JACOBS UNIVERSITY

INDUSTRIAL ENGINEERING

Prof. Dr. Dr.-Ing. Yilmaz Uygun

Chapter 08

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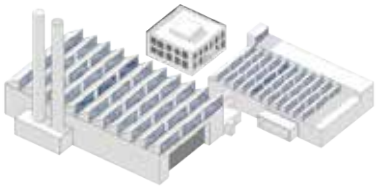
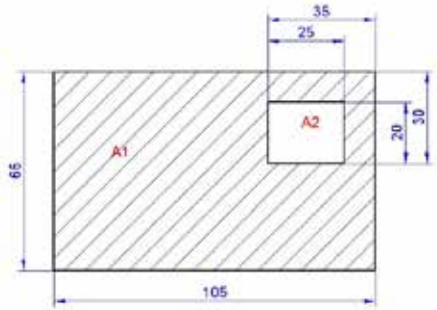
Chapter 08

FACILITY PLANNING

HIERACHIES OF FACILITY PLANNING





TYPES AND PROPERTIES OF SPACES

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Types and Properties

Types of Spaces

- Storage area
- Transportation area
- Handling area
- Office space
- Recreational area
- Buffer zones
- …

Potential Space Properties

- Lighting properties
- Temperature
- Soil bearing capacity
- Clearance
- Safety (theft)
- Fire protection
- Expandability
- Range of use (flexibility)
- …

