Lesson 4
Production planning and production systems

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CBS COPENHAGEN BUSINESS SCHOOL
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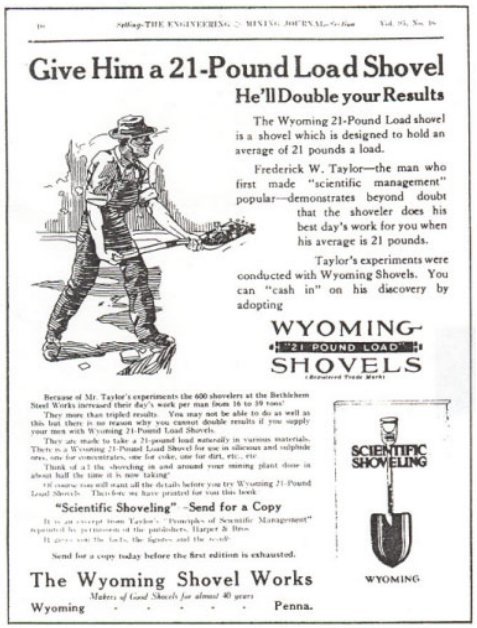
Today's Topics

- Production planning and design
  - Context and development – Milestones in the history of production
    - Production layout, scheduling and materials planning
  - More current approaches and main production systems – From Mass to Lean ("flexible mass") and Agile production systems
- Global Production systems/networks

Taylors „Scientific Management“ - Historical Milestone from craftsmanship to industry

- Frederick Winslow Taylor, 1856-1915
  - From rich Philadelphia family
  - Preparing for college at Harvard but had problems with his eyesight; instead of it:
  - Apprenticeship in industry – and shocked of the inefficiency of his fellow workers
  - 1878, Midvale Steel, laborer--> foreman--> chief engineer
  - By 1881 --> time and motion studies
  - “Shovel experiments” at Bethlehem Steel Works reducing number of people shoveling from 500 to 140
  - 1883, “Night school” and engineering degree from Stevens Institute of Technology

Taylors „Art and Science of Shoveling“



Give Him a 21-Pound Load Shovel

He'll Double your Results

The Wyoming 21-Pound Load shovel is a shovel which is designed to hold an average of 21 pounds a load.

Frederick W. Taylor—the man who first made "scientific management" popular—demonstrates beyond doubt that the shoveler does his best day's work for you when his average is 21 pounds.

Taylor's experiments were conducted with Wyoming Shovels. You can "cash in" on his discovery by adopting

WYOMING "21 POUND LOAD" SHOVELS

Because of Mr. Taylor's experiments the 600 shovelers at the Bethlehem Steel Works increased their day's work per man from 16 to 59 tons!

Their more than tripled results. You may not be able to do as well as this but there is no reason why you cannot double results if you supply your men with Wyoming 21-Pound Load Shovels.

They are made to take a 21-pound load naturally in various materials. There is a Wyoming 21-Pound Load Shovel for use in siliceous and sulphide ores, one for concentrates, one for coke, one for dirt, etc., etc.

Think of all the shoveling in and around your mining plant done in about half the time it is now taking!

Of course you will want all the details before you try Wyoming 21-Pound Load Shovels. Therefore we have printed for you this book

"Scientific Shoveling" —Send for a Copy

It is an excerpt from Taylor's "Principles of Scientific Management" reprinted by permission of the publishers, Harper & Bros.

It gives you the facts, the figures and the results!

Send for a copy today before the first edition is exhausted.

SCIENTIFIC SHOVELING

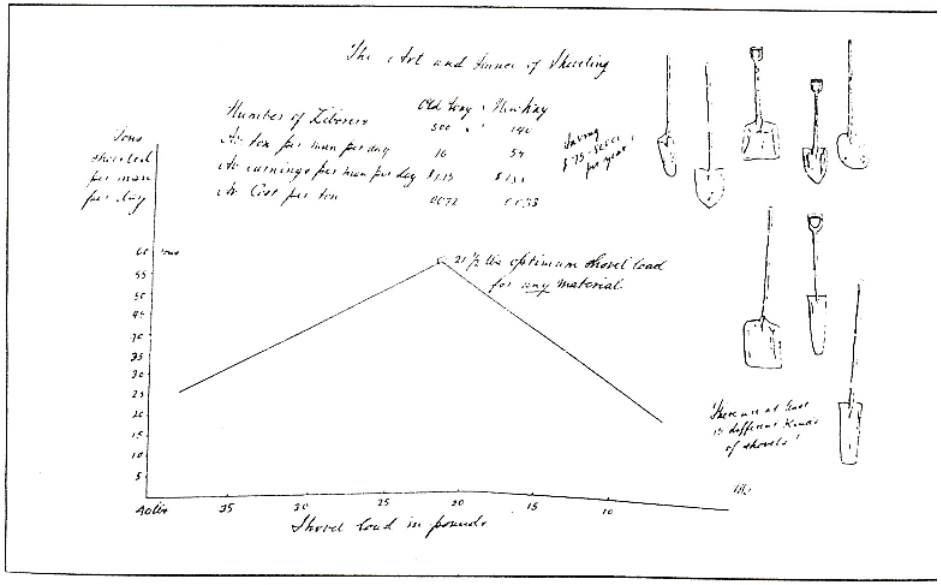
WYOMING

The Wyoming Shovel Works

Makers of Good Shovels for almost 40 years

Wyoming Penna.

Shovel advertisement based on Taylor's research (from the *Engineering & Mining Journal*, Vol. 95, No. 16.). *(Photo courtesy of Stevens Institute of Technology, Taylor collection, Hoboken, N.J.)*



The art and science of shoveling chart drawn by **Taylor** indicating the optimum shovel load at 21.5 lbs. *(Photo courtesy of Stevens Institute of Technology, Taylor collection, Hoboken, N.J.)*

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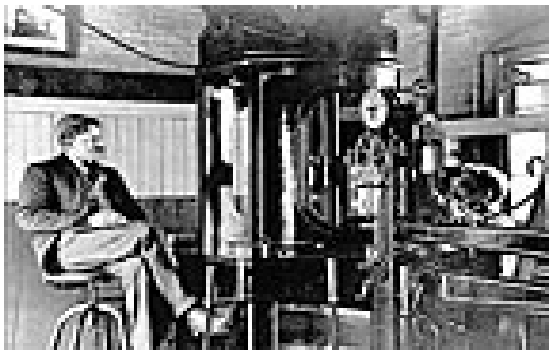
Scientific Management



- Workers experience/decision on their workload (Rules of thumb) as “basic evil”: wrong incentive, wrong rules, shirking
- Developing of a “science” instead – some assumptions:
  - Homo oeconomicus: Workers behavior as result of material incentive
  - According to related payment, human work can be measured and calculated like machine work
  - Task allocation: breaking task into smaller and smaller tasks allows the determination of the optimum solution to the task.
  - For each task then the best routine can be found
  - E.g. work analysis to select best shovel
- It is the job of the management not of the workers to find the best way!
  - Consequently, separate thinking and doing
    - Thinking is job of the management
    - Organization is job of the management

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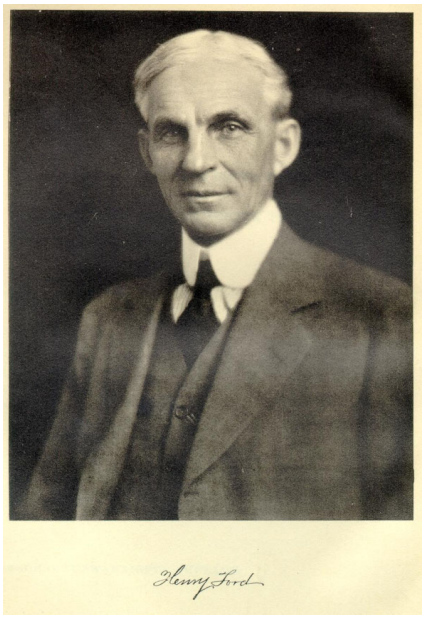
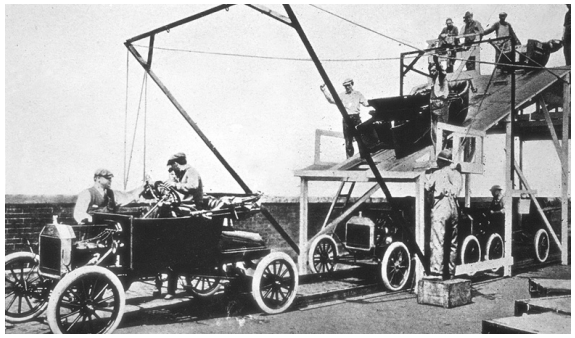
Frank B. Gilbreth, Lillian M Gilbreth - Motion and Time Study in 1907 together with and after Taylor

