

The background of the slide is a semi-transparent, olive-green image of a large industrial machine, possibly a steam engine or a large pump, with various pipes, valves, and a large flywheel. The Georgia Tech logo is overlaid on the left side of this image.

**Georgia
Tech**



CREATING THE NEXT

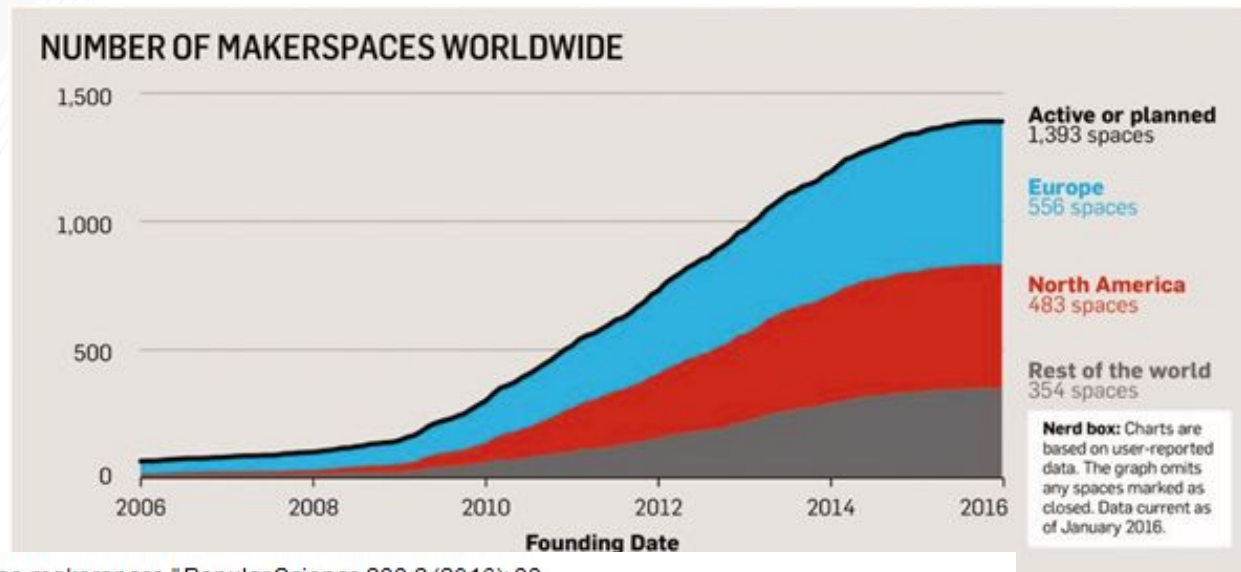
Advancing the Understanding of Maker Communities

Presented by: Kentez Craig and Emily Orton
ETI Thrust Area 2: Advanced Manufacturing
for Non-Proliferation (July 2020)

What is a makerspace?

A collaborative work space to make, learn, explore and share

- Peer-to-peer learning
- Hands-on
- Shared Ownership
- Creative self-efficacy



Examples of makerspaces



FirstBuild Microfactory - For Profit



Freeside Atlanta - Public Nonprofit



Stevens STEM Truck - Mobile



GE FirstBuild - Corporate



Case Western THINKBox - Higher Education

How to classify makerspaces?

- M-1: Primarily Student managed and staffed
- M-2: Faculty/Professionally managed and professionally staffed
- M-3: Faculty/Professionally managed with a hybrid (professional and students) staff

SCOPE

Signals the degree the makerspace is established on campus.

S1: Grassroots and initial efforts.
S2: Supports one or two missions.*
S3: Supports three missions.

-E: Substantial entrepreneurial activity.

*Missions: Education, Research, Service

ACCESS

Denotes the degree that the space can be used by the institute community.

A1: Students in specific courses.
A2: Individuals in specific departments.
A3: Individuals in specific schools.
A4: Entire institute community.

-S: Students only.

-P: Available for use by the public.

BUDGET

Average annual operating budget, including staff, equipment, and materials

B1: < \$50,000
B2: \$50,000 - \$99,000
B3: \$100,000 - \$499,000
B4: \$500,000+



USERS

Measures the number of individuals who access the space each year.