Examples

Network

- Storage areas
- Handling areas
- …

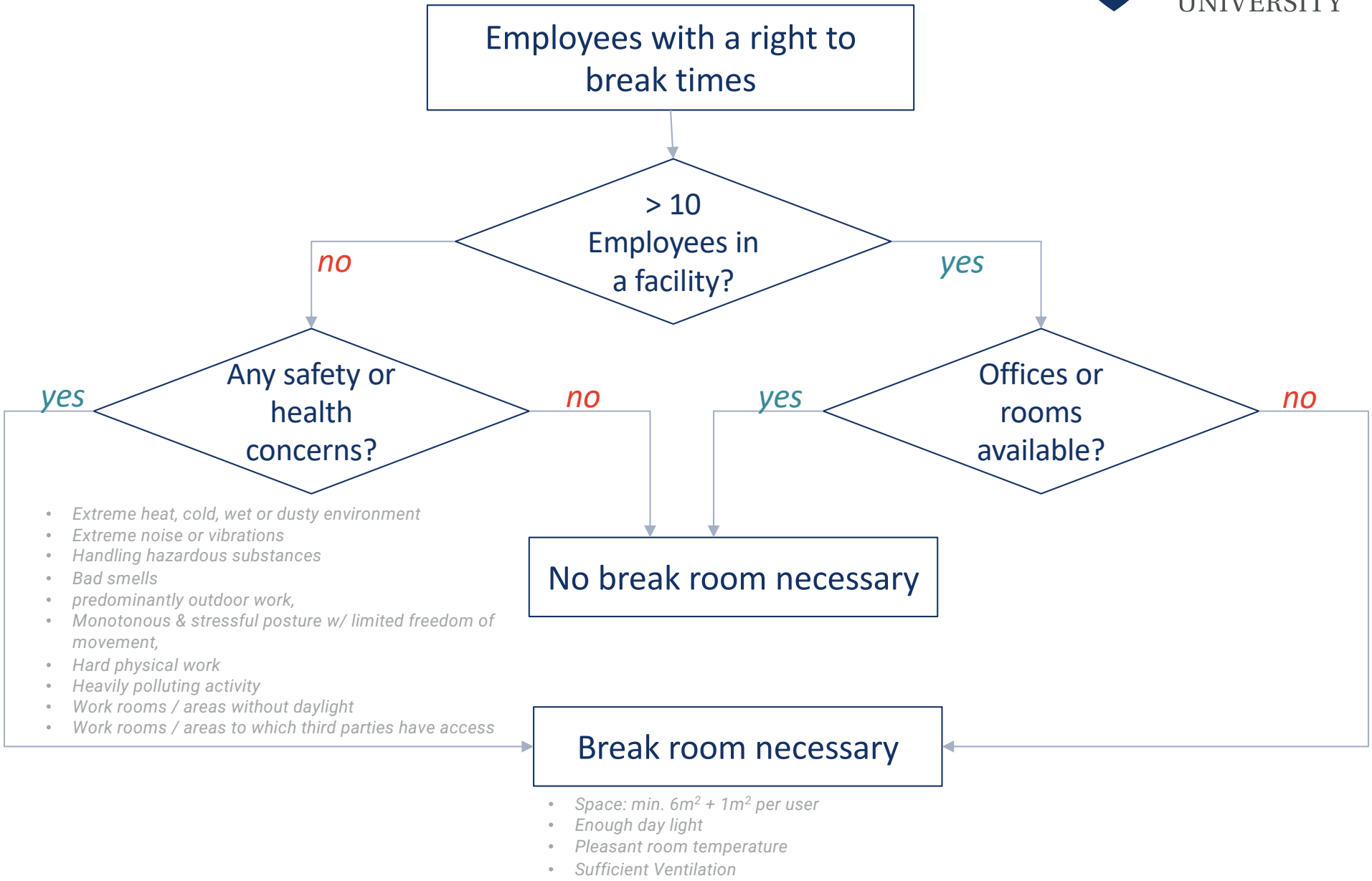
Facility

- Storage areas
- Recreational areas
- Office spaces
- …

System

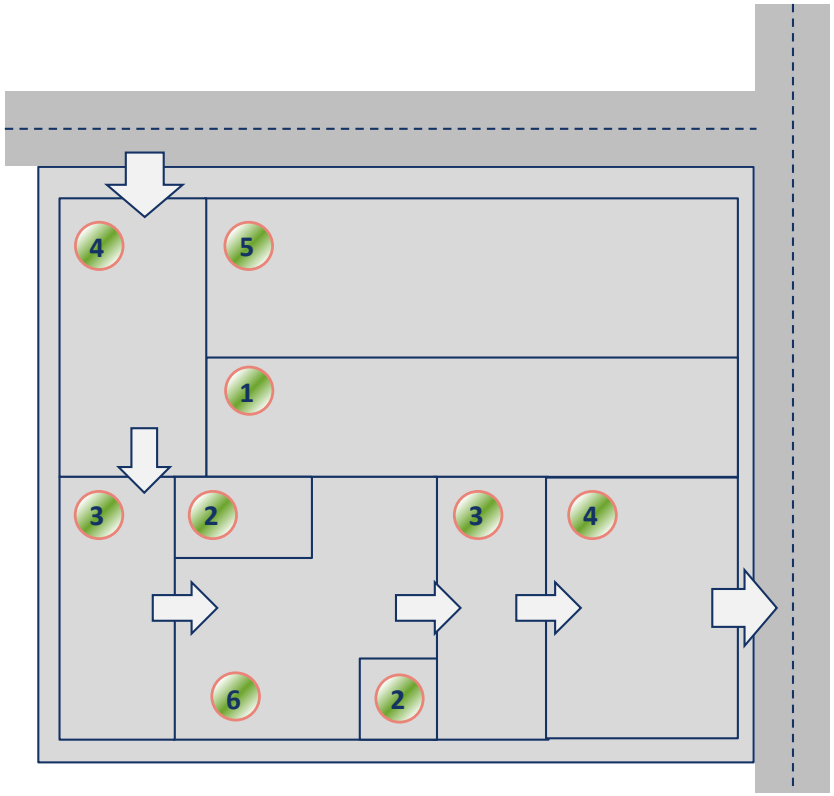
- Buffer zones
- Storage areas
- Picking areas
- Transportation areas
- …

