Engineering Leadership for Industry 4.0:
Is Your Company Ready?”

C. Fred Higgs III

John & Ann Doerr Professor of Mechanical Engineering
Faculty Director of the Rice Center for Engineering Leadership

Rice Global E&C Forum (RGF)

May 2022 Roundtable

RICE UNIVERSITY
Rice Center for Engineering Leadership (RCEL)

In today's world, all major companies have become technology companies. Engineers are being increasingly involved in the creation of new ideas, products, and services, across all sectors of society.

Engineering & construction companies have the 'perfect storm' ahead where they must hire or train a new army of digital savvy (or *Industry 4.0) engineering managers* and be robust against Silicon Valley type tech competition

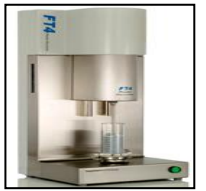
About the MEML Faculty Director

C. Fred Higgs III, Ph.D.

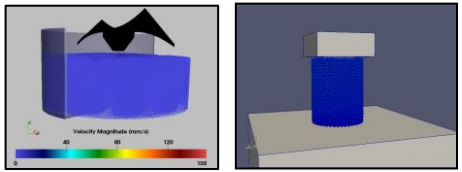
John & Ann Doerr Professor of MechE

Rice University (2016 – now)
Carnegie Mellon University (2003 – 2016)

Department(s):
- Mechanical Engineering (MechE),
- Joint faculty in BioEngineering

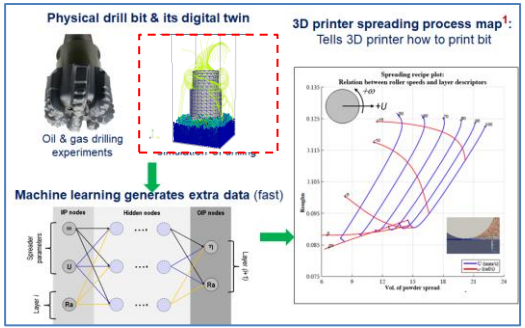


Physical I, II



Digital Twins I, II

Snapshot of Research Application



Particle Flow & Tribology Laboratory **(**PFTL)

Research

- **Particle Flow & Tribology Lab** (PI)
  - Modeling & experiments
- **Additive Manufacturing, Performance, & Tribology (AMPT) Center** (Co-founder)
- **Research sectors:** BioTech, Energy, Additive Mfg, and Nano/micro-tech, Space (“BEANS”)
- **Recent Patents in USPTO review (3 @ Industry 4.0):**
  - AI-guided design for: (i) AM powder spreading, (ii) drill bits, and (iii) Bio-joint implants

HELP wanted:
Binder jet metal 3D printing expertise

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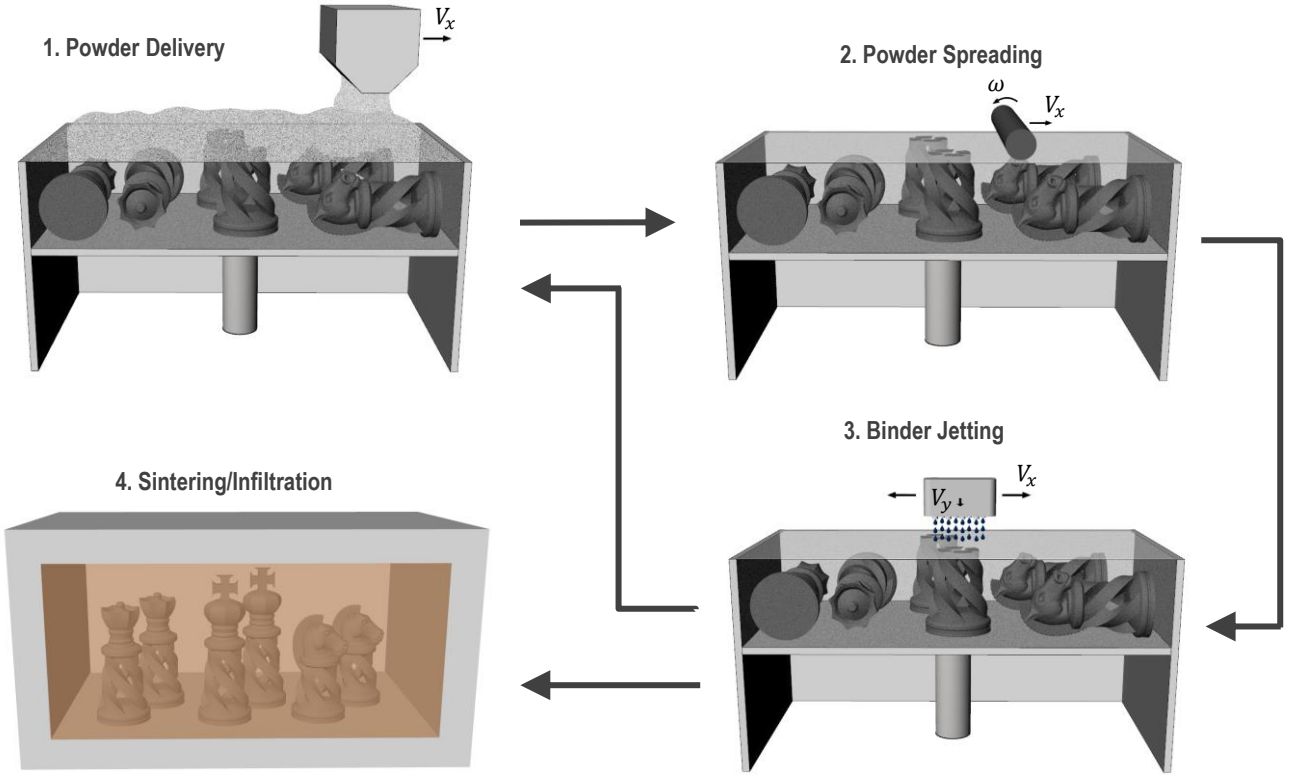
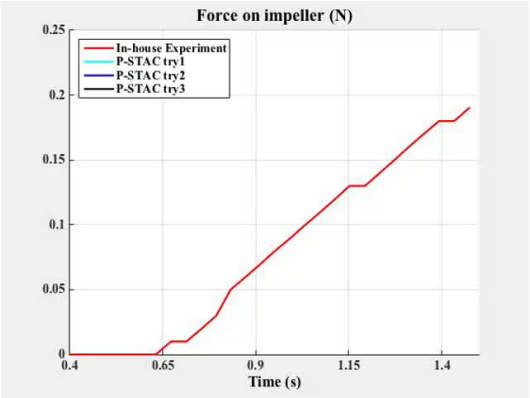
Additive Manufacturing, Performance & Tribology Center

