



The Future of Manufacturing: Trends & Breakthroughs

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Challenges today

**Tight Labour Market &
Demographic Change**

Reduced Productivity Gains

(automating “the long tail”)

Supply Chain Fragility

(Global Coupling)

Changing Demand Patterns

(Velocity, Customisation, Complexity)

Industry 4.0

3rd Industrial Revolution: Digitisation

- Computer and communication technologies in the production process, in three waves:
 - The Lean Revolution (1970s)
 - The Era of Outsourcing (1990s)
 - Wide-Spread Automation (2000s)
- CNC, Kanban, Toyota Production System, Just-In-Time, ERP, Six Sigma, etc.
- **"Today's state-of-the-art"**

4th Industrial Revolution: Cyber-Physical Systems

- Holistic picture of Hardware, Software, & Biology
- ... but what is different?
1. Previous "Industrial Revolutions" required large replacements of means of production (high CapEx)
 2. Industry 4.0 strategies can be applied selectively in projects to augment and optimise brownfield sites
 3. Vertical and horizontal integration
 4. Real-time capability to respond

Industry 4.0 is the application of 4 core features in the value chain:

Interconnection: Connectivity, data & compute

1. Sensors / M2M / IIoT / IoT
2. Edge Computing
3. Blockchain
4. Cloud / Everything-as-a-Service
5. Private Mobile Networks / 5G

Interfaces

Social

Lev. Assets

Human-machine interactions & information transparency

1. VR / AR
2. Robotic Process Automation (RPA)
3. Robotics (incl. co-bots, AGVs, etc.)
4. Digital Twins
5. New interfaces, e.g. chatbots

Interfaces

Dashboards

Autonomy

Analytics & intelligence

1. Big Data
2. Machine Learning / AI
3. Advanced Analytics / Business Int.

Algorithms

Novel processes

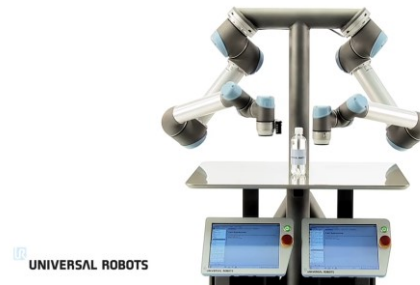
1. 3D Printing
2. Nanotechnology
3. Synthetic biology
4. Quantum computing
5. Matrix production concept

A Cambrian explosion in Robotics

- Reducing costs & improving quality for Sensors, Actuation, Compute
 - Open source / open hardware / global collaboration
 - Efficient, global supply chains and open innovation driving multiple solutions
 - Democratisation / dematerialisation: self-provisioning + lower barriers to entry
→ wider talent pool
-
- Better Perception (vision, touch - where am I, what is around me)
 - Better Reasoning (incl. new modes of training - model learning & RL)
 - Better Actuation (incl. soft → more fine-grained control, e.g. fruit picking)
 - Lower barrier of entry / training requirements / complexity → democratisation

Robots have become ubiquitous

- Self-driving / autonomous vehicles
- Delivery robots incl. side-walk & drones
- Reality capture & digital twins & AR
- Co-bots everywhere (industrial, restaurants, entertainment/marketing etc.)
- Walking robots (inspection, entertainment, etc.)