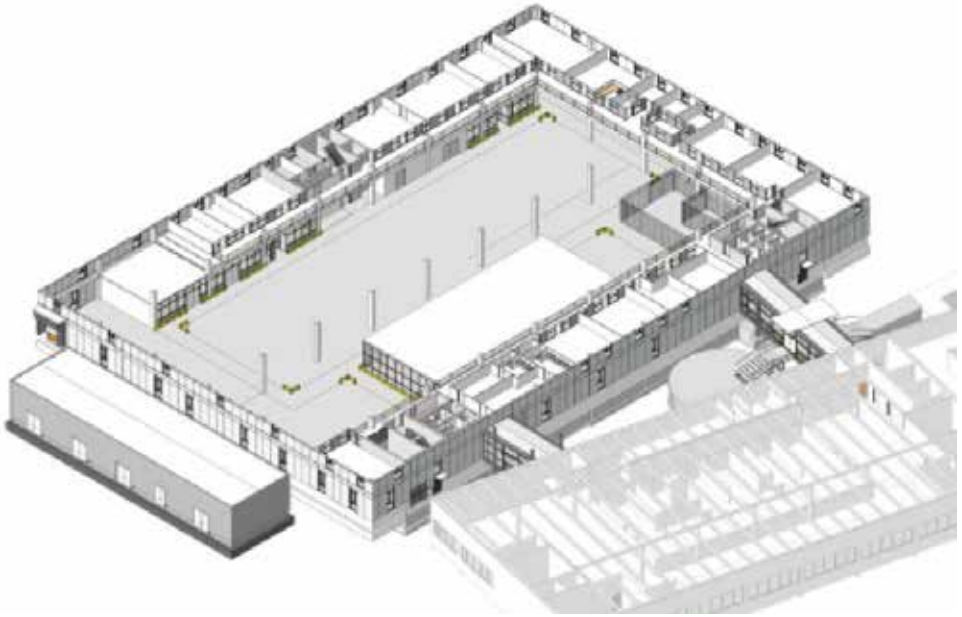
RECREATIONAL AREAS



Source: German Federal Institute for Occupational Safety and Health

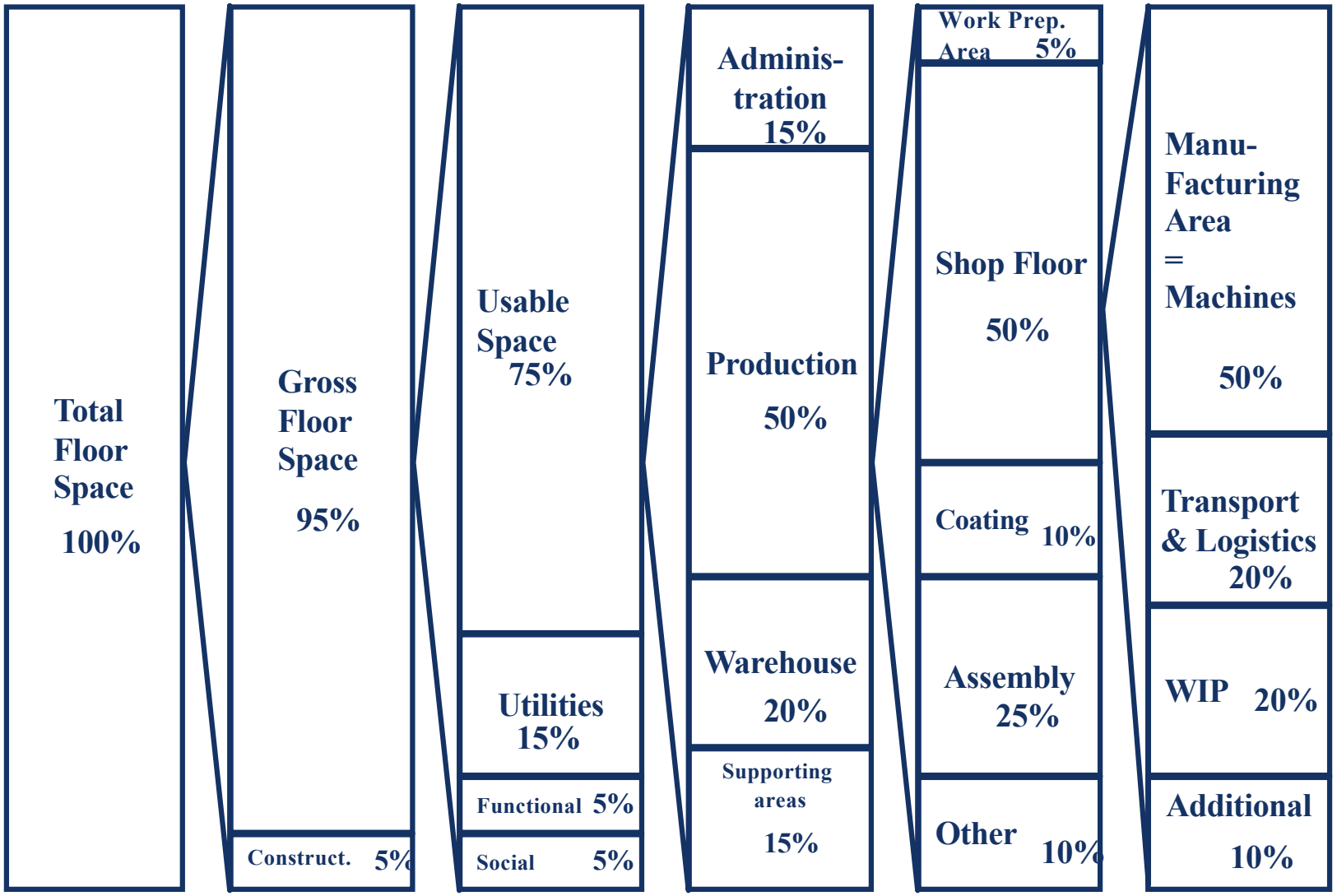
FACILITY-LEVEL SPACE REQUIREMENTS



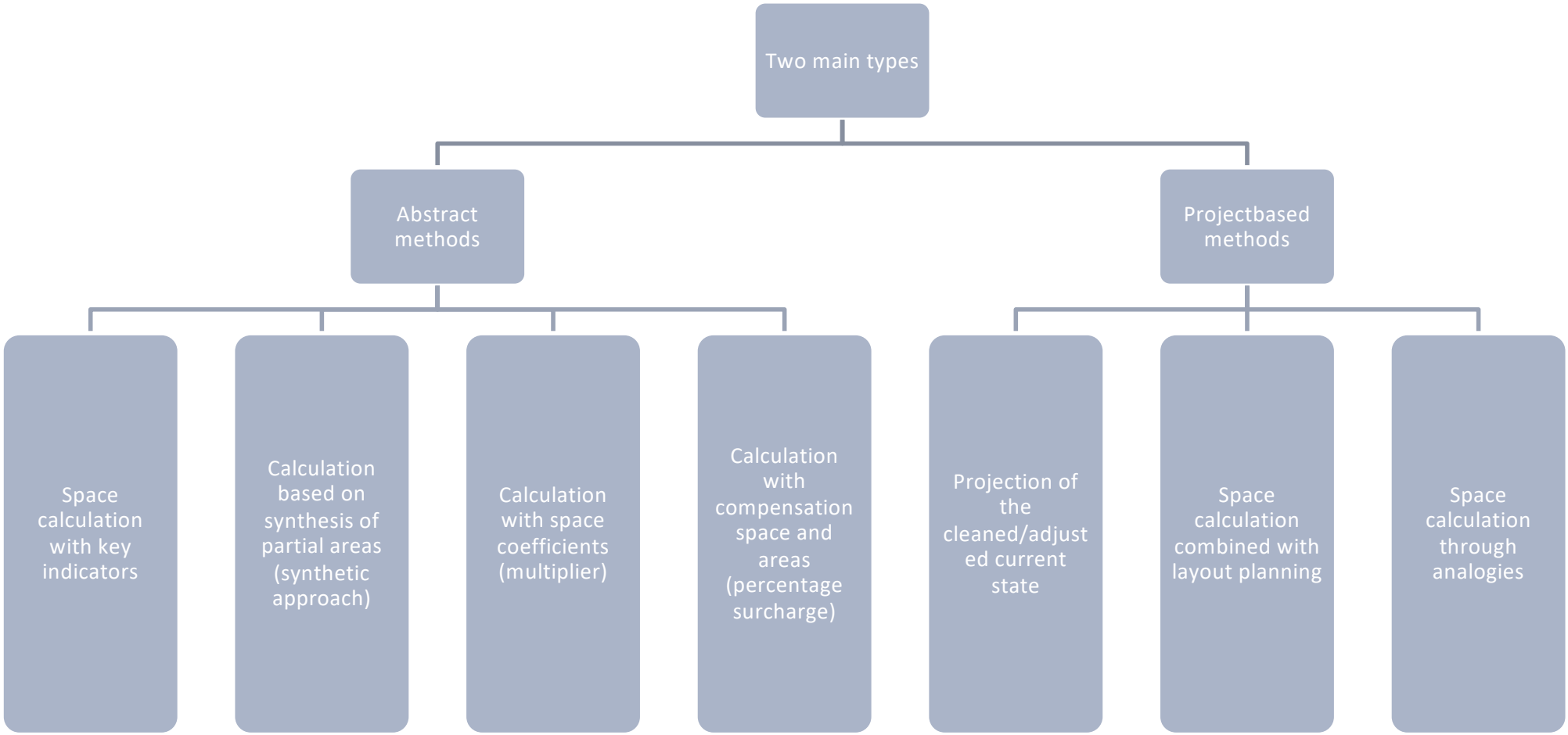


1. Administration
2. Recreational areas
3. Parts delivery / shipping
4. External area
5. Parking lot
6. Manufacturing shop floor

TYPICAL FLOOR SPACE IN A MANUFACTURING FIRM



SPACE REQUIREMENT CALCULATION



SPACE REQUIREMENT CALCULATION
SYNTHETIC APPROACH

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Main Functional Areas:

- Production space
- directly relevant logistics and storage areas
- supporting and other spaces, such as production control, quality control, packaging, etc.

