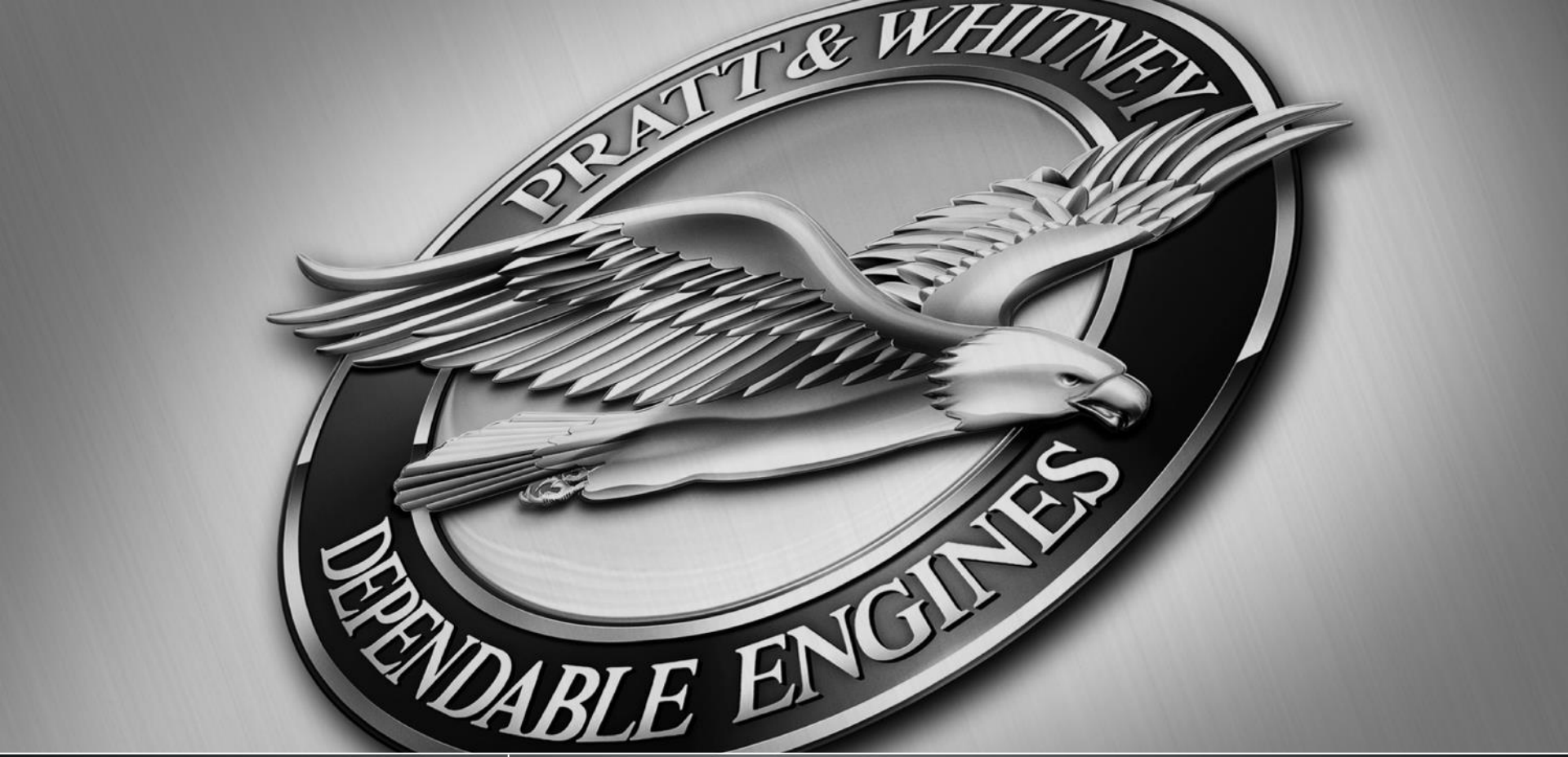


Pratt & Whitney Canada
A United Technologies Company

Aircraft Engine Sustainability

Life Cycle Environmental Impact Reduction

Russell Stratton
May 20th 2016

SUSTAINABLE

ENGINES | SUPPORT | INNOVATION | PEOPLE

EXPORT CLASSIFICATION

Check if presentation contains no technical data [X] or mark export classification below:

Classification	
1. Canadian ECL(s):	
2. ECCN(s):	
3. P-ECCN(s):	
4. USML (ITAR):	
5. P-USML:	

If unsure of classification, contact the originator of the information or your local BAER. For more details, please view the classification instructions.