Tectonic Changes to Manufacturing Landscape

- **From Products To Platforms & Ecosystems**

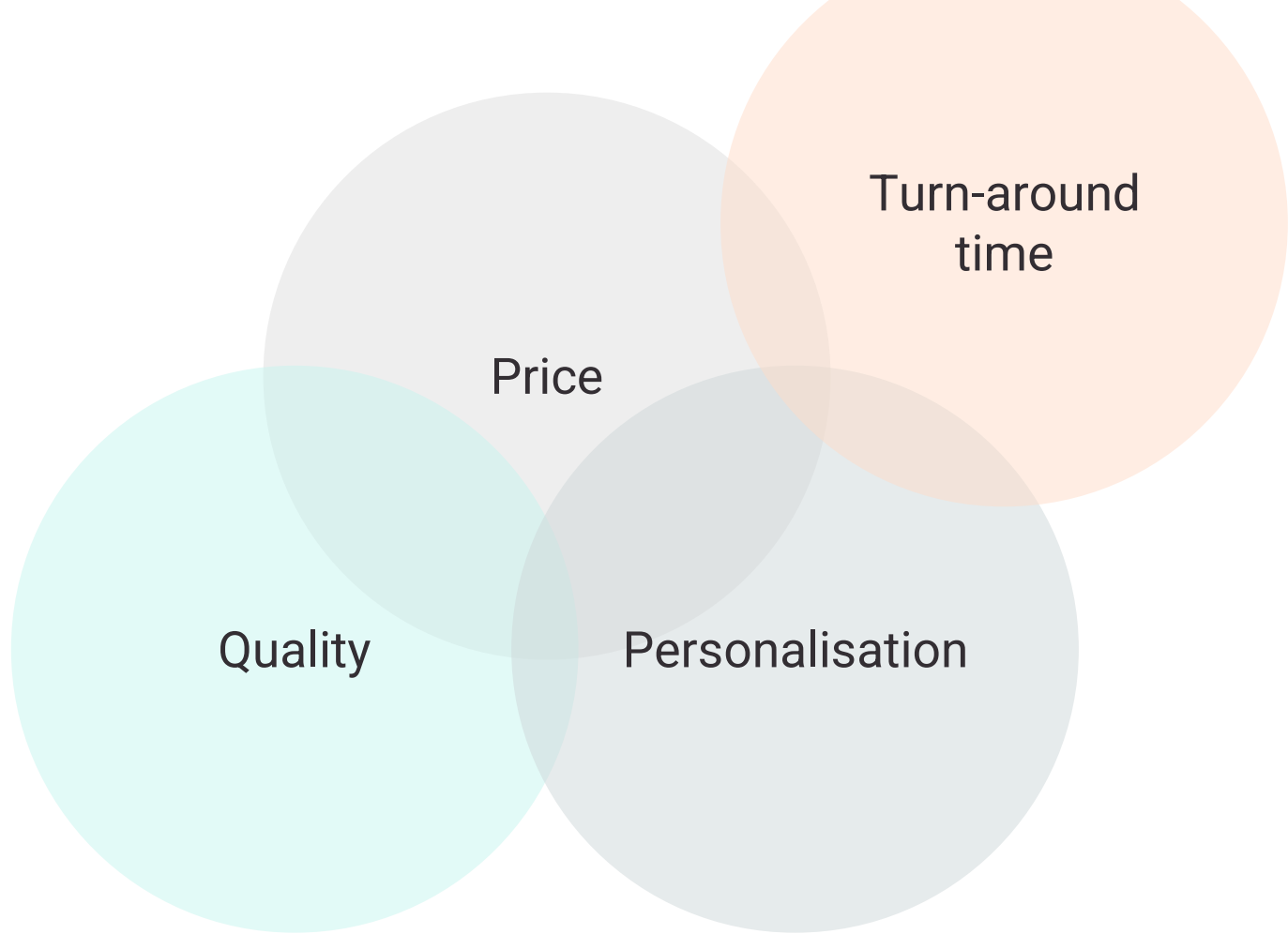
- Can you adopt “Platforms” where products, services, information can be exchanged via predefined streams?
- E.g. Manufacturing platforms in automotive, decentralised 3d printing (Xoom / Atos & SLM Solutions), Ecosystem – Nvidia vs AMD on GPGPU, Digital Skin

- **Machinery from CapEx to OpEx: Pay-by-use / Subscription-based services**

- E.g. office printing most common example ; adhesive applied / rivets placed in manufacturing in integrated assembly lines

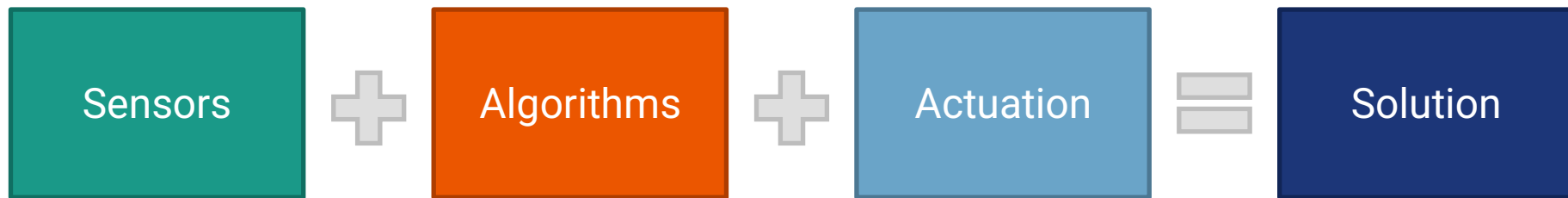
- **Change to IP Business Model**

- E.g. ARM, Qualcomm, SAP – Consulting Services



Building Blocks

- Driving Efficiency & Productivity
- Adding Agility & Resilience
- Adding Value & Pushing Boundaries



Depth cameras
LIDARs
Accelerometers
Touch sensors
Multi-spectral
Augmented data
sources
...