Main Functional Area: $\mathbf{A_{MF} = A_M + A_{WIP} + A_T + A_Q + A_F\ [m^2]}$

A_M = total space of machine

A_{WIP} = WIP area

A_T = transportation area

A_Q = quality control area

A_F = free area

TOTAL SPACE OF MACHINES (AM) – FUNCTIONAL AREAS

Movement areas

Contiguous, unobstructed floor areas at the workplace that are at least necessary to enable employees to change work postures and compensate movements during their work.

Free Movement Area

Contiguous, unobstructed space at the workplace that is at least required to allow employees to change work postures and compensate movements during their work.

Corridors to workplaces*

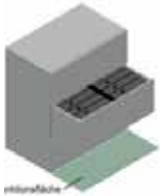
Traffic routes that allow unhindered access to the personally assigned workplaces

Aisles to operating facilities

Used occasionally are traffic routes that allow unhindered access to the use of operating facilities (e.g. heating, windows, electrical supply)

Storage / WIP areas

floor areas required for work equipment (e.g. raw materials, equipment), fixtures, fittings and other items (e.g. waste) regardless of whether they touch the ground or not.



Additional functional areas*

floor areas that are covered by moving parts of work equipment, fixtures and fittings.

Areas for safety distances*

floor areas at workplaces, work equipment, fixtures and fittings that are required to avoid endangering employees.

** If applicable & not covered by other transportation areas*

TOTAL SPACE OF MACHINES (AM) - CALCULATION

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Functional areas of a work station
e.g. CNC Lathe

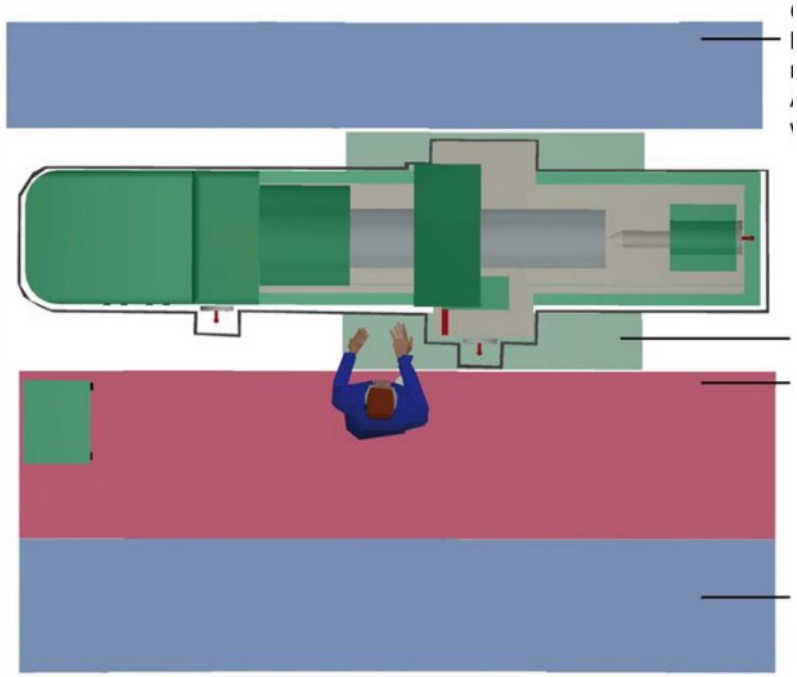
1. Machine footprint M_{fi}
2. (Operator´s) Movement area A_{Opi}
3. (Raw) Material supply area A_{Mati}
4. Tool supply area A_{Ti}
5. Aisle to operating facilities (Maintenance) A_{Mi}
6. Area for scrap A_{Si}

