Future Rotorcraft Technology Needs

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UK VLN

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- Why R&T for rotorcraft?
- What makes a rotorcraft competitive?
- Capability vs cost – steering the R&T objectives
- Product development strategy
- Rotorcraft complexity – technology challenges
- AW technology priorities

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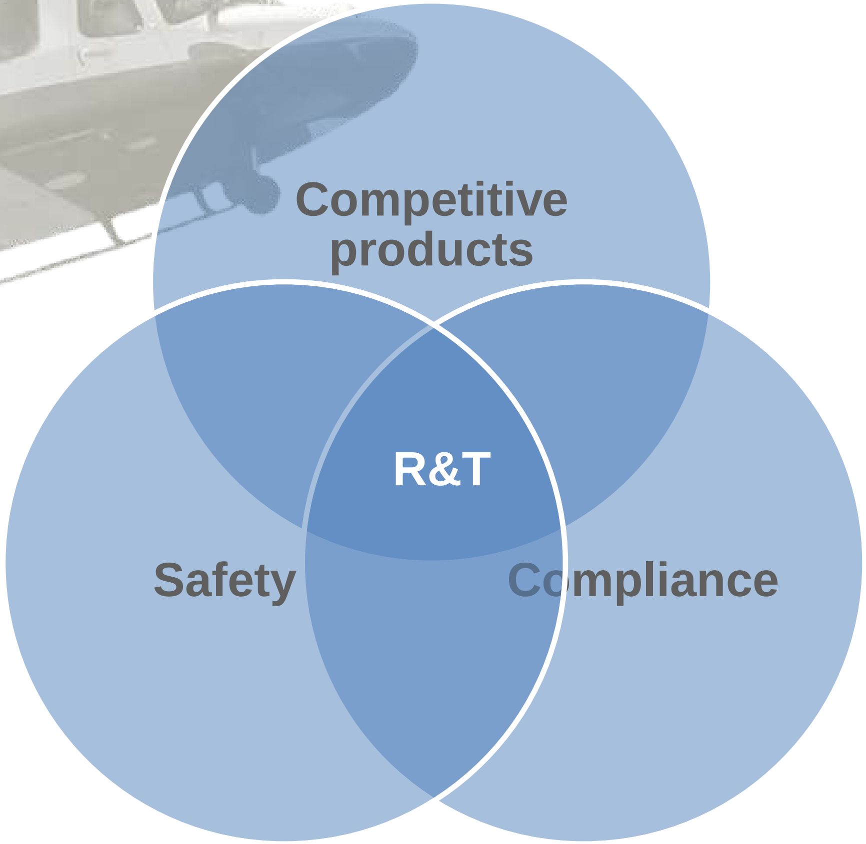
Why R&T for Rotorcraft?



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

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

University of Southampton

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University of Glasgow

University of Liverpool

University of Leicester

City University London

[dstl]

Manchester 1824 The University of Manchester

ARA

University of Bristol

University of Bath

What makes a Rotorcraft Competitive?

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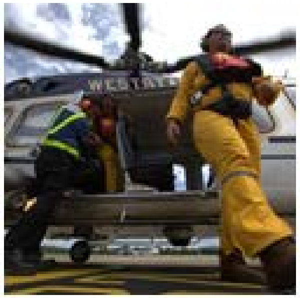
Diverse Applications


CORPORATE VIP

OIL & GAS

EMS

SAR

LAW ENFORCEMENT

UTILITY





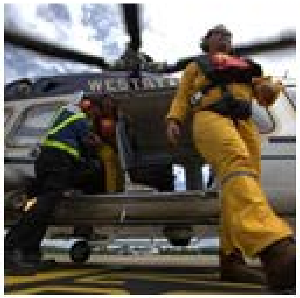

Diverse Applications

CORPORATE VIP

Emphasis on

- Comfort – minimum cabin noise and vibration
- Speed
- Cabin space and layout

Diverse Applications



OIL & GAS

Emphasis on

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

Diverse Applications

EMS

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
- Speed

CORPORATE VIP | OIL & GAS | EMS | SAR | LAW ENFORCEMENT | UTILITY

Diverse Applications

Emphasis on

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

CORPORATE VIP | OIL & GAS | EMS | SAR | LAW ENFORCEMENT | **UTILITY**

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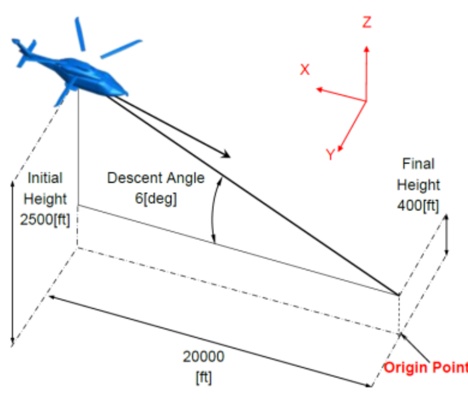
Universal Considerations

