SMART 3D Manufacturing of Printed Electronics

C. Mike Newton, nScrypt/Sciperio

Anand Kulkarni
Principle Key Expert
Siemens Technology

Jason Benoit
Mechanical Engineer
Sciperio

Dr. Emily Sassano
Senior Scientist
Sciperio

Kyle Stoodt
Research Scientist
Siemens Technology

19TH INTERNATIONAL CONFERENCE & EXHIBITION ON DEVICE PACKAGING
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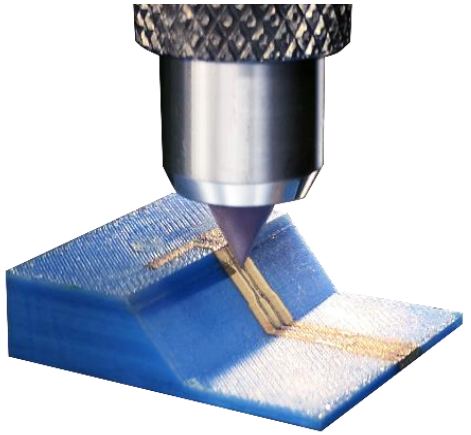
Award winning 3D fabrication tools and solutions for next generation Smart Manufacturing with a wide range of materials

Electronic packaging
Life Science
3D Printing
Textiles

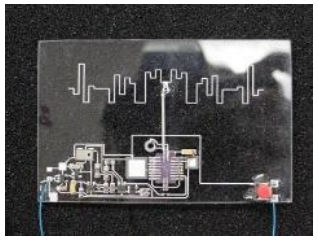
No retooling
Precision
Proven
Fully smart
Minimal labor
Production speeds
Industrially hardened



Vision: ***is to drive the next industrial revolution using direct digital manufacturing technology that will eliminate the need for retooling and one day lead to mass innovation by democratizing the Smart Manufacturing of complete products in multiple industries, ranging from fully functioning electronic devices to biological products.***

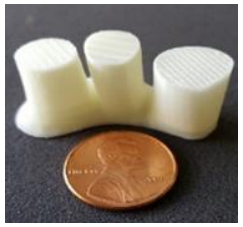
nScrypt will make mass, complicated manufacturing, personalized and simple

1st to print conformal antennas



1st to print 900MHz transmitter

1st to commercialize a bioprinter



1st to put linear motors on a 3D printer for superior prints

1st to print multi-layer, multi-material electrically functional structures

1st to add precision milling and pick and place on a single platform

Sciperio

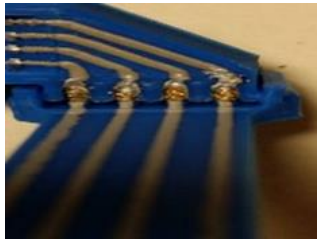
nScrypt

1999 2000 2001 2002 2003 2010 2011 2012 2014 2015 2016 2019

20 years of first

1st and ONLY to print on a living ant

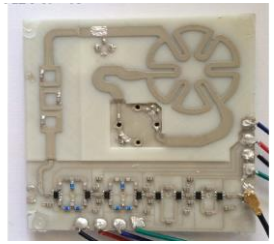
1st to combine 3D printing and printed electronics



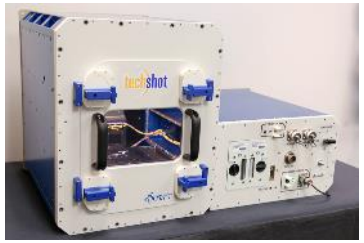
1st to commercialize Z tracking for conformal printing

1st to use a paste to print metal 3D structures

1st to print a Phased Array Antenna



1st Bio Printer in ISS



nScrypt

Technology and Products

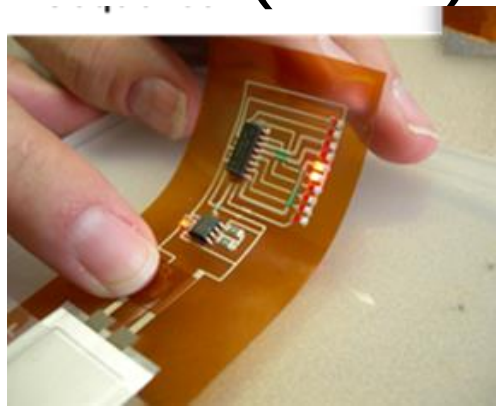
- **Precision Microdispensing => SmartPump™**
- **Direct Digital Manufacturing => Multi-material printing, pick and place, and micro-milling**

- **3Dn Series**
- **3Dn-DDM Series**
- **BAT Series**
- **SVA Series**

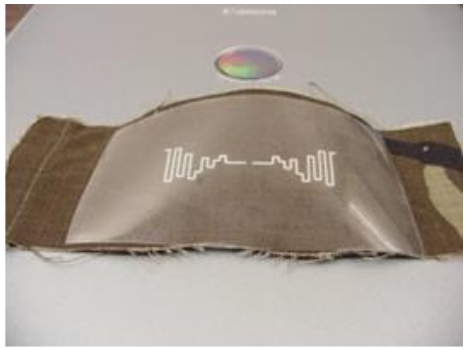
Direct Digital Manufacturing (DDM)

Printed Electronics

Flexible Hybrid Electronics (FHE)



Smart Textiles



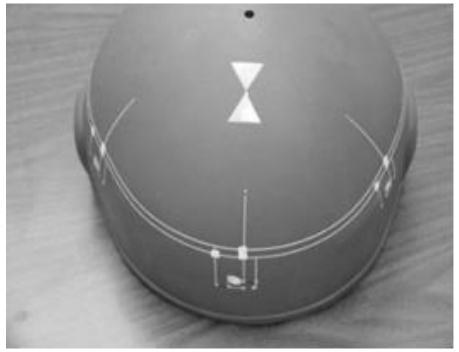
*** Digital Twin Engine**

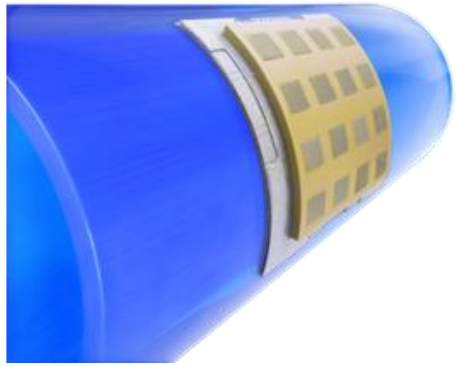
000551https://semiengineering.com/the-cyber-industrial-revolution/

Direct Digital Manufacturing (DDM)

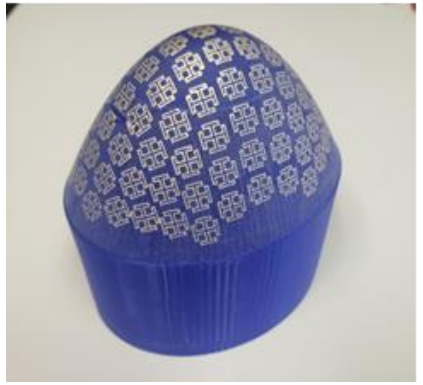
Printed Electronics – Additive Manufactured Electronics (AME)

Conformal Electronics



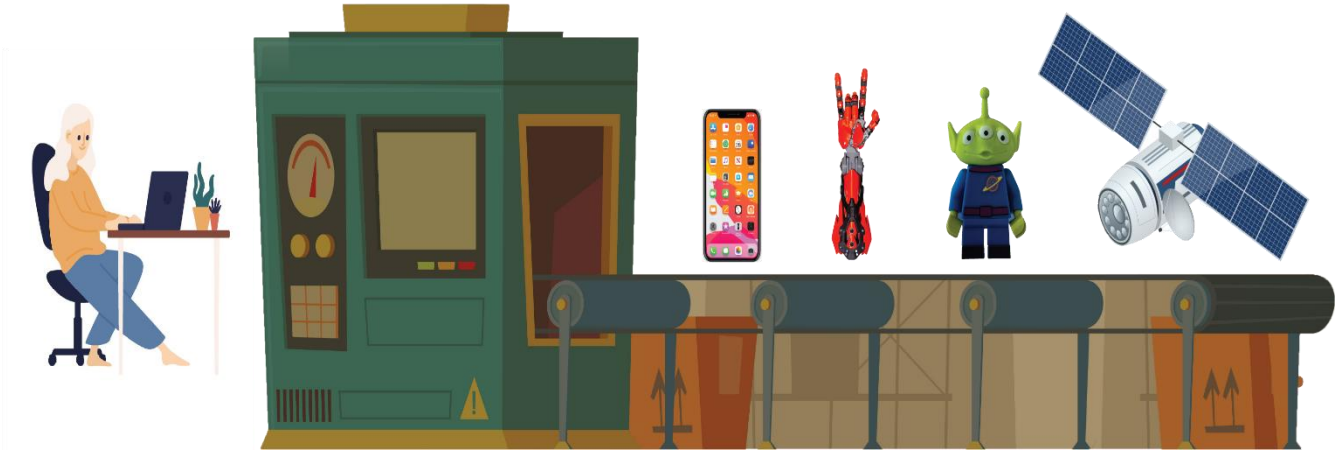


3D Printed Electronics



Direct Digital Manufacturing (DDM)

Automated Innovation = Digital to Physical



IDEATE *DTE CREATE

* Digital Twin Engine

Industrial Revolution

1st Mechanization, Waterpower, Steam Power

2nd Mass Production, Assembly Line, Electricity

3rd Computer and Automation

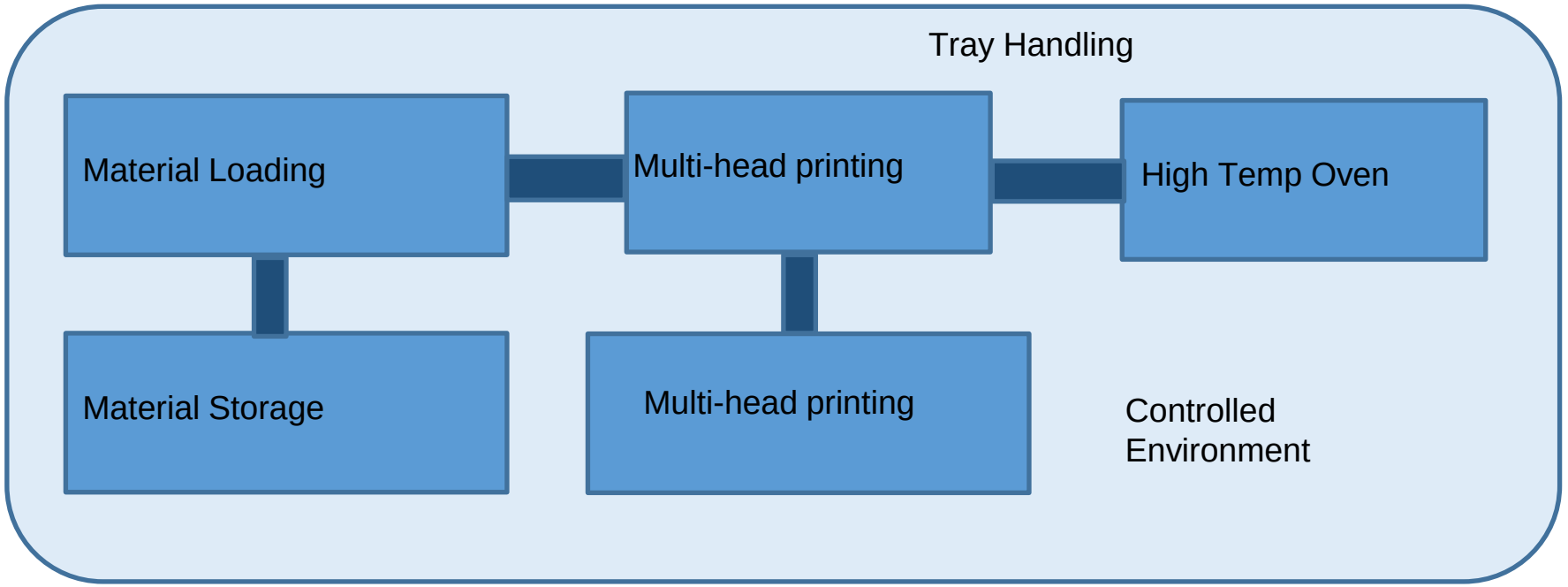
4th

The age of purely mechanical industrialization is over. Welcome to the new data-driven electro-mechanical age.

"Welcome to the Cyber-Industrial Revolution"

000553https://semiengineering.com/the-cyber-industrial-revolution/

Smart Manufacturing



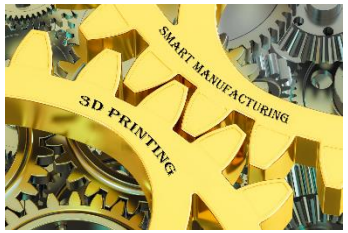
Tray Handling

This is a product, it will move build plates, not trays around. It will be modular and can connect any two tools or oven together.

