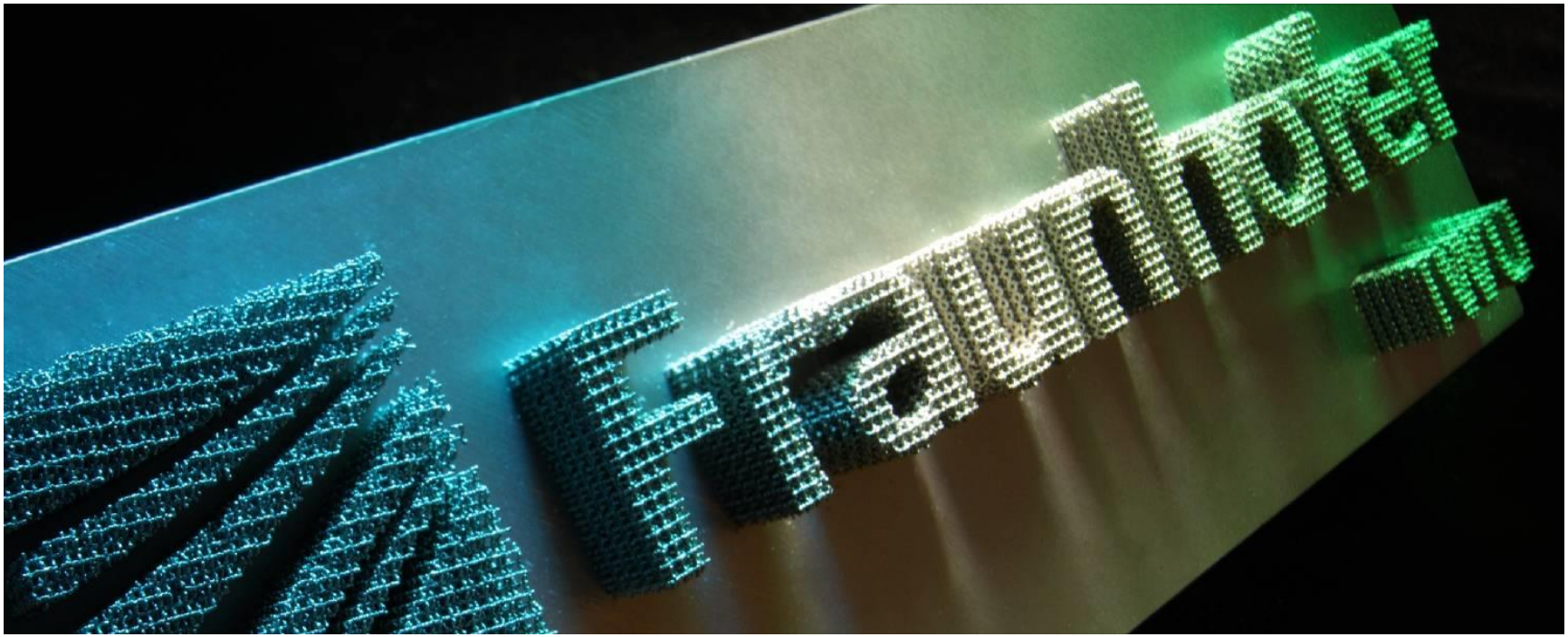
NEXT GENERATION MANUFACTURING TECHNOLOGIES

A FRAUNHOFER PERSPECTIVE

Prof. Dr.-Ing. Welf-Guntram Drossel

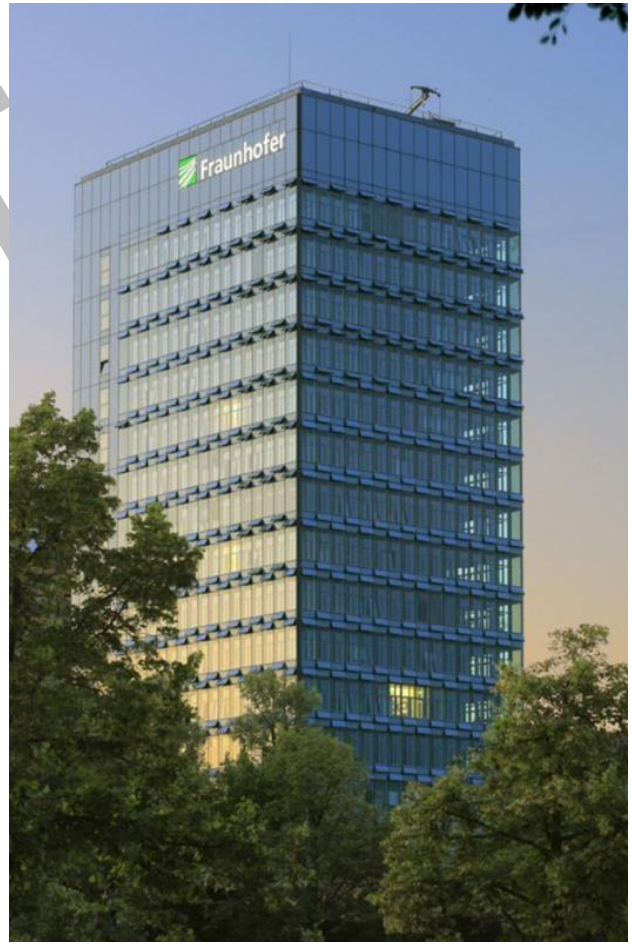


Fraunhofer IWU

The Fraunhofer-Gesellschaft

Largest organisation for applied research in Europe

- Numbers
  - 66 institutes and research units
  - Nearly 24,000 staff
  - More than €2 billion annual research budget
- Mission statement
  - FhG Promotes and conducts applied research
  - In an international context
  - To benefit private and public enterprise
  - Our Customers
    - Industry
    - Service Sector
    - Public Administration



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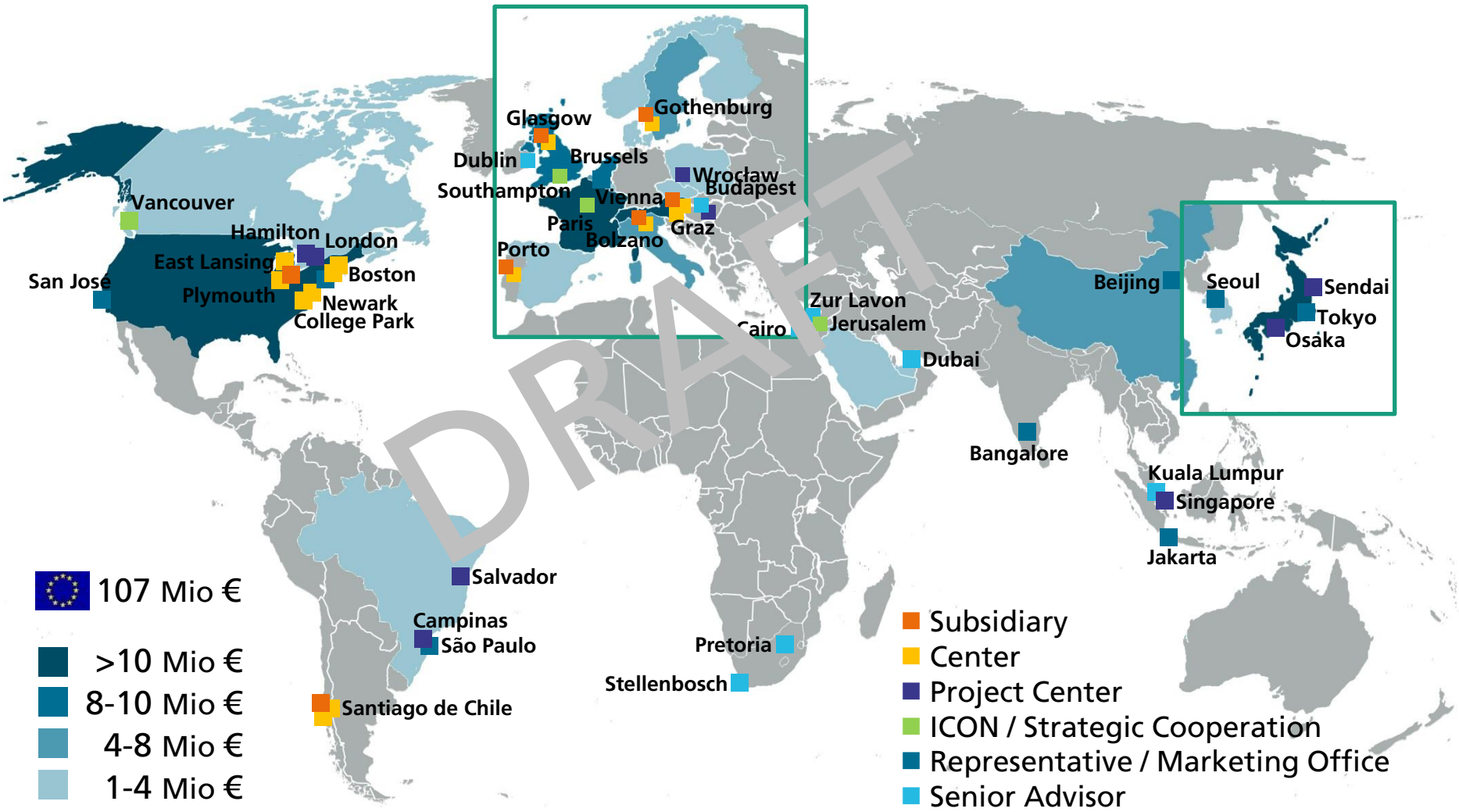
The Fraunhofer-Gesellschaft

Worldwide activities and revenues (2014, without subsidiaries, without licensing)



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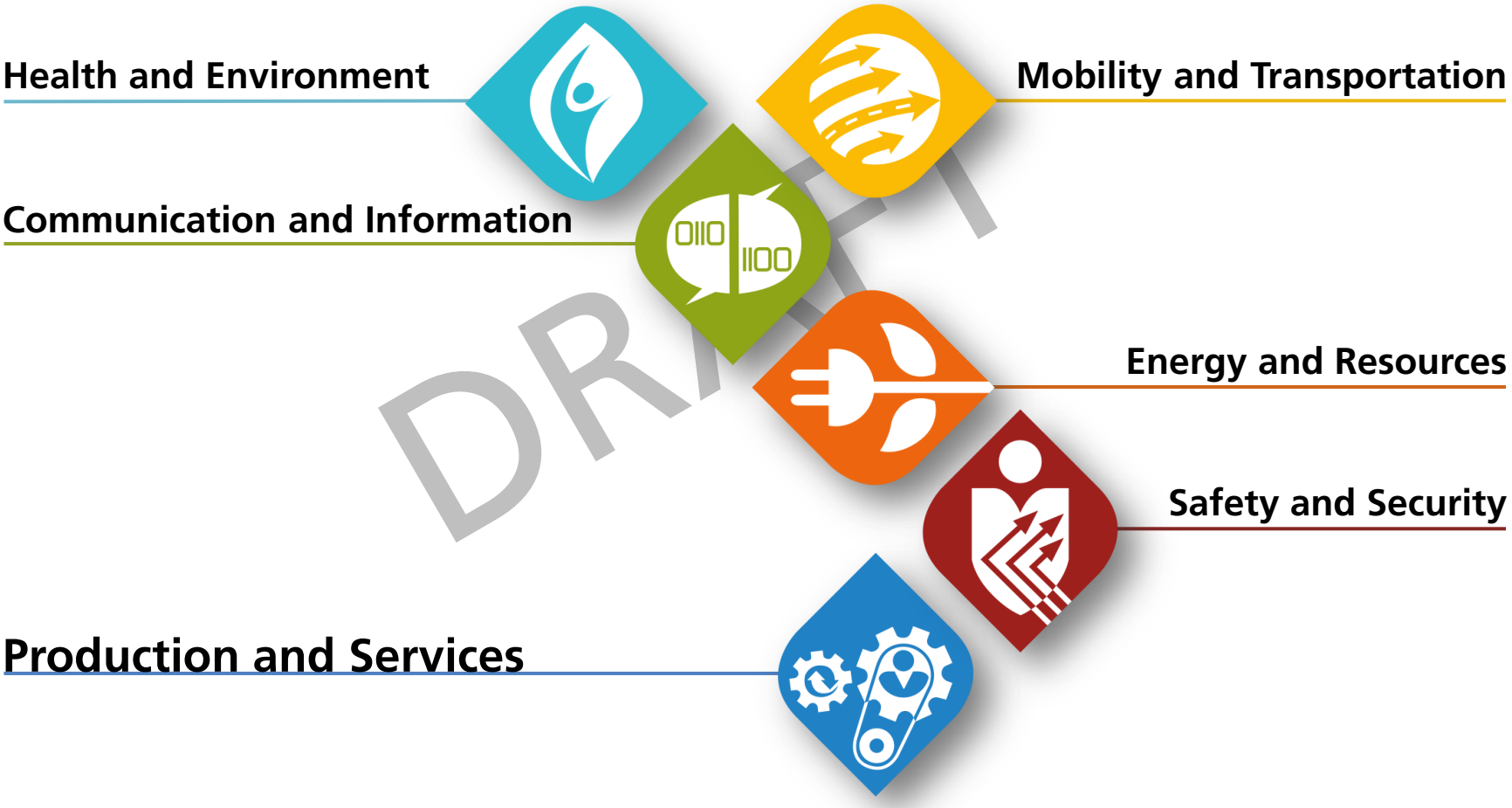
The Fraunhofer-Gesellschaft
Fields of research



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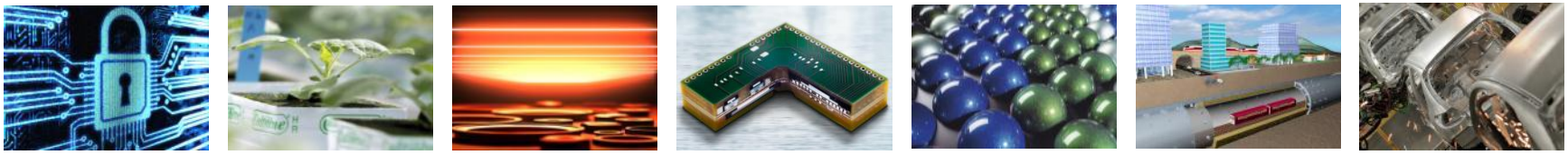
The Fraunhofer-Gesellschaft
Pooling Expertise

- Fraunhofer Groups
  - Cooperation of instiuttes working in related subject areas
  - Foster joint presence in R&D market

- ICT
- Life Science
- Light & Surfaces
- Microelectronics
- Defense and Security VVS
- Materials and Components – MATERIALS

- **Production**
  - Product development
  - Logistics
  - Production organization
  - Production processes
  - Manufacturing systems
  - Manufacturing technologies



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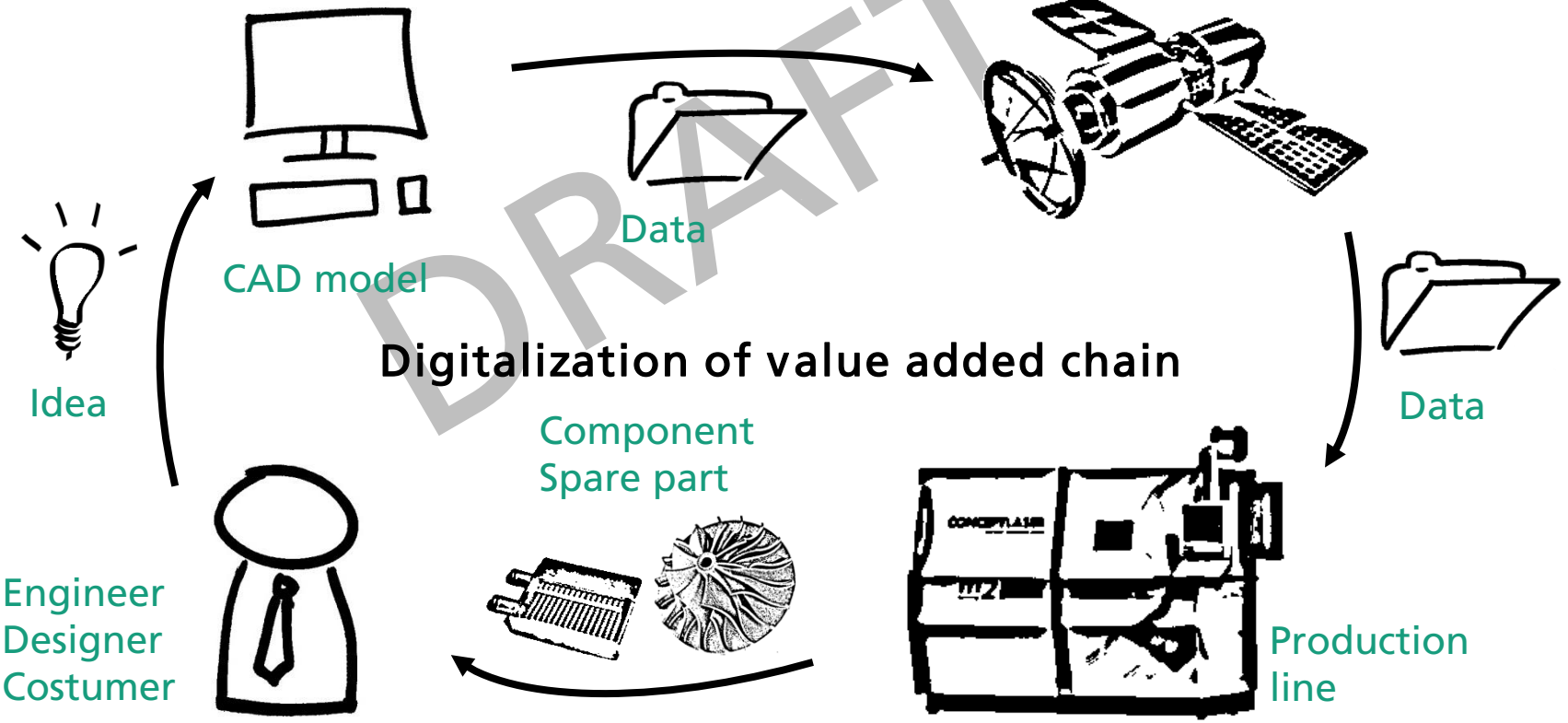
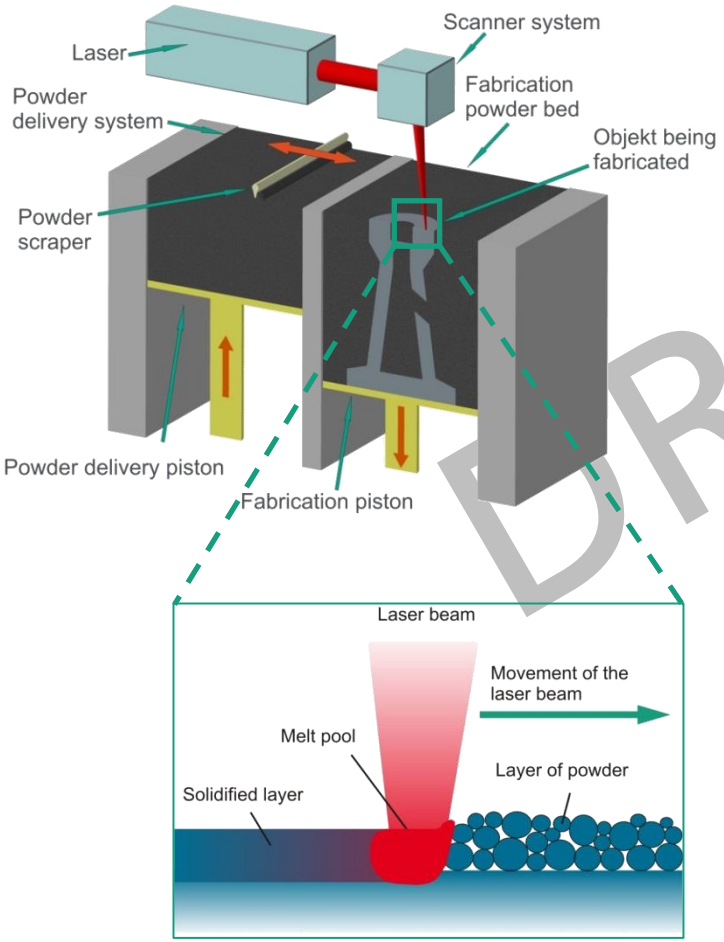
Production
Next generation manufacturing

- Individual, flexible and ressource efficient

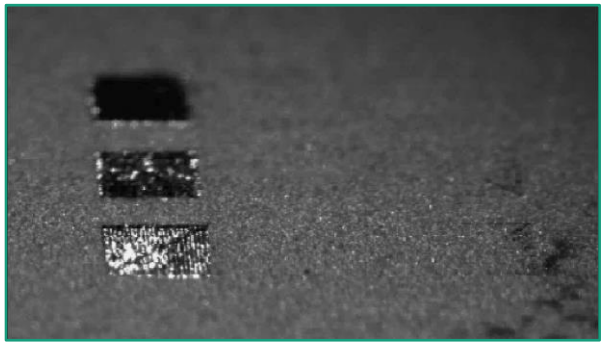


Production

Next generation manufacturing: Additive Manufacturing



- Main advantages
  - Time to production
    - no tools and NC programming
    - no technology planning
  - Freedom of shape
    - Lightwight design
    - Integration of functionality
  - Material diversity



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Additive Manufacturing
A Fraunhofer perspective

- Theses
  - There is a large variety of different technologies
  - AM technologies are prepared for industrial use
  - A profitable use of AM, most often depends on a different way of thinking:
    - This may affect product design as well as the overall production process
  - Additive Manufacturing will not replace other technologies:
    - it is a complementary manufacturing method
    - it is able to extend the possibilities and add value to products
  - Development will be more a continuous evolution than a disruptive revolution
  - Fraunhofer is active in many fields of AM and looking forward to cooperation

Fraunhofer IWU

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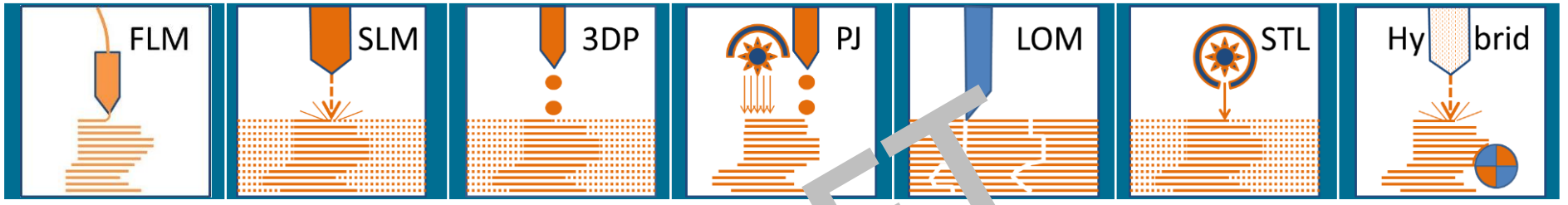
Additive Manufacturing
Technologies



Fused Layer Modeling	Selective Laser Melting /Sintering	3D-Printing	Poly Je	Lam[illegible]nated Object Modeling	Stereo-lithography	Hybrid Systems
Plastics (+Filler materials)	Metals Plastics (SLS)	Si[illegible]a, me[illegible]ls, pla[illegible]tics	Photo-polymer, wax	Paper, plastics, CFRP	Photo-polymers	Metals
• Models • Prototypes • Consumer goods	• Prototypes • Small batch series • Assembly of parts • Repairs • Tools	• Models, prototypes • Casting models	• Models • Prototypes • Casting models	• Models • Casting models	• Models • Prototypes	• Repair works • Single parts • Small batch series

Source: VDMA

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Additive Manufacturing
Technologies

Selective Laser Melting

Turbine wheel)

M2 Cusing (Co...ser)

Selective Laser Sintering

sPro™60 HD-HS High Speed SLS® Center (3D Systems)

Ventilation duct

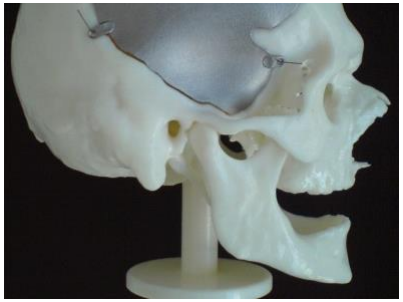
3D-Print...g

Gearing mechanism

ZPrinter 310 + Zprinter 450 (3D Systems / Z Corp.))

Fused Layer Modeling

FORTUS 900mc (Stratasys)



Cranium model for OP preparation

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Additive Manufacturing
Pioneering applications for series production

- Dental crowns, bridges and brackets
  - Manufactured by Laser Beam Melting in CoCr
  - Numbers (as of 2012):
    - 40 EOS DMLS machines for dental production worldwide
  - Cost benefits:
    - Up to 450 crowns and bridges in 24 h

Source: EOS

Source: Concept Laser

Source: Realizer GmbH

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Additive Manufacturing
Pioneering applications for series production

- Fuel injection nozzle
  - Manufactured by Laser Beam Melting
  - Part of the new GE LEAP jet engine
  - 19 nozzles per engine
  - By 2020 more than 100,000 parts
  - Technical benefits:
    - 25 percent lighter
    - Once 18 parts → with AM one
    - 5 times more durable due to an improved cooling system

Source: GE Aviation

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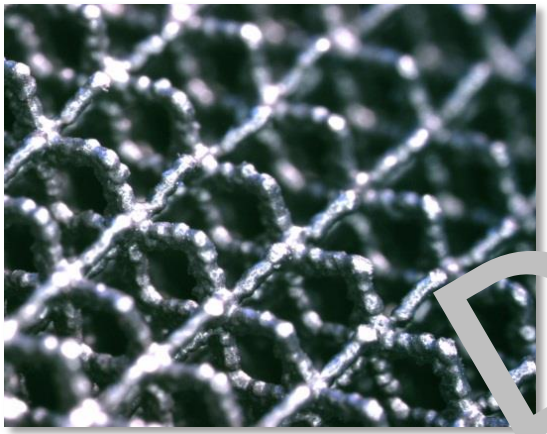
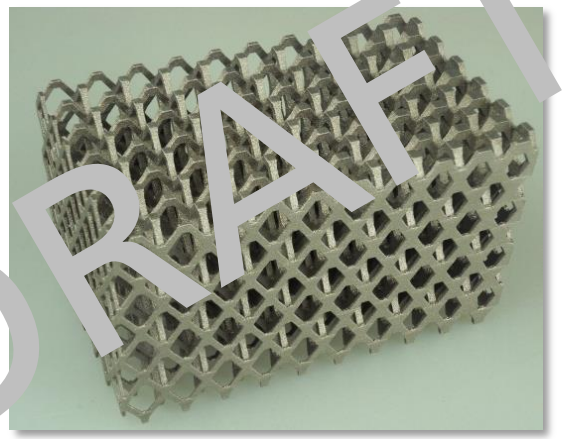
Additive Manufacturing
Different way of thinking

- Laser Beam Melting process and application development
  - Development of functional structures: lattice, bionic/topology-optimized



- Regular lattice structure with 0.3 mm strut thickness
- ✓ Extreme lightweight design



- Graded lattice structure
- ✓ Optimised load distribution

- Topologically optimized axle carrier for a longboard
- ✓ Material reduction

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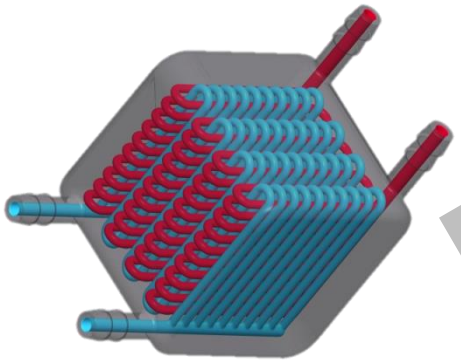
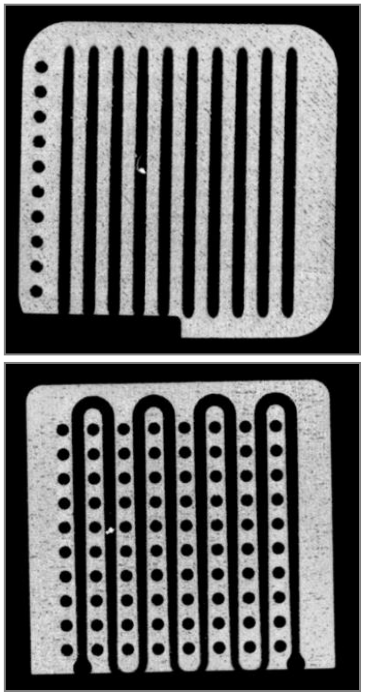
Additive Manufacturing
Different way of thinking

- Example of innovative miniature heat exchanger





3D-CAD-model of heat exchanger → Additively manufactured miniature heat exchanger → Evaluation/inspection with micro computer tomography

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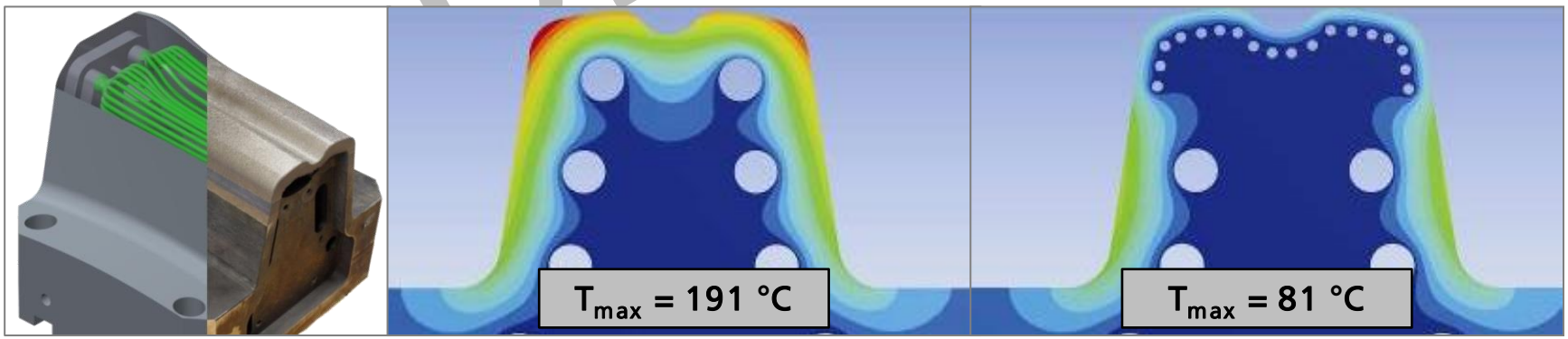
Additive Manufacturing
Different way of thinking

Innovations-Allianz Green Carbody Technologies

- Tooling for hot sheet metal forming
  - Successful application of additively manufactured tooling in hot sheet metal forming under production-like conditions
  - Forming press locking time reduced by half (from 10s to 5s)
  - Cycle time reduced by 20%
  - Improved / adjustable part properties



Press Hardening Tool | Conventional drill holes | Optimized inner cooling channels

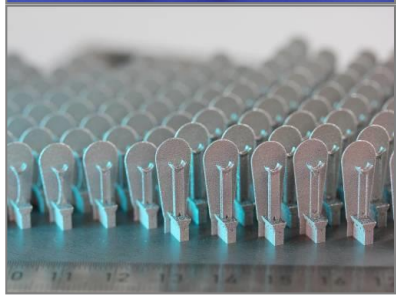
Federal Ministry of Education and Research
MANAGED BY PTKA Project Management Agency Karlsruhe within Karlsruhe Institute of Technology
BRAUN CarTec
Fraunhofer IWU

Additive Manufacturing
Different way of thinking

- Medical engineering
  - Development, design and manufacturing of instruments, devices and patient-specific implants
  - Functional integration (surface / volume structures, channels and cavities)
  - Feasibility studies for medicinal applications







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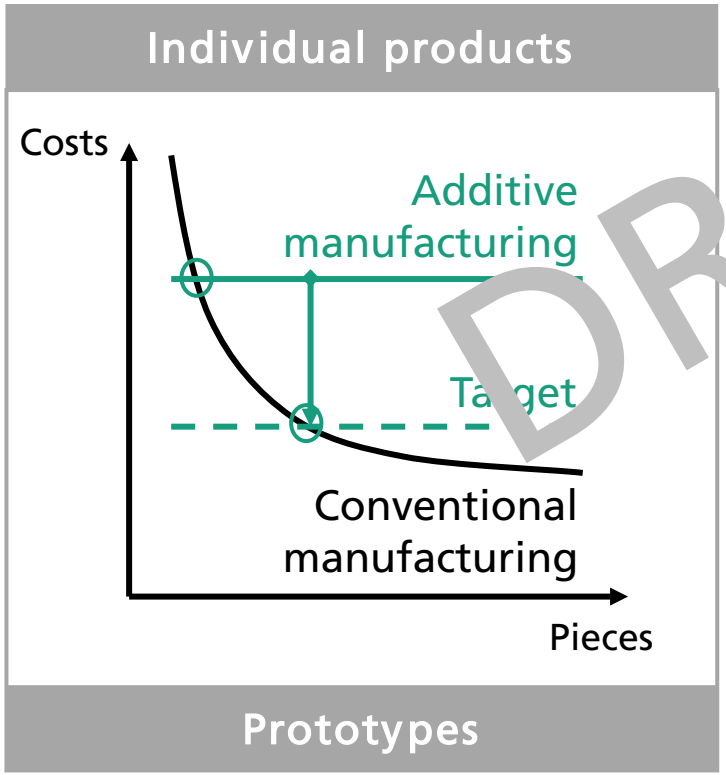
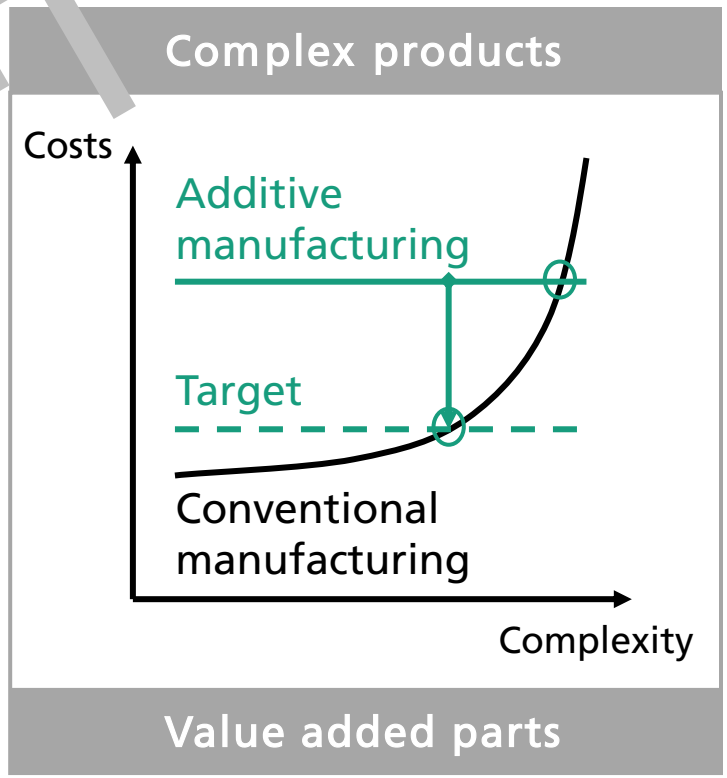
Additive Manufacturing
Complementary manufacturing method

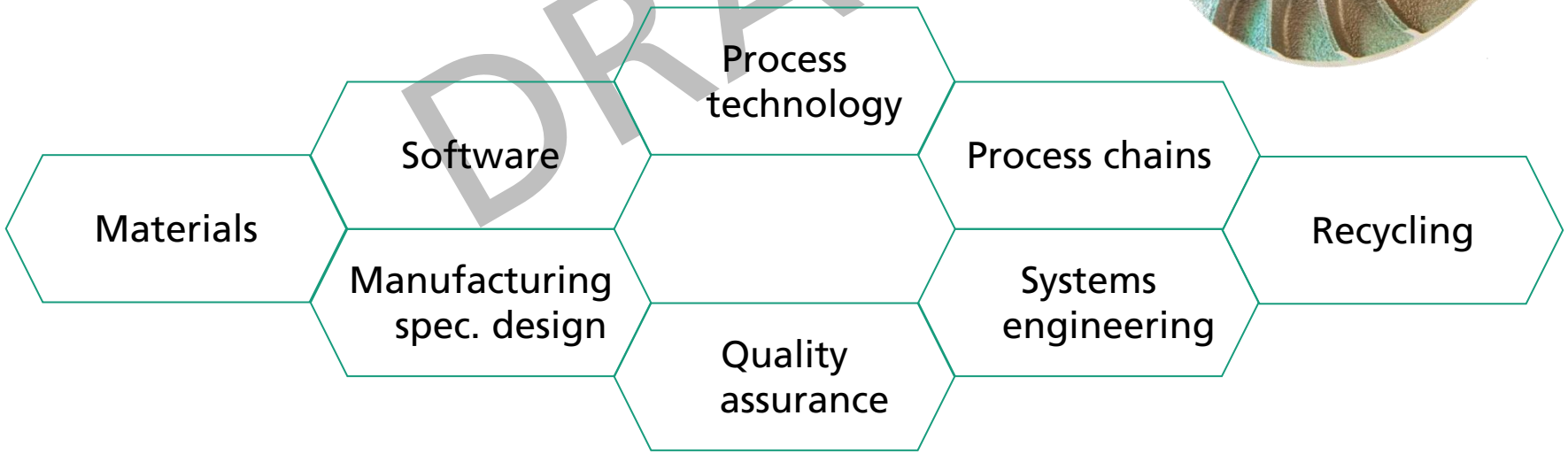
- Prefered for prototyping due to its low costs for single products or small batches





Additive Manufacturing
Complementary manufacturing method

- Challenge
  - Rapid Prototyping → Rapid Manufacturing
- Potential for development



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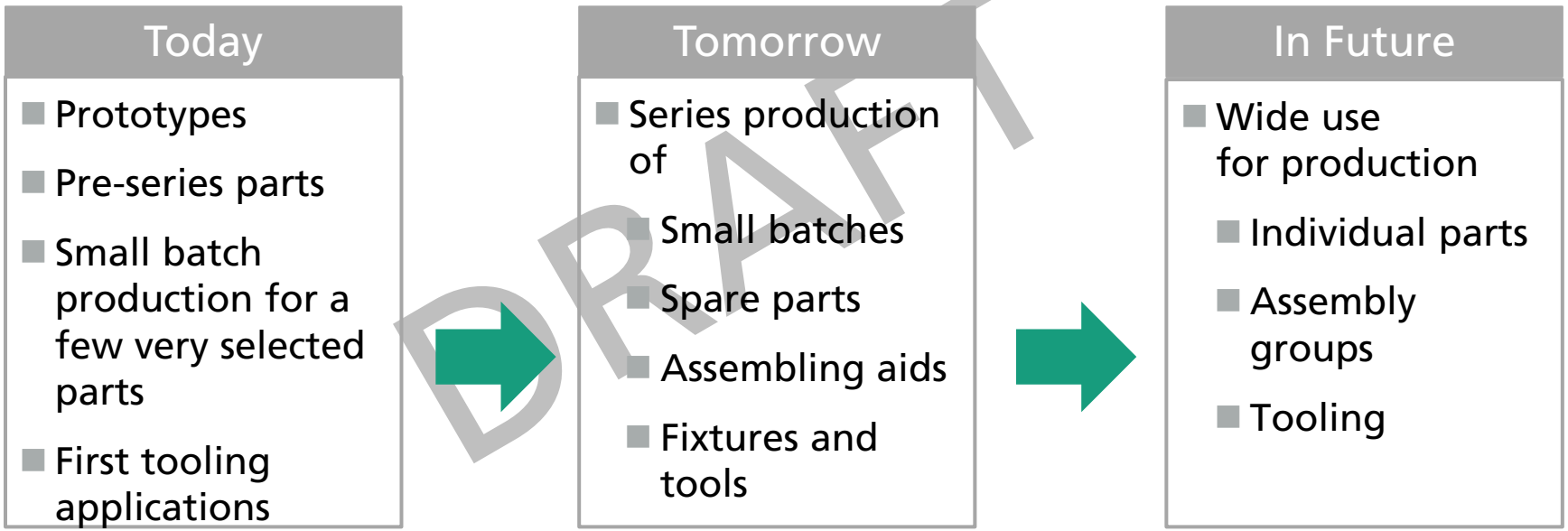
Additive Manufacturing
Continuous evolution

- Facing challenges

Challenges for AM	Necessary Steps
Missing technical standards	Standardisation
Reproducibility	Quality control systems / in-situ feedback control systems
Costs	Gained productivity
Education with regard to AM design	Widely spread teaching of AM principles at universities / colleges
Material variety (e. g. carbon steel, copper, ceramics)	Material and process development

Additive Manufacturing
Continuous evolution

- Forecast



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Additive Manufacturing
Fraunhofer activities

AGENT3D
ADDITIV GENERATIVE FERTIGUNG

- Project AGENT 3D
  - The 3D revolution for product manufacturing in digital age
- Objectives
  - Placing Industry-specific, additive manufactured products succeyyfully on international market
    - Cost reduction > 20%
    - Performance increase >20%
  - Sustainable process chains
  - Sustainable customer-supplier-relationship
  - Interlinking science and industry to innovation motor

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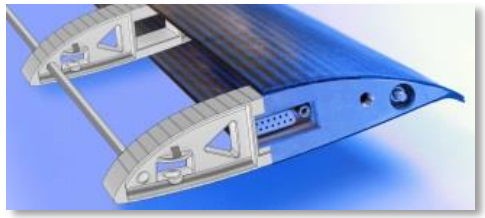
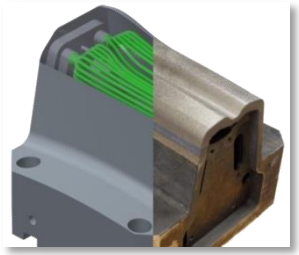
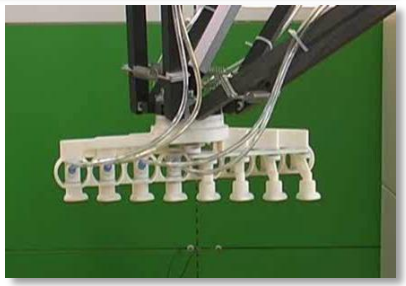
Additive Manufacturing
Fraunhofer activities

Fraunhofer GENERATIV

- Fraunhofer Additive Manufacturing Alliance
  - Developing new rapid strategies, concepts, technologies and processes
  - Close collaboration with national and international partners
  - Enhancing performance and competitiveness of SME
- Fields of research
  - Bio-medical engineering
  - Microsystems technology
  - Automotive engineering & aerospace
  - Tool making
  - Handling and assembly
- Central office: Fraunhofer IWU







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The Fraunhofer-Gesellschaft
Cooperation models

- Different ways of working with Fraunhofer

One-off contracts	Large-scale projects with multiple partners	International cooperation
• Solve the problem • Launch the innovation in the business or the marketplace	• Cooperation between multiple Fraunhofer institutes, external partners and companies	• Fraunhofer offices abroad

Strategic partnerships	Innovation clusters	Spin-offs
• Long-term partnerships that evolve from non-contract, pre-competitive research	• Regional partners from research, industry and universities	• Fraunhofer researchers branch out on their own, often with the customer taking a stake

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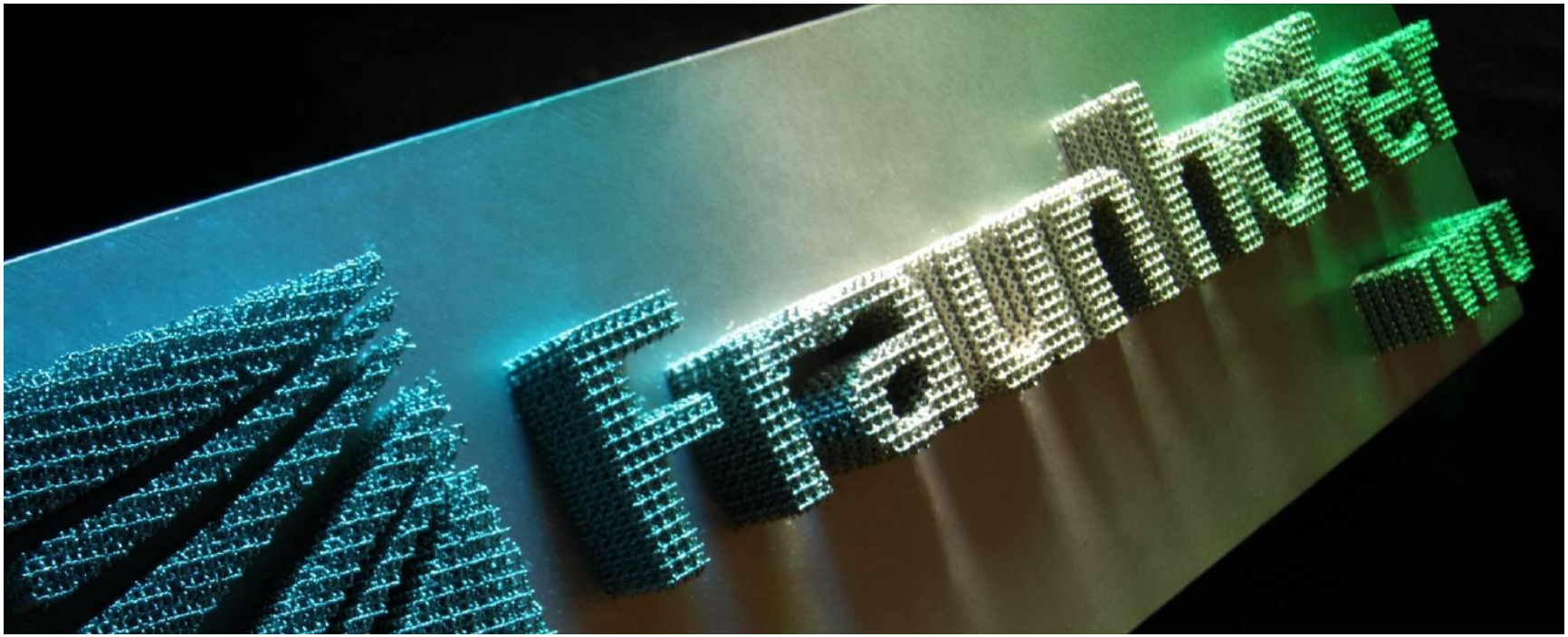

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