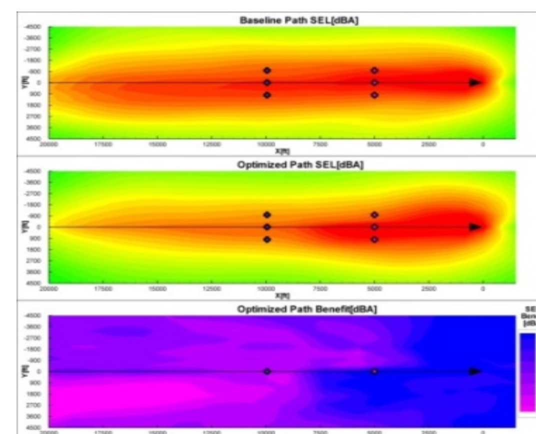
Maximising Safety

- 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

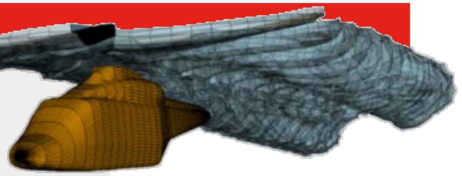




Product Differentiators – Civil Market

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

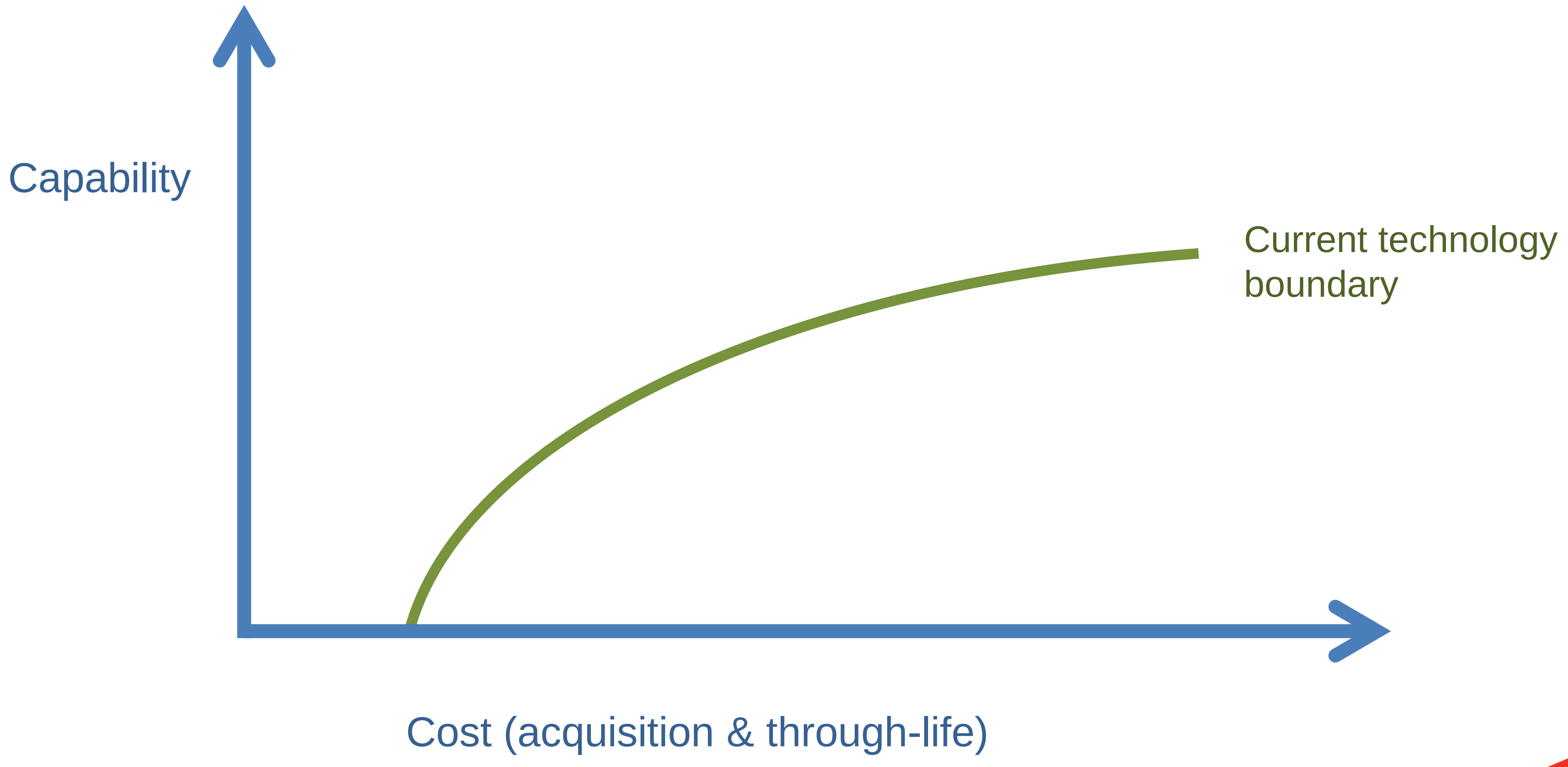
CO_2 & NO_x Emissions,
External Noise

Military Market Perspective

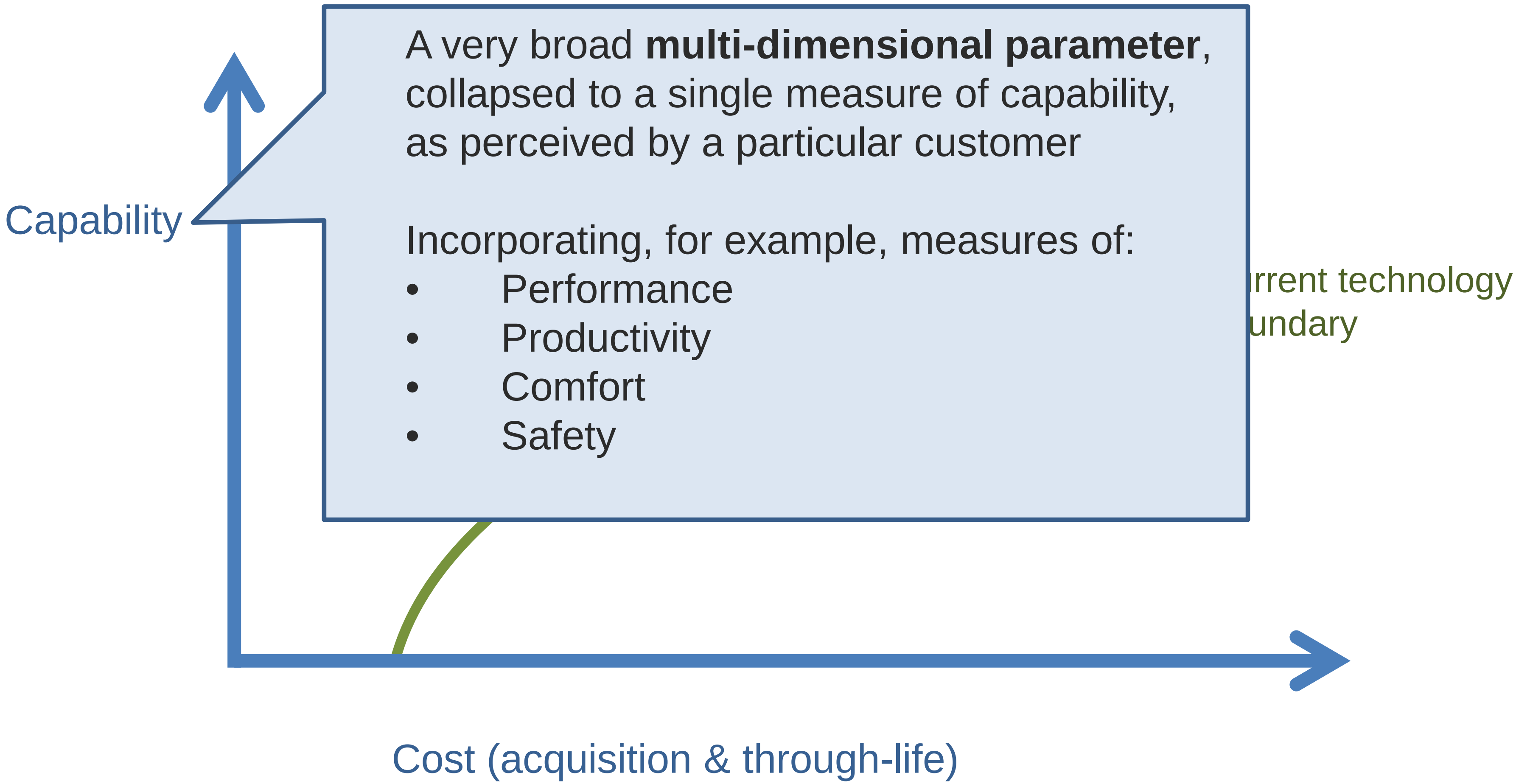
Key issues identified by Dstl for military rotorcraft (excluding mission systems) include:

- 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



Capability vs Cost – Trade Space



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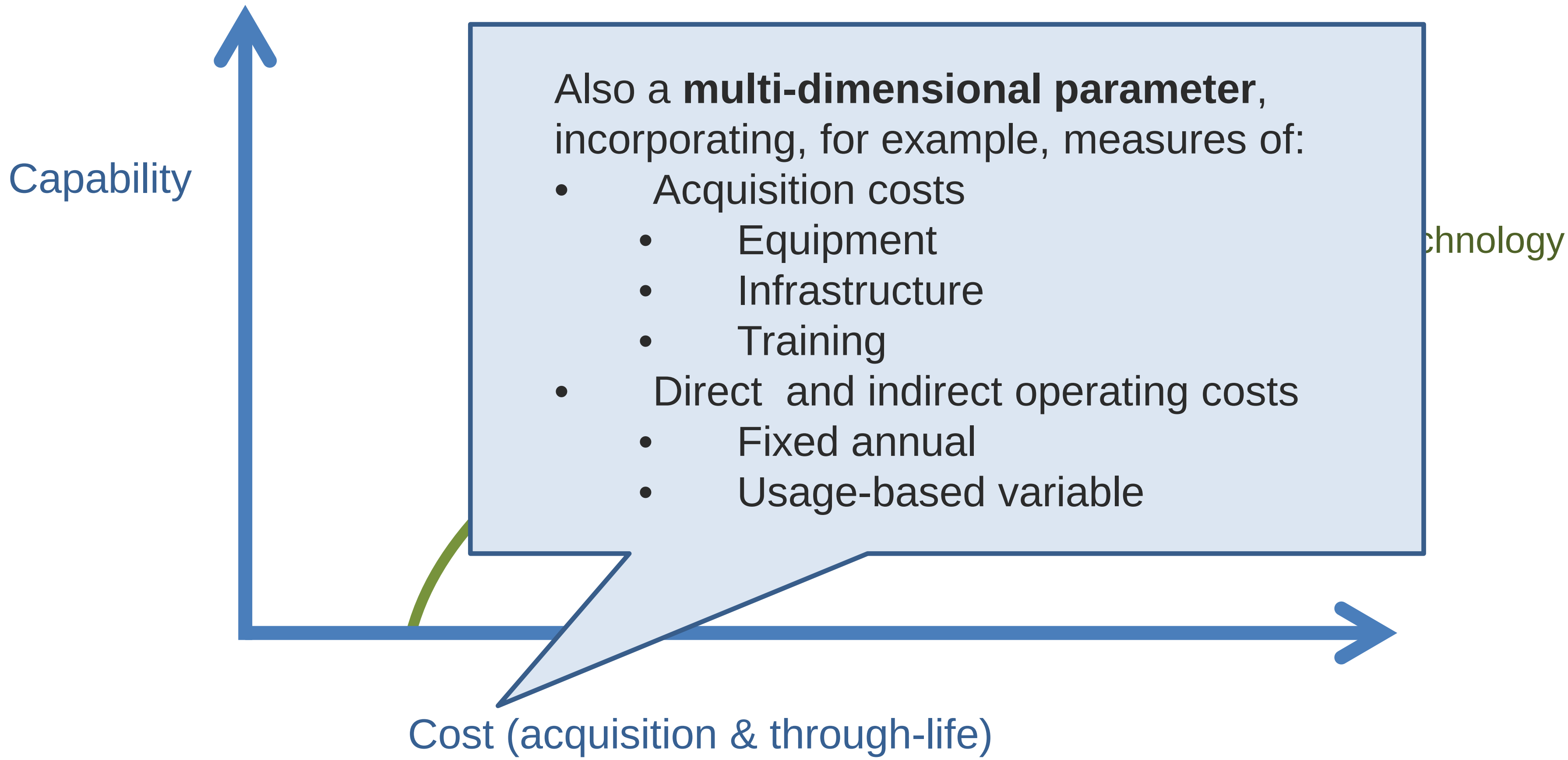

Also a **multi-dimensional parameter**, incorporating, for example, measures of:

- Acquisition costs
  - Equipment
  - Infrastructure
  - Training
- Direct and indirect operating costs
  - Fixed annual
  - Usage-based variable

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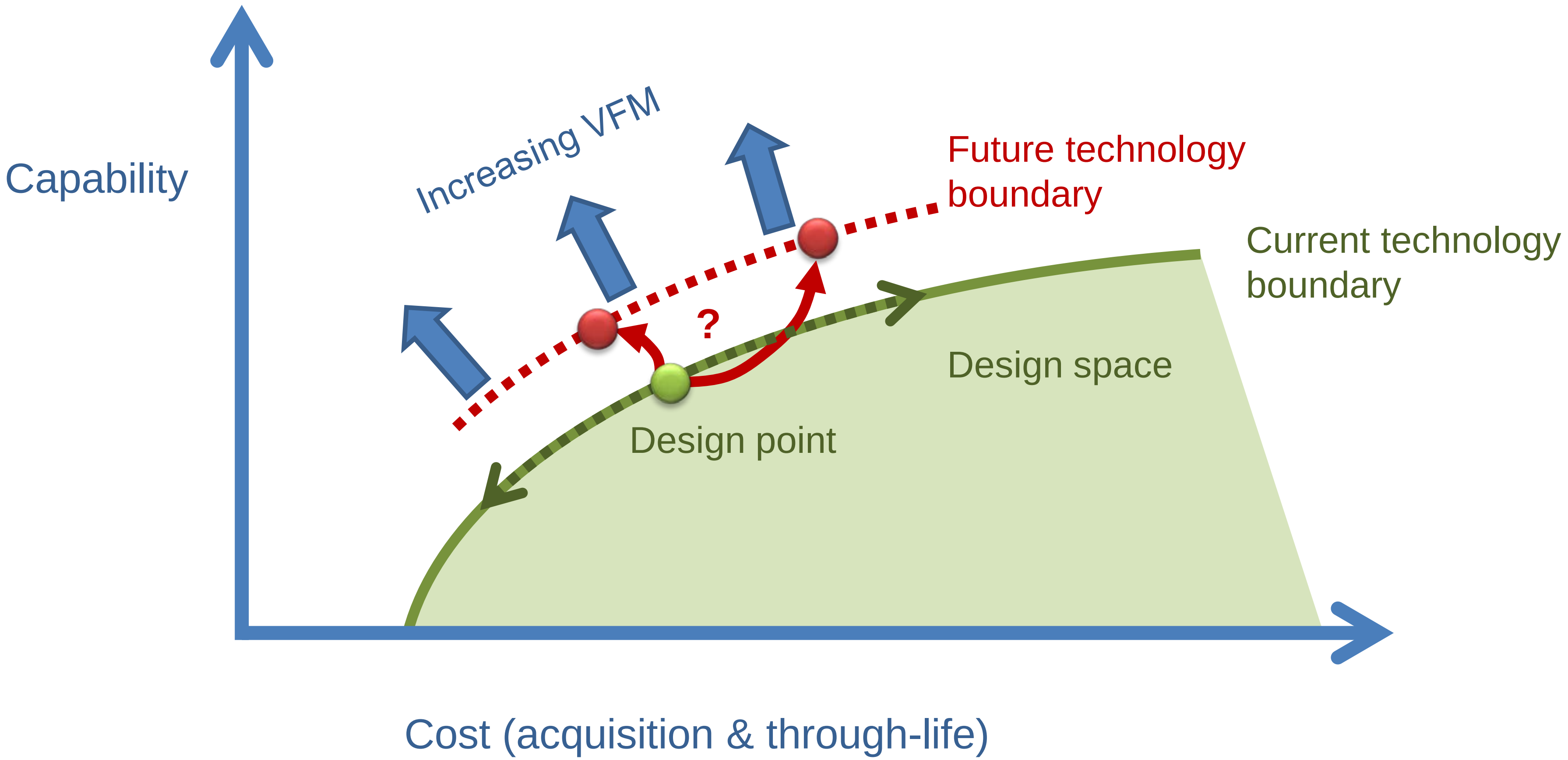
Capability vs Cost – Trade Space



