The Impact of Industry 4.0 on Your Business Model

Session Leaders

D. Scott Sink, Ph.D., P.E., Director, Integrated LeanSigma Certification Program, ISE at OSU

Thorsten Wuest
Assistant Professor for Smart Manufacturing & J. Wayne and Kathy Richards Faculty Fellow in Engineering
Agenda

12:00 Scott Tee-up
Quick Overview of Purpose and Objectives of Webinar Series and Recap of our Kick-off Industry 4.0 Webinar

High Level Overview of this Abstraction

12:15 Thorsten—Impact of Industry 4.0 on Business Models

12:45 Q&A and tee up the rest of the Series

1:00 pm Adjourn
Questions?

How We’ll Handle

Please write your question in the webinar question web form. We will address as many as we can at the end of the webinar and send and email with follow up’s to attendees for those not able to be responded to.
ISE and IISE for Life—how IISE supports you for your entire Career.....

Council on Industrial and Systems Engineering—Senior Leadership of ISE function

Industry Advisory Board—Mid Career, Mgs in ISE related functions

Young Professionals—Early Career 1-15 years out

Career Path and Timeline

You can get involved in Societies, Divisions and also ‘Affinity Groups’ like Young Professionals, Industry Advisory Board and the Council on Industrial and Systems Engineering
We have built a mini-conference specifically designed for Young Professionals, Seasoned ISE Practitioners, Leaders and Managers of the ISE Function in Business and Industry.

Four Focus Areas with 6 great presentations in each of the four areas:

1. **Soft Skills Development**: improving your change leadership and management knowledge and skills
2. **Career Development**: Trends and Emerging Opportunities in our Field
3. Continuing to **broaden and deepen** your ISE Foundational Knowledge and Skills
4. **How to create more Value** for your Organization and in doing so advance your career faster

All Invited Speakers will ensure every session is outstanding.

**Jim Tompkins** is our Industry Track Keynote Speaker— if you haven’t heard Jim speak you are in for a treat!!

Balanced presentations across Industry Segments (Services, Healthcare, Manufacturing, Supply Chain and Logistics)

Goal is to make it efficient and fun for you to do some Personal and Professional Development in 2019
Chapter #1 Highlights—
IIE’s First Chapter (1949)
and also the first Virtual IISE Professional Chapter (2016)

1. **304 Professional Members** in Region IV but also from around the Country/World.

2. **Support and partner with Student Chapters:** Youngstown State, Ohio University, Purdue, and Ohio State University Student Chapters, and also in Michigan.

3. **Partner with IAB—Industry Advisory Board, CISE, and the Young Professionals Group** and a number of **Societies and Divisions**.

4. **Partner with our Sister Chapter #2** in Dayton/Cincinnati on our Annual IISE All Ohio Event and other things

5. **10+ timely, Valuable Webinars** each year; topics developed from Voice of Member

6. **12 Monthly Memo’s** help Members get to know each other and keep members aware of upcoming opportunities AND also provide Self-Help Features on personal and professional mastery

7. quarterly **GoToMeeting small group calls** with members that focus on topics of interest from ‘affinity groups’/segments of our members.
We created and delivered a series of webinars on Operational Analytics in 2017-18

Webinar #1: Foundations 7 Dec 2017 (and GLR Conference)
Share the Framework, the Models, the Abstractions, the Principles
Management Systems Model
Intel “Triangle” Model

Webinar #2: Foundational Data Role--Measurement and Analysis Planning 20 March 2018
Measurement Planning using Value Stream Maps, Data Models derive from refining the Management System Model, The Data Management Role of ISE’s in Process Improvement Projects

Webinar #3: Best in Class ILSS Project Final TG’s 25 April 2018
Showcase best in class projects, shine spotlight on Op Analytics

Webinar #4: Decision Support Role—M&A Execution 12 June 2018
Feature and Knowledge Extraction, Creating Chartbooks and VSM’s, supporting the evaluation phase of DMAIC projects and then also the Control Stage.

