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George.Jetson@SpacelySprockets.Biz

Time to get that 3D Printer - ASAP

To: Jetson, George

George -

I hope you have everything on your action items list done, because I've got the job of a lifetime for you!

At the Executive Strategy Retreat this weekend Shipwell from Purchasing brought in an expert from 5D Systems who told us all about 3D printers. She also let slip that old man Cogswell has ordered their new MakerMax 5000. It's expensive but we have to stay in front of Cogswell. So I ran it in front of the board this morning and they love it.

We have board approval to release our next product with Additive Manufacturing (whatever that is). They even approved 850,000 space buck credits to pay for it.

So I want you to drop everything, get that printer ordered before Cogswell get's his, and then figure out how we are going to use it on our next product. These printers are so magical it will probably be able to make it all in one shot.

George, my boy, your star is rising fast. Take Jane out for a big steak tonight!

Best Regards.

Spacely





All too often the party ends like this:



- Never made parts like we expected
- Too Slow
- Too Much Maintenance cost
- Material too expensive
- Setup takes too long
- The OSHA guy just chewed me out.
- The fire martial???!!!????

WHY???? Hype and Glitz







Since 2012 | have:

- Decommissioned 3 Printers (one from an overhyped government grant).
- Worked a consulting project where the discussion started with "Our VP told us that this project would be done with 3D Printing, we need to make sure that we are doing it the right way".
- Left \$20,000 worth of consulting fees on the table when I told a customer that it was the wrong direction for what they wanted.
- Upgraded my own printer twice.

So how do we avoid This:



And instead build a cool new bridge to profit:



Concept art by MX3D

Actual part by MX3D

What is a 3D Printer?

A: It is **NOT** a magical fabrication machine that instantly makes whatever you want.



Nestle planning 'Star Trek' style food replicator

June 25, 2014



It may sound like something out of Star Trek, but Nestle is developing a food replicator that will create customised consumable items based on the users' dietary requirements.



The company's research arm, the Nestle Institute of Health Sciences (NIHS), has launched the programme, code-named 'Iron Man', as part of an effort to combat health issues using new foods and drinks.

What is a 3D Printer?

A: It is IS possibly the best, most flexible, tool in the manufacturing engineer's toolbox.



In Fact....



A whole new drawer

Vat Polymerization (Stereolithography/SLA) [6]
 Material Extrusion (FDM/FFF) [5]
 Material Jetting (Objet/Projet) [3]
 Binder Jetting (3DP/Z-Printer) [4]
 Powder Bed Fusion (SLS and DMLS) [4]
 Sheet Lamination [4]
 Directed Energy Deposition [4]

8. Direct Write Technologies [5] (NOT an ASTM Category)

35 Different Technologies

35 Different Technologies? Which one is right for me? 90% of the learning material out there is coming straight from the OEM marketing departments machine.

Buying a Printer is a business Decision:

- What are you going to do with it?
- How will that make money?
 > (Hidden value?)
- How Much will it cost to buy (Startup Costs)?
 > (Hidden costs?)
- How Much will it cost to run (Operating Costs)?
 > (Hidden cost not a question mark)



Cost - Initial

- Machine Capital, shipping, install
- File Prep software/computer
- Post Processing Fumes? Support Removal?
- Facility Utilities Power (3 phase?), air, HVAC
- Facility Safety hazards? Explosion proof?
- Facility Setup for Cleanliness
- Support Gas?
- Initial Training AND Learning Curve of operators
- QC system? Not just geometry, also matl props
- Initial Stock of Raw material (s?)
- Build Plates and other consumables

Cost - Operating

- Utilities (Did you notice how much power it pulls? That heat goes somewhere!!)
- Preventative Maintenance/Repairs
- File Prep software/computer Ongoing License?
- Post Processing Time, support materials
- Facility Cleanliness is kind of tough
- Support Gas?
- Labor need operators with specialized skills
- Calibration/accuracy Test strips for matl props?
- Raw material shelf life
- Raw material can't always recycle
- Wear components like Build plates

Things to do with your printer that make \$\$\$\$ MONEY \$\$\$\$:

Make Non-Functional Prototypes If a picture is worth 1,000 words a 3D Part held in the hand is worth a million.

- Form & Fit (Say..... That wall looks really thin.....)
- Assembly space management (Engine Buck)
- Communication with your team, suppliers, management
- Communication with investors
- Communication with customers/early samples

If a picture is worth 1,000 words a 3D Part held in the hand is worth a million.





That First Sample to the Customer....

- 2 Weeks vs 4 Months (For Injection Molded Parts)
- Customer has something solid and realistic in her hands
- Geometrically correct part to protect under-hood space on engine buck

My First Printed Part!!!!

Things to do with your printer that make money:

2. Make Functional Prototypes - Accelerate the design cycle

Fail Early, Fail Often, fail forward

- Test designs quickly and with relatively low cost
- Able to make and test MANY iterations
- Functional Prototypes available for early sales samples
 to customer

Functional Prototypes

RAPIDNYLON

Things to do with your printer that make money:

3. TOOLING

- Grippers/Holders
- Foundry Patterns

LEAN Manufacturing at its best

- Low Volume Injection Mold Tools
- Assembly Fixtures
- Inspection Templates
- Specialized Tools that you can't buy All Fast, Inexpensive, and able to modify quickly for continuous improvement!