- Breaking tasks, activities in single steps and try to make every step more efficient
- Motion Study
  - Improving working methods by better working procedures -> Gilbreth's "Bricklayer-Contest"
  - E.g. used cameras to look at body motions
  - Distances, necessary moves for the activity, number of activities within time intervalls etc.
- Time studies
  - Creating standards
  - Average time of an average worker
- E.g. Germany
  - Verein Deutscher Ingenieure (VDI) later (REFA)
  - Similar institutions all over the world

Henry Fords Assembly Line perfectioning Scientific Management

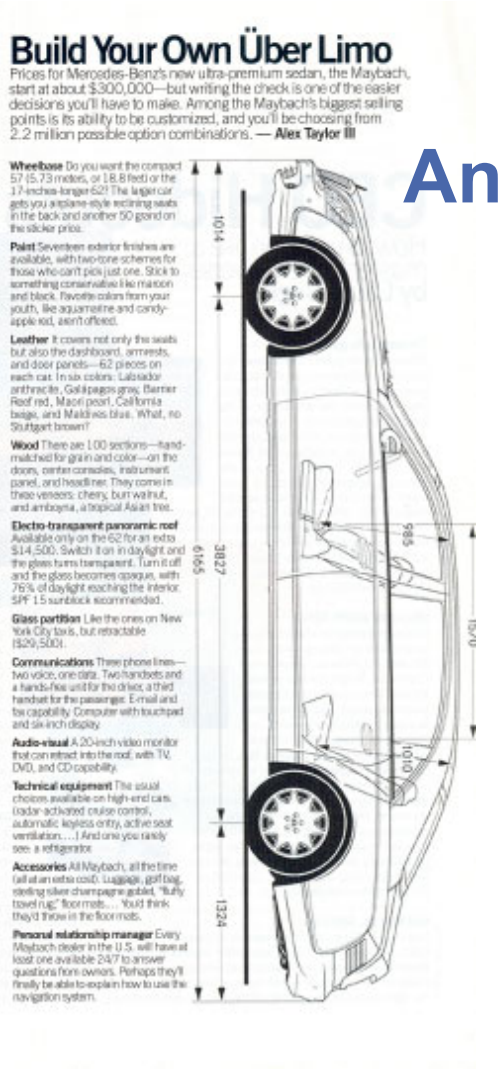




By 1918, half of all cars in America were Model Ts. To meet the growing demand for the Model T, the company opened a large factory at Highland Park, Michigan, in 1910. Here, Henry Ford combined precision manufacturing, standardized and interchangeable parts, a division of labor, and, in 1913, a continuous moving assembly line. Workers remained in place, adding one component to each automobile as it moved past them on the line. Delivery of parts by conveyor belt to the workers was carefully timed to keep the assembly line moving smoothly and efficiently. The introduction of the moving assembly line revolutionized automobile production by significantly reducing assembly time per vehicle, thus lowering costs. Ford's production of Model Ts made his company the largest automobile manufacturer in the world.

What is the product? And how many of them? Fords Model-T-Philosophy

"Any customer can have a car painted any color that he wants so long as it is black"



Build Your Own Über Limo

Prices for Mercedes-Benz's new ultra-premium sedan, the Maybach, start at about $300,000—but writing the check is one of the easier decisions you'll have to make. Among the Maybach's biggest selling points is its ability to be customized, and you'll be choosing from 2.2 million possible option combinations. — **Alex Taylor III**

Wheelbase Do you want the compact 5.7 (5.73 meters, or 18.8 feet) or the 17-inches-longer 6.2? The larger car gets you airplane-style reclining seats in the back and another 50 grand on the sticker price.

Paint Seventeen exterior finishes are available, with two-tone schemes for those who can't pick just one. Stick to something conservative like maroon and black. Favorite colors from your youth, like aquamarine and candy-apple red, aren't offered.

Leather It covers not only the seats but also the dashboard, armrests, and door panels—62 pieces on each car. In six colors: Labrador anthracite, Galápagos gray, Barrier Reef red, Maori pearl, California beige, and Maldives blue. What, no Stuttgart brown?

Wood There are 100 sections—hand-matched for grain and color—on the doors, center consoles, instrument panel, and headliner. They come in three veneers: cherry, burr walnut, and amboyna, a tropical Asian tree.

Electro-transparent panoramic roof Available only on the 62 for an extra $14,500. Switch it on in daylight and the glass turns transparent. Turn it off and the glass becomes opaque, with 76% of daylight reaching the interior. SPF 15 sunblock recommended.

Glass partition Like the ones on New York City taxis, but retractable ($29,500).

Communications Three phone lines—two voice, one data. Two handsets and a hands-free unit for the driver, a third handset for the passenger. E-mail and fax capability. Computer with touchpad and six-inch display.

Audio-visual A 20-inch video monitor that can retract into the roof, with TV, DVD, and CD capability.

Technical equipment The usual choices available on high-end cars (radar-activated cruise control, automatic keyless entry, active seat ventilation…). And one you rarely see: a refrigerator.

Accessories All Maybach, all the time (all at an extra cost). Luggage, golf bag, sterling silver champagne goblet, "fluffy towel rug," floor mats… You'd think they'd throw in the floor mats.

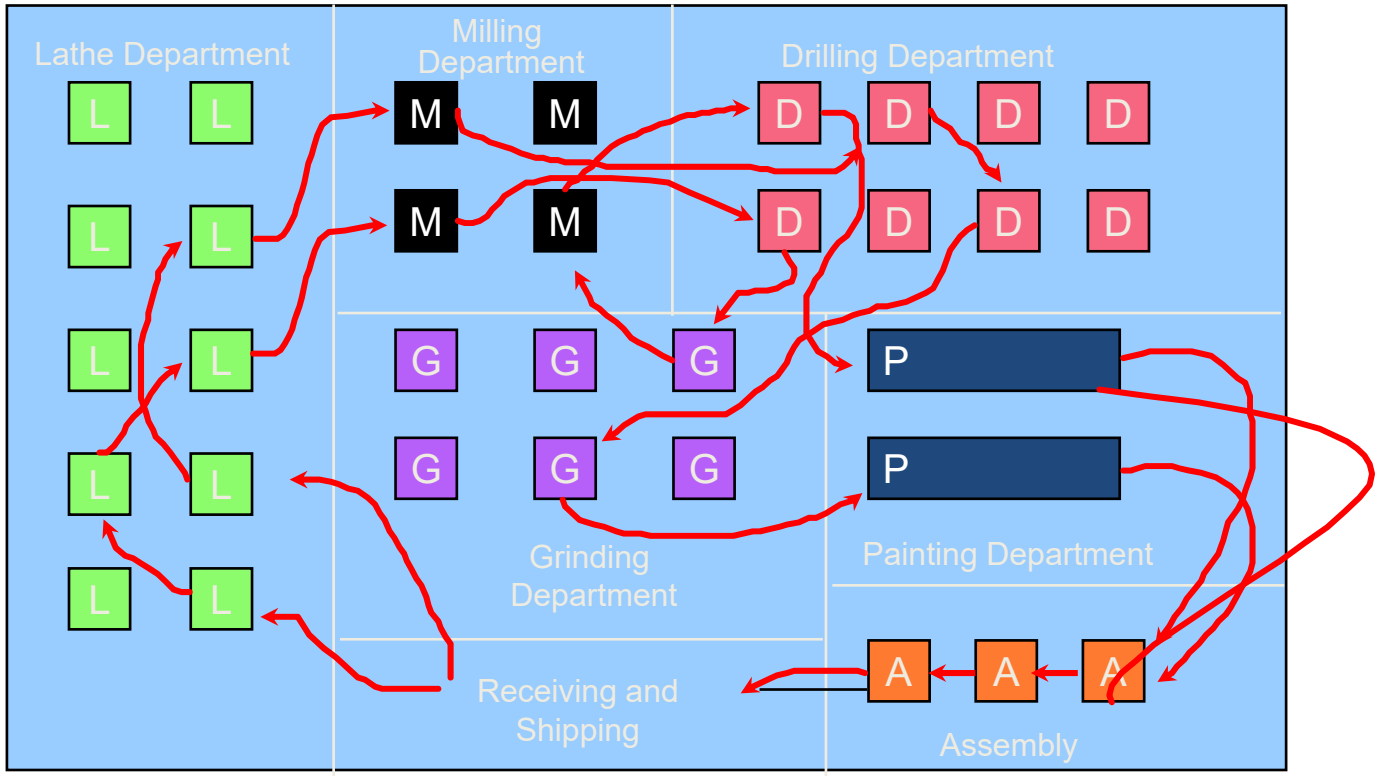
Personal relationship manager Every Maybach dealer in the U.S. will have at least one available 24/7 to answer questions from owners. Perhaps they'll finally be able to explain how to use the navigation system.