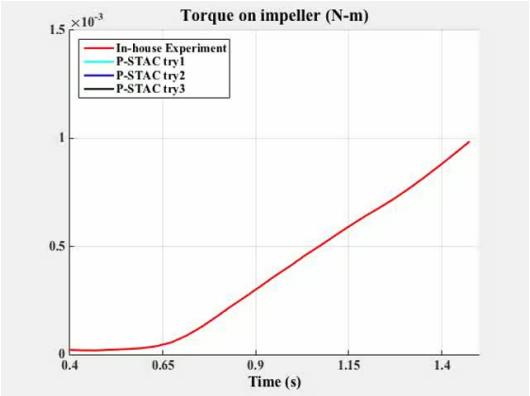
Binder jet additive manufacturing



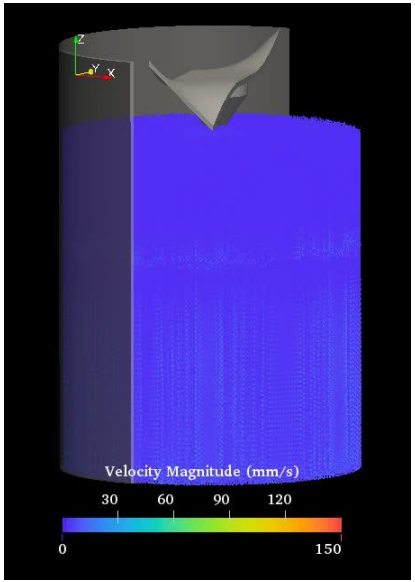
“Spreadability”: Digital twin powder rheometry (250 μm Ti-6Al-4V powder)

Physical powder rheometer





Digital Twin of rheometer



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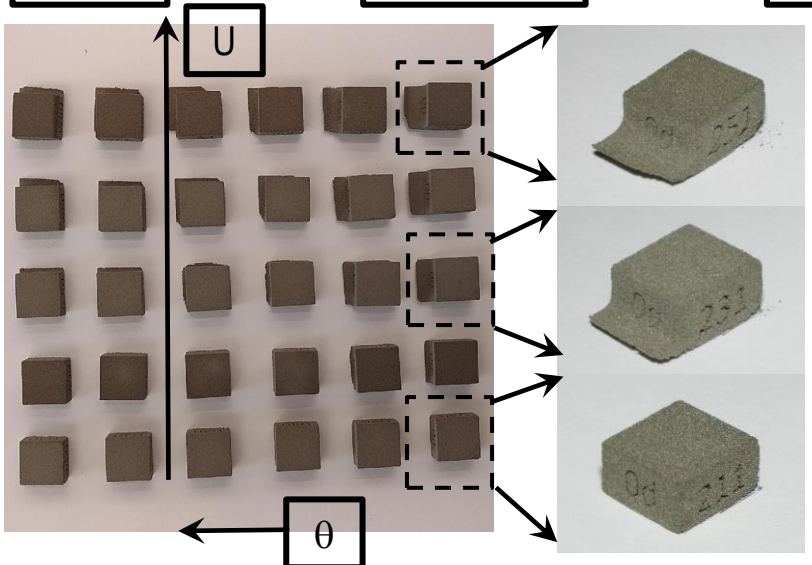
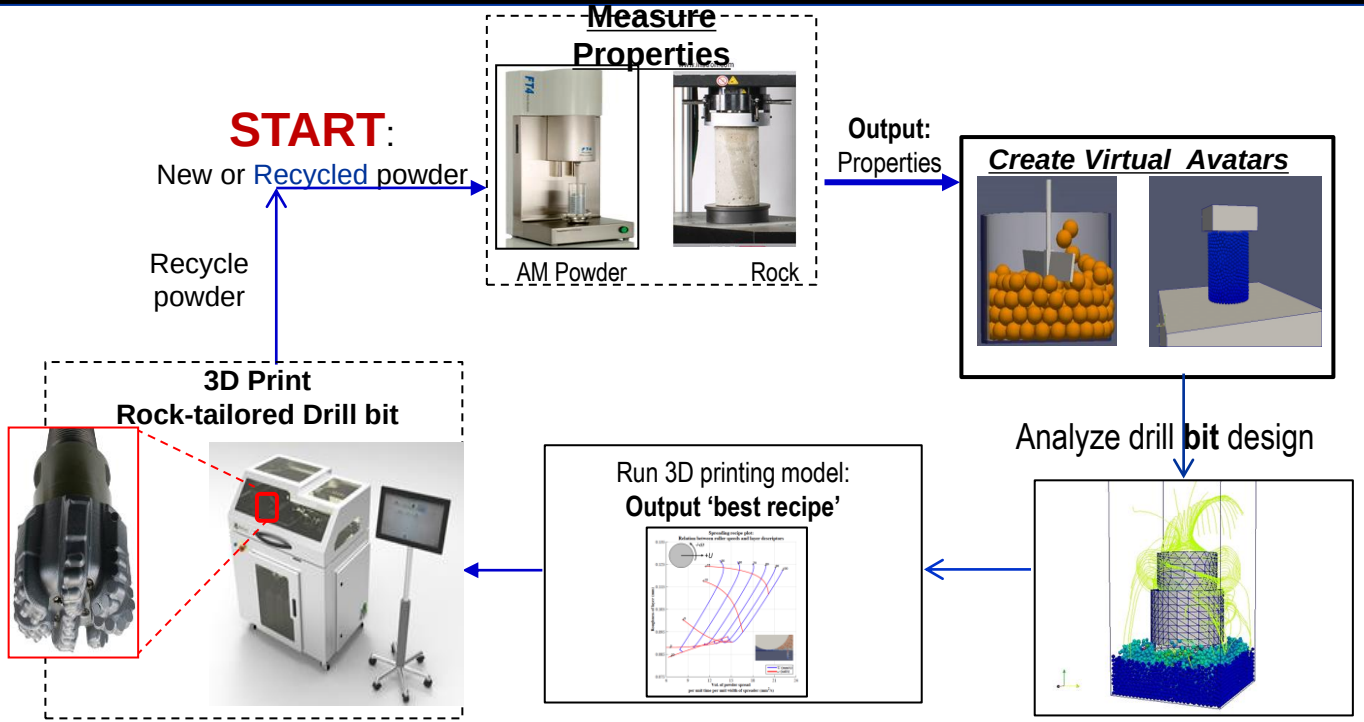
AM Powder Spreading experiments

