

Rolls-Royce Strategy & Developments in AM

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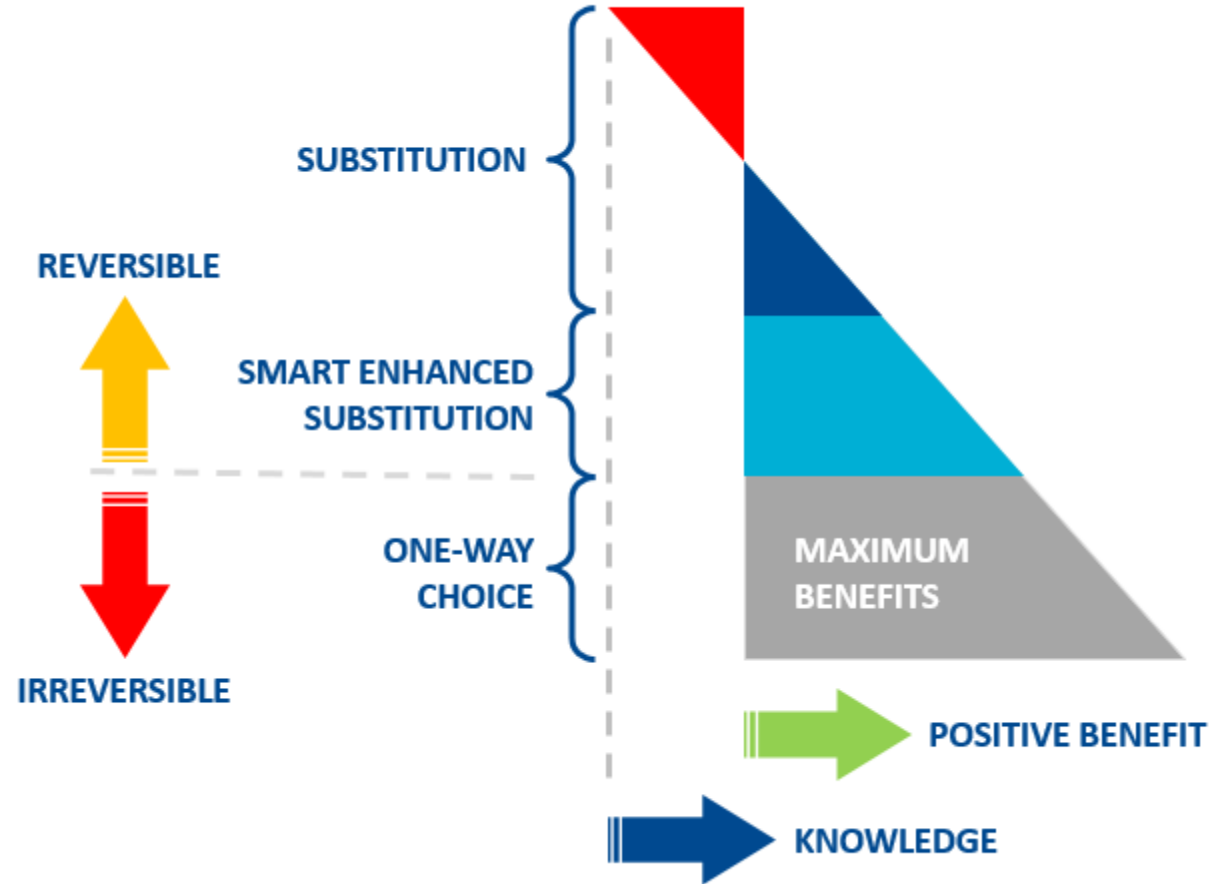
AM Equipment & Product Introduction

- **First Laser Powder Bed Fusion (L-PBF) capability installed in Rolls-Royce Nuclear in 2008 - 200W, 250x250x250mm system**
 - **Manufacture of rig components and Material / Parameter development**
- **2013 - Second L-PBF capability installed to meet increasing development work volume – 400W, 250x250x320mm system**
- **2015 - Third L-PBF capability installed to establish pre-production cell to go from development into production – 400W, 250x250x320mm system**
- **2017 - 4th, 5th and 6th systems installed to meet further increase in R-R programme demands**
- **2018- 7th system planned**
- **No AM components in service in pressure boundary applications**
- **Current focus on material testing and the manufacture of demonstrator units to support Design Report/Safety Justification**

