

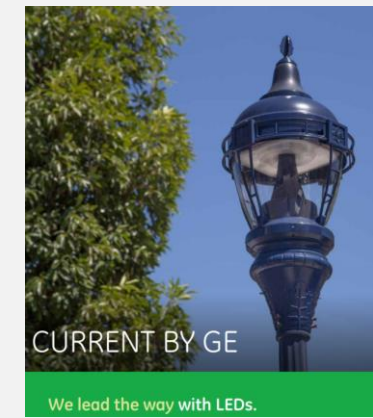
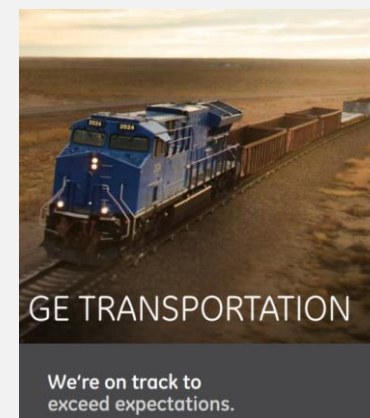
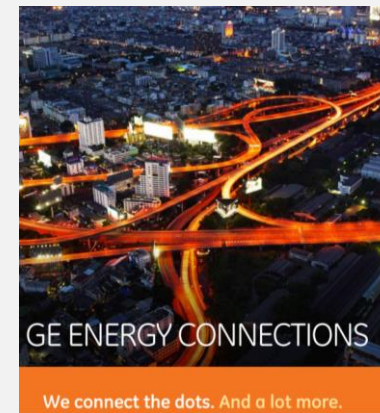
A BRILLIANT TRANSFORMATION IN MANUFACTURING

Christine Furstoss

Vice President and Technical Director, Manufacturing & Materials
GE Global Research



GE ... A Digital-Industrial Company



Spending \$5+B per year on innovation

Local R&D talent Delivering global impact

- Total R&D expenditures '15: \$5+B
- 3,100 patents in '15
- ~3,000+ PhDs, engineers & scientists
- 55,000+ Technologists worldwide
- 100,000+ visitors a year globally
- GRC R&D Collaborations: >300