Object Detection
Localisation / SLAM
Motion Planning
Soft Control
Fleet Management
Route Optimisation
Grasp Planning
“AI”
...

Industrial Arms
Grippers
Mobile Platforms
Soft Robotics
...

Open APIs, Open Data, Common Standards

Low-/No-Code Options Simplify Embodiment

Off-the-Shelf
Localisation & Mapping

Off-the-Shelf
Navigation

Off-the-Shelf
Motion Planning /
Fleet Management

End-to-End Solutions

Middleware Frameworks & Open Protocols

- Common interfaces simplify exchange of data and simplify integration / combination into solutions
- E.g. common sensor process, vision, motion planning, or navigation stacks



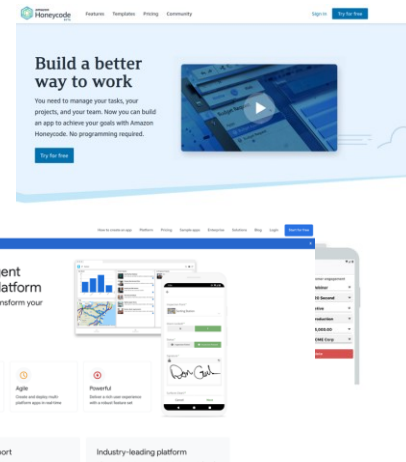
API Connectors

- Automate / Connect APIs: Zapier, IFTTT, etc.
- Well-defined and self-documenting APIs can automatically create integrations



No-Code Platforms

- Democratise interfaces / dashboards
- Reduce prototyping time



Robotic Process Automation

- Automate existing processes of 'legacy systems' by drag & drop
- E.g. export information from emails into ERP
- Self-service automation of data entry & handling



Non-robot applications enabled by these same trends

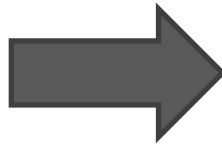
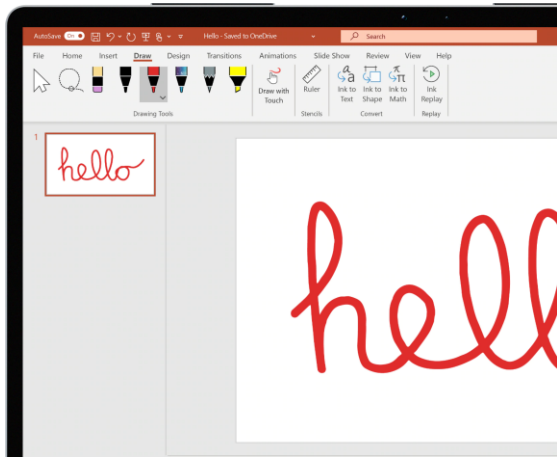
- Distributed Sensors/IIoT + Algorithms → **Predictive/Preventive Maintenance**
- Cameras + Computer Vision (Edge/Cloud) → **Continuous Quality Assurance**
- Virtual Reality, Augmented Reality, and Wearables to Augment Business Processes
 - On-boarding / remote assistance e.g. logistics, installation, repair
 - Hands-free information capture e.g. in logistics
 - Collaborative design



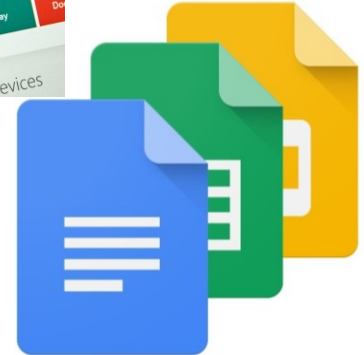
High-performance applications, right in your browser



- Better development tools, improved hardware, and access to native APIs enables **higher performance web apps** with **improved collaboration**



