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INDUSTRIAL ENGINEERING

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Chapter 01

COURSE OVERVIEW

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1	Introduction
2	Strategic Production Planning
3	Product Development
4	Material Technology
5	Engineering Drawing
6	Manufacturing Technologies
7	Manufacturing Resources
8	Facility Planning
9	Logistics Processes
10	Layout Design
11	Ergonomics
12	Case Studies
13	Wrap-up & Exam Preparation

ORGANIZATIONAL ISSUES

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Attendance highly recommended

- Consecutive exercises in MS Excel (following through is key) => most important part for exam
- Relevant and irrelevant topics/slides for the final exam will be revealed in class
- Please note: no recording of classes

Grading

- Final Exam: 100% (theory + Excel exercises)
- Bonus assignment with 2 parts: (up to) +5%

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Chapter 01

INTRODUCTION

OUTLINE

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1	Industrial Engineering
2	Production
3	Industry 4.0
4	Globalization & Production
5	Production as a System
6	Excel Tutorial (separate file)

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INDUSTRIAL ENGINEERING

DEFINITION OF ENGINEERING

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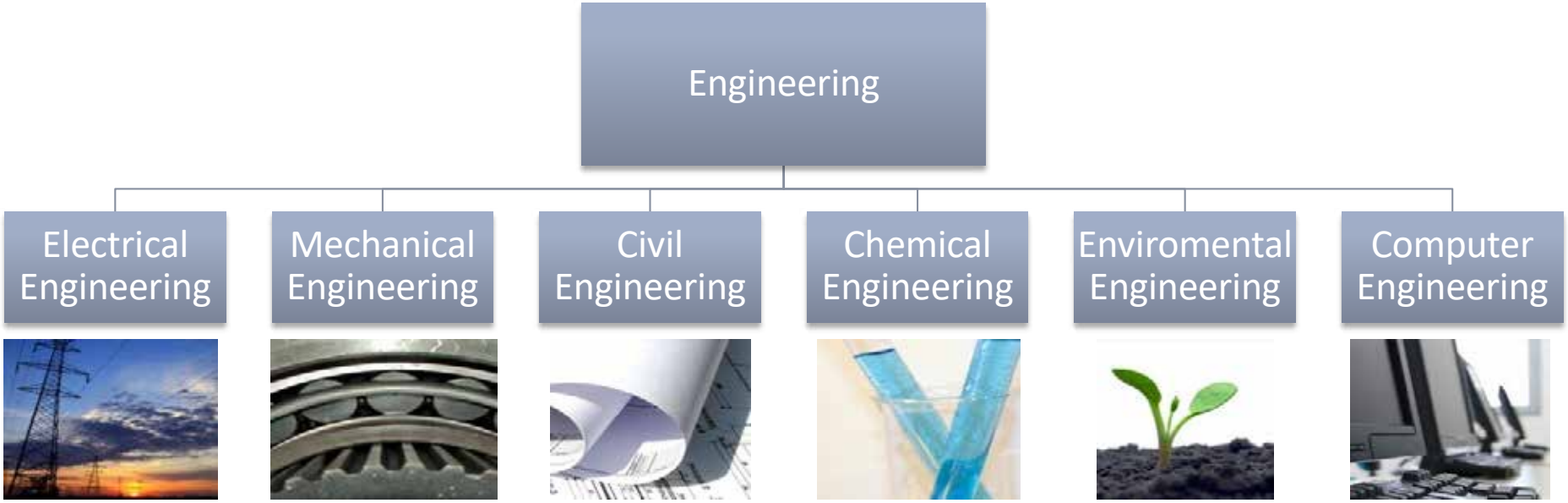
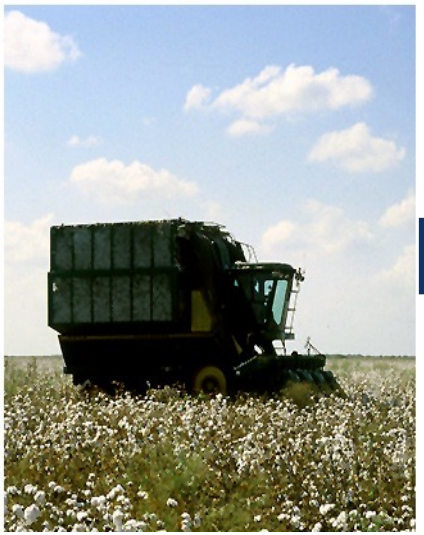
Engineering is the discipline, art and profession of acquiring and applying scientific, mathematical, economic, social, and practical knowledge to design and build structures, machines, devices, systems, materials and processes that safely realize solutions to the needs of society



Engineering is the main driver of technological progress

INDUSTRY

The collective large-scale manufacturing of goods in well-organized plants with a high degree of automation and specialization



PRIMARY
Cotton is grown and picked on a cotton farm

SECONDARY
Cotton is processed to cloth

TERTIARY
Cotton clothes (e.g jeans, shirts etc)

Secondary industry is the main turf for Industrial Engineers

WHAT IS INDUSTRIAL ENGINEERING?

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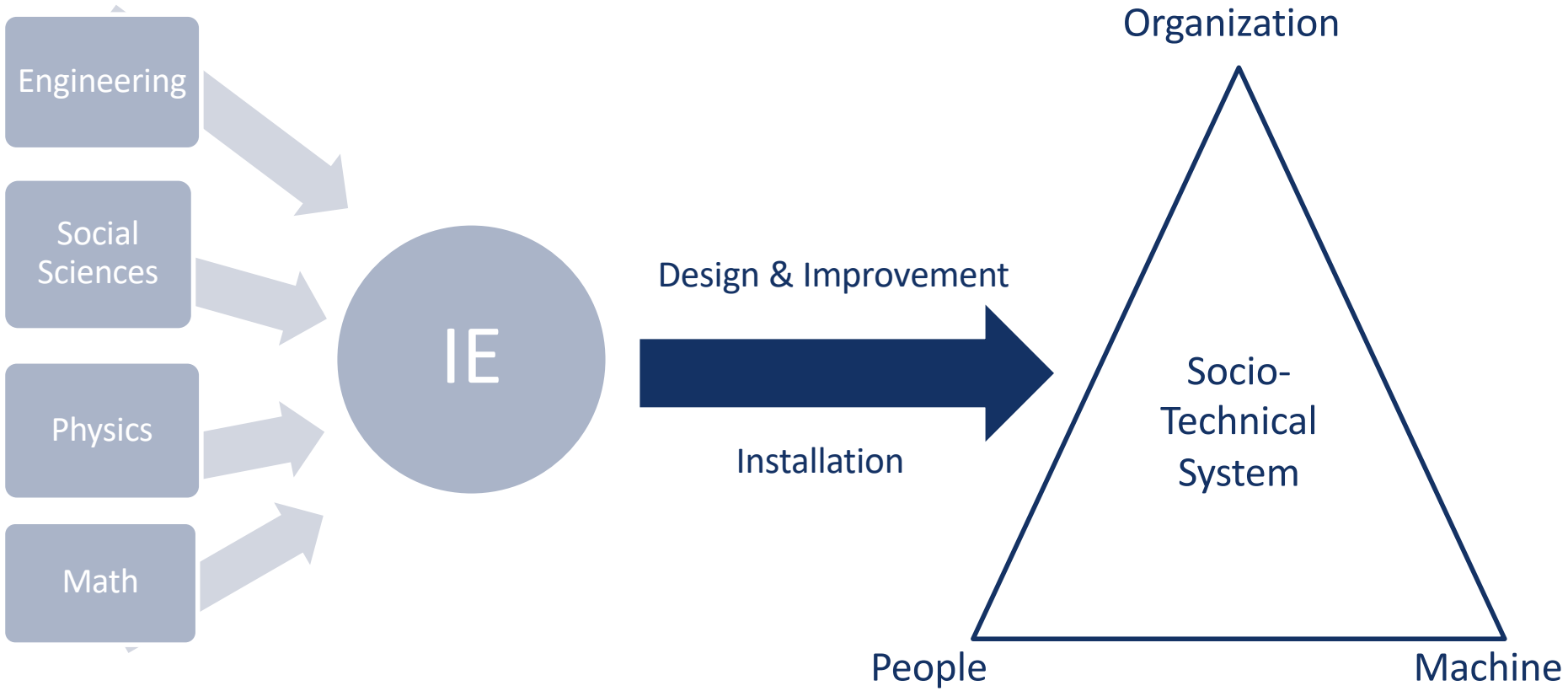
IE is concerned with the design, improvement and installation of integrated systems of people, material, equipment, and energy.



