3D PRINTEN

Technologie Update Uneto-VNI

Hanno Schouten

TNO innovation for life

INHOUD

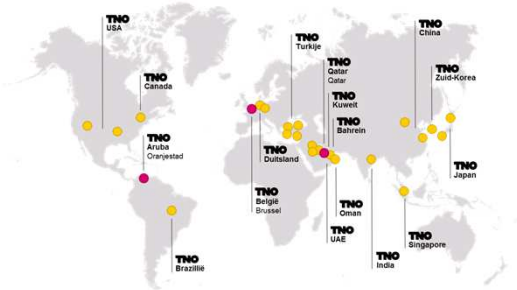
- TNO & 3D printen
- Wat is 3D printen
- 3D print technieken
- 3D print voorbeelden

2

TNO innovation for life

TNO AT A GLANCE

- Dutch research organization for applied scientific research
- Established by law and started in 1932
- Independent of public and private interests
- Assisting companies to innovate by doing R&D
- Supporting government in policy making



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ADDITIVE MANUFACTURING AT TNO

- Active in AM for almost 20 years:
  - from fundamental to applied
  - material, process and equipment
  - strategic alliances
  - shared innovation and bi-lateral
  - IP track record in AM
- Application focus:
  - medical – dental
  - structural & freeform electronics
  - food & pharma
  - high tech applications

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CONNECTING TWO ECOSYSTEMS

Focus on high speed AM systems

Multi material, multi technology and mass customization

with industrial partners

Focus on functional AM materials

Improved quality, durability and new functionalities

with industrial partners

5

WAT IS 3D PRINTEN?

ze kunnen tegenwoordig alles gewoon printen

printen is sneller

printen is goedkoper

we staan aan de vooravond van een revolutie

power to the people!

printen maakt transport overbodig

printen geeft geen afval

de volgende industriele revolutie

6

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WAT IS 3D PRINTEN?

- "*op basis van een digitale bouwtekening driedimensionale objecten computer gestuurd produceren door het object laag na laag op te bouwen*"
  - Container begrip voor 7 verschillende processen
  - Sinds de jaren '80
  - Grote toename in activiteiten sinds 2012

x1000 hits	**2010**
Rapid Prototyping	8.000
Digital Manufacturing	481
3D Printing	392
Additive Manufacturing	303
Free Form Fabrication	180
Rapid Manufacturing	107
Additive Fabrication	56
Layer Manufacturing	38
Direct Digital Fabrication	3

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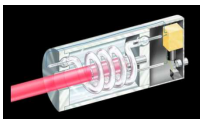
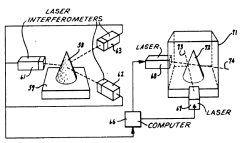
UITVINDINGEN AAN DE BASIS VAN 3D PRINTEN

- 1892 – Blanther: layering method of producing molds for topographical maps
- 1956 – Munz: system for selectively exposing photo emulsion in layerwise fashion
- 1960 – Maiman: 1st visible laser light



- 1972 – Ciraud: manufacturing process where laser beam fuses powder particles
- 1977 – Swainson: polymerization of photosensitive polymer with two laser beams
- 1981 – Introduction of personal computer by IBM



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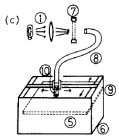
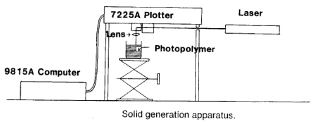
EERSTE 3D PRINTERS (SLA)

- 1981 – Kodama:

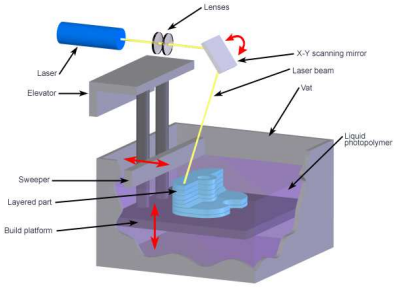


- 1982 – Herbert:



Solid generation apparatus.

- 1984 – Hull: (founder of 3D systems) invents stereolithography (SLA), patented in 1987, 1st machine sold in 1988



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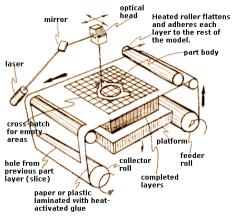
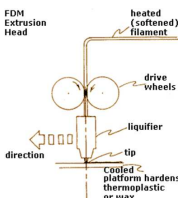
EERSTE 3D PRINTERS (‘80)

- Layer Object Manufacturing (LOM)



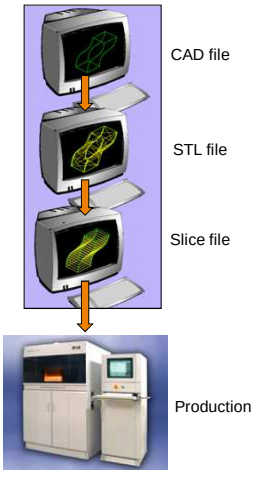
LOM™, registered by Helisys of Torrance, California, USA

- Fused Deposition Molding (FDM)



FDM, developed by Scott Crump, 1988

3D printing workflow:



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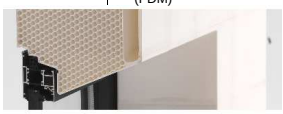
3D PRINTEN IN DE BOUW

- **Voxeljet** (binder jetting)
- **Glasspowder printer** (powder deposition)
- **IMCRC** (extrusion)
- **Emerging Objects** (various techniques) *printed house*
- **MX3D Metal** (weld-torch)
- **Total Kustom** (extrusion)
- **FreeFAB Wax** (FDM)
- **C-Fab** (FDM)

1996 — 2006 — 2012 — 2015

- **Contour Crafting** (extrusion)
- **D-shape** (binder jetting)
- **KamerMaker** (FDM)
- **IAAC Minibuilders** (extrusion)
- **BAAM** (FDM)
- **WASP** (extrusion)
- **Win Sun** (extrusion) *printed buildings*
- **Lab3D** (FDM)



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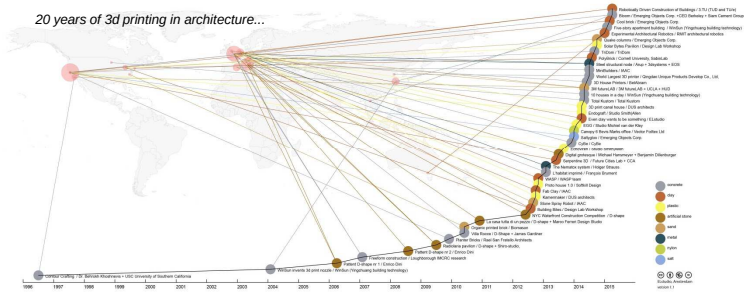
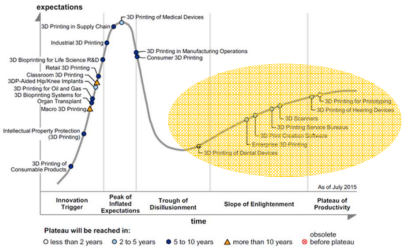
AM HYPE … WORDT WERKELIJKHEID





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NAMEN VOLGENS ISO

ISO/ASTM F42

- *Vat Photo polymerization*
- *Powder Bed Fusion*
- *Binder Jetting*
- *Material Extrusion*
- *Material Jetting*
- *Directed energy deposition*
- *Sheet Lamination*

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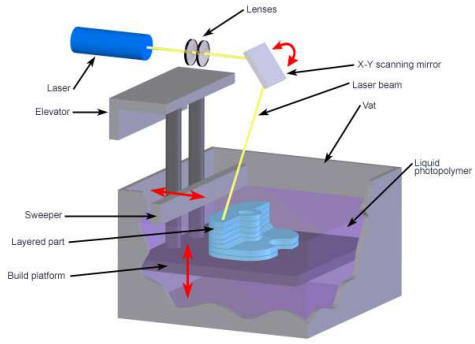
VAT PHOTO POLYMERIZATION

- Ook bekend als Stereo Lithography (SLA)
- Zeer hoge resolutie (beste oppervlakte kwaliteit)
- Laagdikte: 0,05 – 0,20 mm
- Materialen: Epoxy / Acrylaat hars



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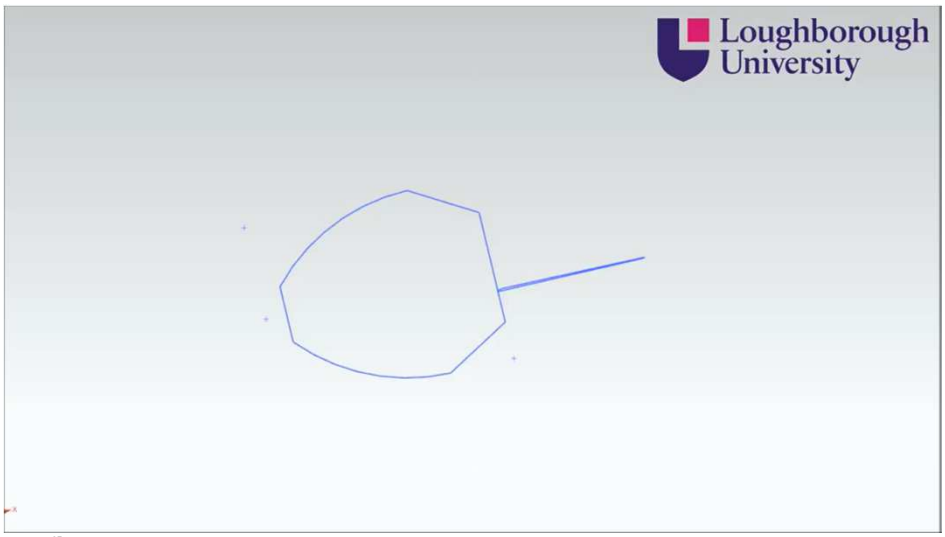
VAT PHOTO POLYMERIZATION



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VAT PHOTO POLYMERIZATION

- Succesvolle toepassingen:
  - Gehoorapparaat behuizing
  - Dentale toepassingen

Courtesy of Invisalign

Courtesy of Phenix

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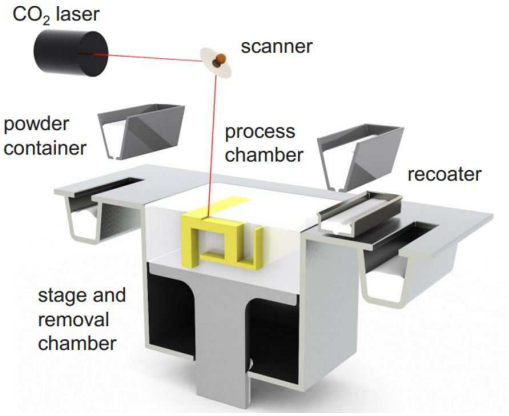
POWDER BED FUSION

- Ook bekend als *Selective Laser Sintering* (SLS)



Courtesy of Sculpteo.com

Courtesy of EOS

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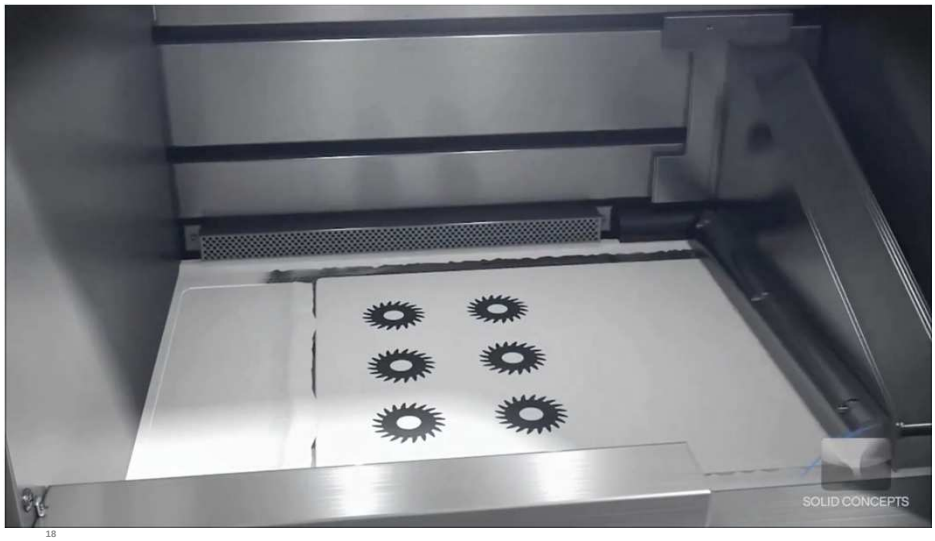
POWDER BED FUSION



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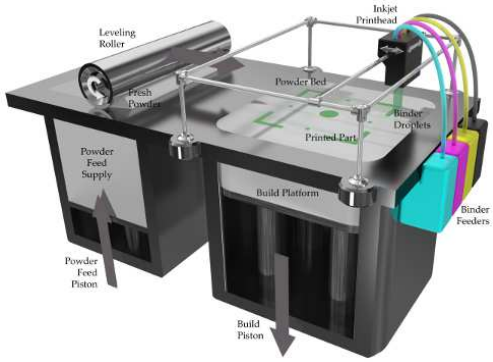
BINDER JETTING

- Ook bekend als *3D-printing* (3DP)
- Poeder wordt gebonden door 'lijm'
- Laagdikte: 0,18 – 1 mm
- Materialen: gips, zand, polymeer (PMMA)



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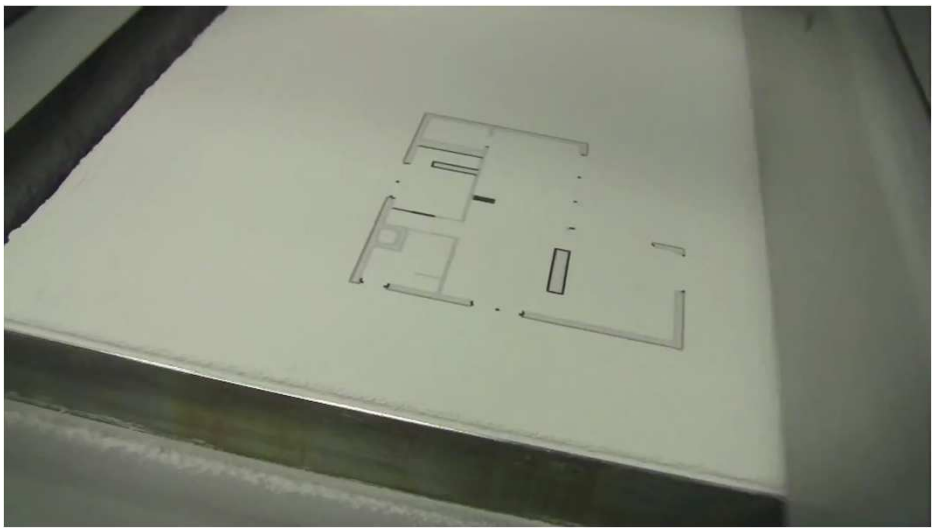
BINDER JETTING



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BINDER JETTING

- Bekende voorbeelden:
  - D-Shape by Enrico Dini
  - Z-Corp (3D-Systems)
  - VoxelJet

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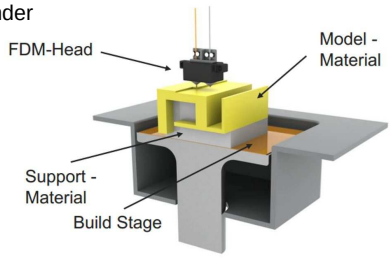
MATERIAL EXTRUSION

- Ook bekend als *Fused Deposition Molding* (FDM)
- Populair als thuis printer
- Laagdikte: 0,10 – 1 mm
- Materialen:
  - polymeren (PLA, ABS, Polycarbonaat, ...)
  - gemixte materialen met polymeren als binder
  - ook: beton, voedsel, ...



Courtesy of Sculpteo.com

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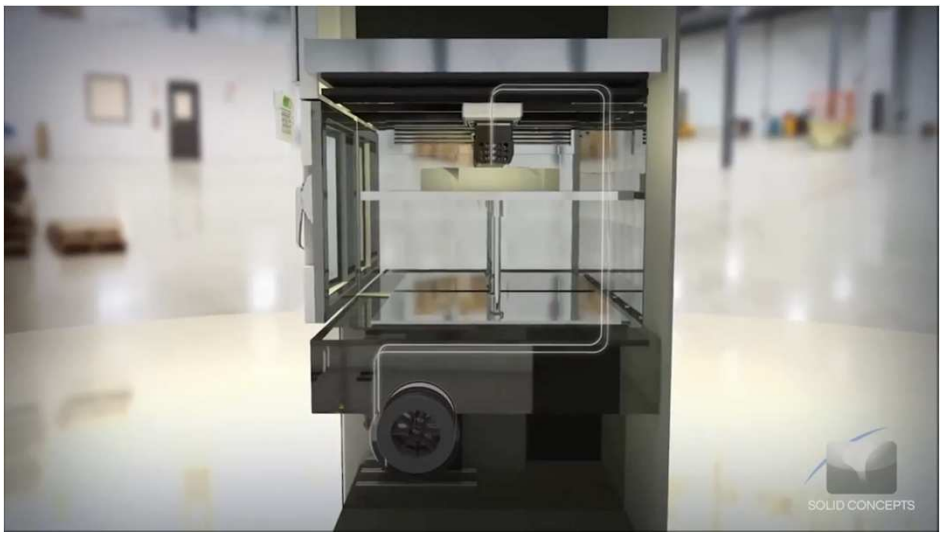
MATERIAL EXTRUSION



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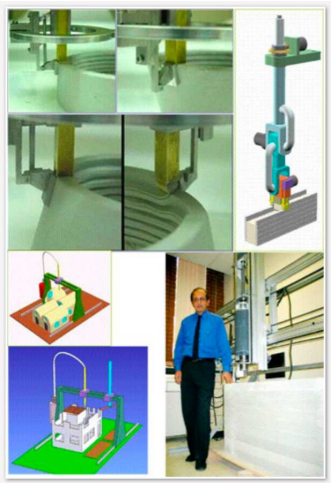
MATERIAL EXTRUSION

- Voorbeelden uit de bouw sector:
  - Contour Crafting
  - KamerMaker



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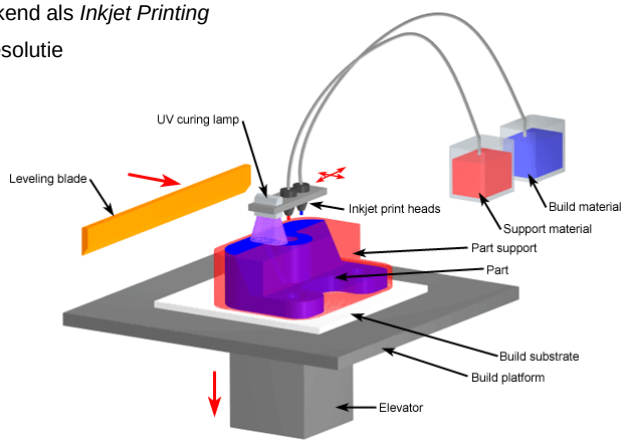
MATERIAL JETTING

- Ook bekend als *Inkjet Printing*
- Hoge resolutie



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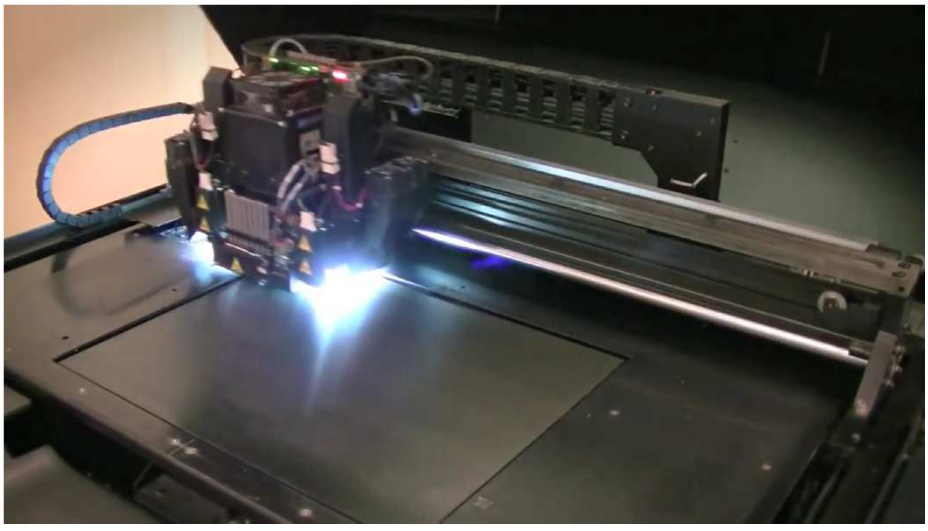
MATERIAL JETTING



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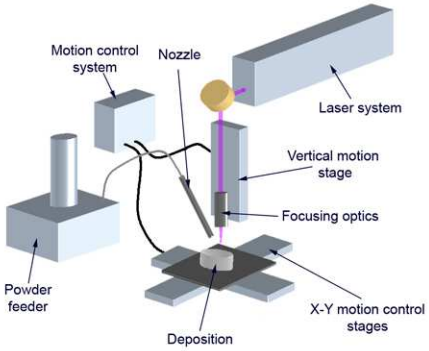
DIRECTED ENERGY DEPOSITION

- Beter bekend als *Laser Cladding*
- Materialen: metaal soorten
- Alternatief proces: draad ipv poeder



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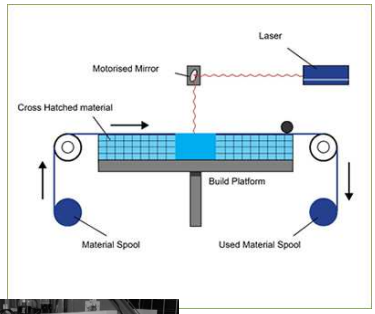
SHEET LAMINATION

- Meest bekend: *Layer Object Manufacturing* (LOM)
- Materialen: papier, hout, metaal

- Voorbeelden:
  - MCOR (papier)
  - Fabrisonic (metaal)



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WAAROM 3D PRINTEN?

- **Vormvrijheid**
  - geen productgebonden gereedschappen
  - economisch verantwoord ontwerpen

- **Aanpasbaarheid**
  - aangepast aan menselijk lichaam
  - standaard onderdelen in combinatie met aanpassingen
  - 3D meetdata als input

- **Functie integratie**
  - bespaart assemblage (tijd & geld)
  - verbeterde functionaliteit

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VOORBEELDEN (VORMVRIJHEID)

- Speelgoed, mode, spullen, ...

Courtesy
www.wolfprint3d.com

3D ultrasound scans

FABJECTORY
virtual objects in real life

Nintendo Mii

$50 – 100

shapeways*

shapeways*

Jewelry

- Interieur, kunst, ...

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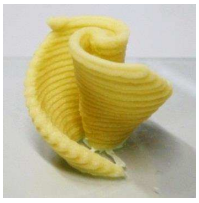
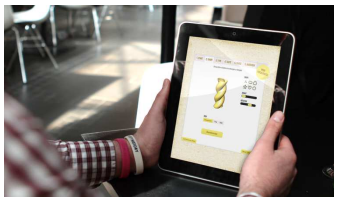
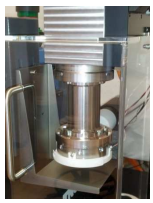
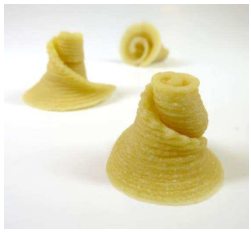
VOORBEELDEN (VORMVRIJHEID)

- Pasta printing

Barilla
TNO



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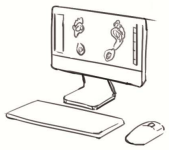
VOORBEELDEN (VORMVRIJHEID & FUNCTIE)

ADD·FACTOR
TNO

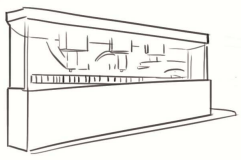
Personalised footwear


1) Gait cycle analysis


2) 3D scanning of the feet and pressure analysis


3) Adjusting parameters and generate model


5) User receives insole or shoe and can enjoy walking


4) Product prints while the customer waits

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VOORBEELDEN (FUNCTIE VERBETERING)

- Lightweight & integrated
- Proces:
  - Selective Laser Melting
  - 68 uur
  - materiaal: 65,-
  - productie: 2500,-

Compolight

TNO

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VOORBEELDEN: GEHOORAPPARATEN

- Rond 2008 is de complete productie van in-ear gehoorapparaten overgestapt op AM!