Webinar #5: Putting it all together 24 July 2018
Revisiting the Management Systems Model with Case Examples
That has led to the creation of this Industry and Service Systems 4.0 Series

Webinar #1: Overview Industry 4.0  
11 Oct 2018 (Jack Feng, Paul Cohen)
Overview the History and Evolution of NNMI and Industry 4.0
Discuss ISE and Corporate/Plant Implications and Strategies
Discuss ISE Mfg Systems Eng Research Implications

Webinar #2: Industry 4.0 Impact on Business Models (Thorsten Wuest)  
22 Jan 2019

Webinar #3: Smart Logistics: Industry 4.0 and the End2End Supply Chain (Jim Tompkins, Tompkins Int’l; David Poirier, The Poirier Group; Benoit Montreuil, Ga Tech)  
6 Feb 2019

Webinar #4: Smart Analytics (Scott Sink, ISE at OSU; Jared Frederici, The Poirier Group; and Matheus Scuta, Ford)  
26 Feb 2019

Webinar #5: Smart Grids (Elaine Johns, CEO Enervision)

Webinar #6: Smart Factory (TBD)
the standard of living, quality of life, cost of labor gaps are still significant and a big factor impacting our competitiveness which is why the Trade War is raging and will probably escalate.

Trade wars win battles they don’t win the War.

“Industry 4.0” is just a label we’ve given to the integration of technology and data utilization that reflects a solution/path forward for us. It’s an umbrella term for the confluence of a large number of innovations that are coming to fruition and now being integrated.

We want to help you understand this buzz word, “Industry 4.0” and then think about how you can play a role, as an ISE in making it happen.

We also want to help you understand what the US Government is doing with initiatives like NNMI to facilitate a speedier migration to the future state.

And, for most manufacturers in the US, there are still significant gaps in understanding all this and therefore the migration strategies of often flawed and moving too slowly.

Let’s look at some High Level “Models”/Views of this Abstraction
In the fourth industrial revolution, digital analytics enables a new level of operational productivity.

1st
Mechanization, water power, steam power

2nd
Mass production, assembly line, electricity

3rd
Computer and automation

4th
Cyber physical system

- Maturation of new cyber physical technologies (artificial intelligence, 3-D printing, robotics)
- Data analytics driving efficacy and effectiveness and new business models
- Pervasive sensing and actuation
- Ubiquitous connectivity throughout the supply chain
- Unprecedented levels of data and increased computing powers

McKinsey&Company | Source: Forbes; World Economic Forum
We do know that Adoption Rates of “Technology” have dramatically gotten faster—but how does that translate in the world of industry?
The Hype Cycle
The Connected Factory in Action

**INNOVATION**
- **Tap Commercial Innovation**
  Mobilize employees and supervisors to move across the factory floor and access data whenever they are. The iPad and other mobile devices are making their way into industrial settings — along with an expectation that much of the commercial innovation they bring will also apply to industrial activities.
- **Connect Engineers With Machines (MEM)**
  Apply predictive maintenance. Gain early warnings when production, equipment or network performance is about to degrade.

**AGILITY**
- **Connect & Collaborate Externally**
  Extend visibility beyond your four walls. Link the extended supply chain and distribution to enable dynamic workflows. Help and expertise are available in an instant.
- **Expandable Infrastructure**
  Design and build an Industrial Ethernet infrastructure to eliminate cost and effort to expand or improve processes. One infrastructure for safety, control, SWFA, Physical Security, and LAN.

**EFFICIENCY**
- **Link Information & Operational Technology**
  Bridge the gap from data center to control room to collaborate and share best practices and common goals between manufacturing and IT.
- **Optimize Assets**
  Identify where your people, equipment, works in process and finished goods are in real-time. Adjust the schedule and inventory on the fly.