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AM Product Introduction



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Lead Applications - General

- **Pressure boundary components – various Nuclear systems**
- **Manual Globe Valves and Piping Tee Fittings**
- **Stainless Steel**
- **Direct ‘Substitution’ – no change to engineering definition**
- **No ‘as-built’ surface texture (100% machined or polished)**
- **Laser Powder Bed Fusion (L-PBF)**
- **First application (MGV) to be HIPed post AM**
- **Solution Annealed condition also being developed**



Manual Globe Valve

- **Manually operated to open and close to initiate/isolate flow**
- **Designed to the ASME Code Section III**
- **Class 1 valve Sizes range from 1” to 2”**
- **Fitted in numerous types of nuclear systems, e.g. coolant make-up, pressure relief**
- **A high number of valves fitted in each system**
- **Striving to reduce cost and delivery time in order to satisfy build programmes/customer needs:**
 - **Convolut ed supply chain - raw material, HIPing, machining. Striving for cell manufacture in one facility.**
 - **Reduce, ideally eliminate HIP cycles – hard facing powder consolidation/HIP bonding of hard facing to main body**
 - **Reduce, ideally eliminate subtraction machining**
 - **Reduce amount of raw material usage and waste**



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Manual Globe Valve



As-built MGV



Finish-machined MGV



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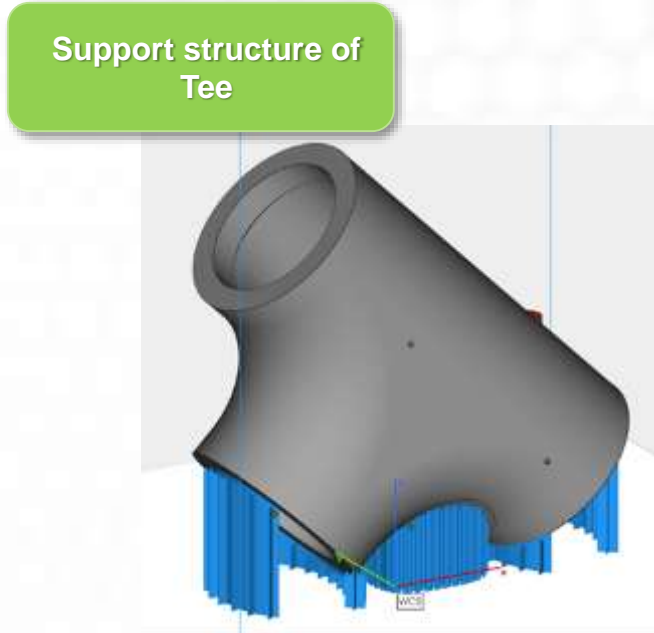
Pipework Tee Fittings

- **Welded into pipework to provide junctions, e.g. for instrumentation line off-takes**
- **Designed to ASME Code Section III**
- **Class 1 fittings; Sizes range up to 2”**
- **Fitted in numerous types of nuclear systems, e.g. coolant make-up, pressure relief**
- **Eliminating potential for variation and the costs associated in ensuring variation is acceptable:**
 - Eliminating hand dressing of the crotch corner - an artisan operation with inherent variability.
 - Must eliminate structural discontinuity, the sharp corners, can't totally eliminate by subtraction machining
 - Reducing the amount of inspection to provide assurance that the crotch corner has been created as required.



