

Digital twins – your systems' presence in Industry 4.0

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Engineering Faculty

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Buzzwords



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Digital twin

Incarnations

Cloud computing

Big data

Cyber-physical systems

Industrie 4.0

Internet of things



ENGINEERING
EZOBUNJINELI
INGENIEURSWESE



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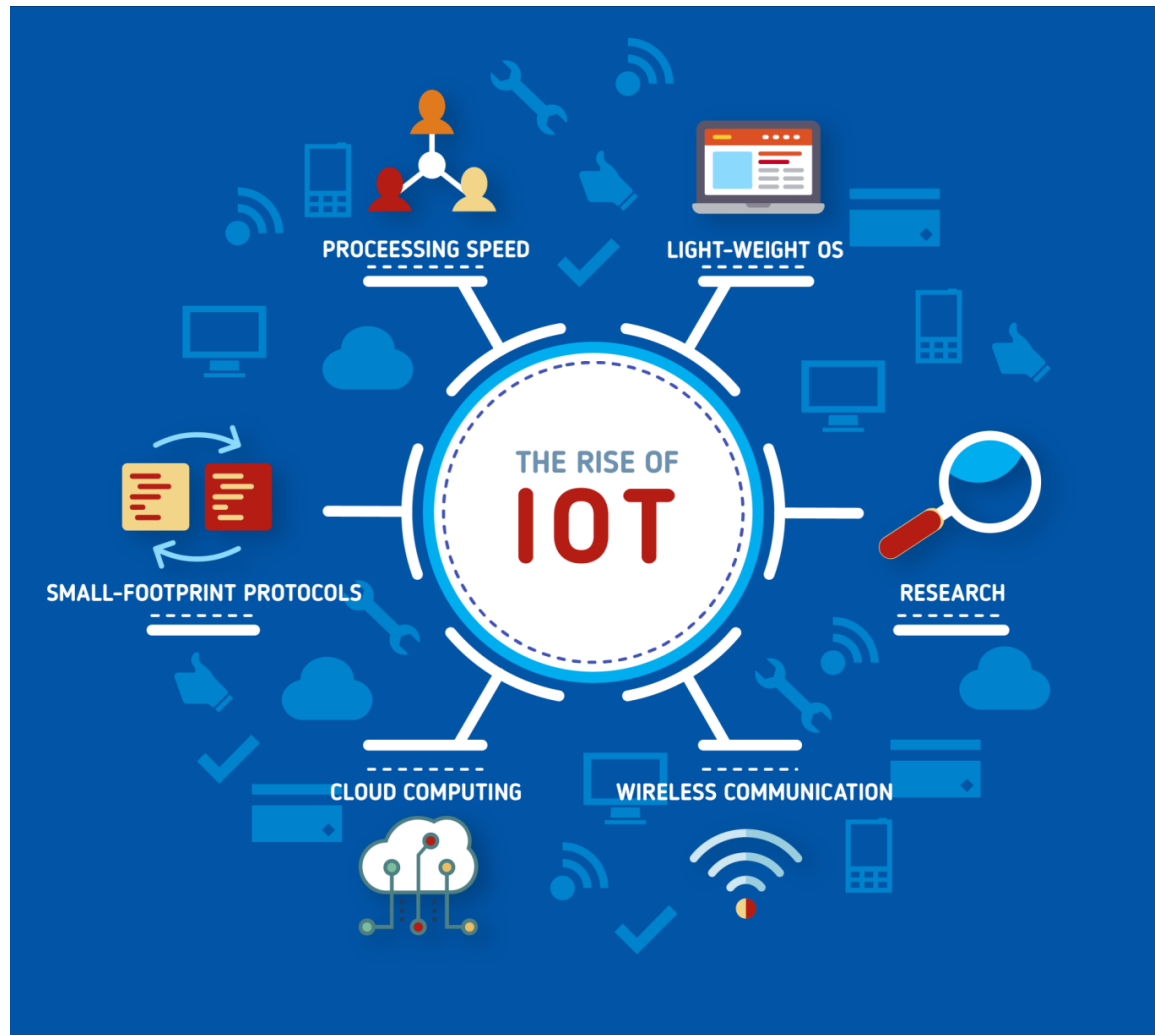


The Birth of Internet of Things



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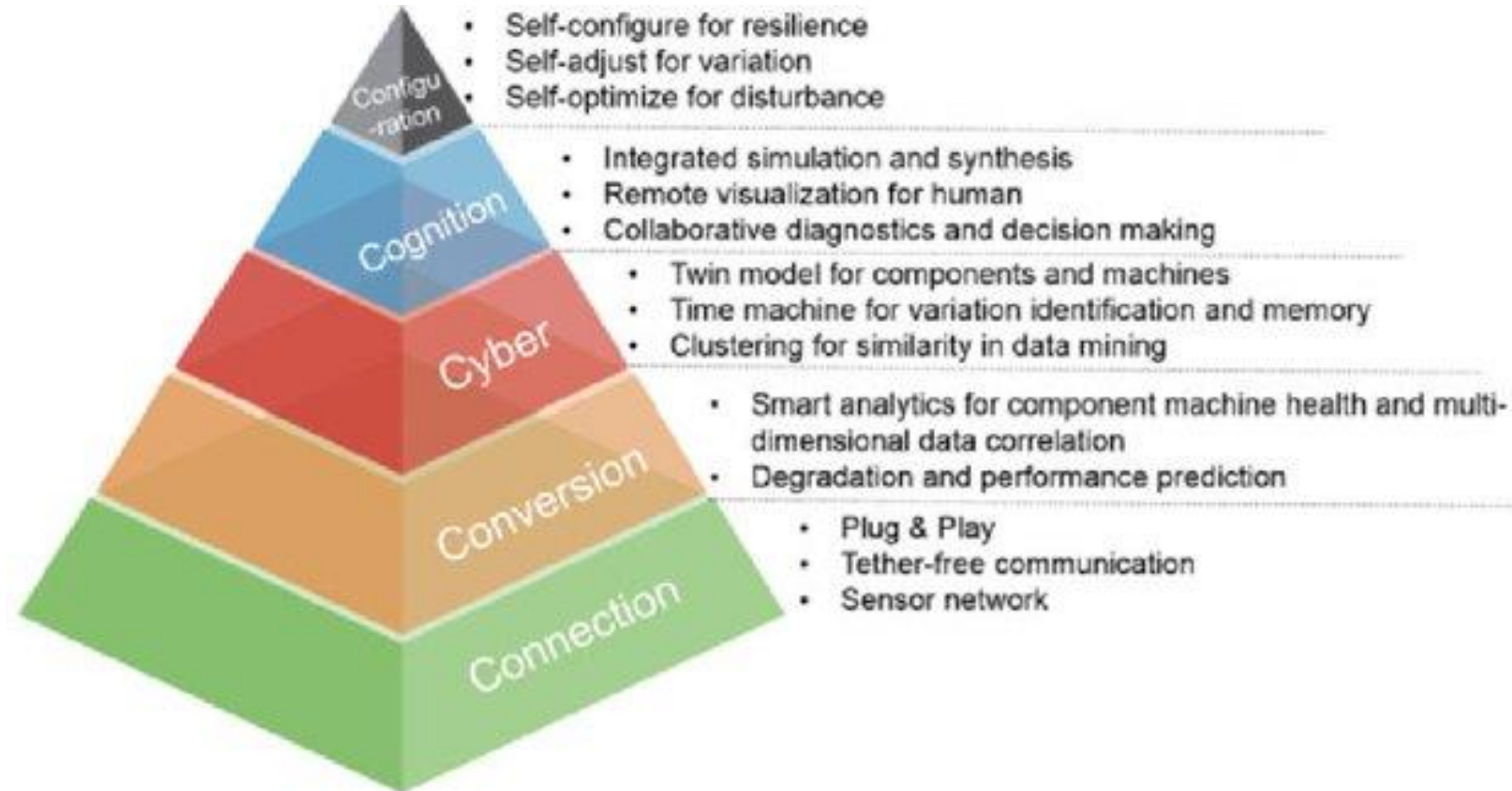
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<https://taazaa.com/the-technologies-that-enable-the-internet-of-things/>



- 5-C architecture for CPSs



Roy, R., Tiwari, A., Stark, R. & Lee, J. 2017. Predictive Big Data Analytics and Cyber Physical Systems for TES Systems. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture. 231(13):2241–2241.