**RISK**
- **Secure Physical & Cyber Assets**
  Traditional security devices, like keypad entry systems, call boxes and security cameras, send power from Industrial Ethernet cables, with secure networks, to protect your processes, people, and plants from cyber sabotage.
- **Maximize Uptime**
  Design ruggedized industrial networking infrastructure that withstands harsh environments with redundant connections, power and configuration backup — especially for business processes under extreme conditions.

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**THE OHIO STATE UNIVERSITY**
How are various Nations doing?

INDUSTRY 4.0: THE STATE OF THE NATIONS

01 Industry 4.0: Enabling manufacturers to increase competitiveness...
- Business growth: Smart products, Smart services
- Efficiency gains: Smart production, Smart factories

02 ...but are businesses making the most of the opportunity?
The first in-depth study into Industry 4.0 readiness
- 400+ industrial manufacturing executives
- Asset efficiency: a key driver of competitiveness
- Aerospace, Automotive, Machinery, Process, Electronics

03 Key findings
- 85% of businesses see the potential of Industry 4.0
  Yet only 15% have dedicated strategies in place
- Almost 87% see the value of a predictive maintenance strategy driven by real-time data
  Yet 91% of surveyed companies in German-speaking countries don’t measure operating efficiency based on real-time data
- 88% consider energy management important
  Yet only 15% regularly implement practices into their processes
- 99% are aware of the potential of information efficiency through the implementation of data standards
  Yet only 11% have systematically implemented data security and standards
- 81% are aware of the potential of monitoring machine status for maintenance purposes
  Yet only 17% have put principles into practice

04 Industry maturity in Industry 4.0 implementation
- The most mature industries: Automotive, Electronics - Process
- Industries planning the heaviest investment between now and 2020: Electronics, Machinery, Process

05 Country maturity in Industry 4.0 implementation
- The most mature adopter: China 57%
- Countries with similar maturity footprints:
  - United States 32%
  - United Kingdom 26%
  - Germany 21%
- The least mature adopter: France 14%

06 Towards 2020: The 5 leadership characteristics to help seize competitive advantage
- Agree and implement industry-wide data standards
- Be flexible in sourcing key skills
- Build strong partnerships in order to innovate quickly
- Focus on quick wins
- Build a clear, holistic roadmap

About the survey: 43 executives surveyed (online and telephone interviews) between January and March 2016 in China, France, Germany-speaking countries, the United Kingdom, and the United States.
Closing the Gap

- Government investment in private-sector led partnerships
- Addresses the market failure of industry underinvestment in “pre-competitive” applied R&D
- Focus on “de-risking” new technologies and materials to scale-up for U.S. manufacturers

(courtesy of DMDII)
And NAE’s Advanced Manufacturing National Program Office has a model for how to accelerate the transformation

User Facilities to support Industry RD&D

INPUT: Innovators with new production-enabling technologies

OUTPUT: Data to demonstrate business case for manufacturing new materials or products:
- Processes established
- Production rate data
- Cost estimates based on production data
- Risks understood / quantified
- Partners identified

INPUT: Innovators with ideas for new materials or products

OUTPUT: Market adoption of innovative new production-enabling technologies

Advanced Manufacturing National Program Office
Designing, Building and Growing the NNMI

3) Public Input and the NNMI Design

- 15 Institutes + Pilot
- Full-size Institutes
- Vision of 45 Institutes
- 6 x 2014 Institutes

March 2012
January 2013
January 2014

Additive
Power Electronics
Digital Mfg & Design
Light-weight Metals

Congressional Authorization
Formation of Network and More New Institutes

PCAST/AMP Call for NNMI
Public Comment
NNMI Framework

The Design Continues...
Since Launching in 2012:
- Over $1 billion Federal funding matched by over $2 billion non-Federal funding
- 1,300+ companies, universities, and non-profits involved
- 40+ states participating

