Building the Smart Factory – a case study on the Model Factory at ARTC - Singapore
The Advanced Remanufacturing and Technology Centre

Leading Public-Private Partnership Research Centre in Asia

- Bridging the gap between Research and Industry
- Focus in Developing Advanced Manufacturing and Remanufacturing Capabilities
- Co-Create and Value Capture with Industry through the Implementation of Solutions
Executive Summary: Model Factory @ ARTC

Model Factory @ ARTC is a public-private partnership programme to co-develop a model factory and to collaborate and develop Future of Manufacturing (FoM) technologies, based on real applications in advanced manufacturing and remanufacturing.

Accelerate adoption of Digital Technologies across key industries in Singapore and create a marketplace for digital technology and applications, with unique reach in Asia and beyond.

Generate potential intellectual property portfolio in Industry 4.0 technologies.

Foster industry alignment by identifying list of immediate outcomes from the FoF development.

Regular sharing of best practices to facilitate value capture through review of latest learning.

A*STAR’s Research Institutes (RIs) & Universities

Provide a training ground for future engineers and create a digital culture for knowledge management.

To jointly develop a test bed model on a smart factory where heavy equipment industry players (aerospace, marine, machinery) can validate and test new concepts for the next innovation of manufacturing.

Industry Members

Made Possible
Model Factory

Integrated Additive Manufacturing Supply Chain
All stages of additive manufacturing are integrated through a digital workflow, to optimise product design, reduce lead time, and improve supply chain efficiencies.

Virtual Manufacturing Lab
The Virtual Wall provides the front-end digital twin visualisation platform which equips the user with immersive capabilities in design and process developments.

Smart Quality Management
Adaptive quality assurance systems demonstrate the concept of closed-loop quality control system by connecting the measurement equipment with the machine using IoT.

Intelligent Machining
Sensorised machining centres predict tool wear and the need for maintenance of the equipment. They also monitor the machine health, and improve its performance.

Manufacturing Intelligence Control Room
It is a central nervous system composed of a network of cyber physical systems with a modular architecture that allows seamless integration with existing plant components (including monolithic ones) or newly developed ones. The data aggregator engine with real-time factory data allows full visibility of all activities, and control of ongoing processes.

Digitised Lean Assembly Line
In the assembly line, human and robot collaboration are enabled, thereby optimising the assembly process capability, agility, and efficiency.

Augmented Reality (AR)
AR provides visual assistance which can simplify complex processes in assembly, maintenance and repair processes. It assists operators to address factory issues quickly and reduce machine downtime. Remote assistance allows workers to have live calls with their supervisors to conduct troubleshooting and maintenance.

Autonomous Logistic Systems
Autonomous Vehicles can be deployed by logistics systems, to transport raw materials, work in progress, and finished goods in a factory reliably, efficiently, and safely. Logistics systems can automatically allocate job orders to ARVs and manage the fleet and enable data exchange with other systems in a factory.
Model Factory In The News

24 Aug 2018, The Business Times

New A*Star facility enables firms to test advanced manufacturing technologies

By Claudia Cheng

24 Aug 2018

The Agency for Science, Technology and Research (A*STAR) has launched a facility that will allow firms to test technologies in a simulated manufacturing environment. The Model Factory at the Advanced Remanufacturing and Technology Centre (ARTC) will enable firms to test new technologies in a safe and controlled environment, without the need to invest in expensive machinery.

At its launch on Thursday, real-time demonstrations showed how A*STAR’s simulation tools, which are based on real-world factory data, can help firms test new technologies before they are implemented in actual manufacturing processes. Manufacturers can also use the facility to test new processes and equipment in a controlled environment, allowing them to optimize their operations and reduce waste.

The Model Factory is part of A*STAR’s efforts to promote the adoption of advanced manufacturing technologies in Singapore. The research centre aims to help firms develop and test new technologies, as well as to support the country’s development as a leading global manufacturing hub.

14 Nov 2018, Tech in Asia

Video: Can a non-engineer survive a day at the model factory?

Can a non-engineer survive a day at a model factory of the future without breaking anything? Tech in Asia finds out.

Launched in August as part of Singapore’s Agency for Science, Technology, and Research (A*STAR)’s Model Factory Initiative, the Model Factory @ ARTC is a 15,000 square feet facility that houses state-of-the-art technologies, allowing enterprises to invest and integrate advanced manufacturing processes into their production setups.

24 Aug 2018, The Straits Times

28 June 2019, The Straits Times

Businesses can test latest tech at new model factory

Meanwhile, A*STAR’s Advanced Remanufacturing and Technology Centre has signed a memorandum of understanding with Singtel and industrial estate developer JTC Corporation to integrate 5G technologies into its smart Model Factory in Jurong.