INDIA

1999



CHINA

2000



GERMANY

2004



DETROIT

2009



BRAZIL

2010



SAN
RAMON

2011



ISRAEL

2012



OKLAHOMA

2013



SAUDI
ARABIA

2015

A robust, aligned innovation network that delivers for the future

Local R&D talent Innovating for China



China Technology Center

> \$1B

in China
R&D since
2003

\$250MM

ICFC funding
generated ~70
products &
solutions

~ 3K

Technologists

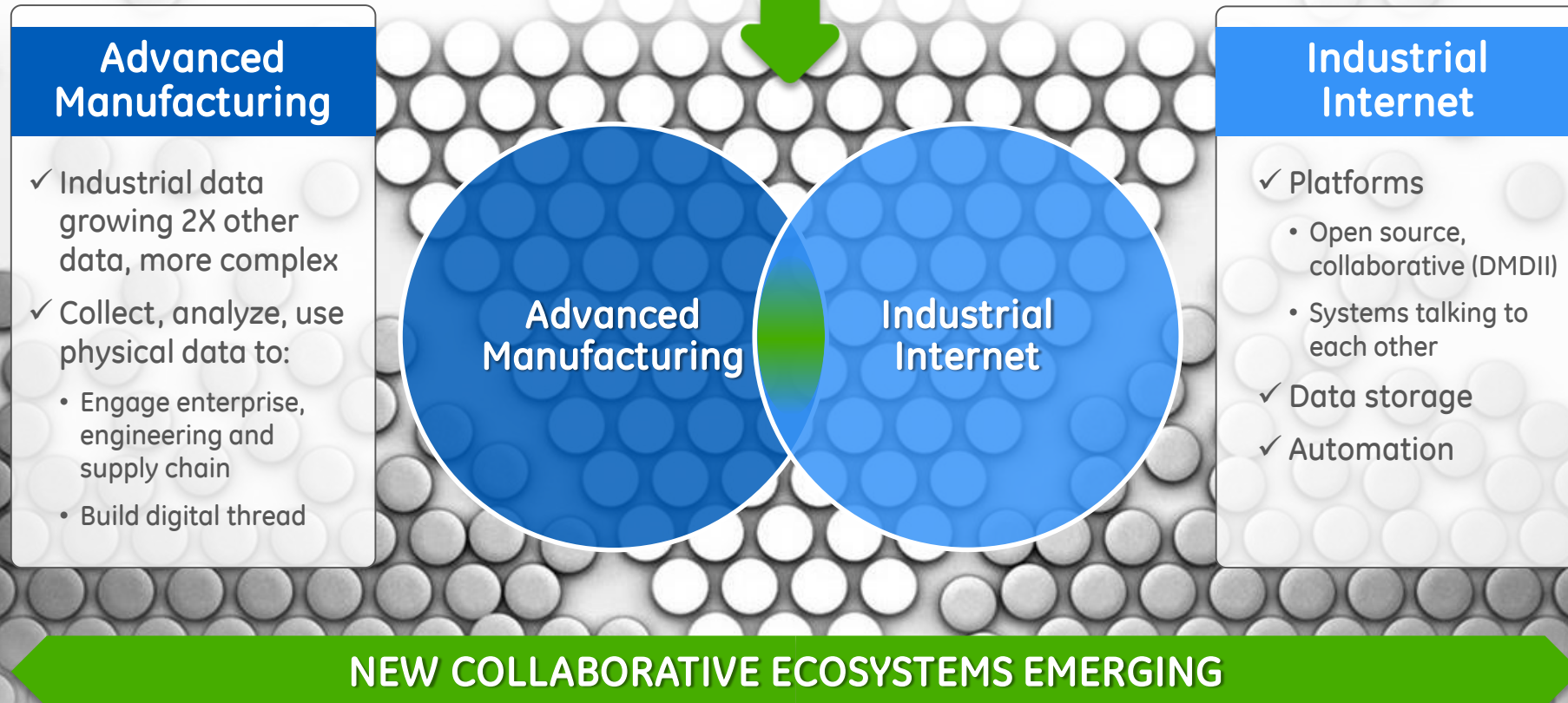
60+
labs

1,500
patents filed
up to 2015

Building world-class products and services across the country

The Physical and Digital worlds are converging ...c

BRILLIANT FACTORY



1% productivity savings = \$500MM for GE

What is physical + digital?

