ptc

LIVEWORX

A NEW ERA IN PRODUCT LIFECYCLE INNOVATION

SESSION ID: CA1607C

ONLY WITH ADDITIVE: MICRO-JET ENGINES WITH AN UNINTERRUPTED PRINT PROCESS

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Jose Coronado
Product Management Director, PTC

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AGENDA

- Technion-PTC partnership
- Additively Manufactured Pre-Assembled Turbojet Engine (APE) for Unmanned Aerial Vehicles
- Creo technology used in this project
- Lessons learned and futures

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TECHNION AND PTC PARTNERSHIP

- PTC Establishes R&D Center at the Technion – Israel Institute of Technology

- On April 29, 2021 PTC entered into a long-term strategic collaboration agreement with the Technion – Israel Institute of Technology
  - To jointly research and upgrade learning processes relating to advanced manufacturing technology
  - With a long-term Strategic Collaboration vision.
- PTC has also allocated an annual budget for joint research.
- This project is part of such research activities.

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TECHNION TURBOMACHINERY LABORATORY

Research & Development in:

- Micro Gas Turbines
- Basic and Applied Heat Transfer
- Measurement Technique Development

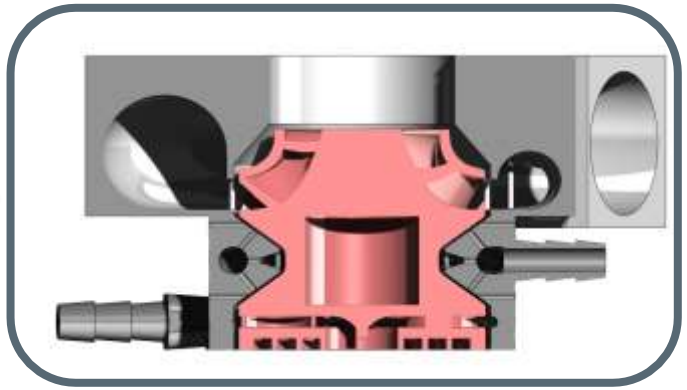
Propulsion and Power Generation
of
Business Jets, UAVs, Drones

https://bcukurel.net.technion.ac.il/

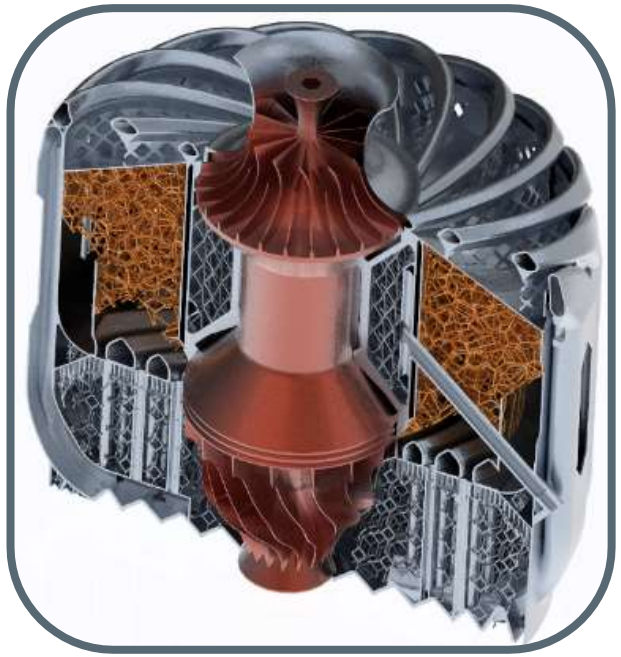
JOURNEY OF ADDITIVELY MANUFACTURED TURBOMACHINES

- Design for Additive Manufacturing as a Research Direction
- Gradual complication of requirements and evolution of capabilities

Removal of assembly requirement



AM from metal powders



Miniaturized Turbines

- Monolithic rotor compressor, turbine, generator
- Porous media combustor

Emergency Ventilator

- Air-driven hydrostatic bearing
- Preassembled design Rotor/stator in single AM step