IE is a cross-cutting discipline that integrates knowledge from different disciplines to develop integrated solutions

WHAT DO INDUSTRIAL ENGINEERS DO?

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Industrial Engineers are cross-trained engineers capable of understanding and managing complex engineering and socio-technical systems

Industrial Engineers strive for

- a **better** way to make a product faster and easier
- a **safer** way in products and processes
- a **cheaper** & less expensive way in products and processes

Industrial Engineering is all about efficiency

EXAMPLES OF DECISIONS FACING AN INDUSTRIAL ENGINEER

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Industrial Engineers make tough decisions all the time

Outsourcing
Make or buy a needed component

Quality Improvement
Reduction of 1 % defective parts

Process Optimization
Where is the bottleneck and how to remove it?

Resource Planning
Automated or manual packaging

Ergonomics
Acceptable load for a warehouse operator

Capacity Planning
How many airline counters?

Decisions involve and impact many other departments

WHERE DO INDUSTRIAL ENGINEERS WORK?

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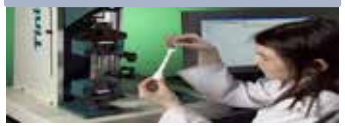
Aerospace & Airplanes	Machinery Manufacturing	Banking	Material Testing	Medical Service
				
Military	Construction	Forestry & Logging	Consulting	Mining
				
Oil & Gas	Plastics & Forming	Electronics	Energy	Retail
				
Entertainment	Shipbuilding	Insurance	Transport & Logistics	Automotive
				

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PRODUCTION

PRODUCTION

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The terms “production” (manufacturing) may have different aspects

Production

Function	Institution	Output
Combination and transformation of production factors to products according to specific methods	Location where factor combination takes place	The quantitative result of the factor combination

Production is the core function of industrial companies

AUTOMOBILE MANUFACTURING

PENCIL MANUFACTURING

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INDUSTRY 4.0

THE FOURTH INDUSTRIAL REVOLUTION: INDUSTRY 4.0

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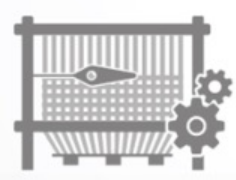
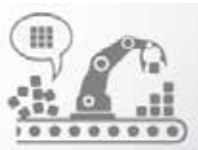
Industry 1.0 "Mechanization"	Industry 2.0 "Electrification"	Industry 3.0 "Automation"	Industry 4.0 "Autonomization"
Mechanical production equipment with water and steam power	Mass production with division of labor and electrical energy	Automation of production with electronics and IT	Cyber physical production based on the internet of things & services



1784
first mechanical loom

1870
first conveyor belt

1969
first programmable logic controller (PLC)

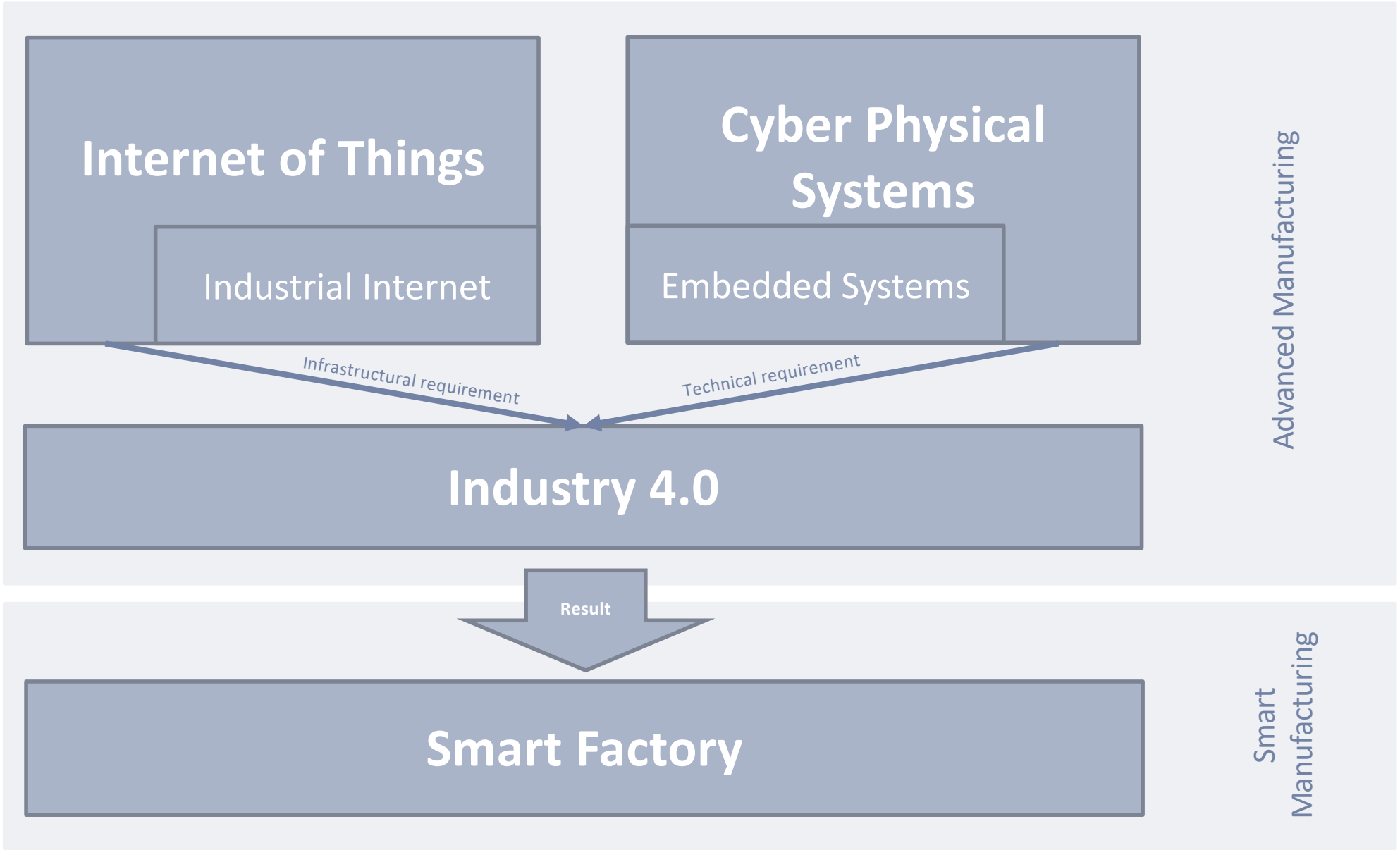


...