Stl file → 3D Printer → Green Part



Rock-tailored Design-for-Additive Manufacturing Drill Bit Framework



Methodology:

Measure properties of AM and rock materials**, Create virtual avatars** to model, **Analyze** to find best drill bit**, Run 3D printing model,** Print **Real 3D parts**

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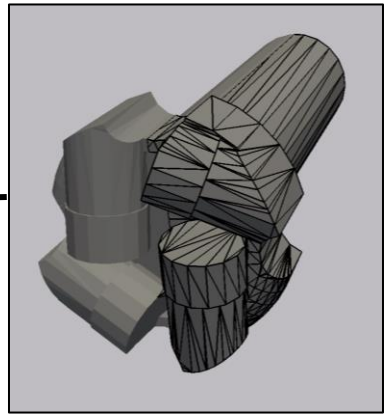
Additive Manufacturing, Per

HELP wanted:
Binder jet metal 3D printing expertise

Metal component

Metal 3D printer
(binder jet)



Computer-aided design
(CAD) file

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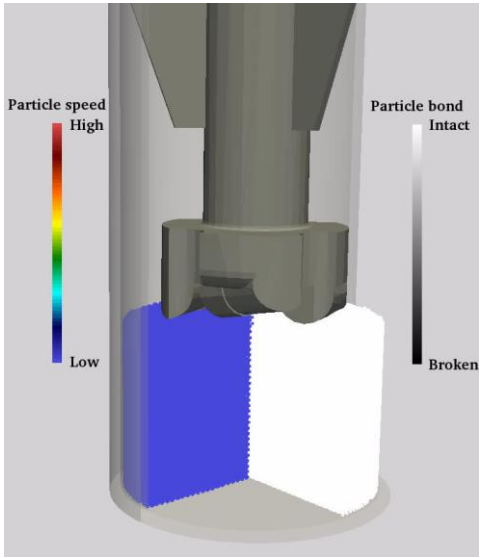
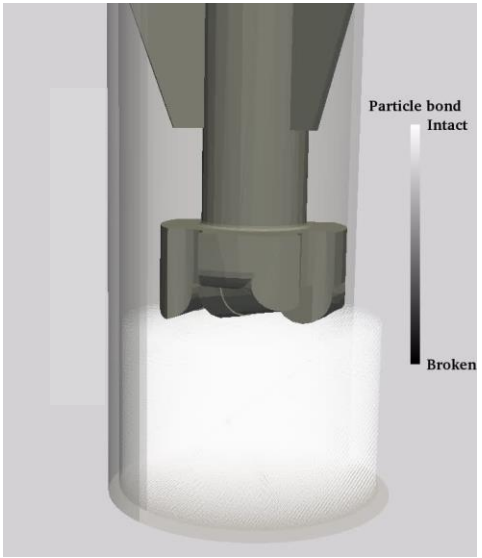
Drilling into weak concrete-like rock: Dry conditions

P-STAC 265k particles

Experiment





Visualizing grain speed

Visualizing rock fracture

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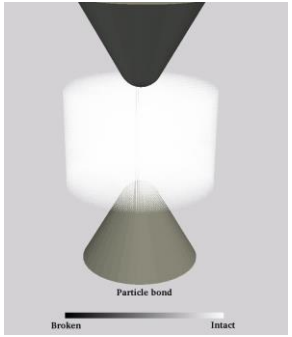
Generate virtual avatar