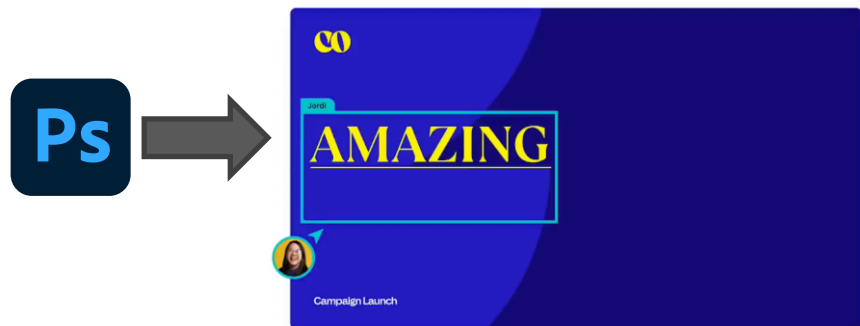
Microsoft Office 365 Online
Google Docs



High-performance applications, right in your browser

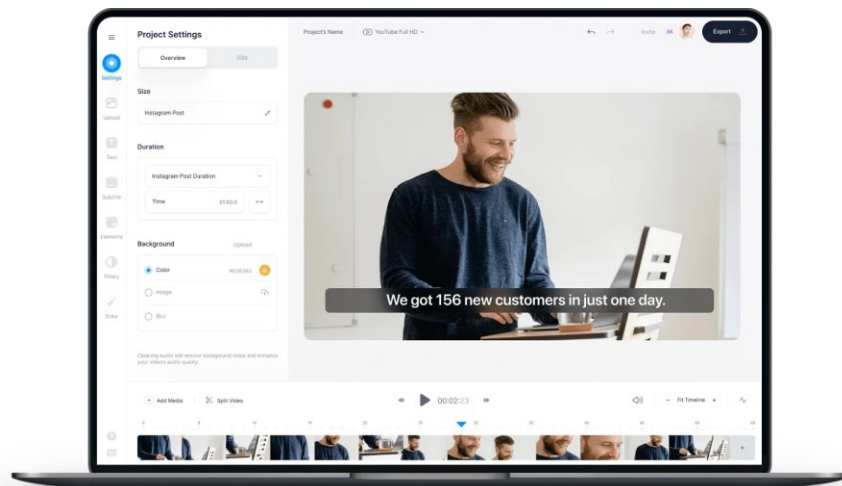


Photo Editing & Desktop Publishing



Canva.com

Video Editing

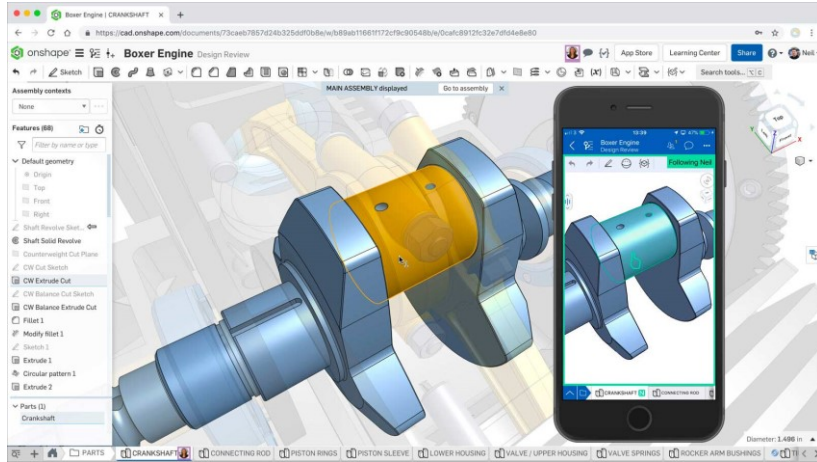


VEED.io

High-performance applications, right in your browser



Computer Aided Design (CAD)



OnShape.com

Self-Provisioned Automation



Vention.io

High-performance video games, VR / AR, etc. – where might this take us next?