U1: Less than 100 people.
U2: 100 to 1,000 people.
U3: 1,000 to 3,000 people.
U4: Greater than 3,000 people.

MANAGEMENT

Indicates the leadership structure of the organization.

M1: Student leadership.
M2: Professional leadership.
M3: Hybrid leadership.

FOOTPRINT

Quantifies the physical size of the facility.

F1: Less than 1,000 SF
F2: 1,000 - 5,000 SF
F3: 5,000 - 20,000 SF
F4: Greater than 20,000 SF

How to classify makerspaces?

Assets

location
funding
fidelity



Culture

membership
administration
safety



Continuity

education
maintenance
growth



What is the Invention Studio?

- Accessible during work hours by anyone at Georgia Tech
- Staffed entirely by student volunteers who receive 24/7 access



2,268

Unique Users

34,245

Tools Used

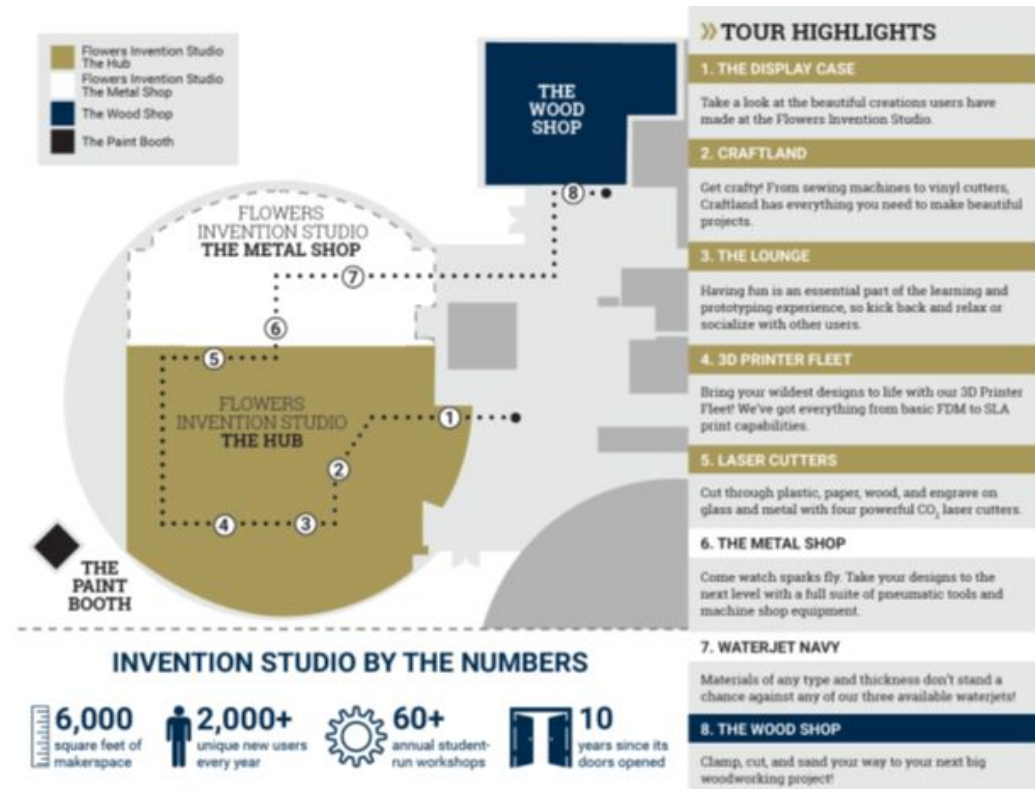
196,984

Total Tool Usage Hours

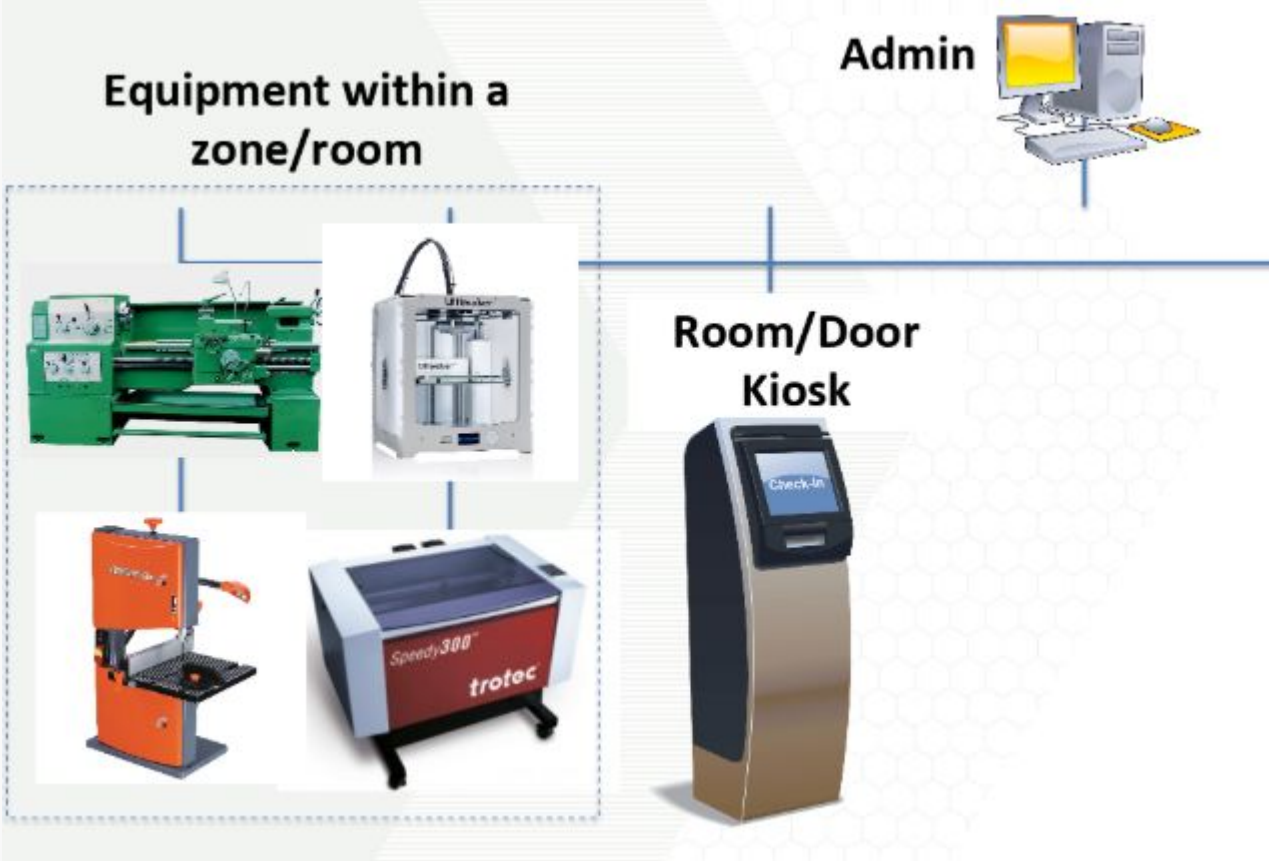
118

Total Student Volunteers

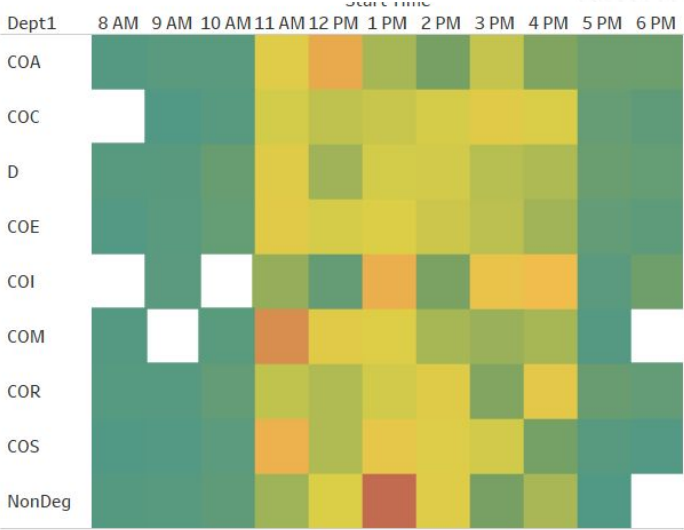
Annual data from 2019



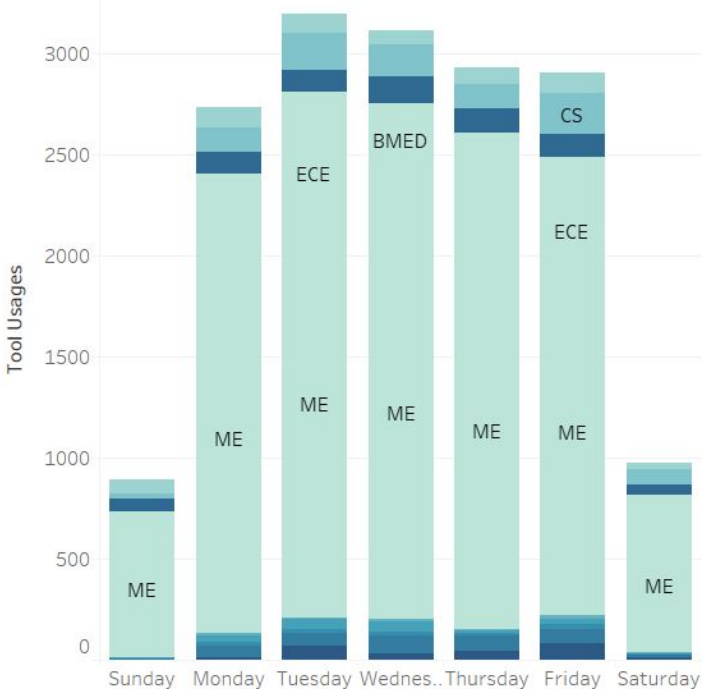
Makerspace usage Data Streams (through manual intervention)