What is a good product?
And how many different one of them?

Prices for Mercedes-Benz's new ultra-premium sedan, the Maybach, start at about $300,000—but writing the check is one of the easier decisions you'll have to make. Among the Maybach's biggest selling points is its ability to be customized, and you'll be choosing from 2.2 million possible option combinations. — **Alex Taylor III**

Turning back to Craftmanship?

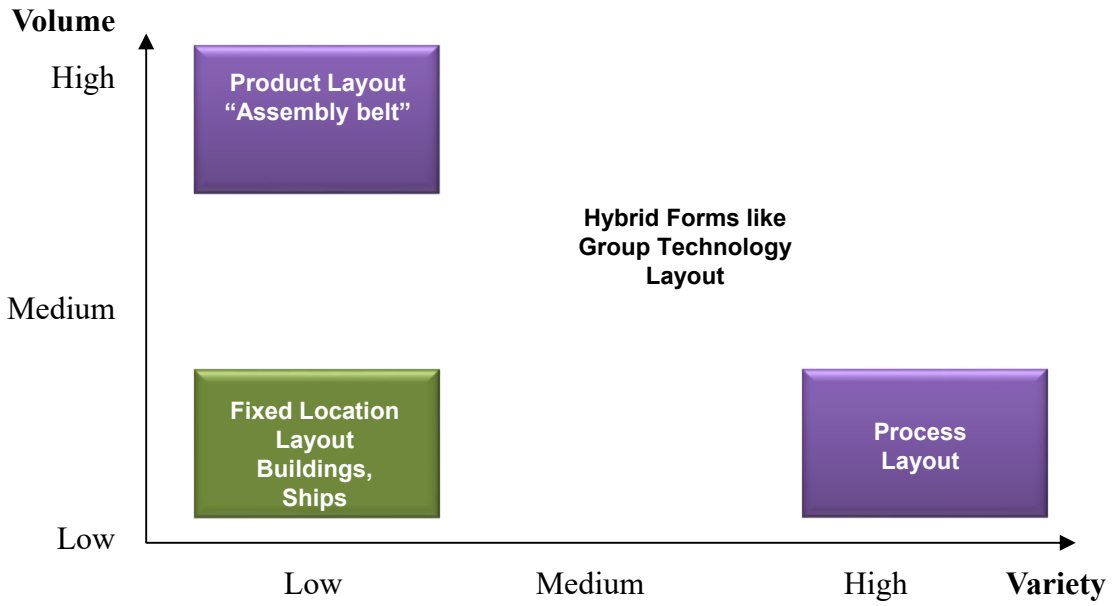
Process Layout – Job shop layout



Are there other ways to organize production – Basic Layout-types Why, how?

Criteria for the Organization	Basic Type - Characteristics	Key Advantage Key Disadvantage
The production process	**Product layout „line“, „flow shop layout“** • **Layout that uses standardized processing operations to achieve smooth, rapid, high-volume flow** • **Linear arrangement of specialized workstations to produce a specific product**	High volume production with unlearned but specialized workers possible High initial setup costs and setup times; thus inflexible
The machine processes (single tasks)	**Process layout , „job shop layout“** • **Centers/machines grouped by process they perform** • **Departments (sewing, kitting…) more universal machinery**	Allows for different product routings; flexibility Need for routing, scheduling, and transportation between single production steps; + setups
The final product	**Fixed Position Layout** • **Product/ project stationary; workers, materials, and equipment are moved as needed** • **Used in projects where the product cannot be moved**	Suitable for big single products/processes „one time“

When doing what?
Basic Types of Layout
Volume vs. Variety



Just to notice! "Operations" Management
Some more Milestones in History

Contributions to Operations Management Since 1900

1900	Scientific Management Functional Organization Cost Systems	Frederick Taylor
1900	Motion Study	Frank Gilbreth
1901	Gantt Charts for Scheduling and Monitoring	Henry Gantt
1910	Efficiency Principles	Harrington Emerson
1913	Moving Assembly Line	Henry Ford
1914 (& 1933)	Statistical Tables and Techniques	Karl Pearson
1915	Economic Order Quantity Concept for Inventory Management	F. W. Harris
1924	Statistical Techniques for Quality Control	H. F. Dodge G. H. Romig W. A. Shewhart
1934	Activity Sampling Techniques	L. H. C. Tippett
1938	Operations Research	P.M.X. Blackett & Others
1947	Applications of Linear Programming	G. B. Dantzig
1949	Systems Analysis	Norbert Weiner Jay Forrester
Since 1950	Computer Applications – Simulation – Materials Requirements Planning (MRP) – Computer Aided Design and Manufacturing (CAD/CAM) Decision Theory Numerically Controlled Machines Robotics	Numerous Contributors

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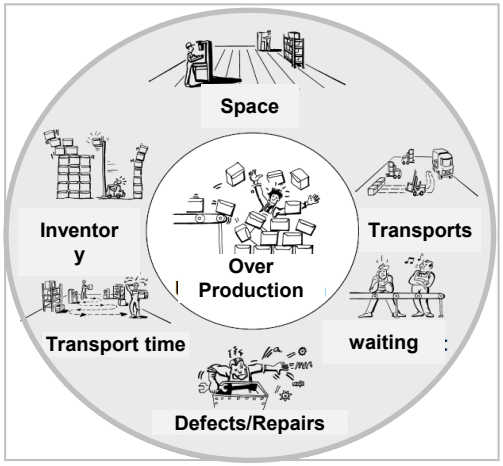
History continued:
But also the other side of "Taylorism"

Henry Knolle, May 9, 1871–February 25, 1925. The man known as "Schmidt" in Taylor's Pig Iron Story, 1899.

- Human work as a production factor:
  - Workload and Bonus: Bringing the predefined daily workload results in premium pay
  - Fixation of the new Systems in operating instructions record cards (bureau for work planning)
  - Responsibility for the work design on foremen (bosses)
- But "Worker Reactions"
  - "Congress investigated complaints by government workers and the use of stopwatches was banned by law in government shops"
  - "workers had gone on strike at the Watertown Arsenal when specialists came in with stopwatches"
  - "Taylor blamed this on union agitators but it was in fact directed at Taylorism – skilled workers did not want to loose control of their work"
  - "workers weren't convinced by Taylor's belief that rationalizing management so that it was fair according to scientific principles would eliminate the conflict between workers and management"

Mura, muri, muda

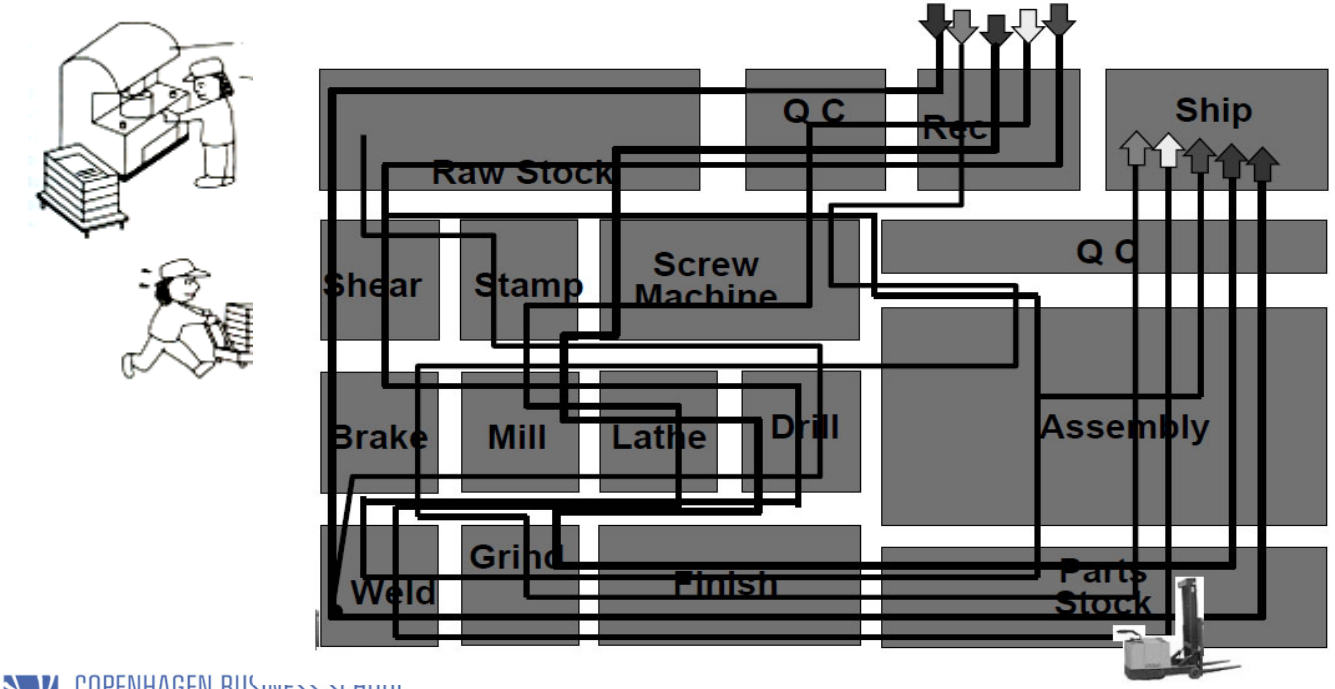
Mura: "Unevenness"



Muri: Overburden, unreasonableness

- Muda: wasteful activities
  - Overproduction and early production producing over customer orders, producing unordered materials / goods.
  - Waiting, idle time (time when no value is added to the product) .
  - Transportation handling more than once, delays in moving materials, unnecessary moving or handling .
  - Inventory - unnecessary raw materials in stores, work in process (WIP), & finished stocks .
  - Motion - movement of equipment or people that add no value to the product .
  - Over-processing - unnecessary processing or procedures (work carried out on the product which adds no value) .
  - Defective units producing or reworking scrap.

