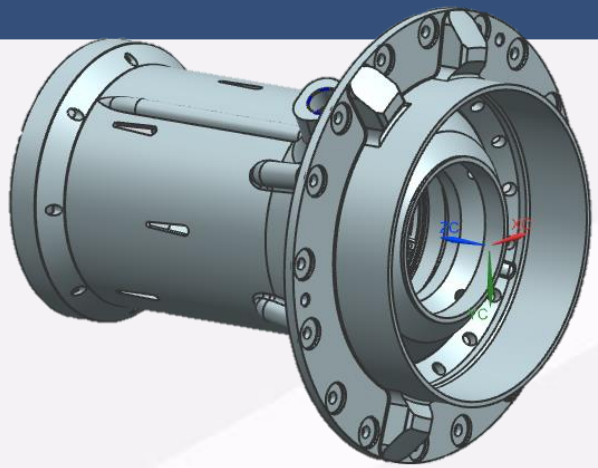
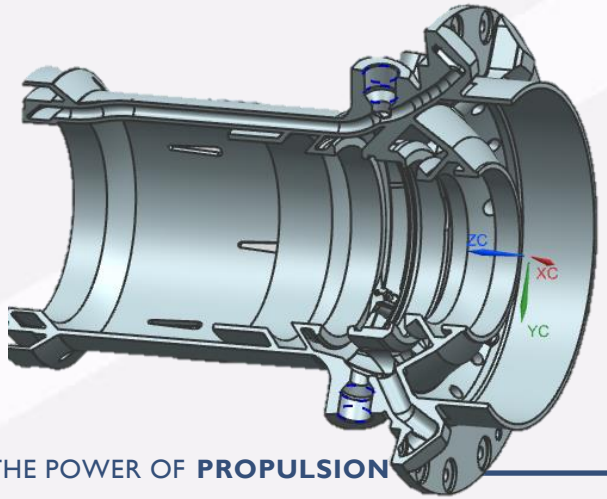
BET SHEMESH ENGINES

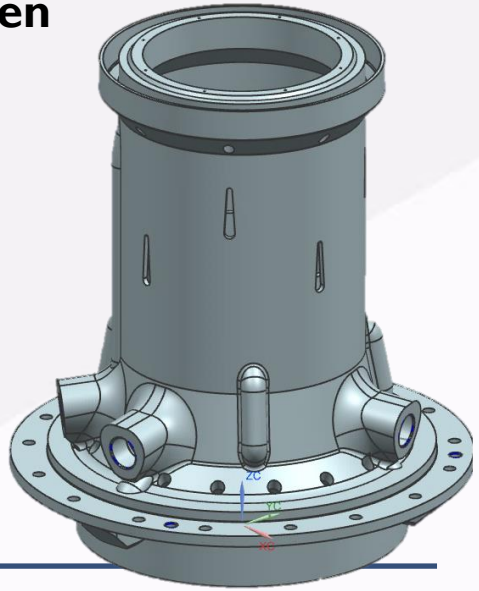


Configuration Adaptation of 3D AM Bearing Housing

M. Zakai, Y. Nahmana, O. Kam, A.Y. Cohen and M. Shapira



19th Israeli Symposium on
Jet Engines and Gas Turbines
Nov 2022



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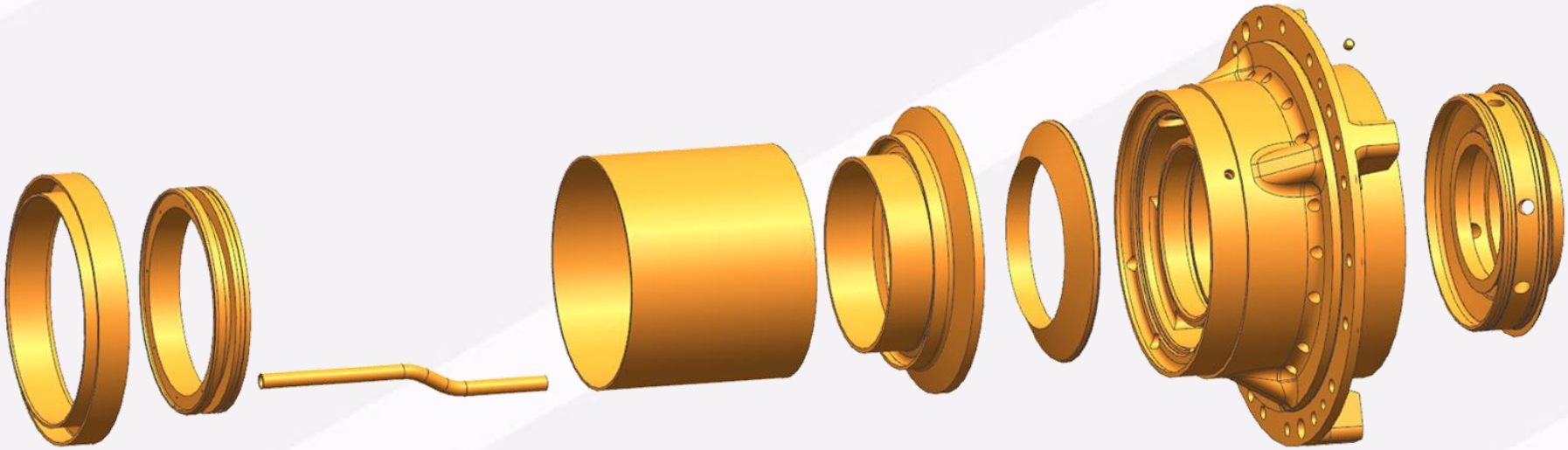
Motivation for Change