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Pipework Tee Fittings



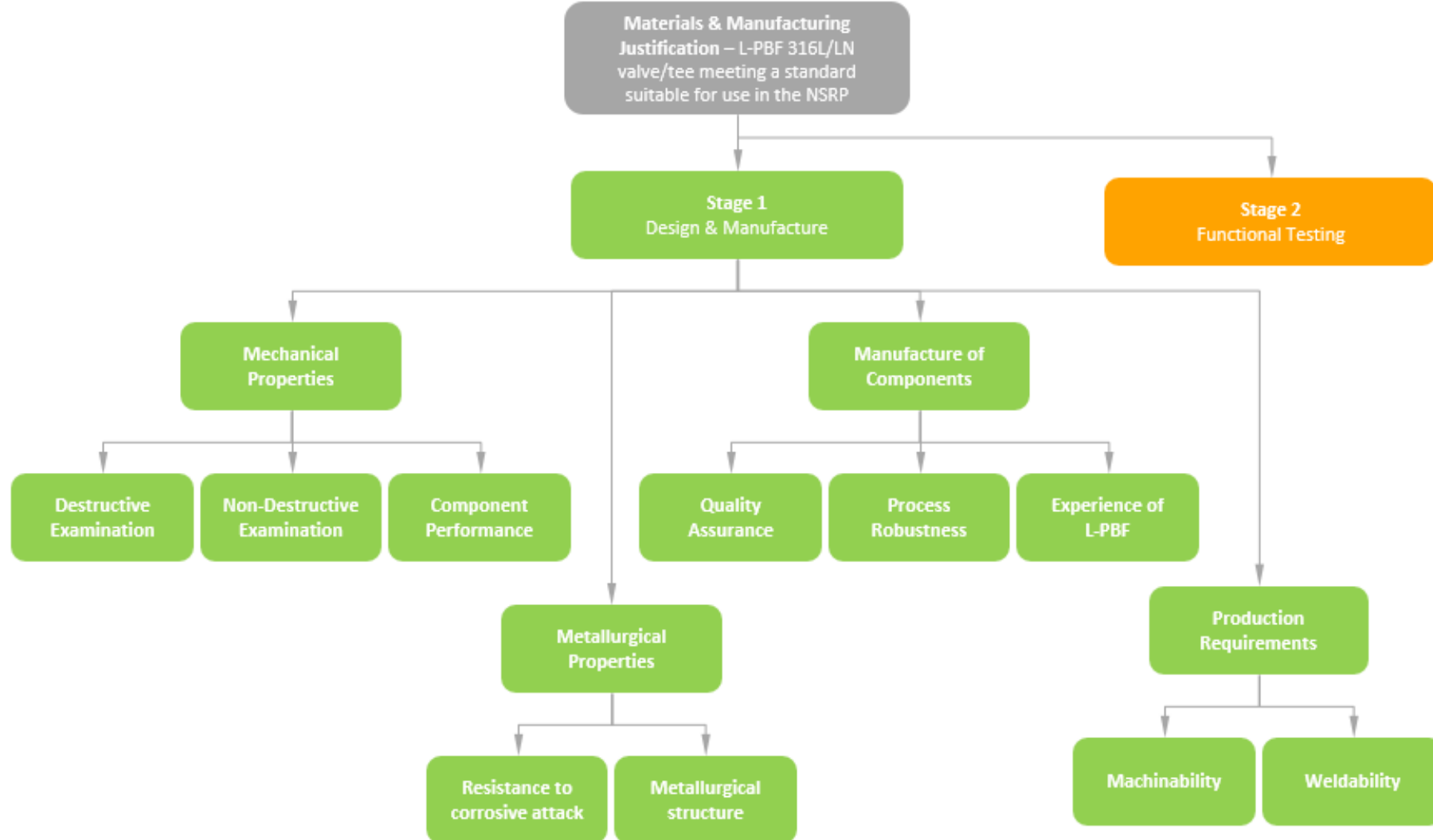
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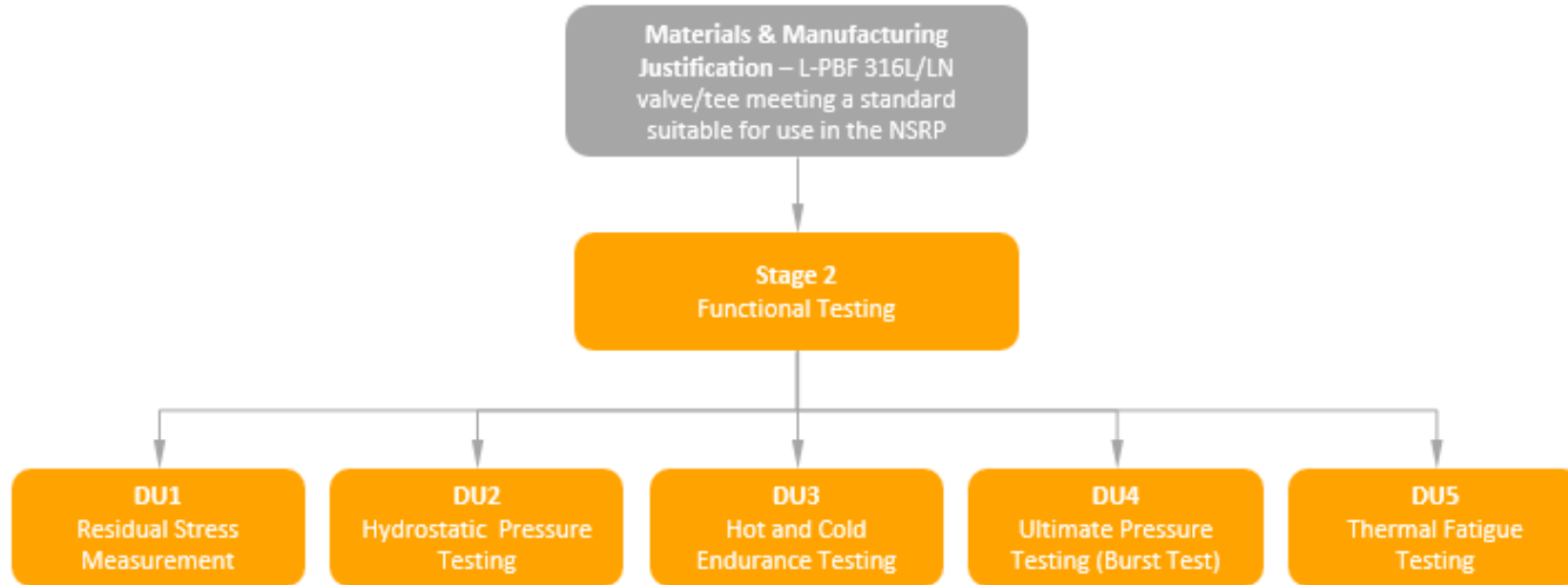
Justification Strategy