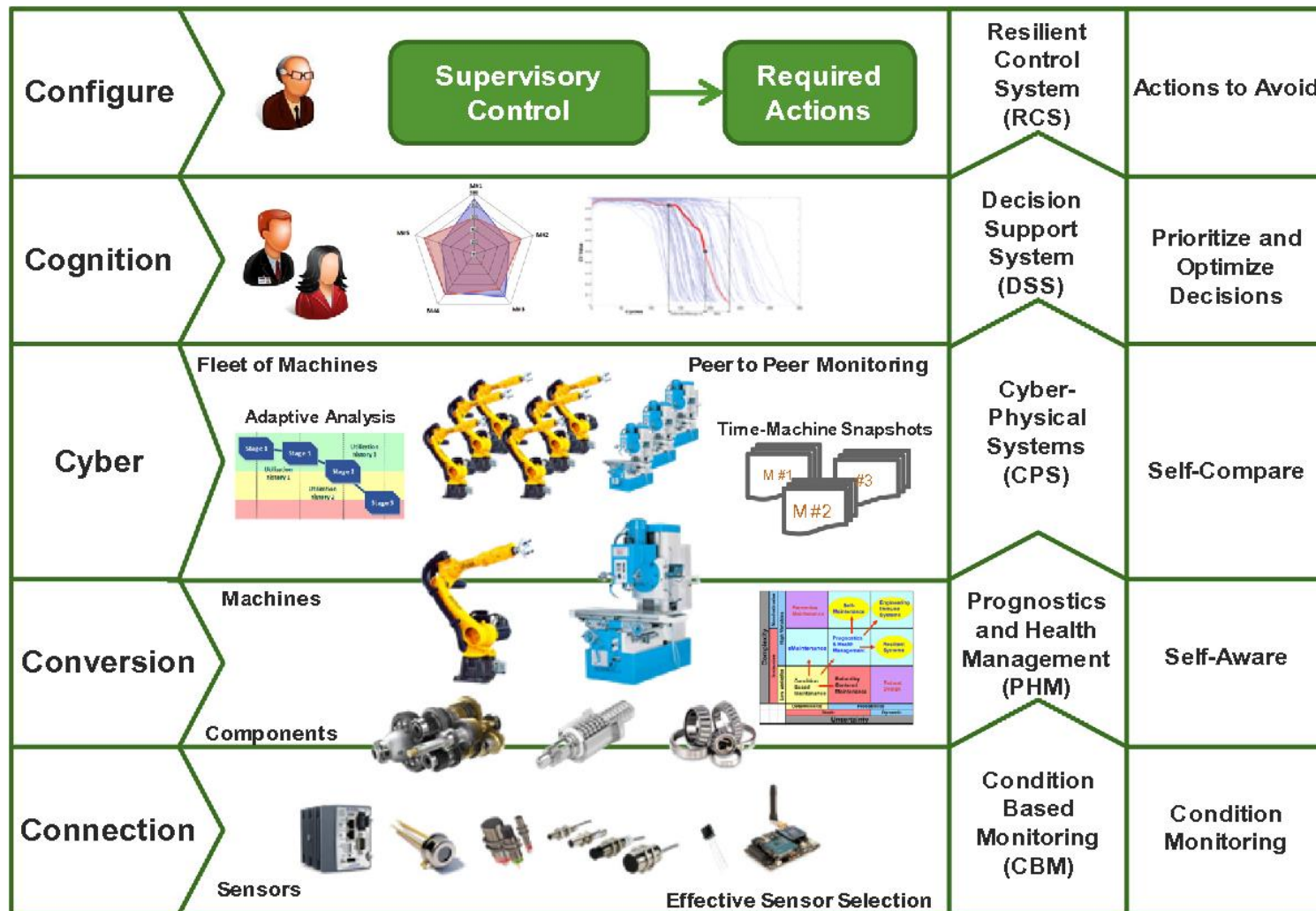


Cyber-Physical Systems



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A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems
 Jay Lee, Behrad Bagheri, Hung-An KaoPublished 2015
 DOI:10.1016/j.mfglet.2014.12.001