A MAJOR CANADIAN EMPLOYER

Corporate headquarters
Engine development, production and aftermarket

GLACIER
Cold weather testing and research facility

Maintenance, Repair & Overhaul

Component manufacturing

Engine production

Thompson

Engine production
Assembly & test
Flight testing

Halifax

Altitude test facility with the National Research Council Canada

Mirabel
Saint-Hubert
Longueuil
Ottawa
Lethbridge

Engine development and production

Mississauga

GLOBAL SERVICE NETWORK

~**12,000**

In more than **200**

Some **52,000**

Our product stewardship challenge

GLOBAL CUSTOMER BASE

30+ major aircraft OEMs

EMPOWERING THE FUTURE

Business Aviation

PW300

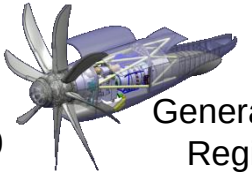
PurePower PW800

Helicopter Market

PW210

General & Regional Aviation

PT6A-140



Next Generation Regional Turboprop

PW127N

PW150C

Q400

Our sustainable product journey continues…

THE RISK IMPERATIVE

Long-term Environmental

- $ Political Instability
- $ Floods/Mudslides
- $ Wildfires
- $ Drought
- $ Storms Damage
- $ Dying Coral
- $ Infrastructure Loss
- $ Climate Refugees

- $ Biodiversity
- $ Glacier Loss
- $ Famine
- $ Water Scarcity
- $ Ecosystem Loss
- $ Political Instability
- $ Diseases
- $ Sea Level Rise

By 2050, Climate Change could cost Canada $21 – $43 billion per year

Regulatory Compliance

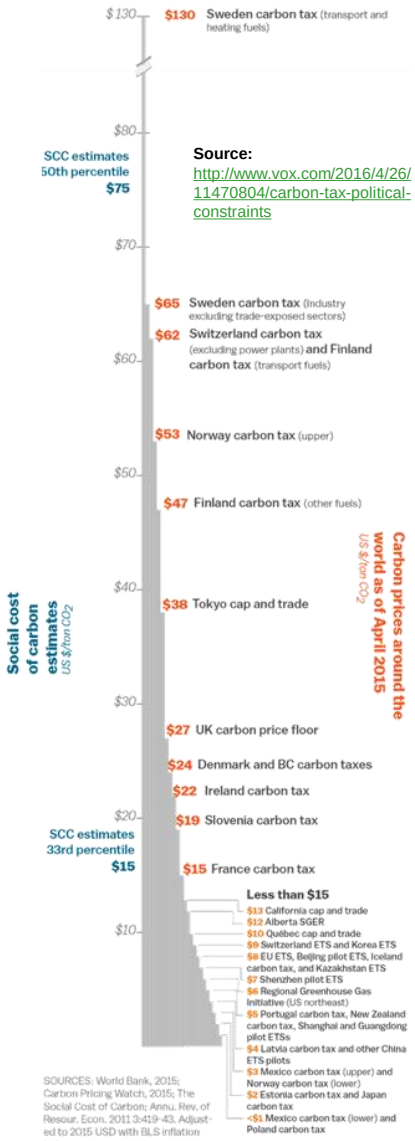
- NOx Standard
- CO2 Standard
- nvPM Standard

ICAO • OACI • ИКАО 国际民航组织 • ايكاو

REACH COMPLIANCE

Product and Operations

- Over 75% of Canadians live in a province with carbon pricing
- Carbon price growth is inevitable
- Customer operating costs (fuel and future carbon offsetting)
- Material price volatility and scarcity risk
- Manufacturing energy intensity and material efficiency



SUSTAINABILITY AND BUSINESS

88% of investors surveyed **see sustainability as an opportunity** for competitive advantage.

78% as a **differentiator in determining industry leaders**

91% believe that sustainability should be **better embedded into discussions between companies and investors**

88% believe that they should pay **greater attention to sustainability in company valuations**

Source: *United Nations Principles for Responsible Investment*

Data from over 10,000 mutual funds and 2,800 separately managed accounts over the last seven years indicate: investing in **sustainability has usually met and often exceeded the performance of comparable traditional investments**, both on an absolute and risk-adjusted basis across asset classes and over time

Source: *Morgan Stanley Institute for Sustainable Investing*

UTC INFLUENCE / ALIGNMENT

2020 Goals Released to Public

- ✓ UTC Continued Commitment
- ✓ PWC's Influence: Continue to Lead; UTC's "Sustainability Lab"

"The whole future of our company is really going to be based on two things: innovation and sustainability"
– Greg Hayes, UTC CEO (Feb 2016)