3D PRINTING



25-50% ↓ NPI time

6 months to **3 weeks**
tool procurement

20-80% performance
improvement w/weight
reduction

HOLE DRILLING CONTROLS



+50% yield
improvement

+20% cycle time

Platform for multiple
businesses

ADAPTIVE WELDING



2x-4x productivity

12% → 70%
working efficiency

Enabler for new
Service repairs

Leading to unprecedented quality, efficiency and speed in manufacturing

A new view of automation

Robotics



Using robots for repeatable processes

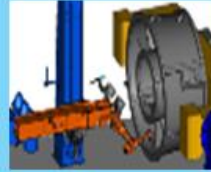


Robotic deburring
Working efficiency
12% → 70%



Mobile and Field
Speed, Flexibility
Safety

Sensor Feedback



Real-time for process control



Agile Welding
2X-4X productivity



Automated Repair
1.8X yield
6X speed

Automated Inspection



In-line, incoming and quality



Visual inspection
In-situ milling
Less variation



Inline Inspection
Early detection
+30% productivity

Technology convergence: hardware, process, controls, data, analytics

Technology Convergence: hardware, process, controls, data, analytics

Manufacturing process trends... design enabling

Fine Feature Machining



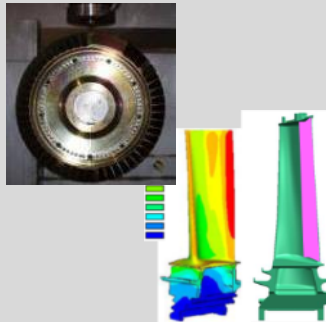
Surface Engineering



Joining



Hybrid Processes



...with new materials



...with distributed manufacturing/services



...with automation



Additive... a breadth of technologies

DIRECT METAL LASER MELTING



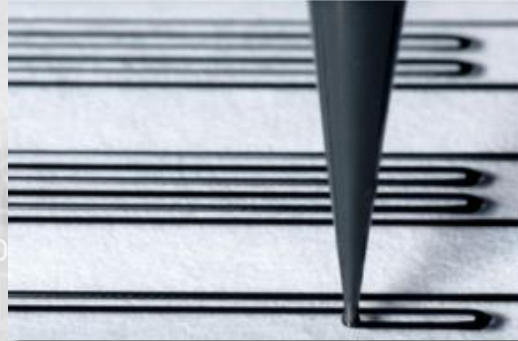
25-50% ↓ NPI time

6 months to **3 weeks**

tool procurement

20-80% performance improvement with new features

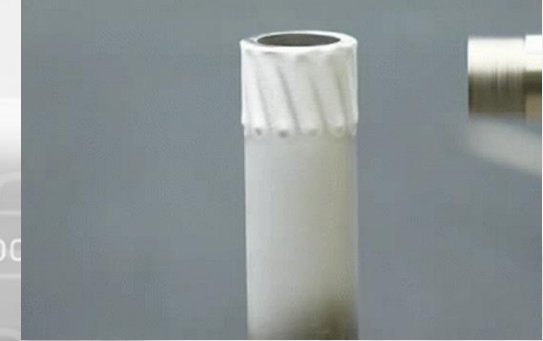
DIRECT WRITE & MICRO PRINTING



Enabling sensors, electronics, transducers,
20% cycle time savings

Platform for multiple materials

COLD SPRAY



2x-4X productivity

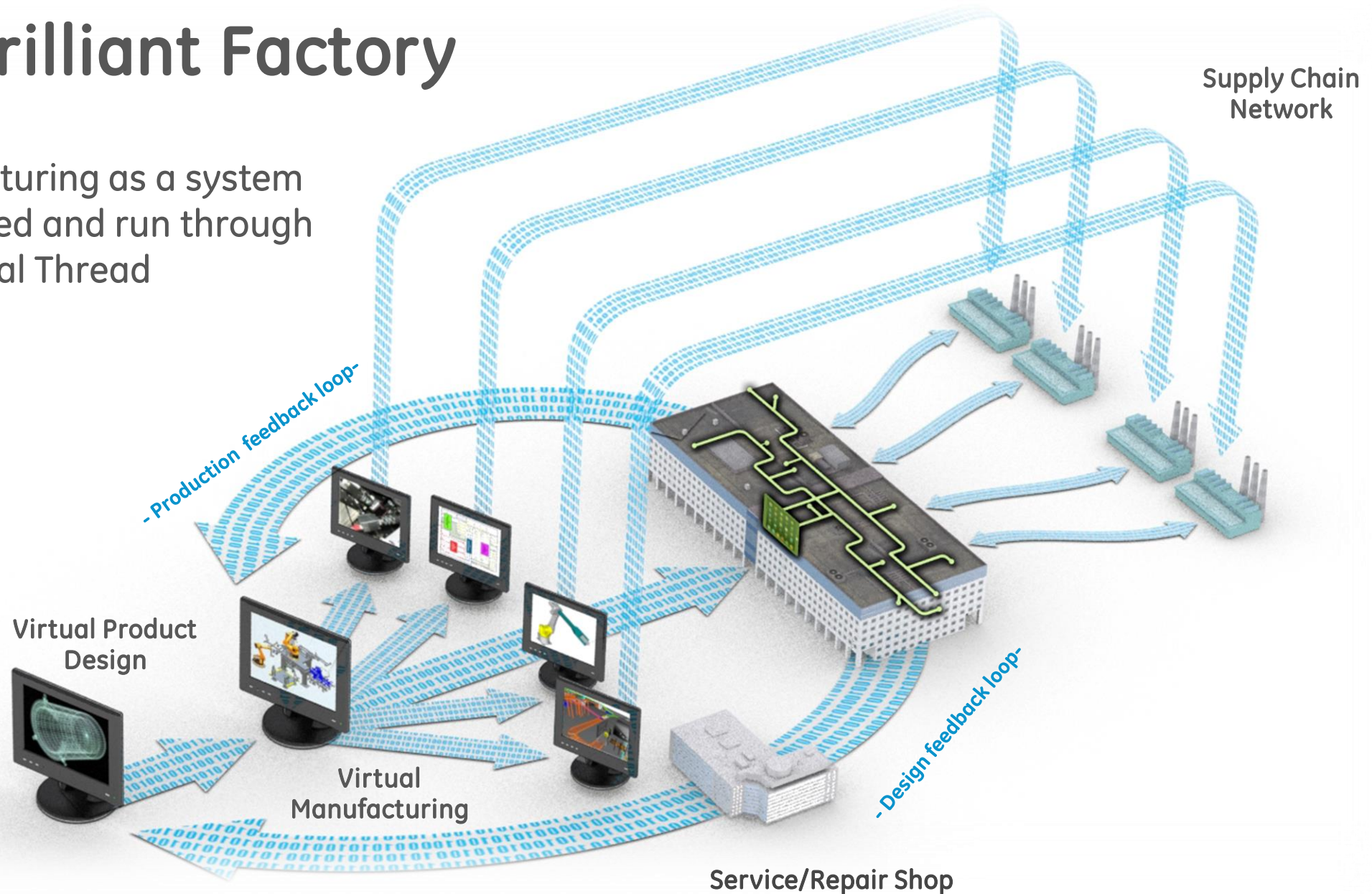
Customization on demand

Transforming Service opportunities

Unprecedented quality, flexibility, speed

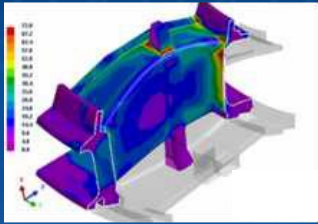
GE's Brilliant Factory

- Manufacturing as a system
- Connected and run through the Digital Thread

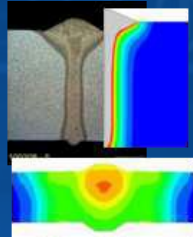


Digital + Physical Enablers

Virtual Manufacturing

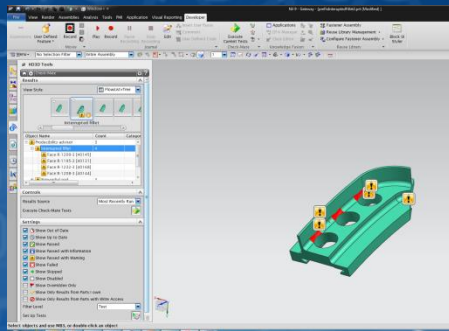


Solidification