What is wrong here?



Waste of Overproduction

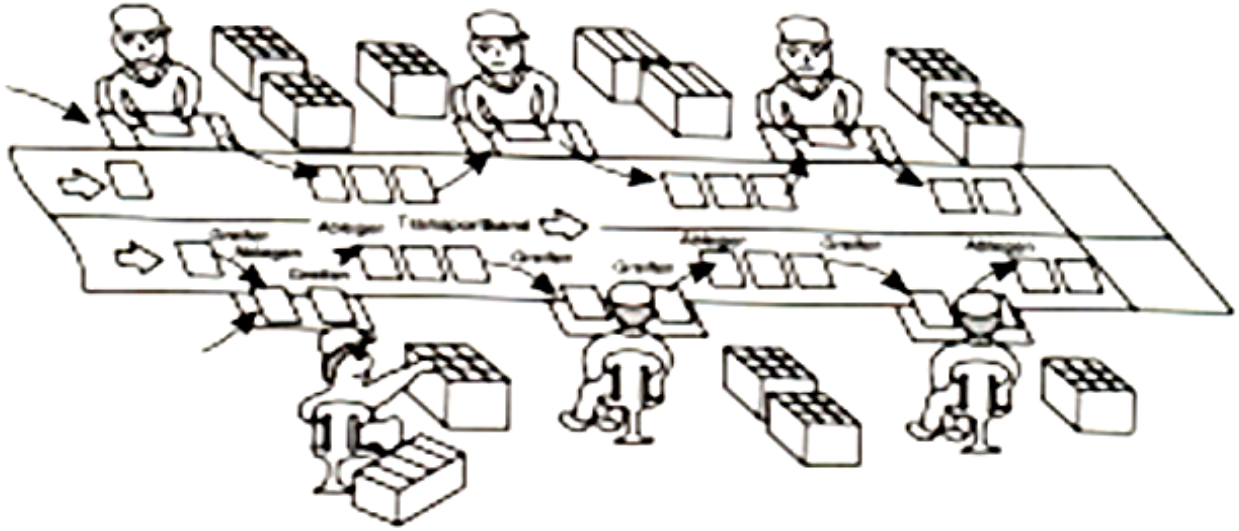
Waste of Overproduction – What are the reasons?

- Making products FASTER than really needed!
- Making products SOONER than needed!
- Making MORE products than neeeded!
- Producing in BATCHES!

Waste of Waiting

- Causes of Waiting Waste
  - "Working" by intense observation
  - Long set-up times
  - Waiting for tools
  - Unbalanced workload between
  - Batch processes
  - Equipment breakdowns (due to bad maintenance)

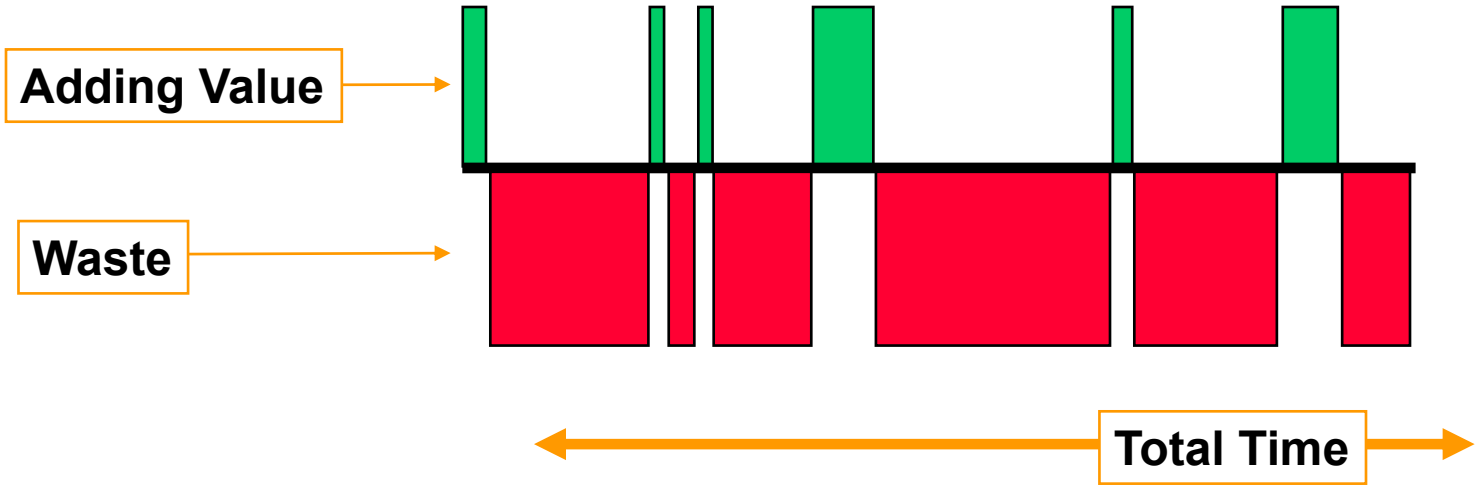
Motion waste



- Causes of motion waste
  - Poor ergonomics
  - Poor plant or workstation layout
  - Storage/packaging/sorting/ looking for items
  - Etc.

What is wrong here

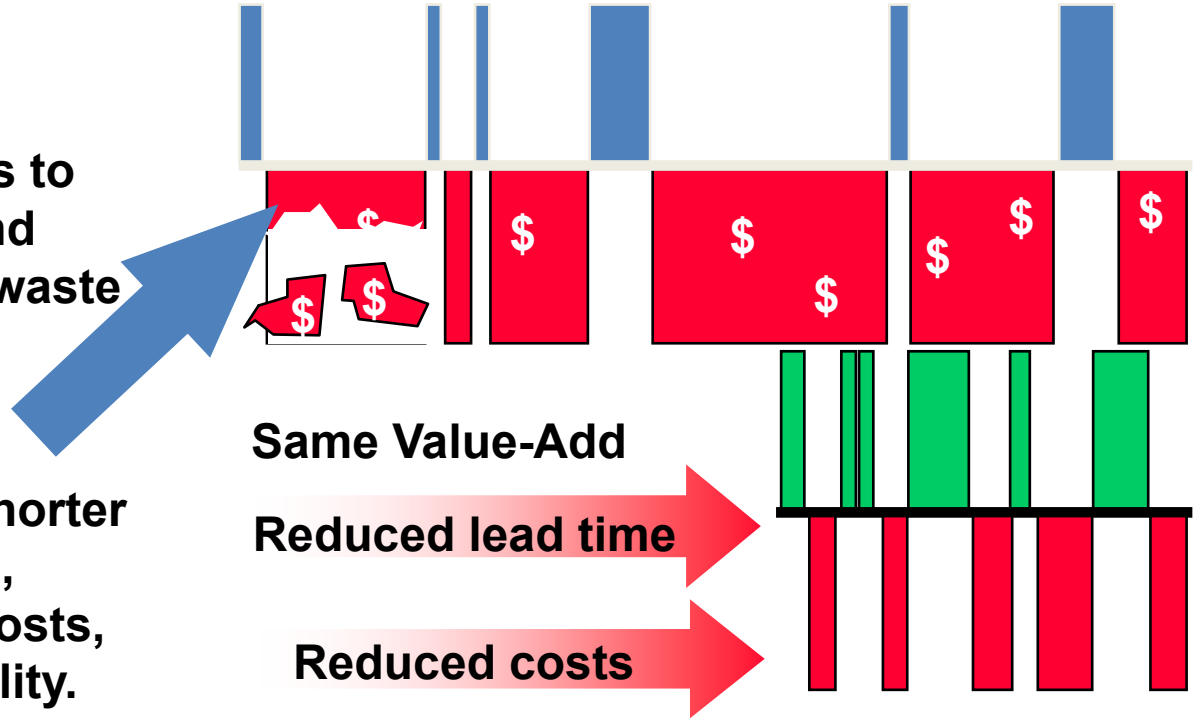
Lean - A Strategy Based on Lead Time Compression



A strategic focus to *economically* make drastic reductions in lead time to <u>better serve the customer</u>. Think No Cost/Low Cost.