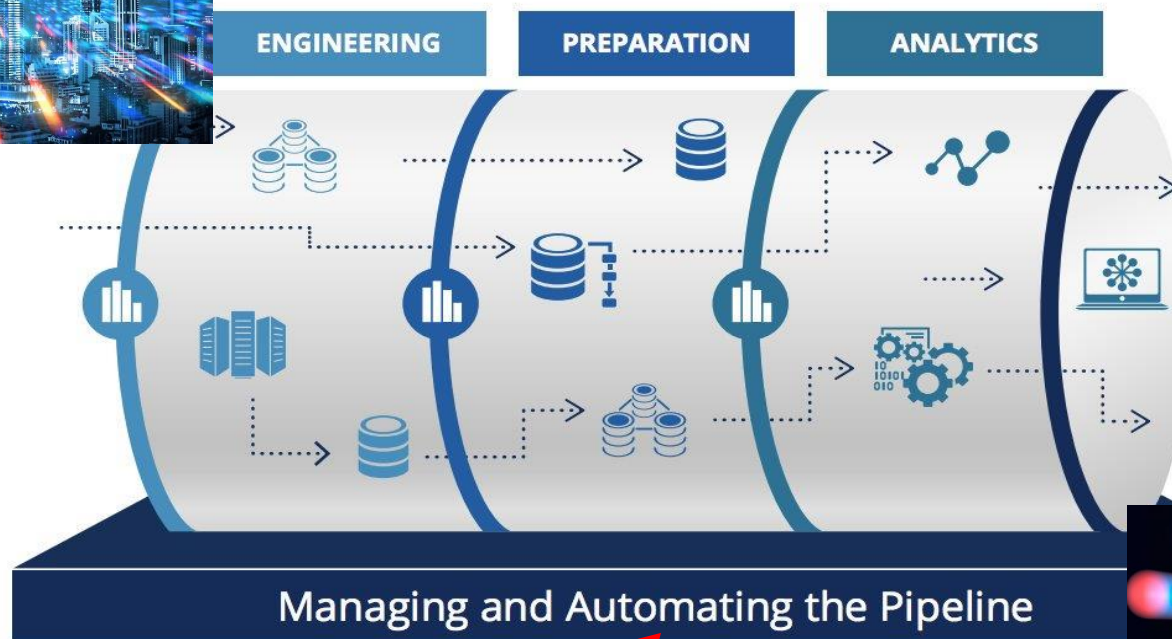


Big Data



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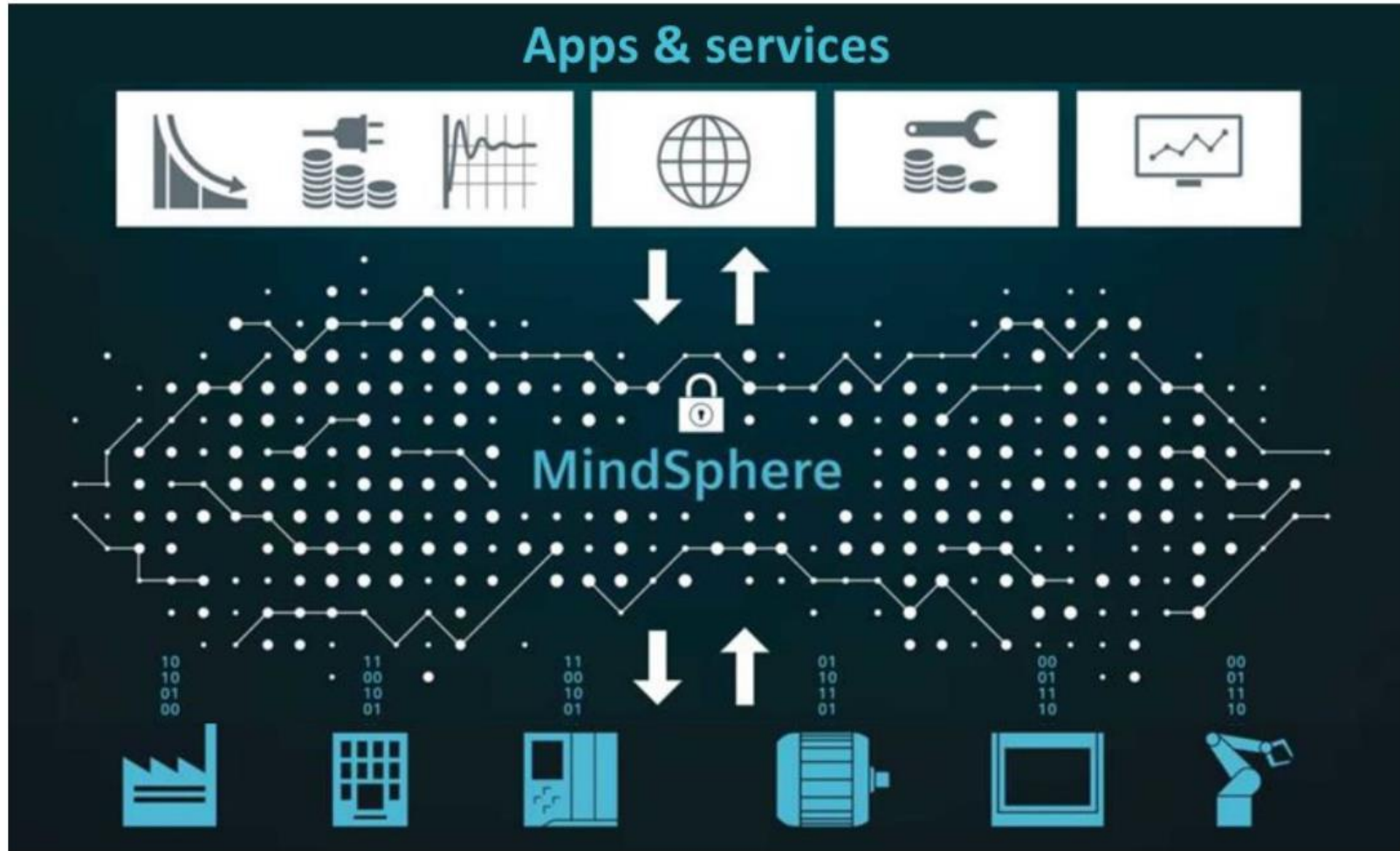


Cloud Computing



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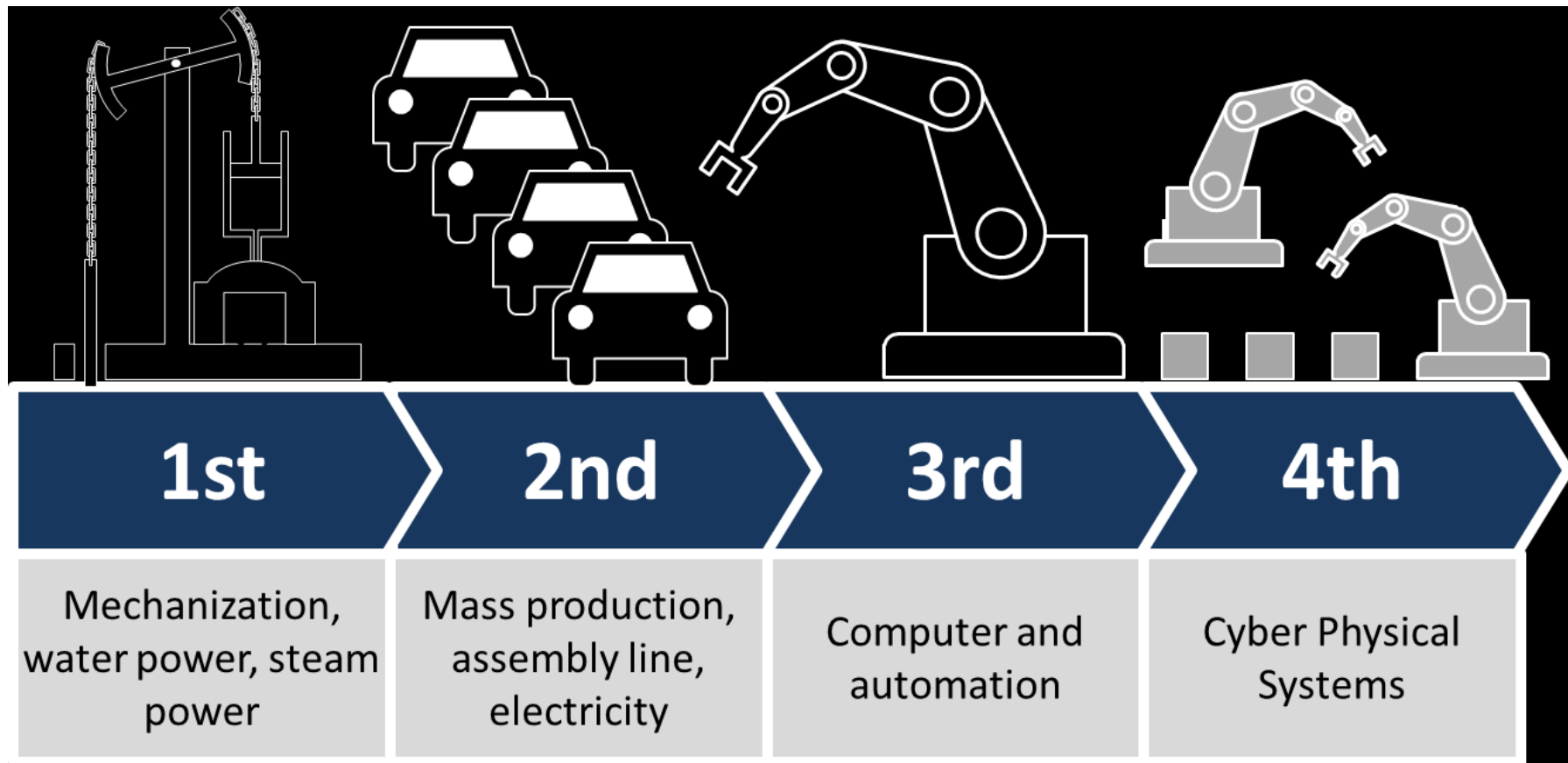