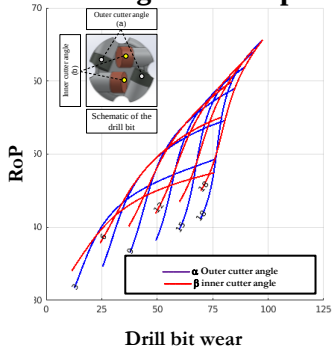
Point-load testing of rock

435k particles



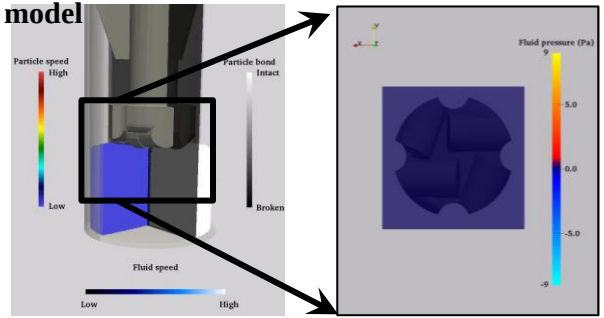
Deliver design chart

Layman-tractable guide to improve drilling



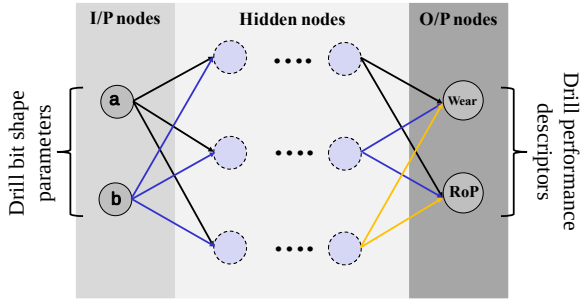
Run virtual laboratory

Experimentally compared physics-based model



Develop surrogate model

Back-Propagation Neural Network



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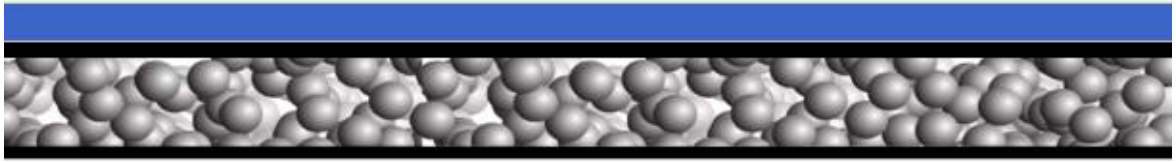
Patent Pending (2021)



Drillogy

Enter text

"AI-guided design of rapid-excavating and wear-resistant drill bits"

Drillogy is a rock-specific drill bit shape generator optimized for maximizing the RoP, minimizing the bit wear and scheduling the drilling of an oil or natural gas well

Inventors:

C. Fred Higgs III and Prathamesh S. Desai

Particle Flow and Tribology Laboratory

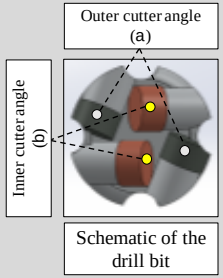
Rice University

Drillogy

Optimized schedule of the drill job

Depth of well	2000	mm
Rotational speed	150	rpm
WoB	2.5	N
Bit fail criterion	50000	wear
Bit replacement time	60	s

The bit which will complete the drill job in the LEAST TIME should have **outer cutters** at **6.5°** (α) & **inner cutters** at **7.0°** (β)
This bit must be replaced <u>once</u> at the depth of 1020 mm



Schematic of the drill bit

Calculate optimized drilling schedule

Done!

Is this relevant to the construction industry?