Benefits: Reduce barriers to entry, reduce development cost, faster iteration

Case Studies

Robotics – Material Handling / AGV



Robotics– Material Handling / AGV



Line to Matrix Production / Micro-Factories



Robotics – Autonomous Vehicles on Large Sites



Robotics – Co-bots

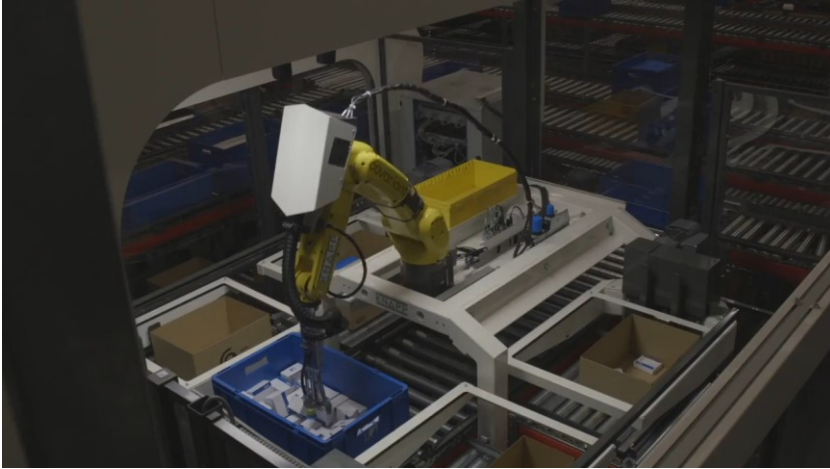
- Safe around people without cages, low cost
- Easy set-up through kinaesthetic teaching
- Easy redeployment through shopfloor staff
- Limited motion planning & collision avoidance (but this is changing right now!)
- Up & coming: **No-Code Robotics**
 - Programming with Mixed Reality
 - Wearables to guide the robot
- **More variety (100s) - Cobot selector**
- **More capability / Apps**
- **New business model: € / h**