Manufacturing USA – 14 Institutes Now

America Makes
Additive Manufacturing Youngstown, OH

AIM
Robots in Manufacturing Pittsburgh, PA

AIM Photonics
Integrated Photonics Albany and Rochester, NY

REMADE Institute
Recycling Materials Rochester, NY

ARMI
Tissue Biofabrication Manchester, NH

Affoa
Fibers and Textiles Cambridge, MA

ARPA-E
Process Intensification New York, NY

Digital Manufacturing and Design Chicago, IL

Lightweight Metals Detroit, MI

Clean Energy Los Angeles, CA

Nextflex
Flexible Hybrid Electronics San Jose, CA

SMART Manufacturing Institute

Clean Energy

Biopharma Manufacturing Newark, DE

Advanced Composites Oak Ridge, TN

Wide Bandgap Semiconductors Raleigh, NC

https://www.manufacturingusa.com/institutes
The Case for Action

We are entering into an Industrial Revolution
Effective implementation of technology will determine the winners
Systems issues abound
Industrial and Systems Engineers need to step up
It starts with a thorough understanding of Industry 4.0

Impact on Business Models
Advanced vs. Smart Manufacturing

Two different ways of differentiation

**Advanced Manufacturing**
New technologies, products, materials and processes

**Smart Manufacturing**
Use of data throughout the product life cycle

Source: Shipp et al. 2012

**Advanced Manufacturing**
Focus on physical manufacturing-technology

**Smart Manufacturing**
Focus on data and analytics

Source: Mittal, Khan & Wuest 2017

*Schmid & Wuest, 2017*
SMART MANUFACTURING PRINCIPLES

/ CONNECTIVITY
/ VIRTUALIZATION
/ DATA UTILIZATION
38 technologies (27 char. / 7 enabl. factors)
We decided to **cluster**, resulting in:

1. 3-D Printing / Additive Manufacturing
2. Cloud Manufacturing
3. CPS (Cyber Physical Systems) / CPPS (Cyber Physical Production Systems)
4. Cyber Security
5. Data Analytics
6. Energy Saving / Energy Efficiency
7. Intelligent Control
8. IoT / IoS / IIoT
9. IT based Production System
10. Smart Product / Part / Material
11. Visual Technology

IoT / Industrial Internet

Industrial Internet of Things (IIoT)

- Heavy Machinery
- Transportation
- Smart Cities

Network Connectivity

(Consumer) Internet of Things (IoT)

- Wearable's
- Phones
- TV's
- Appliances
- Home Monitoring
- Home Automation

Automation
- Factories
- Healthcare

Kohls & Wuest, 2018
Digital Twin (1/2)

*Industrial Internet of Things*
Digital Twin (2/2)

Cyber-physical systems

**Intended influence**
Support, coordinate, enrich, control, analyze, etc.

**Virtual World**
- Digital Twin
- Internet
- Analytics
- Games
- Cloud

**Physical (“real”) World**
- Robotic systems
- Integrated production systems
- Humans
- Manufacturing systems
- Devices

**Modelling**
Measure, observe, evaluate, follow-up, etc.

Kohls & Wuest, 2018
Business as usual?

Sounds great!

*We have a bunch of new technologies available – can we not just get to work and use them to make our lives easier?*
Case 1: Eagle Manufacturing

Concept to revise boiler controls (goal)

*Plant maintenance can control and monitor the steam boilers from outside of the plant instead of coming to the plant to schedule and check on them physically.*

Provided by: Eagle Manufacturing, jmcknight@eagle-mfg.com
Case 1: Eagle Manufacturing

Solution
• Using newer technology
• PLCs with integrated **Ethernet** and SMTP (email) protocol
• along with advanced HMI and **smart hub network** functionality

Benefits:
• Better control & scheduling of system
• Real-time alarm monitoring (through mobile devices)

After

Provided by: Eagle Manufacturing, jmcknight@eagle-mfg.com

Dr. Thorsten Wuest
thwuest@mail.wvu.edu
Successful Smart Manuf. Project?