1800 1900 1970 today t

based on [Wahlster 2014; Bosch 2015]

KEY TERMS


Internet of Things
Industrial Internet
Cyber Physical Systems
Embedded Systems
Infrastructural requirement
Technical requirement
Industry 4.0
Advanced Manufacturing
Result
Smart Factory
Smart Manufacturing

IDEAL INFORMATION & MATERIAL FLOW IN INDUSTRY 4.0

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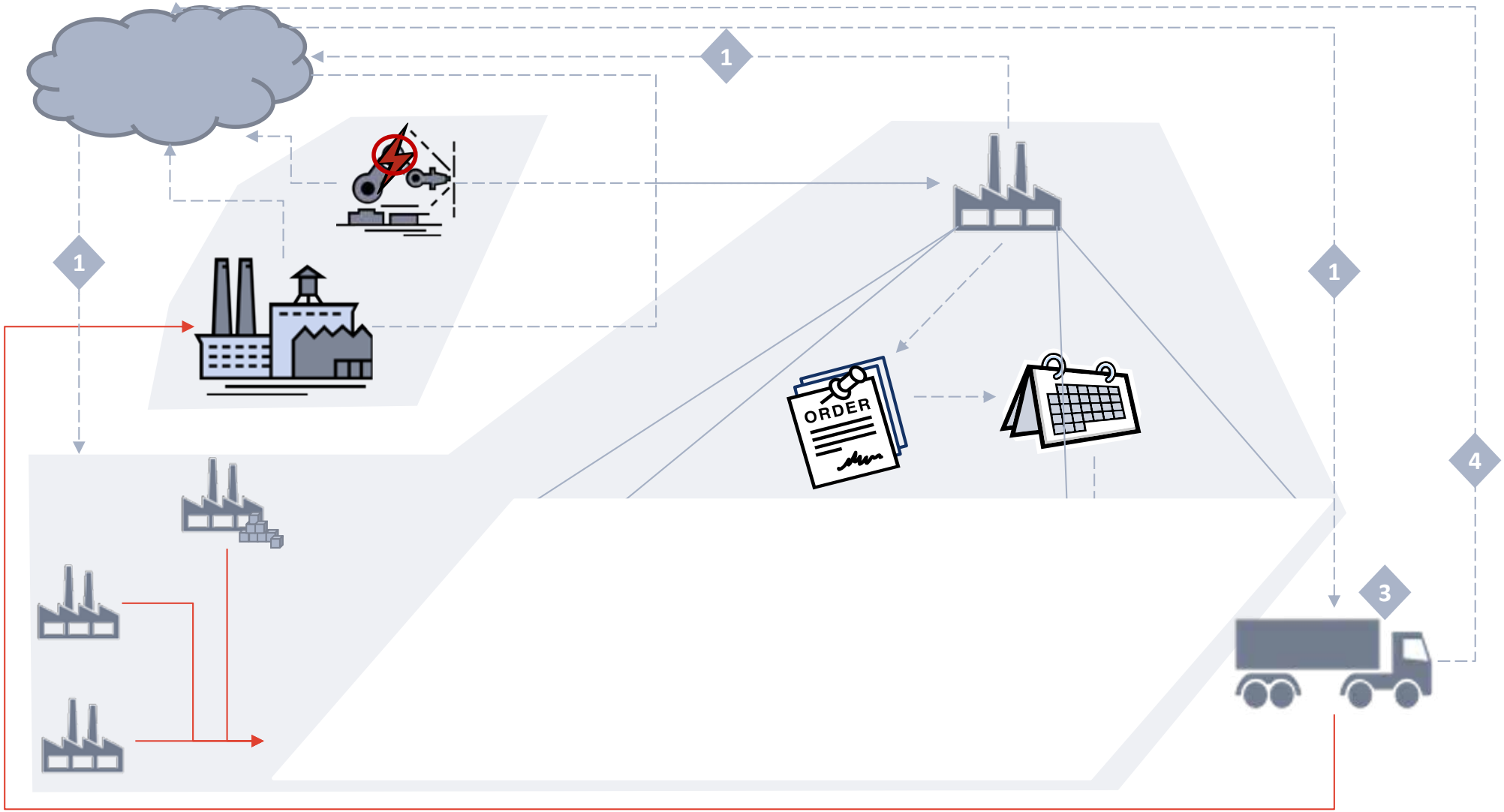


1 Precise and rapid matchmaking

2 Remote Quality Control (CMM, 3D Scan, CT)

3 Custom Shipping (esp. P2P)

4 Ubiquitous Tracking & Tracing

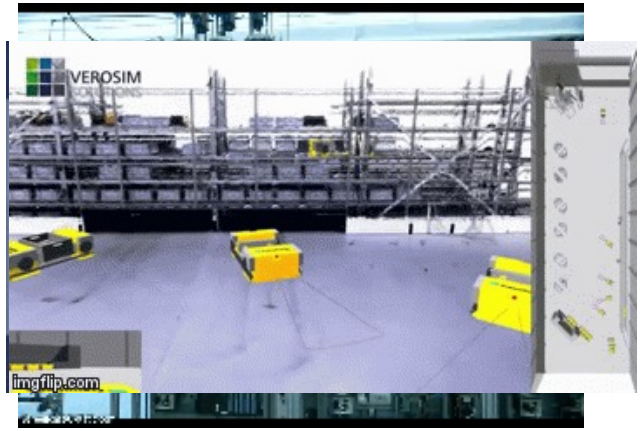
Information Flow

Goods Flow

GENERAL DEVELOPMENT STRATEGIES

Development approach	centralized	decentralized
New development	New centralized systems and platforms for data consistency (e.g. SMLC)	New decentralized systems through distributed self-control (e.g. Fraunhofer IML)
Further development	**Central control through autonomous identification of materials (e.g. SAP)**	Decentralized control through direct communication of materials with machines (e.g. DFKI)

Degree of centrality of control



Pictures
[SAP 2014] [DFKI 2014] [SMLC 2014] [IML 2015]