- ❑ Business Operations
- ❑ Products
- ❑ Suppliers

OUR 2028 VISION

Fleet Emissions

Significantly reduce our 52,000+ engine fleet impacts

Sustainable Products

Designed, manufactured and serviced to minimize impacts

Zero Waste Sites

All by-products 100% recycled

Carbon Neutral Sites

Only sustainable energy sources

Influence

Be a force for positive change

Be the best aerospace company FOR the world

2028 SUSTAINABILITY GOALS

Scope and Relationships

Sustainable Products
- Ecodesign
- Supplier sustainability
- MOCs in product
- Material intensity
- Design recyclability
- Take-back policies

Zero Waste
- Industrial recycling
- Domestic recycling
- MOCs in manufacturing
- Factory water consumption
- Non GHG factory emissions

Positive Influence
- Reputation
- Employee engagement
- Suppliers / partners
- Industry leadership
- Community engagement
- Corporate policies

Emissions
- Fleet emissions
- Fleet oil consumption
- Noise
- Alt. energy compatibility

Carbon Neutral
- Renewable energy
- Energy efficiency
- Operations GHGs

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LIFE CYCLE ANALYSIS (LCA)

Methodology

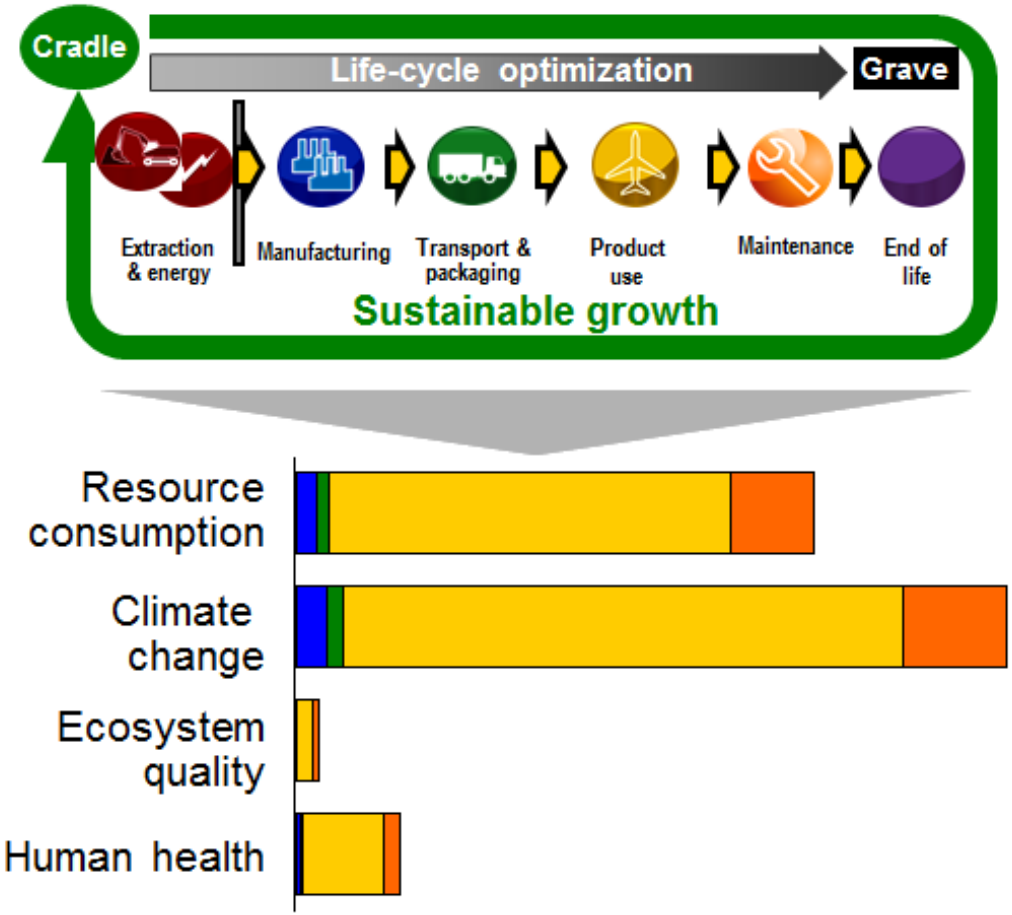
Assesses environmental impacts from material extraction to end of life

Can vary in scope (company to product to subcomponent)

Are used to identify the key environmental impacts (hotspots)

