• Effective November 15th 2011 AgustaWestland is the sole owner of 609 Program
• AW is pursuing FAA Type-Certification and the aircraft model is now identified AW609 and it is part of AW product line
Powered Lift Evolution

- Powered lift evolution since Fifties recognized as a market need
- Operating Conditions: avoid runways for military operations during Cold War; fly with “flexibility” point-to-point within “overcrowded” area today
- Technology as a Critical Factor: several key improvements paved the way to modern VTOLs
- Challenging Evolution: several configurations explored; few concepts proved to be valid
Manufacturers’ strategies comparison

Expanding Rotorcraft Performance

- Bell–Boeing (USA) Tilt Rotor
  - In service

- AgustaWestland (EU/USA) Tilt Rotor
  - Production prototype

- Sikorsky (USA) Hybrid helicopter
  - Technology demonstrator

- Eurocopter (EU) Hybrid helicopter
  - Technology demonstrator
AgustaWestland Tiltrotor vision

Tiltrotor as complementary helicopter solution to answer additional market demands:

• FASTER

• FARTHER

• W/OUT RUNWAY
AW609 Specifications

9 pax / 16,800 lb Max GW (Useful Load 5500 lb)
Increased GW (STOL) up to 18000 lb
275 kts Max Cruise / Up to 700 nm Range
25,000 ft Max Ceiling
5,000 ft HOGE

Pressurized cabin
Dual Pilot IFR
Transport Category Design Standards
Flight into known icing
Cleared to fly Over Water
Transport & Normal Category Performance
Dimensions & Size Comparison

**AW609**
- 26 ft diameter (7.9 m)
- 60 ft (18.3 m)
- 10 ft (3.0 m)
- 33 ft (10 m)
- 15 ft (4.5 m)

**AW139**
- 19 ft (5.8 m)
- 44 ft (13.3 m)
Design Features

Hydraulic & Electrical
• Triplex 3000 psi Hyd Sys
• 3 DC GENS + 28AhBatt
• 2 PMG’s + 2 FCC BATT’s
• 2 AC GENS

Power Plant
• PWC PT6C-67A engines
• AEO Power Ratings: Takeoff (1940 shp), MCP
• OEI Power Ratings: 30 sec (2492 shp), 2 & 30 min, Continuous

Flight Controls/Avionics
• FCS – Triplex Digital Full Authority FBW
• Collins State-of-the-art Avionics suite

Rotors / Drive
• 26 ft. dia. Proprotors w/mechanical interconnect

Conversion System
• Via dual telescopic ball screws w/mechanical interconnect

Fuel System
• 2480 lb capacity
• 10 crashworthy fuel cells

Ice Protection
• Rotor Anti-ice / De-ice
• Wing De-ice Boots
• Engine Inlet
• Windshield Heated

Airframe
• Largely Composite Fuselage
• Pressurized Cabin
• Vapor Cycle Air Conditioning
• Full Composite Wing
• Rudderless
The Proprotor

- **HELICOPTER: LOW COLLECTIVE**
- **AIRPLANE: HIGH COLL. & FLOW VARIATION WITH R**

- **BLADE TWIST (~40 DEG)**
- **BIG COLL. EXCURSION (0-60 DEG)**
The Interconnecting Driveshaft

NORMAL OPS

RUDDER

FAILED ENGINE

NEED RUDDER FOR OEI

GOOD ENGINE

ICDS

FAILED ENGINE

ICDS: NO RUDDER NEEDED

Safety requirement turned into an opportunity
“INTUITIVE” Flight Controls

Conventional Helo Cockpit Controls:

- Center Stick and Pedals
- Collective/Power Lever (has Thumbwheel for RPM & Nacelle Tilt Commands)

creating typical aircraft behaviors by different aeromechanic means

Reconfigurable Flight Controls

Flight Controls from VTOL/Conversion to A/P mode are transparent phased with nacelle tilt angle
The Conversion