EXAMPLE OF CENTRALIZED CONTROL: OPEN INTEGRATED FACTORY

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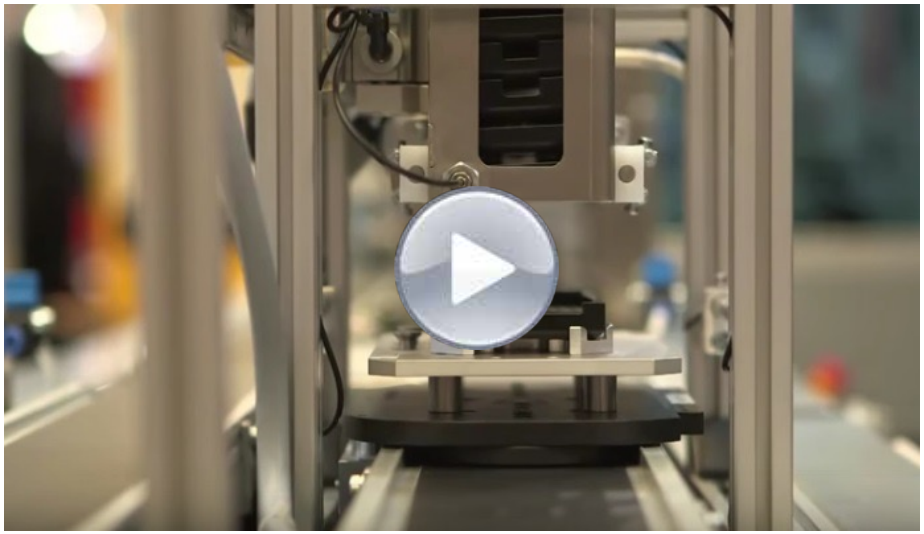

Video produced based on [SAP 2014]

OPPORTUNITIES BY INDUSTRY 4.0

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Product

- Digital product memory
- Integrated compliance
- Service-enabled products

Process

- One-piece flow
- Asset information management
- Predictive maintenance
- Adaptive & transparent logistics
- Anticipatory quality management

After Sales Service

- Fraud-secure warranty management
- Targeted recall management
- Service cross-selling

0110011011
1100111010
1001100111

Consistent and autonomous data exchange

Smart Products | Smart Processes | Smart Services

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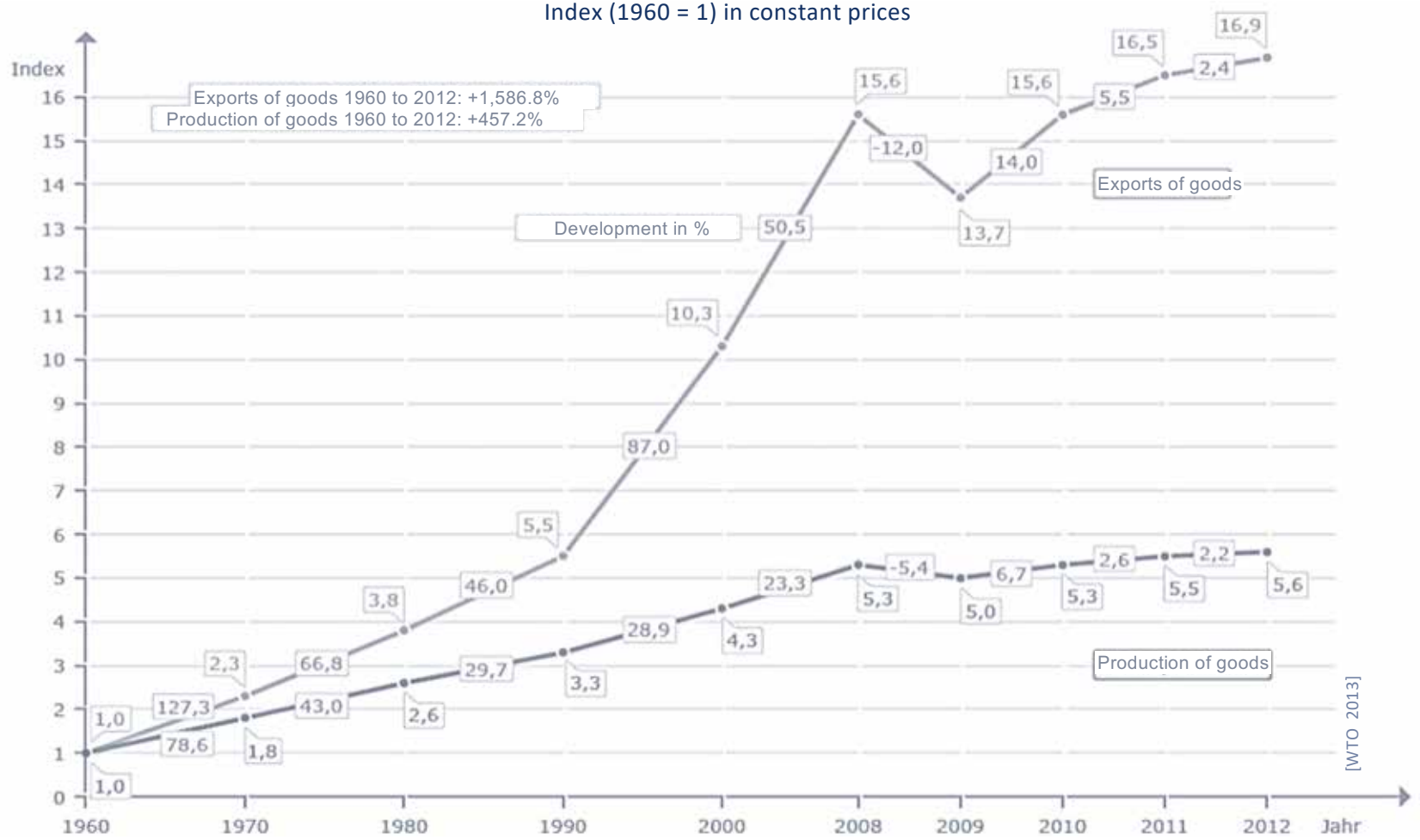
GLOBALIZATION & PRODUCTION

