Future Rotorcraft Technology Needs

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• What makes a rotorcraft competitive?
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Why R&T for Rotorcraft?

Rotorcraft market characteristics

- Small fleets
- Diverse applications
- Demanding environments
- Complex product
- New era of advanced configurations
- Competing with FW for supply chain influence

Technology leader, collaborator or follower?

Technology may enable the product but it does not sell it
Technology Development Enabling Product Competitiveness

Product & Service Development
Design, Manufacture & Delivery

Competitive Solutions

Market Needs & Concerns, Legislative Requirements

Product & Service Differentiators, New Concepts

Enabling Technologies, Manufacturing Capabilities, Skills & Knowledge

Technical Risks, Immature Knowledge, Technology Challenges

Research & Technology Development

OEM

SMEs

Academia

Other Industry
General Technology Strategy

- Focus PV investment on developing competitive products;
- Little direct investment in speculative research
- Scout globally for promising generic enabling technologies
  - Novel materials
  - Innovative manufacturing techniques
- Guide academia and ROs engaged in low TRL research projects towards developing technologies with good exploitation potential
  - Coordinate using the UK Vertical Lift Network
- Exploit generic emerging enabling technologies into rotorcraft-specific applications
UK Vertical Lift Network (VLN)

A national network comprising industrial, scientific and academic organisations with a shared coherent vision to...

... inspire, grow and protect the rotorcraft sector within the UK
What makes a Rotorcraft Competitive?
Diverse Applications

CORPORATE VIP
OIL & GAS
EMS
SAR
LAW ENFORCEMENT
UTILITY
Diverse Applications

Emphasis on

• Comfort – minimum cabin noise and vibration
• Speed
• Cabin space and layout
Diverse Applications

Emphasis on

- Payload range
- Cost per passenger seat mile
- All-weather operations
- Marinisation features
- Cat A performance from elevated heli-decks
Diverse Applications

Emphasis on

• Operational serviceability

• All-weather day-night

• Cabin space and accessibility

• Cost of ownership
Diverse Applications

Emphasis on

- Operational serviceability
- Payload range / endurance
- All-weather day-night ops
- Mission reliability
- Sophistication of flight automation (SAR modes)
- Winching capability
Diverse Applications

Emphasis on

• Cost of ownership
• External noise

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Diverse Applications

Emphasis on

- Cost of ownership
- Versatility of cabin configuration
- External cargo capability
Universal Considerations

Maximising Safety
- HUMS diagnostics/prognostics
- Systems reliability
- OEI performance
- Run-dry transmission
- Fault and damage tolerance
- Ditching/flotation performance
- Crashworthiness
- Ease of emergency egress
- Advanced training systems

Minimising Environmental Impact
- Noise
- Emissions
Product Differentiators – Civil Market

**Operational Capability**
*Payload, Range, Endurance, All Weather Operation, Speed*

**Cost of Ownership**
*Availability & Maintainability, Acquisition & Direct Operating Costs*

**Safety**
*Reliability, Survivability, Flaw Tolerance*

**Comfort**
*Vibration, Internal Noise, Cabin Environmental Control*

**Environmental Impact**
*CO₂ & NOₓ Emissions, External Noise*
Military Market Perspective

Key issues identified by Dstl for military rotorcraft (excluding mission systems) include:

• Means of reducing cost of ownership

• Means of reducing logistic footprint and improving operational availability

  ➢ “towards the maintenance-free deployed helicopter…”

• Benefits vs risks of advanced configuration rotorcraft

• Increasing levels of automation; reduce pilot workload, improving safety
Capability vs Cost – Trade Space

Cost (acquisition & through-life)

Capability

Current technology boundary
A very broad multi-dimensional parameter, collapsed to a single measure of capability, as perceived by a particular customer.

Incorporating, for example, measures of:
- Performance
- Productivity
- Comfort
- Safety
Capability vs Cost – Trade Space

Also a multi-dimensional parameter, incorporating, for example, measures of:

- Acquisition costs
  - Equipment
  - Infrastructure
  - Training
- Direct and indirect operating costs
  - Fixed annual
  - Usage-based variable
Capability vs Cost – Trade Space

- Capability
- Cost (acquisition & through-life)

- Current technology boundary
- Future technology boundary
- Design space
- Design point

Increasing VFM
Product Development Strategy
Why Rotorcraft? Why Vertical Lift?