Industry 4.0



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Wikipedia



Industry 4.0



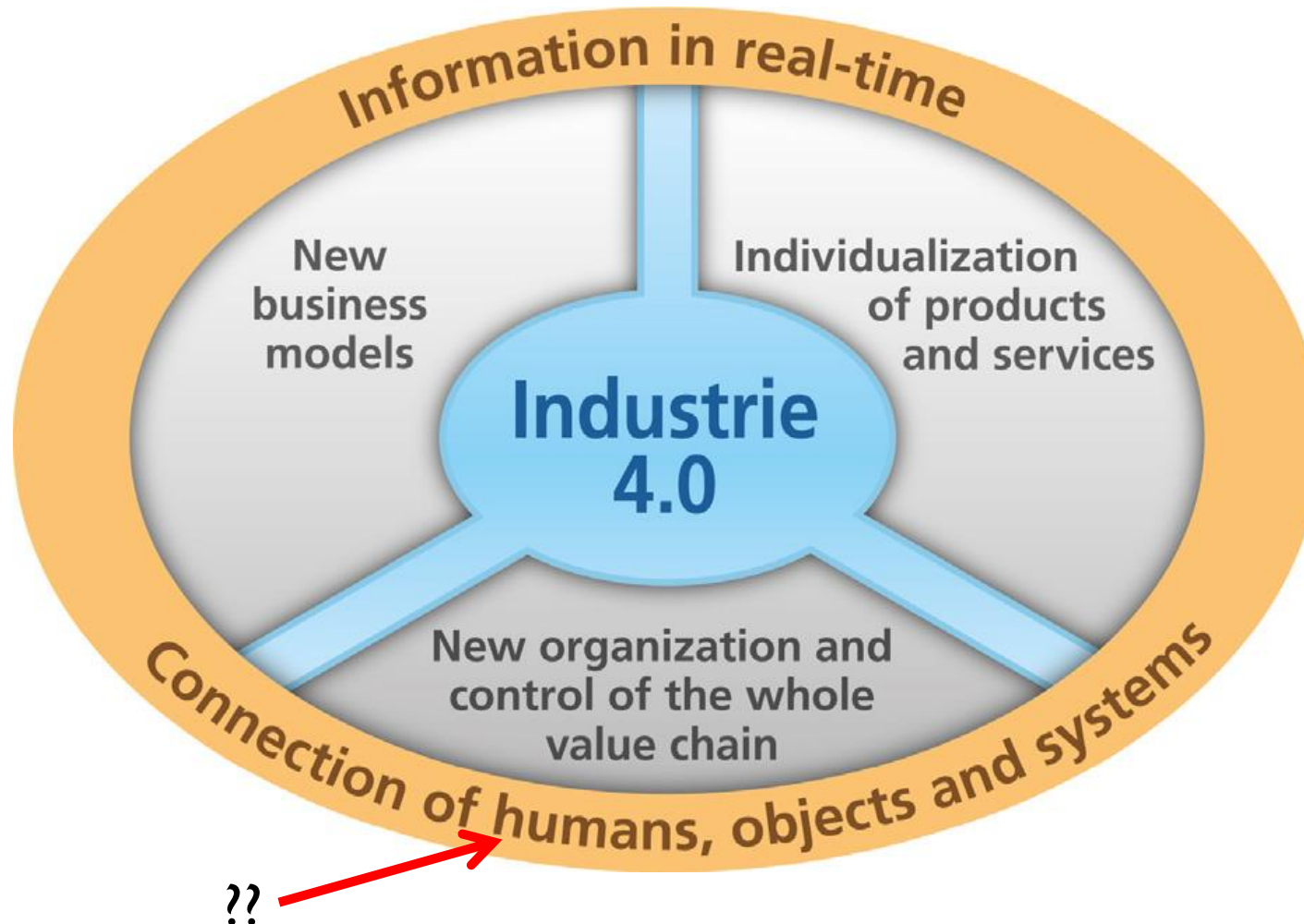
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Physical Internet – a Novel Application Area for
Industry 4.0
International Journal of Engineering and Management
Sciences 4(1):152-161
DOI: 10.21791/IJEMS.2019.1.19.
Eszter Puskas, Gábor Bohács



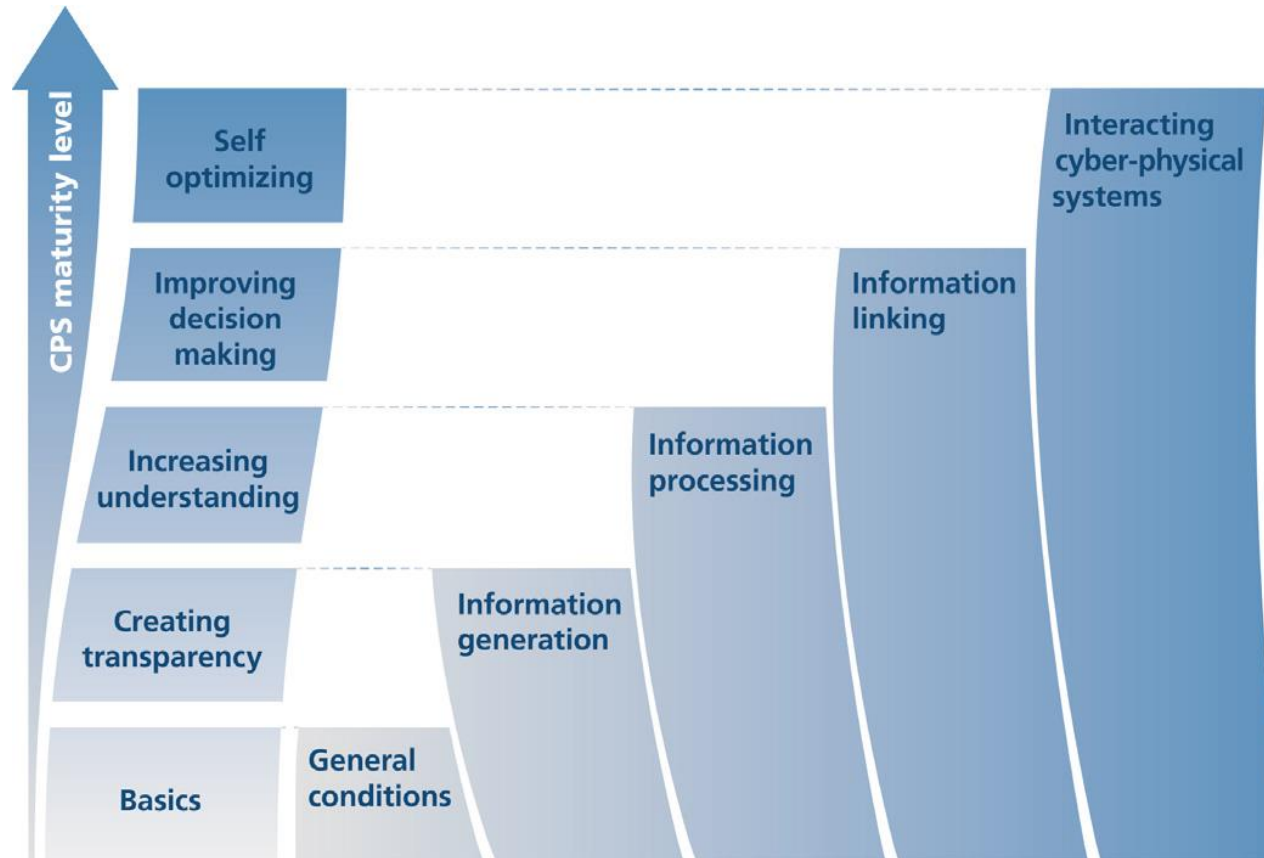


Cyber-physical systems in manufacturing,
Monostori et al, CIRP Annals - Manufacturing
Technology 65 (2016) 621–641

??