Calculation of Total Space of Machines

$$A_M = \sum_{i=1}^{n} A_{Mi}$$

$$A_{Mi} = M_{fi} + A_{Opi} + A_{Mati} + A_{Ti} + A_{Mi} + A_{Si}$$

TOTAL SPACE OF MACHINES (AM) – FUNCTIONAL AREAS

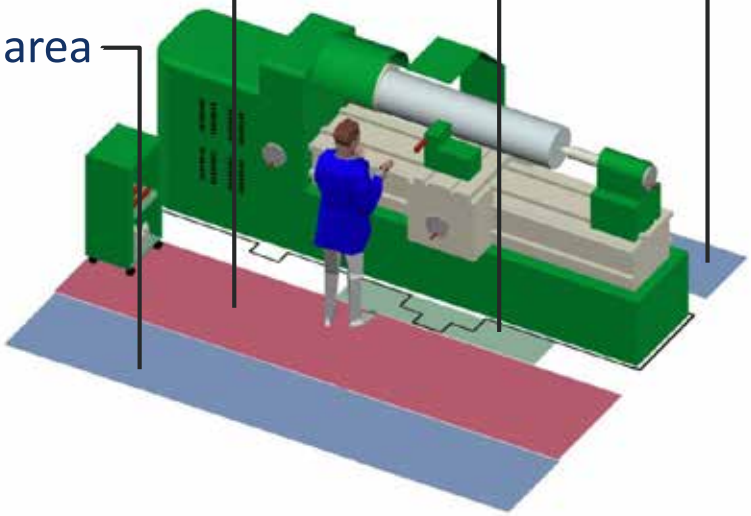


Aisle to operating facilities
- width: min. 0.5 m

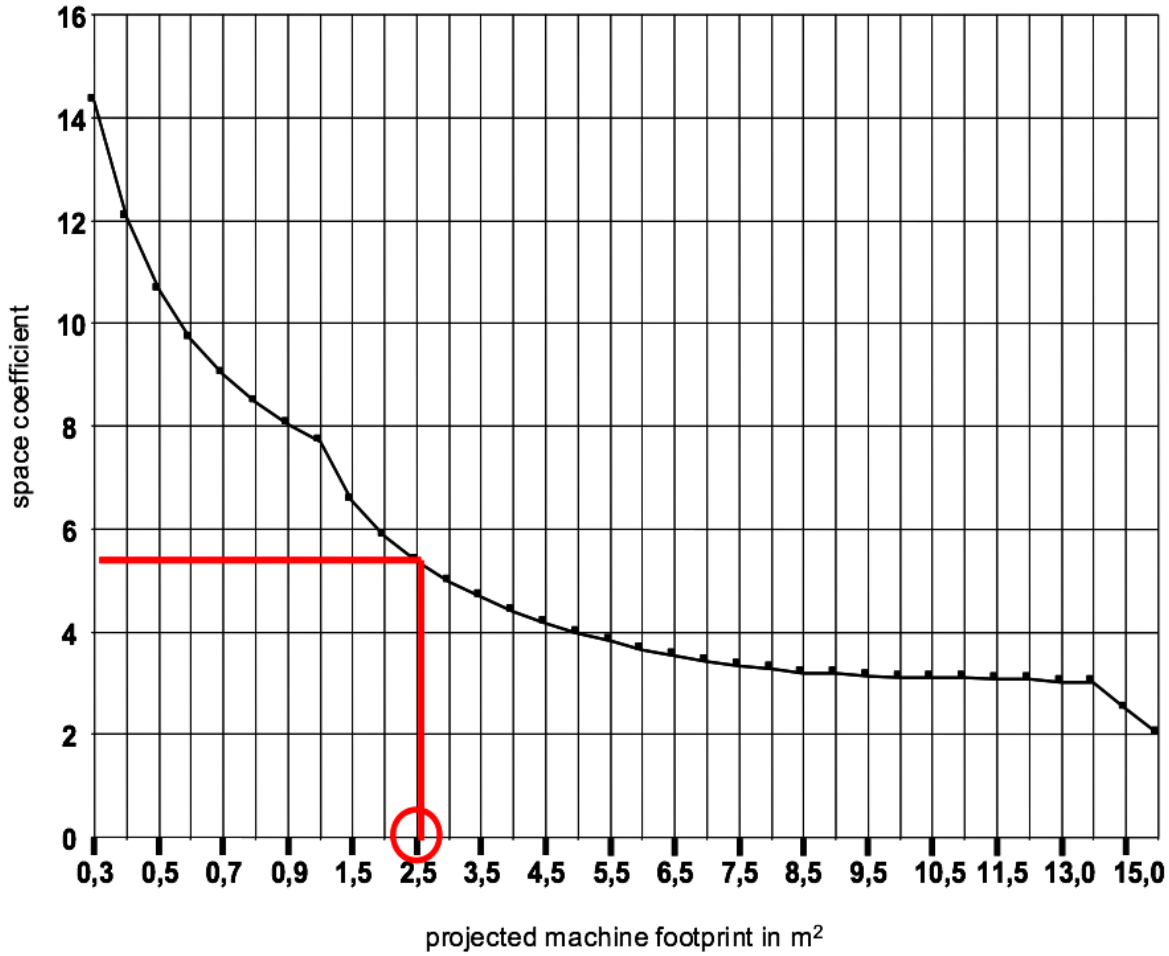
Technical area

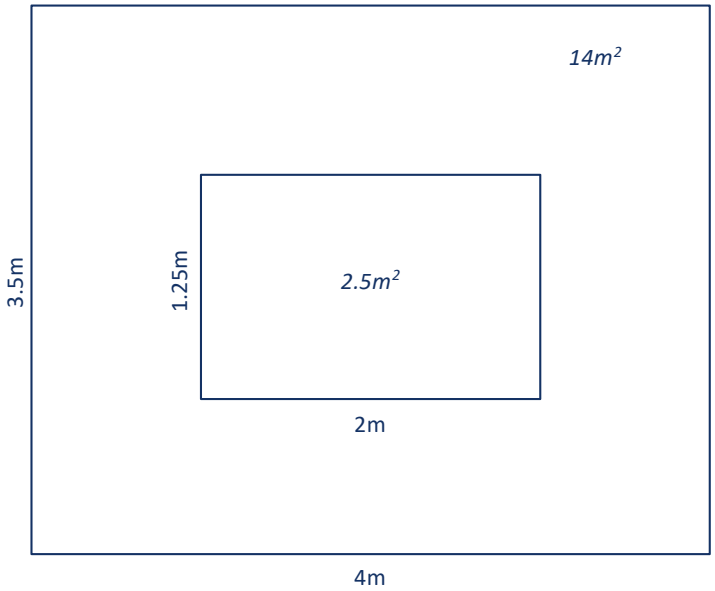
Movement area
- width: min. 1m
- depth: min. 1m
- total: min 1.5 m^2

Transportation area

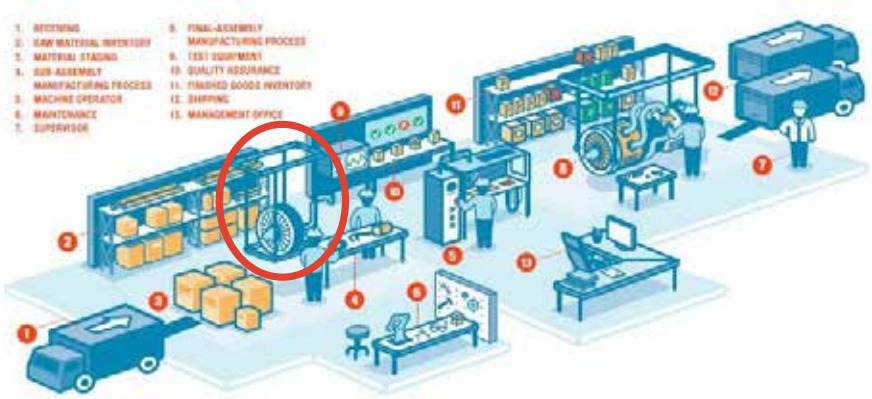


TOTAL SPACE OF MACHINES (AM) – SPACE COEFFICIENT





STORAGE OR WIP AREA FOR PROCESSED PARTS (A_{WIP})



Calculation of Storage/WIP area

$$A_{WIP} = 0.2 * A_M$$

Condition:

- *Handling of material in bins*
- *Piling up to 3 bins*
- *Transportation with fork lifts, cranes, etc.*

OVERALL TRANSPORTATION AREAS (A_T)

Calculation of Transportation Area

$$A_T = (0.2 \ldots 0.3) * A_M$$

Condition:

- *Path width 2.5 – 3.0 m*

OVERALL TRANSPORTATION AREAS (A_T)
PATHS FOR MOVEMENT OF EMPLOYEES

	Min. Path Widths
Walkways dependent on # of simultaneously present people in the building (up to …)	
5	0.88 m
20	1.00 m
200	1.20 m
300	1.80 m
400	2.40 m
Corridors to workplaces	0.60 m
Path for people between rack stores in warehouses	1.25 m
Path for people in side aisles in warehouses for manual handling	0.75 m

OVERALL TRANSPORTATION AREAS (A_T)
PATHS FOR VEHICLES

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	Vehicle Type	Width a_L	Length
1	Manual forklift	0.8 – 1.3 m	1.2 – 2.0 m
2	Forklift with conductor in upright position	0.9 – 1.5 m	1.5 – 2.5 m
3	Forklift with conductor in sitting position (capacity 3t)	0.9 – 1.5 m	2.5 – 3.8 m
4	Mobile cranes (up to 9t)	1.5 – 2.5 m	3.5 – 5.5 m
5	Small trucks (capacity up to 1.5t)	1.5 – 2.4 m	4.0 – 5.0 m