This 3D-printed house is made entirely from mud

N. Italy
200hrs

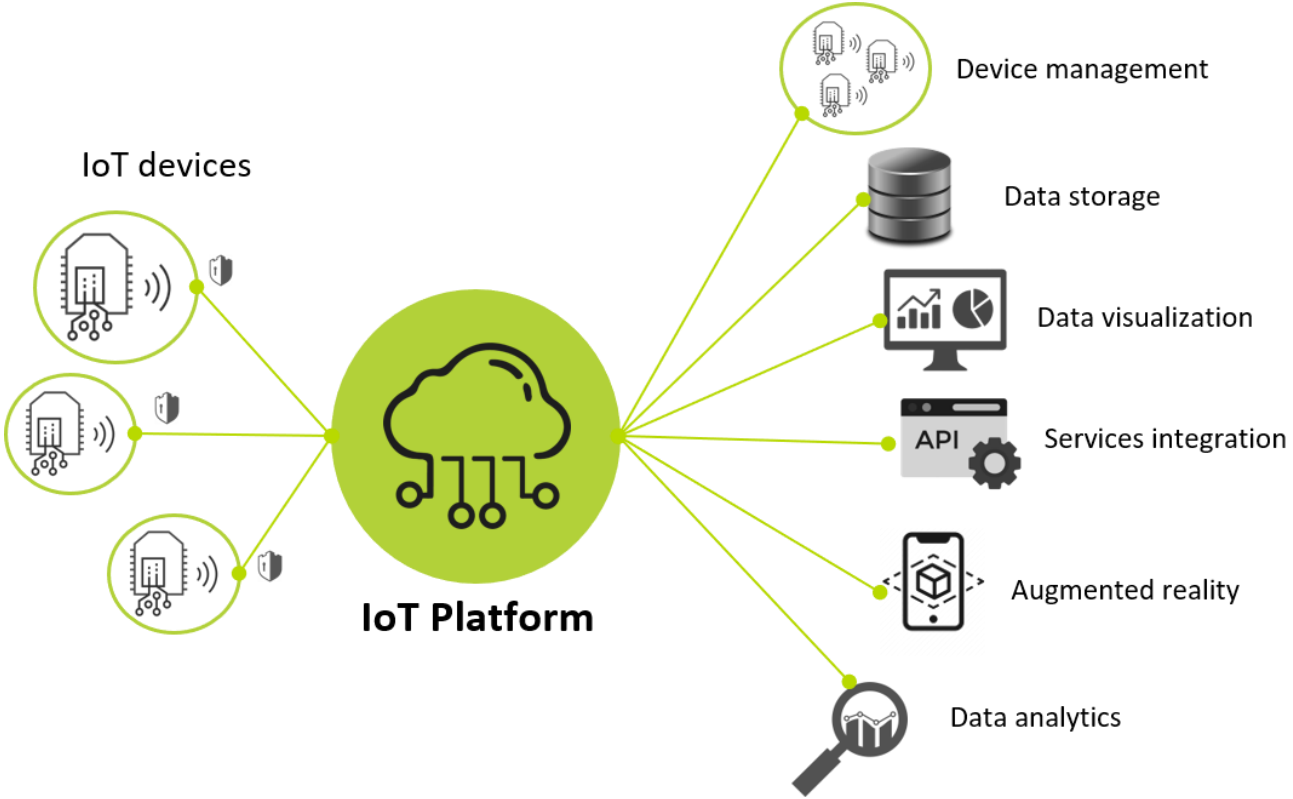
Source: Wired.com

This 3D-printed house is made from concrete

Germany

Source: Gira.com

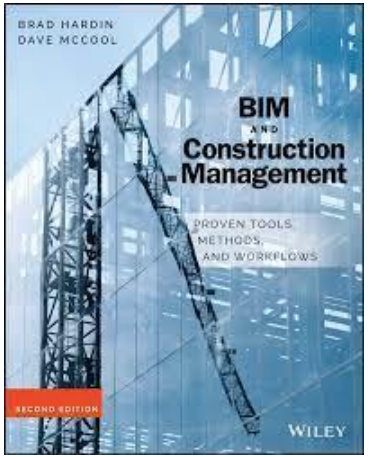
Digital Platform



Source: IoT Studio — Globant

Digital Platform: **Pop Quiz!**

Construction?



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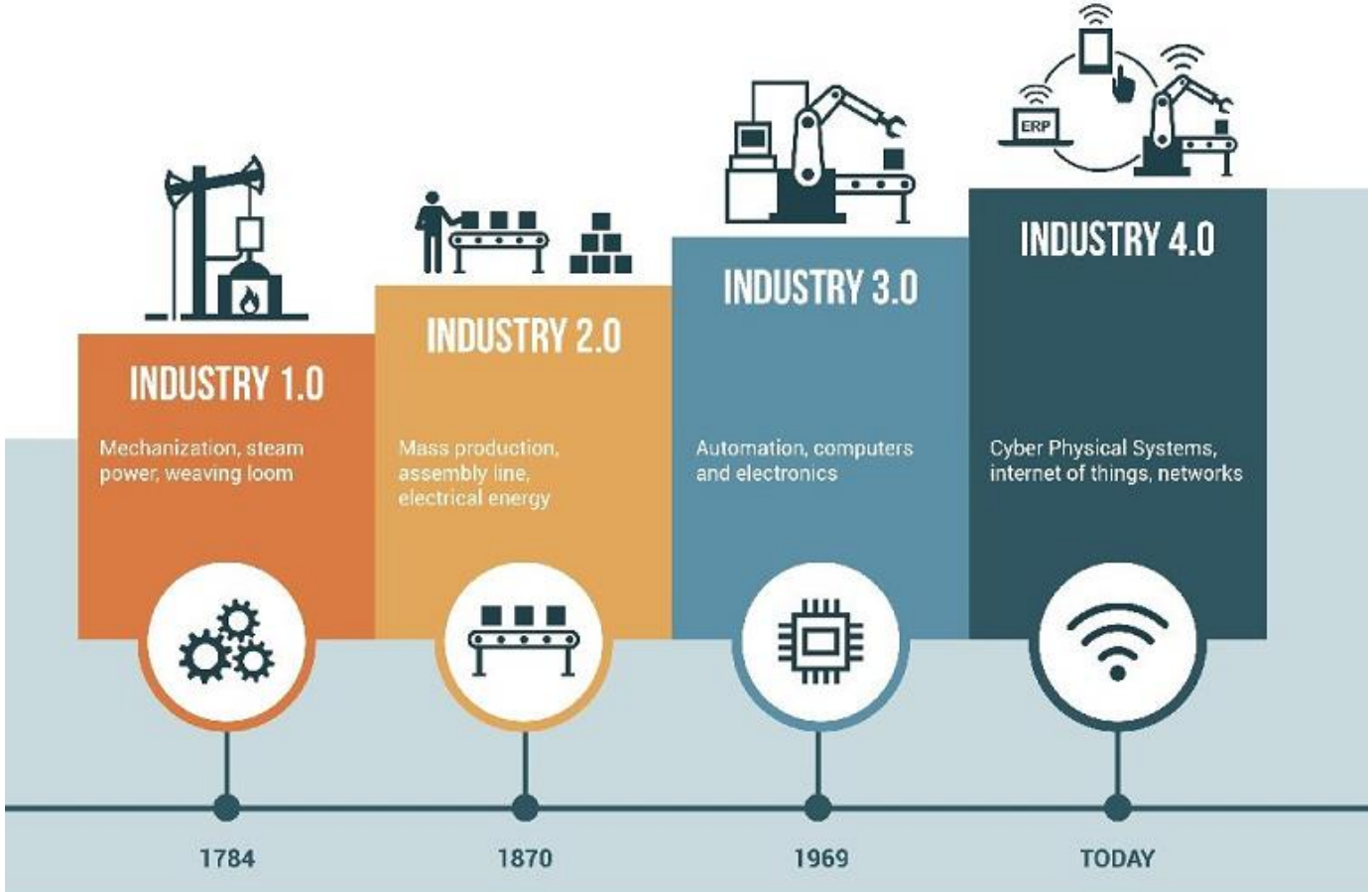
The 4 Industrial Revolutions