- Control phasing
- FCS augmentation
- Conversion protection
- Low workload
- Constant altitude

Conversion Corridor

<table>
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<tr>
<th>KCAS [kts]</th>
<th>NACELLE [deg]</th>
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<td>105</td>
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<td>15</td>
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0 deg. 75 deg.
160 knots 80 knots
Transition to APLN
217 Pilot Training Tasks

- Common Tasks
  (Can be Trained in any Aircraft)

- Helicopter Maneuvers
  - Hover/Slow Flight
  - Autorotations

- Airplane Maneuvers
  - High Speed/High Altitude
  - Stalls

- Tiltrotor Unique Maneuvers
  - Use of Nacelles
    - Attitude Control (Center of Gravity)
    - Thrust Vector Control (Airspeed)

Less Than 5% New Tasks

136 Common Aviation Tasks
15 Airplane Tasks
56 Helicopter Tasks
10 Tiltrotor Unique Tasks
Certification Basis

- AW609 Certification Basis established by FAA under the provisions of Part 21.17(b) for “Special Class Aircraft” with portion of Part 25, 29 and new specifics TR

- Certification Basis managed through Issue Paper G1 between FAA and Applicant iaw FAA rules

- All AW609 activities (testing, analytical substantiation, conformity, compliance findings, ..) are performed in accordance with the Certification Plan accepted by the Certification Authority, and identified within Applicant Project Specific Certification Plan and several System Specific Certification Plans

Certification Basis
Mostly: FAR25 + FAR29 + TILTROTOR

Powered Lift Category
Tiltrotor Class Aircraft

Concurrent FAA Type Certification & EASA Type Validation underway
Flight Prototypes Plan

A/C 1
- Envelope Expansion
- Ice Shapes (risk mitigation)
- FCS & Handling Quality
- External Noise
- Performance
- HV/Autorotation

A/C 2
- Envelope Expansion
- Load Level, Vibration Survey
- Stall & Buffet demo
- Avionics Development
- Kits
- Drive System Endurance Test

A/C 3
- Icing Trials (HISS + Nat. Icing)
- Cold Weather demo
- Propulsion
- Cooling Hot Weather, Hot Fuel & Hyd. test
- Cabin Pressurization
- Mini Load Level Survey

A/C 4
- HIRF, Lightning, EMC
- Electrical & Weather Radar demo
- Lighting, ECS, Night Flight
- Internal Noise
- Equipment Temperature Survey
- Avionics
- Functional & Reliability, Maintenance flights, Customer demos
Air Vehicle Testing Overview

Accomplishments

- About 800 Flight Hours + 300 Ground Run
- Envelope expansion in 3 flight regimes
  - 25,000 feet press alt
  - 293 KEAS
  - +3.1, -1.0 g
  - GW / cg to limits
- Flutter clearance
- High Rate of Descent testing
- Category A performance testing
- Autorotation
- Flight control law software / hardware improvements

Envelope Expansion Testing Complete
High Rate-of-Descent Testing

- AW609 will have a sink rate warning system
- Goal is to maximize allowable descent rates at slow speed while providing safety margin

- Used the simulator for recovery technique and practice
- Simple recovery technique

- Developed vortex ring state (VRS) predictions based on V-22 data
- Used a Laser Optical Air Data Sensor for airspeed measurement
Optical Air Data Sensor

- Needed an accurate way to measure very low airspeed at high altitude
- Triple laser system was developed to provide airspeed cueing on helicopters in brown-out conditions
- Adapted it to the 609 for HROD testing
- System required calibration, filtering before it was usable

- Calibrated it with a pace truck going up and down the runway
- Filtered it within our existing instrumentation display
High Rate-of-Descent Data Points

- 609 limitation
- 609 proposed
- TF Boundary
- Asym Boundary
- Onset Boundary

Remaining

- 60KT
- 50KT
- 40KT
- 30KT
- 20KT
- 10KT

Min Pwr

T723R40

T723 roll off

T726R58

T726 roll off

12 dg GS

AgustaWestland Proprietary Information
WINGS’ FEATURES – Why such emphasis on aeroelastics