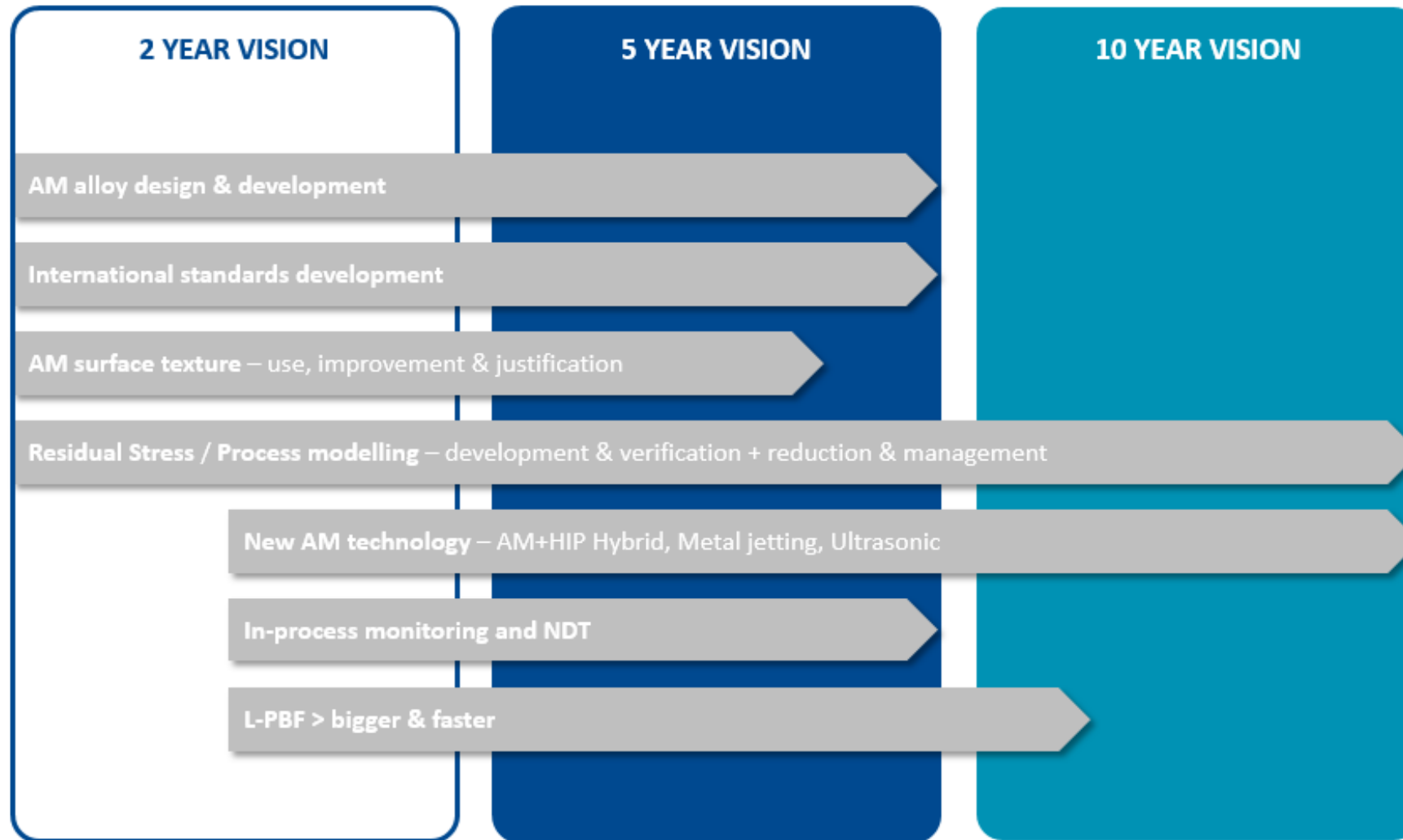
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Justification Strategy