4 Feb 2019, Physorg.com

A*STAR has built a testbed for digital twins, the virtual counterparts of real manufacturing equipment. These factory innovations could help companies save huge amounts of time and money by predicting and adjusting for their partner machine’s condition on the go.
# R&D Themes in Model Factory

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<tr>
<th>Themes</th>
<th>Project Topics</th>
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<td>Intelligent Systems &amp; Connectivity</td>
<td>Connectivity between machines</td>
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<td>Cybersecurity for secure network architecture</td>
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<td>Smart and self power sensors for connectivity</td>
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<td>Human Robot Collaboration</td>
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<td>Autonomous logistic AGV</td>
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<td>Virtual Manufacturing</td>
<td>Optimized production systems design with advance processes simulation &amp; modelling</td>
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<td>Digital Factory with real time monitoring and localization tracking</td>
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<td>Performance management with Digital Control Room for interconnected systems</td>
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<td>Augmented Reality for maintenance</td>
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<td>Digital Thread for Additive Manufacturing</td>
<td>End-to-end additive manufacturing (from design to post-processing) + integration in discrete line</td>
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<td>Condition Monitoring &amp; Data Analytics</td>
<td>Edge analytics for machine health monitoring</td>
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<td>Real-time process monitoring of machinery for performance optimization and prediction</td>
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<td>Predictive and remote maintenance with prognostic modelling and data analytics</td>
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<td>Yield Optimization with advance data analytics</td>
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<td>Adaptive QA - root-cause analysis for test failures with data analytics and pattern recognition</td>
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From R&D to Deployment: Through Mini Factory

R&D

Intelligent Systems & Connectivity
Digital Thread for Additive Manufacturing
Virtual Manufacturing
Condition Monitoring & Data Analytics

Deployed to
Feedback to

Stage 1
Completed
Architecture, Connectivity Interoperability & Visualization

Stage 2
Completed
Infrastructure, Cybersecurity, AR/VR, Data Analytics & Scalability

Stage 3
1st half 2020
Shop Floor Integration, Digital Life Cycle, Machine Learning, Agility & Reliability

Stage 4
2nd half 2020
Factory-Factory Integration, Digital Culture, Supply Chain Network

Mini Factory: An Integrated Shopfloor to demonstrate Connectivity, Agility & Reliability

AM Line
LMD
Robotic Cold Spray
Industry Robots
CMM Machine
Virtual Manufacturing Lab
Surface Enhancement Machine
Manufacturing Intelligence Control Room
AGV
NTX 1000 Machine
NLX 2500 Machine
Assembly Line
Mini Factory 2: Demonstrate Agile Shopfloor to Fulfil Customised Orders

**CUSTOMISED ORDER**

**WAREHOUSE**
Parts Availability Check

**COBOT ASSEMBLY CELL**
Manufacture Order

**ORIGINAL PROCESS**

WAREHOUSE
Operator manually checks for parts availability for customised order

COBOT ASSEMBLY CELL
Stop production to try new cobot motion for customised order

**OPTIMISED PROCESS**

WAREHOUSE
3D vision system for automatic parts availability check

COBOT ASSEMBLY CELL

1. **Simulation** of a new cobot motion by **Robot Motion Planning** software
2. **Verification** of the simulated cobot motion by **Digital Twin** Model (created based on past actual data)
3. Release of new cobot motion plan to actual cobot

**Barriers to Agility:**
- Manual checks
- Stopping production
Mini Factory 2: Video Demonstration
We have shared our work in IIC Journal of Innovation (Nov 2019) - Digital Twin

Digital Twin Development for Serial Manipulators: Data Driven Optimized Planning and Sequencing of Tasks

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Get the report here!
**Completed Deployment Project:**
Deployed an ‘Automated Machine Utilisation Tracking’ system at a Singapore factory

**PROBLEM**
- How utilised are my 3 machines?
- Should I buy another 1 more machine?

**DEPLOYED SOLUTION**
- Non-Intrusive Sensorisation
- Edge Analytics for Automated Detection of Machine Status w/o manual inputs

**CHALLENGES FACED**
- **Challenge 1:** Our assumptions on the process differ from the actual process
  - Learning Point: Need for technical team to understand the process from the operator itself, not the manager
- **Challenge 2:** We are not designed for larger scale deployment which client wants after the successful pilot
  - Learning Points:
    - For R&D organisations, partner with a system integrator to do larger scale deployment upon a successful pilot
    - This conversation with a system integrator should be done early in the process
Upcoming Effort in ARTC

Microservices-Enabled Digital Supply Network

Proposal for IIC Testbed
Overview

Summary
Transform supply chains into a **digital supply networks** with seamless digital information flow enabled by **microservices**

Participants
• Advanced Remanufacturing & Technology Centre (ARTC), A*STAR

Potential Collaborators:
  IIC Members: Siemens, ABB, Microsoft, TUV SUD, NI
  IIC Non-Members: Nestle, P&G, Coca Cola, Voestalpine
Business View

• Supply Chains can be further optimized but
  • Information flow across Supply Chains has to evolve to network-based
  • But today, each node in the supply chain has its own legacy backend systems where data are kept and shared only within its corporate firewalls
  • A benefit example of data exchange between nodes:
    • Location data can be used not for just for monitoring
    • Can be used to verify goods delivery for automatic issuance of supplier payments

• Problem: Incompatible systems, data formats & processes
Objective and Deliverables

Objective
Deploy a microservices-based architecture to integrate the complex information flow of 8 supply chain nodes at Model Factory @ ARTC testbed facility

- For end-to-end data exchange and visibility across nodes managed by different systems

Deliverables
1. Develop microservices-enabled architecture that supports multi-parties data exchange
   - Agile, scalable, open-source/commercial based
2. Deploy the architecture at Model Factory @ ARTC facility using actual and simulated data
   - Nodes labelled with * will use actual generated data from our testbed facility, while others will use simulated data
Thank You