- CPS Maturity Model



Cyber-physical systems in manufacturing,
Monostori et al, CIRP Annals - Manufacturing
Technology 65 (2016) 621–641



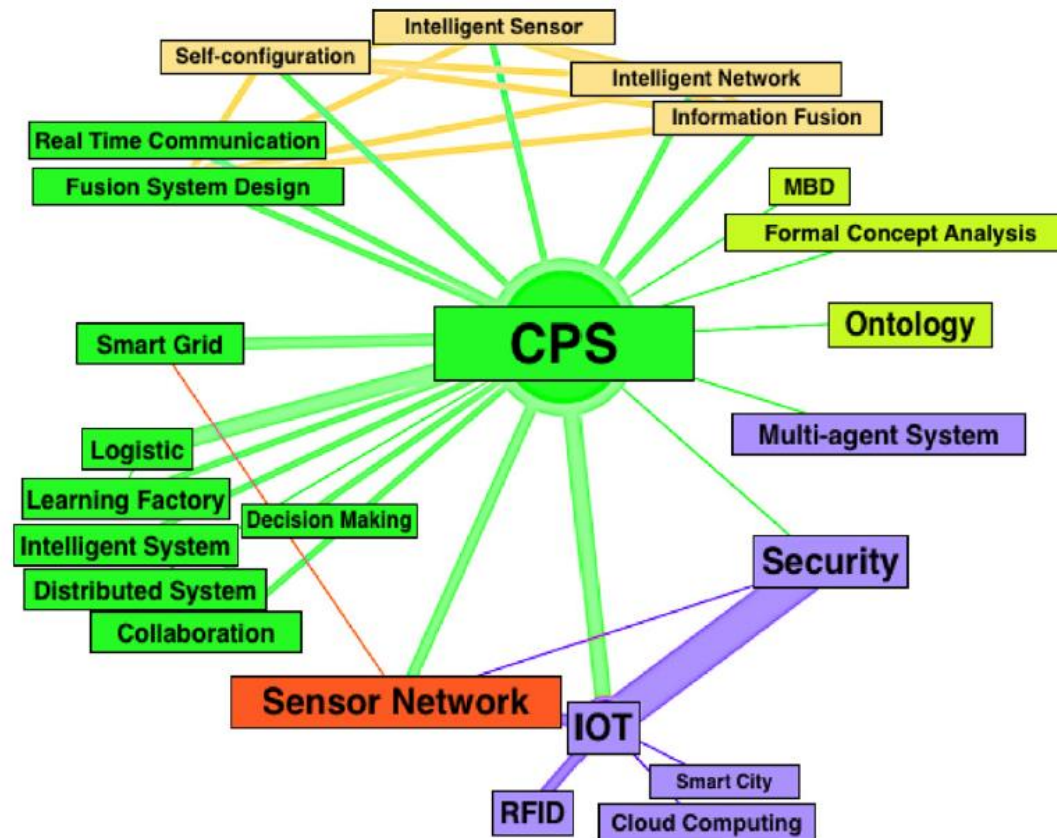
Cyber-Physical Systems



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- Important concepts



Cyber-physical systems in manufacturing,
Monostori et al, CIRP Annals - Manufacturing
Technology 65 (2016) 621–641



What is a Digital Twin?



- NASA Definition (adapted)
 - Modelling and simulation of the as-built [system] state,
 - as-experienced loads and environments, and
 - other [system] specific historyto enable
 - high-fidelity modelling of individual vehicles
 - throughout their service lives

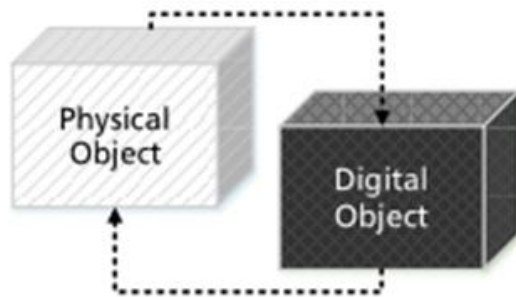
Hochhalter, Leser, Newman, Glaessgen, Cornell, Willard & Heber, 2014



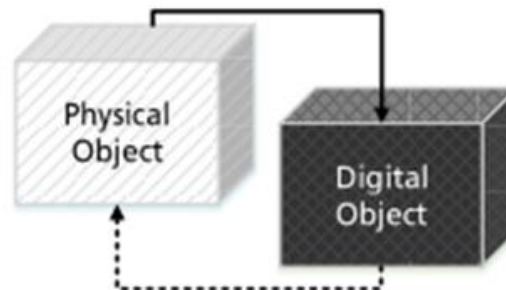
What is a Digital Twin?



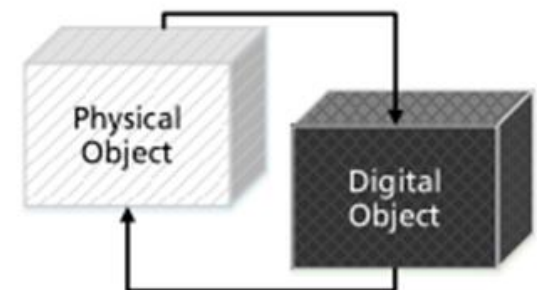
-----> Manual Data Flow
-----> Automatic Data Flow



Digital model



Digital shadow

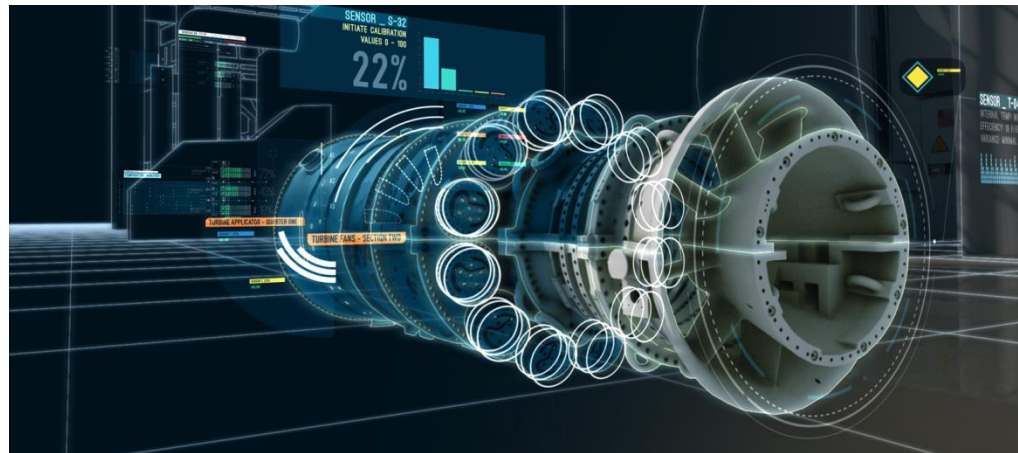


Digital twin

Kritzinger, W., Traar, G., Henjes, J., Sihn, W. & Karner, M. 2018. Digital Twin in manufacturing: A categorical literature review and classification. IFAC-PapersOnLine . 51(11):1016–1022.



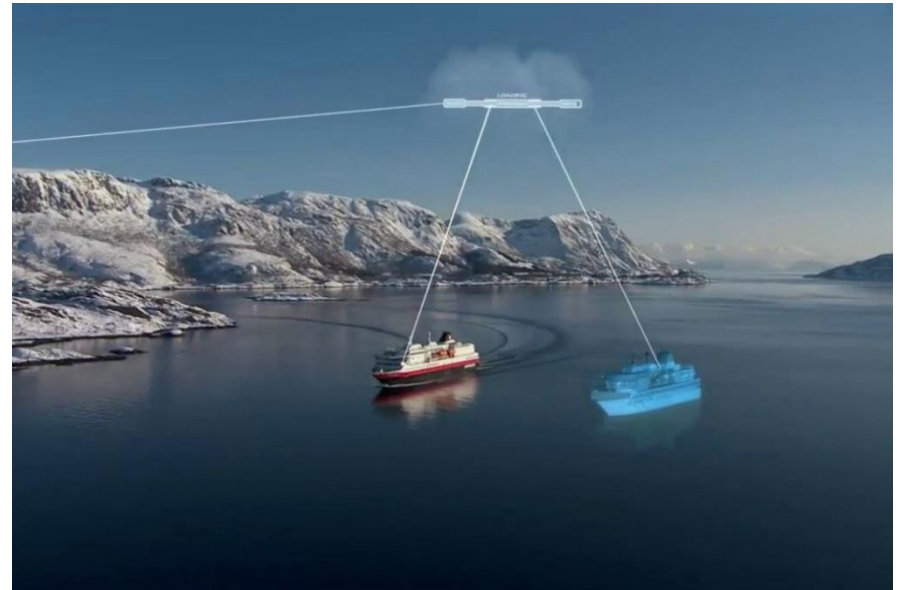
- General Electric



GE.com



- A Digital Twin to develop Blue Denmark
 - Imagine having access to information about every bit of your ship - from engine performance to hull integrity - available at a glance throughout the full lifetime of the vessel



What are Digital Twins For?