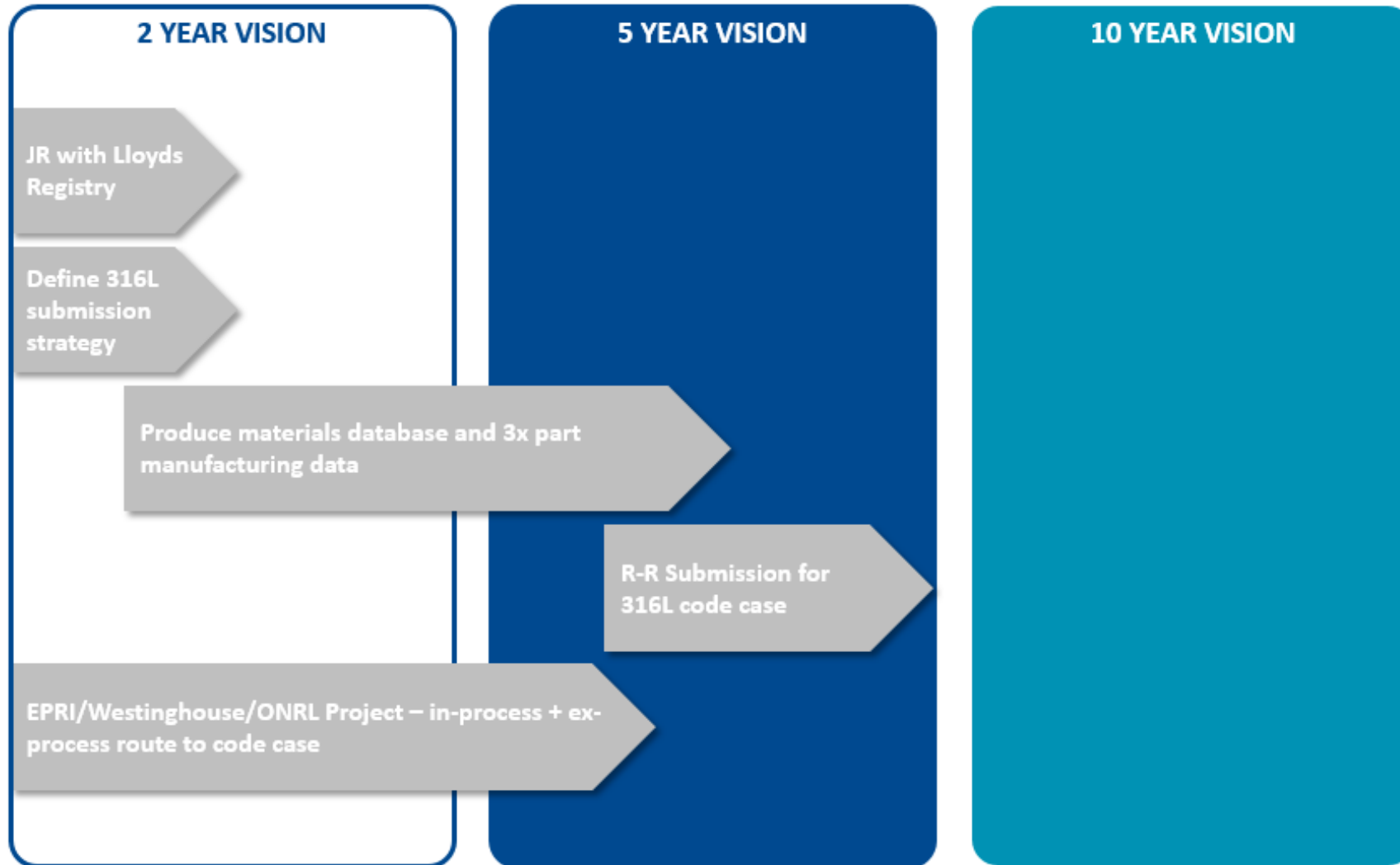
R&T Strategy – Enabling Technology Themes



