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The Challenge for ODS Materials: An Industrial Gas Turbine Perspective.

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Drivers & Requirements for Industrial Gas Turbines

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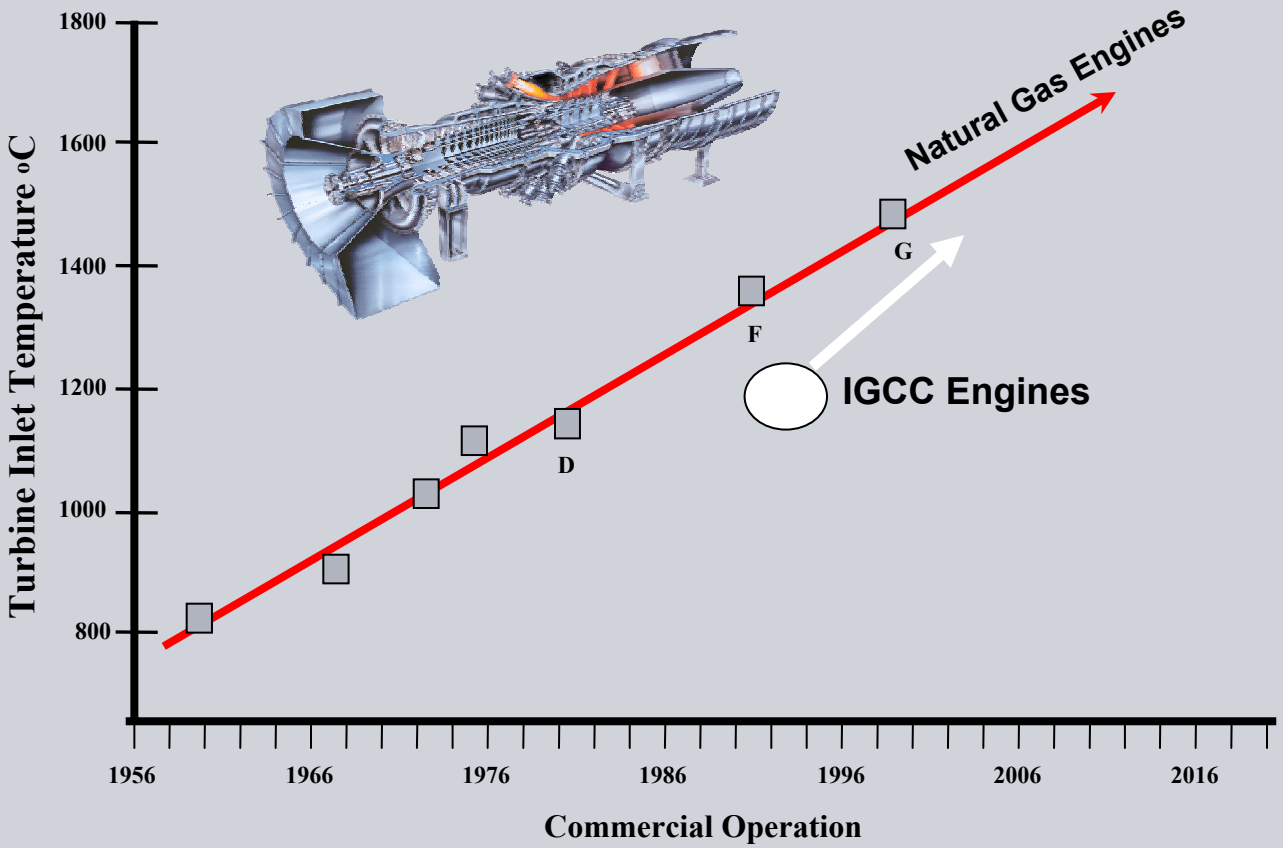
Business drivers/ Customer requirements