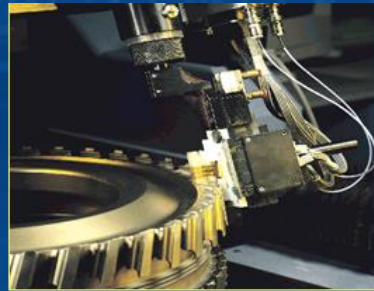
Welding

PROCESS MODELING

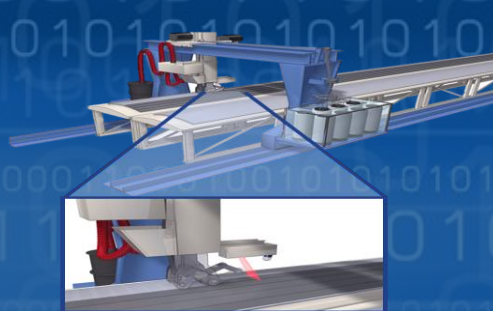


PRODUCIBILITY ADVISOR

Factory Digitization



INSPECTION GUIDED MANUFACTURING

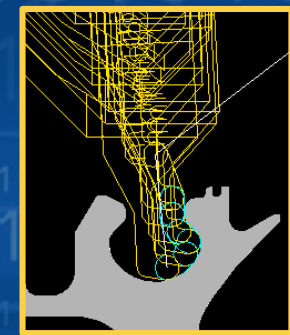


REAL-TIME ADAPTIVE PROCESS CONTROL

Services

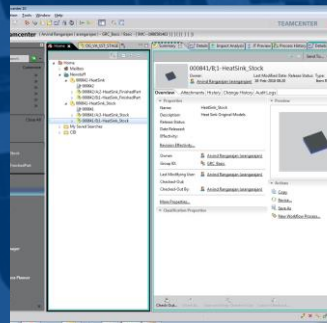


FIELD AND IN-SITU INSPECTION

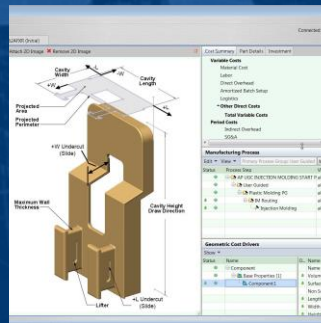


QUALITY FEEDBACK

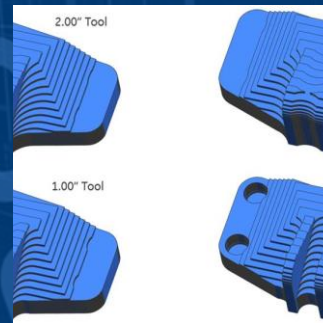
Digitally integrated manufacturing software tool chain



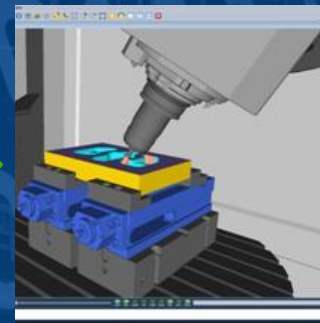
MODEL UPDATE
IN PLM



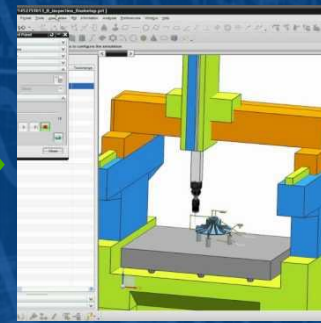
COMPUTE
SHOULD COST



PROCESS
PLANNING



TOOLPATH



CMM
PROGRAM



MFG.
EXECUTION

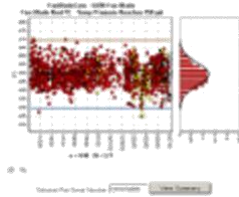
Reduce design changes from months to days:

Automated workflow generation and integration, manufacturing process planning, process modeling, factory scheduling, inventory management.

Bringing it all together ... composite fan blade

INFORMATICS

- ✓ Automated data collection and handling
- ✓ Real-time yield analytics
- ✓ Adaptive processing