- Improved planning and dynamic scheduling
 - Decrease bottlenecks and resource conflicts
- Improved maintenance
 - Using diagnostic and predictive analytics
- Optimization of complex systems
 - Simulation using mathematical and statistical models
 - Sending control commands to the local microcontrollers
 - Real-time sensor data to track effectiveness
- ...



What are Digital Twins For?



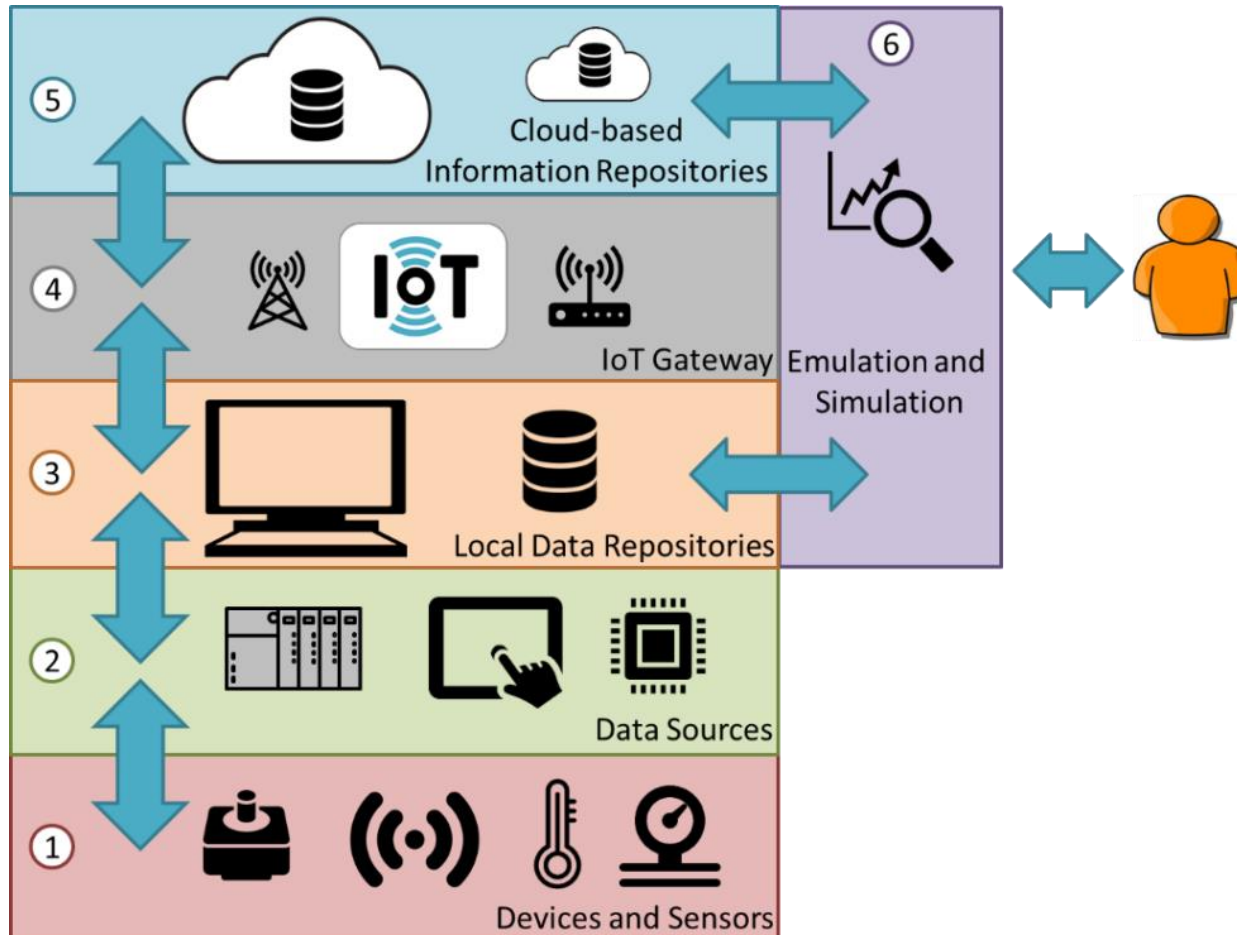
- ...
- Centralized and integrated data from whole lifecycle
 - Differing levels of access, using cloud storage and analytics
 - Used for simulation, optimization, design information or more effective concurrent work of multidisciplinary teams
- Augmented reality technology
 - Virtually assisted installation and maintenance
 - Worker training
- Reduced energy consumption
 - Energy monitoring and forecasting



- Implementation focussed
- Suitable for existing/legacy systems
- Vendor neutral where possible
- Maximum use of "off-the-shelf" software
 - Reduced development cost and time
 - Cyber-security included
- Human integration
 - Augment workers, rather than replace them
- Complex systems' control and coordination
 - With provision for future changes/expansions



Six Layer Architecture for Digital Twins



Redelinghuys, Basson, Kruger, "A Six-Layer
Architecture for Digital Twins with Aggregation",
accepted for SOHOMA 2019



Hierarchy of Digital Twins



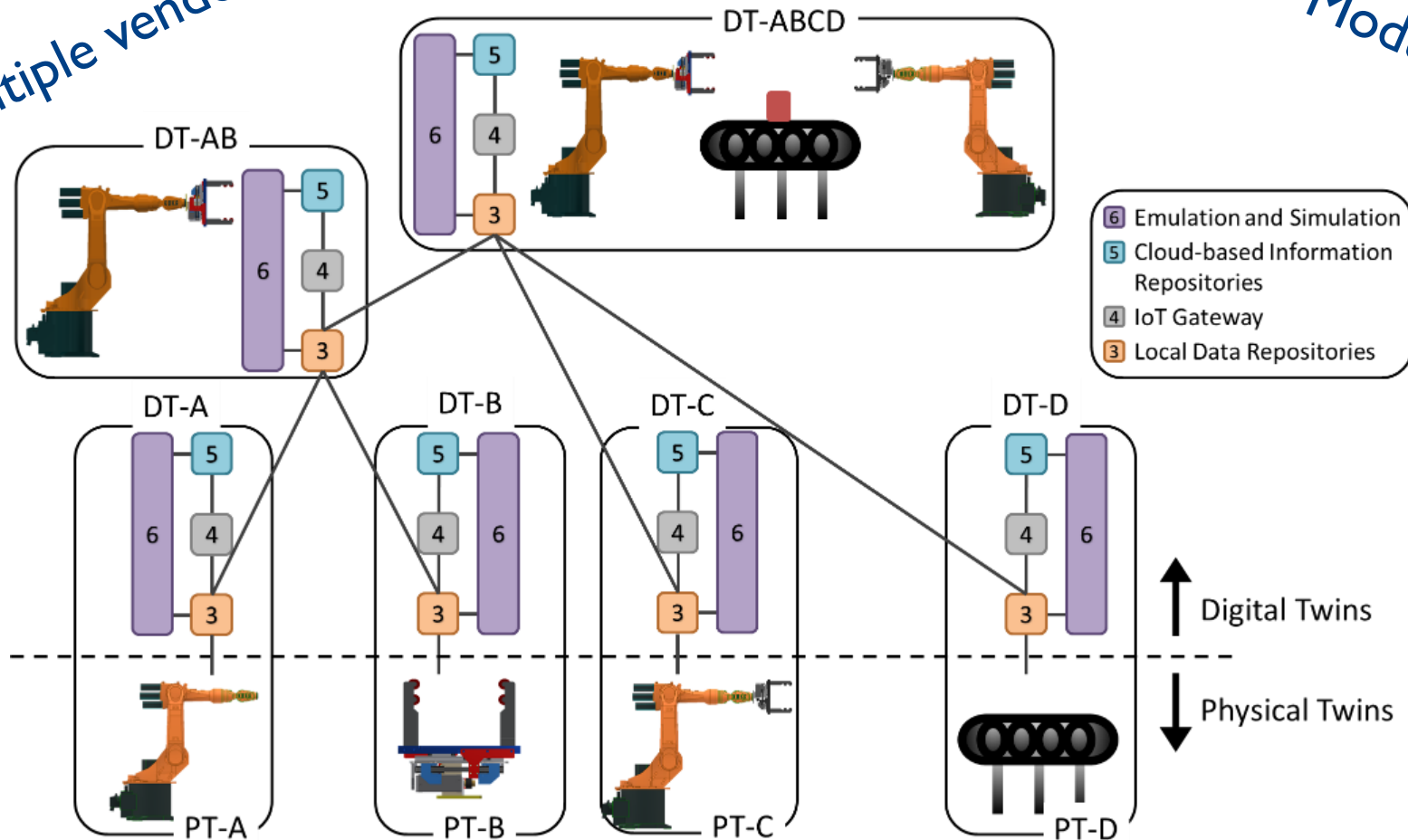
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Multiple vendors