Product Development Strategy

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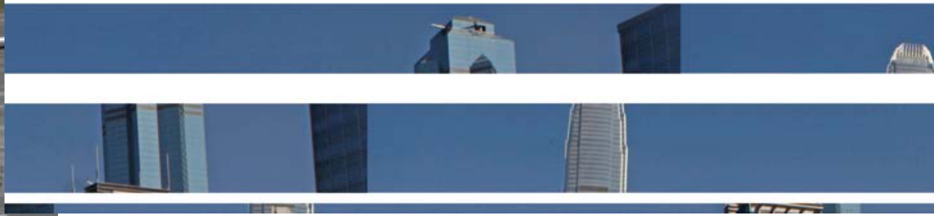
Why Rotorcraft?   Why Vertical Lift?



Fixed Wing

- Large, expensive, infrastructure & real estate requirements
- Distance from urban centres

Rotorcraft

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

Product Development Categories

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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

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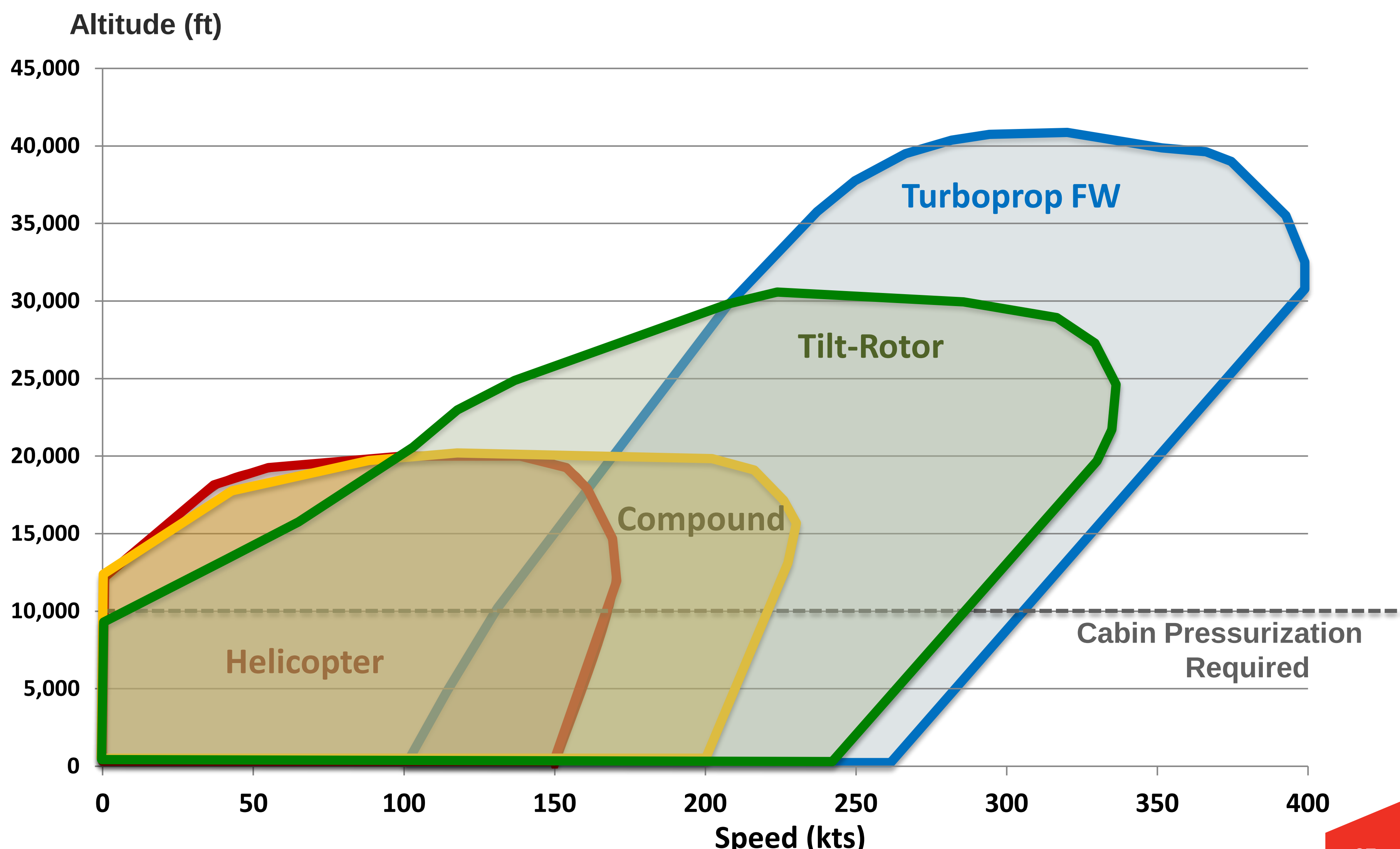
Advanced Configuration Rotorcraft – Faster, Smoother



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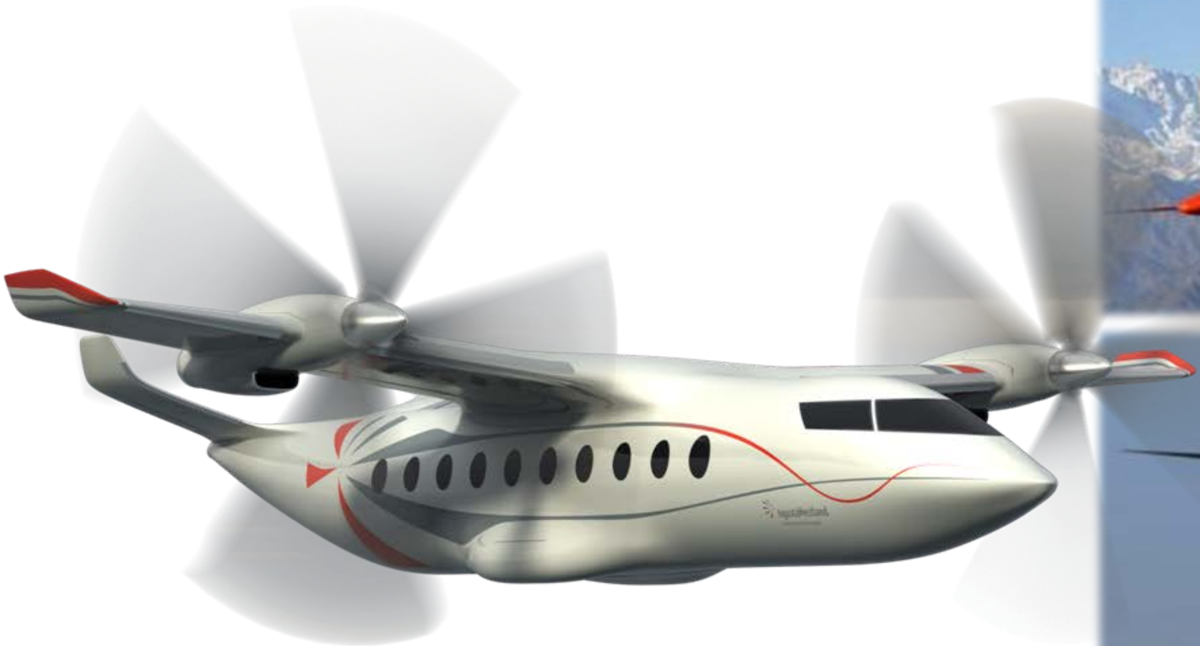
AW Tilt Rotor Aircraft