Bearing House Assy



- A relatively small component that is composed from multiple parts that are welded and brazed at multiple stages: perfect candidate for AM

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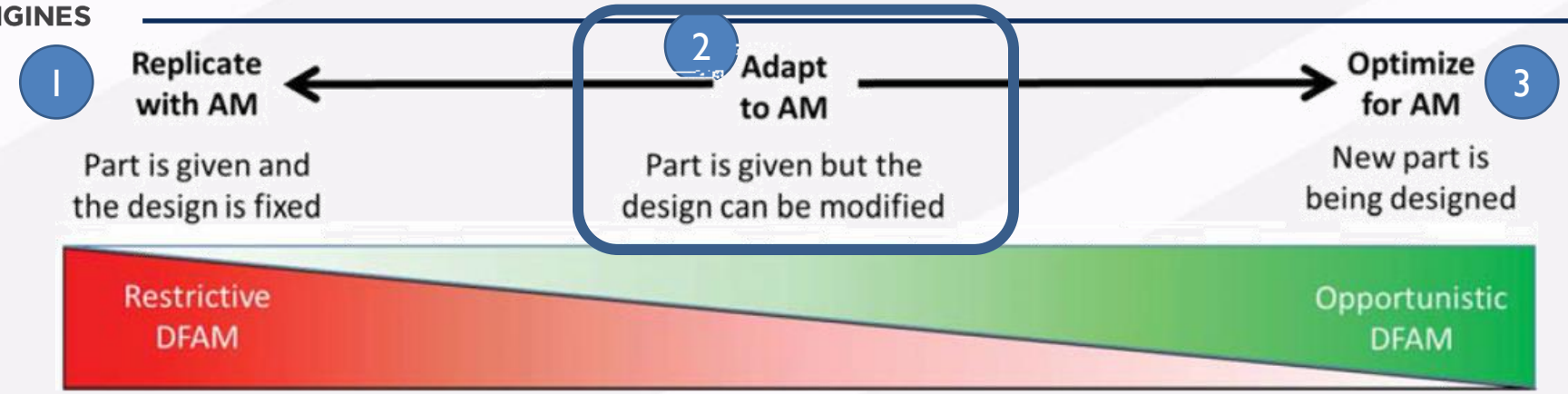
Three AM Use Cases