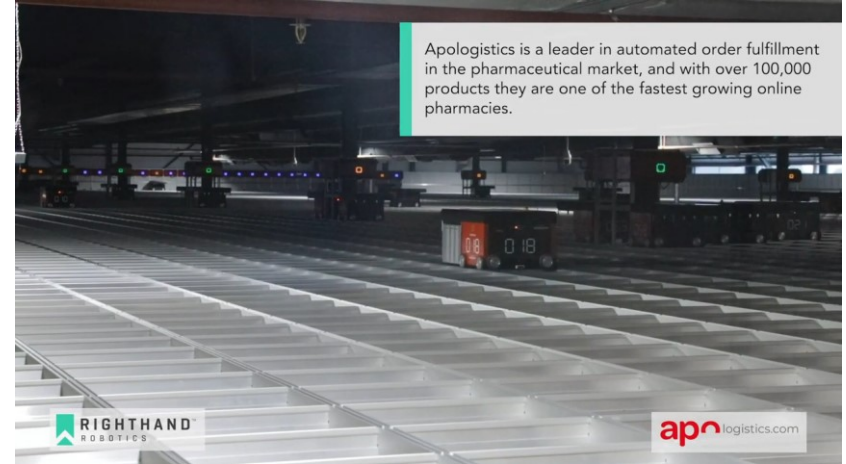
Robotics – Co-bots



Robotics – Bin Picking



Covariant AI Bin Picking



Right Hand Robotics Bin Picking:
Online Pharmacy
10-15x fewer employees

Robotics – Unloading / Stacking

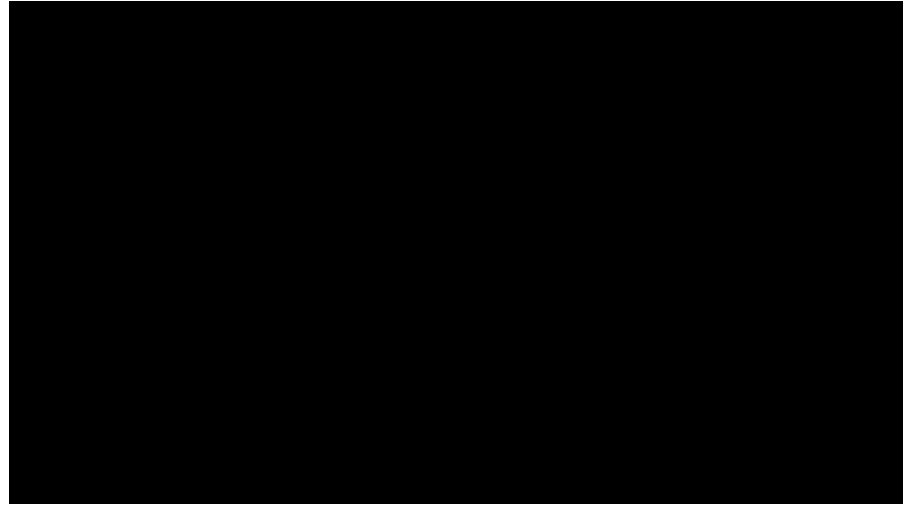


Boston Dynamics Stretch



Pickle Robotics Dill

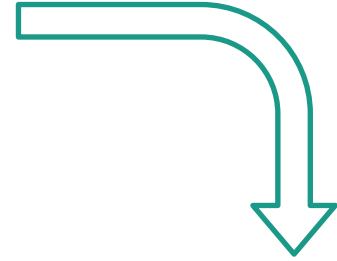
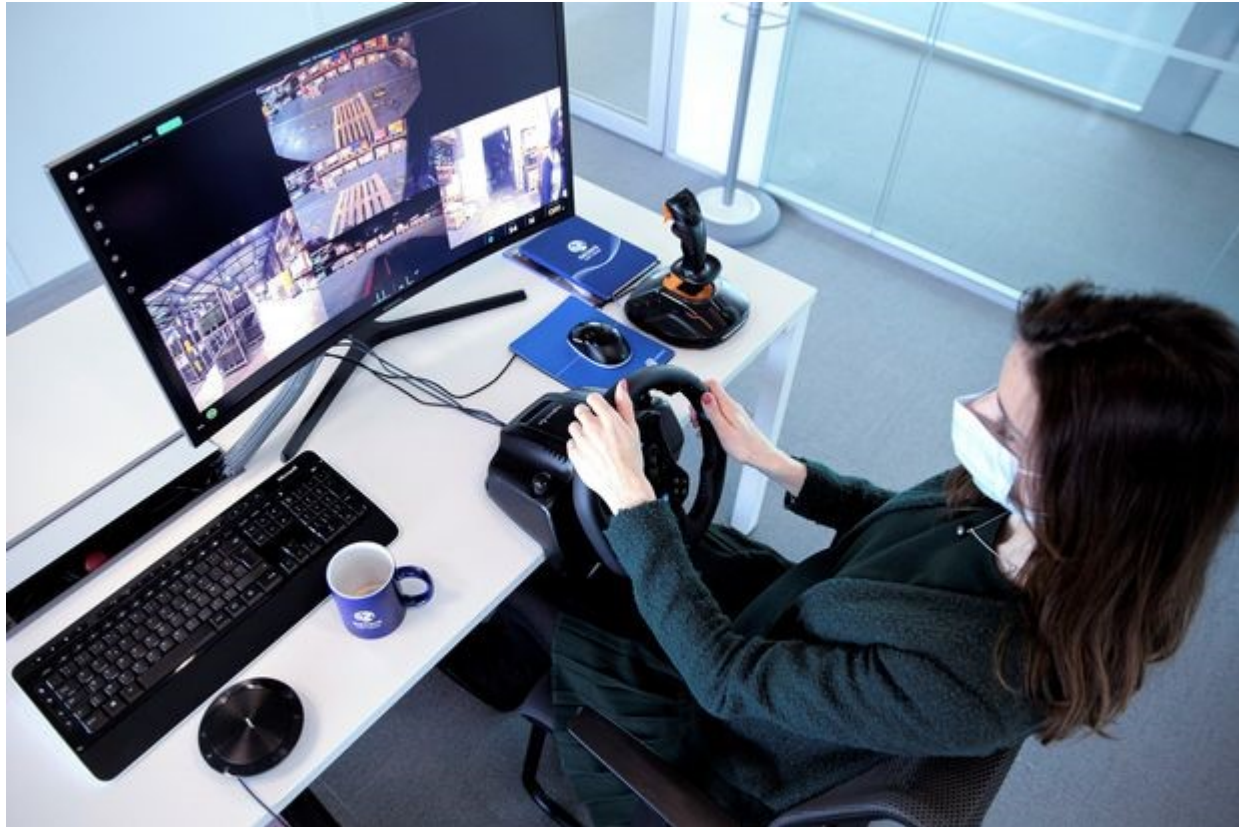
Exoskeletons