NEW ECOSYSTEMS

- ✓ IT, Software
- ✓ Materials

2020 fan blade
EXPERIENCE

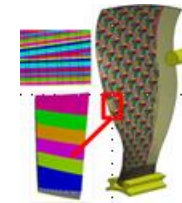
100+

million flight hours



PRODUCIBILITY

- ✓ Engineering integration
- ✓ Robust process designs



VIRTUAL MANUFACTURING

- ✓ ~2x improvement in design cycle

AUTOMATION

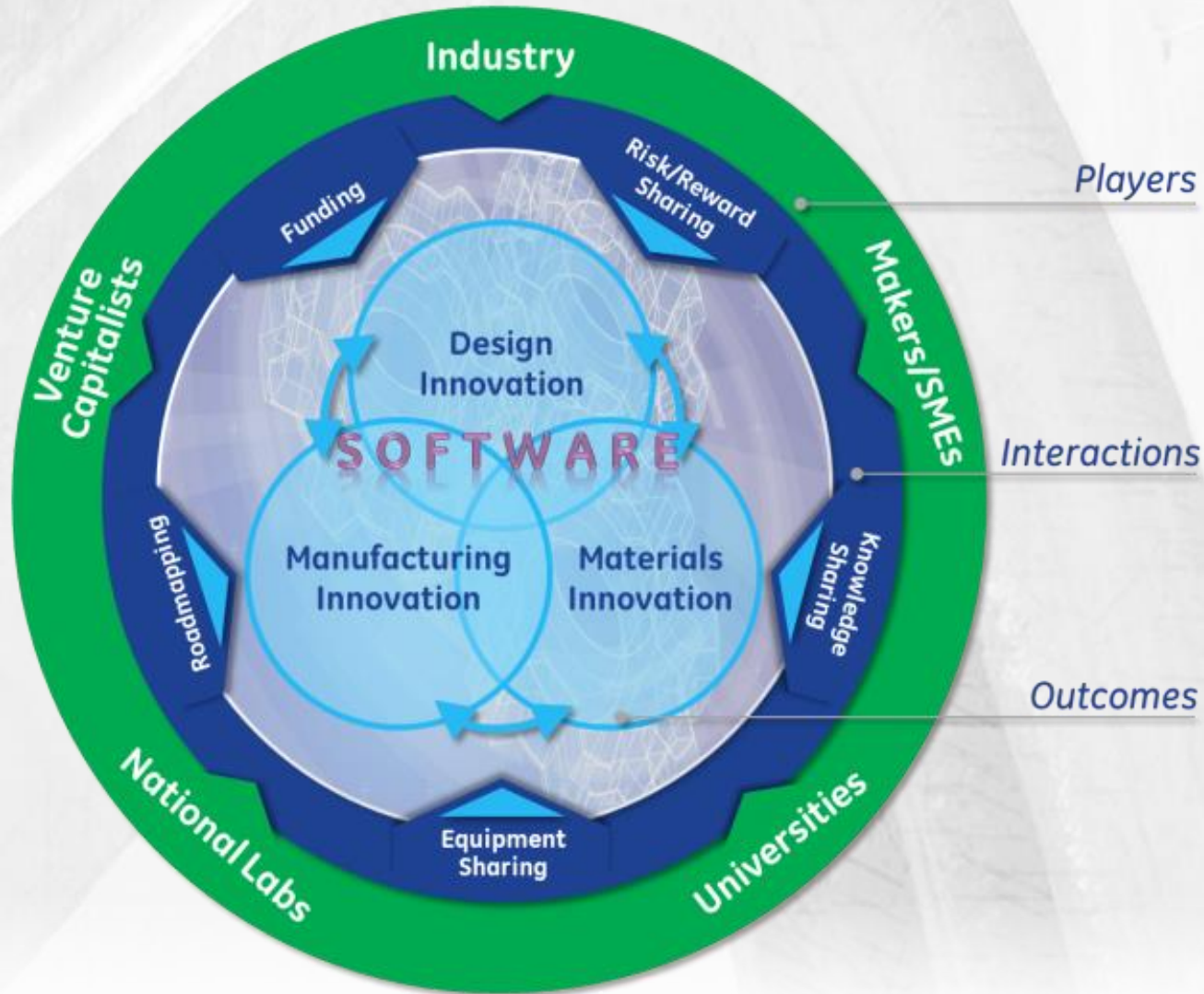
- ✓ Repeatable processes
- ✓ Real-time feedback for process controls
- ✓ In-line inspections for higher quality + speed

First time yield from <20% to >95%

Accelerating innovation through collaborations



Success = building an ecosystem



Engaging with GE:

GE Ventures

Investing: Select RMB direct investing

Partners: Introduction to partners

... China Materialia

Licensing: Access to technologies for growth

GE Global Research

Early stage development

GE Business Units

Collaboration for production

- Karen Kerr, Senior MD-karen.e.kerr@ge.com
- Milton Chou, Senior Director-milton.chou@ge.com



Table with multiple columns and rows of data, likely representing system logs or configuration parameters.



Table with multiple columns and rows of data, likely representing system logs or configuration parameters.



Table with multiple columns and rows of data, likely representing system logs or configuration parameters.