Currently completing the development and certification of the AW609



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

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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

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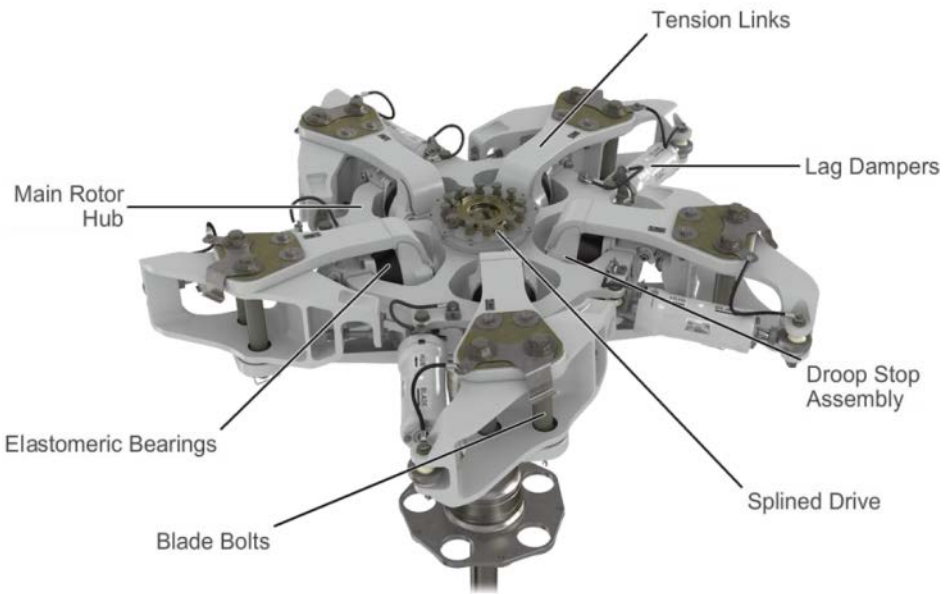
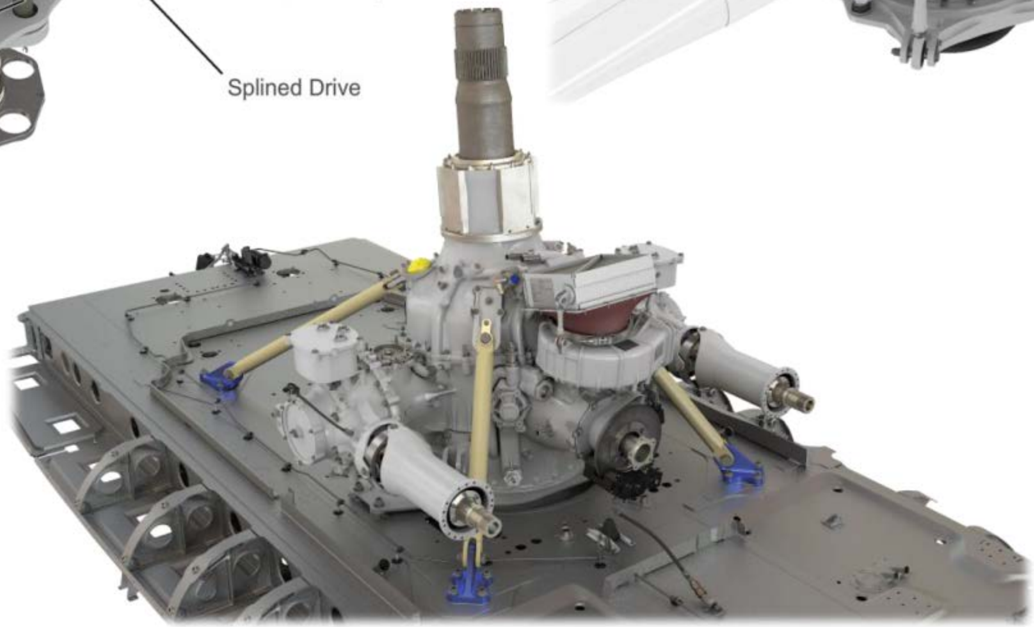
Main Gearbox and Rotor Head