Controlled Environment

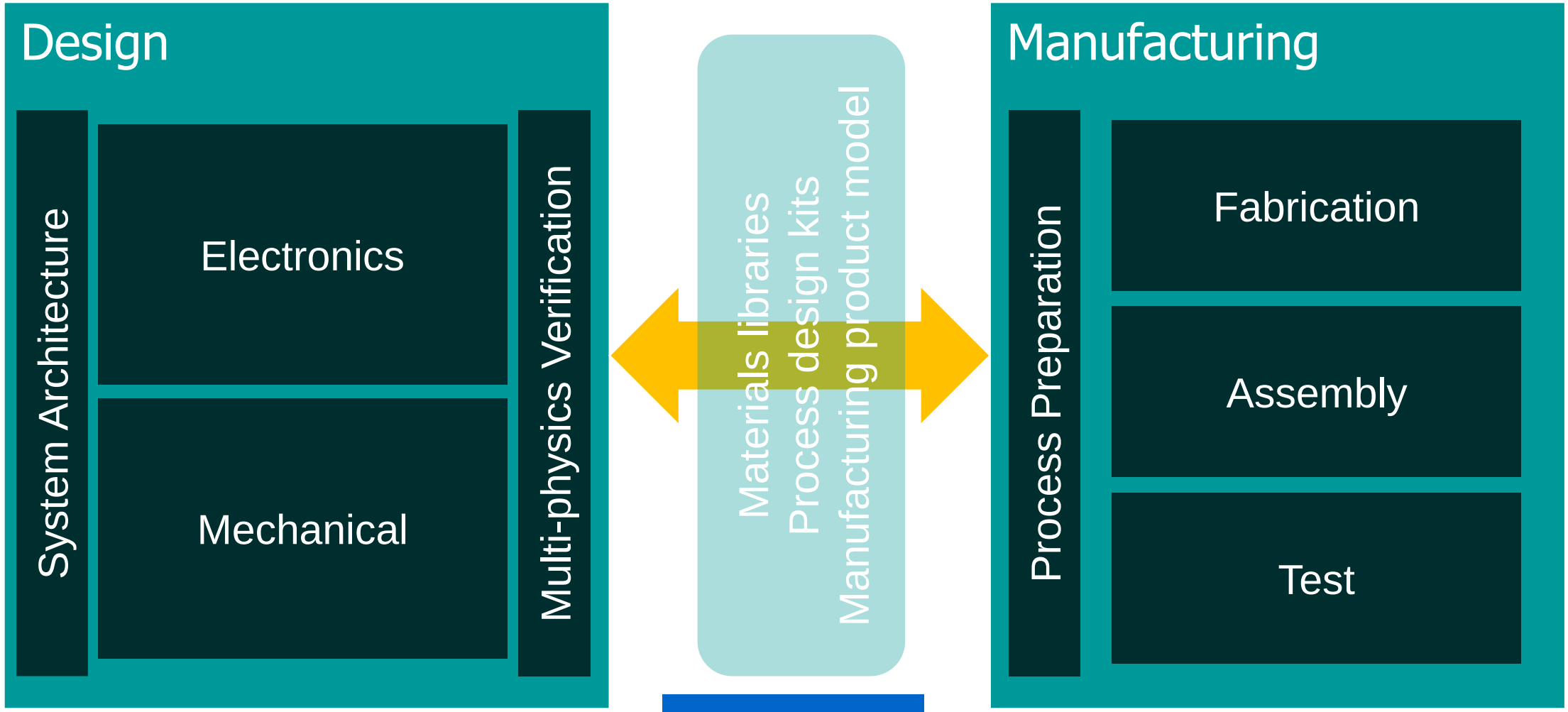
This is localized. Each Tray Handler, Printer, Storage, etc… will have a local and controlled environment to eliminate the need to control the environment in the room.

Smart Manufacturing



We have sensors in our product now, add more sensors. Develop software to pull sensor data and use it for health monitoring of our systems.

Automating Design Integrated with SMART 3D Manufacturing



Technology Conversion

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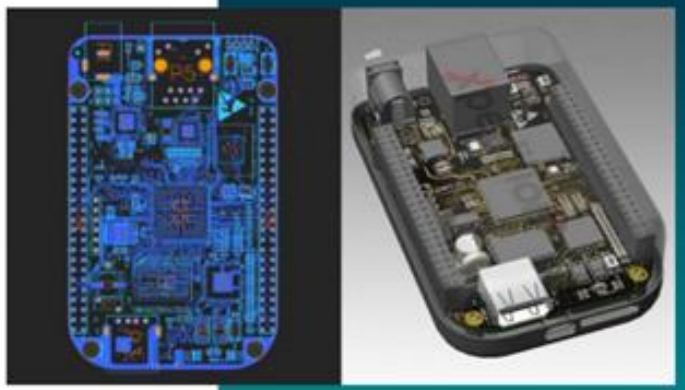
SIEMENS Ingenuity for life

nScrypt

Sciperio A Science Revelation

Siemens –nScrypt Relationship – Path for 3D Printed Electronics



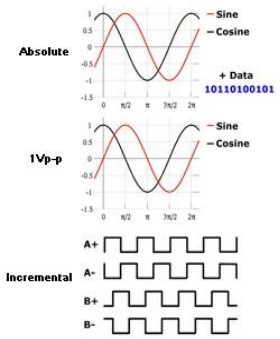
Our portfolio of products for the design and development of electronic systems and integrated circuits (IC). Solutions include Electrical & Wire Harness Design and Electronic Systems Design as well as IC Design, Verification, Test and Manufacturing.

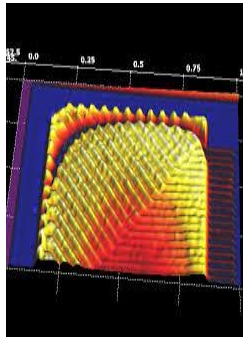
SIEMENS

nScrypt

Connecting 3D Printing to Smart Manufacturing

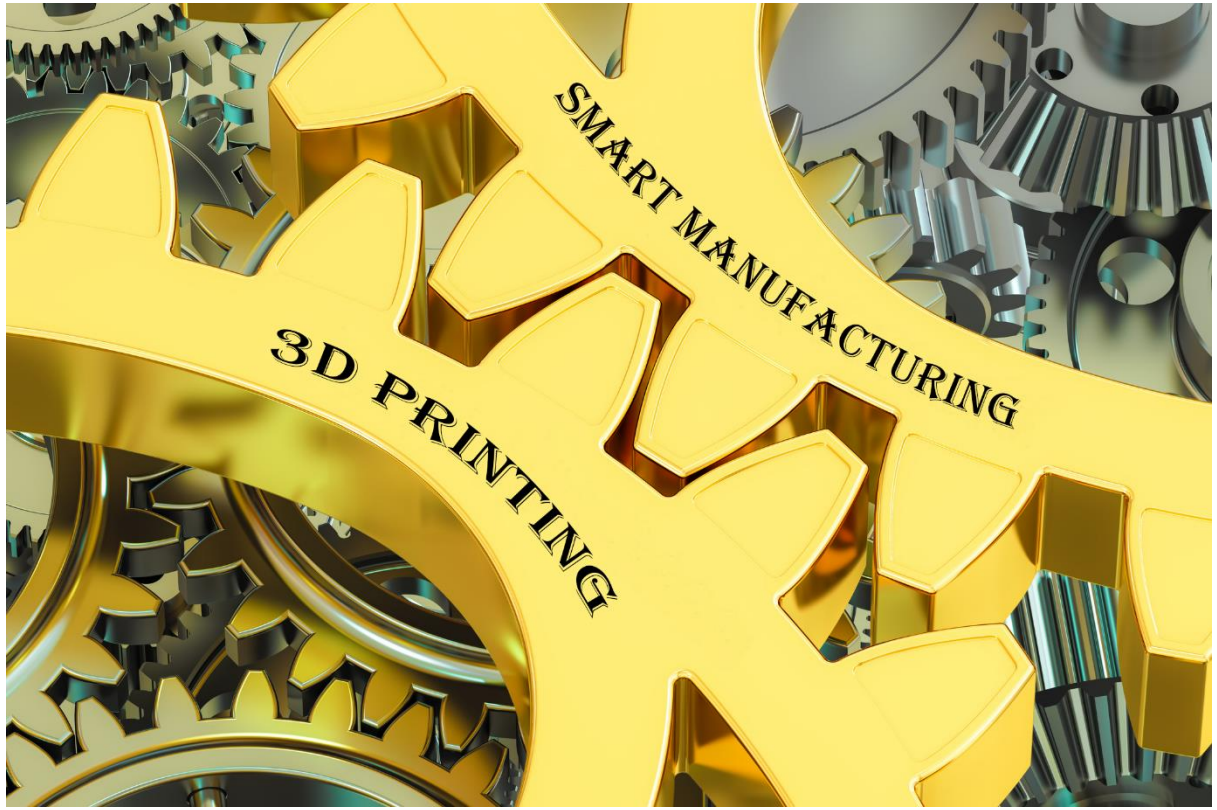
- Sensor feedback during prints
- Sensor feedback during processing
- Real time in situ adjustments





Feedback

Is it smart to put 3D Printing in Smart Manufacturing?

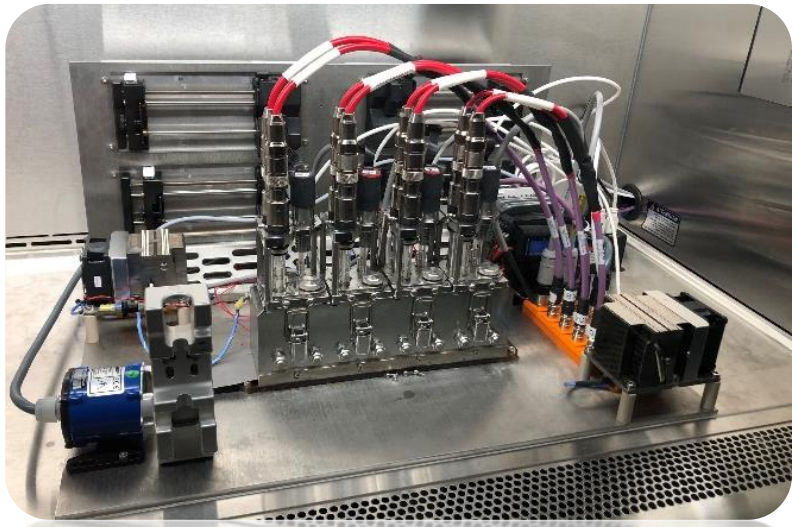


Is it smart to put Smart Manufacturing in 3D Printing?

In Situ Metrology & Industrial IoT

Direct digital manufacturing process that can be done anywhere, anytime!

- Automate
  - Intelligent planning
  - On system probing
  - Machine tool metrology
- Integrate
  - Fusion of sensors both system and lab
  - Machine and full lab networking
- Communicate
  - Intelligent machine network
  - Tool condition monitoring
  - Lab environmental monitoring
  - Product health monitoring
- Digital Twin
  - Machines
  - Materials
  - Processes
  - Products



Perfection through Smart Automation

In Situ Metrology & Industrial IoT

Cloud:

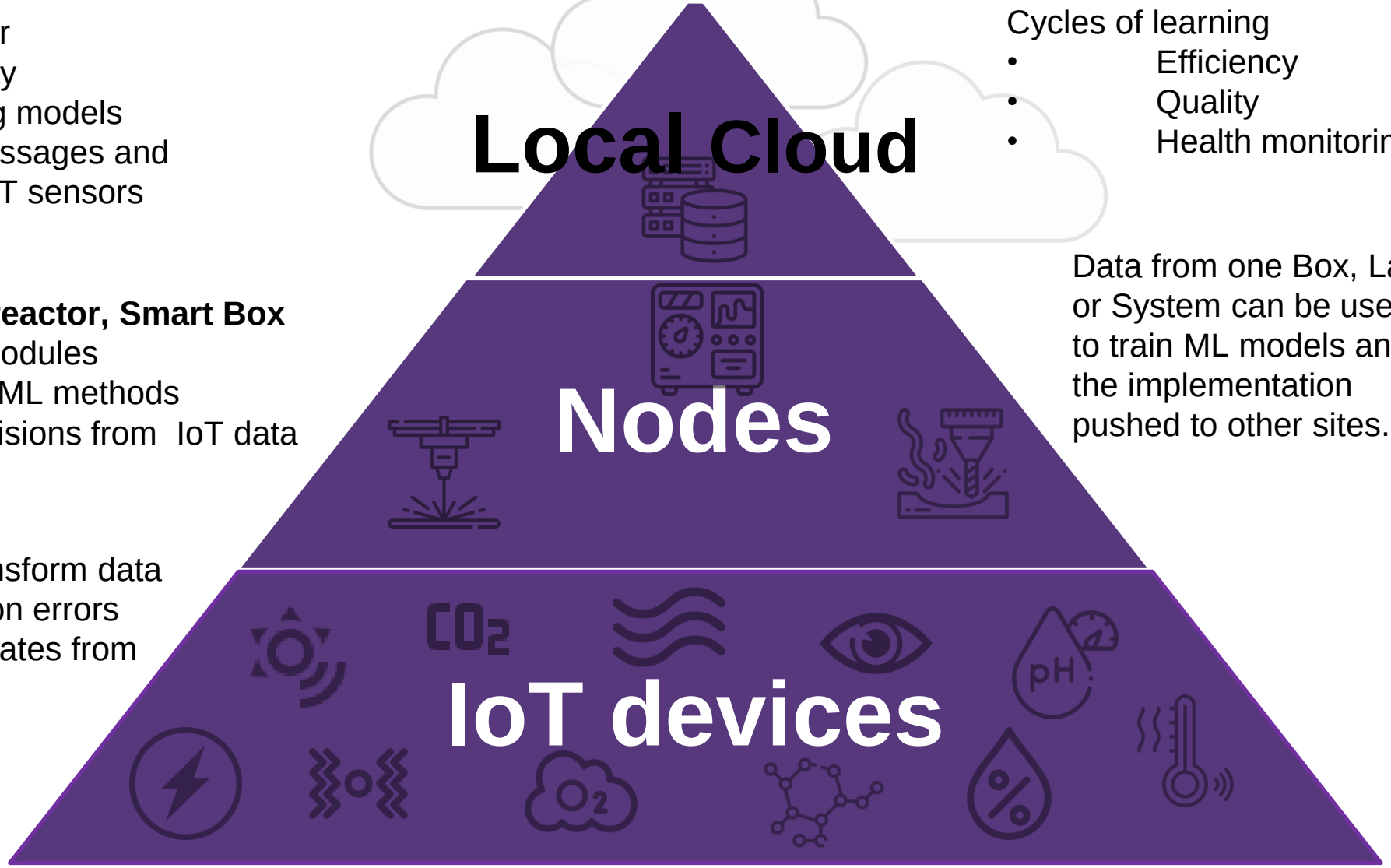
- High computing power
- Large storage capacity
- Trains machine learning models
- Sends and receives messages and models to nodes and IoT sensors