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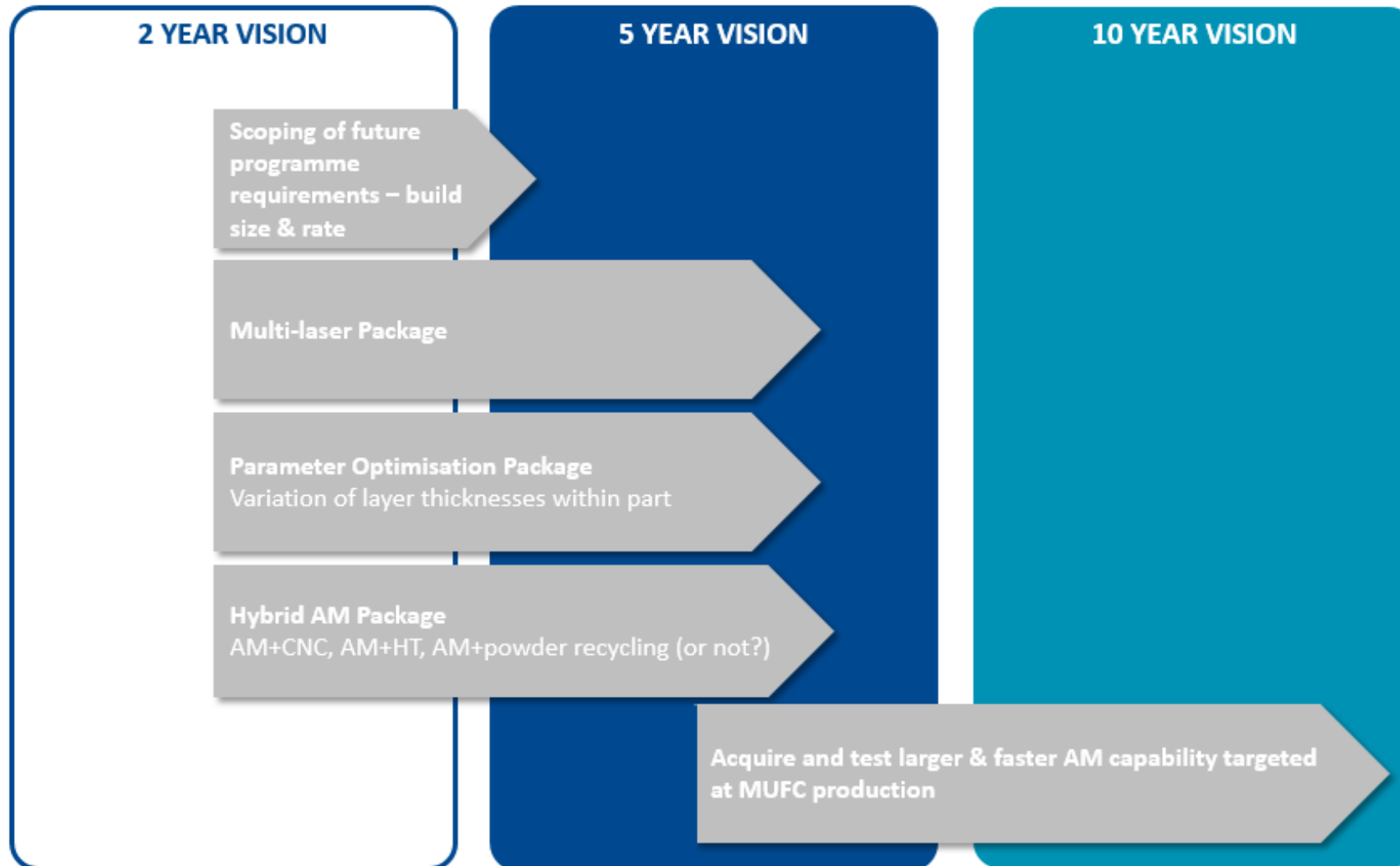
International Standards



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L-PBF – Bigger & Faster



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Key Takeaways

- **Material Substitution only results in more complicated shapes to inspect – Transitioning to enhanced substitution provides greater benefits**

HOWEVER

- **Material Substitution only for Pressure Boundary components in a Nuclear application requires extensive effort in inspection and testing to be compliant with ASME requirements**

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