The Eurocopter X³ Hybrid Helicopter
Making High Speed Cost Effective

American Helicopter Society
Future Vertical Lift Aircraft Design Conference
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San Francisco, CA
Agenda

• History of Eurocopter’s High Speed Helicopters
• Objectives of the X³ Program
• Selecting the X³ Configuration
• Creating the X³
• Test Program Methodology
• Flight Test Results
• The Future of X³
Eurocopter’s High Speed Helicopters
Flettner F185

• 1936
• ~50 knots

• Principal Characteristics
  o Nose Mounted 140hp engine
  o Gearbox provided power to the Rotor and Two Variable-pitch Airscrews Mounted on Outrigger Arms
  o Act as a Helicopter in Hover Flight / Act as an Auto Gyro in Forward Flight

• Lessons Learned
  o When the Rotor was Powered, the Airscrews Provided Thrust in Opposite Directions to Counteract Torque
  o When the Rotor was Freely Turning, the Airscrews took up the Full Power of the Engine and the Pitch was Altered to Give Thrust for Forward Flight
Eurocopter’s High Speed Helicopters
BO 105 HGH

• 1975
• 218 knots

• Principal Characteristics
  o Addition of Fixed Wings
  o A National Advisory Committee for Aeronautics (NACA) 23 Series varying from 15% Thickness/Chord Ratio at the Roots to 12% at the Tips
  o Airbrakes are Mounted Above and Below the Leading-edge of Each Wing
  o A Shorter-legged Landing Gear is Added

• Lessons Learned
  o Max Blade Tip Speed was Mach 0.97
Eurocopter’s High Speed Helicopters
Gazelle SA 349-2

• 1977
• ~ 190 knots

• Principal Characteristics
  o Astazov 14 Engine
  o Stronger Transmission
  o Fitted with Small Wings for High Maneuverability
  o The Wing has a 'Zero' Profile of about 12% Thickness with Ailerons and Spoilers

• Lessons Learned
  • Need for Spoilers to Achieve Normal Autorotation
Eurocopter’s High Speed Helicopters
Dauphin Grande Vitesse

• 1991
• 201 knots
• Principal Characteristics
  o Main Rotor Hub with Fairing
  o Cleaned Fuselage
  o Reduced Rotor Speed
  o Uprated Gearbox
• Lessons Learned
  o Importance of Faired Rotor Hub
  o 200 knot Barrier for the Conventional Helicopter Configuration
Objectives of the X³ Program

- Cost-effective High-speed Flight
- Realistic Configuration for Real Markets and Real Missions
- Helicopter-like Operations
  - Helicopter Versatility in Hover
  - Helicopter Mission Versatility
  - Helicopter Autorotation Characteristics
  - Minimal Aircrew Training
  - Use of Existing Heliports
- Low Environmental Impact
  - Low Noise
  - Low Rotor Downwash
  - Low Fuel Consumption
- Payload / Range
  - Superior due to Efficient Helicopter Rotor

All At An Affordable Cost!

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Selecting the $X^3$ Configuration

- Blade tip propulsion with propulsion propellers
  - Noise generated by bulky motors on blade tips
- Pusher propeller plus tail rotor
  - High power through long rear transmission shaft
- Ducted steerable pusher propeller
  - High power through long rear transmission shaft
- Conventional rotor with turbofan propulsion
  - High weight and fuel consumption
- Tandem rotors
  - High complexity – good for transport but not best for speed
- Tilt Rotor
  - Complex mechanics, asymmetric vortex-ring, high downwash, low hover efficiency
- Contra-rotating rotors
  - High vibration due to very rigid rotor, rotor head resistance
X³ Configuration Criteria

- Good Hover Performance Requires Low Disk Loading
  - Existing Conventional Rotor

- Rotor Speed Reduced in Forward Flight to Avoid Advancing Blade Drag
  - Large Rotor RPM Range

- Wing to Unload Rotor at High Speed to Avoid Retreating Blade Stall

- Auxiliary Propulsion to Avoid Low Lift / Drag Ratio at High Speed
  - Turboprop Efficiency of Propellers
  - Props and Rotor Driven Directly from the Main Gearbox
Creating the $X^3$ Technology Demonstrator

2 x RTM 322 Engines  EC155 Main Rotor
Modified EC175 Main Gearbox
Dauphin Fuselage
Specially Constructed Tailplane
Specially Constructed Propeller Gearboxes
Modified Conventional Propellers for Propulsion and Anti-torque

Constructible Primarily with Proven Existing Components

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Test Program Methodology

• Classified Work within the Factory for 2 Years
• Smallest Possible Team including the Finest Experts
• Extensive Simulation to Test Configuration and to Design Controls
• Validation of the Concept in Undisturbed Environment
• Flight Tests conducted at Istres Test Centre
• Military Registration and Full Cooperation of the Authorities
Goals of the Technology Demonstrator

Proof of Concept for:

- Aircraft Control and Trim Strategies
- Anti-Torque and Yaw Control
- Propulsion
- Rotor Speed Governing
- Power Management System
Results of Phase 1 Flight Test
September – December 2010

• Achievements
  • 185 Knots at 500 MSL
  • 12,000 feet DA
  • 60° bank angle
  • 2 g
  • 12 Flight Hours

• Handling qualities
  • Hands Off Stability without Autopilot or Fly-by-wire
  • Simple Trim Control of Propulsion
  • Easier to Fly than Conventional Helicopter

• Problem - Feedback oscillations in wings during first flight only
  • Solved by use of Flex-ball Control Element
Results of Phase 2 Flight Test
April – August 2011

• Achievements
  • 232 Knots Level Flight
  • Goal was 220 Knots
  • Steep Climbs up to 50°
  • Only 80% of Full Power
  • 50 Flight Hours

• Handling qualities
  • Hands Off Stability without Autopilot or Fly-by-wire
  • Higher Speeds are Clearly Within Reach

• Flew Every Day at the Le Bourget Airshow
The Future of X³

• Transpose the Proof of Concept into the Eurocopter Product Family
• Define which Weight Class is Optimal for this Configuration
• Define which Types of Missions are Best Suited
  • Search and Rescue
  • Distant Offshore
  • Reconnaissance / Attack
  • VIP Transport

• Validate
  • Mission Cost Effectiveness
  • Cruise and Hover Performance
  • Increased Speed for … 10 – 20% More Vehicle Cost?