Nodes: nScrypt System, Bioreactor, Smart Box

- Run complex logic modules
- Recipient of trained ML methods
- Make actionable decisions from IoT data

The IoT sensor do work:

- Standardize and transform data
- Detect simple function errors
- Receive pushed updates from local cloud



Cycles of learning

- Efficiency
- Quality
- Health monitoring

Data from one Box, Lab, or System can be used to train ML models and the implementation pushed to other sites.

In Situ Metrology

Size and Position Detection

Detect pen tip → Crop video

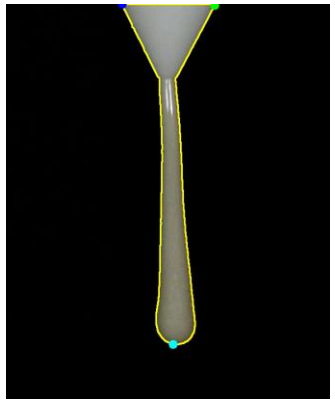
Original video 720 x 1280 pixels per frame (921,600)

Cropped video 720 x 592 pixels per frame (426,240)

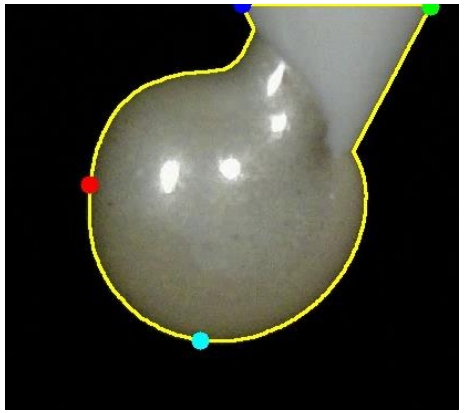
Reduce computation time, remove unnecessary pixels

Detect aspects of good and poor flow

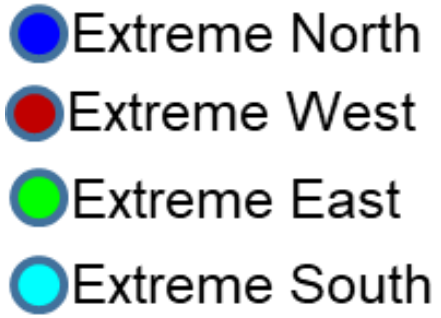
Extreme points location can be used to discover aspects of material flow



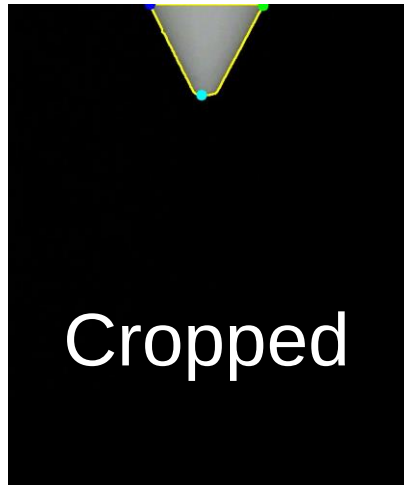
Good



Poor



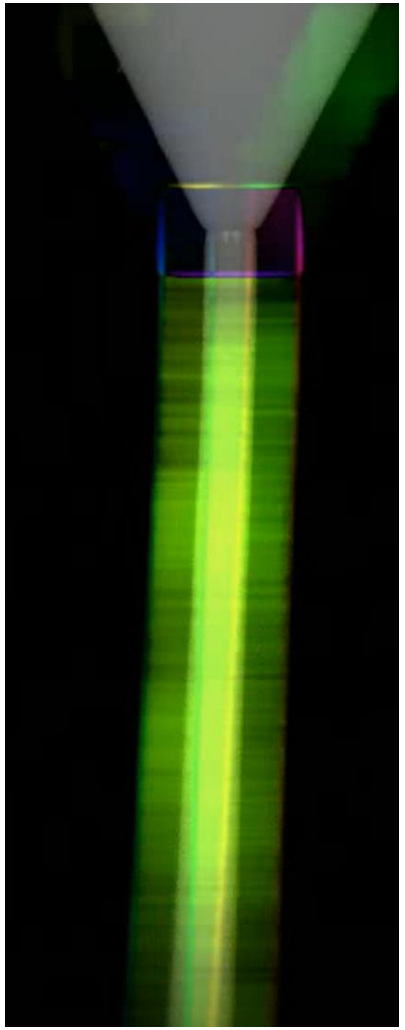
Points may overlap



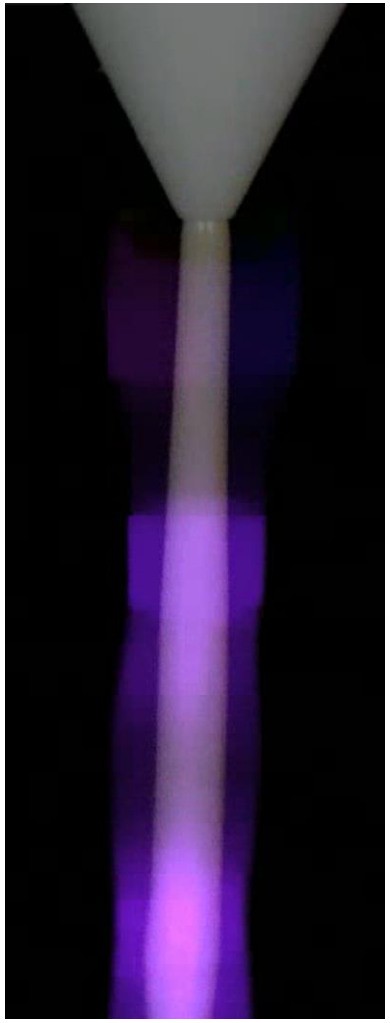
In Situ Metrology

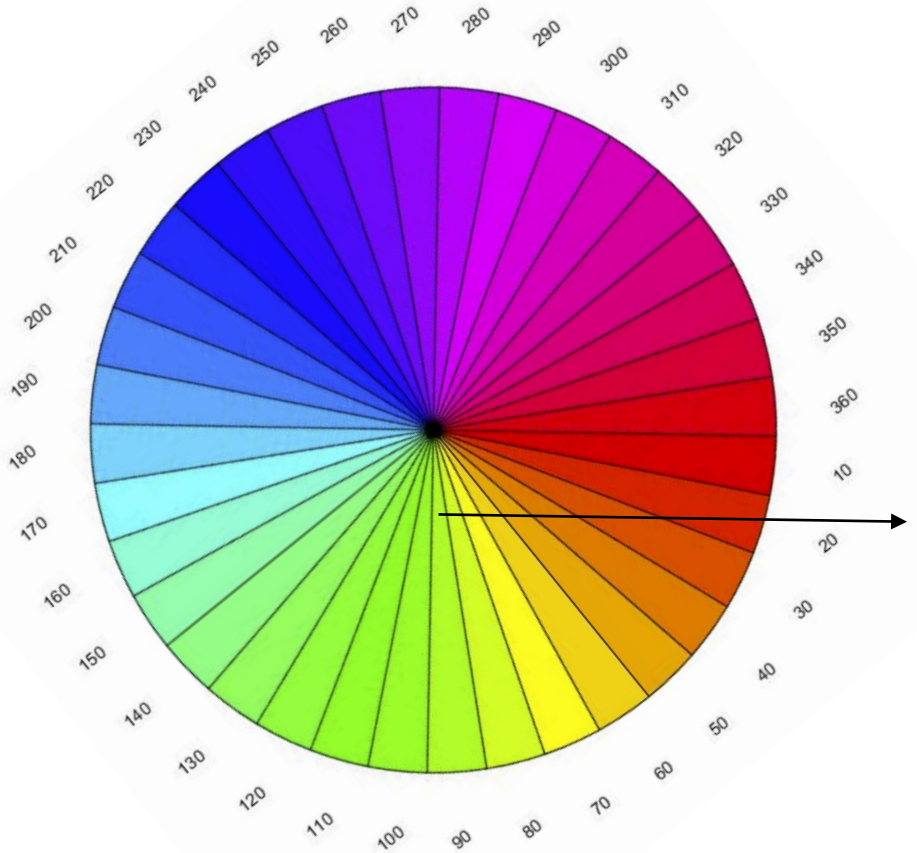
Material Flow

90 degrees



270 degrees



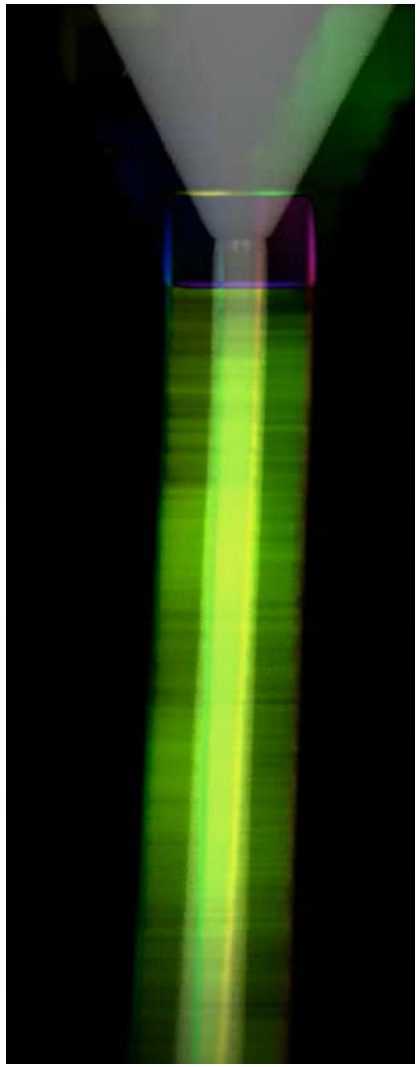


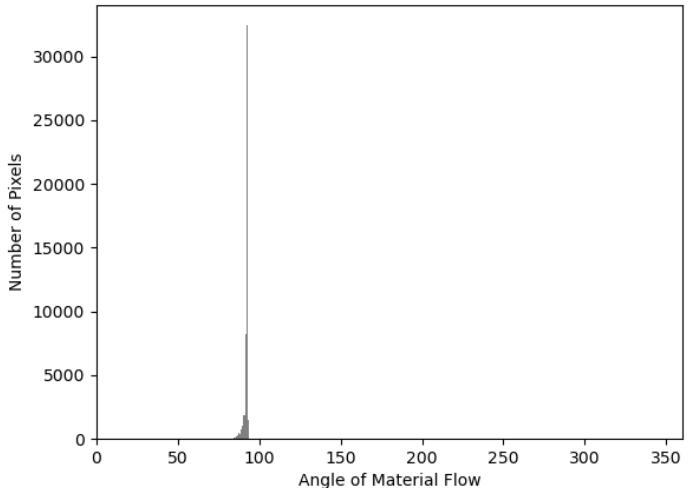
Angle of pixel flow

In Situ Metrology

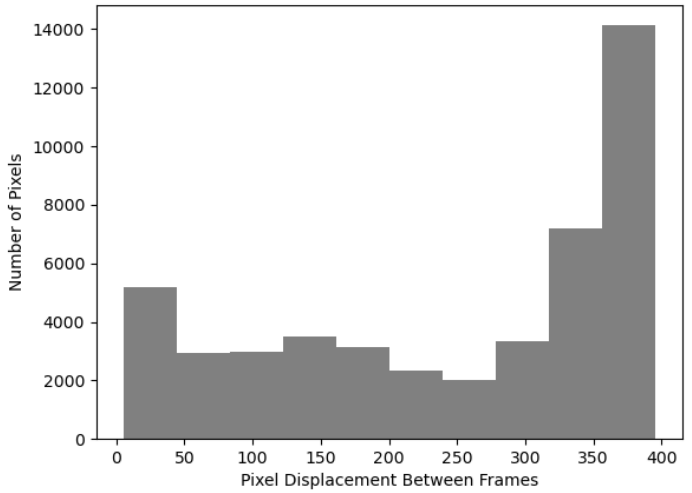
Optical Flow through Pixelation

Dense optical flow results between two consecutive video frames. The hue represents the direction of the material flow, in this case, 90 degrees from the tip origin. The color's intensity represents the flow speed or pixel displacement between images.