LIFE CYCLE ASSESSMENT

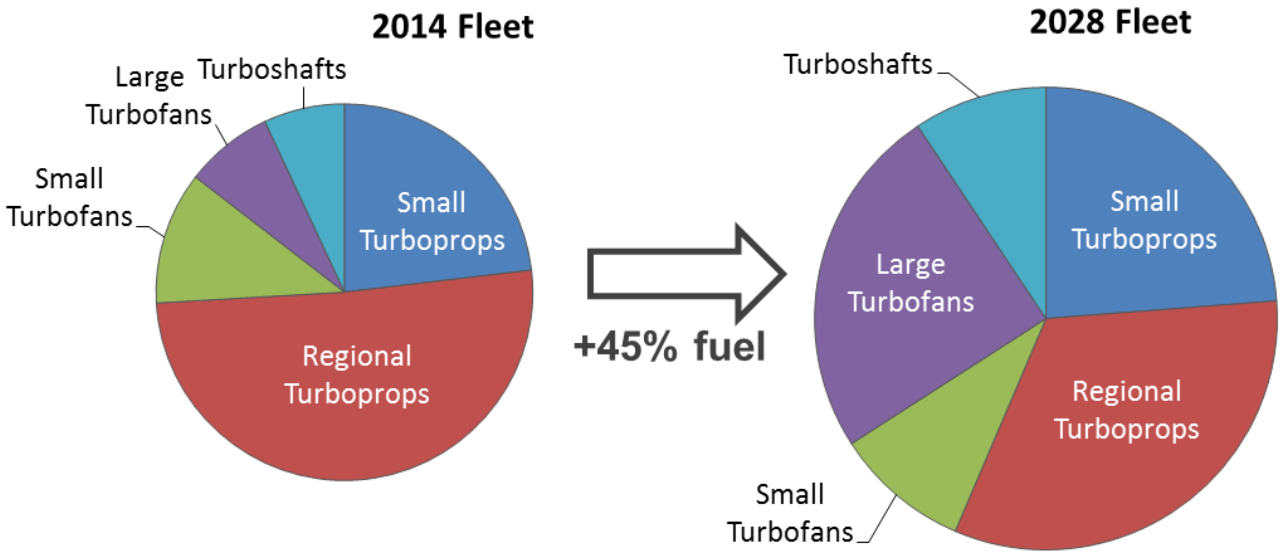
Company Level



Our footprint clearly extends beyond our four walls

FLEET EMISSIONS

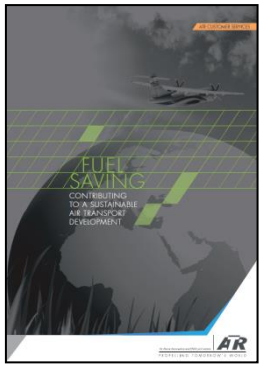
- P&WC sees significant future growth in fleet emissions

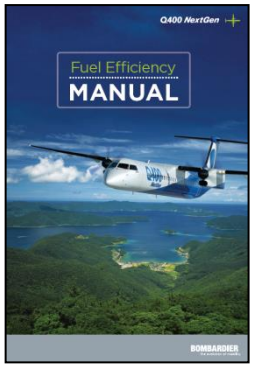


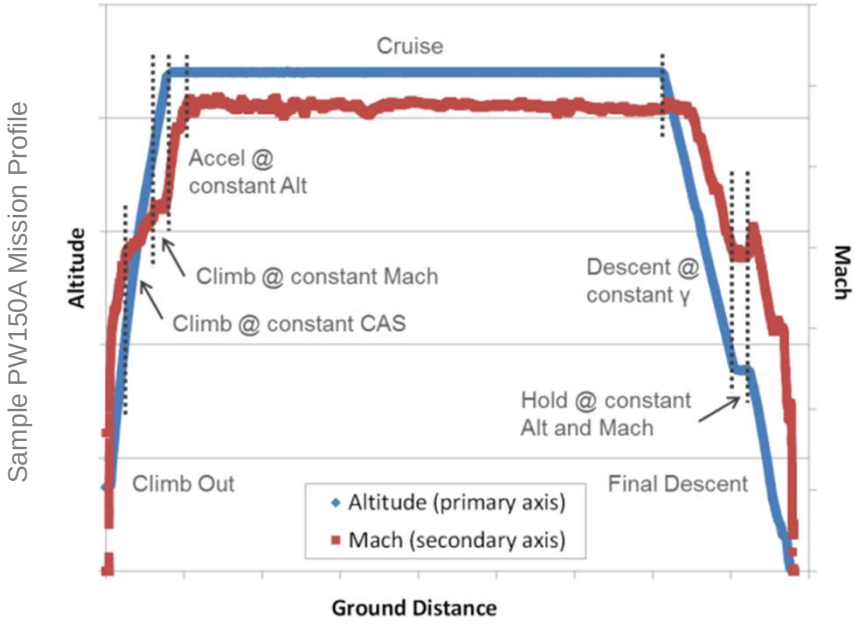
- P&WC fleet emissions reduction strategies include:
  New Product Introduction, Upgrades, Retrofits, Operational Efficiency
  - Operational efficiency: near-term lever to reduce fleet emissions
  - Indirect support: industry adoption of sustainable alternative jet fuels