Restrictive DFAM

Aspects of an AM process that limit what can be built

Opportunistic DFAM

Aspects of an AM process that enable unique geometries or materials to be built

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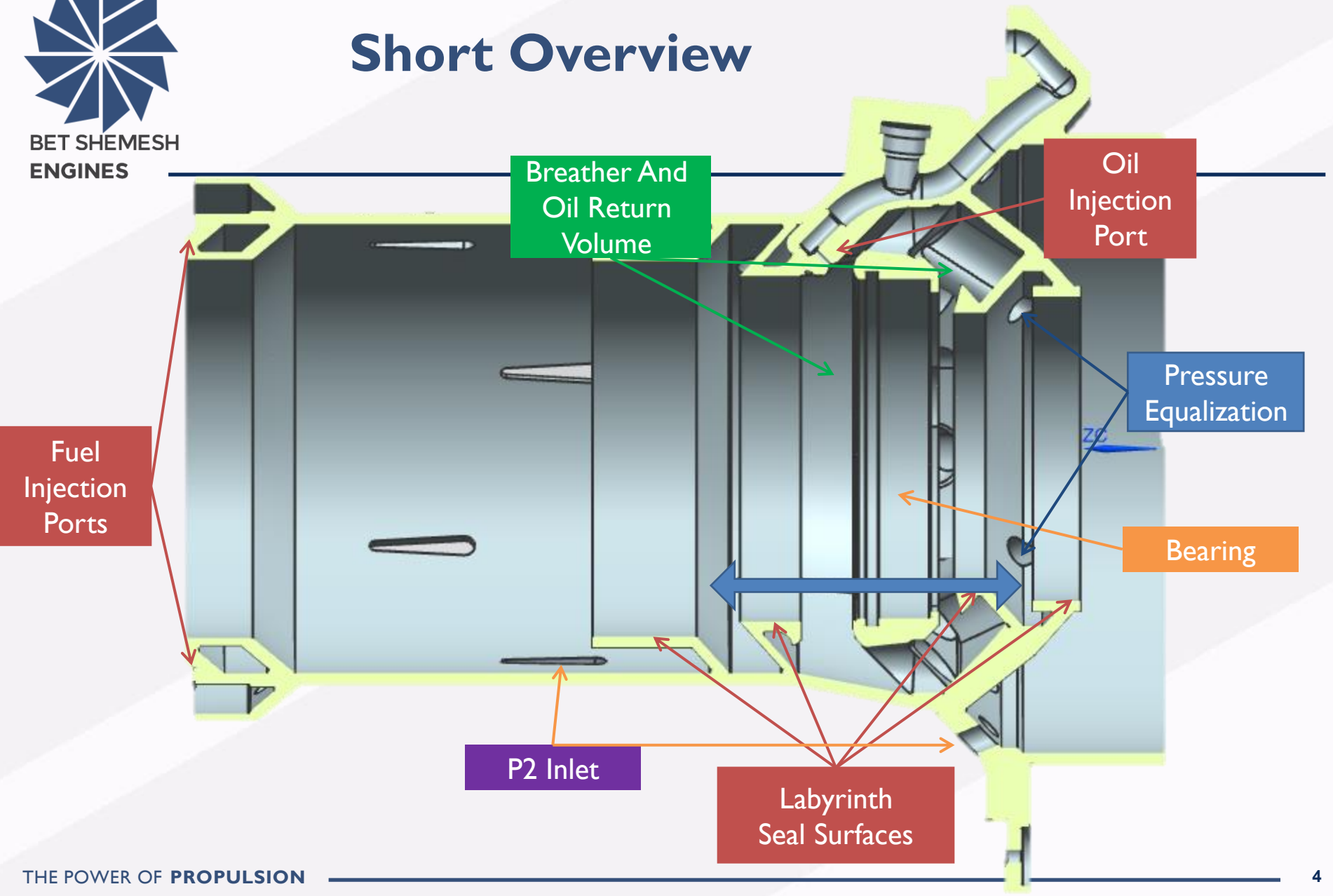
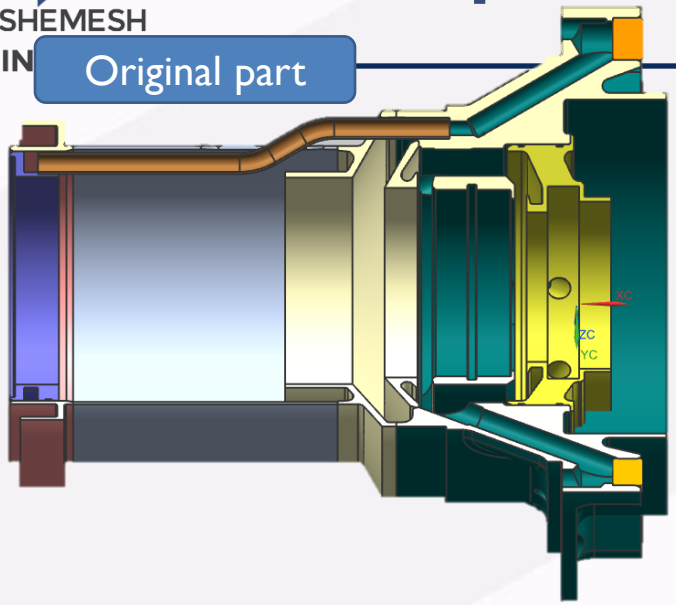
Short Overview