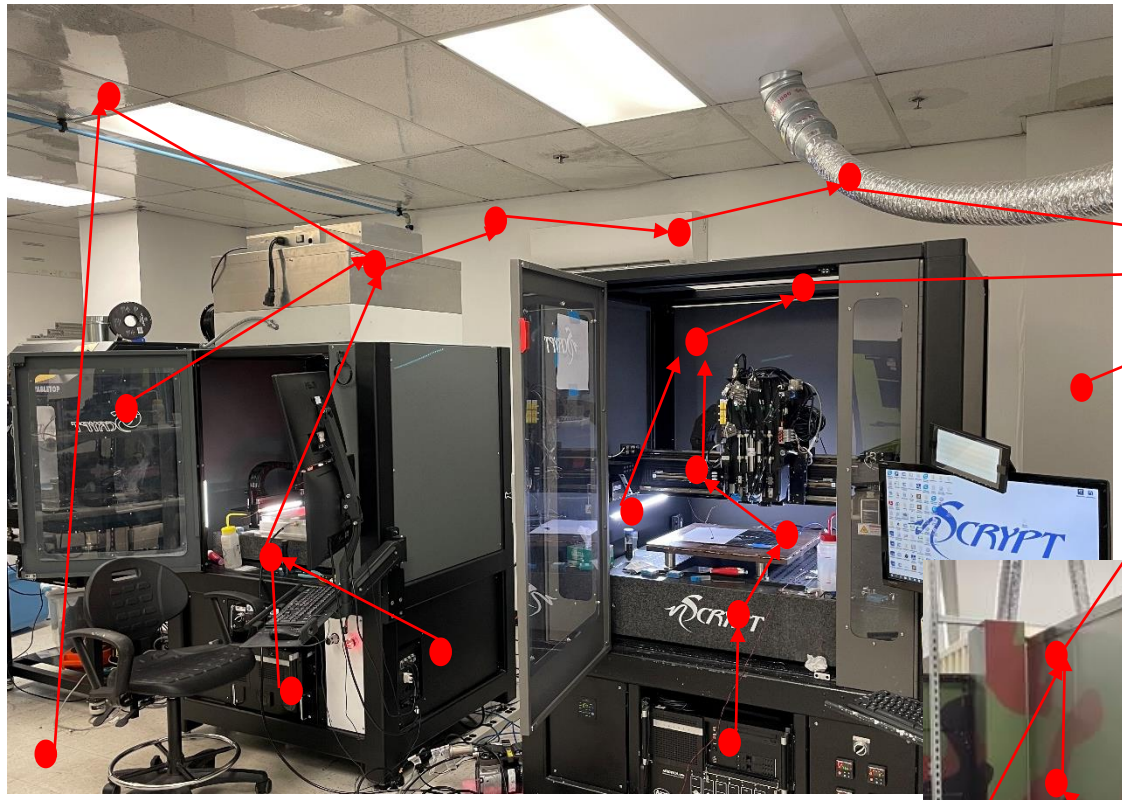
Histogram of the pixels in the flow field and their relative direction from the pen tip between frames.



Histogram of the magnitude of the movement of each pixel between two consecutive frames.

Industrial IoT

SMART 3D Manufacturing



Local Cloud

- Integrate
- Automate
- Communicate
- Fabricate
- Digital Twin

- Sensorize the equipment
- Sensorize the lab
- Sensorize the box
- Mesh the sensors (wireless or hardwired)
- Sensor Fusion
- Machine Learning

Factory in a Lab
Or
Factory in a Box, that can be forward deployed.

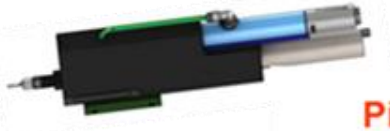
Applications

Process Gizmos – End Effectors

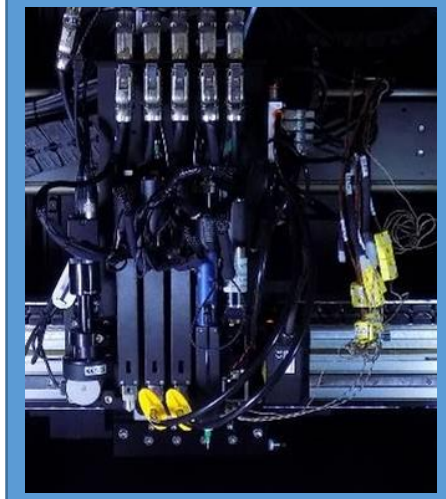
Micro Dispensing

Thermoplastic Extrusion (3D)

Milling/Drilling Polishing



Pick & Place



Many Feedstock formats

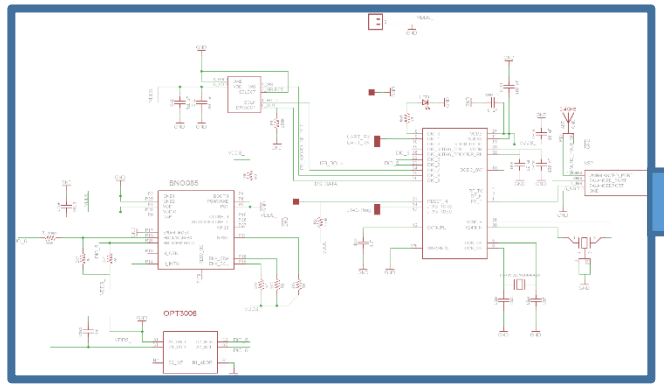
- Inks, Pastes, Elastomers
- Thermoplastics
  - Filament
  - Pellets
- Thermosets
  - Conductive
  - Dielectric
- Metals and Ceramics
- Energetics
- Electronic Components
  - SMT
  - Packaged
  - Bare Die

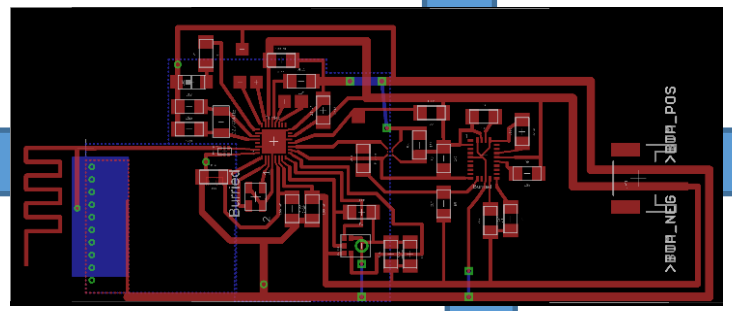
Process **Precision Control** **Materials**

Bluetooth LE Manufacturing Demonstrator

TI CC2640R2F (4mm x 4mm 32pin VQFN) SoC Bluetooth Microcontroller (http://www.ti.com/product/CC2640R2F

Sensor Temperature (DEMO)