TIME OF DAY



WEEKDAY



Makerspace side-channel data streams

- What can side channel tool data tell us about the user and the activity?
- How can it help with accessing, comparing and benchmarking makerspaces?

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Side Channel Data Collection Techniques - WIP

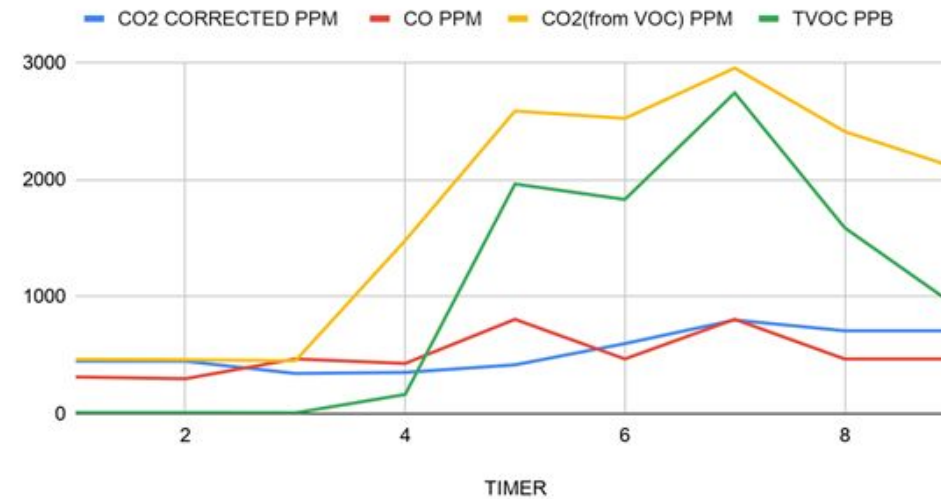
- Development of material detection utilizing gas sensing and classification technologies for laser cutting usage characterization is ongoing.