GLOBAL PRODUCTION

Development of global manufacturing & cross-border goods trade

Index (1960 = 1) in constant prices



Production is growing, becoming international & more complex

EXAMPLE 1: MANUFACTURING NETWORK OF A COMPLEX PRODUCT

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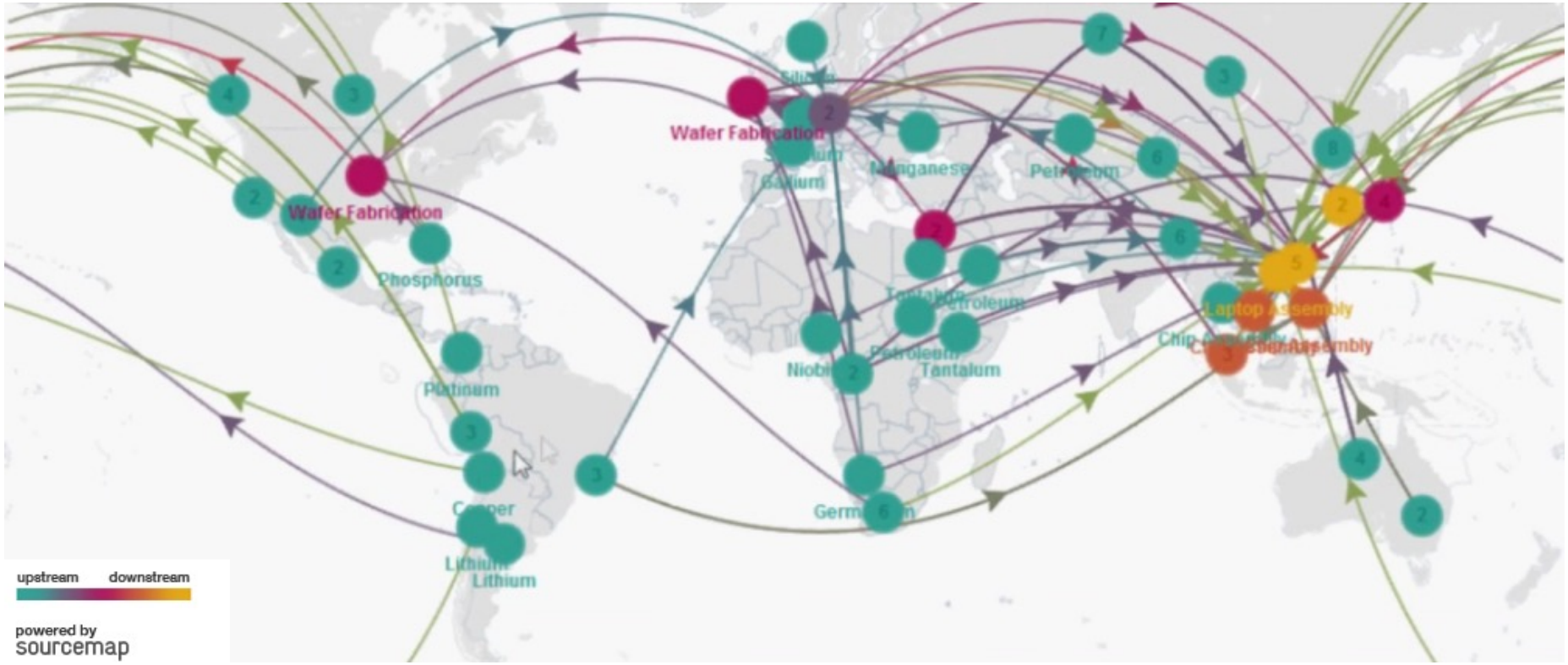
Laptop Manufacturing



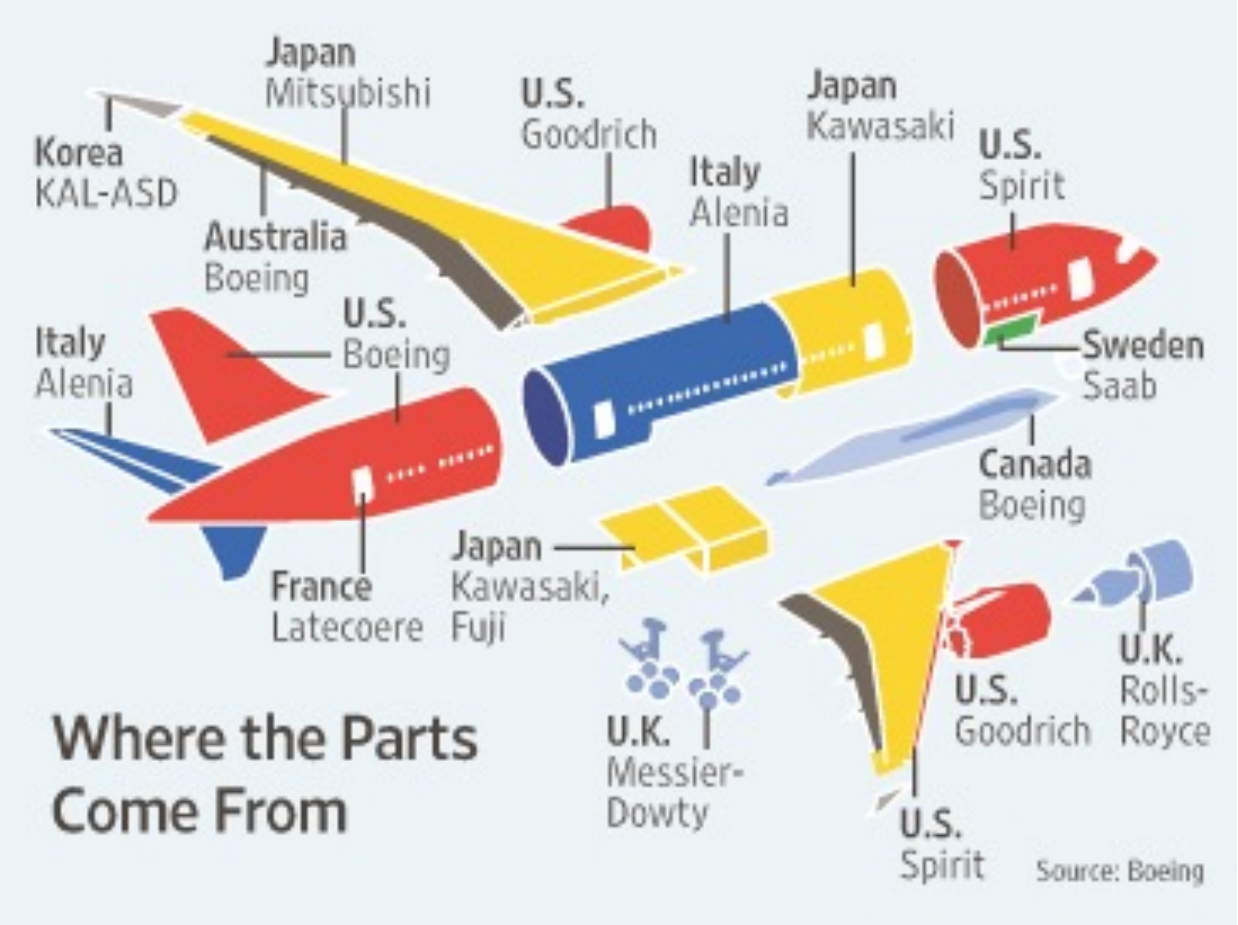
Suppliers are all over the place
Final manufacturing in East Asia