3. TOOLING

- Grippers/Holders
- Foundry Patterns
- Low Volume Injection Mold Tools
- Assembly Fixtures
- Inspection Templates
- Specialized Tools that you can't buy



The Printed Part

CONTACT SURFACE

3D printing allows engineers to easily design the contact surface for optimal gripping.

SURFACE HARDNESS

These jaws are hard enough to process thousands of stainless steel pipe couplings without wearing down.



Thermoset Mold Humanetics Innovative Solutions

WET SANDED

Wet sanding the part while in green state yields exceptional surface finish in 15-20 min.

Things to do with your printer that make money:

4. Production methods previously impossible

- Sand Molds and Cores with <u>overhangs/negative draft</u>
- Direct print investment shells
- Part serialization IN THE MOLDs
- Conformal cooling channels in injection molds
- 5. Mass Customization Hearing Aides, Dental aligners

6. Supply Chain Remote printing – Put your printer at your customer

Things to do with your printer that make money:

Z-Make production parts

PLEASE -- NO --- Don't Try This.

But there is a way.....

Things to do with your printer that make money: But there is a way.....

Make the parts that Cogswell Cogs Can't Make!

Tell your designers and engineers to design the perfect parts that function better than anything in the past.....

Holes do not need to be straight (Or round)



Tell your designers and engineers to design the perfect parts that function better than anything in the past.....

Use that Topologic Optimization to make the part that used to require too much machine time but is now super light and just as strong.



Use that Topologic Optimization to make the part that used to require too much machine time but is now super light and just as strong.





Or just mesh it for lightweighting



Surfaces can be organic in shape Flat and straight no longer serve a purpose



(And work with Metals that you didn't think you could work with!)



And we can get some pretty fine details on small parts too.



Tell your designers and engineers to design the perfect parts that function better than anything in the past.....

Embed components into the main part



Tell your designers and engineers to design the perfect parts that function better than anything in the past.....

Mix your materials.... Feel free to mix layers of steel and aluminum and copper and titanium in the same part.



Closing Tips

- Recognize that this technology is very powerful, diverse, and dynamic. But it doesn't replace what you already have. It supplements it.
- It's the wild wild west out there, and most of the folks giving you information are selling something. Try to find the people who actually want to sell information, not machines.
- Make a careful business decision based on a planned use case and calculated costs. Don't follow the glitz.
- Remember that making parts is one of the hardest ways to make money in this business.
- > The Real trick is in making the part that no one else makes!

Startup can be slow. Do not expect to get good parts the first day.

Research Research Research

- Google..... and look for sources that include OEMs and also trade journals.
 - TCT Magazine (www.tctmagazine.com)
 - Rapid eNews (www.multibriefs.com/.....)
 - Additive Metal Manufacturing (Additivemet.com)
- Go to a Show
 - FormNext Frankfurt Germany, 18-22 November 2019
 - Rapid + TCT Anaheim CA, April 20-23 of 2020, McCormick Place in 2021
 - Local Makers programs

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Remaining Slides are Backup

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8. Direct Write Technologies [5] (NOT an ASTM Category)

1. Vat Polymerization (Stereolithography/SLA) [6]

- Classic Vat Single Point Laser
- Vat with DLP/Multiple DLPs
- Inverted laser (FormLabs pull the material out of a shallow puddle)
- Inverted DLP
- CLIP/DLS (Carbon High Speed Continuous process)
- VP with magnetic alignment of particles

2. Material Extrusion (FDM/FFF – Stratasys and most Desktops) [5]

- Melted plastic filament head drive OR Bowden tube
- Multi head with soluble support
- Pelletized feed
- Electric arc enhanced
- Full Length filament (Mark Forged)
- Bound Metal Deposition (might be a binder process?)

3. Material Jetting [3]

- Plastic Multijet/Polyjet (Objet & 3D Sys Projet systems)
- MHD Liquid Metal Jetting (Vader/Xerox)
- Nano-Particle Jetting NPJ (XJet)

4. Binder Jetting [4]

- Plastic/Plaster powder with post process infiltration
- Plastic Powder binder chemically fuses the powder
- Metal Powder with Post Process sintering
- Sand (for foundry industry)

5. Powder Bed Fusion [4]

- SLS Plastic Sintering
- DMLS Metal Laser Melting (Many specialized methods)
- EBM Electron Beam Melting
- HP Jet Fusion (plastic) & Voxeljet High Speed Sintering

6. Sheet Lamination [4]

- Glued Paper (MCor Iris system)
- UC Metal (Fabrisonic)
- Woven Fiber Mat Cutting & fusing (Envisiontec)
- CBAM non-woven mat (Impossible Objects)

7. Directed Energy Deposition [4]

- Laser + Powder (LENS & Hybrid)
- Wire + Laser (Lincoln & Sciaky)
- Cold Spray (Spee3D & VRS)
- MELD Stir Weld Deposition

8. Direct Write Technologies [5]

- Aerosol Jet (Optomec)
- Quill based deposition (nano scale research only)
- Film Energy Deposition
- Circuit board writers
- Slurry/BioPlotters (EnvisionTec)