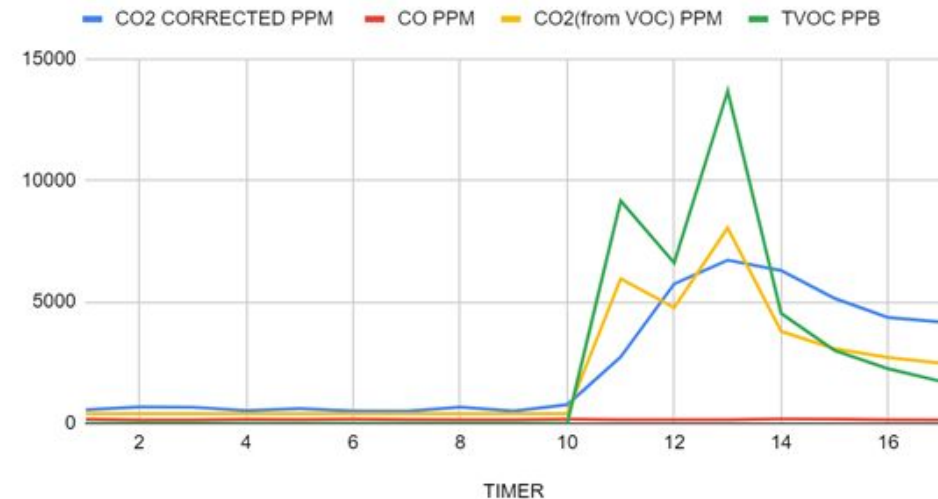
Ongoing Side Channel Data Development - Current Status

- Designed and built low cost circuits to collect emission data and conducted design of experiments to determine parameters needed to identify cut materials
- Initial data showed feasibility in the ability to detect the differences in categories of materials (Plastics vs woods, etc.)
- Increased granularity is expected to be attainable through improved sensor selection.
- Reaching out to Honeywell and others for sensor recommendations

Acrylic 50 Power, 10 Speed, 5 Passes



Acrylic 50 Power, 5 Speed, 5 Passes



Ongoing Side Channel Data Development - Future Plan

- Develop the granularity of the types of materials the system is able to distinguish
- Solve the issue of sensor fouling due to exhaust soot
- Work with the manufacturer (Trotec) to broaden the testing and verification of our system
 - Variety of machine types and materials
 - Fiber Laser marking may be of interest with its applications in production batch tracking
- Alert system for users and staff for detected unsafe or questionable condition - will help make makerspaces safer!

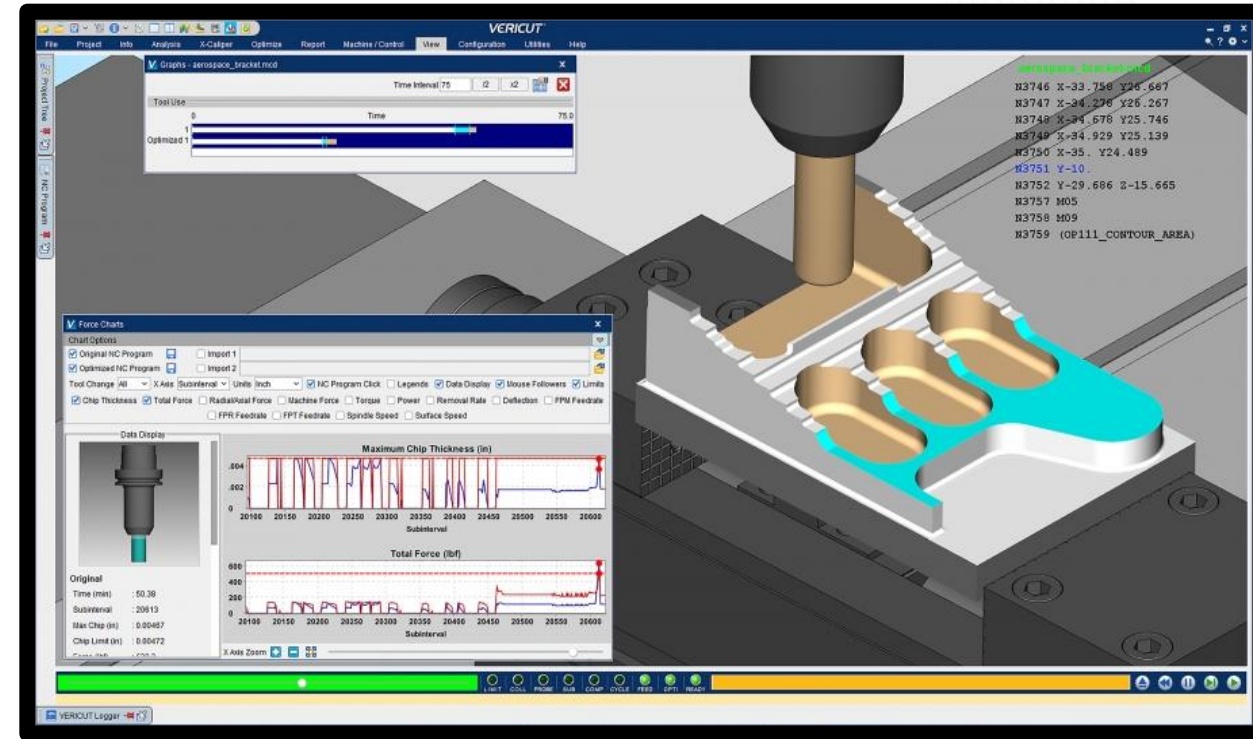
New Side Channel Data Collection from CNC machines