EXAMPLE 2: MANUFACTURING NETWORK OF A SIMPLE PRODUCT

Toothpaste Manufacturing

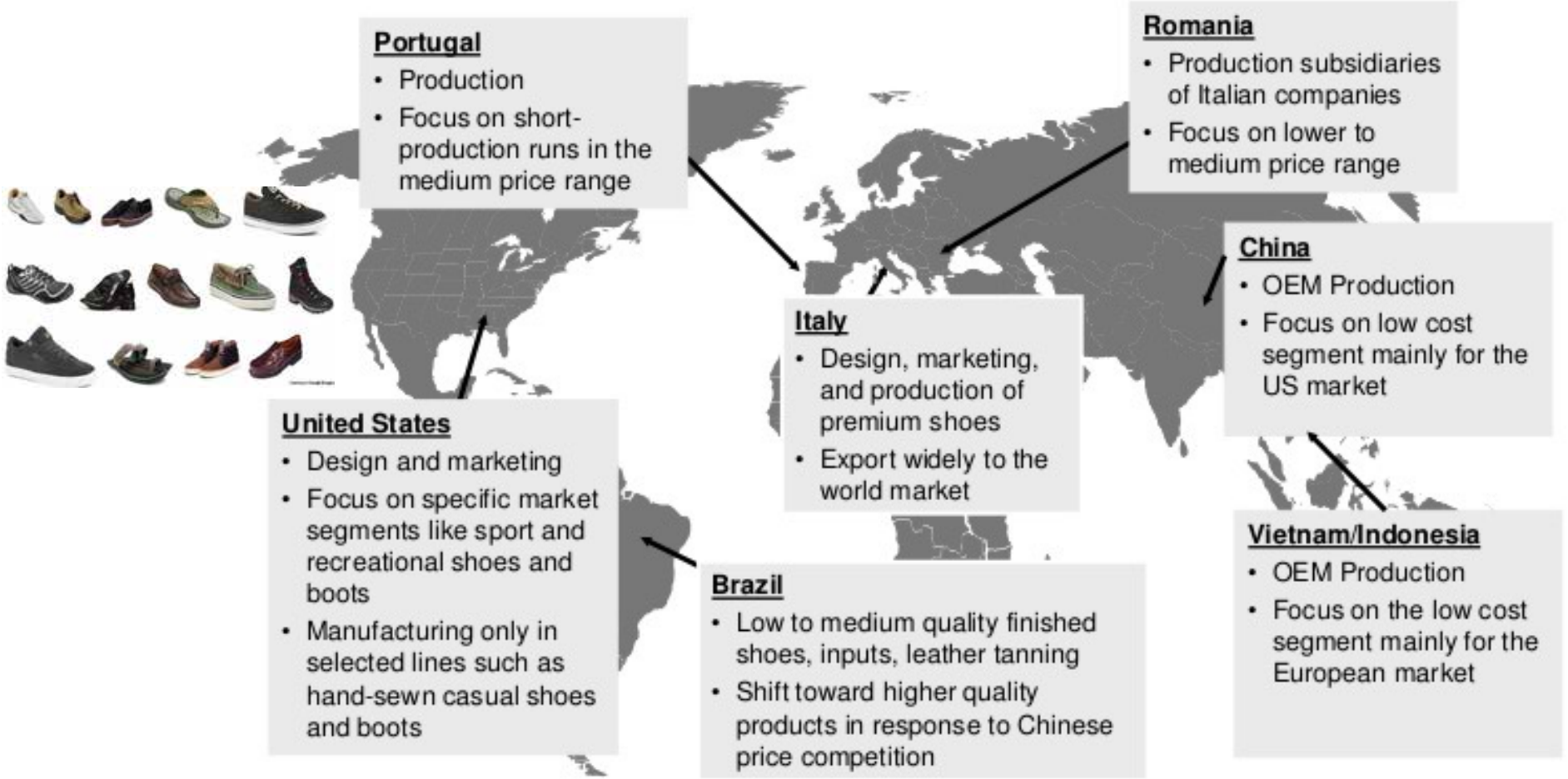
Suppliers are located in one region
Final manufacturing is all over the place

EXAMPLE 3: NATIONALITY OF COMPONENTS IN AEROSPACE



Patchwork products

EXAMPLE 4: GLOBAL POSITIONING OF MANUFACTURING SITES IN FOOTWEAR



Regional clusters and strategies for location of manufacturing sites

IMPLICATIONS ON MANUFACTURING

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Global suppliers

Global customers

Global markets w/ regional strategies

Hardly manageable supplier base

Diverse customer requirements

Ever harder to produce the right products, in the right quantity and time

Production technologies need to support in managing this complexity

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PRODUCTION AS A SYSTEM

PRODUCTION AS A SYSTEMS - ASPECTS

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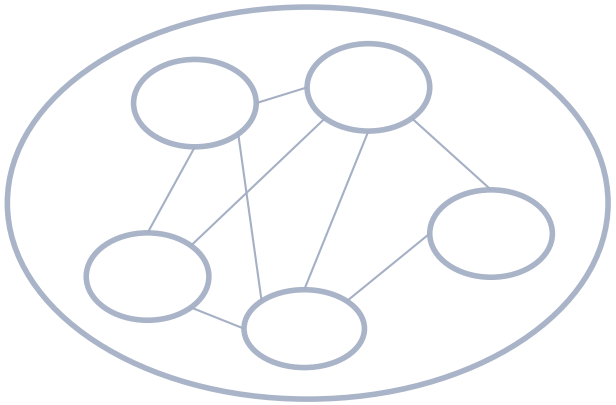
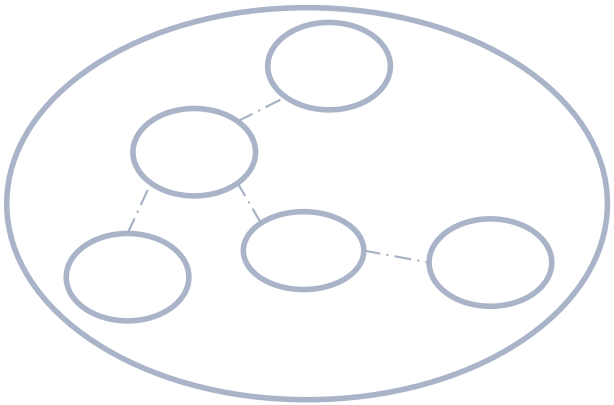
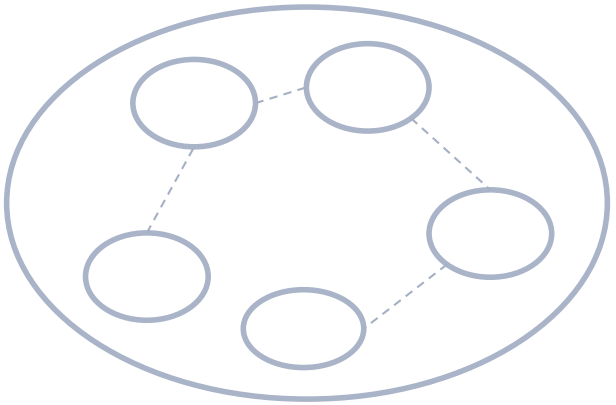
Material flows



Chain of command



Information flows



- Each system can be analyzed based on particular filters that highlight specific **Aspects of a System**
- An industrial firm may be considered by specific aspects like material flow, information flow, paths
- Elements of a system may be relevant as to several aspects and may appear in several illustrations, e.g. Department is relevant as to material flow, information flow, etc.
- The different aspects of a system serve only for temporary reduction of complexity but show interdependencies among each other, like material and information flow
- The insights drawn from representations are strongly influenced by the respective aspect
- The consideration of a system through different aspects is the basis for the description of the layered structure of a system