**YES!**

- Eagle Mfg. successfully developed their own SM solution, implemented it, & achieved their objective
- Great first step in their Industry 4.0 / SM journey
- Such projects are essential for many SMEs to ‘get their feet wet’
- Evolutionary approach

*But are we not talking about the 4th Industrial REVOLUTION?*
To truly transform your organization, we need to approach the Industry 4.0 & SM journey **holistically**

Organizations can **not continue to develop small-scale solutions** without coordination

Otherwise we **lose key benefits** such as insights from data analytics

How can we **address this complexity**?

- (IIoT) platforms
- Marketplaces & composition of microservices & applications
- Etc.

There are various supporting **tools, models, & frameworks** available for companies to identify their maturity

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A business model “[…] describes the method or means by which a company tries to capture value from its business […].” ¹

Business Model Canvas

Business Model 4.0

- Business model is a key aspect in the transition towards Industry 4.0
- Often neglected and not a priority as it is not ‘technical’, etc.
- However: We can not continue ‘business as usual’ & expect to fully benefits from opportunity

¹ Source: http://lexicon.ft.com/Term?term=business-model
Product Service Systems

“A [Product Service System] is an integrated product and service offering that delivers value in use. A PSS offers the opportunity to decouple economic success from material consumption and hence reduce the environmental impact of economic activity. The PSS logic is premised on utilizing the knowledge of the designer-manufacturer to both increase value as an output and decrease material and other costs as an input to a system.”

(Baines et al., 2007)

Continuous revenue creation (MOL) vs. one time sale (BOL)

Benefits:
- **Business**
  - Competition outside of ‘cost’
  - Installed base (No. unit sales vs. No. of units in operation)
  - Constant revenue
- **Strategy**
  - Lock-in effect (customers)
  - Lock-out effect (competitors)
  - Reduction of direct competitors through customization
  - … customer demand!
- **Sustainability**
  - Less waste / better for environment

(Baines et al., 2007)
Pay-per-Use / Pay-per-Outcome

Based on Menon et al., 2018
Case 2: KAESER COMPRESSORS

Background:
- KAESER is a leading global manufacturer of compressed air systems and services
- Industry is characterized by high competition
- Transformed towards service-based BM in response to shifting customer demands
- Customers no longer purchase customized air compressors but pay for used compressed air
- KAESER manufactures, operates, & owns the systems
- Industry 4.0 technologies play a key role (e.g., data analytics & predictive maintenance)

Key benefits (customer):
- reduced cost & increased flexibility,
- transfer of operational risks,
- increased transparency,
- improved operational planning.

Key benefits (manufacturer):
- reduction in service cost,
- development of a long-term partnership
- synergies in product development & innovation

Lessons Learned
- Lack of cost transparency on customer side
- Changing role of sales dept. (*ISEs!*)
- Emphasis of partnerships & inter-disciplinary teams
- Introduction of new risks
- Need to ‘ease in’ the new BM
- Privacy & Security concerns

Morphological Box

Interested in rethinking your I4.0 BM and/or using the morphological box?

Contact me or my colleagues to discuss options!
Conclusions

• We are in the midst of a **major disruption**: Industry 4.0 / Smart Manufacturing
• New technologies, such as IoT and Digital Twins open **new opportunities**
• Difficult to translate technological progress in business success
• Industry 4.0 needs to be approached **holistically**, and that includes rethinking the business model and value proposition
• Pay-per-use / pay-per-outcome BM are promising desirable benefits, yet developing sustainable and successful PPU/PPO BMs is challenging

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<thead>
<tr>
<th>Traditional one time sale:</th>
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<tbody>
<tr>
<td>Beginning of Life</td>
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<td>Middle of Life</td>
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<td>PPU/PPO</td>
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<td>End of Life</td>
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• **Our Morphological Box** is a tool that can be used flexibly, at different levels of detail, and at different phases of the transition to support companies in the decision and design process
Key Takeaway

The big question remains: *Why should Industrial & Systems Engineers care?*

Well, I think it is safe to say we all agree that this is an inter-disciplinary challenge involving technology, business and economics, complex systems, people, you name it.