Security

Modularity



Redelinghuys, Basson, Kruger, "A Six-Layer Architecture for Digital Twins with Aggregation", accepted for SOHOMA 2019



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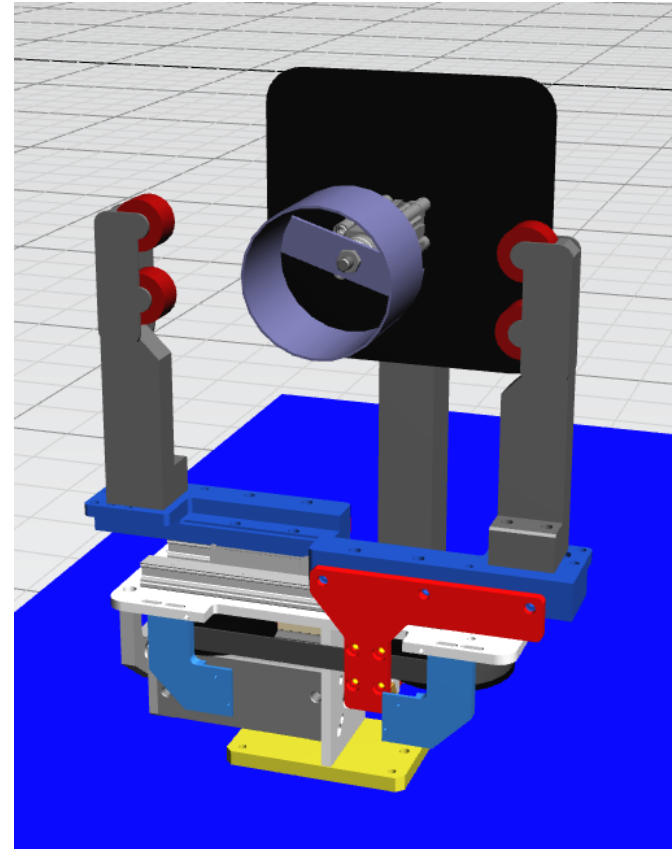
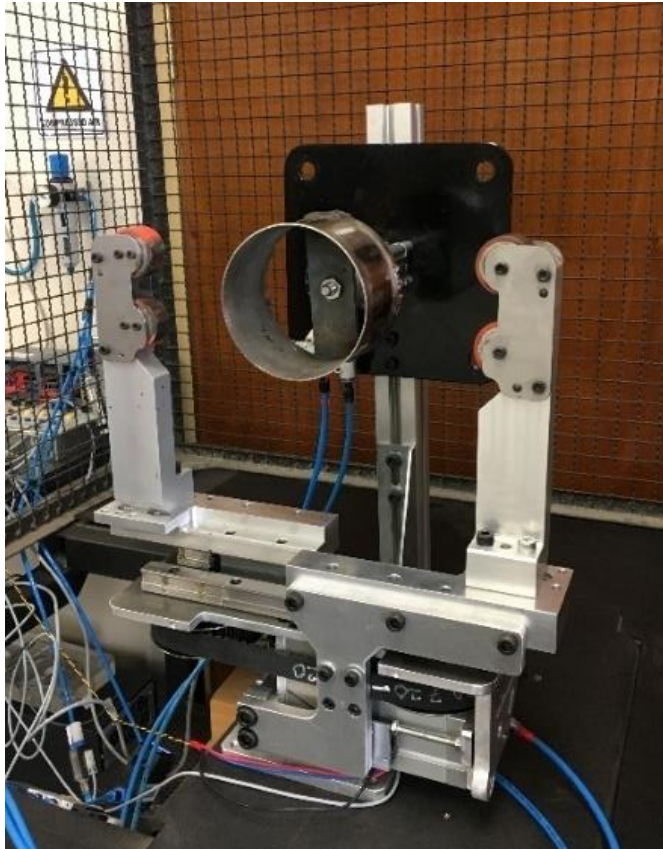


Digital Twins in Manufacturing

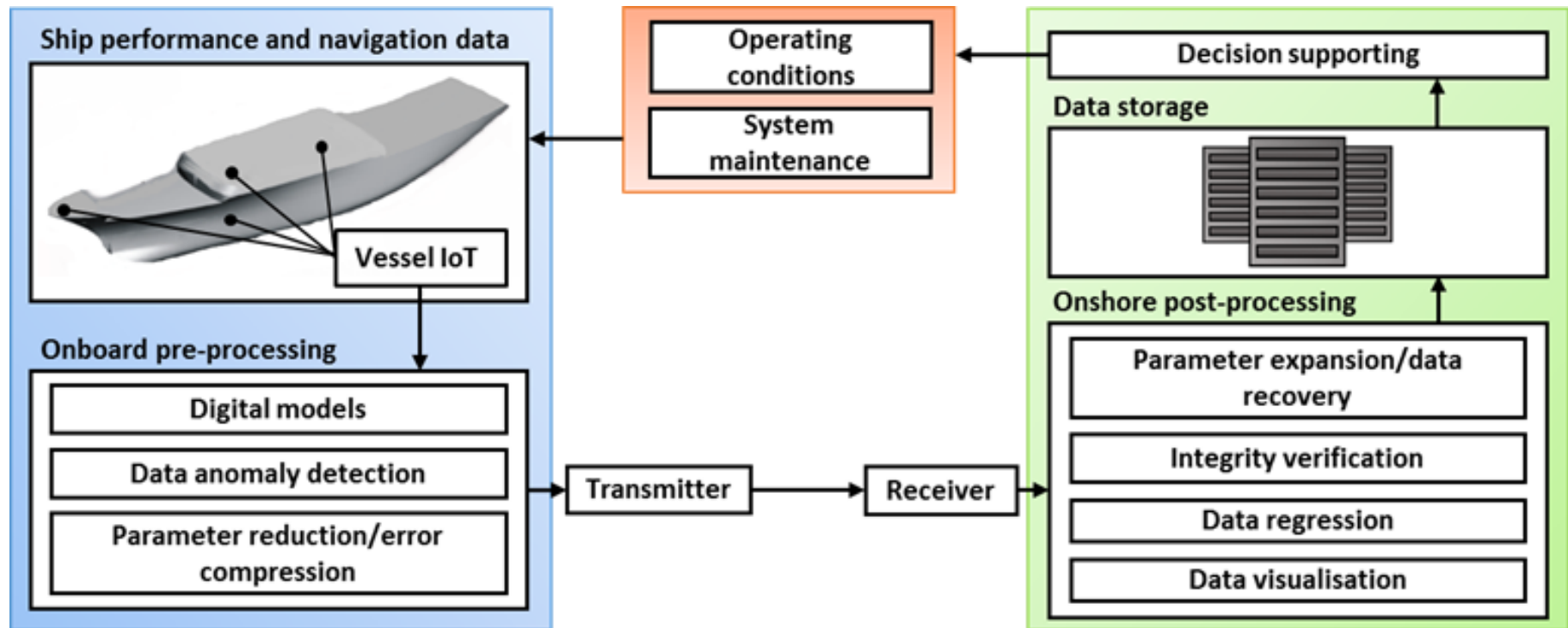


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Digital Twin for SA Agulhas



Adapted from: Perera, L., Mo, B.: Ship performance and navigation information under high-dimensional digital models. In: Journal of Marine Science and Technology. 1 – 12 (2019).