Tiltrotor Loads:
Rotor & wing loads; Helo. vs. Airplane mode

Big nacelle mass & whirl flutter:
minimize pylon oscillations

Wing stiffness, 23% airfoil, downstop, FCS margins

Wing torsion
Wing bending

Big nacelle mass & whirl flutter:
minimize pylon oscillations
Wing stiffness, 23% airfoil, downstop, FCS margins
Aeroservoelastic Testing

- Inputs accomplished through an FTIP panel on center console of cockpit
- Symmetrical and asymmetrical (differential) collective pitch
- Symmetrical and asymmetrical (differential) longitudinal cyclic
- Asymmetrical flaperon inputs

Bending moments created:

- Wings fore and aft
- Wings up and down
- Wing torsion

All at 90, 60, 30, 5 and 0 deg In
Wing Bending Using Symmetrical Collective Inputs
Wing Chord Bending Using Symmetrical Longitudinal Cyclic
Wing Torsion Using Longitudinal Cyclic
AW609 AIRSPEED vs. NAC ANGLE: POWER ON
ENVELOPE EXPANSION VTOL/CONVERSION MODE TEST POINTS ON
FLUTTER CLEARANCE ENVELOPE

NACELLE ANGLE (DEG)

AIRSPEED (KEAS)

100% Nr and 105% Nr ON Down stop
1.15 VDCON On Downstop @100%Nr
255 kt

100% Nr and 105% Nr OFF Down stop

VDCON On Downstop @100%Nr(222 kt)

1.15 VDCON FLUTTER CLEARANCE SPEED

AgustaWestland Proprietary Information
APLN Mode Flutter Testing

AW609: POWER ON: AIRPLANE MODE/84% NR
ENVELOPE EXPANSION TEST POINTS ON
ALT VS VELOCITY FLUTTER CLEARANCE ENVELOPE

![Graph showing velocity versus density altitude with test points and flutter clearance speed](image-url)
Category A Testing (On-going)

- Will use OEI training mode for testing with minimal actual OEI validation points
- Validated OEI training mode with run-stand engine failures at maximum power
- Takeoff and landing profiles developed in AW609 simulator
- First cut at TDP / LDP heights determined on simulator

AW609 OEI performance is enhanced by:

- Moving softstop
- Optimal rotor RPM
- Super droop
Takeoff Profiles developed in Simulator

**Take-Off Decision Point (TDP)**

- **TDP = 40ft**

**Accelerate to**

- **$V_{TOSS}$ (45KIAS)**

**Continued T/O**

- **$75^\circ$**

**Gear-Up**

**+ve ROC @ $V_{TOSS}$**

**Above 1500ft AGL:**

1. Go-around with roll-on landing
2. Convert & proceed to alternate

**Accelerate to $V_Y$ (75KIAS)**

- $\geq 200$fpm ROC / 3% gradient

**400-1500ft AGL**

- $\geq 1500$fpm ROC / 1.2% gradient

**85-90°**

**85-90°**

**15ft min.**

**35ft**

**400ft**

**Take-Off Distance**

**Technique OK for MTOW @ ISA**

AgustaWestland Proprietary Information
All Engine Inoperative – P/Off Entry Into Autorotation

Tiltrotor capability to safely handle a dual-engine failure emergency in normal cruise Demonstrated in flight May, 15th 2009

Airplane mode gliding

Rapid Reconversion

Airflow keeps rotors turning

Airflow inversion with respect to the rotors

Helicopter Autorotation

Flare before touchdown

Airflow keeps rotors turning

The Tiltrotor stops descending
Autorotation Testing (November 2013)

- First stage will review previous testing (2009)
- Second stage will evaluate steady-state conditions of windmilling in APLN mode and autorotation in VTOL mode
- Third stage will look at transitioning to 95 degrees nacelle angle from 75 and from APLN at various GW, CG combinations
CONCLUSIONS
“A New Way to Fly”

- AgustaWestland is committed to the continuous improvement of the performances and the comfort of its helicopters at a reduced operating cost.