OPERATIONAL EFFICIENCY

Fuel efficiency manuals

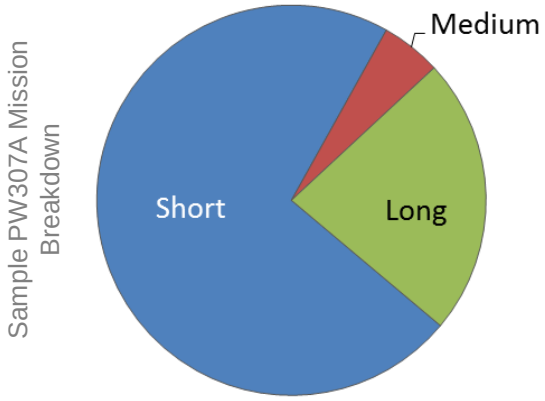






Analytics of aftermarket engine health management operational data

- By 2017, help customers identify more efficient operating practices through mission analysis and fuel burn trends



TECHNOLOGY DEVELOPMENT

Major Portion of Technology Portfolio links to Sustainability:

Additive Manufacturing

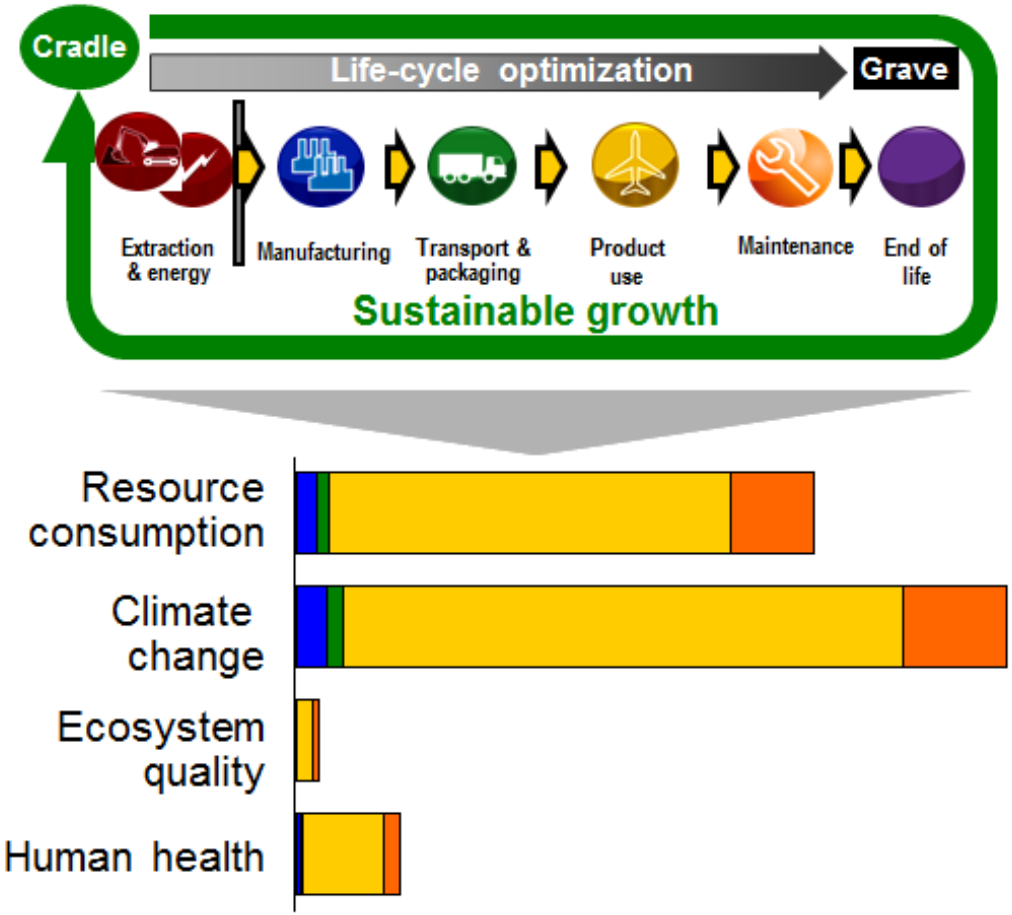
- Advanced Manufacturing (improved buy-to-fly)
- Improved fuel efficiency
- Materials of Concern elimination (REACH)
- Alternate fuels
- Advanced Combustion Technologies
- Oil Consumption reduction
- Noise reduction technologies
- Thermoplastics vs Thermosets
- Optimized aircraft operational algorithms
- Disruptive Technologies

Biofuel commercial Flight (GARDN)

Additive DPHM

LIFE CYCLE ASSESSMENT (LCA)