BET SHEMESH ENGIN

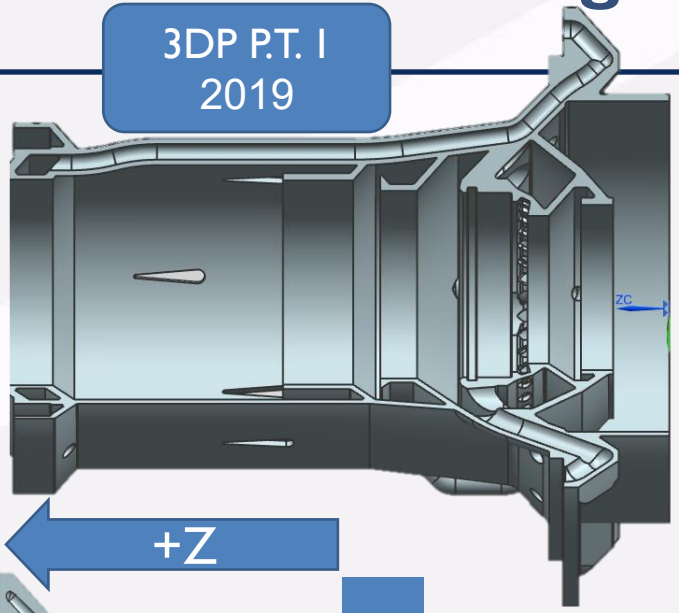
Machine Rear Bearing Housing Adaption for Additive Manufacturing

Original part



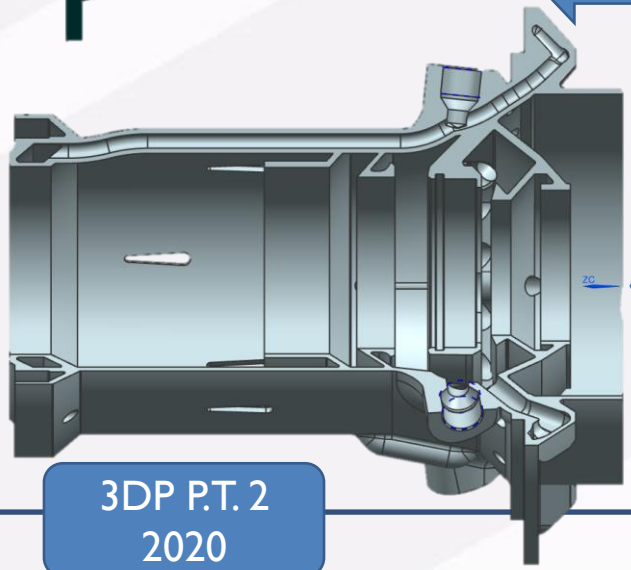
Adapt to AM

3DP P.T. 1 2019



+Z

Performance feedback and design improvement



3DP P.T. 2 2020

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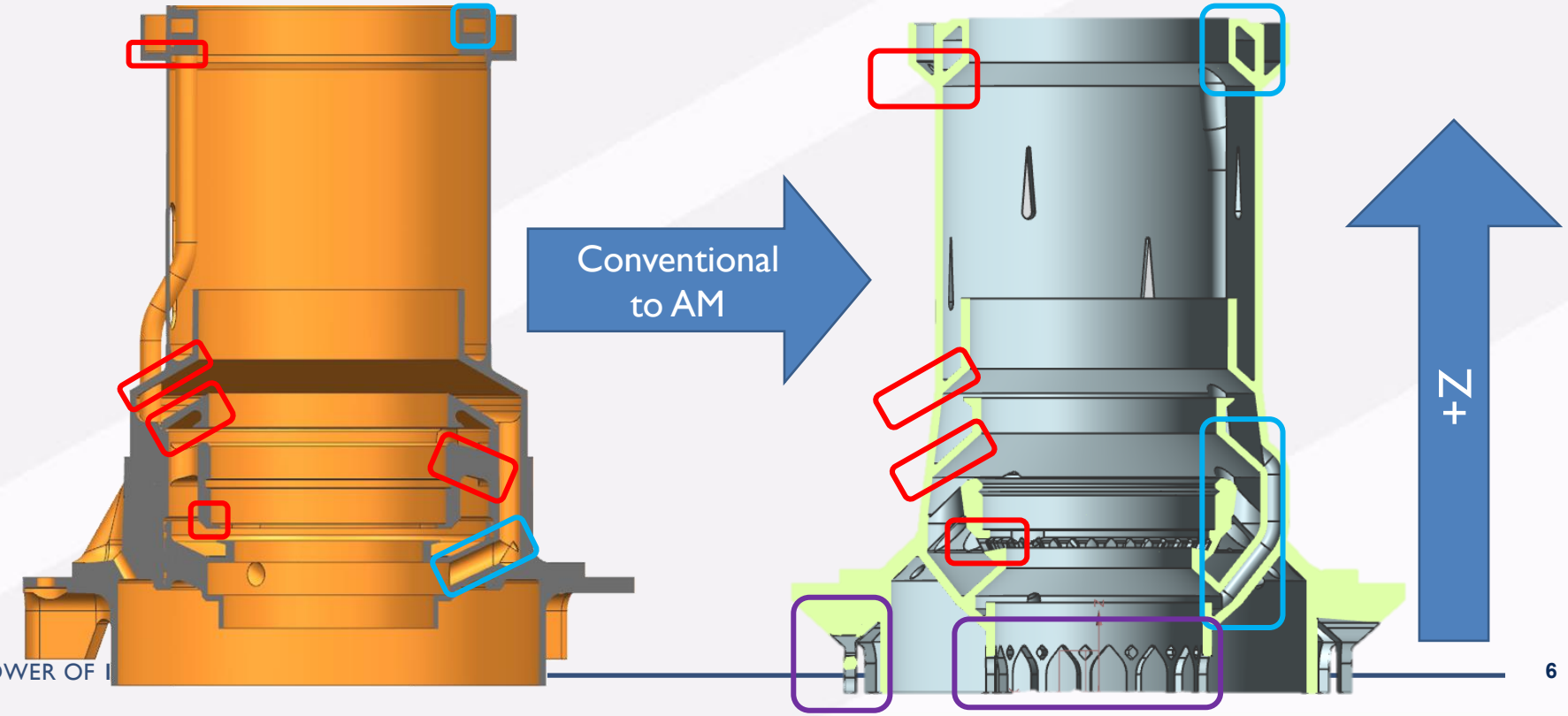
Challenges with original design

- Internal overhangs surfaces
- Horizontal enclosed volumes (red) – need internal support that is hard to remove



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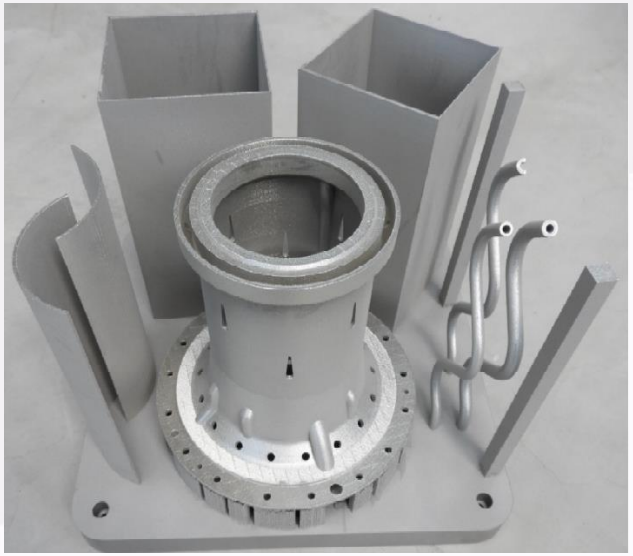
Approval procedure: Step 1 - printed prototype

- literature reviews
- Redesigns for AM
- Choose printing technology and material

- Manufacture tensile specimens with right printing parameters.
- Metallurgical and tensile inspections along with 3D scan.
- Choose Heat Treatment

- Conduct simulations using Worst-Case material properties and finalize the design.
- Manufacture P.T. #1



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Approval procedure: Step 2 - System level test

- Metallurgical and tensile inspections on specimens.
- P.T. inspection:
  - ✓ FPI + X-Ray.
  - ✓ Salt bath corrosion inspection.
  - ✓ 3D Scan and compare to CAD model.
  - ✓ Oil and fuel flow tests.
- System level performance:
  - ✓ No signs for mechanical damage or deterioration on the part.
  - ✓ Machine vibration: slight improvement.
  - ❖ Increased oil consumption – Up to 40% in compared to reference convectional bearing housing (still within limits).
- Performance and manufacture feedbacks and redesign.
- Manufacture P.T. #2

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Approval procedure: Step 3 - System level test of new design

- Metallurgical and tensile inspections on specimens.
- P.T. inspection:
  - ✓ FPI + X-Ray.
  - ✓ 3D Scan and compare to CAD model.
  - ✓ Oil and fuel flow tests.
  - ✓ Vibration test (after system level results)
- System level performance:
  - ✓ No signs for mechanical damage or deterioration on the part.
  - ✓ machine vibration: slight improvement.
  - ✓ Oil consumption: slight improvement in compared to reference convectional bearing housing.
- ✓ Part qualification -vib. Salt. Humidity, shock, functional …
- Rerouting fluids lines and repeat system level tests:
  - ✓ machine vibration: slight improvement.
  - ✓ Oil consumption: slight improvement in compared to reference convectional bearing housing
- ✓ Serial production – End of the project.

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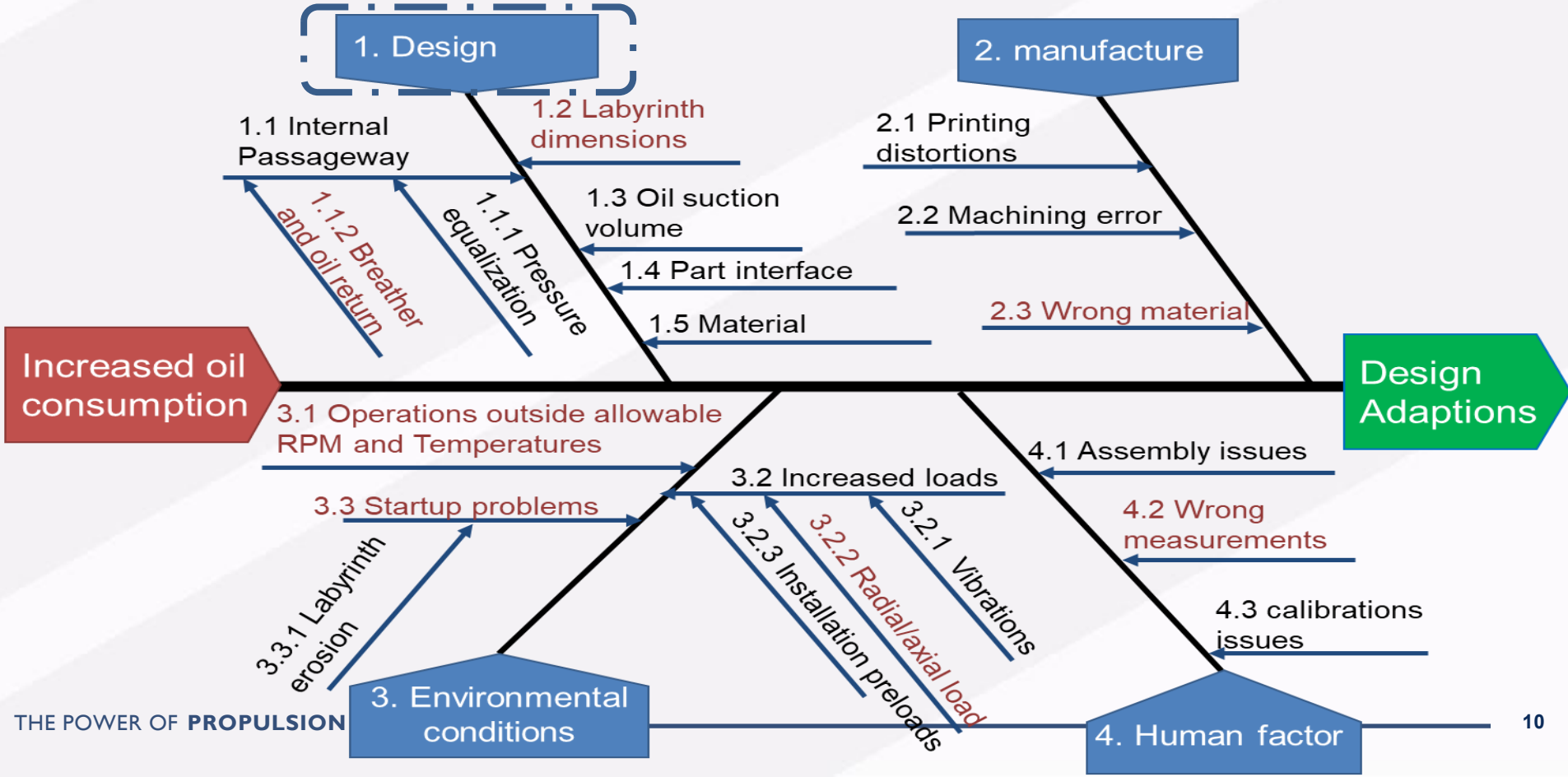
Design Improvement procedure

Even though the oil consumption was within the limits, a full analysis (fishbone) was performed in order to examine the changes and improve the design



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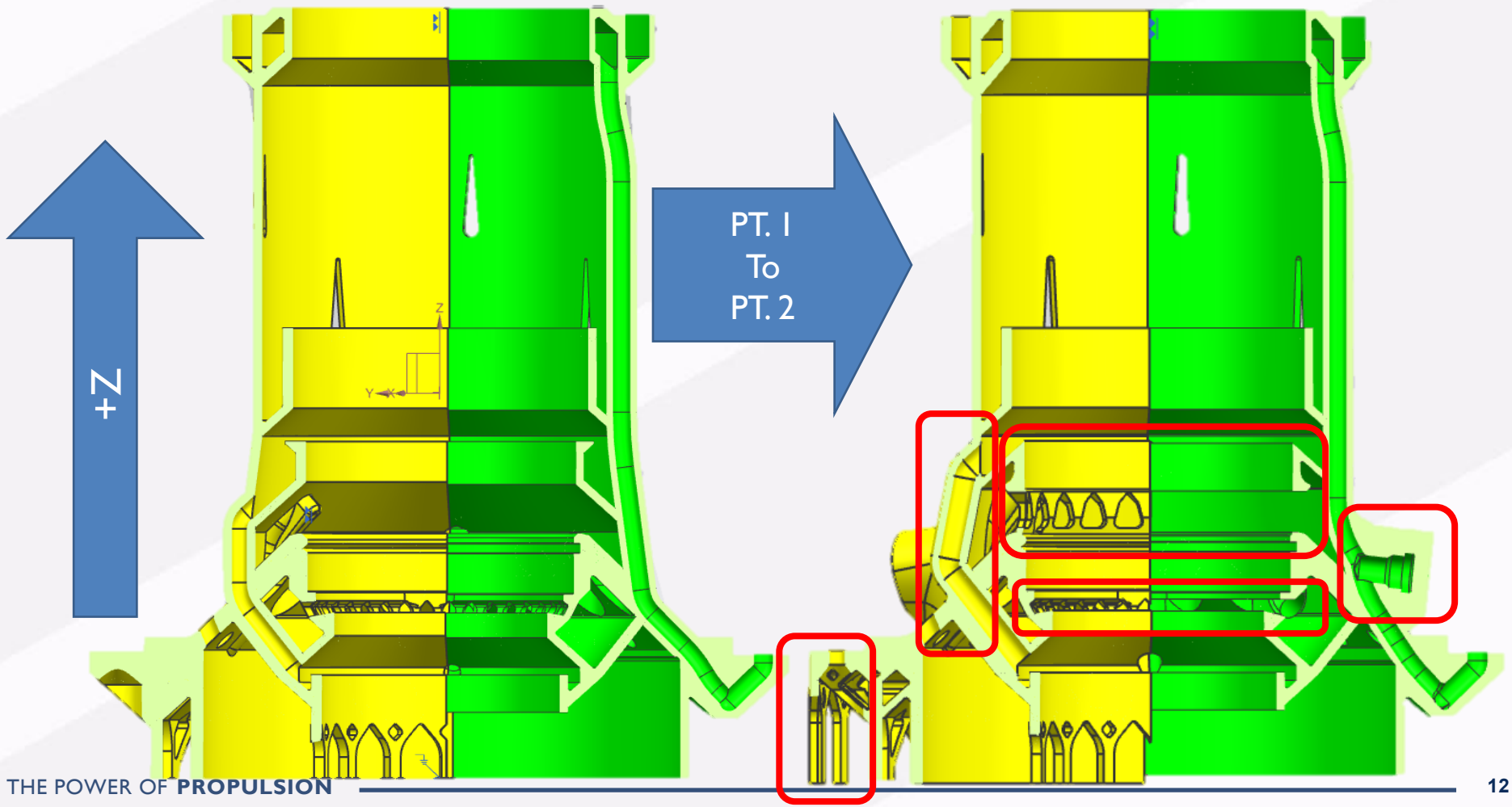
Design improvement