AM Pre-Assembled Engine

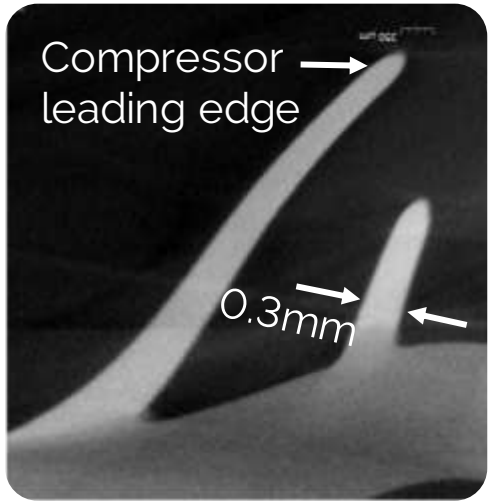
- Pre-assembled AM from metal
- Fuel-driven hybrid bearing

AM OF ROTORS

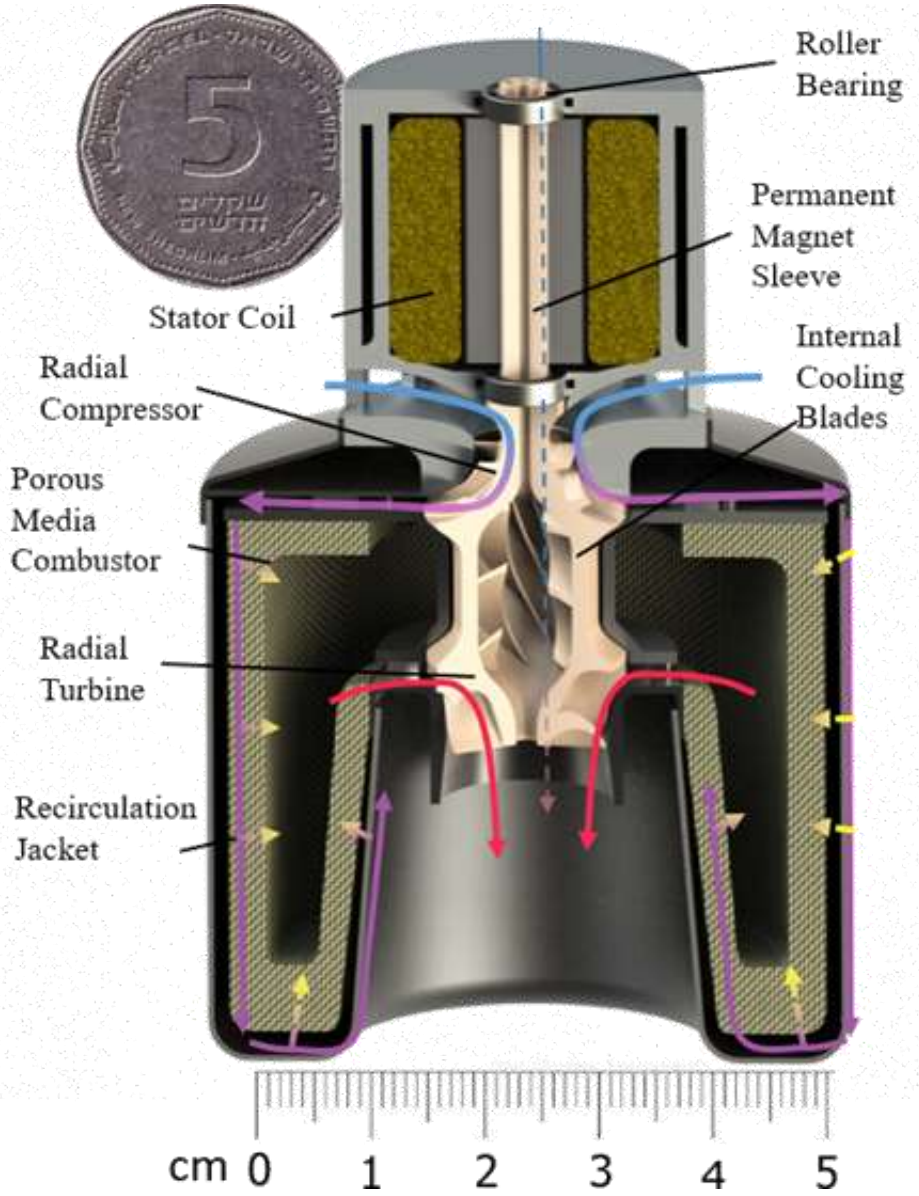
Drone Hybrid Energy Supply System for 300W

- Successful test up to design RPM of 500k
- Achieved pressure ratio of up to 2
- Fuel consumption: 300 g/h (H-C) or 100g/h (H_2)

Additively Manufactured Monolithic Rotor



20 µm Tolerances

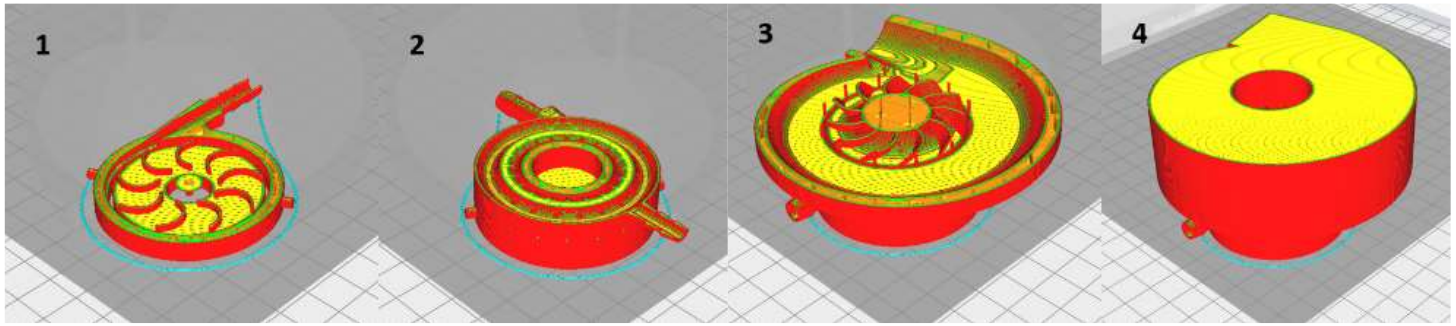


Extends Flight Time & Reduces Downtime

PRE-ASSEMBLED ADDITIVE MANUFACTURING

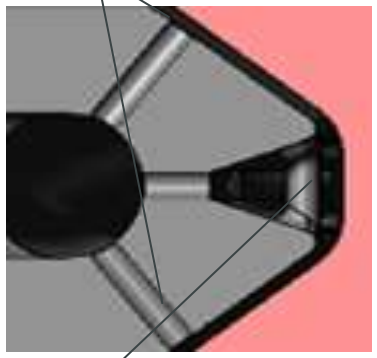
On-Demand Turbocharger for Medical Ventilators

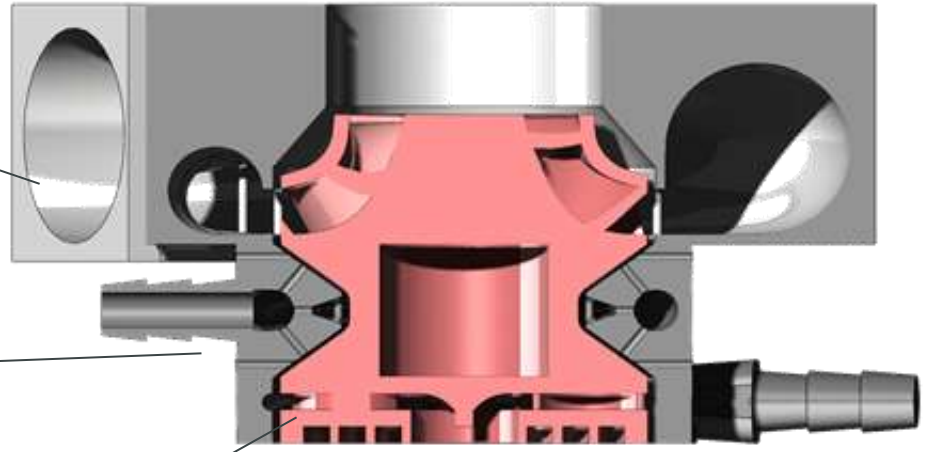
- Single uninterrupted print simultaneously produces rotating and stationary components
- Only fluidic-bearing geometries are compatible with 3D printing



