flight Test:

Large-Scale Testing: