

Additive Manufacturing

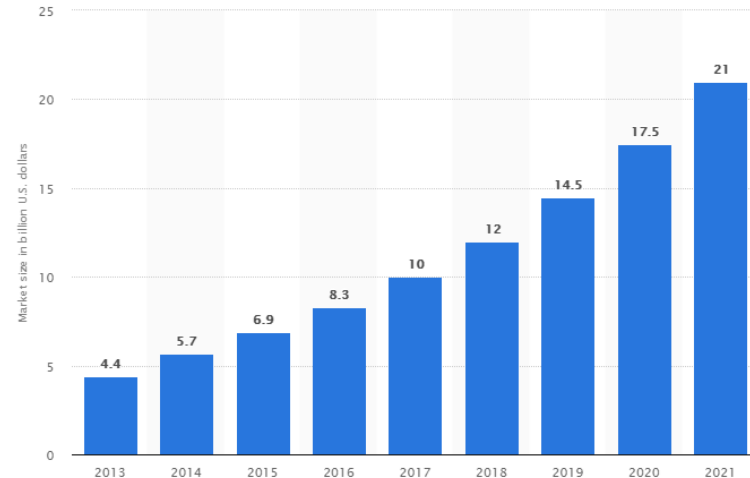
- Den moderne betegnelse for 3D-printing/Rapid Prototyping
 - Lagdelt laserhærdning af flydende plast i et elevatorlignende setup
 - Udtænkes omkring 1981 hos GE i Frankrig
 - Bedømmes til ikke at have nogen kommerciel fremtid
 - GE skrinlægger hurtigt projektet
 - 3D-Systems dannes i 1984
 - 3D-systems udtager patent på processen
 - STL-formatet introduceres
 - SLA-printning bliver kendt i de kommende år, og 3D-Systems dominerer
- Teknologisk Institut i Århus anskaffer den første 3D-Systems printer omkring 1990
 - Den første Pro/ENGINEER-licens i Danmark anskaffes til at drive denne printer



Additive Manufacturing

- Bedre og flere materialer
 - Nyloner, Metaller, Kulfiber
- Nye anvendelser
 - F.eks. i læge- og tandlægefag, proteser o.lign.
- Bedre og billigere printere
 - Nu kan man købe en 3D-printer i lufthavnen sammen med tidens andre gadgets
- Finans og medier har fået øje på 3D-Print
 - Udnævnt til den næste revolution indenfor fremstilling

3D printing market size worldwide from 2013 to 2021



- Design for manufacturing
 - I stedet for begrænsninger af typen
 - Fræsning:
 - Fler-akset simultan fræsning, lange udhæng, mange opstillinger
 - Gnistning:
 - Langsom process, håndtering af gnistgab, mange elektroder
 - Sprøjtstøbning:
 - Fyldning, afformning, delelinier, komplekse forme
 - Styktal:
 - Høje styktal nødvendige for at retfærdiggøre værktøjsomkostninger
 - Afledte effekter:
 - » Lager
 - Plads, omkostninger, tilgængelighed

Additive Manufacturing

- Andre bindinger ved Additive Manufacturing
 - Materialer
 - Styrke
 - Volumen af emne, Højde af emne
 - Tolerancer
 - Cyklustider
 - Pris/emne
 - Pris/serie
- Resulterer i forskellige optima for de forskellige processer
- Men alt er i bevægelse:
 - Hurtigere print flytter grænsen i retning af større serier end hidtil
 - Husk at vi startede med prototyper
 - Stadigt mere komplekse emner (funktioner/emne) favoriserer Additive Manufacturing
 - Fremstillingsprocessen er fundamentalt mindre følsom overfor kompleksitet end traditionelt



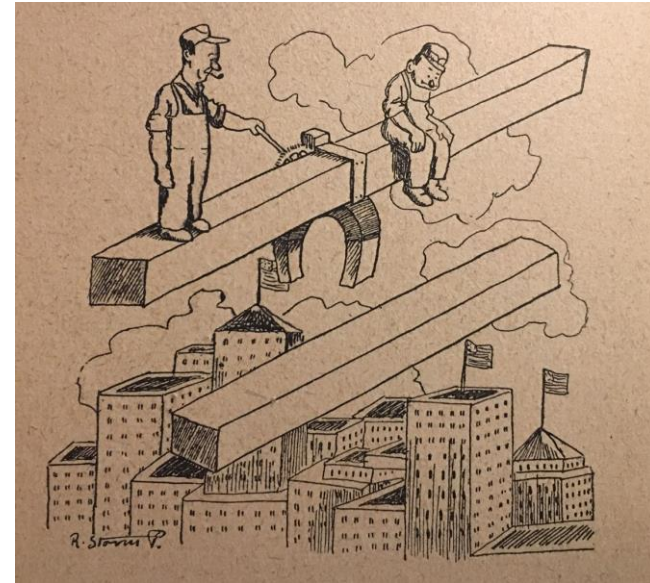
Additive Manufacturing

- Nogle gange kommer der et gennembrud
 - Og processen vendes på hovedet.....

- Eksempel:

- Hurtig 3D-printer fra Carbon 3D

- <https://youtu.be/UpH1zhUQY0c>



Additive Manufacturing

- Nye friheder
 - Hurtigere fra design til emne – ingen leadtime for værktøjer
 - Vægtreduktion
 - Hule emner
 - 3D-optimerede gitterstrukturer
 - Organiske former
 - Print af reservedele on demand
 - Design anywhere, Print anywhere



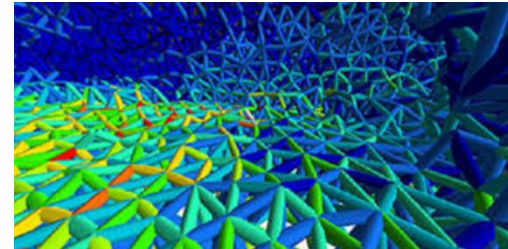
Additive Manufacturing

- 3D-optimerede gitterstrukturer
 - Opbygning af gitre parametrisk i Creo
 - Beregning og optimering v.hj.af Creo Simulate



Additive Manufacturing

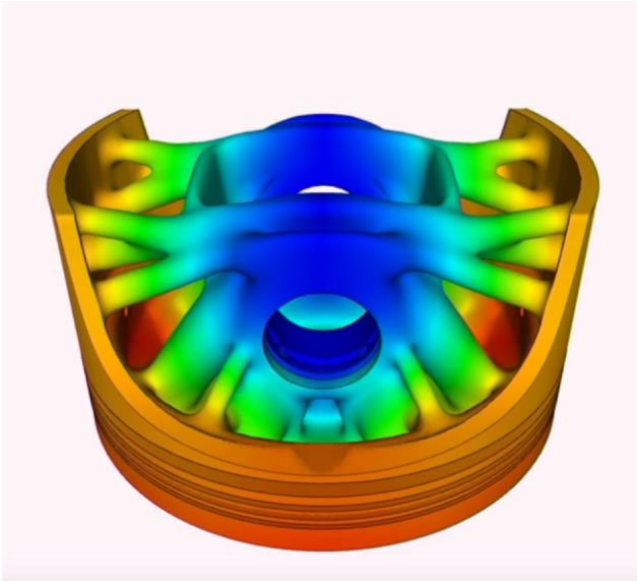
- Creo support for Design for Additive Manufacturing
 - Lattices
 - Automatisk genkendelse af lattices af Creo Simulate som
 - Solider
 - Shells
 - Beams



- <https://www.youtube.com/watch?v=bjzshB3hckY>
- <https://www.youtube.com/watch?v=DpK5dx-mhY8>

Additive Manufacturing

- Organiske former:
 - Resultat af shape optimization/topology optimization



- Shape/Topology Optimization
 - Ikke en del af Additive Manufacturing, men frembringer geometrier, som matcher dårligt med andre fremstillingsmetoder
 - https://cdn2.hubspot.net/hubfs/2519598/Frustum2018/Home/home_page-generate_teaser.mp4

Additive Manufacturing

- Frustum Inc.
 - Overtaget af PTC i 2018
 - Baggrund for et kommende optimeringsinitiativ



- First to market with the next gen volumetric geometry kernel **TrueSOLID™**
- Allows for indeterminate geometry to blend together with engineering intent precisely

→ What is impossible with Gen 3 CAD takes seconds with **TrueSOLID™**

- Eksempel:
- 3D-print til kritisk anvendelse
 - Veldefineret loadcase – Bremsecaliber Bugatti Chiron
 - <https://youtu.be/SRA5CFLYkUQ>
 - <https://youtu.be/hPkY8nBWxoU?t=157>

Additive Manufacturing

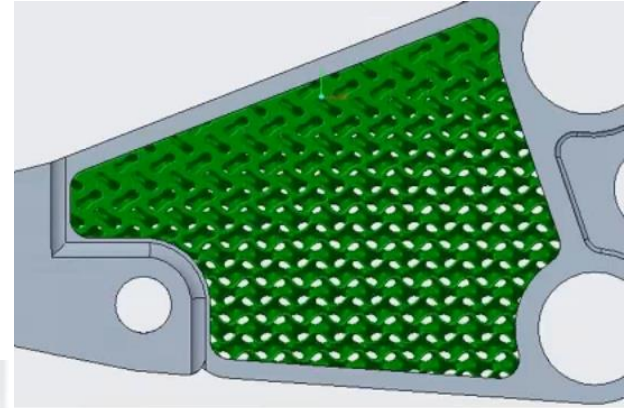
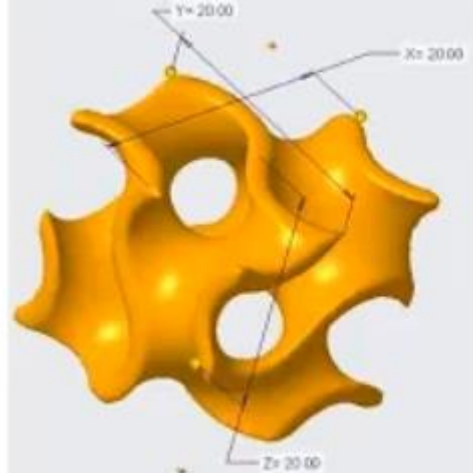
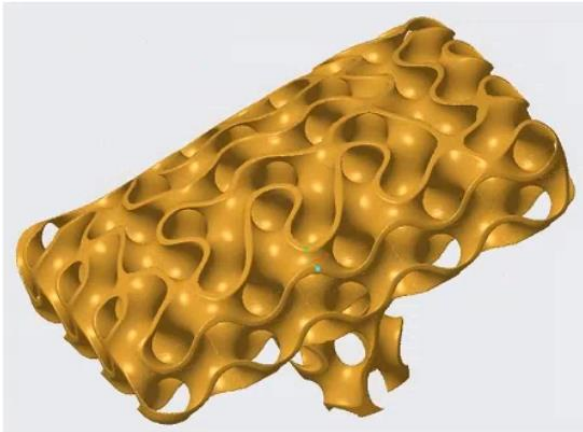
- Additive Manufacturing Creo 6.0
 - Hastighed ved generering af lattices
 - Forskellige lattice-typer/Celle-typer
 - Formel-drevne
 - Stokastiske
 - Brugerdefinerede Celler
 - Flere supportede printere
 - Slicing i Creo

 - (Topology optimization)
 - Ikke en del af Additive Manufacturing, men god sammenhørighed

Part Name	Creation Time in Creo 5 (seconds)	Creation Time in Creo 6 (seconds)
cylinder.prt	137	6
triangle.prt	138	7
square.prt	107	5
pentagone.prt	132	5
hexagone.prt	108	5
octagone.prt	111	6
sphere.prt	136	7

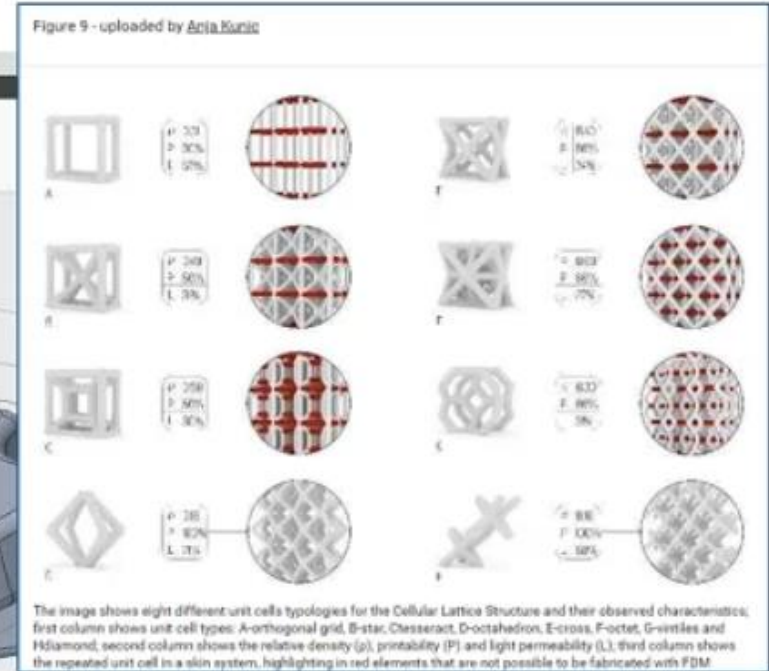
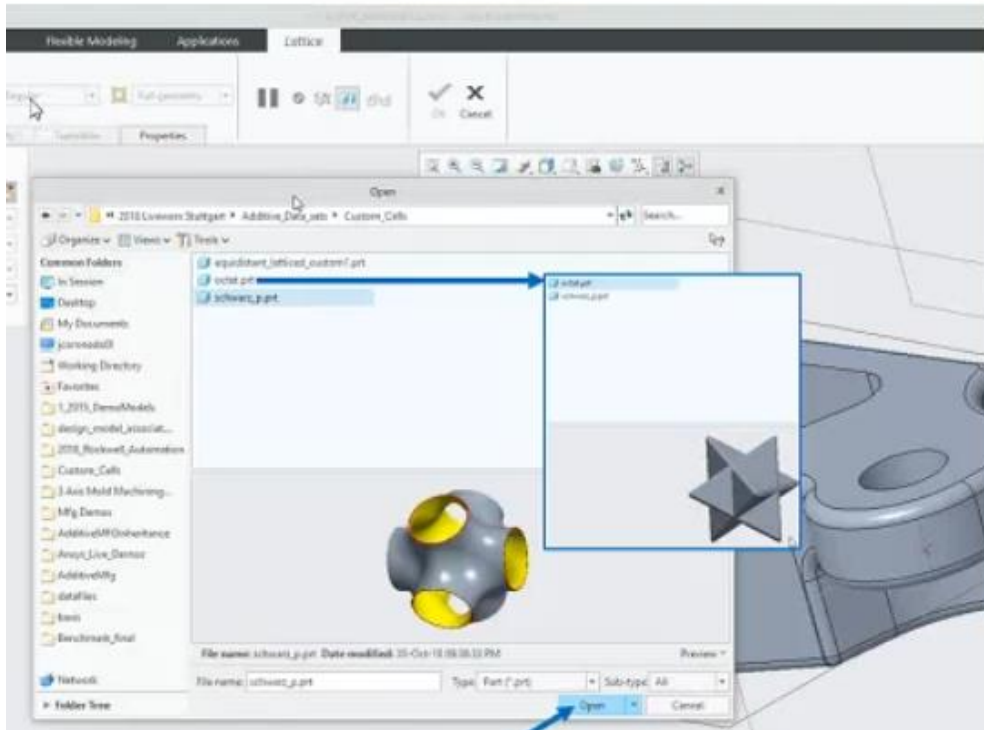
Additive Manufacturing

- Nye typer af formeldrevne celler/lattices
 - Selvbærende (kræver ikke understøtning)
 - Lave spændinger
 - Parametrisk varierende volumenandel
- Stochastic Lattices
 - Gunstige til f.eks. implantater



Additive Manufacturing

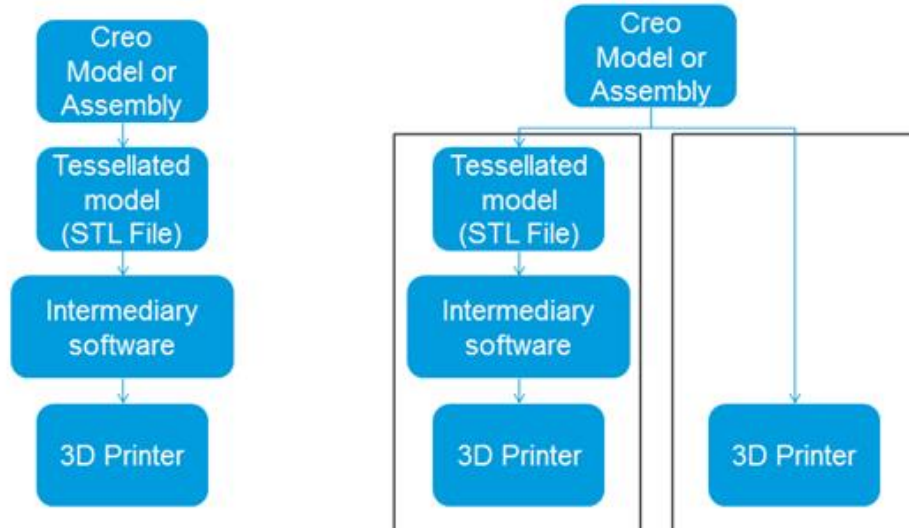
- Brugerdefinerede Celler



https://www.researchgate.net/figure/The-image-shows-eight-different-unit-cells-typologies-for-the-Cellular-Lattice-Structure_fig6_321234750

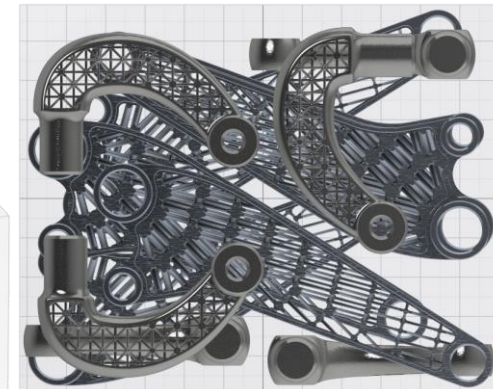
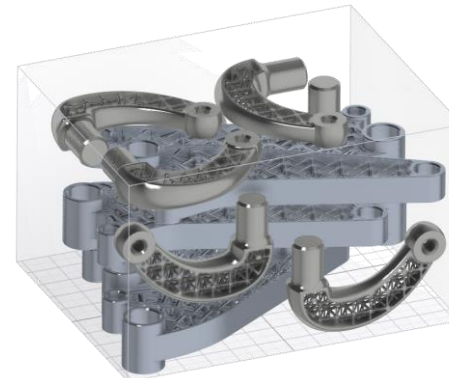
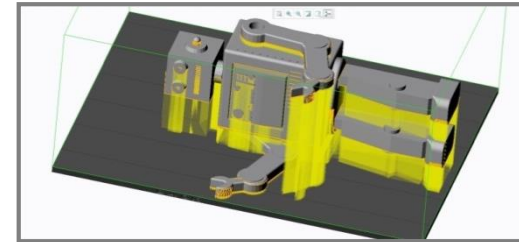
Additive Manufacturing

- PTC er committed til at fortsætte integrationen af Additive Manufacturing, som startede i Creo 3.0
- Workflow
 - Before Creo 3.0 M040
 - After Creo 3.0 M040



Creo 4.0 og Creo 5.0

Description	Creo 4.0	Creo 5.0
Creo Parametric		
• Print Check	✓	✓
• Create Print Trays	✓	✓
• Direct Connect to Stratasys Plastic Printers	✓	✓
• Direct Connect to 3D System Plastic Printers	✓	✓
• Direct Connect to i.materialize Print Bureau	✓	✓
• Direct Connect to Plastic Printers in the Materialise Library		✓
• Direct Connect to 3D Systems ODM Print Bureau		✓
Creo Additive Manufacturing Extension		
• Lattice Modeling	✓	✓
• Modify, Manage and Save Print Tray Assemblies	✓	✓
• Automatic Positioning and Nesting in Print Tray Assemblies	✓	✓
• Global Interference Check	✓	✓
Creo Additive Manufacturing Plus Extension for Materialise		
• Direct Connect to Metal Printers in the Materialise Library		✓
• Generate and Customize Metal Support Structures		✓
Creo Topology Optimization Extension		
• Topology Optimization		✓
• Semi-Auto Geometry Conversion		✓

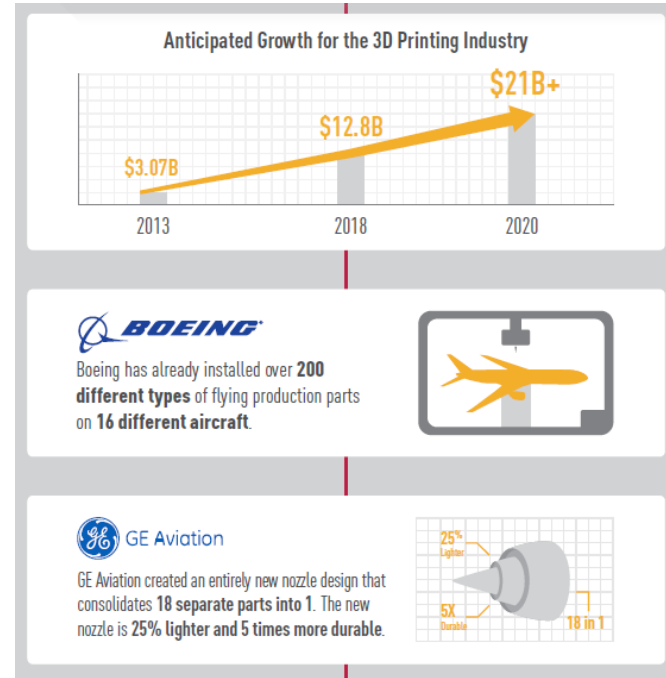
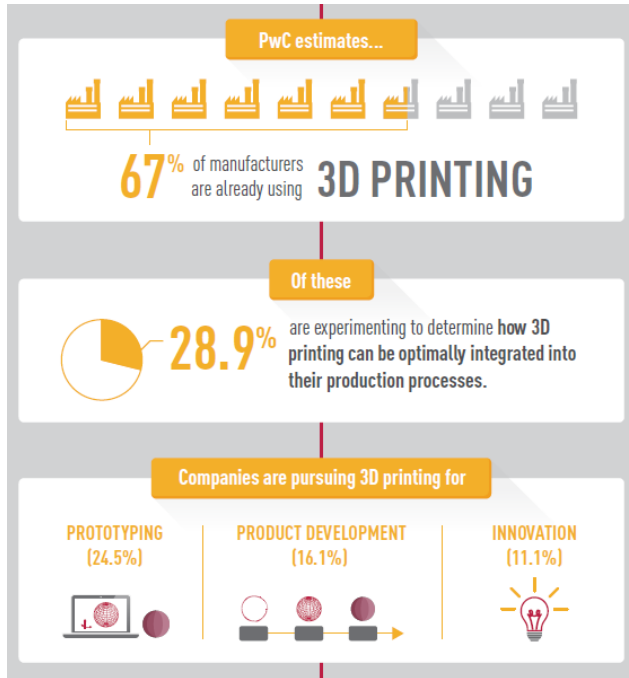


Additive Manufacturing Comparison Chart



	Freemium (Creo 3.0 M040)	Creo Additive Manufacturing Extension (Creo 4.0)	Creo Additive Manufacturing Plus Extension (Creo 5.0)
Capability	3D Plastic Printing Print Connectivity	Lattice creation, tray assembly and printer connectivity	Metal printer connectivity and support generation
3D printing from part or assembly mode	✓	✓	✓
Connectivity with GrabCAD Print and 3DS Print	✓	✓	✓
Tray Assembly creation (Printability, Nesting)		✓	✓
Lattice modeling		✓	✓
Build processor framework (Plastic printers)	✓ (Materialise- powered)	✓ (Materialise-powered)	✓ (Materialise-powered)
Build processor framework (Metal printers)			✓ (Materialise-powered)
Support Generation			✓ (Materialise-powered)

Additive Manufacturing



- 15 jobs på JobIndex
 - Søgestreng "3D Print" og "Additive Manufacturing"

The End