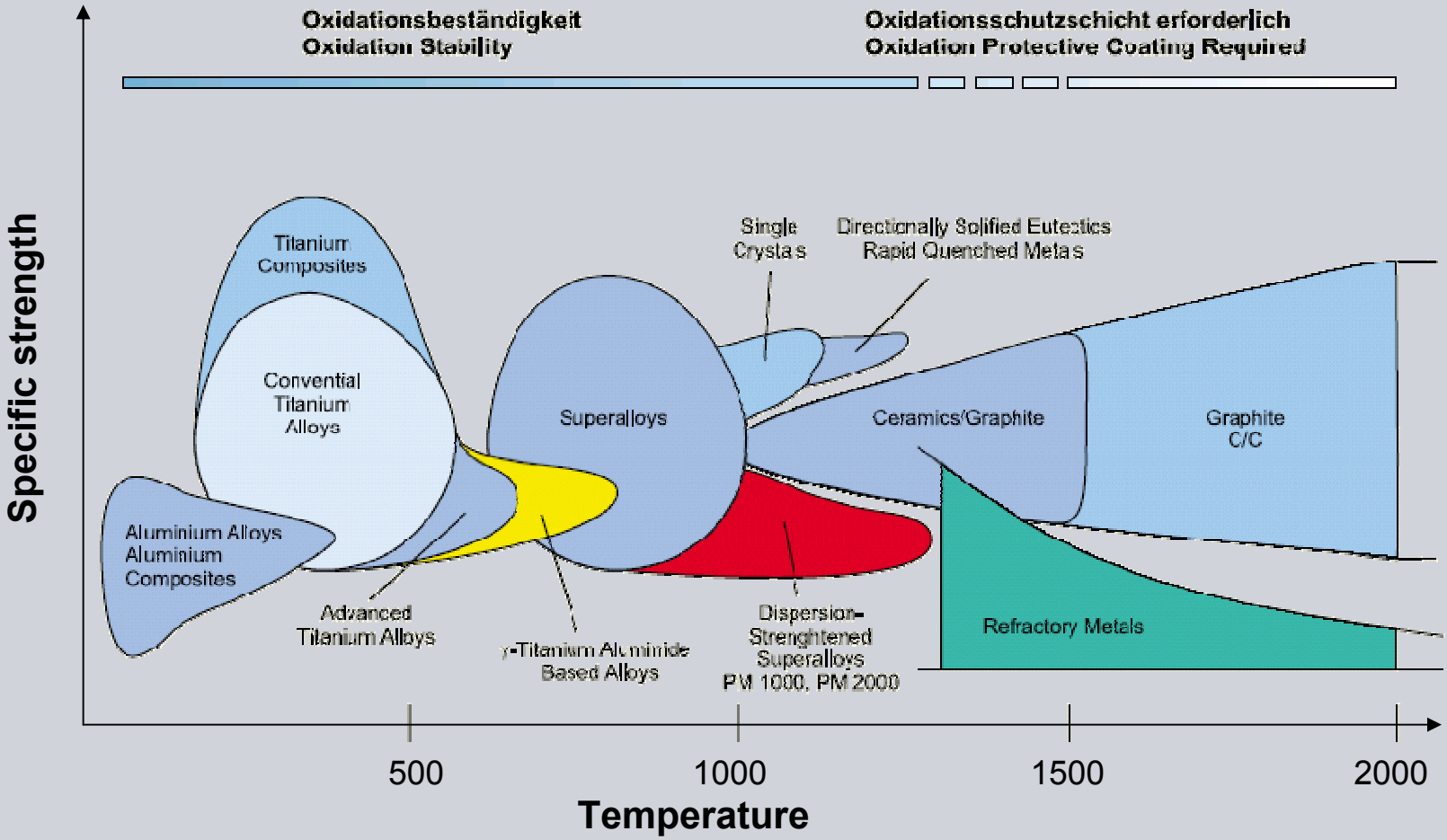
Cost
- First cost
- Life cycle cost
- Operation cost