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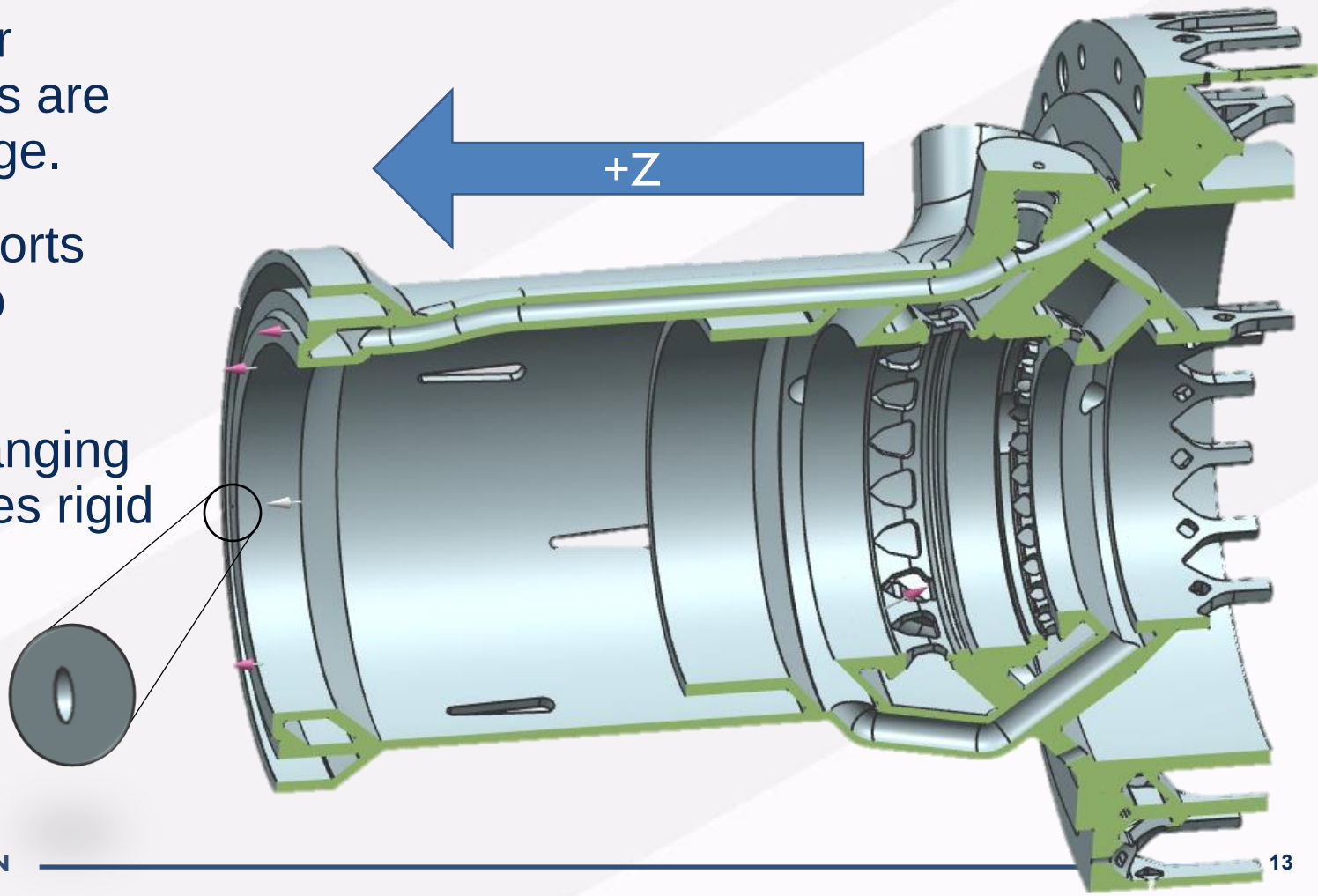
Manufacture Feedback

- Small powder removal holes are hard to enlarge.
- Internal supports are difficult to remove
- Large overhanging flange requires rigid support



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Improvement Summery

- Simplify the manufacture processes:

	# of parts	# of Weld/Brazing	# of H.T. / Stress relief	Lead time
Convectional	14	5	6	~8 Month
AM	1	0	1	~3 Month

- Reduce weight by 30%.
- Reduce the cost.
- 0 parts disqualified
- Small improvement in oil consumption and vibration.

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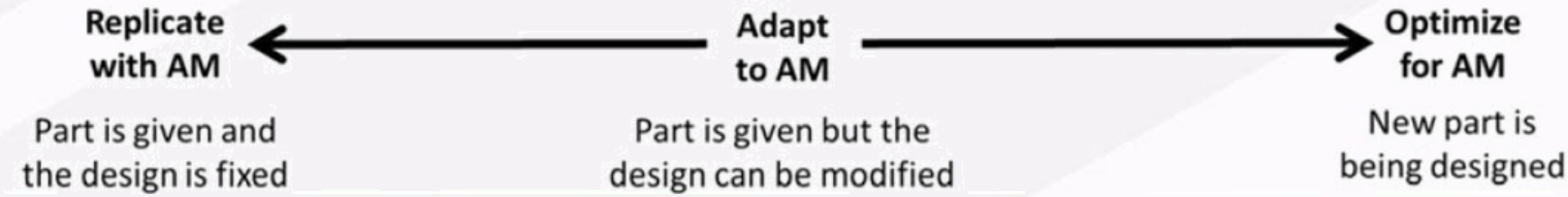
Adaption to AM process
Insights and conclusions

- Avoid unnecessary changes.
  - Easier to isolate the causes of undesired changes.
- Avoid printing small holes and enlarge them by machining.
  - May cause drill bit breaking.
- Minimize internal support removal.
  - Hard to machine and locate all chips and debris.
- When designing large and complex parts, attention must be given to post-machining geometries which may be problematic.
- Part Functionality and geometry.



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Thank you!