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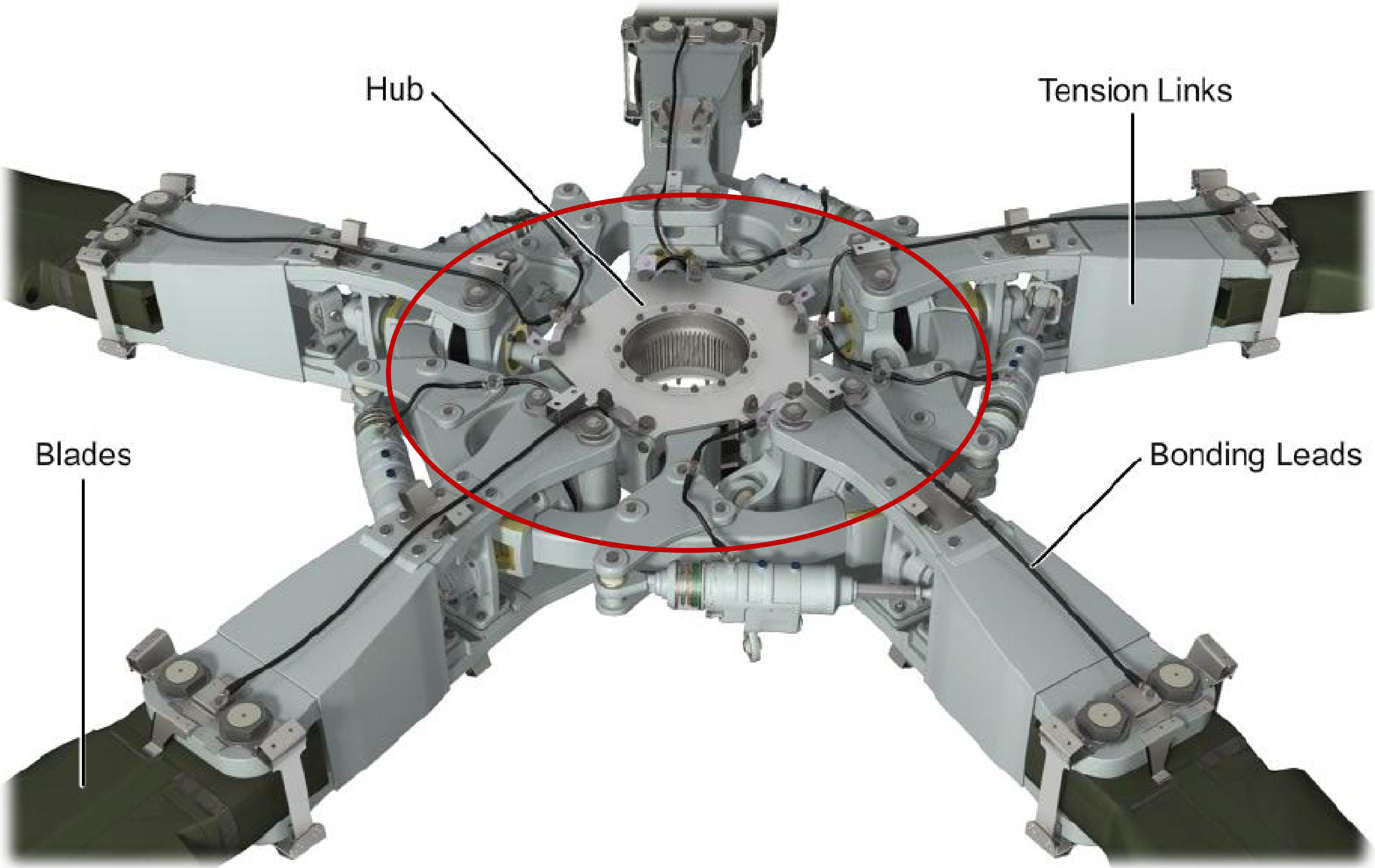
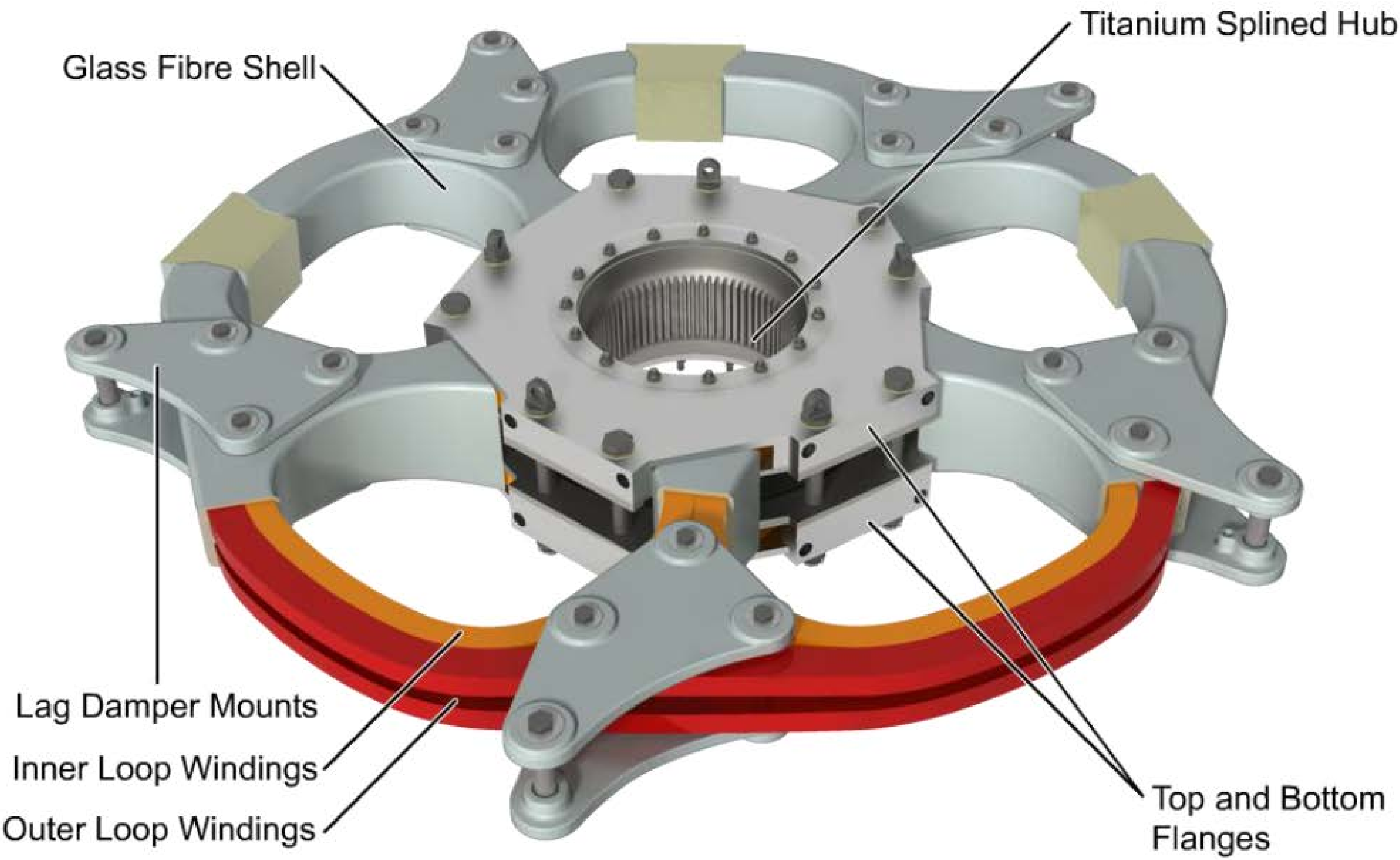
Main Rotor Hub – Example of Construction



Main Rotor Hub – Example of Construction



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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: **+10º/-9º**
- Blade flap: **+18º/-7º**
- Strain mid-spar: ~**750με +/- 1500με**