Company Level



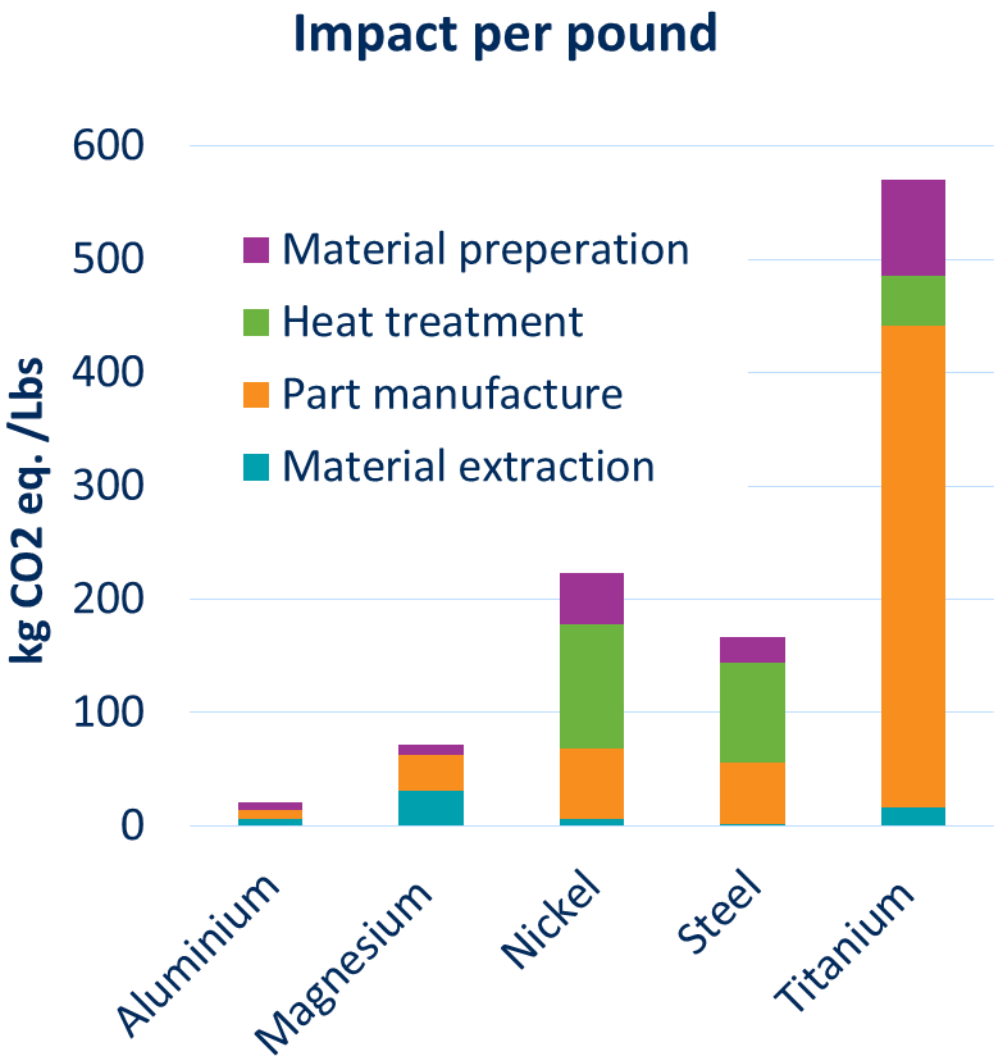
Our footprint clearly extends beyond our four walls

LIFE CYCLE ASSESSMENT (LCA)

Product Level

GHG impact heavily dependant on types and quantities of metals used

Carbon footprint of different metals depends on how and where they are extracted, prepared, heat treated, and machined



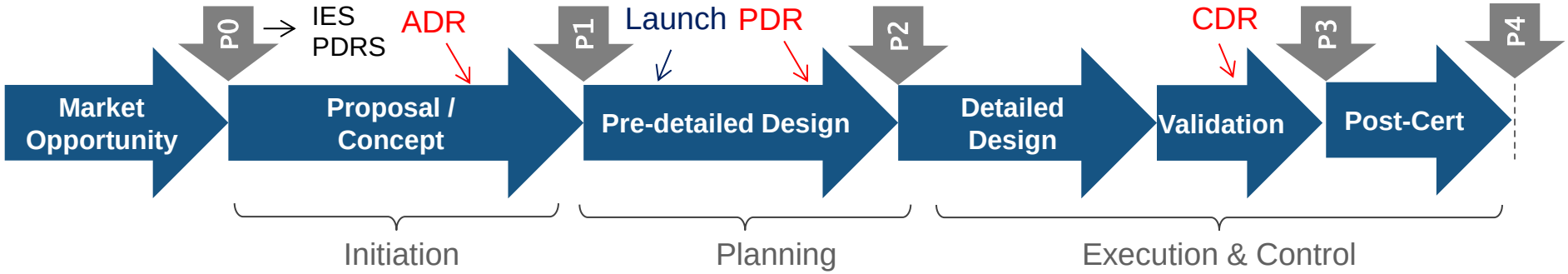
ECODESIGN – P&WC APPROACH

Through both **process** and **execution**

PROCESS

- Sustainable execution requires cascaded accountability down from leadership, to program leaders, to program execution, creating a mandate for day-to-day work