Technology Conversion

V1

Printed Circuit Board (PCB)
- FR4 Substrate
- Etched Copper Interconnect

BASELINE TECHNOLOGY

V2

Flexible Hybrid Electronics (FHE)
- Kapton Substrate
- Printed Interconnect

WEARABLES

V3

3D Printed Electronics (3DPE)
- Printed Peek Substrate
- Printed Interconnect

SMART STRUCTURES

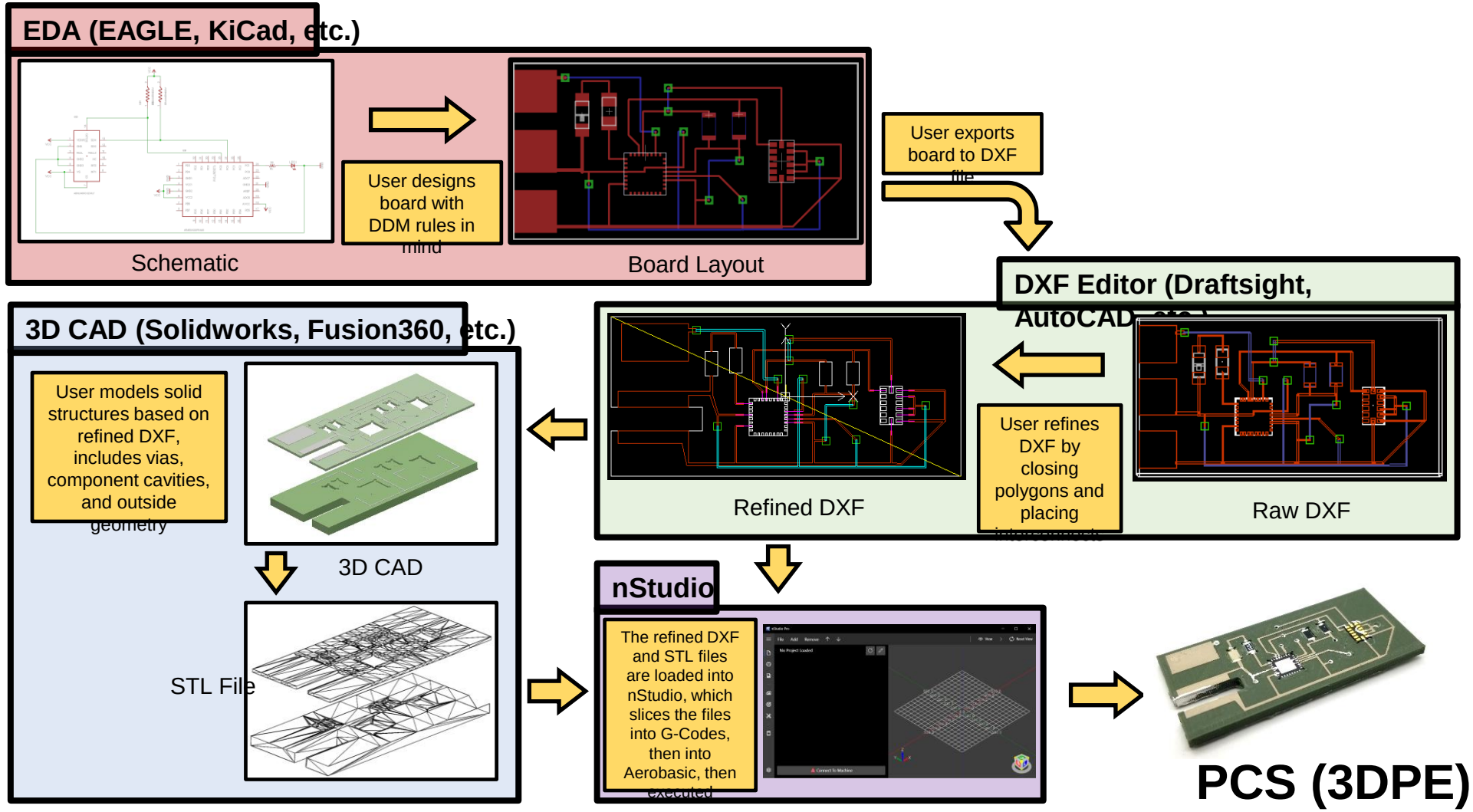
Printed Electronics

Future Sensor Suite
- Acoustic
- Gyroscope
- Magnetometer
- Accelerometer

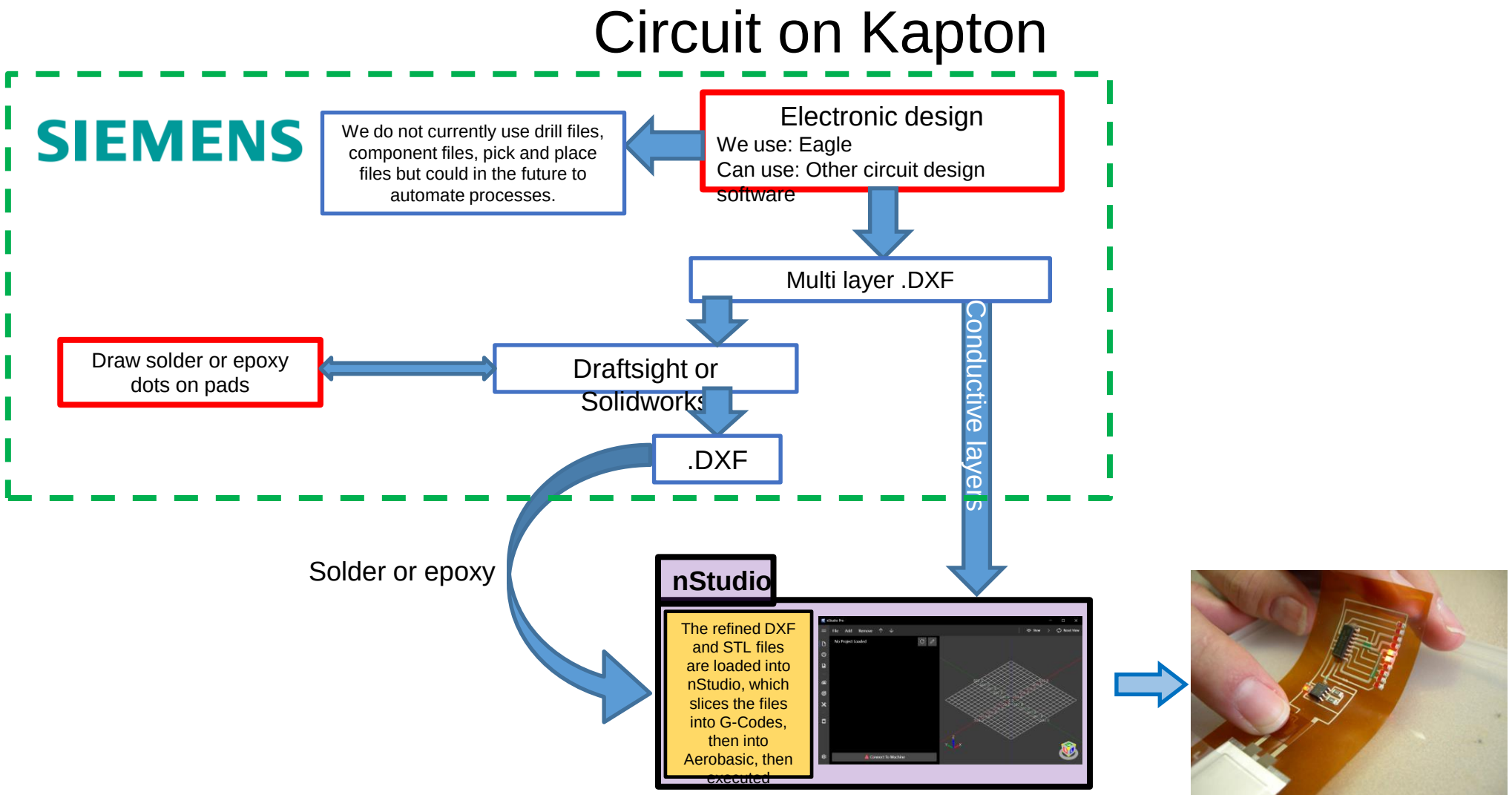
SIEMENS Ingenuity for life

Sciperio A Science Revelation

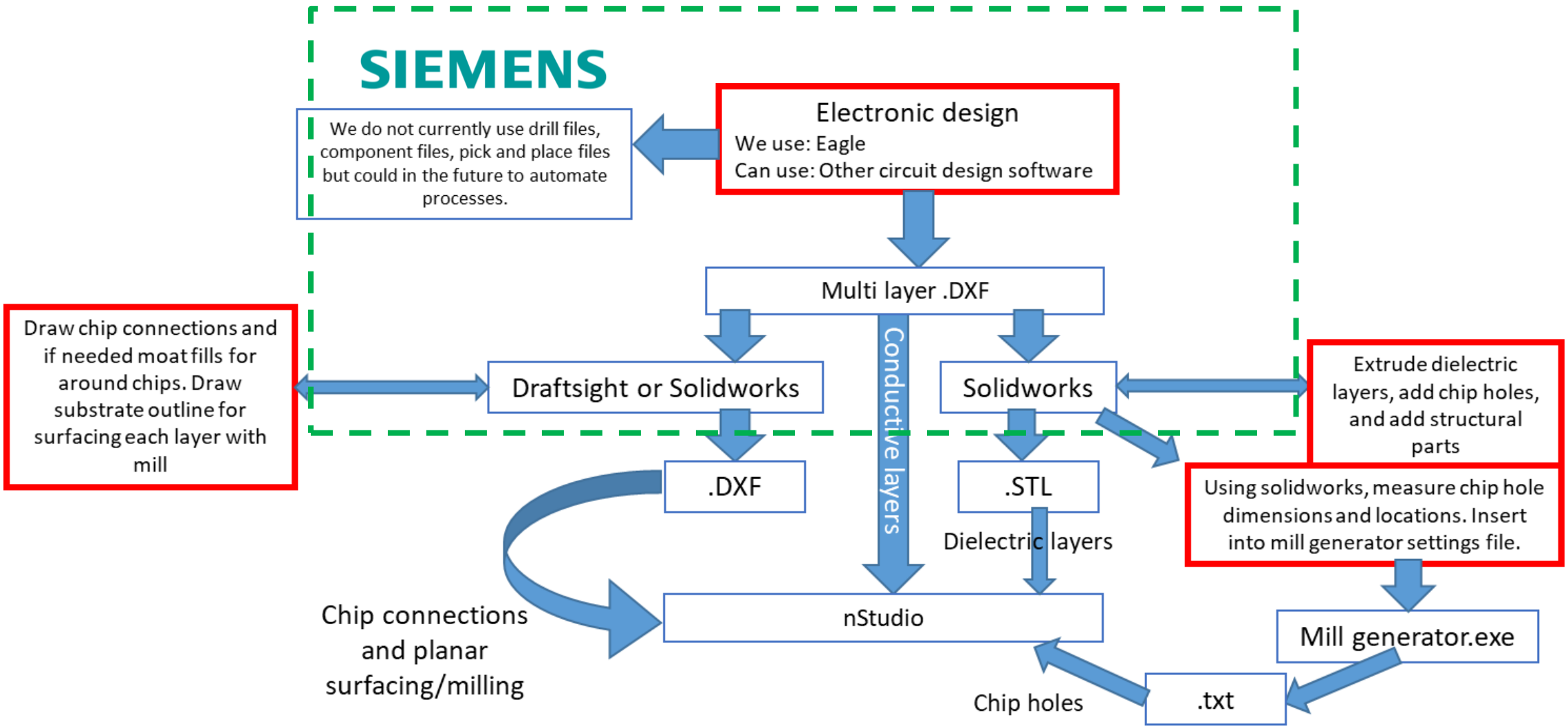
Planar PCS Workflow - Current



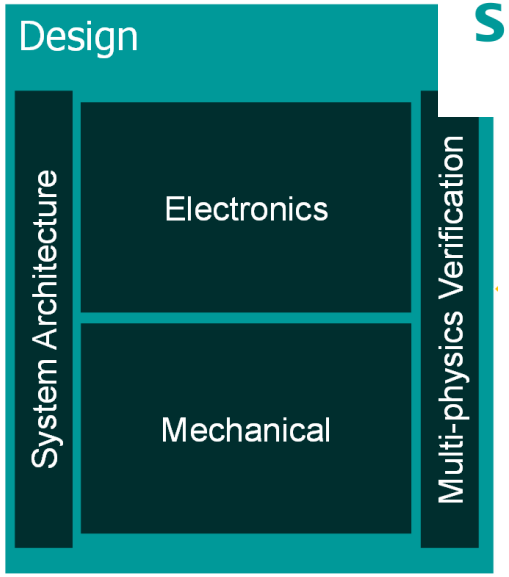
Flexible Hybrid Electronics (FHE) Workflow



PCS Workflow – Current to Siemens



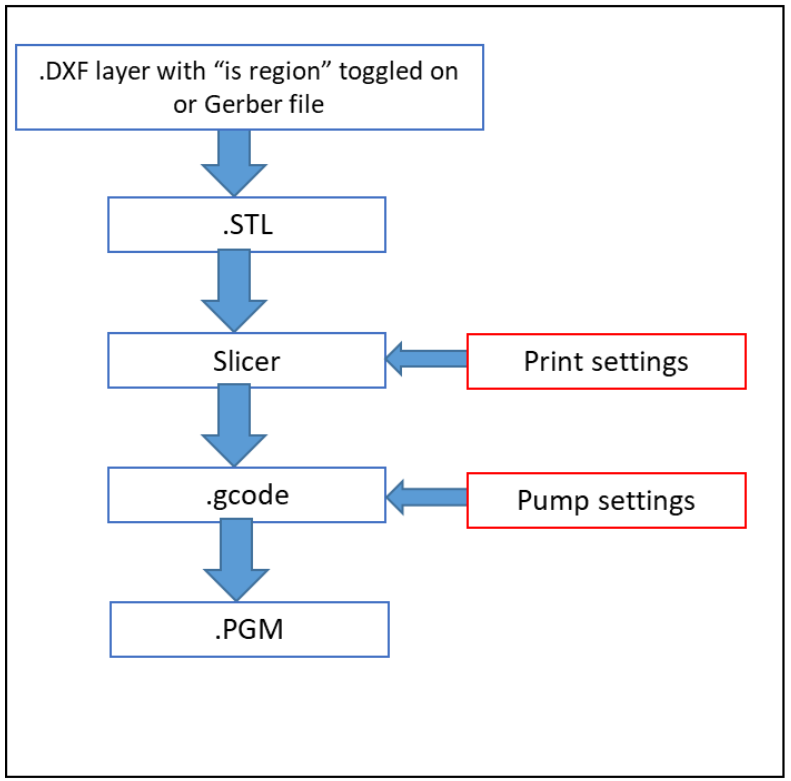
PCS Workflow – Current Development

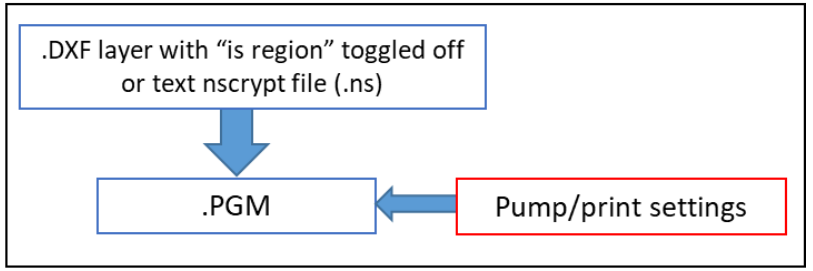


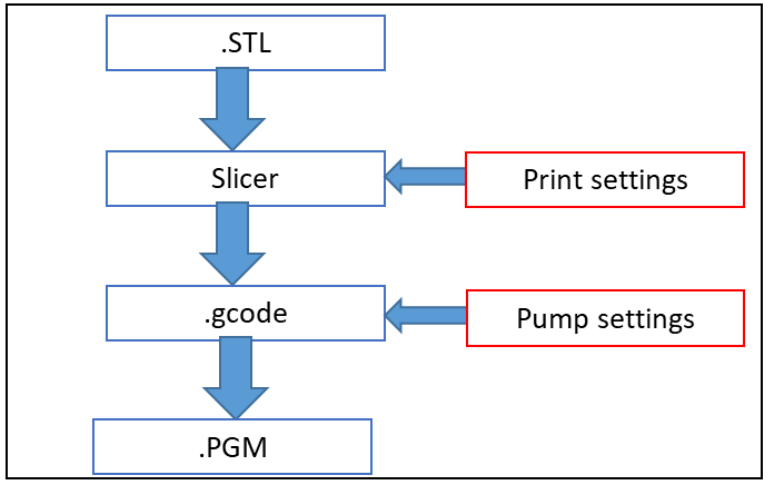
SIEMENS
Ingenuity for life

* Maya HTT
SC3D SST

nStudio file flow (all done behind the scenes)







*https://www.mayahtt.com/

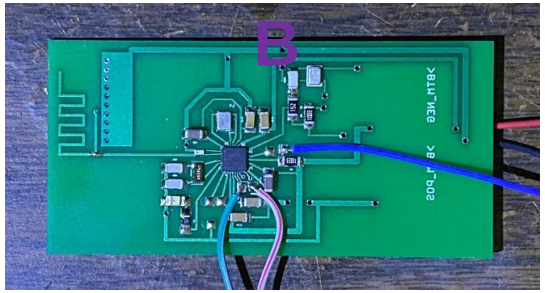
https://www.youtube.com/watch?v=0r8uPZIzk58

Technology Conversion

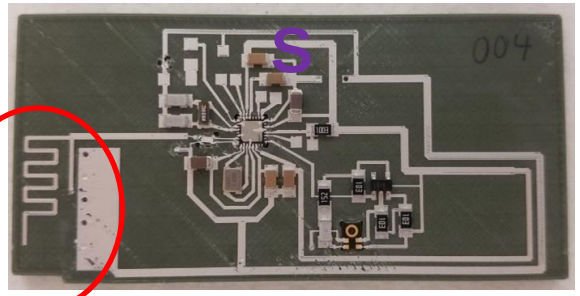
TI CC2640R2F (4mm x 4mm 32pin VQFN) SoC Bluetooth Microcontroller (http://www.ti.com/product/CC2640R2F