Performance
- Plant power
- Plant efficiency

Capabilities
- Emissions
- Operational flexibility
- Regulatory compliance
- Upgradeability
- Reliability, availability
- Time-to-market



The Potential of ODS Materials



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The Message (from the Materials Engineer)

ODS alloys exhibit excellent oxidation and corrosion resistance, along with outstanding creep resistance at temperatures of up to 1300 °C

The Interpretation (by the Design Engineer)

- ODS alloys are expensive
- ODS alloy have poor properties (except oxidation, corrosion & creep resistance).
- ODS alloys are difficult to manufacture
- ODS alloys can not be repaired

“The first thing you hear about a new material is always the best”

The Design Perspective

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- Wherever possible, a Designer will use an existing validated alloy in preference to new material.
  - Minimize risk: experience, current design philosophy
  - Minimize lead time: existing materials properties database
  - Lowest cost: existing materials properties database
- Will consider a new material only once the other alternatives have been explored and exhausted.
  - Coatings
  - Cooling scheme (geometry, film cooling, etc.)
  - Other conventional alloys
  - Additional cooling, etc.

Don’t under estimate the “The Comfort Factor”

What Drives the Introduction of a New Material?

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The Chicken and the Egg

What drives the successful introduction of a new material into the gas turbine?

- The availability of a new material (the egg), or
- The component design (the chicken)

“Technology Push” versus “Technology Pull”

Integrated Approach

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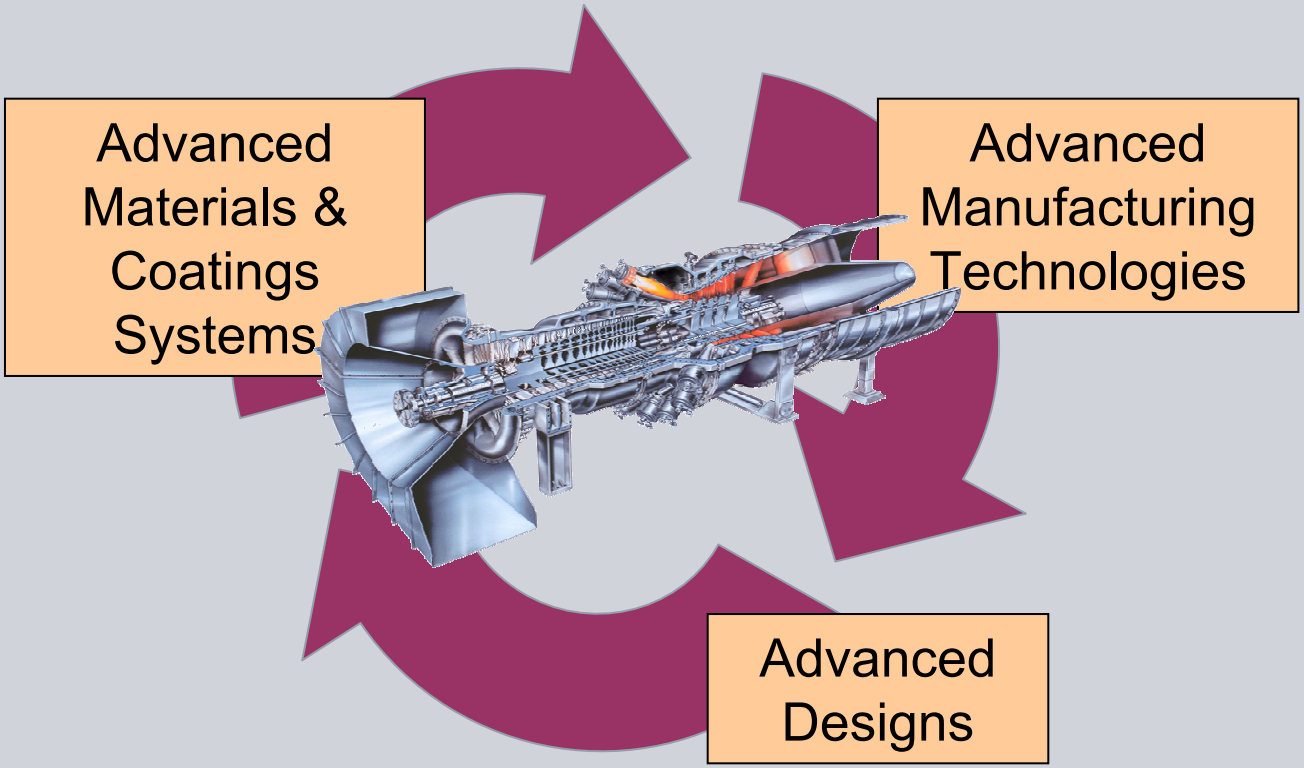