Courtesy of Widex

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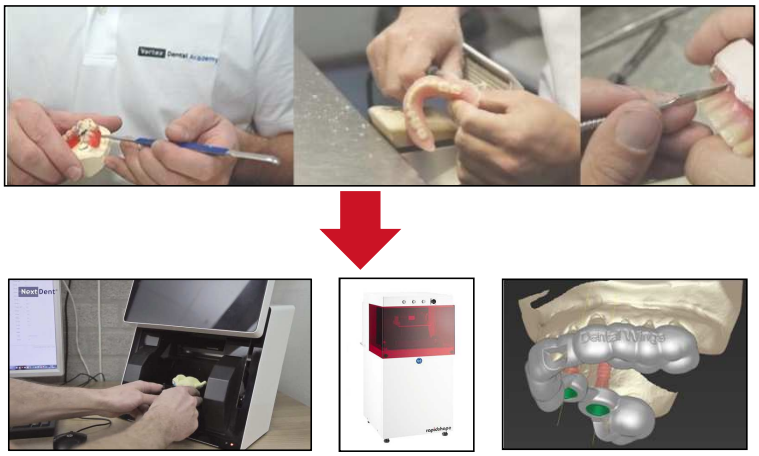
VOORBEELDEN: DENTAAL



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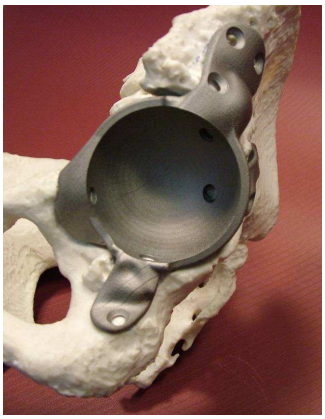
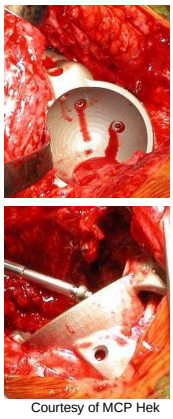
VOORBEELDEN: MEDISCH

- Titaan implantaten





Courtesy of MCP Hek

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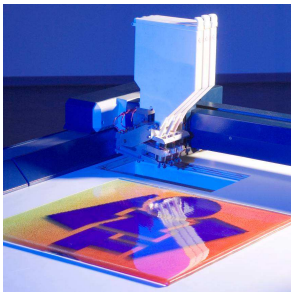
VOORBEELDEN: GLASPOEDER PRINTER

- Nederlands Instituut voor Beeld en Geluid
- TNO & Saint Gobain



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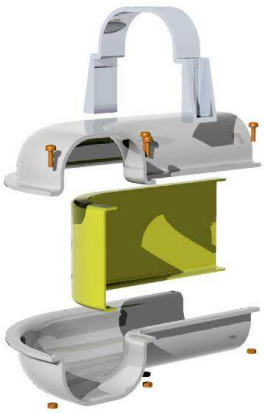
VOORBEELDEN: FUNCTIE INTEGRATIE



16 onderdelen + assemblage

1 onderdeel

Courtesy of 3DSystems

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VOORBEELDEN: LUCHTVAART

Additive Manufacturing of functional parts for Aircraft Engines

19 Additive fuel nozzles to be installed on every CFM LEAP engine (over 4500 sold)
100.000 Additive parts will be manufactured by GE Aviation by 2020
300+ 3D printing machines currently in use across GE

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VOORBEELDEN UIT INSTALLATIE SECTOR…

- Kogelkraan
  Juni 2014 / http://www.teesing.nl

- Gietbouwdoos
  Juli 2015 / ABB

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THANK YOU FOR YOUR ATTENTION
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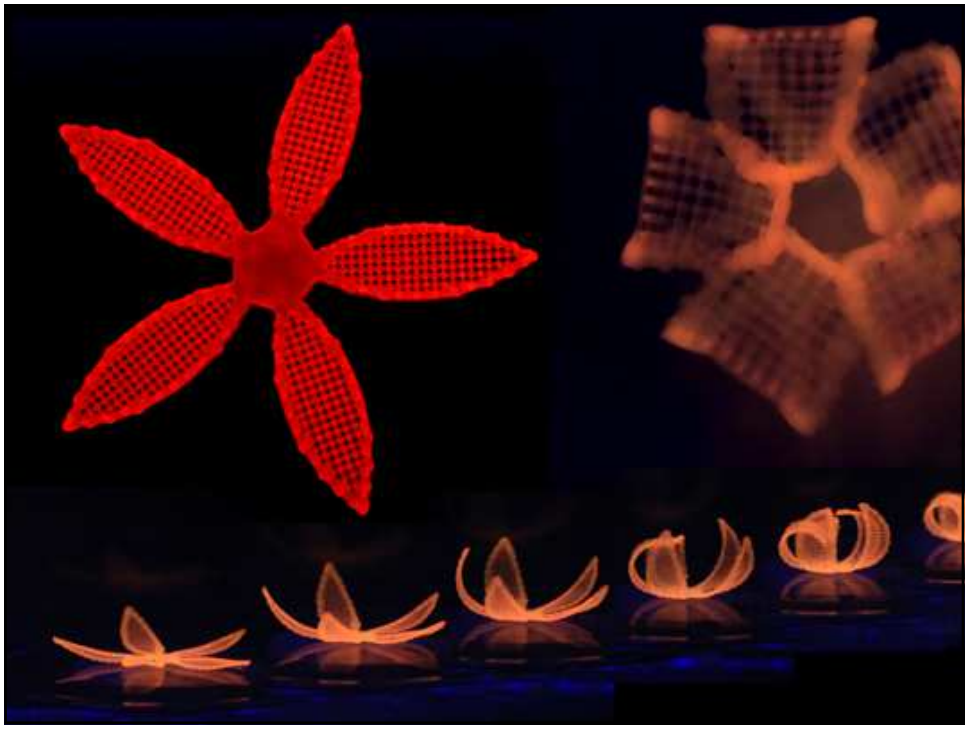
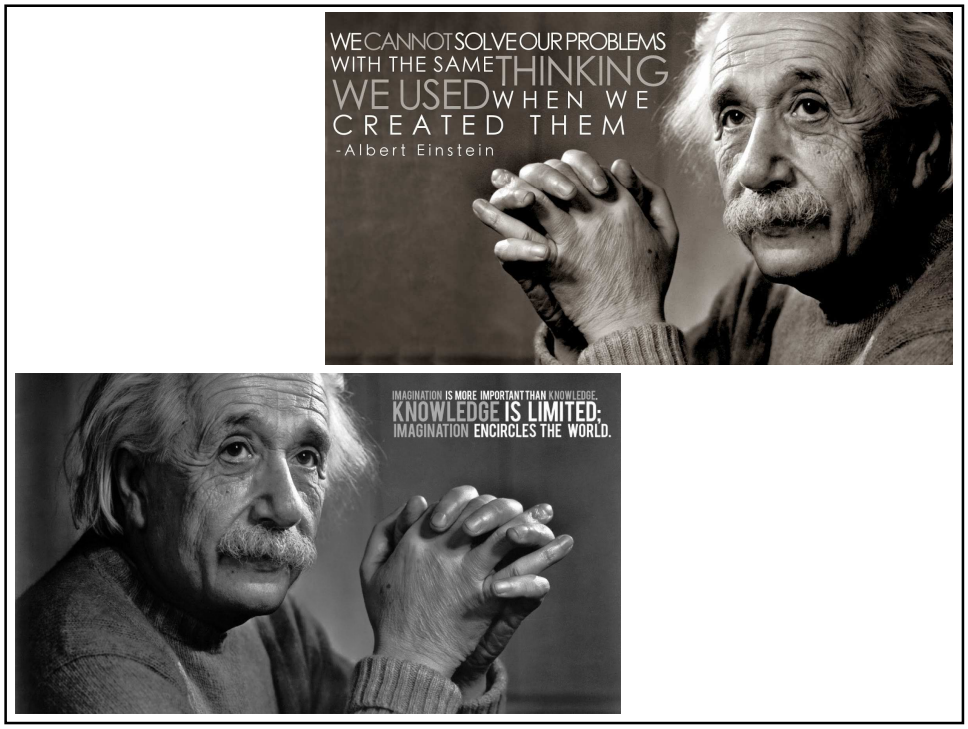
PROGRAMMA