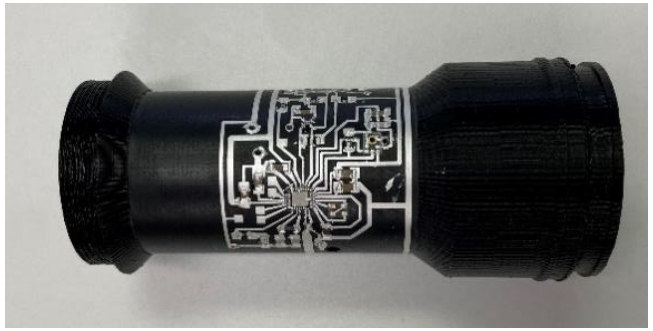
I2C Based Sensor interface protocol

PC

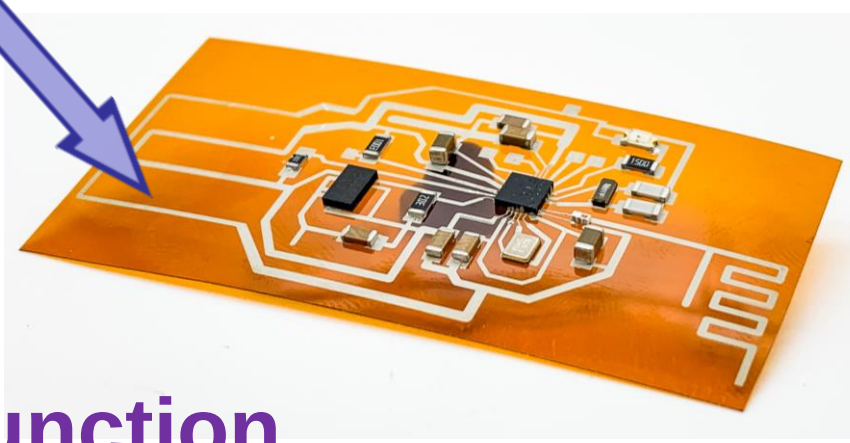


PC





Printed Antenna



Sensor Suite:

- Acoustic
- Temperature
- Gyroscope
- Magnetometer
- Accelerometer

Multimaterial ~ Multifunction

Demonstration Application – *Space

SIEMENS
Ingenuity for life

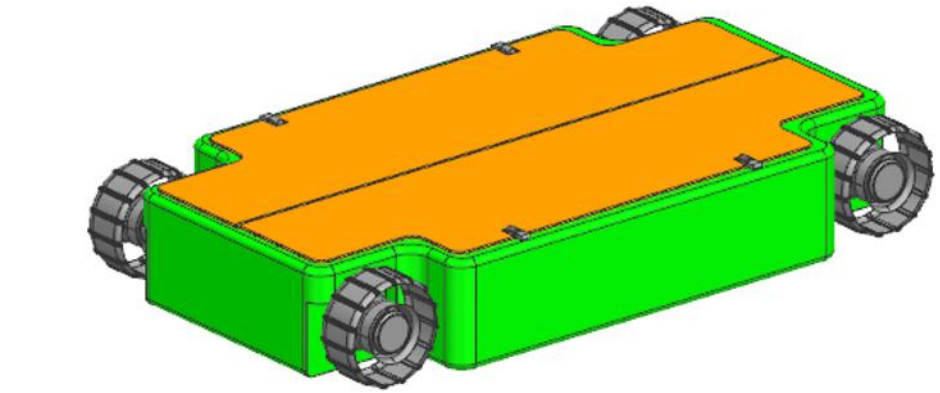
Sciperio
A Science Revelation

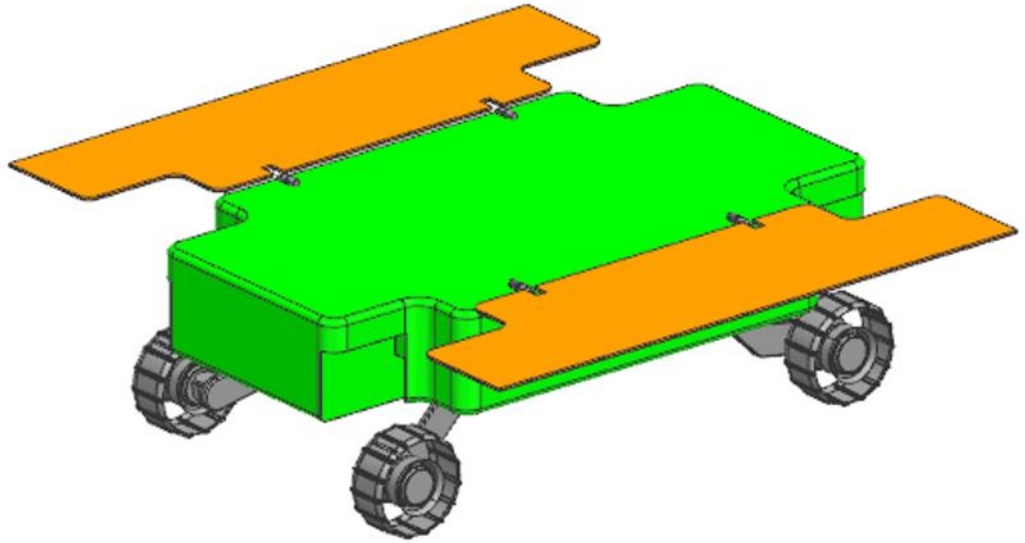
Attributes	Astronaut	Land Rover
Sensing	Personal Health	System Health
Interconnect Reduction	Personal Area Network (PAN)	**Structural Area Network (SAN)**
Manufacturing Technology	Flexible Hybrid Electronics	3D Printed Electronics
Mechanical	Flex/Conformable	Smart Structures
DDM on Demand	Yes	Yes

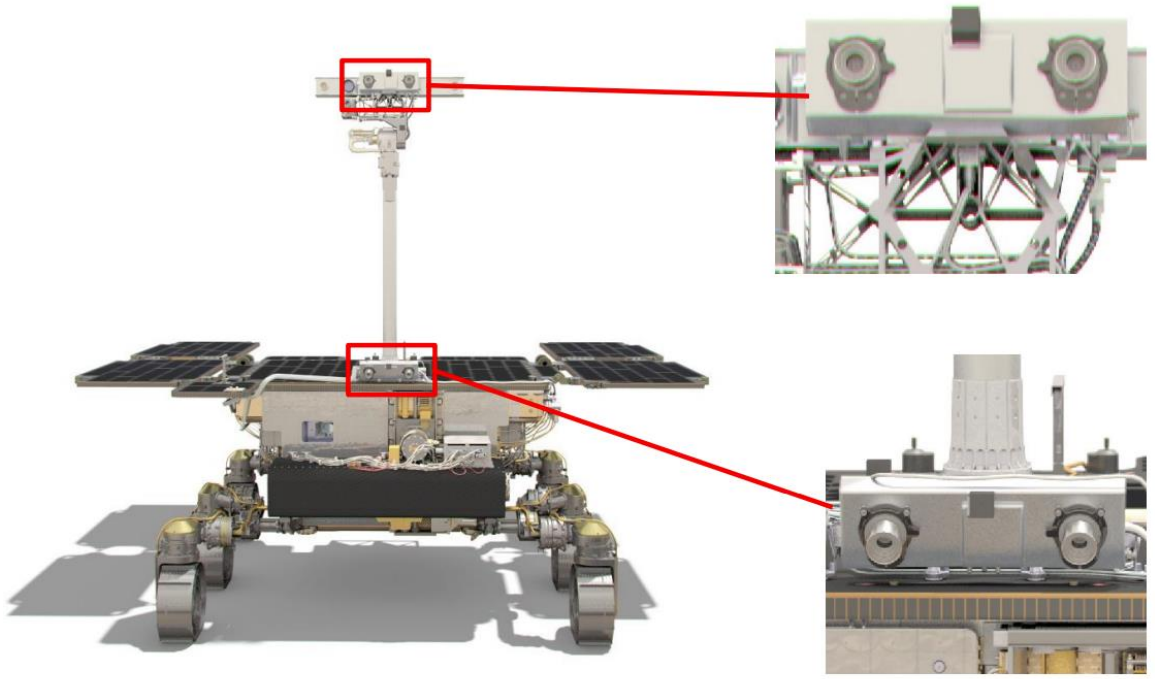
Primary Application

* Applicability to: Transportation, Industrial IOT, Consumer Medical, Unmanned Systems & others

MAYA Lunar Rover Model



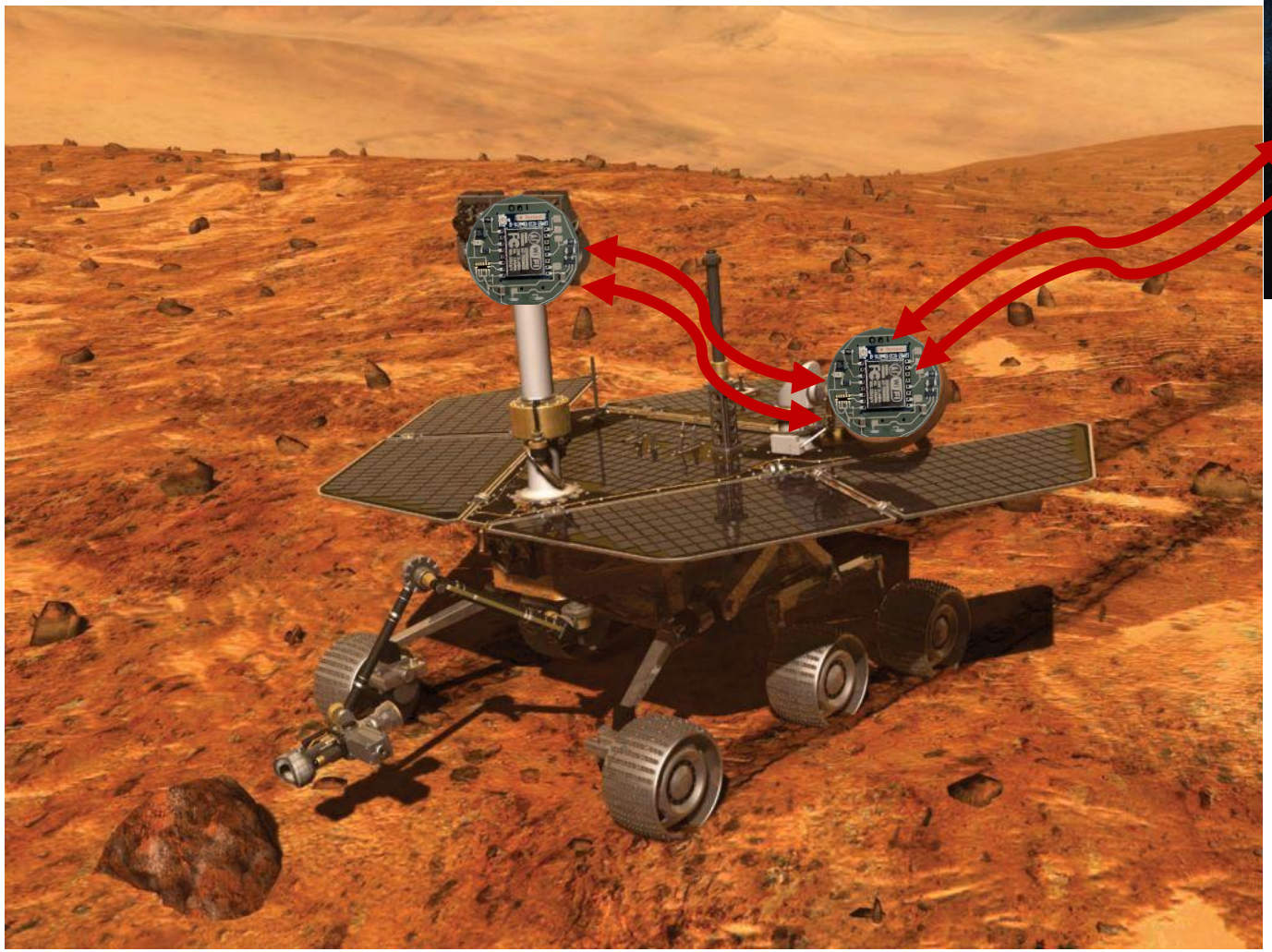


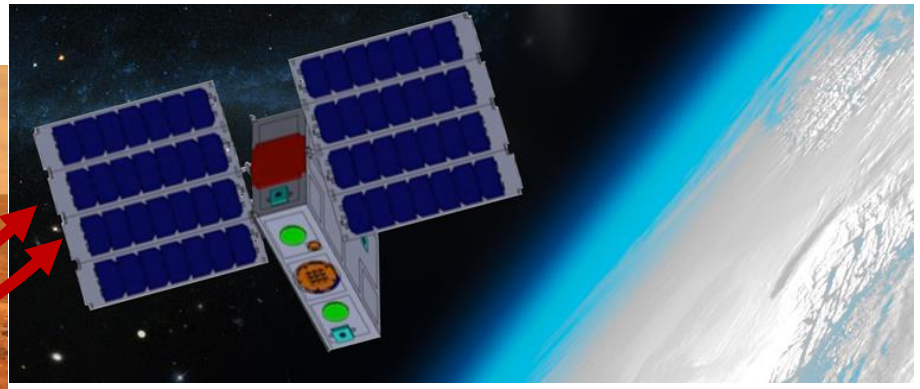


- Cameras are attached to rover with three fasteners.