Lean - A Strategy Based on Lead Time Compression

Lean Tools to identify and eliminate waste

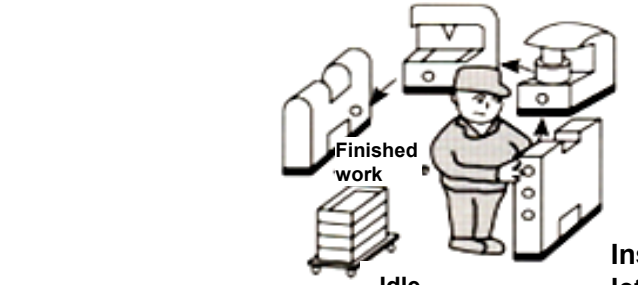


Result: Shorter lead times, reduced costs, better quality.

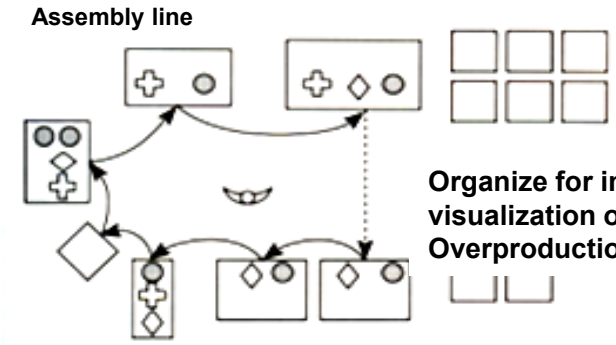
Uneven processes and waste of defects

- **Money and time wasted to find mistakes and fix or replace products**
  - Causes
    - Lack of process controls
    - Delayed reaction to detected problems
    - Poor quality of incoming materials
    - Lack of maintenance
    - Inadequate operator training
    - Poor worker instructions

What could be done?
E.g. avoiding overproduction

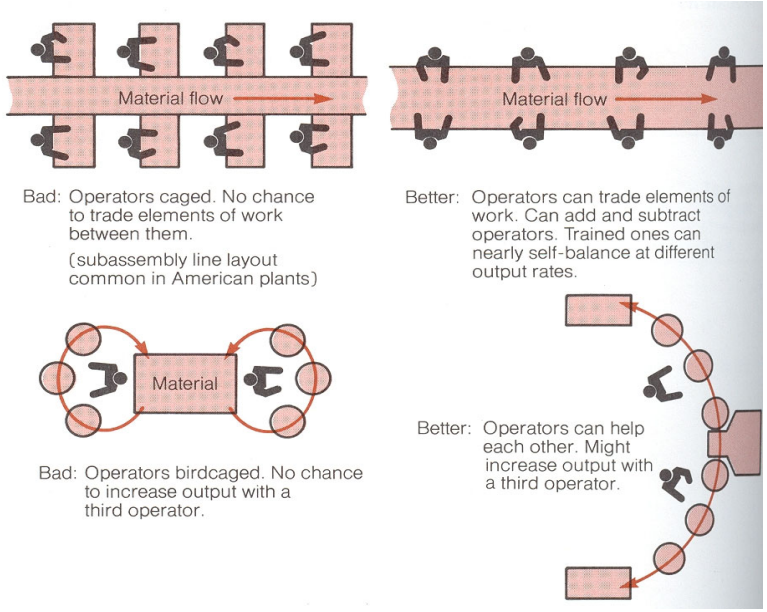


Instruct workers to let their hands rest



Organize for immediate visualization of Overproduction

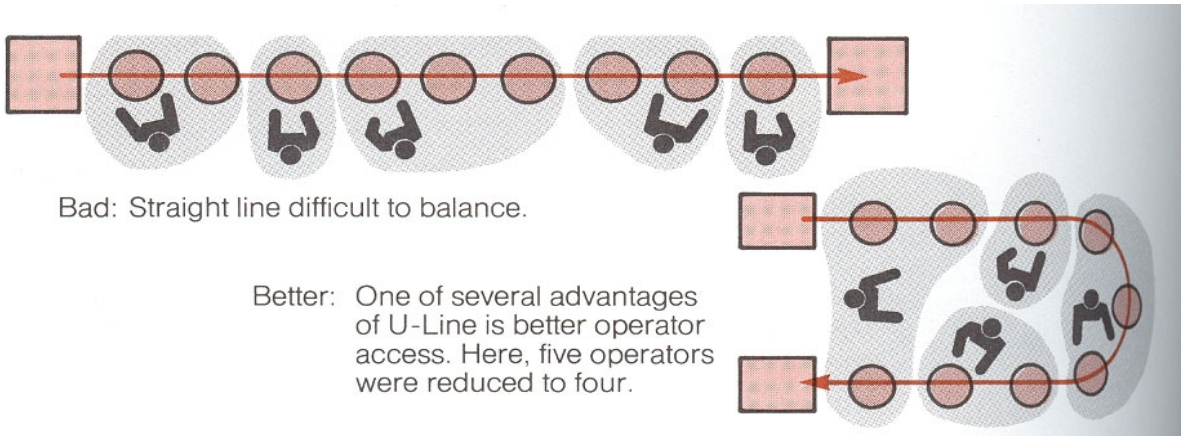
Improving the flow not the single activity …



- e.g. „Principles of flow systems“ … a flow is the better, the …
  - …less „media disruptions“ along the flow occur (Unification of objects“),
  - … more even, smooth, and quick the flow is running („Leveling“, „Impulse reduction“, „Economics of Speed“),
  - … earlier and more robust errors are addressed
  - … stronger the alarm signals are when errors or overload occurs
  - … more succeeding processes overlap
  - … clearer the “baton passing” is at the interface

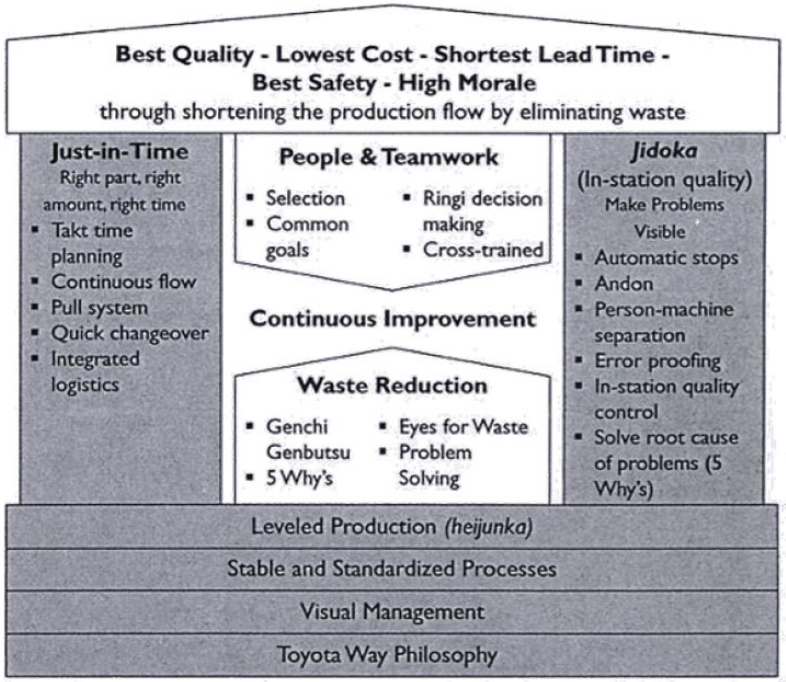
With Humans and Machines as supporting elements

- The better, the shorter, more direct and less interrupted the linkage between source and sink is designed
- The more related activities are bundled (in time and place) and linked (Segmentation; Flow-Units)
- The closer the information flow can be coupled with the physical flows



Wrap up the major ideas so far

Elements of Lean Management: Lean Philosophy techniques and tools



- Lean Philosophy
  - Eliminate waste
  - Involve everyone
  - Improve continuously
- Basically **two „pillars“**
  - Flow (Just-in-Time)
  - „Autonomation“ (human/machine-systems aiding the humans)
- Lean techniques (JiT-Techniques)
- JiT as a Planning and Control-Method (Pull, Kanban)

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Beyond Leanness: Agility, Adaptability & Alignment

- Agile supply chains are those that that respond both quickly and cost-efficiently (Lee, 2004)

Building the Triple-A Supply Chain

Agility

Objectives:

Respond to short-term changes in demand or supply quickly; handle external disruptions smoothly.