Rotorcraft
- Smaller, lower cost, infrastructure & real estate requirements
- Proximity to urban centres
- Convenience
- Unique, desirable, operational capabilities

Fixed Wing
- Large, expensive, infrastructure & real estate requirements
- Distance from urban centres
Product Development Categories

AgustaWestland

**Speed, Range**
- High Speed Tiltrotor

**Versatility**
- User-Friendly Conventional Helicopter

**Automation**
- RW UAV, Automated R/C
New Generation Conventional Helicopters

Increasing use of composites
- Improved strength/weight
- Reduced maintenance

Trends towards
- Electrical actuation
- FBW

Emphasis on
- Reduced direct operating cost (DOC)
- Improved reliability and availability
- Reduced pilot workload – “carefree handling”
- Improved comfort – reduced cabin noise and vibration
Advanced Rotorcraft Configurations
Advanced Configuration Rotorcraft – Faster, Smoother

Altitude (ft)

Speed (kts)

Turboprop FW

Tilt-Rotor

Compound

Helicopter

Cabin Pressurization Required
Major new investment programme to develop **Next Generation Civil Tilt Rotor (NGCTR)**

- Cruise speed 300+kt @ 25,000 ft
- Long range 700+ nm

Part-funded under the EU Clean Sky 2 Fast RotorCraft (FRC) Programme
Next Gen CTR – Technology Challenges

Multidisciplinary optimisation (MDO) of whole aircraft architecture

Optimal architecture, materials and manufacturing techniques for
• Rotors – high twist, high strain
• Wing – complex dynamic loading

Design for X
• Manufacturing cost
• Operational serviceability & COO
Unmanned Air Systems

SW-4 “Solo” Optionally Piloted Helicopter

• 5 hrs endurance / 320kg payload at 1.8T MTOW
• Remote Engine Start-up/Shutdown capability
• Auto Take-off / Landing capability
• Integrated FMS/FCS
• Ground Control Station
• Line Of Sight data-links
  - Command & Control and Mission System
• Lost Link management
Generic Challenge for Rotorcraft Technology

**Operational Serviceability and Productivity**
- Minimise scheduled downtime
- Eliminate unscheduled AOG
- Perfect in-flight reliability of mission critical systems
- Maximise aircraft utilisation

**Affordability**
- Acquisition cost
  - Development NRC
  - Unit recurring costs
- Fixed Operating Costs
  - Maintenance manpower
  - Support infrastructure
- Variable Operating Costs
  - DMC, R&O
  - Fuel & consumables

**Capability vs Cost**
Can we close gap between FW and RW?
Rotorcraft – Mechanical Complexity
Main Gearbox and Rotor Head
Main Rotor Hub – Example of Construction

- Hub
- Tension Links
- Blades
- Bonding Leads
Main Rotor Hub – Example of Construction

- Glass Fibre Shell
- Titanium Splined Hub
- Lag Damper Mounts
- Inner Loop Windings
- Outer Loop Windings
- Top and Bottom Flanges
Main Rotor Blade – Harsh Operating Environment

For an intermediate/medium size helicopter, typical main rotor blade statistics...

- Rotational speed: ~300 rpm (5Hz)
- Transonic tip: ~ Mach 0.9
- Centripetal acceleration at tip: ~ 800g
- Centrifugal tension at blade root: ~250kN
- Blade lead/lag: +10°/-9°
- Blade flap: +18°/-7°
- Strain mid-spar: ~750µε +/- 1500µε
Main Rotor Blade – Harsh Operating Environment

Many conflicting design challenges with exacting technology demands:

- Vertical lift performance (HOGE)
- Speed and agility
- Safety and efficiency
- Low noise, low vibration
- Aeroelastic stability
- Protection against erosion, corrosion, water ingress
- Icing protection
- Lightning protection

Main rotor system – hub, controls and blades – is major driver of whole-life-cost and operational availability
Main Rotor Blade – Typical Construction