https://tfaws.nasa.gov/wp-content/uploads/TFAWS19-ID-01.pdf

SAN Demonstrator Platform – Moon Rover



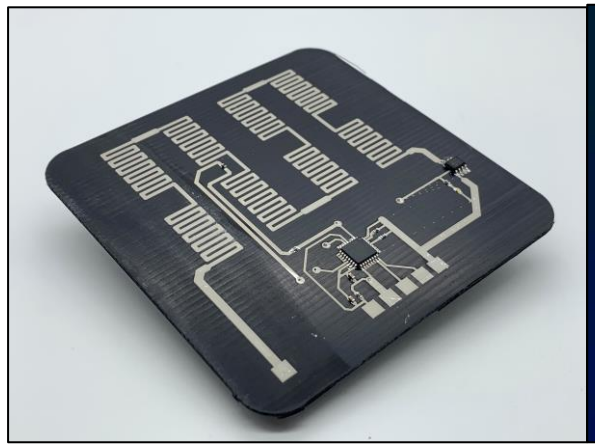


- Siemens EDA Layout Tool
- Space Environment Simulations - MAYA
- Inter module comm.
- Sensor Data exchange

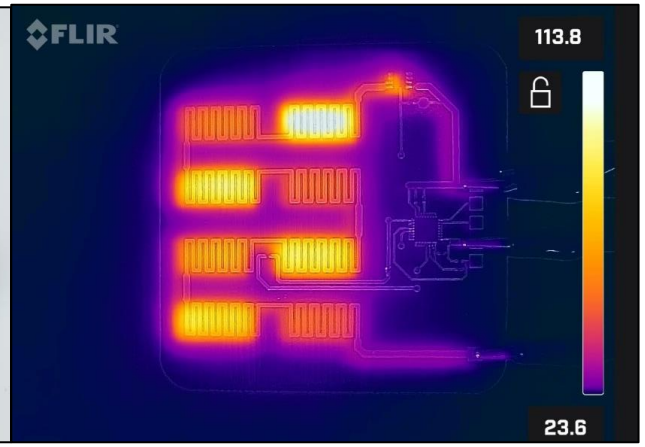
SIEMENS
Ingenuity for life

Sciperio
A Science Revelation

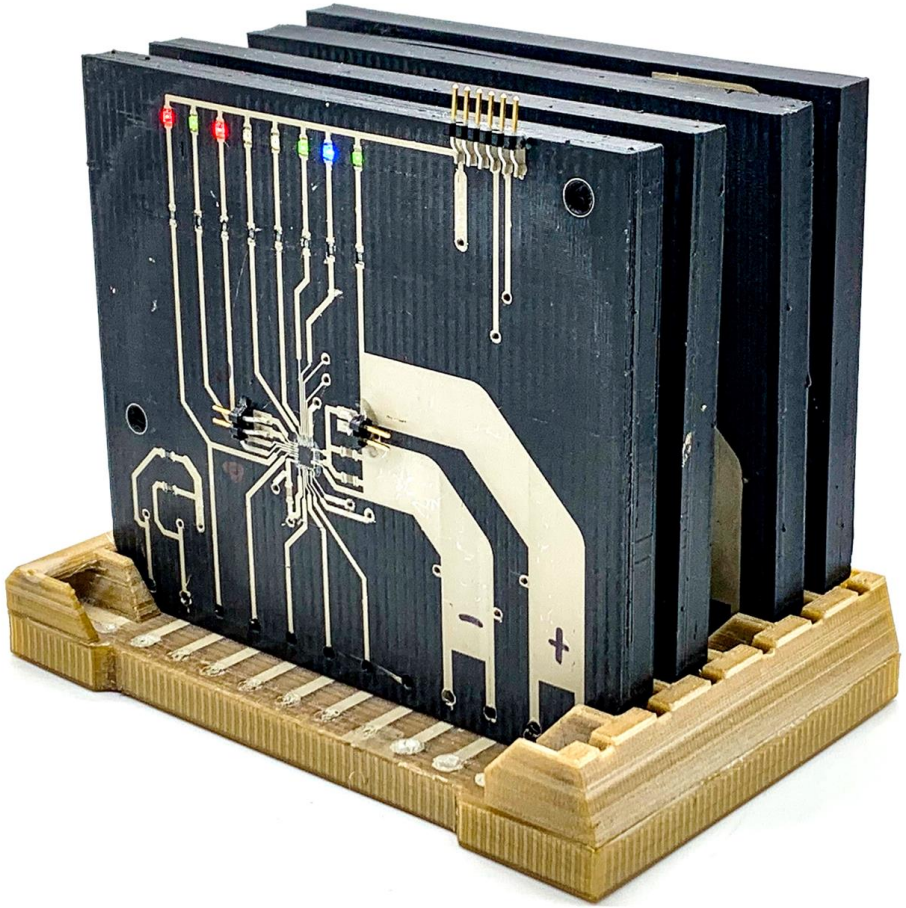
3D Printed Electronics 6U Cubesat

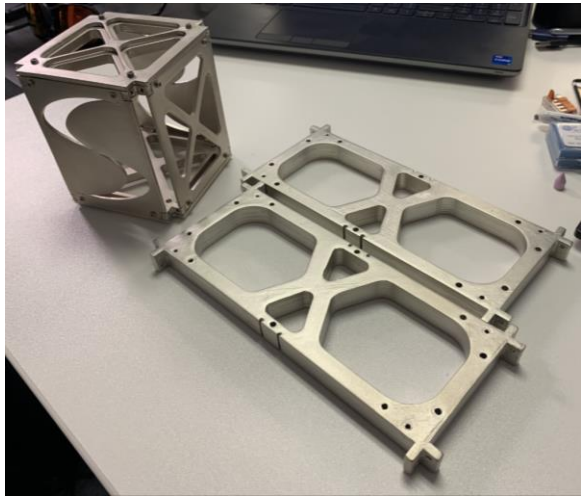


Printed demonstration circuit



Thermal view of variable-resistance traces

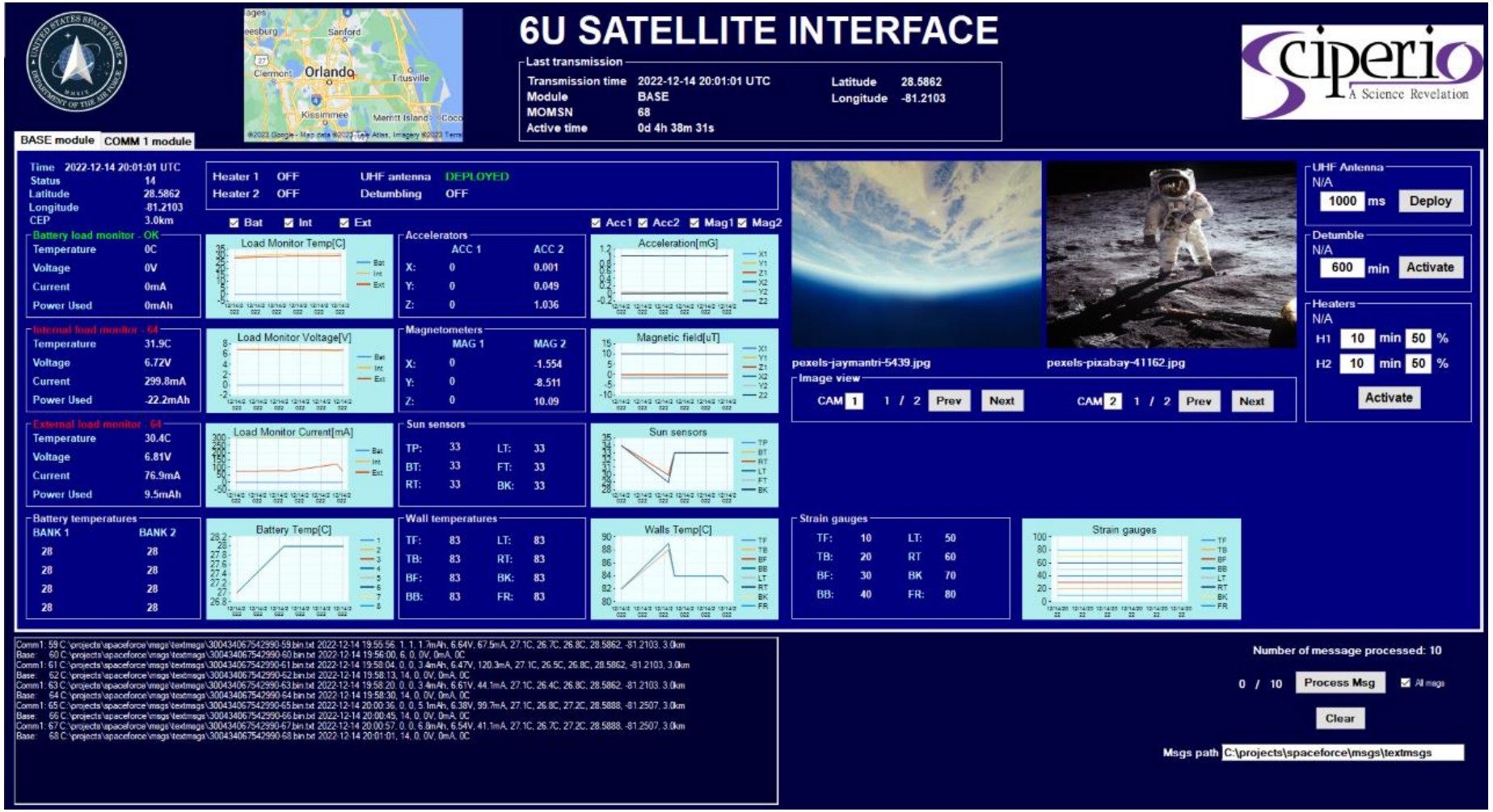




Multimaterial ~ Multiprocess ~ Multifunction

Space IoT

- Software and Firmware development has been progressing since August
- Program has been written to control and monitor our satellite
- Currently capable of:
  - Requesting picture from any camera module
  - Displaying pictures
  - Separate tab for each module
  - Display approx. GPS location of sat through Iridium estimation
  - Display sensor info (some implemented, some in progress)



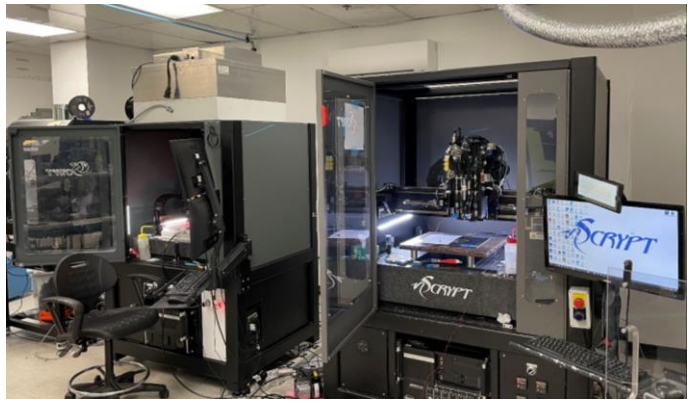
Point of Need Manufacturing

nScrypt is a capital equipment company that productized Direct Digital Manufacturing Systems and has sold a number of 3Dn Factory in a Tool (FiT) systems around the world…….including on the International Space Station.

The core of nScrypt strategy is SMART 3D Manufacturing – Secure, Modular and Mobile which enables:

- Distributed manufacturing.
- Local and regional manufacturing which include remote and underserved communities.
- Point of Need manufacturing for DoD, Civil and Commercial applications => Leveraging commercial systems will harden the tools and bring the cost to the DoD down.
- Harsh Environment Manufacturing => Our partnership with the DoD is a critical piece.

nScrypt and parent company Sciperio, working with their DoD (**Picatinny's HAMIC Initiative**) and Civil partners, have validated the need for a distributed and extreme manufacturing capability and the global market trend towards digital transformation.