- Another common tool found in other local makerspaces are CNC Mills
- The ability to identify the materials being processed here would allow for many different formats of monitoring by capturing G-code and built-in sensor data.
- Reliant on data from solely the internal sensors of the machine
- Data transmission through existing industry standards and protocols to an AWS server for predictive analysis



New Side Channel Data Development - Current Status

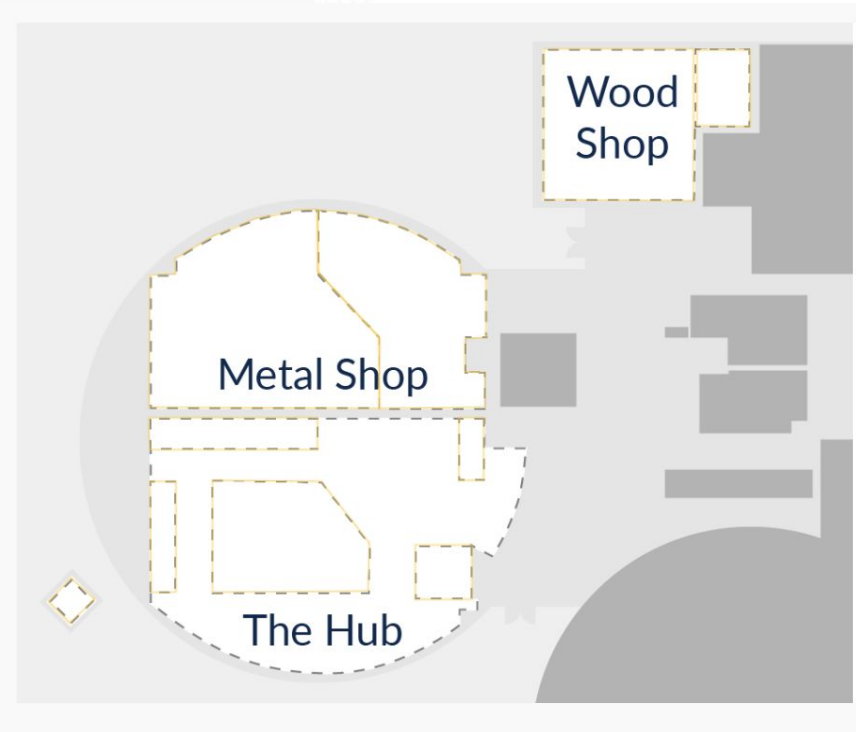
- Current simulation software is already developed to estimate cutting forces and cutting loads (VeriCut by CGTech).
 - Used here for the baseline comparison between material types.
- The system we propose is designed to compare the simulation data with the measured machine data to make a material prediction.
- The license key has been obtained for the OPC-UA and VeriCut software



- The raw data export and storage system is being configured for testing to start later this month.