- Blade Tip Cap
- Trailing Edge Upper Skin
- Leading Edge Fairing
- Blade Spar
- Trailing Edge Honeycombs
- Trailing Edge Lower Skin
Rotorcraft Serviceability & COO - Challenge Summary

- Rotorcraft performance very sensitive to weight budget
- Use of simplex mechanical systems
- Constrained design margins for critical systems: structures, transmission, rotor systems
- Material selection and processing dominated by strength/weight criteria
- Harsh environment: debris, icing, salt water, vibration (self-inflicted)
- Susceptibility to: erosion, corrosion, fatigue, delamination, impact damage, component wear, etc.
- Dependence on thorough inspection, HUMS, accurate prognostics, etc.
- Cost and practicality of replace or repair
- High-cycle usage spectrum; frequent system stressing
AW Technology Programmes & Priorities
AW Technology Development Priorities

1. **Tilt-Rotor** technology development

2. Technology exploitation for **selected system** capability development programmes (e.g. active rotors)

3. Exploitation of **key enabling technologies** to improve generic design, manufacture and test capabilities.

Targeted at improving the competitiveness of key **industrial capabilities**

- Whole rotorcraft design & manufacture
- Rotor systems (blades/heads/controls) design and manufacture
- Rotorcraft transmissions design and manufacture
- Rotorcraft avionic & electrical systems integration
- Through-life support
Whole Rotorcraft Design & Manufacture

- Helicopter and Tilt-Rotor Aeromechanics
- Vibration prediction and reduction technologies
- Methods for reducing design lead time and errors
- Flexible, Low Cost aircraft and component assembly processes
  - Reducing the time and cost of assembly and increasing flexibility to incorporate change
  - In conjunction with HVM catapults
- Application of Advanced Materials to Rotorcraft
  - Targeted exploitation of new materials and processes to reduce weight, cost and development time
  - “Design for X”
Rotor Systems  Design and Manufacture

• Advanced Blade Design for Low Cost
  ➢ Innovative design and manufacturing techniques,
  ➢ Exploiting new materials technology
    o Significant unit cost reductions
    o Unique prop-rotor requirements

• Exploitation of Active Blade Technologies
  ➢ Continuing active blade programme
  ➢ Develop full spectrum of potential benefits.

• Low-complexity rotor hubs and controls to reduce operating costs.

• Improved bearing designs/materials for longer life.

• Efficient blade inspection and production test methods
Transmissions Design & Manufacture

- Low Cost Transmission Systems
  - Targeted improvements in architecture and component design
  - Associated maintenance philosophy to reduce cost of ownership

- Damage monitoring and prognostics to increase TBO and MTBUR.

- Improved materials and lubrication systems in transmissions

- New manufacturing methods and machines(e.g. use of ALM)
Rotorcraft Avionic & Electrical Systems Integration

- Advanced cockpits and navigation/guidance systems
  - Increased automation
  - Aircrew workload reduction

- Advanced Power Management Systems
  - Maximise use of installed power
  - Power distribution levelling
  - Management of emergency power

- Exploration of power recovery/harvesting technologies
  - Reduce engine power demand from ancillary systems.
  - Focused on vibration energy as well as heat
Through-life Support

- Application to rotorcraft of latest monitoring/prognostics technologies to improve operational serviceability and reduce ownership costs.

- Complex system maturity testing processes

- Reducing cost and increasing availability through use of usage and maintenance data.
Finally...
R&T Engineer’s Perspective

- Market Needs & Concerns, Legislative Requirements
- Technical Risks, Immature Knowledge, Technology Challenges
- Product & Service Development
  Design, Manufacture & Delivery
- Market
- Enabling Technologies, Manufacturing Capabilities, Skills & Knowledge
- Product & Service Differentiators, New Concepts
A Typical Company Shareholder’s Perspective?

Market Needs & Concerns, Legislative Requirements

Product & Service Differentiators, New Concepts

Market

Product & Service Development
Design, Manufacture & Delivery

Enabling Technologies, Manufacturing Capabilities, Skills & Knowledge

Research & Technology Development

Technical Risks, Immature Knowledge, Technology Challenges
THANK YOU FOR YOUR ATTENTION