Global Newswire reports global digital transformation market size was valued at USD 594.6 billion in 2021 and projected to grow to USD 2038.9 billion by 2028

Forward Deployed - Printing simply but useful in Austere Environments

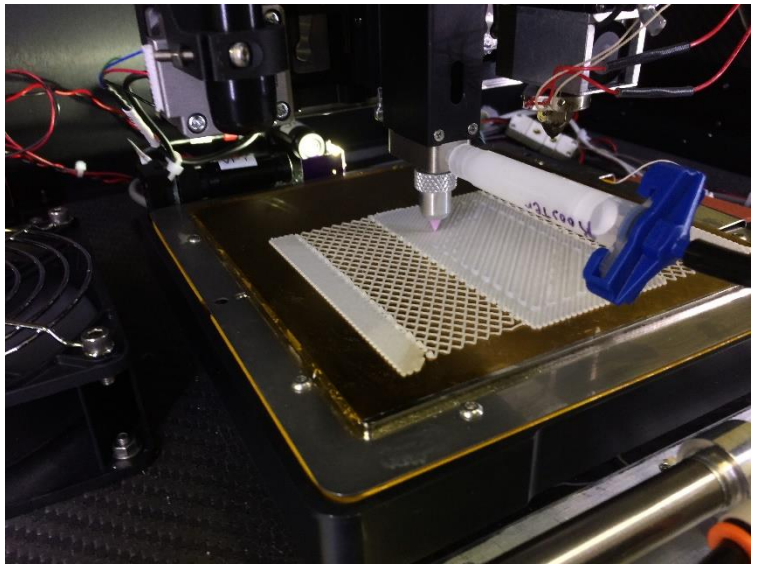
Bioprinter configuration:

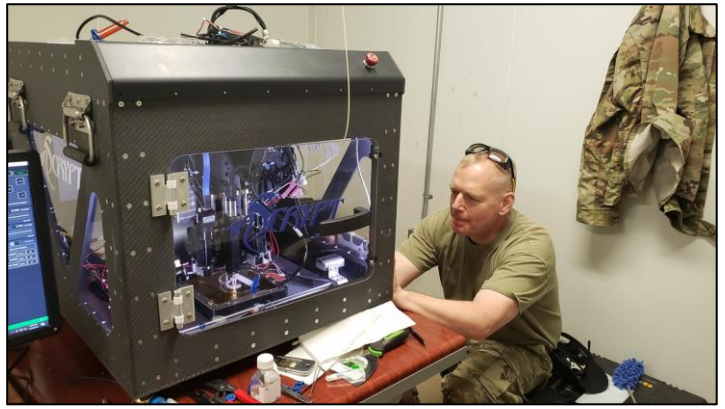
biologics

non-biologics

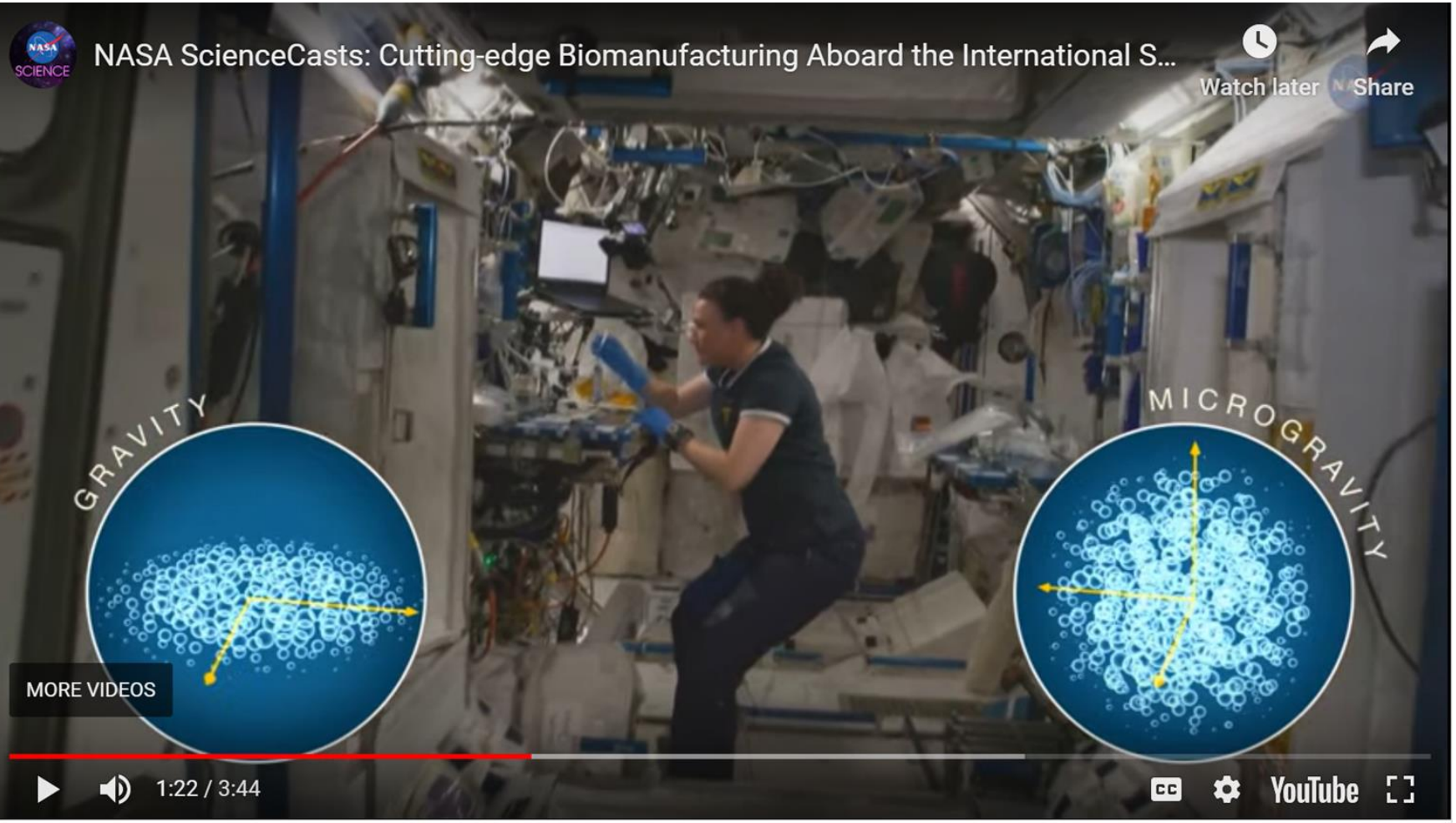
Forward-deployed prints:

- scalpel handle and hemostat
- bioactive bandages (hydrogel layer with antibiotics over a flexible structural layer)
- T9 vertebrae surgical model
- bioprinted meniscus (mesenchymal stem/stromal cells and a hydrogel scaffold)





Space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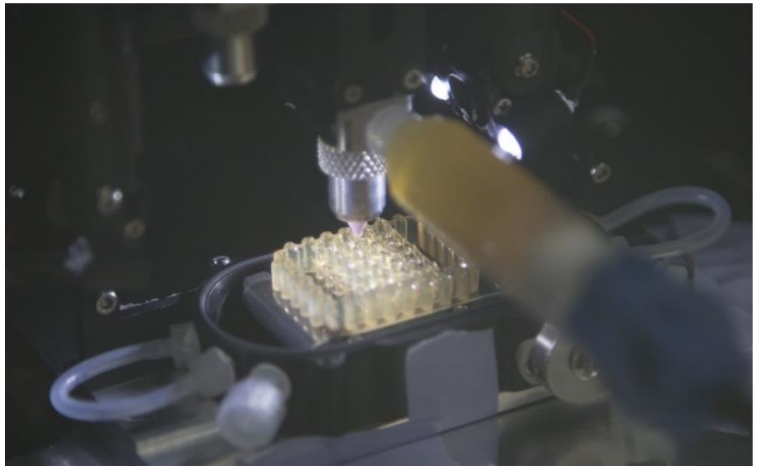
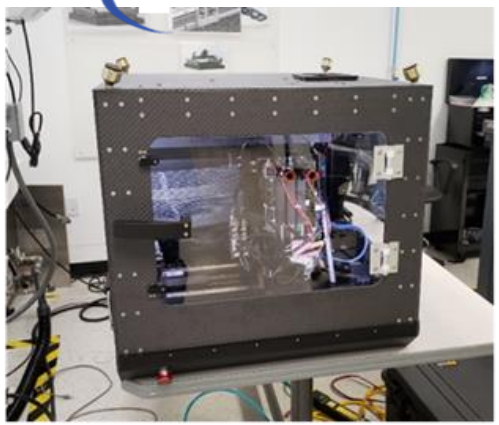



techshot
techshot
techshot

Direct Digital Manufacturing

RUGGED



A Factory in a Tool

Factory in a Tool (FiT) will provide a forward deployed capability for printing electronics and tissue engineered products for the warfighter.

Factory in a boX (FiX) for Austere Deployment

Modular Mobile Direct Digital (M2D2) Manufacturing Systems

A Factory in a boX (FiX)

Original Technology from DARPA Mesoscopic Integrated Conformal Electronics (DARPA MICE) 1999-2002.

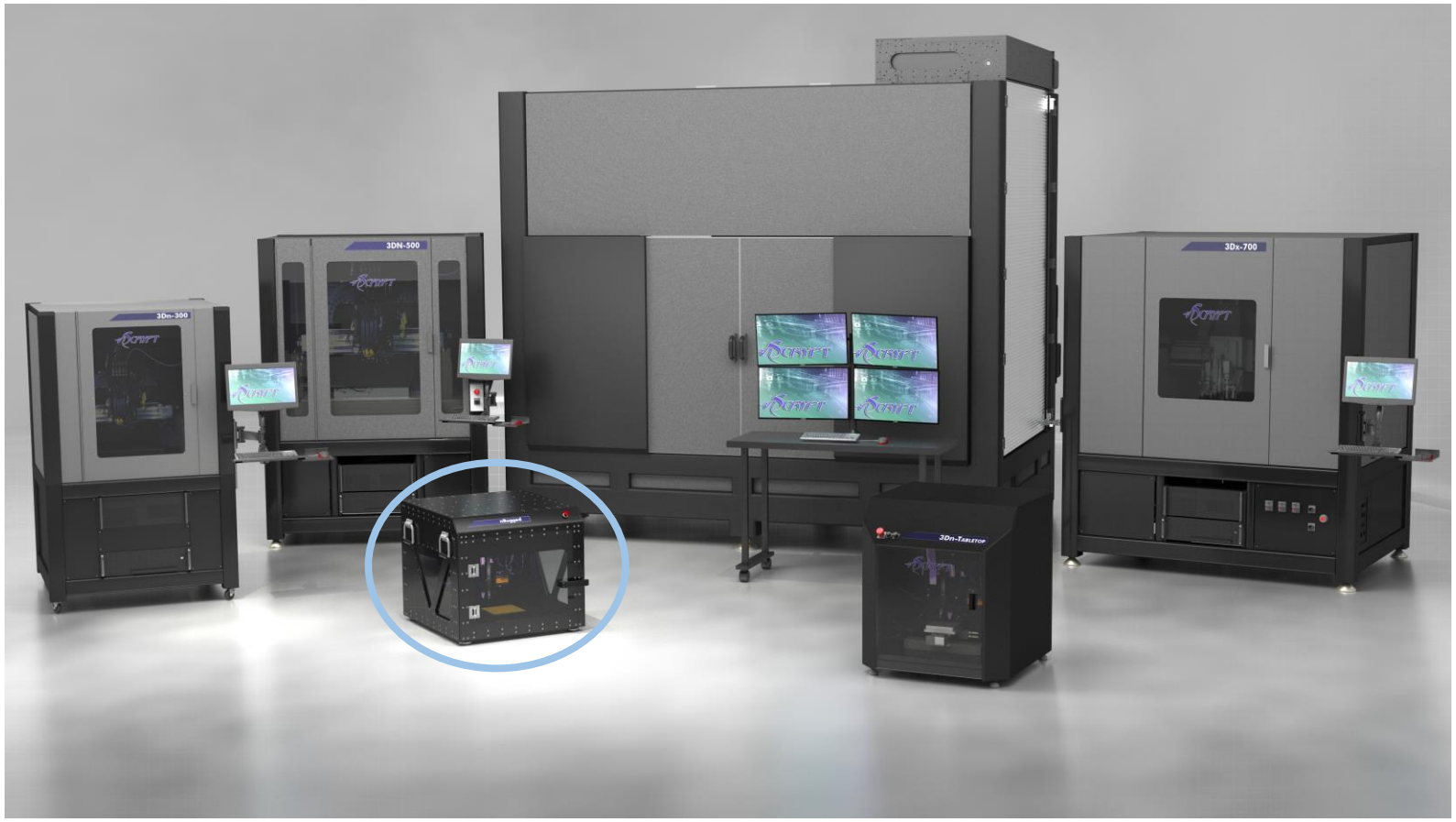
Moved from TRL 1 to TRL 9 => Sell equipment across the U.S. and around the world.

Continue to build on the technology with Army, Air Force, Navy, Space Force, NASA and Nextflex.

Army pressed for ruggedized and austere => nRugged™ emerged (TRL5).

New industry is emerging => Direct Digital Manufacturing

Manufacturing shift is immanent => Distributed Manufacturing



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C. Mike Newton.
nScrypt, Inc., Sciperio, Inc.
Orlando, Florida,
www.nscrypt.com
mnewton@sciperio.com

nScrypt, Inc.
12151 Research Pkwy, Suite 150
Orlando, FL 32826
Phone: 407-275-4720 • Fax: 407-275-4759

General: **info@nscrypt.com**
Global Sales: **sales@nscrypt.com**
Global Technical Support:
support@nscrypt.com

www.nscrypt.com

Abstract Title: SMART 3D Manufacturing of printed electronics

Printed electronics has been around for many years, reaching back to screen printing of thick film hybrid microelectronics. As time went on new material technologies emerged and integrated with graphically based printing processes like gravure, ink jet and others. Additionally, 3d printing matured over time, again with new material technologies and printing processes to include fused deposition modeling (FDM). Born out of the desire to print engineering models the technology has evolved into the ability to print higher performance structures as the final product. The idea in creating a factory in a box for 3D printed electronics was enabled in creating the ability to print multimaterial with multiple printed processes that included additive and subtractive methods. This integration allowed for the ability to print electronics and the electronic packaging in the same system. The goal was the ability to achieve the green -button, meaning load a digital file, press the green button and the electronic device, module or product emerged. True digital to physical manufacturing. Missing in this process is the integration of machine learning, artificial intelligence and in situ monitoring of processes and materials and digital twin. This presentation will cover the industry evolution of SMART 3D Manufacturing of electronic products the enable distributed manufacturing at the point of use/need.