Innovative Manufacturing Technology: Bridging the Gap

Manufacturing & Supply Considerations

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- Material cost
- Material availability: Ability to source locally on globally basis
- Sole Source Concerns:
  - Lack of competition (price)
  - Stability – labor disputes, political issues, etc.
  - Acts of God – fire, severe weather, earthquakes, etc.
- Manufacturing base: experienced vendors (e.g. machining, joining)
- Inspection:
  - Non Destructive Inspection
  - Acceptance criteria – composition, mechanical, microstructure
- Vendor qualification and surveillance
- Compatibility with other materials – CTE; joining; wear
- Re-work and non-conformance – scrap rates

The Future for ODS Alloys

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Critical Questions for ODS Implementation

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What can you do?

- Develop components or sub-components that take advantage of the attributes of ODS alloys.

By when?

- Good question – commercial availability of ODS alloys?

What difference will it make?

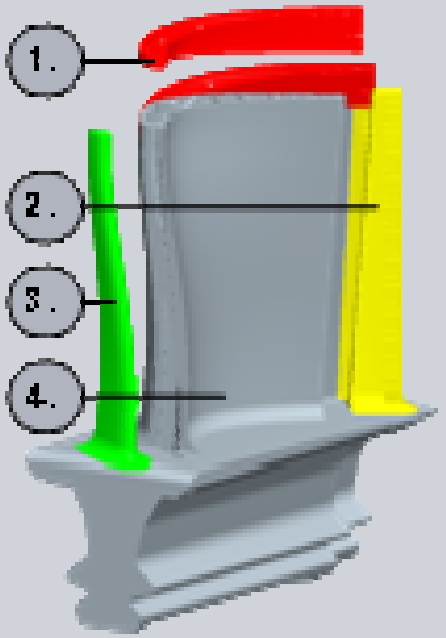
- Greatly improved materials system performance: 5x increase in TBC spallation life compared with SOA gamma prime strengthen superalloys

What makes you think that you can do it?

- Modular component design
- Additive manufacturing technologies

Modular Component Design: Potential Advantages

- Addresses manufacturing limitations
- “Expensive” manufacturing processes maybe cost effective for smaller sub-components
- The individual sub-components / segments can be offered with different properties to match specific component section needs (leading edge, airfoil tip etc.)
- Advanced but costly materials could be selectively used where they are needed, or where specific disadvantages do not limit their use.
- Rapid prototyping: an individual section of the part can be redesigned or upgraded to fulfill a specific need.
- Reduced fall-out rates after service: Repair of blades / vanes by sub-component replacement may be possible.



Challenges of Modular Components

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- Joining of dissimilar materials
- Differences in thermal expansion
- Cooling air leakage
- Wear at interfaces
- Fit-up of individual parts – machining tolerance
- Additional manufacturing operations
- Development and qualification of vendor base

Key Success Factors

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Concurrent Engineering Approach

Materials Engineering
- Adequate materials data for preliminary design
- Validated properties for final design
- Materials system benefits

Design Engineering
- Tangible benefit: balance risk with reward
- Appropriate design and lifing rules

Manufacturing
- Guaranteed supply base
- Robust processes: Quality; on-time delivery

Service
- Qualified repair processes

Thank you

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