SYSTEM MODELS

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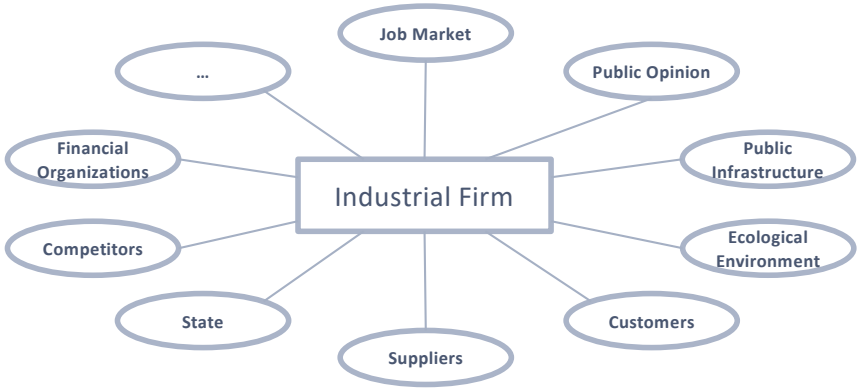
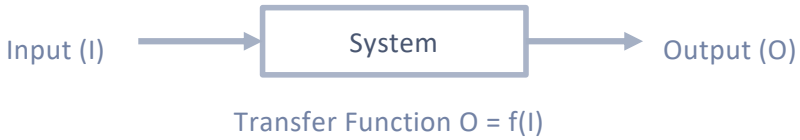
Environment-based Model



Effect-based Model

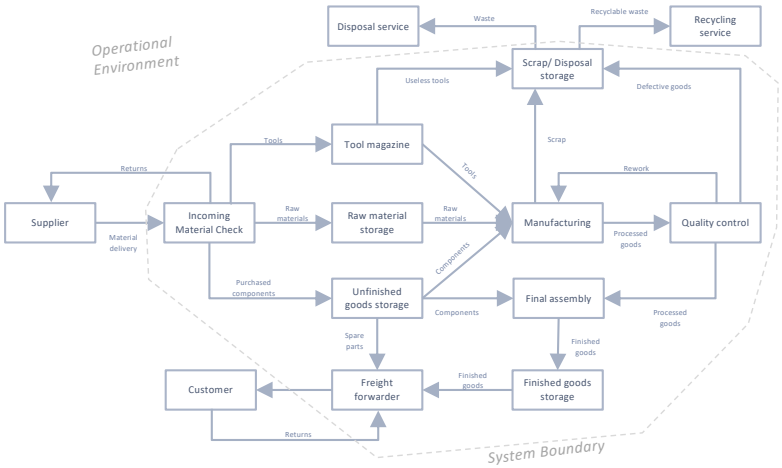


Structure-based Models

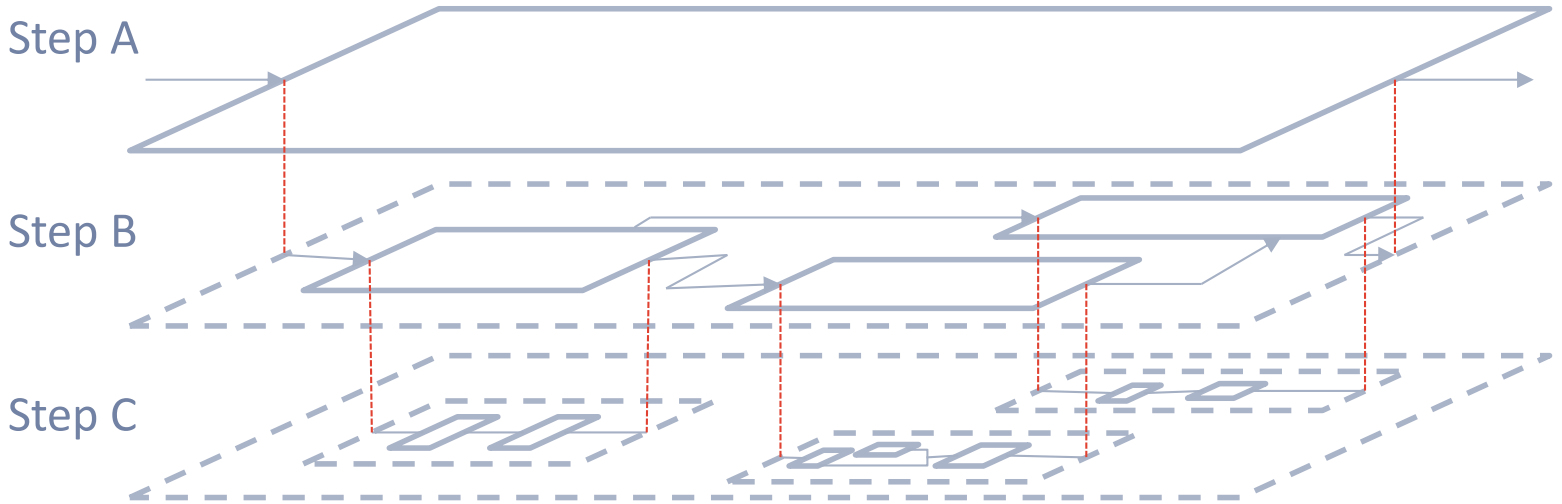
Matrix

from \ to	Supplier	Incoming materials storage	Tool magazine	Raw material storage	Unfinished goods storage	Disposal storage	Shop floor	Quality control	Final assembly	Finished goods storage	Customer
Supplier		100									
Incoming materials storage	5		10	70	20						
Tool magazine						10	5				
Raw material storage							70				
Unfinished goods storage							100		65		10
Disposal storage											
Shop floor			5			10		170			
Quality control					155	5	10				
Final assembly										65	
Finished goods storage											65
Customer											