Methods:

- Promote flow of information with suppliers and customers.
- Develop collaborative relationships with suppliers.
- Design for postponement.
- Build inventory buffers by maintaining a stockpile of inexpensive but key components.
- Have a dependable logistics system or partner.
- Draw up contingency plans and develop crisis management teams.

Adaptability

Objectives:

Adjust supply chain's design to meet structural shifts in markets; modify supply network to strategies, products, and technologies.

Methods:

- Monitor economies all over the world to spot new supply bases and markets.
- Use intermediaries to develop fresh suppliers and logistics infrastructure.
- Evaluate needs of ultimate consumers—not just immediate customers.
- Create flexible product designs.
- Determine where companies' products stand in terms of technology cycles and product life cycles.

Alignment

Objective:

Create incentives for better performance.

Methods:

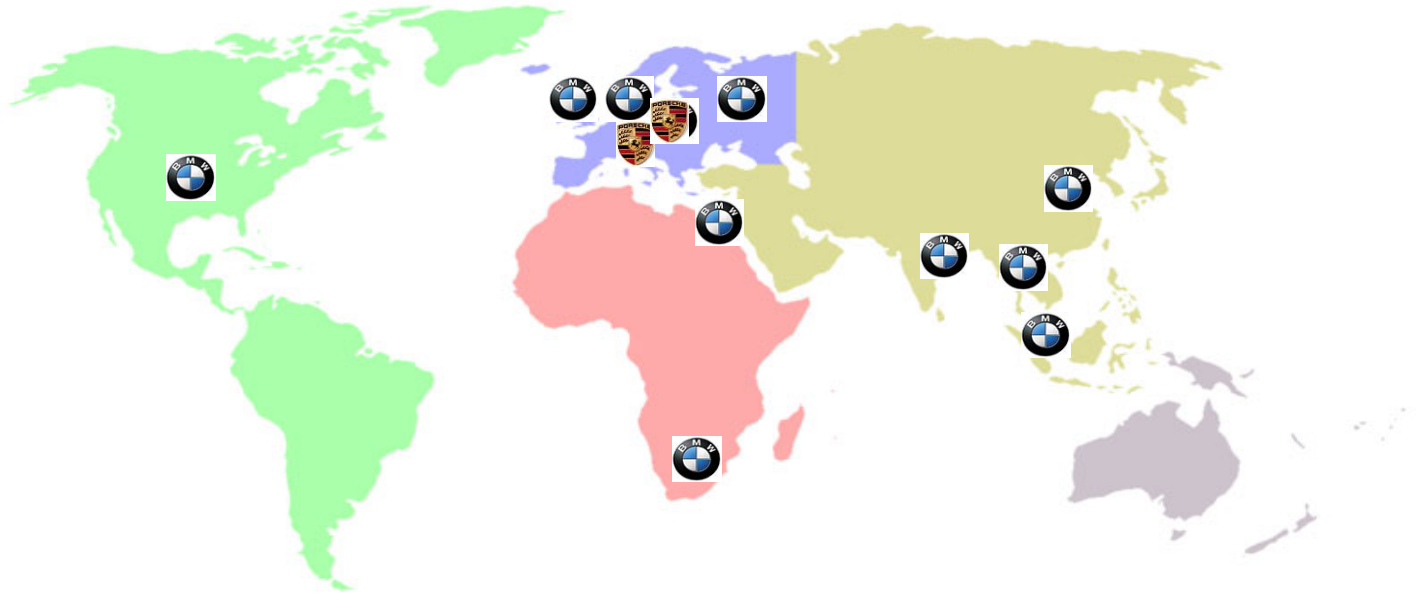
- Exchange information and knowledge freely with vendors and customers.
- Lay down roles, tasks, and responsibilities clearly for suppliers and customers.
- Equitably share risks, costs, and gains of improvement initiatives.

Today's Topics

- Production planning and design
  - Context and development – Milestones in the history of production
    - Production layout, scheduling and materials planning
  - More current approaches and main production systems – From Mass to Lean ("flexible mass") and Agile production systems
- Global Production systems/networks

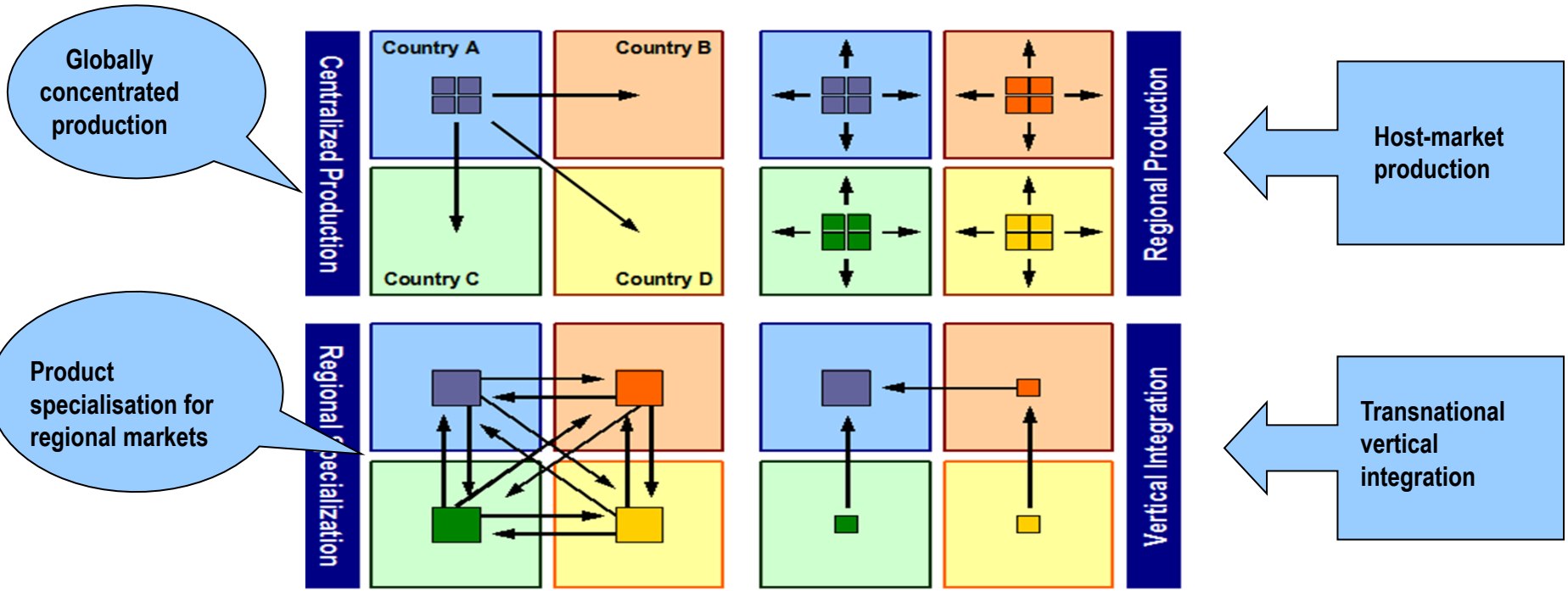
Where in the world is Porsche and BMW competing?

… und where do they produce?



Source: Spina

Broad production location strategies Dicken (2003)