1/5 real time

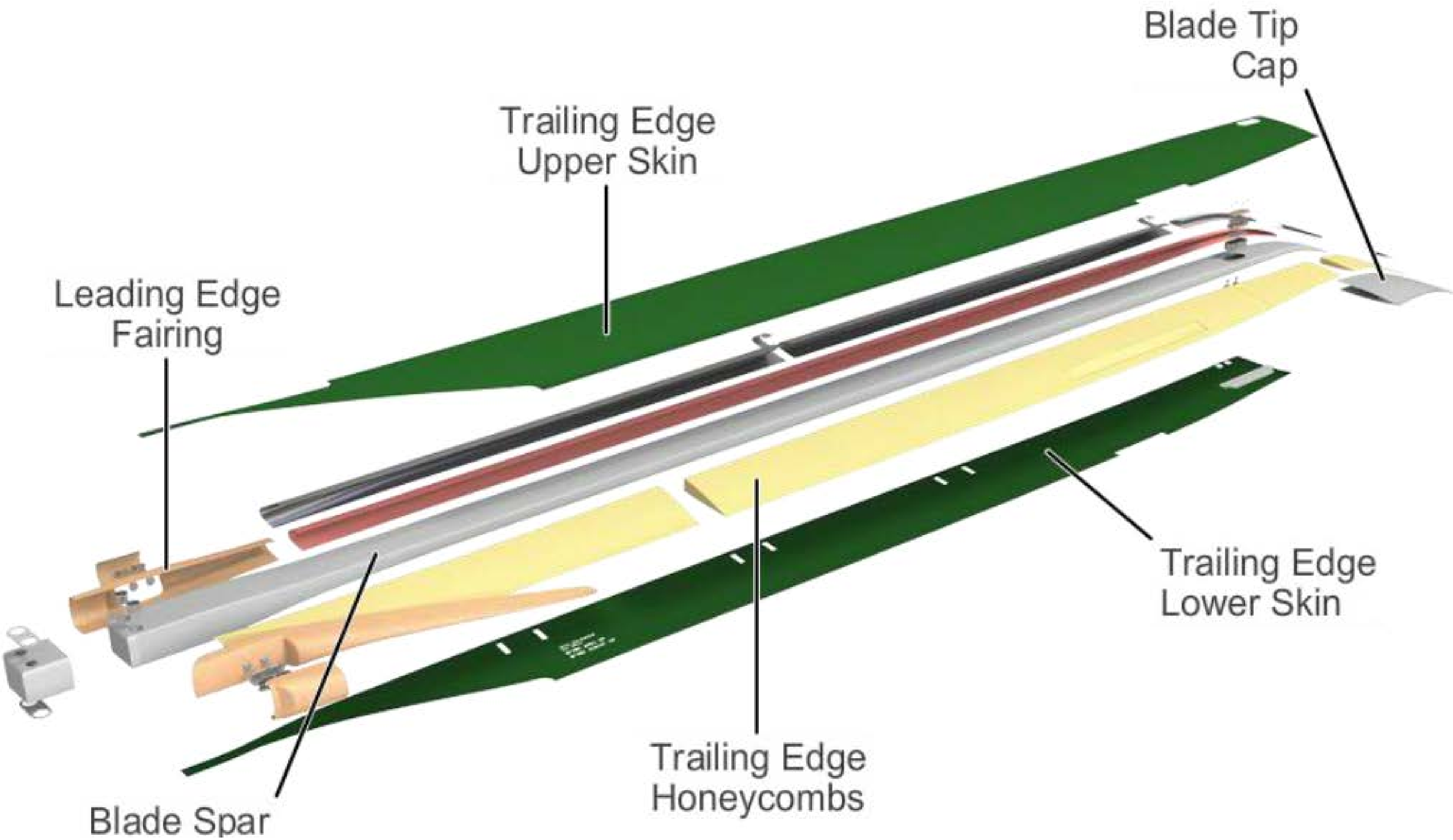
Main Rotor Blade – Harsh Operating Environment

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



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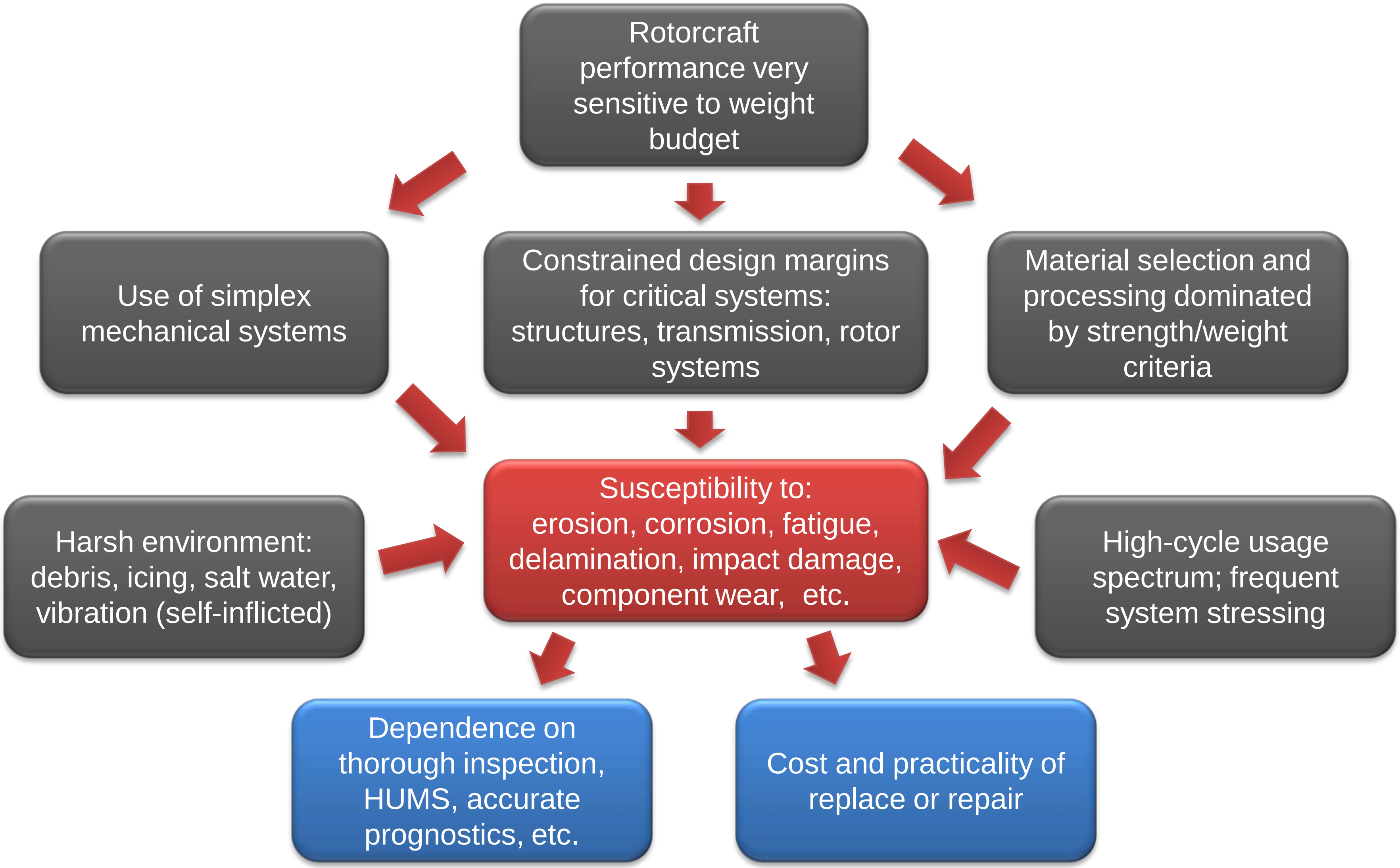
Rotorcraft Serviceability & COO - Challenge Summary



AW Technology Programmes & Priorities

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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...