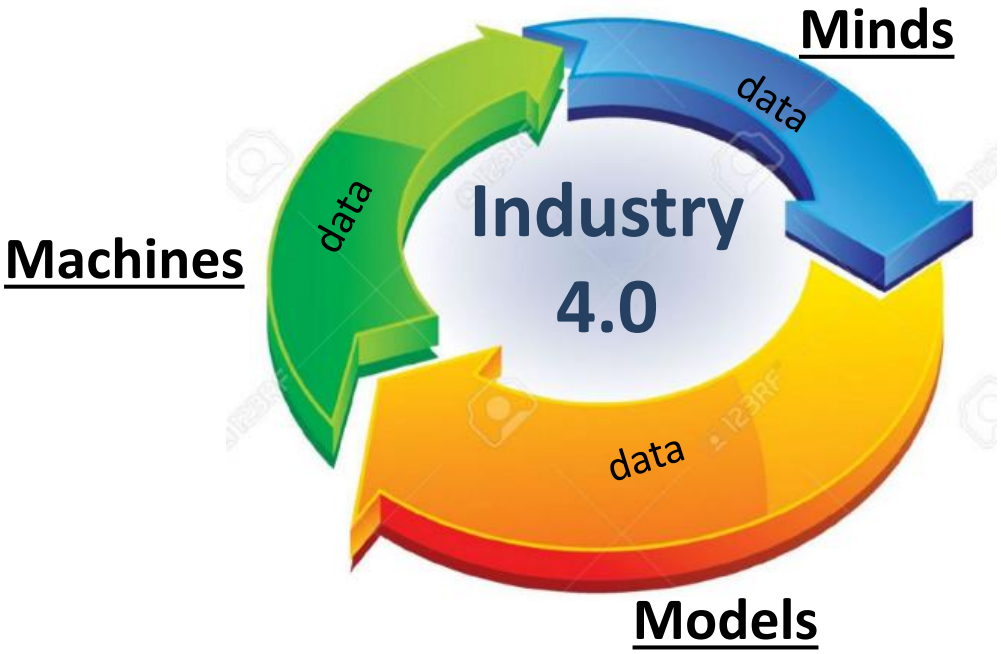
Source: http://www.sustained-quality.com

Industry 4.0

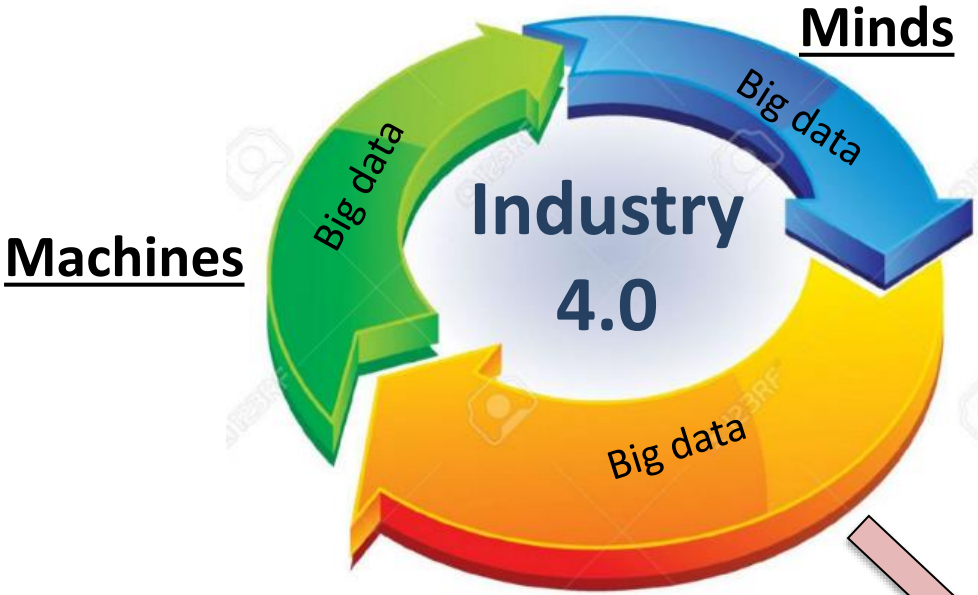
Industry 4.0 refers to the companies driving the 4th Industrial Revolution, in which technologies span the **physical**, digital, and **biological** worlds.

They are changing how people work and live, and how products are produced and consumed.

Industrial Revolution 4.0



Industry 4.0



- Sharing sensor data
- Interpretation of data (AI)
- Optimization of performance (Model + Analytics)

1st Industrial Revolution: Steam power mechanizes production.

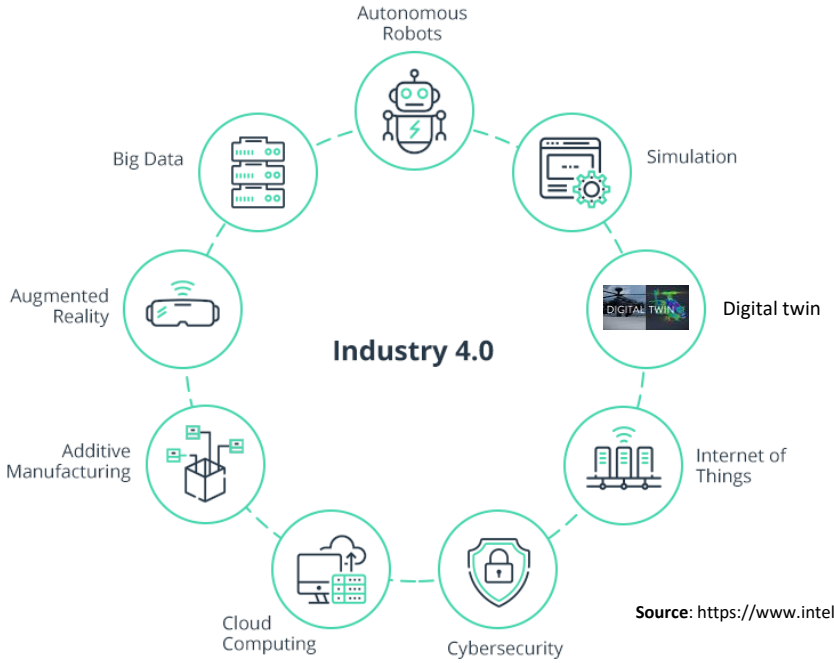
2nd Industrial Revolution: Leads to mass production.