- P&WC is targeting its engineering standard work to build sustainability into our core business activities

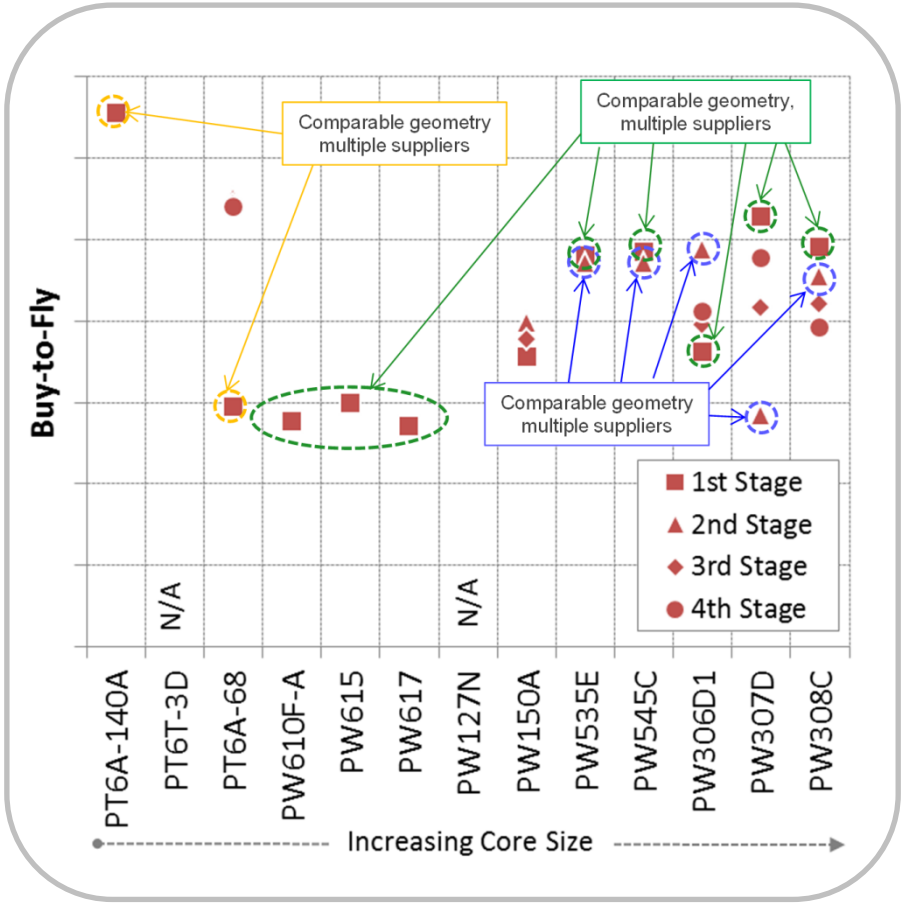


ECODESIGN – P&WC APPROACH

Through both **process** and **execution**

EXECUTION

- Environmentally focused design requirements
- Building capability and knowledge to explore trade space between eco-design KPI and conventional performance metrics
  - Supporting calculation methods, benchmarking, best-in-class standards
  - Significant potential improvements identified within existing products



END-OF-LIFE

A future business necessity

Alloy	Approx. Years Remaining
Titanium	72
Magnesium	1700
Aluminum	750
Nickel	42
Steel	83
Copper	36
Iron	69

- Price volatility (*medium term)*
- Supply stability *(long term)*

Approximately **2.3 million lbs of metal** reaches end-of-life **each year** in overhaul and retirement of P&WC engines