- 09:00: Ontvangst / koffie
- 09:30: Welkomstwoord - korte voorstelronde / kennismaking
  Inleiding 3d printing / AM, markt, Kurzweil / Hype Cylce ....
  Enkele voorbeelden uit de installatiebranche
- 09:55: 3d printing / AM: wat houdt de technologie in?
  Waarom 3d printen?
  Printable materialen en voorbeelden
- 11:00: Korte rondleiding labo (2 groepen)
- 11:30: Brainstormsessie (3 groepen)
- 12:15: Contouren vervolg: Technologie Cluster (of evt. BIA)
- 12:30: Afsluiting met lunch.

2 | Additive Manufacturing installatiebranche

3d printing installaties





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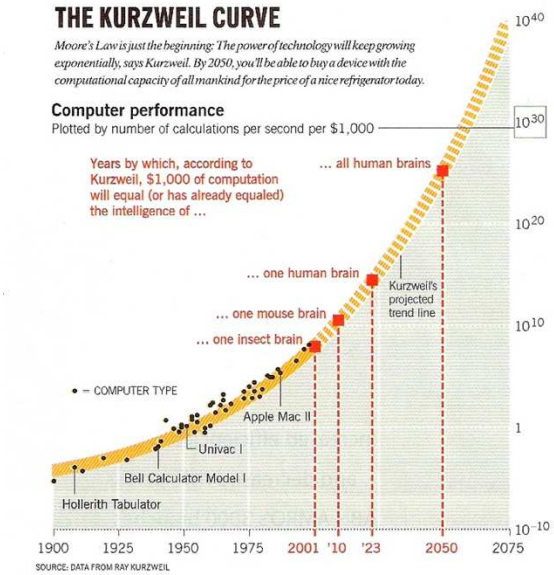
MAAKINDUSTRIE / ROBOTISERING / AUTOMATISERING

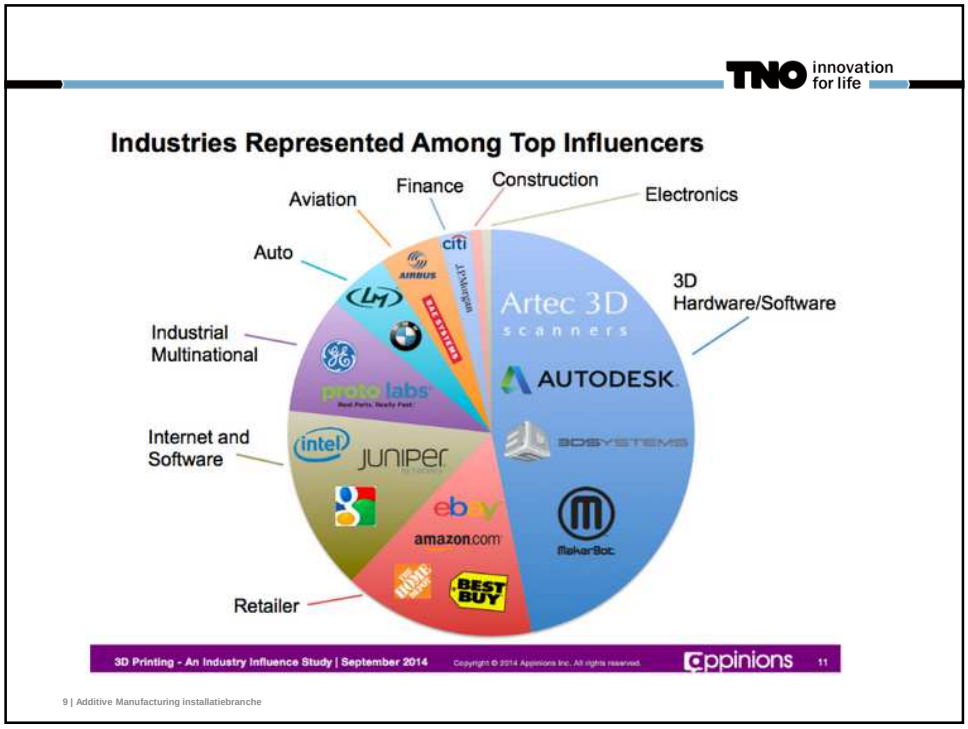
TNO innovation for life

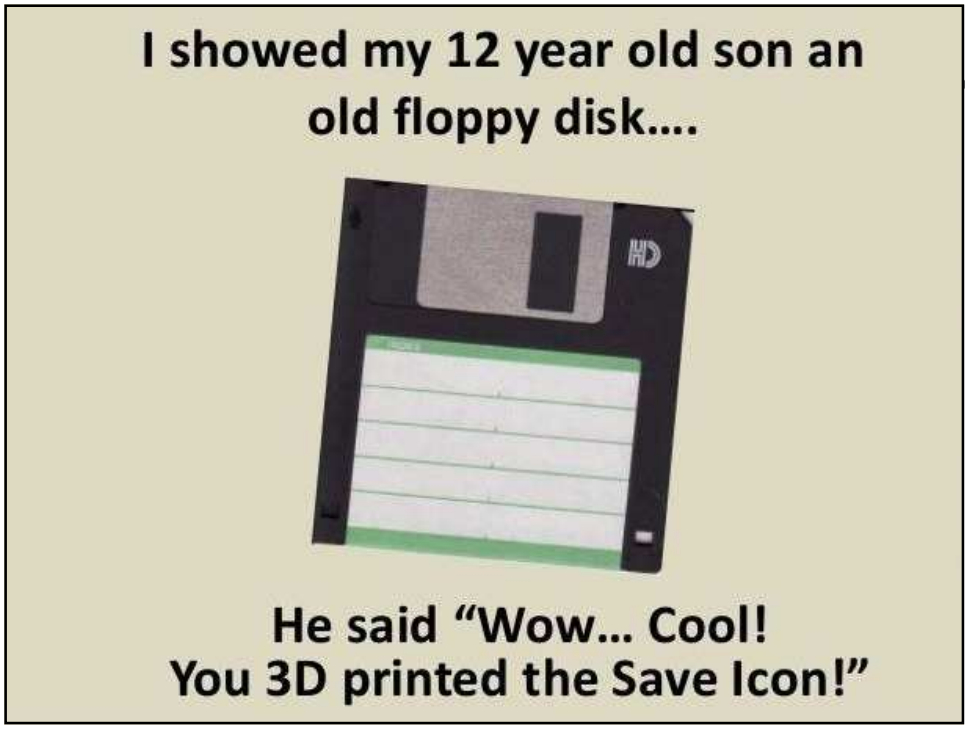
TNO innovation for life

KURZWEIL



3d printing installaties





ing. Peter Kuindersma

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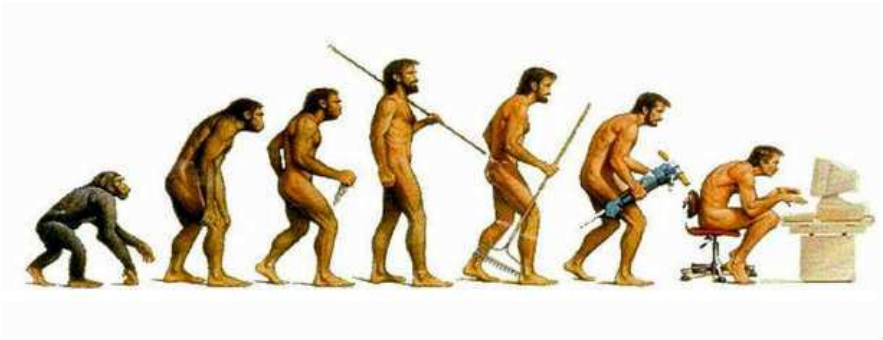
DIGITALIZATION?



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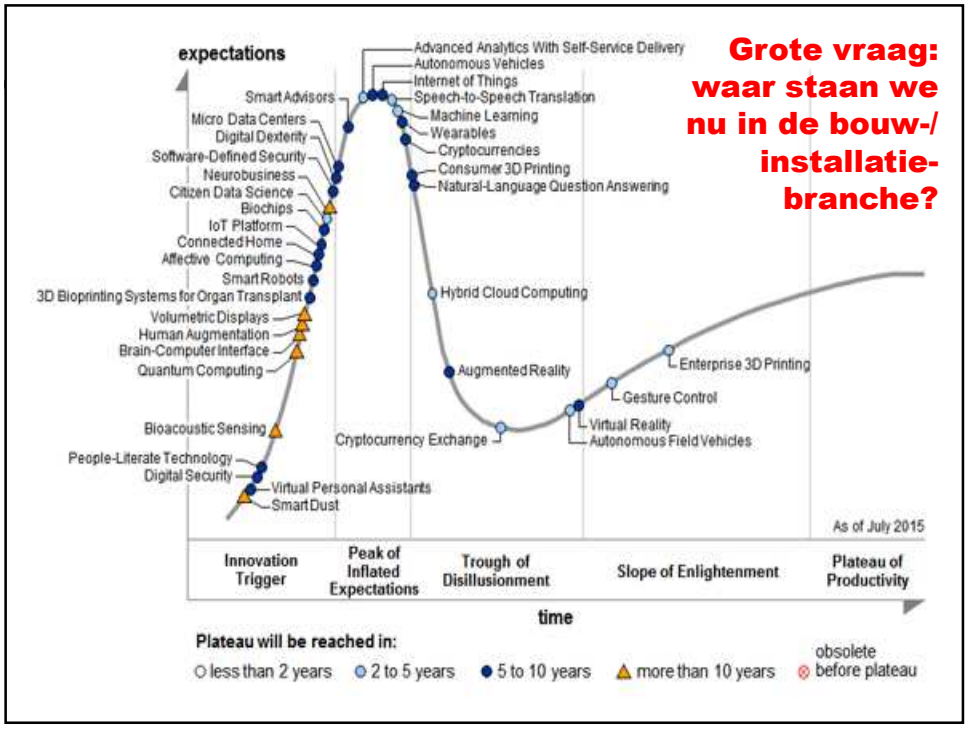
DE VOORDELEN; MAAR ZIJN ER OOK NADELEN..

Lower costs	Better design	Customisation	Sustainability	New business models
• No tooling or cheaper tooling • Less transportation • Lower warehousing • Less working capital required	• Complexity for free • Added features (cooling, isola-tion, structures, porosity, con-ductivity, etc.) • Hybrid materials • Light-weight • Less assembly by integrated design	• Ergonomics • Interfaces with other products • Body contours (external and internal) • Aesthetics • Use specific variations	• Less waste • Light weight • Less fuel consumption • Efficient supply chains • Life Cycle Analysis	• Prototyping • Shorten lead time or time-to-market • Small series • Supply chains (on demand, on location) • Services • Co-creation / home creation

14 | Additive Manufacturing installatiebranche



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EQUIPMENT FOR ADDITIVE MANUFACTURING (EFAM)

EFAM ontwikkelt samen met kennispartners en industriële marktpartijen innovatieve fabricage processen en bijbehorende hoge-precisie machineconcepten voor het deponeren en patroneren van functionele materialen. Deze laag-bij-laag depositie/patroneren wordt gezien als de holy grail voor veel verschillende toepassingen, zoals geïntegreerde en flexibele elektronica, gepersonaliseerde medicijnen en voedsel, zonnecellen en OLED verlichting.

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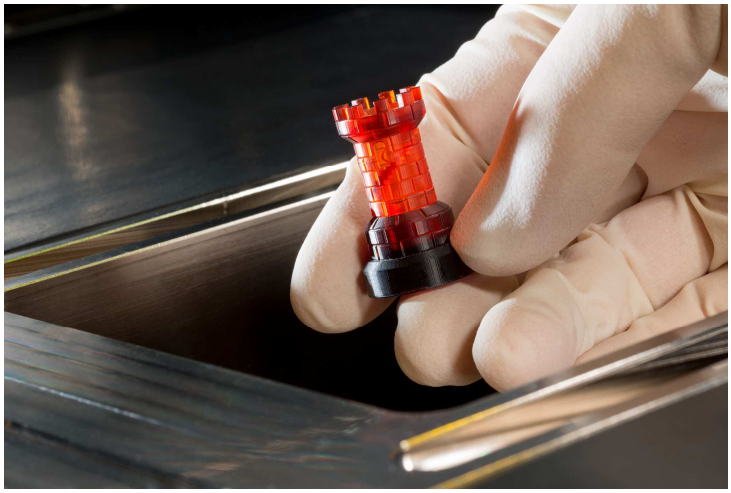
RONDLEIDING LABORATORIUM



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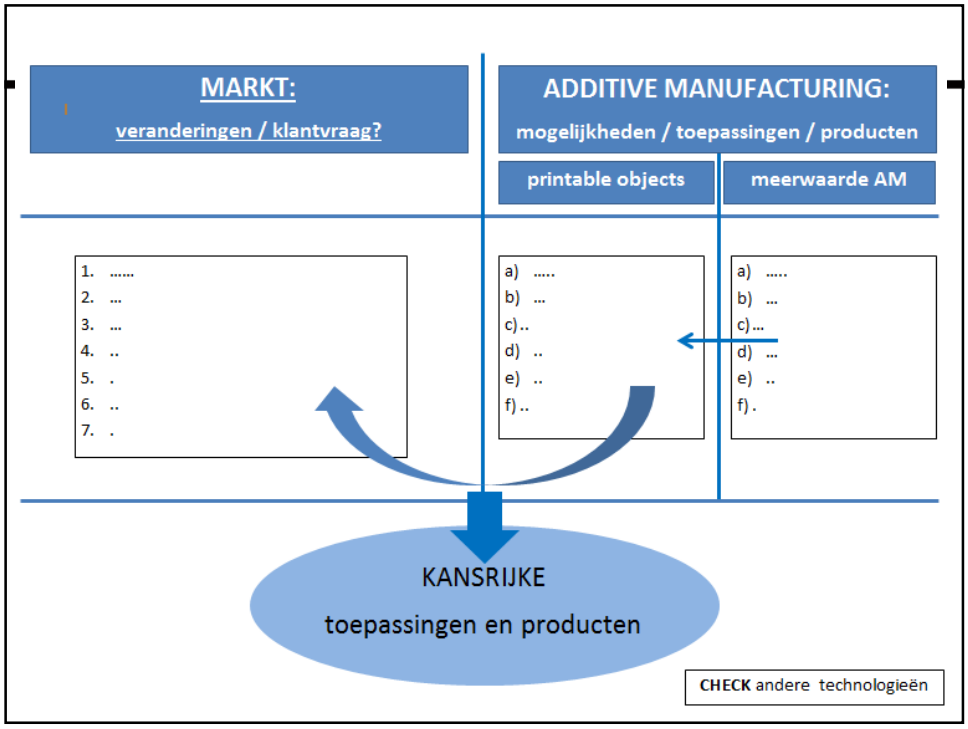
MARKT:
veranderingen / klantvraag?
ADDITIVE MANUFACTURING:
mogelijkheden / toepassingen / producten
printable objects
meerwaarde AM
1. .....
2. ...
3. ...
4. ..
5. .
6. ..
7. .
a) .....
b) ...
c) ..
d) ..
e) ..
f) ..
a) .....
b) ...
c) ...
d) ...
e) ..
f) .
KANSRIJKE
toepassingen en producten
CHECK andere technologieën


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EN NU VERDER .....
We gaan verder met een Technologie Cluster of een Branche Innovatie Agenda.
TECHNOLOGIE CLUSTER VOOR MKB-BEDRIJVEN
BRANCHE INNOVATIE AGENDA (BIA)
De keuze daarvoor wordt snel gemaakt, en wordt gemaakt door UnetoVNI en TNO.
Beoogde looptijd: eind mrt t/m eind sept.
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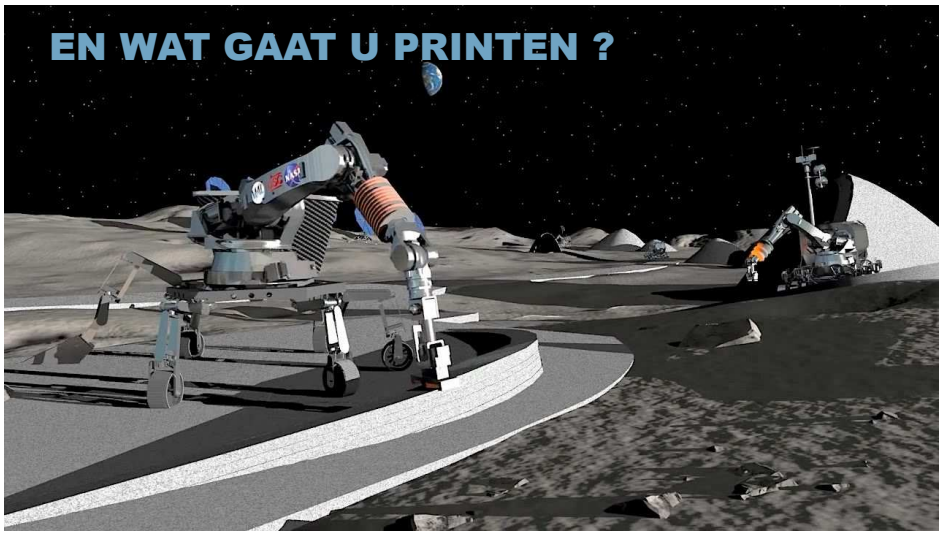
EN WAT GAAT U PRINTEN ?



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ZIJN ER NOG VRAGEN?

LAAGSPANNINGS-WONING

innovation for life

TECHNOLOGIE ZOEKT ONDERNEMER

TNO-ers bruisen van de ideeën. Jaarlijks biedt TNO een aantal van haar productideeën aan in het TNO programma 'Technologie zoekt Ondernemer'. Wij zoeken hiervoor innovatieve ondernemers in het MKB, die perspectiefvolle productideeën van TNO verder willen ontwikkelen en commercialiseren. Deze ideeën zijn gebaseerd op onderzoeksresultaten van TNO en sluiten aan bij een maatschappelijk thema of een economische behoefte.