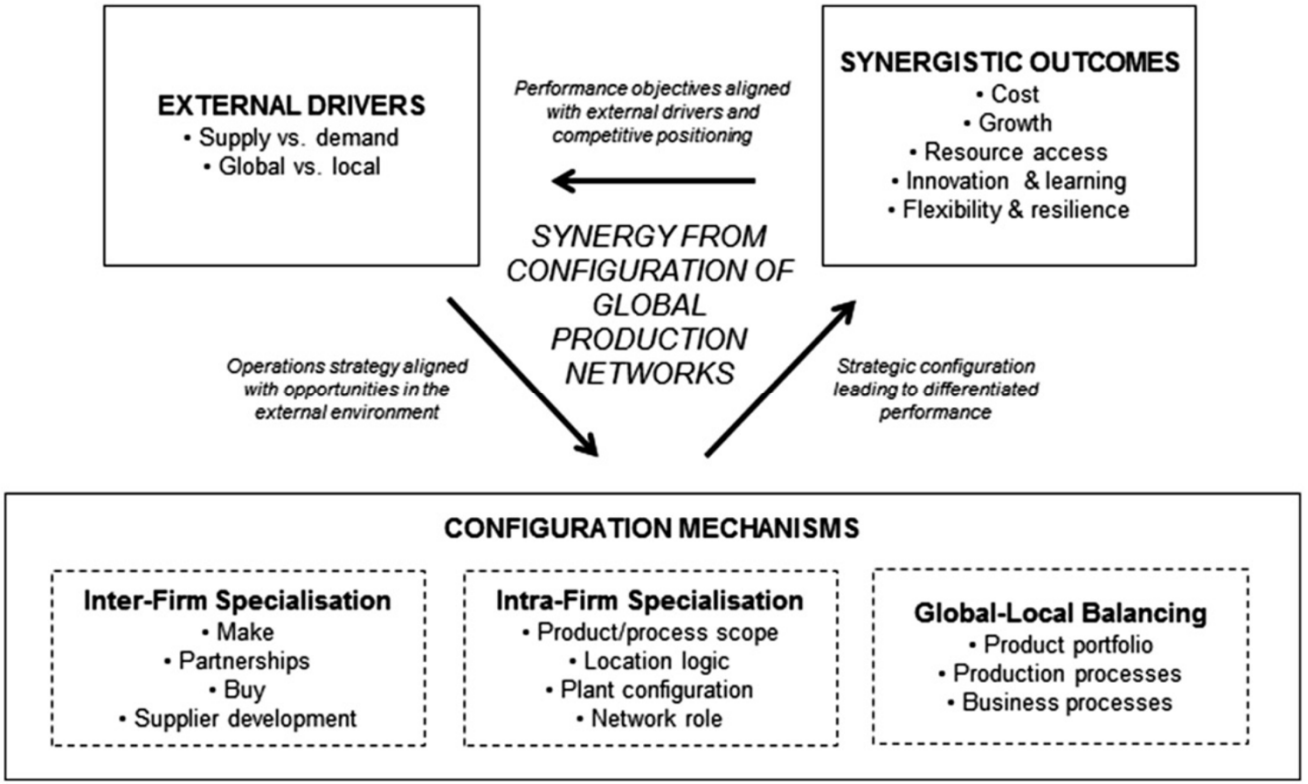
Three questions for you

From the article from Christodoulou et al

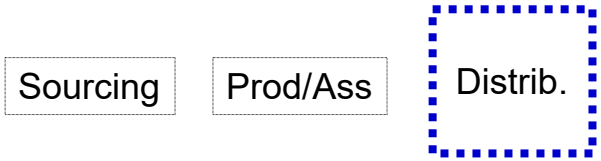
Questions

- Read in particular until including section 3 and identify drivers for GPN
- What are dilemmas when designing GPN
- In the context of Covid-19 or Ukraine/Energy, how do you assess the balance of global vs. local pressures

Christodoulou et al



1 - "The Porsches"



- Strong global brands from strong local roots
- Competitive advantage of local sourcing and manufacturing (districts, valleys)
- Industries:
  - luxury goods (watch industry);
  - OEM and capital equipment
  - EU Automotive (top brand: Ferrari; Porsche; BMW till mid 90's)
- Difficult to maintain as delivery and cost pressures increase

Source: Spina

2 – "Cloners"

Sourcing	Prod/Ass	Distrib.
Sourcing	Prod/Ass	Distrib.
Sourcing	Prod/Ass	Distrib.

- Replications of multi-country operations

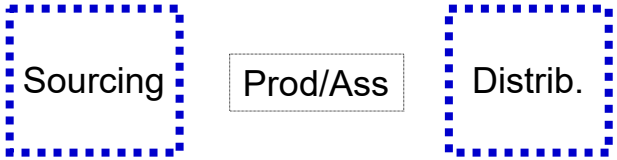
- Localized supply chains, products
- Critical issue: knowledge transfer and best practice implementation from one country to another

Source: Spina

3 – "Shoppers"

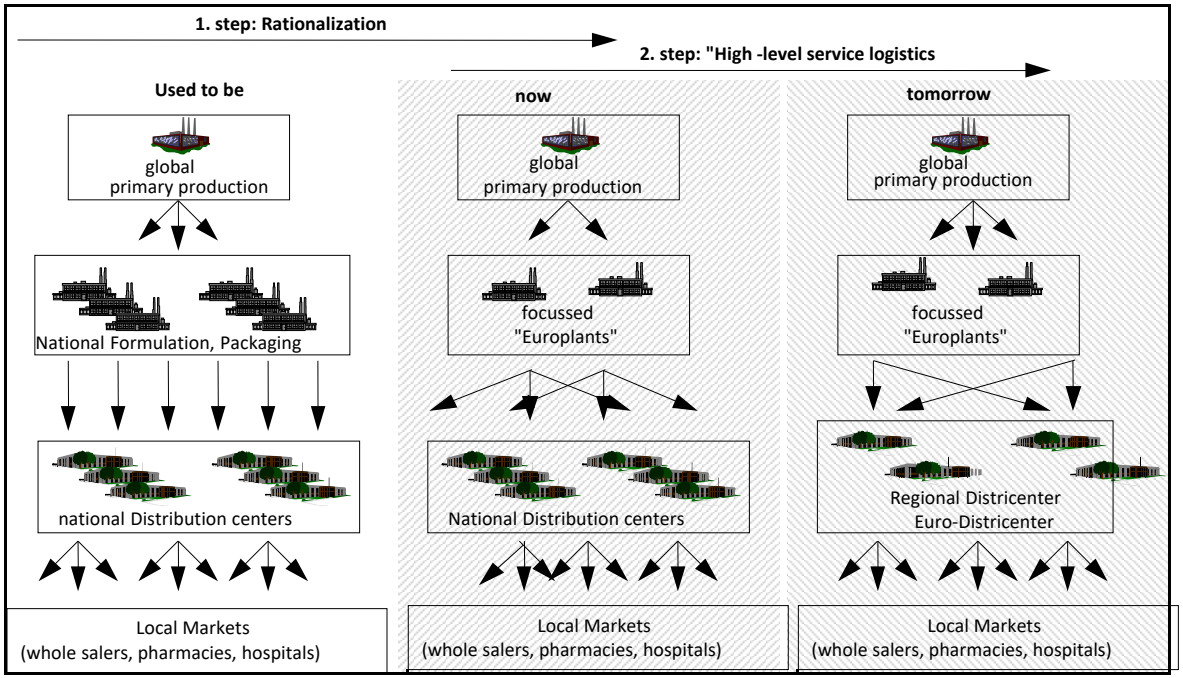
- Shopping around the world, downstream operations at the local theatre
- Global commodity markets or global concentration of part suppliers
- E.g.: papermills, sugar, transplants, high–end fashion, EMS (Electronic Manufacturing Service)
- Supply Chain: Complex inbound

4 – “Outreachers”

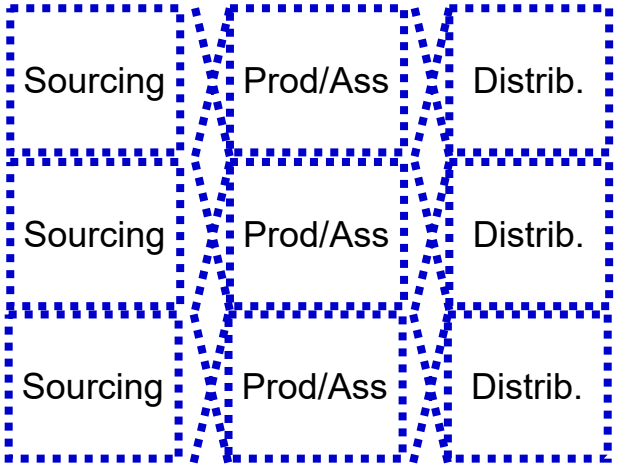


- Global brands, huge R&D investments paid back on a global scale only
- International markets for sophisticated technologies and parts
- E.g.: Aerospace, Supercomputing, Semiconductors, Integrated textile-apparel chains (Zara, etc..)
- Sometimes evolution of the “Porsches”