Waspaloy

- HP disks
- LP disks
- PT disks

Titanium

- Blisks
- Fan blades
- Impellers
- Tis shafts
- Diffusers
- HPC Cases

Inconel – Nickel - Cobalt

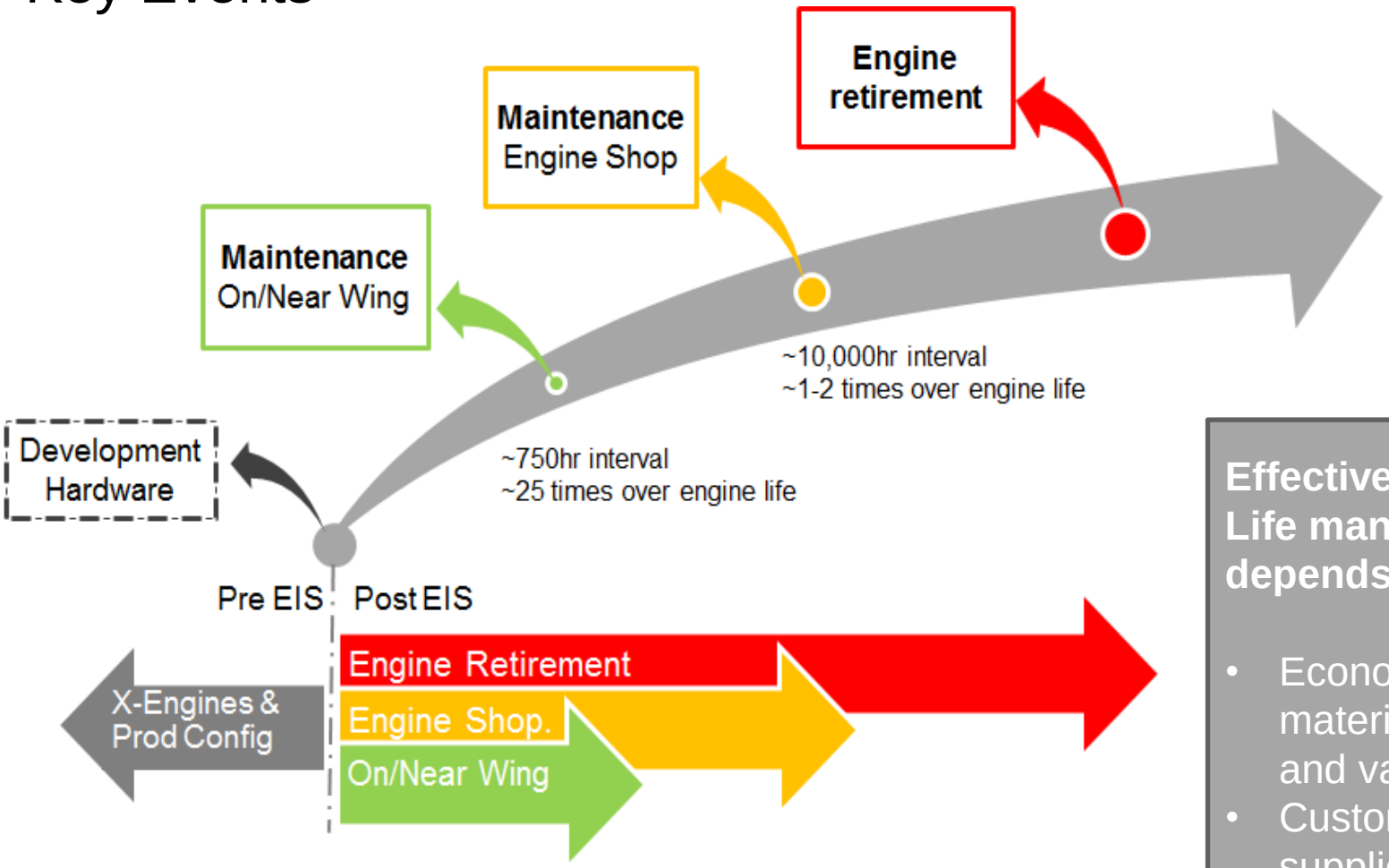
- Cases
- Blades
- Shrouds
- Stators
- Vanes
- C.C liners
- Exhaust

Ferrous Metal

- Mg Hsg
- Cases
- LP Shafts
- Stators
- Small parts

END-OF-LIFE

Key Events



Effective End-of-Life management depends on:

- Economics of material recovery and value
- Customer and supplier contracts

BEST PRACTICES AND KEY PROCESSES

WINNING BEST PRACTICES

I. Management Commitment

II. Aggressive Targets & Assignments

III. Embedded Processes & Protocols

IV. Proven & Continuous Return

V. Clear & Consistent Communication

VI. Company Wide Engagement

VII. Dedicated R&D / Innovation

Corporate Strategy

- Compelling Vision
- R&D
- Impact metrics and tracking
- Sustainable development structure

Individual Contributors

- Employee Performance Reviews
- Dedicated resources
- SD Champions
- Training programs

Business Processes

- Budgets
- Green process improvement
- Supply Chain Management
- Standard Work
- Design metrics and targets

Making Sustainability Stick – A Worthy Challenge

“When you are being asked to make the business case for sustainability..
..perhaps ask them to make the business case for being un-sustainable”

Ray Anderson

1934 - 2011