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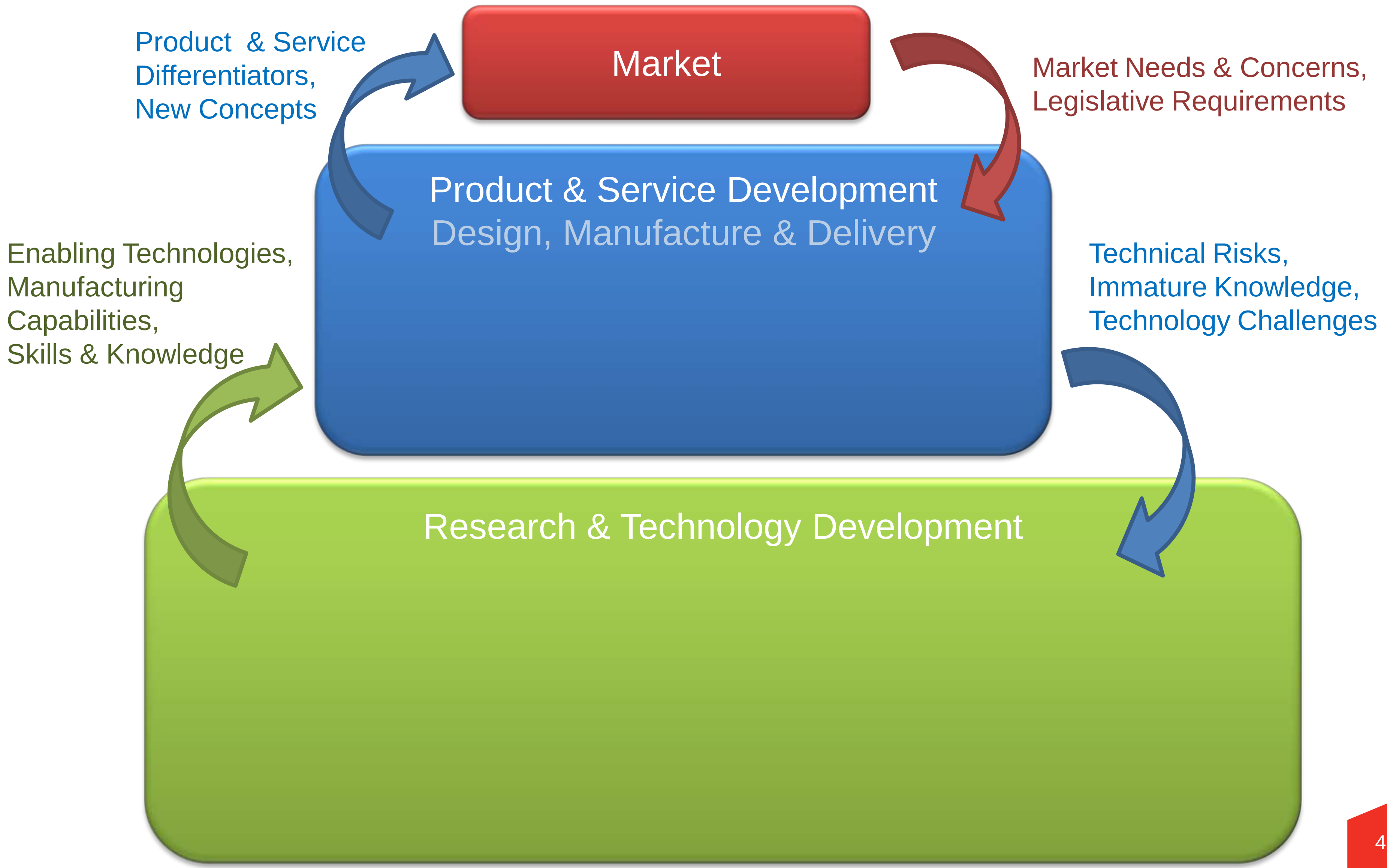
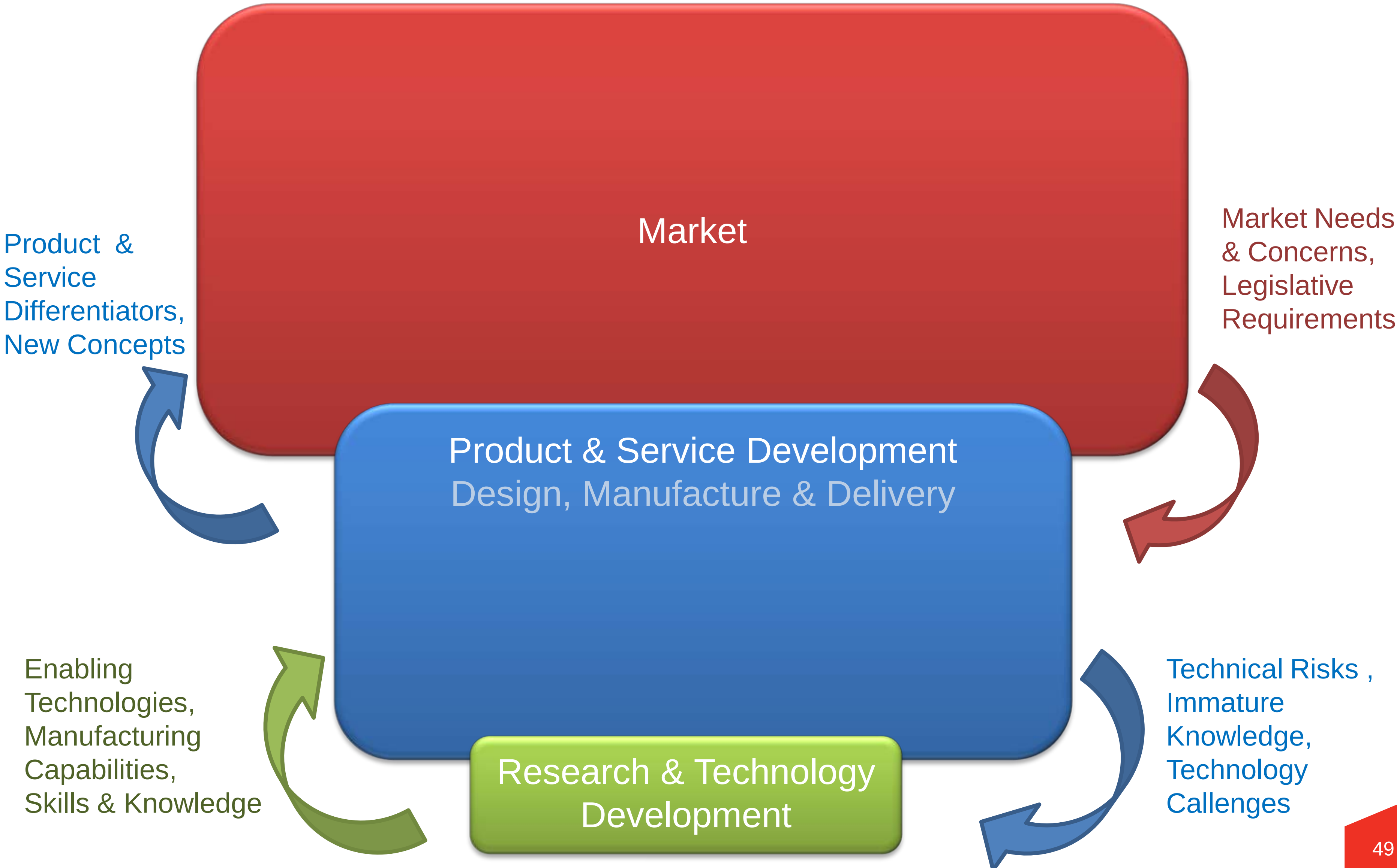
R&T Engineer's Perspective



A Typical Company Shareholder's Perspective?



THANK **YOU** FOR YOUR ATTENTION

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