Robotics + Haptic Input + 5G = Remote Teleoperation



Robotics - Teleoperation



Robotics – Facility Inspection & Monitoring



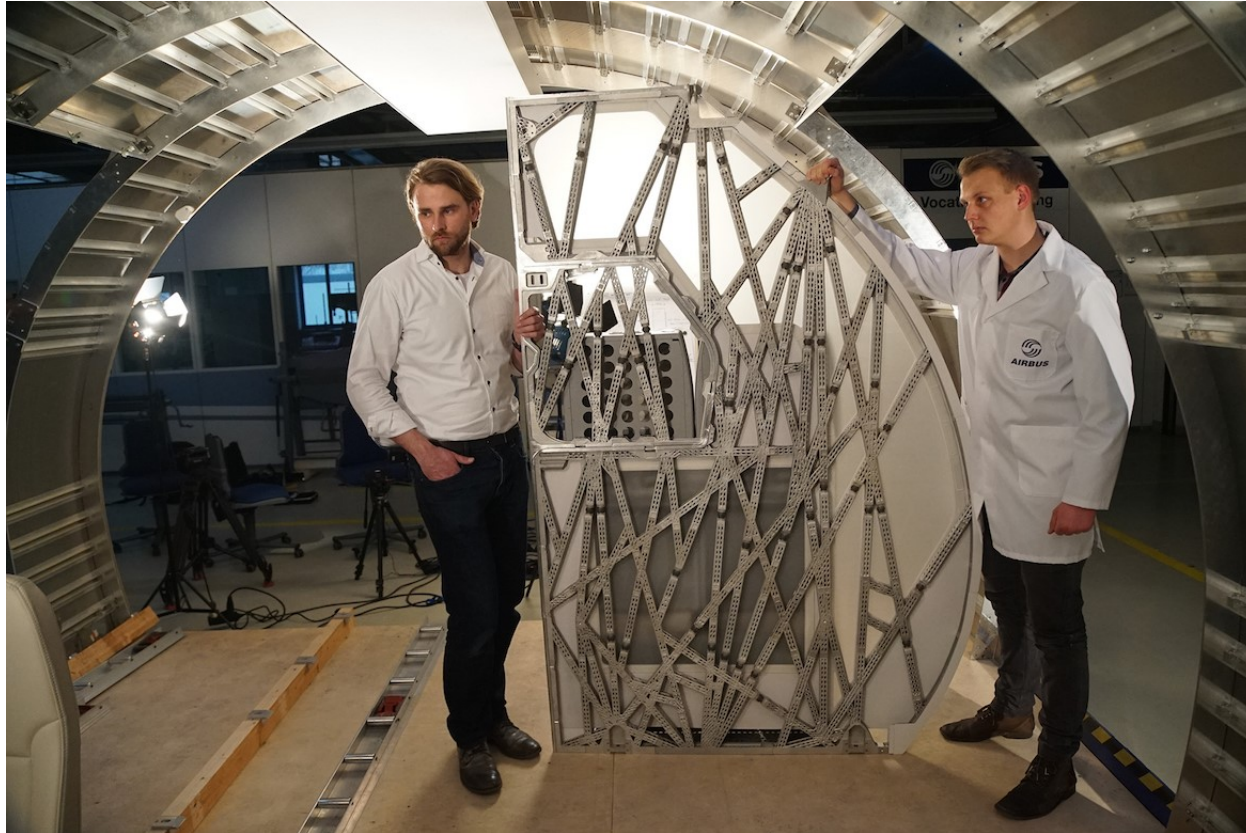
Boston Dynamics Spot



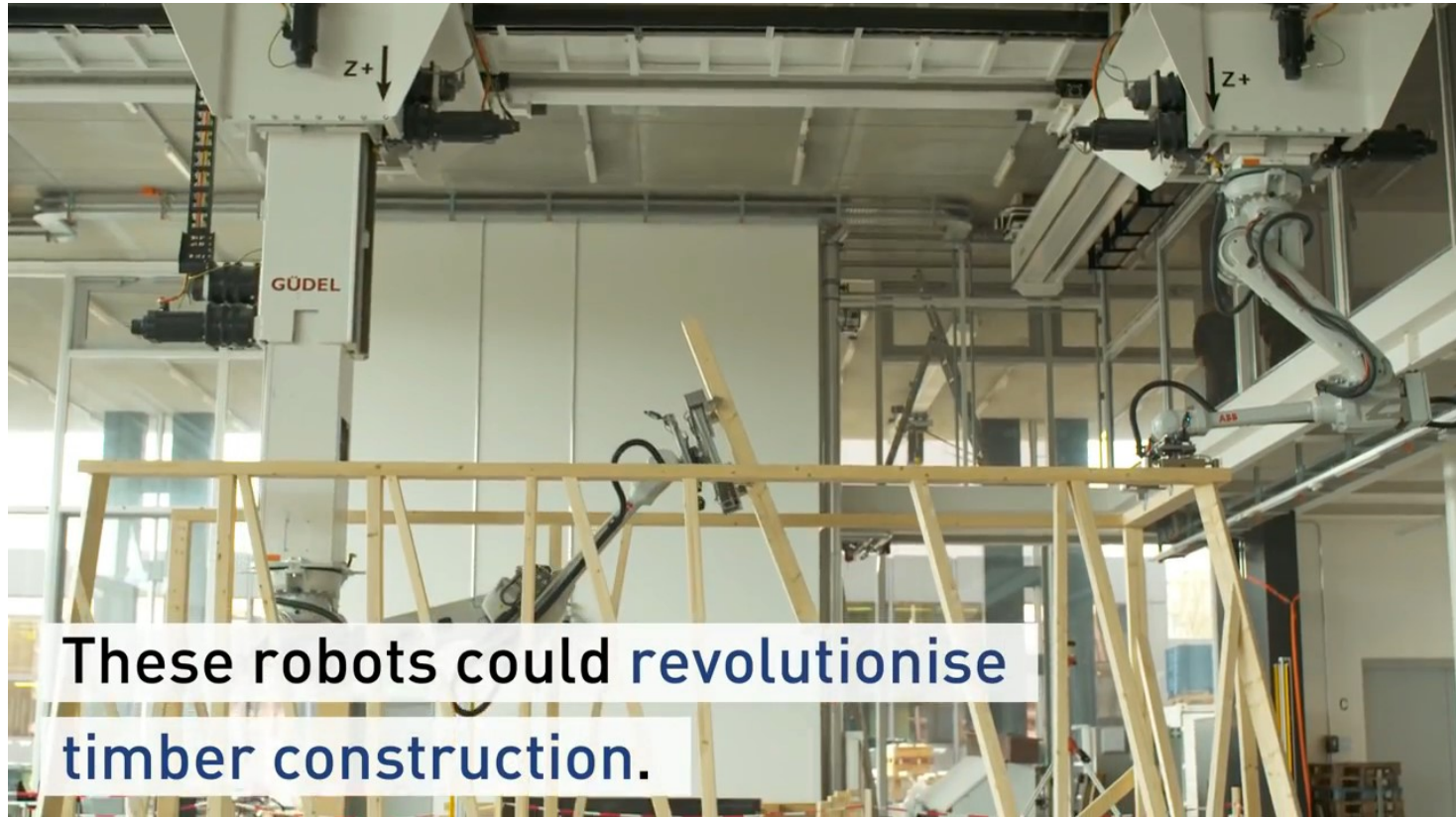
Anybotics Anymal

Adding Value & Pushing Boundaries

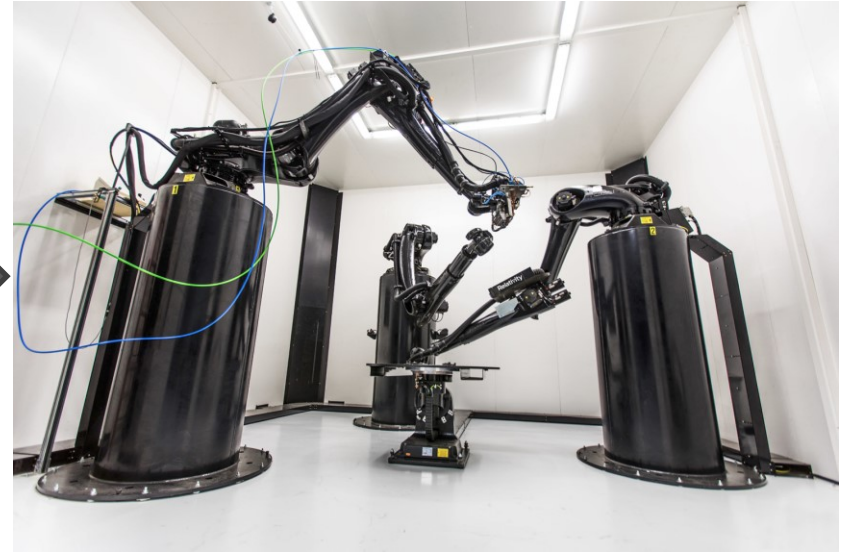
Generative Design



Large-Scale Prefab & Algorithmic Design = Limitless Complexity



From invention to value-add innovation



Off the shelf hardware + software +
sensors = 10x innovation

The Six Ds of Exponential Organizations (by Peter Diamandis)

“The Six Ds are a chain reaction of technological progression, a road map of rapid development that always leads to enormous upheaval and opportunity.”

Peter Diamandis and Steven Kotler, *Bold*

1. Digitised
2. Deceptive
3. Disruptive
4. Demonetised
5. Dematerialised
6. Democratised

Industry 4.0

Cloud

3D
Printing

Sensors

Robotics

VR /
AR

IIoT
Ind. Internet
of Things

IoT
Internet of
Things

Big
Data

ML
Machine
Learning

AI
Artificial
Intelligence

Advanced
Analytics

BI
Business
Intelligence

Edge
Computing

M2M
Machine to
Machine

IA
Intelligent
Automation

RPA
Robotic
Process
Automation

XaaS
Everything
as a Service

Block-
chain

Digital
Twin

Private
Mobile
Network

5G



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