*Industrial & Systems Engineers uniquely qualified to work in such an environment - the future of our profession is bright!*

*I challenge each of you today, to:*

• *Think about the impact of Industry 4.0 on your organization as a whole, on your department, and on your main tasks,*

• *Embrace the emerging opportunities rather than fight the change, and*

• *take a few moments each day over the next week to (re)think about what a PPU/PPO BM might look like in your line of work!*
Further reading from our group

Smart Manufacturing Technologies (Open Access) -> [link](#)

Industry 4.0 & Smart Manufacturing (Open Access) -> [link](#)

Machine Learning in Manufacturing (Open Access) -> [link](#)

Industrial Internet Platforms -> [link](#)

2018 World Manufacturing Forum Report (Open Access) -> [link](#)

Data Analytics in Manufacturing -> [link](#)

Operator 4.0 -> [link](#)
Questions
Upcoming Webinars from Chapter #1

Feb 6, 2018
Industry & Service Systems 4.0: Smart Supply Chains

- James Tompkins, Chairman, Tompkins, Int'l—The Digital Imperative

- Benoit Montreuil, Director, Supply Chain & Logistics Institute, ISE at Georgia Tech—The Physical Internet

- Scott Sink, Senior Advisor to The Poirier Group—Practitioner View
Upcoming Webinars from Chapter #1

Feb 26, 2018
Industry & Service Systems 4.0: Smarter Analytics

- **Matheus Scuta**, Global Manufacturing Analytics Scientist, Ford Motor Company—*Integrating Analytics into Manufacturing*

- **Jared Frederici**, Sr. Consultant, The Poirier Group, Toronto, Canada—*Smarter Analytics*

- **Scott Sink**, Director, ILSS Certification Program, ISE at Ohio State—*Operational Analytics: By What Method*
Upcoming Webinars from Chapter #1:

**Becoming a Change Master**

March 5, 2018

Soft Skills 4.0—Becoming a Change Master

- **Bob Gold**, Founder, The Gold Group, Behavioral Technologist—
  *The Art and Science of Persuasion*

- **Scott Sink**, Director ILSS and Operational Analytics Certification Program, ISE at OSU—
  *How to Become a Change Master*
March 21, 2018
The IISE Industry Practitioner Track—Orlando

Scott Sink, Director ILSS and Operational Analytics Certification Program, ISE at OSU—Overview of our Track for Young Professionals, Seasoned ISE’s, ISE Students

Kaz Takeda, Disneyland Resort Manager, Industrial Engineering and Co-Chair Track—Highlights for Seasoned Practitioners

Jared Frederici, Sr. Consultant and Co-chair for Track—Highlights for Young Professionals and Students

Accelerate my Career Progress and Success
Learn about Industry 4.0
Strengthen my Soft Skills
Operational Analytics
Expand and Extend my Network of Peers
Learn about Service 4.0
Get some Altitude on my life and job and career and have some Fun
The “Industry Track”
Orlando May 18-21 2019

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- Goal is to make it efficient and fun for you to do some Personal and Professional Development in 2019
And, in addition to those 24 Practical, Pragmatic Presentations by hand-picked presenters we’ll wrap around some Networking opportunities:

- the Annual CISE Leadership Mixer
- the Annual Industry Advisory Board Mixer
- Industry Track Kick-off and Capstone Plenary Sessions
- The Executive Roundtable
- Townhalls for IAB and Young Professionals
- Huge opportunity to build your network and mentor and get mentored
So, First things First, take some time out and invest in yourself

It Pays Off—I’ve attended 30+ IISE Conferences and the Return on Investment has been 25+:1 !!