Graph



SYSTEM HIERARCHIES



EXAMPLE I

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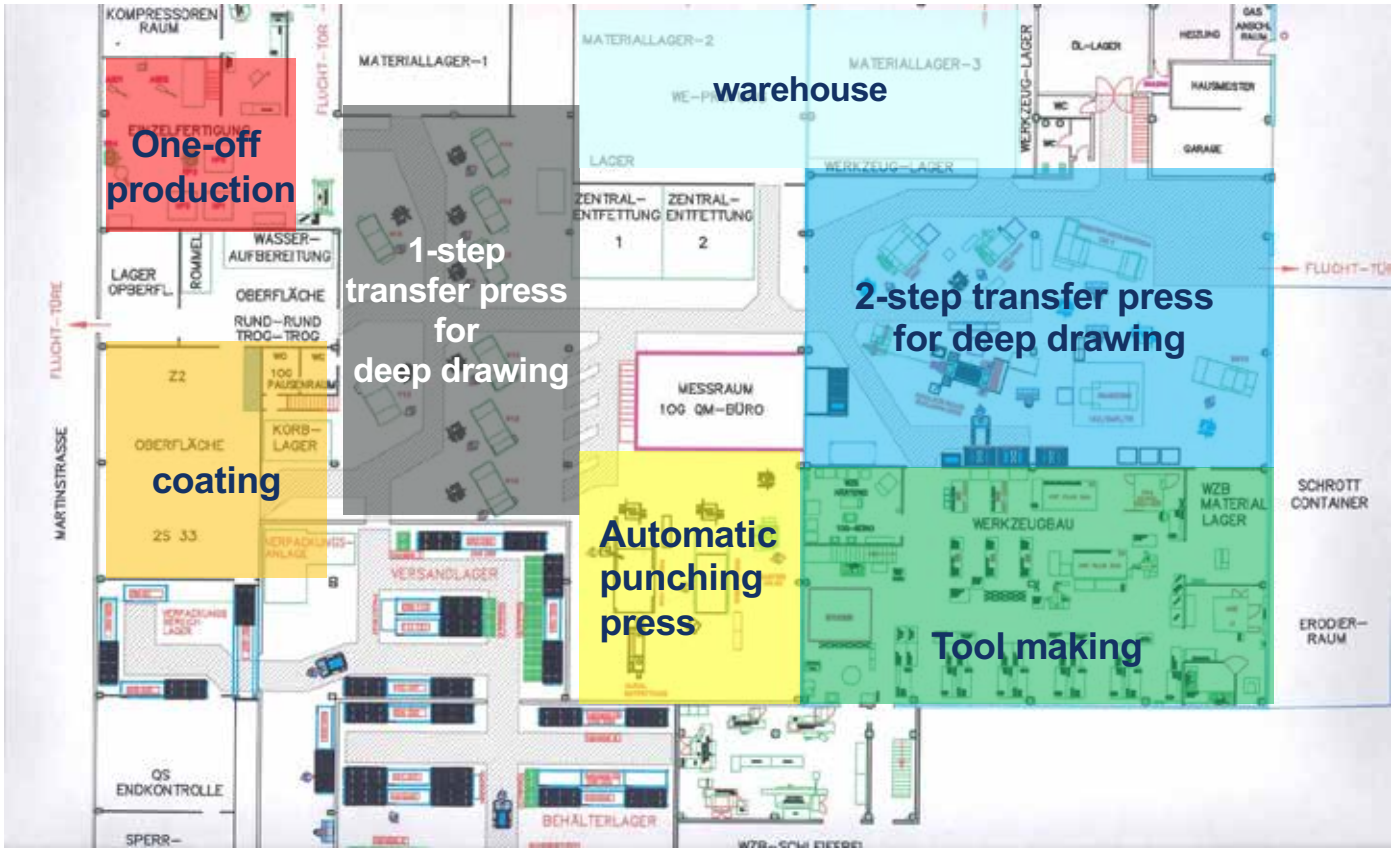
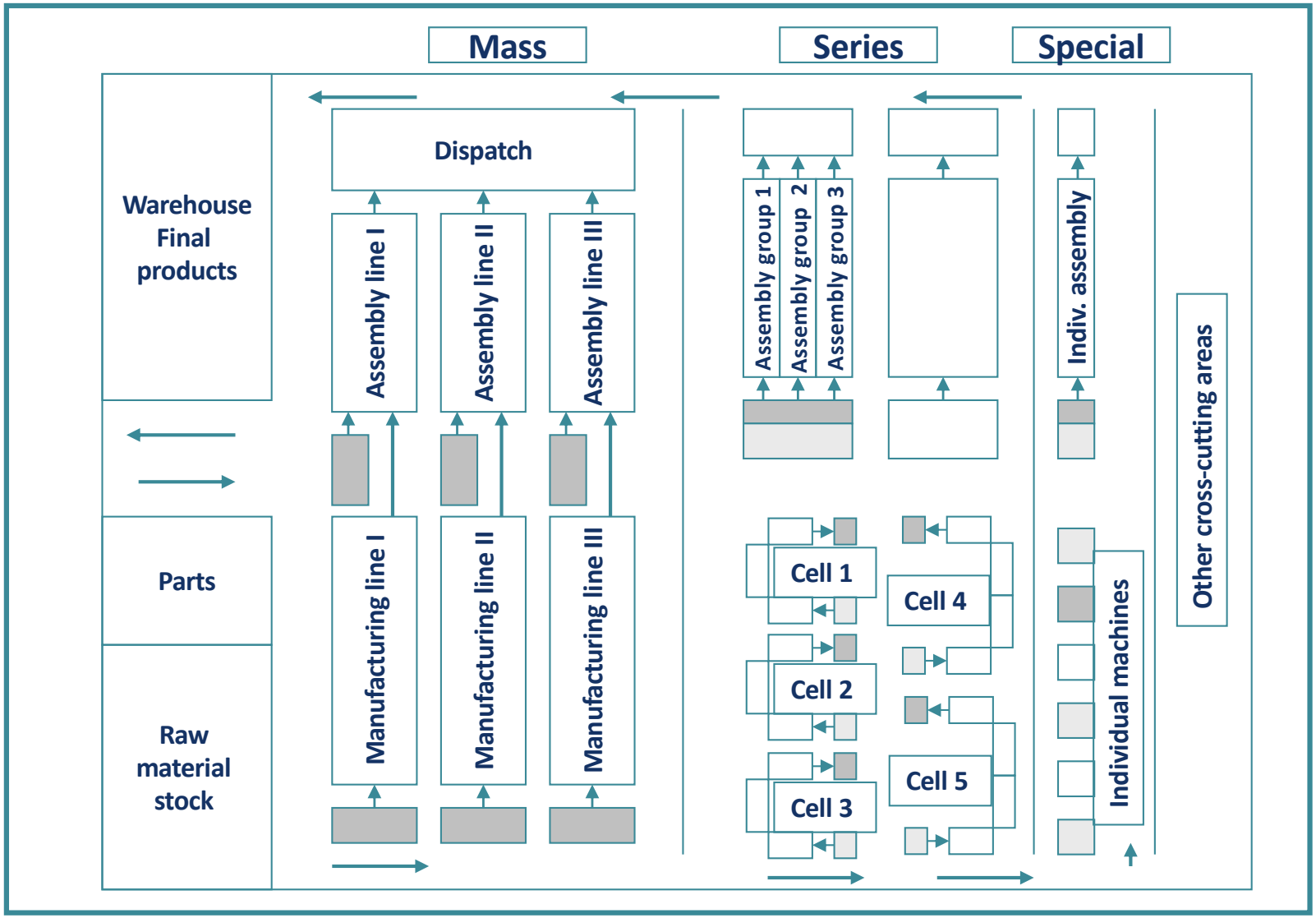
Sleeve & cylinder manufacturing



Product portfolio

EXAMPLE II


Mass
Series
Special
Warehouse Final products
Parts
Raw material stock
Dispatch
Assembly line I
Assembly line II
Assembly line III
Manufacturing line I
Manufacturing line II
Manufacturing line III
Assembly group 1
Assembly group 2
Assembly group 3
Cell 1
Cell 2
Cell 3
Cell 4
Cell 5
Indiv. assembly
Individual machines
Other cross-cutting areas

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THANK YOU!