Serving global Markets – Economies of Scale don`t stop at borders



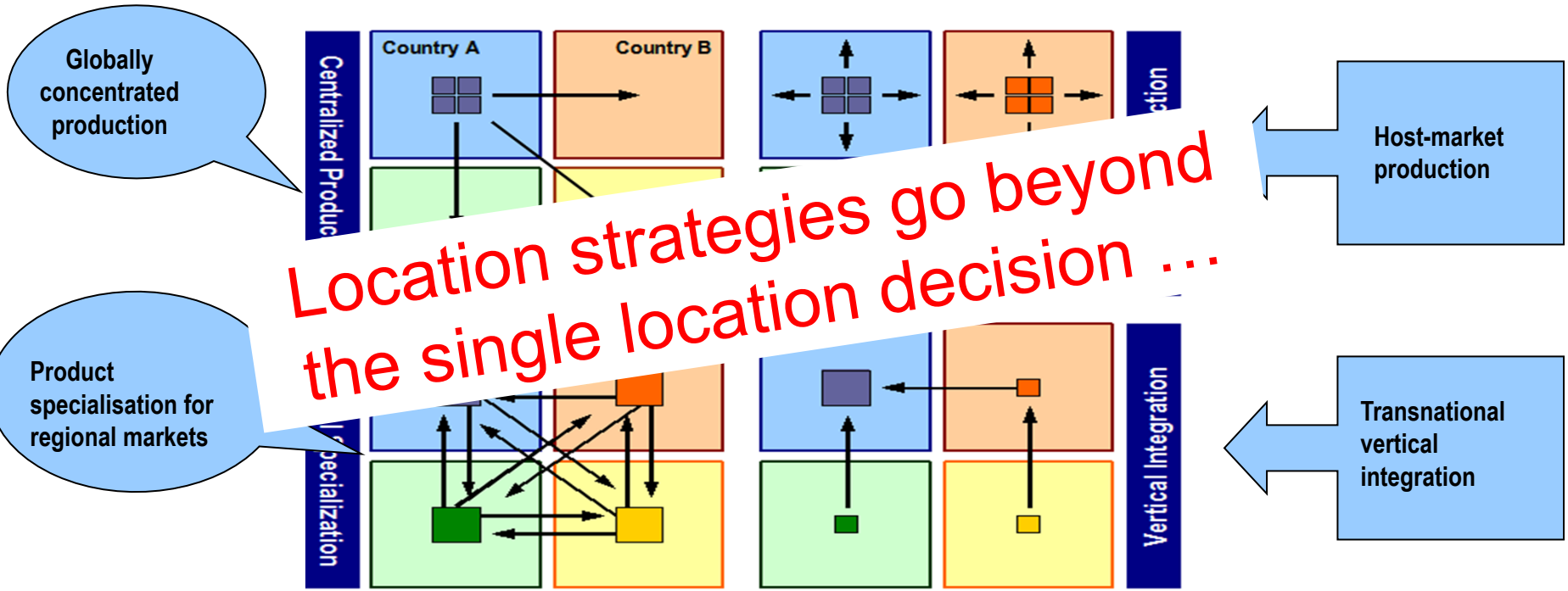
5 – "Full players"



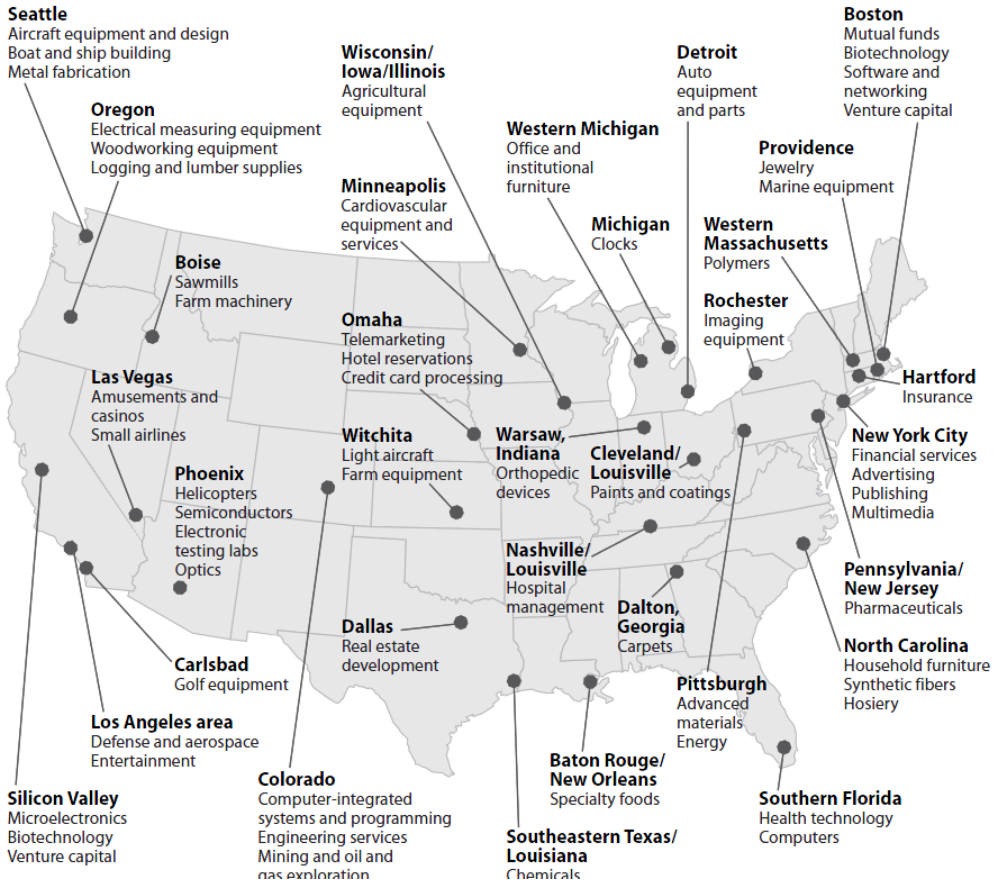
- Large scale producers, global branding, large scale suppliers
- E.G.: Consumer electronics, Chemical, Food (partially), Pharma (partially)
- Complex SCM, cross-country flows

Source: Spina

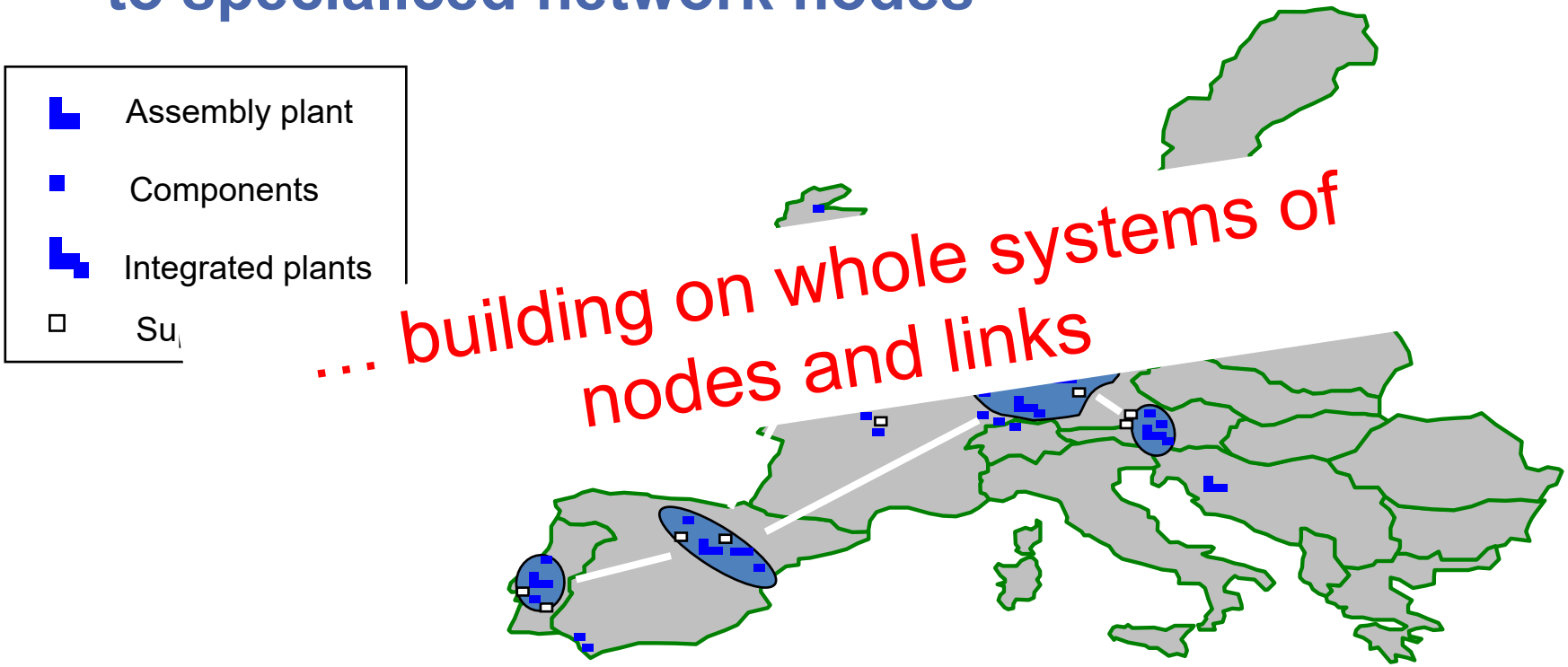
Broad production location strategies Dicken (2003)



Another issue - agglomeration



And a view away from single location to specialiced network nodes



Yourself - voluntary

Questions

- Where do we produce different products – go to the internet and check “footprints” of well known companies
- Where are clusters and hotspots, e.g. for automotive, for apparel
- How are these connected, what markets do they serve, local vs. global