3rd Industrial Revolution: Computers automate production & enhance speed.

The 4th Industrial Revolution

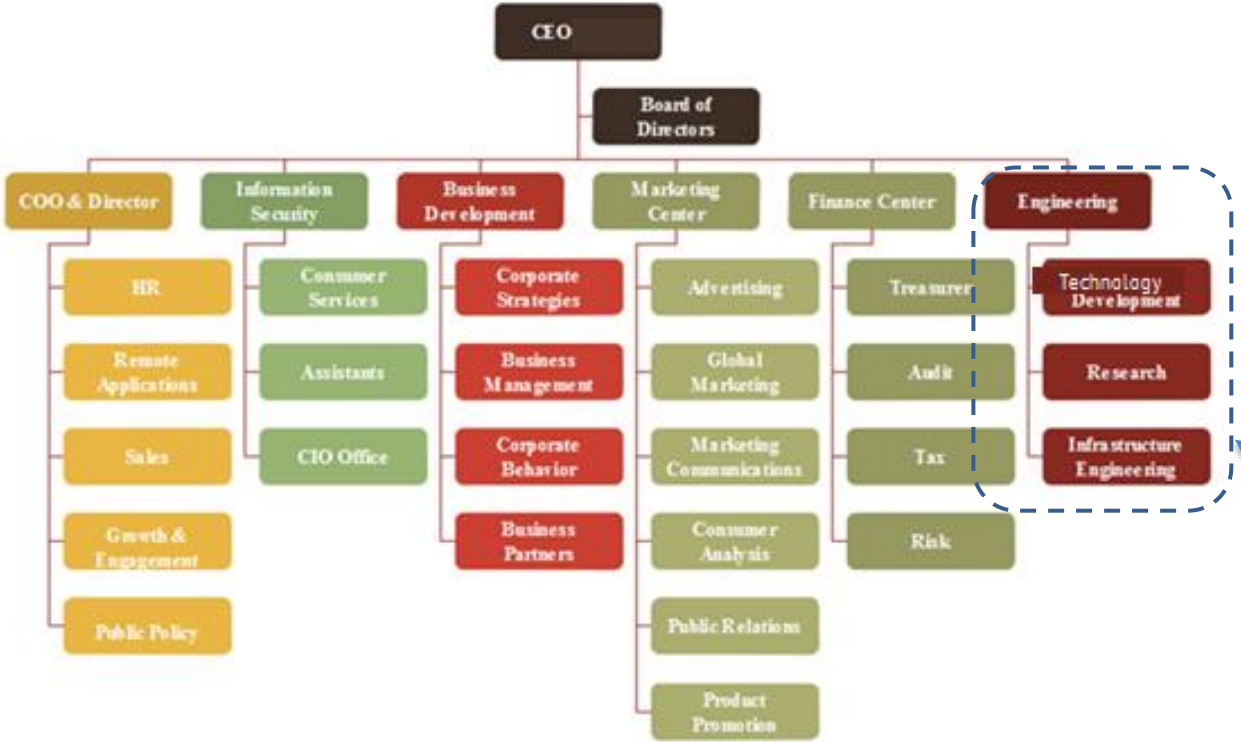
Industry 4.0

- **Industry 4.0 companies develop data-enabled technologies** that lead to radically smarter and connected products/services.
  - BIOLOGICAL (human, neuro, etc.)
  - PHYSICAL (machines, sensors, etc.
  - DIGITAL (algorithms, models)
- Industry 4.0 companies changing
  - People & Products.
- Companies will need an engineering leader manager who can put an I4 'lens' atop of existing practices and products



Source: https://www.intellias.com/

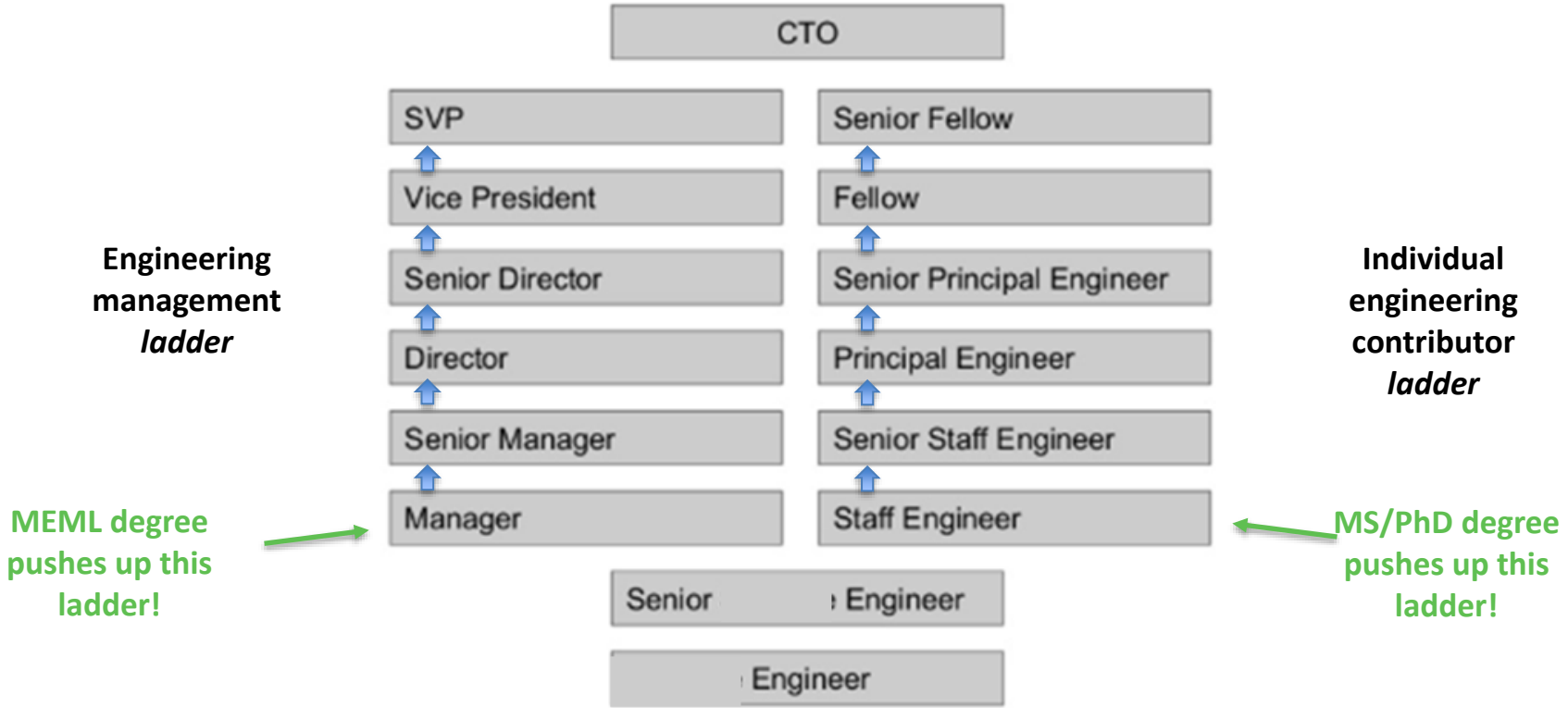
Career Ladders for Engineers in Industry Today