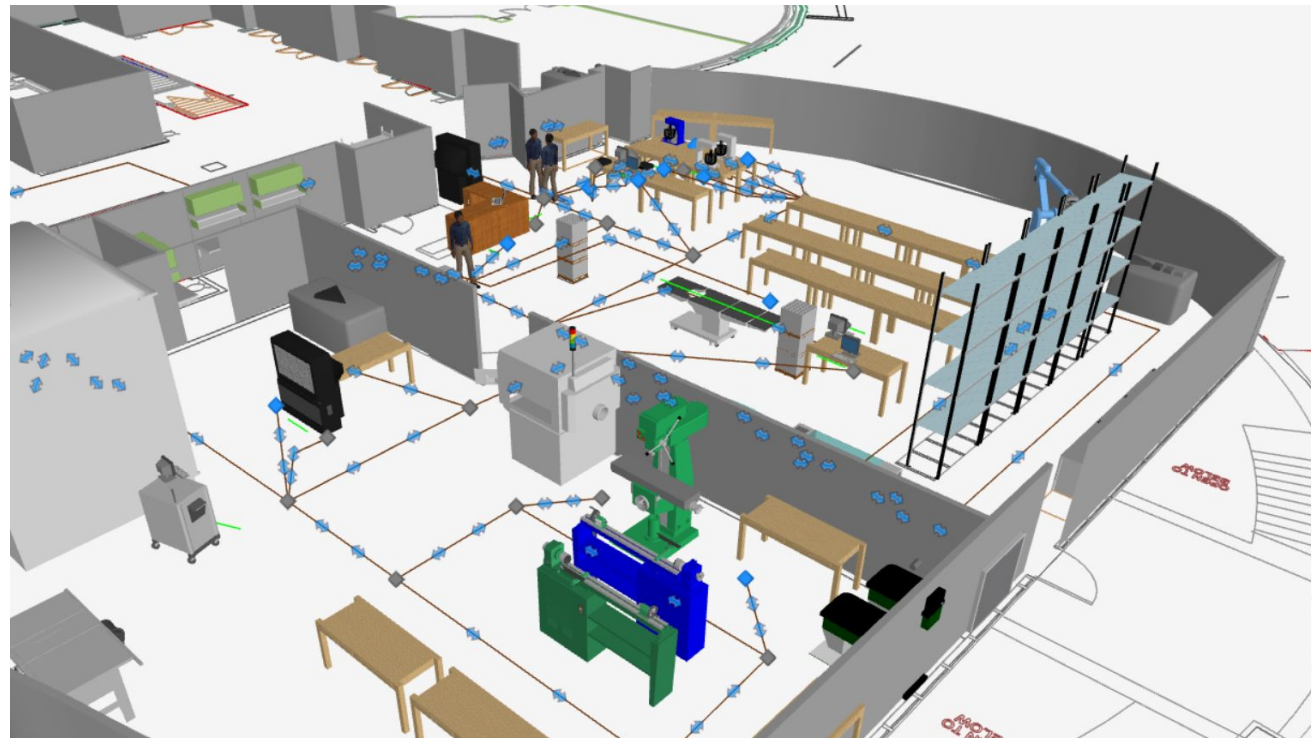
New Side Channel Data Development - Future Plan

- Development of a ML algorithm for analysis of the machine data and matching to a material cut profile.
- Determine the effect on this algorithm from the tool path selected.
 - Tool paths to be tested:
 - 2D / 3D Adaptive
 - Conventional pocketing
 - Drilling
 - Side Milling
 - Slot Milling
 - Facing
 - Ideally, one of these will be able to be shown to be an easy indicator of the material type.



 **Simio**

Forward Thinking



Thank You

- Summary of current and ongoing work
 - A framework to assess/compare makerspaces to better understand maker communities
 - Novel techniques to extract data from makerspace equipment/tools to create insights about the community and the activities within the space
 - Study and analysis of side channel data from manufacturing equipment like laser cutters and CNC machines to estimate materials being used
- Potential wider impact of research
 - Improve understanding of makerspaces used for education, training and innovation
 - Enhance safety features and reliability of advanced manufacturing tools
 - Improve final product quality resulting from manufacturing