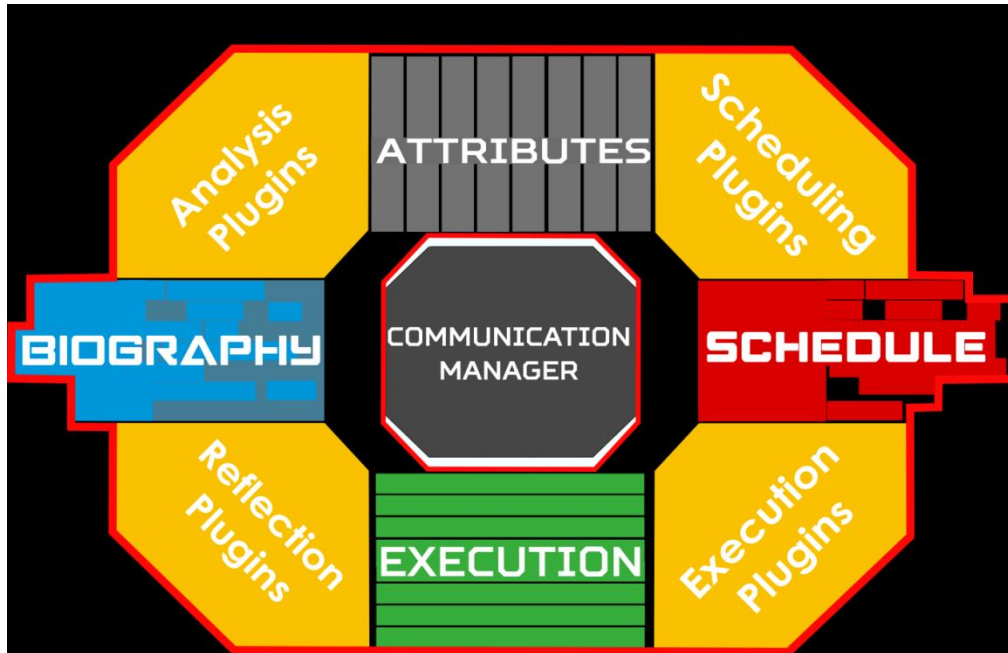


Digital Twin for Worker



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<https://www.sonaca.com>



<https://http://www.aatcomposites.com>

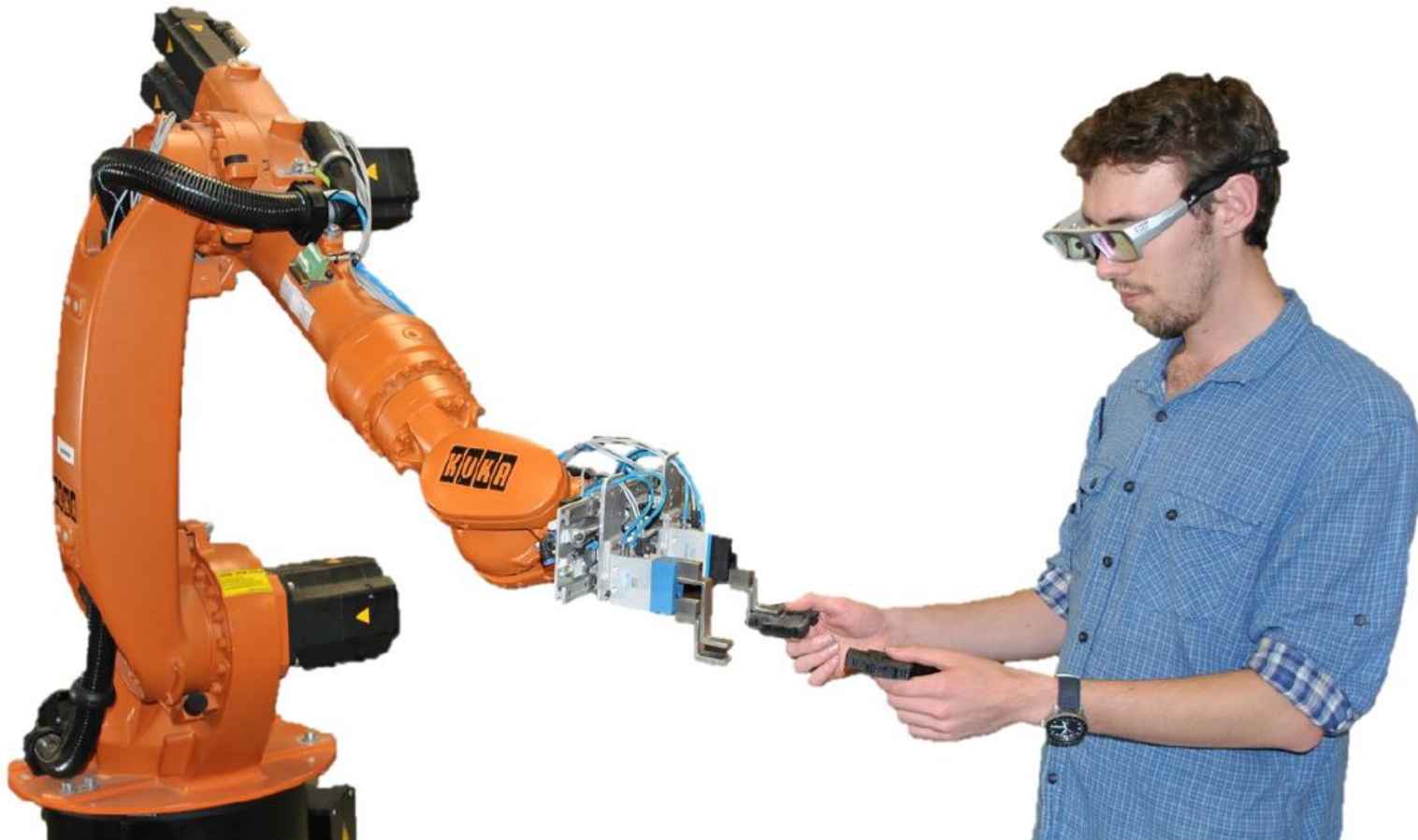


Human-Robot Collaboration



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Digital Twin for Table Grape Farm



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Production Weeks		51	52	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Marketing Weeks		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Varieties	Type																		
Prime	Seedless																		
Flame	Seedless																		
Starlight	Seedless																		
MIDNIGHT BEAUTY	Seedless																		
Sugraone	Seedless																		
Sable	Seedless																		
Sundance	Seedless																		
Sweet Joy	Seedless																		
Sweet Sapphire	Seedless																		
Thompson	Seedless																		
Adora	Seedless																		
Sweet Celebration	Seedless																		
Crimson	Seedless																		
Autumn Royal	Seedless																		
Magenta	Seedless																		
Melody	Seedless																		
Scarlotta	Seedless																		
Allison	Seedless																		



Digital Twin for Heliostat Field



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Thank You

Dankie

Enkosi



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<http://www.mecheng.sun.ac.za/research-groups-and-centres/groups/>