- The Tiltrotor solution is developed in parallel and as a complementary solution, not substitutive or competitive with future improved helicopters.

- The Tiltrotor provides fundamental operational step-changes and answers to the rotorcraft market demand: FASTER, FARTHER, WITHOUT RUNWAY.

- FAA Type Certification process with concurrent EASA Validation is ongoing with Type Certification Basis established since “day one” for AW609 design/safety/testing.

- System testing and Flight Testing are successfully proceeding in line with the Certification Plans.

AW609 is progressing towards the Type Certification.

AW609 is ready to pave the way to “A new way to fly”
Backup Slides
THE TILTROTOR

THE AW609 OVERVIEW

PROGRAM HIGHLIGHTS

CONCLUSIONS
The pursuit of High Speed VTOL solution

45 aircraft have flown over 45 years in an attempt to go fast without the need for runways.

Includes only aircraft built and flown with intent to enter production.

AgustaWestland Proprietary Information
Tiltrotor: a Proven Solution

Demonstrated Technology, Flying Reality and Achieved Operational Capability
Tiltrotor: the solution

Formula simplicity: same elements to produce lift in hover and thrust in forward flight

Architecture clearance: rotor is far from ground in VTOL operations

Ride quality: nacelles and engines far from cabin

Scalability: formula proven on a range of applications, from 1 ton UAV (Eagle Eye) to 30 ton tiltrotor (V 22)

Open performance potential: no immediate hard limits imposed by physics
THE TILTROTOR

THE AW609 OVERVIEW

PROGRAM HIGHLIGHTS

CONCLUSIONS
Performances and Missions

Utility

Transport Category VTOL
Elevated Helipad

ISA Day

250 nmi radius

2 Pilots + 9 Passengers
1980 lbs Passenger & Baggage Allowance

Reserves: 30 min. + 30 nmi

Design Speed-Altitude Envelope

True Airspeed (kts)

Pressure Altitude ft

-50 50 150 250 350

0 5000 10000 15000 20000 25000 30000

Airplane Mode
84% Nr

VTOL/Conversion Mode
100% Nr

AgustaWestland Proprietary Information
Program Highlights Certification Testing

Several Structural tests in progress or completed
All in accordance with Test Plans agreed with Civil Authority
Program Highlights Ice Protection System

Wind Tunnel

Ice Shape Definition

Horizontal Stabilizer – Ice Shape flight risk reduction testing

Artificial Icing Flight Test
Stall: new task for rotorcrafts, common for fixed wing

Stall has important implications on take-off and landing for fixed wing; it affects only airplane mode envelope for tiltrotor

Thick wing design, resulting from dynamics requirements, produces benign stall behaviour

Envelope expansion tests to define stall speeds and to introduce lift enhancements
Program Highlights
Carefree Maneuvering through FCS

High Flapping Protection

Low Speed Regime
SEMI - ACTIVE

CPMS limits control to reduce flapping

High Speed Regime
ACTIVE CYCLIC

Cyclic input to reduce flapping with high roll rate

CPMS - Control Power Management System

Max Flapping constrained by structure

Gimbaled rotor 11 deg flapping limit
Total hub flapping held below limit during aggressive maneuvering

Long Cyclic Command

Flapping/Cyclic deg

Carefree maneuvering activation at Low Speed Regime

CPMS system tuning verified in flight
Program Highlights
Downwash

Downwash is a relevant topic to be considered for VTOL operations.

With respect to helicopter higher disk loading causes higher induced velocity.

However symmetrical rotors plus the wing produce sweet spots useful for rescue operations.

Analytical and experimental tests performed to assess SAR operations.

Operating results are comparable with higher class helicopters.
THE TILTROTOR

THE AW609 OVERVIEW

PROGRAM HIGHLIGHTS

CONCLUSIONS