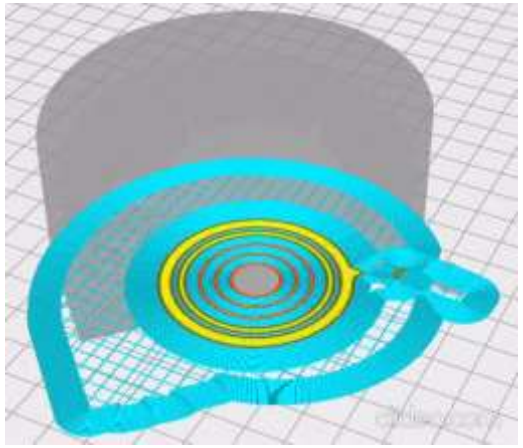
Each element is supported by previous layers

- **Printing time ~ 18 hours**





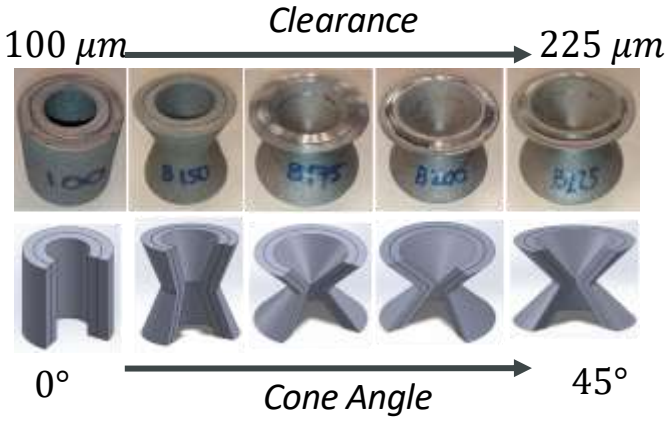
Rotating at 36 kRPM



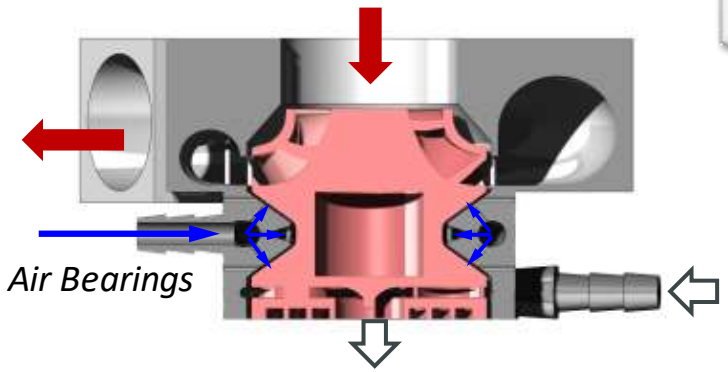
Support-Free Assembly with Fluid Bearing

CRITICAL BUILDING BLOCKS

Leveraging Existing Knowledgebase and Direct Metal Laser Sintering of Inconel

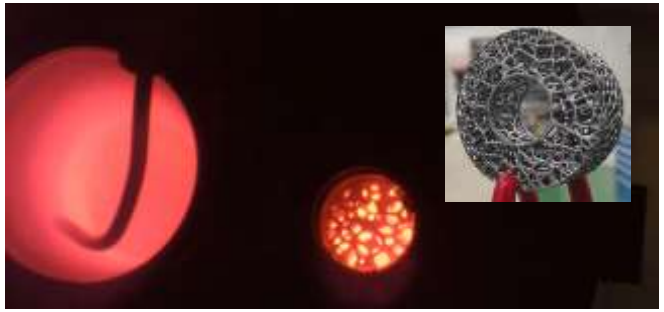


Cantilevered Inconel Monolithic Rotor Operated at Design Speed of 500 kRPM



Preassembled Rotor/Stator Turbomachinery System with Hydrostatic Bearing Operated at Design Speed of 36 kRPM

- Self-Supported Additive Manufacturing
- Monolithic Turbo-Machinery
- Hydrostatic Bearings
- Premixed Porous Media Combustor

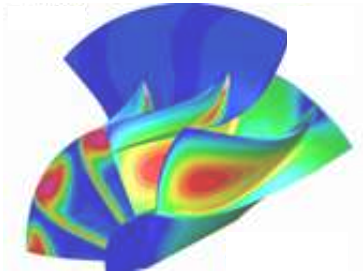


Stable Operation at 0.45 Equivalence Ratio

TRL3: Proof of Concept Technology Demonstration for All Critical Components

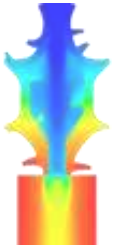
DISRUPTIVE TECHNOLOGIES

System Level Design Optimization of Self-Supporting Layout in Additive Manufacturing



Stress Analysis

Heat Transfer



Supports

Self-Supported Additive Manufacturing

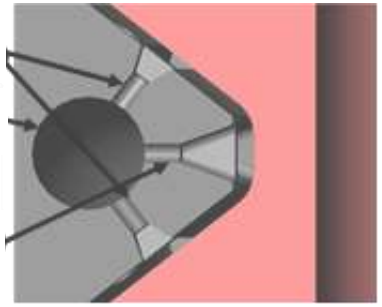
Thermo-Dynamic Cycle

Monolithic Turbo-Machinery

Radial/Axial Feed

Fluid Plenum

Radial Feed



Hydrostatic Bearings

Premixed Porous Media Combustor

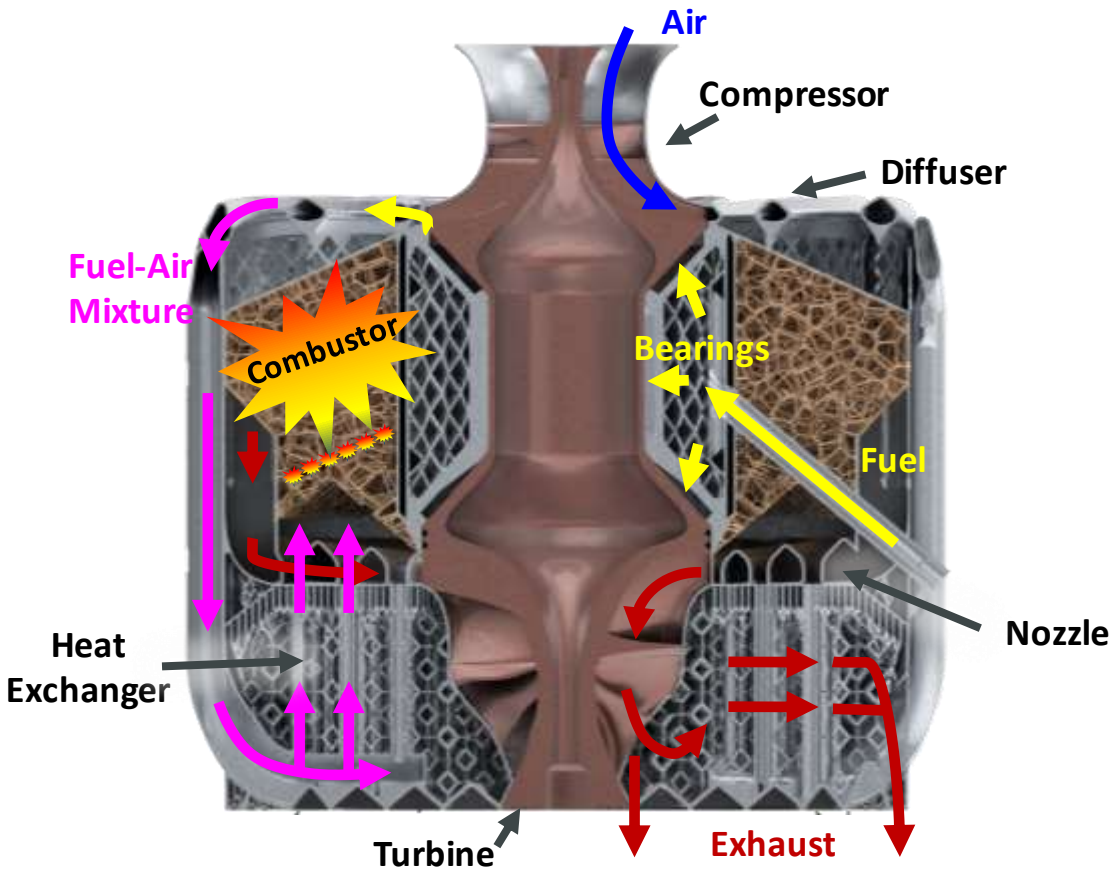
Preheating Zone *Flame Front* *Reaction Zone*

Expanding Design Space via Previously Unexplored Methodologies

ADDITIVELY MANUFACTURED PRE-ASSEMBLED TURBOJET

Simultaneous Uninterrupted Print of Pre-Assembled Rotating and Stationary Parts

- Disposable Micro-Turbojet Engine:
  - Airflow: 1.4 kg/s
  - Fuel Consumption: 30 g/s
  - Diameter: 250 mm
  - Pressure Ratio: 4
  - Rotational Speed: 50 kRPM
  - Turbine Inlet Temperature: 1100 K
  - Material: Inconel 718
  - Thrust: 700 N



- Monolithic Rotor
  - Turbine - Bearing Journal - Compressor
- Stationary Section
  - Heat Exchanger - Nozzle Guide Vane - Combustor and Bearing Housing - Diffusor - Intake

Breakthrough in Turbine Architecture: Provisional US Patent Application No. 63/112,187

MONOLITHIC SELF-SUPPORTING ROTOR/HOUSING

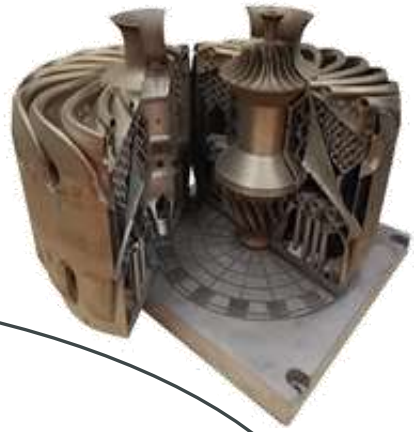
- Overhang less than 35˚
- Extended exducer with self-supported blades
- Modified pipe diffuser
- Diamond turbine stator
- Tear-drop fuel orifice
- Zig-zag “floor” geometry minimizing build plate contact area to ease part cutoff

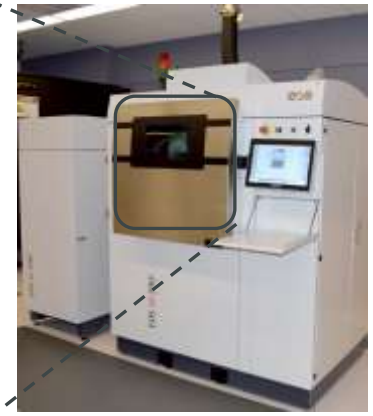
IMPACT

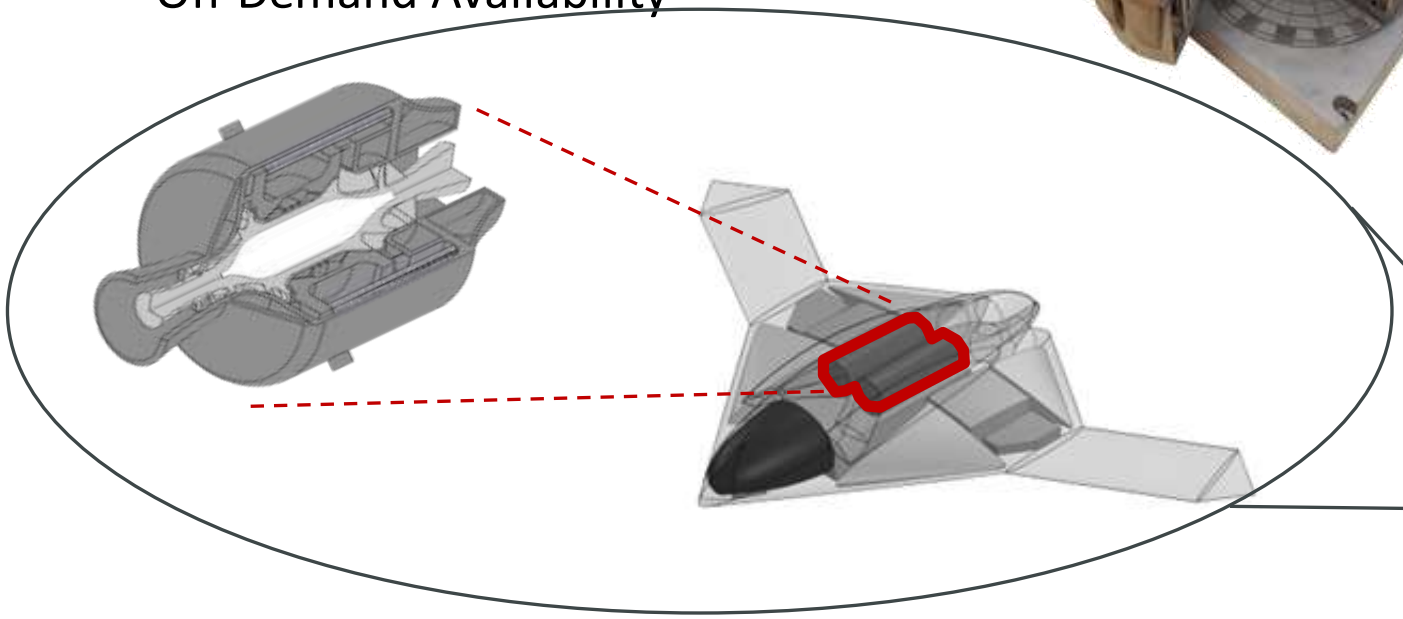
Single-Step Manufacturing of Self-Supported Engine Architectures

- Only Requiring Metal Printer
- No Supply Chain / Short Delivery Time
- Manufacturing at Platform Producer
- On-Demand Availability

Powder Bed Fusion
Inconel 718







Engine Cost Diminished to Depreciation and Raw Material ~$3k

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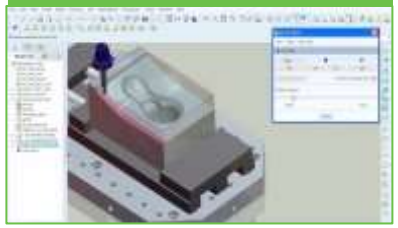
CREO MANUFACTURING SOLUTIONS PORTFOLIO

Creo Prismatic & Multi-Surface Milling

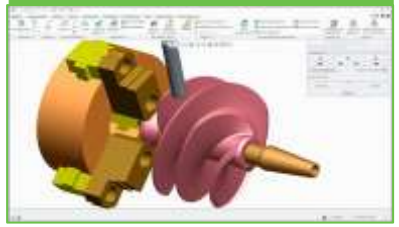


Multi-Surface 3-axis milling with high-speed machining support

Creo Production Machining Extension

Added support for 4-axis turning and wire EDM

Creo Complete Machining Extension



2.5- to 5-axis milling, multi-axis turning, multi-task machining and 4-axis wire EDM

Creo NC Sheetmetal

NC programming for turret punch presses, contouring laser/flame machines, nibbling and shearing

Creo Computer-Aided verification

Digital inspection and verification of machined parts and assemblies

Creo Reverse Engineering Extension

Reverse engineer from point cloud or faceted model geometry

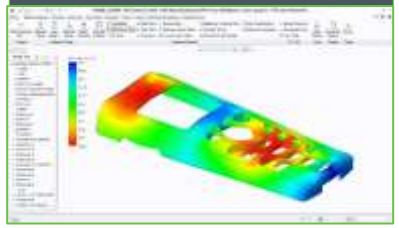
Creo High Speed Milling Extension

Specialized capabilities to speed 3 axis HSM

Creo High Speed Milling Advanced Extension

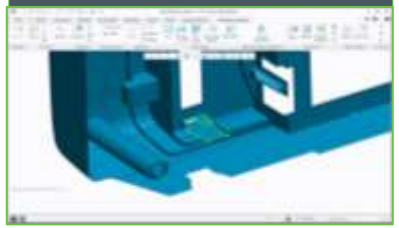
Specialized capabilities to speed 3 and 5 axis HSM

Creo Mold Analysis Extension



Mold filling analysis

Creo Tool Design Option



Accelerate the design of production mold and cast tooling

Creo Expert Moldbase Extension

Automate and speed moldbase design

Creo Progressive Die Extension

Automate and speed progress die design

Creo Parametric

Connectivity with polymer printers and service bureaus

Creo Additive Manufacturing

Parametrically controlled lattice structures and data-managed tray assemblies

Additive Manufacturing Advanced for Materialise

Creo AM functionality plus Support structures for metal and build processors

Generative Topology Optimization

Find the most efficient distribution of material within a user-defined design space

Generative Design Extension

Consider many scenarios in parallel and quickly with cloud-based GDX

CNC Machining

Inspection

Mold/Tool/Die

Additive Mfg.

CREO MANUFACTURING SOLUTIONS PORTFOLIO

Creo Prismatic & Multi-Surface Milling

Multi-Surface 3-axis milling with high-speed machining support

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Creo High Speed Milling Advanced Extension

Specialized capabilities to speed 3 and 5 axis HSM

Creo Mold Analysis Extension

Mold filling analysis

Creo Tool Design Option

Accelerate the design of production mold and cast tooling

Creo Expert Moldbase Extension

Automate and speed moldbase design

Creo Progressive Die Extension

Automate and speed progress die design

Creo Parametric

Connectivity with polymer printers and service bureaus

Creo Additive Manufacturing

Parametrically controlled lattice structures and data-managed tray assemblies

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Creo AM functionality plus Support structures for metal and build processors

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Generative Design Extension

Consider many scenarios in parallel and quickly with cloud-based GDX

CNC Machining

Inspection

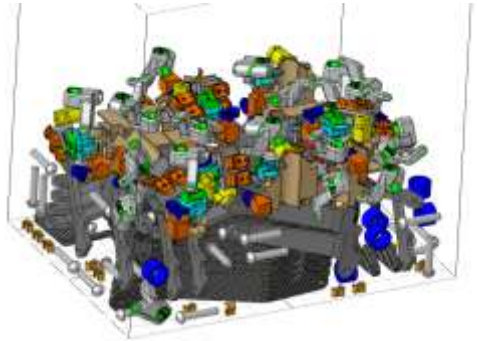
Mold/Tool/Die

Additive Mfg.

Creo Manufacturing Solutions are aligned with customer's requests

Additive

- Lightweight design
- Self-supporting geometries
- Enable interoperability



Fully embedded into the Creo design environment

CREO ADDITIVE MANUFACTURING IN ACTION

- Self supported geometric design

AGENDA

- Technion-PTC partnership
- Additively Manufactured Pre-Assembled Turbojet Engine (APE) for Unmanned Aerial Vehicles
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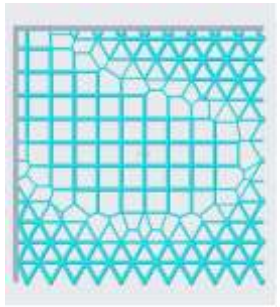
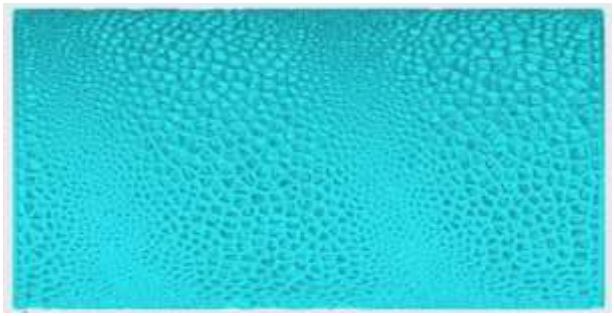
LESSONS LEARNED

We are adjusting our roadmap to focus on:

- **Lightweight designs**
  - Intelligent transitions



  - Pore size driving lattice

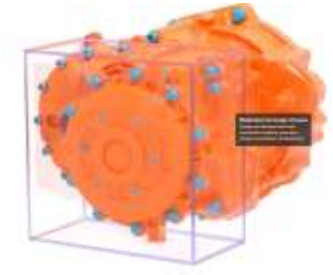


  - Close the loop with point-cloud MFG QA systems

- **Self-supporting geometries**
  - Printability modifiers
  - Support structures

  - Slicing and hatching

- **Interoperability for printing and post-processing equipment**
  - Connectivity with key 3D Printer manufacturers
  - Enable digital thread with post-processing manufacturers towards certification



  - Enable connectivity with AM MES systems

Fully embedded into the Creo design environment

ADDITIVELY MANUFACTURED PRE-ASSEMBLED TURBOJET ENGINE (APE) FOR UNMANNED AERIAL VEHICLES

- Freedom of design
- Printable lattice modelling
- Optimize for 3MF

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