MEML will fill the gap between engineering and management

A MEML degree needed

*For those who want to **lead** engineering, not **leave** engineering*

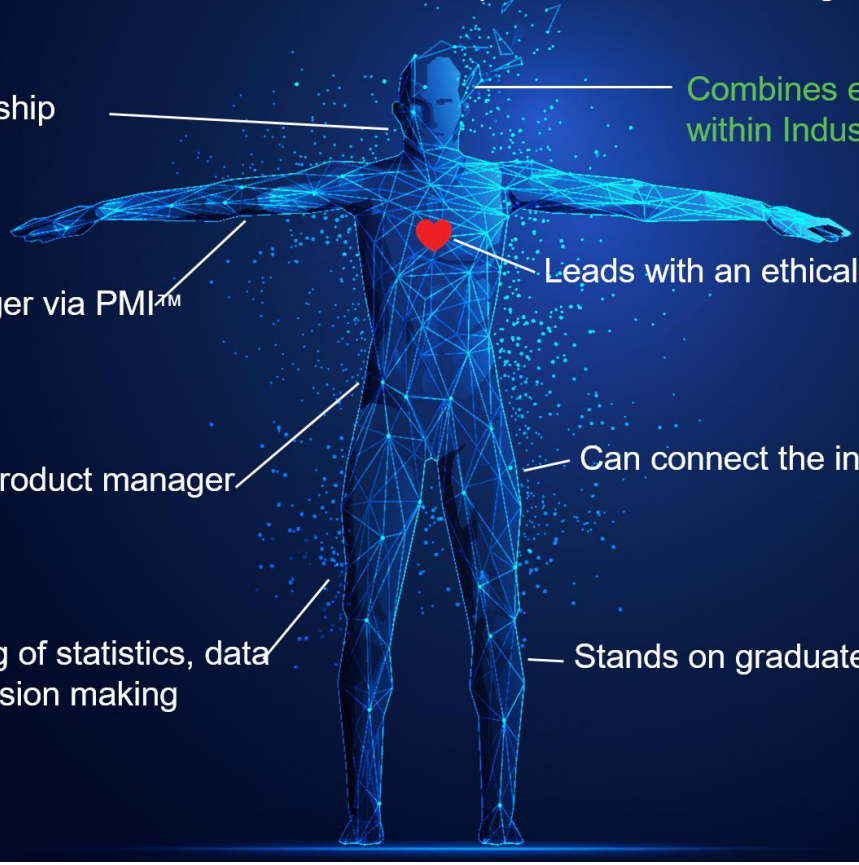


"I skate to
where the puck is going to be,
not where it has been."

WAYNE GRETZKY

The I4 Engineering Leader

Companies in the 4th Industrial Revolution require a NEW kind of Engineering Leader



Knows engineering leadership theory & application

Combines engineering and product management within Industry 4.0 framework

An engineering project manager via PMI™ (PMP™)
(Qualifies for 35 PDU hours)

Leads with an ethical-technical heart

Is a data-blooded, I4 product manager

Can connect the internal knobs to economics

Working understanding of statistics, data science, and AI in decision making

Stands on graduate-level engineering knowledge

Masters of Engineering Management & Leadership:
Degree Requirements (Either On-campus, Online, or Mixed)

Engineering Manager Leadership Breadth (6 courses)

- RCEL 501: Engineering Management & Leadership Theory and Application
- RCEL 502: Engineering Project Management *(with PMI® PDU hours)*
- RCEL 503: Engineering Product Management in Industry 4.0
- RCEL 504: Ethical-Technical Leadership
- RCEL 505: Engineering Economics
- STAT550/RCEL 506: Applied Stat & Data Science for Engineering Leaders

Engineering Discipline Specialization (EDS) (3 courses)

3 graduate courses in an engineering department or a multidisciplinary focus area..

- **Department EDS:**
  BioE, ChBE, CEE, CAAM, CS, ECE, MSNE, MECH, STAT
- **Multidisciplinary EDS:**
  Data science, Industrial Engineering, Financial Engineering

MEML Capstone Project

Devise Industry 4.0 solutions to solve real-world problems while exhibiting engineering manager leader skills.

For more answers to questions….

Contact me here: higgs@rice.edu
C. Fred Higgs III, Ph.D.
Rice University
Master of Engineering Management & Leadership (**MEML**)
School of Engineering

Email Linkedin Twitter (@higgsf)