1

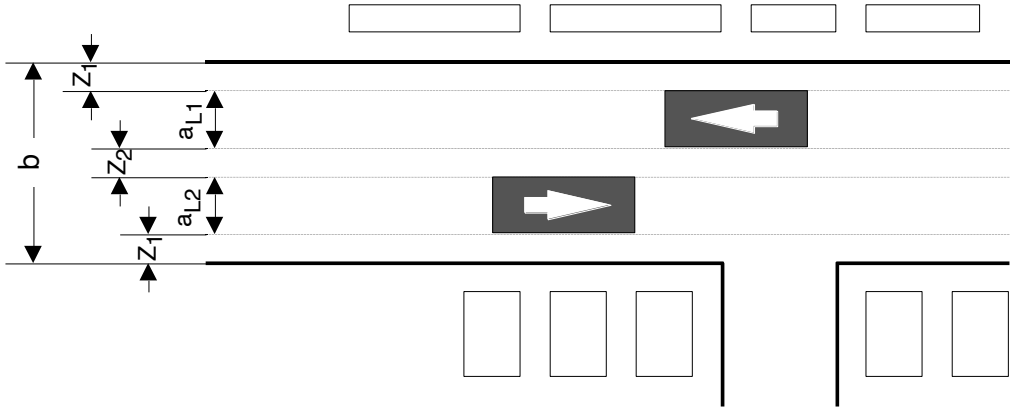
2

3

4

5

OVERALL TRANSPORTATION AREAS (A_T)
PATHS FOR VEHICLES



Total path width	$b = a_{L1} + a_{L2} + 2Z_1 + Z_2$
Vehicle widths	
One way	$a_{L2} = 0$
Two way	$a_{L1} = a_{L2}$
Edge distances	
For goods	$Z_1 = 0.5$ m
For people	$Z_1 = 0.75$ m
Traffic distances	
one way	$Z_2 = 0$
two way	$Z_2 = 0.4$ m
less people and goods flow	$2Z_1 + Z_2 \geq 1.1$ m

OVERALL QUALITY CONTROL AREA (A_Q)

Calculation of Quality Control Area

$$A_Q = 0.13 * A_M$$

Condition:

- *25% - 35% of parts in quality control work places*
- *Rest in self-control*

OVERALL FREE AREA (A_F)

Calculation of Free Area

$$A_F = 0.18 * A_M$$

Examples:

- *Building restrictions (pillars, etc.)*
- *Shop floor management*
- *Terminals*
- *Disposal areas*

FLOOR CHARACTERISTICS

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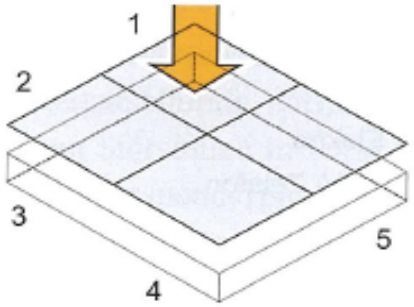
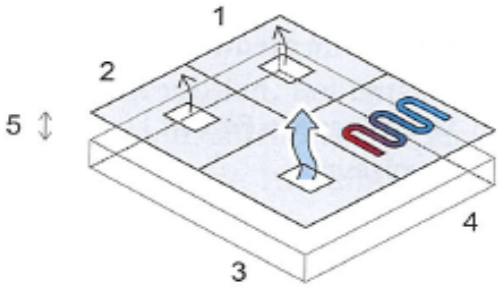
Surface

1 Load-bearing capacity
2 Durability
3 Evenness
4 Slipperiness
5 Easiness to clean



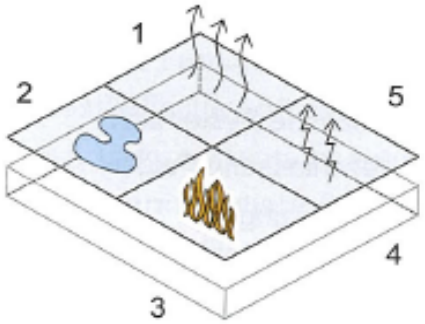
Installation

1 Power
2 Phone connection
3&4 HVAC
5 Clear installation hight



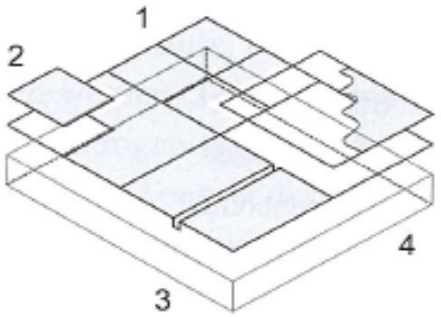
Construction Physics

1 Thermal insulation
2 Tightness
3 Fire protection
4 Noise protection
5 Discharge capability



Elements

1 Dimensional system
2 Mounting plates
3 Construction joints
4 Rearrangement effort



CONSTRUCTION SHAPES

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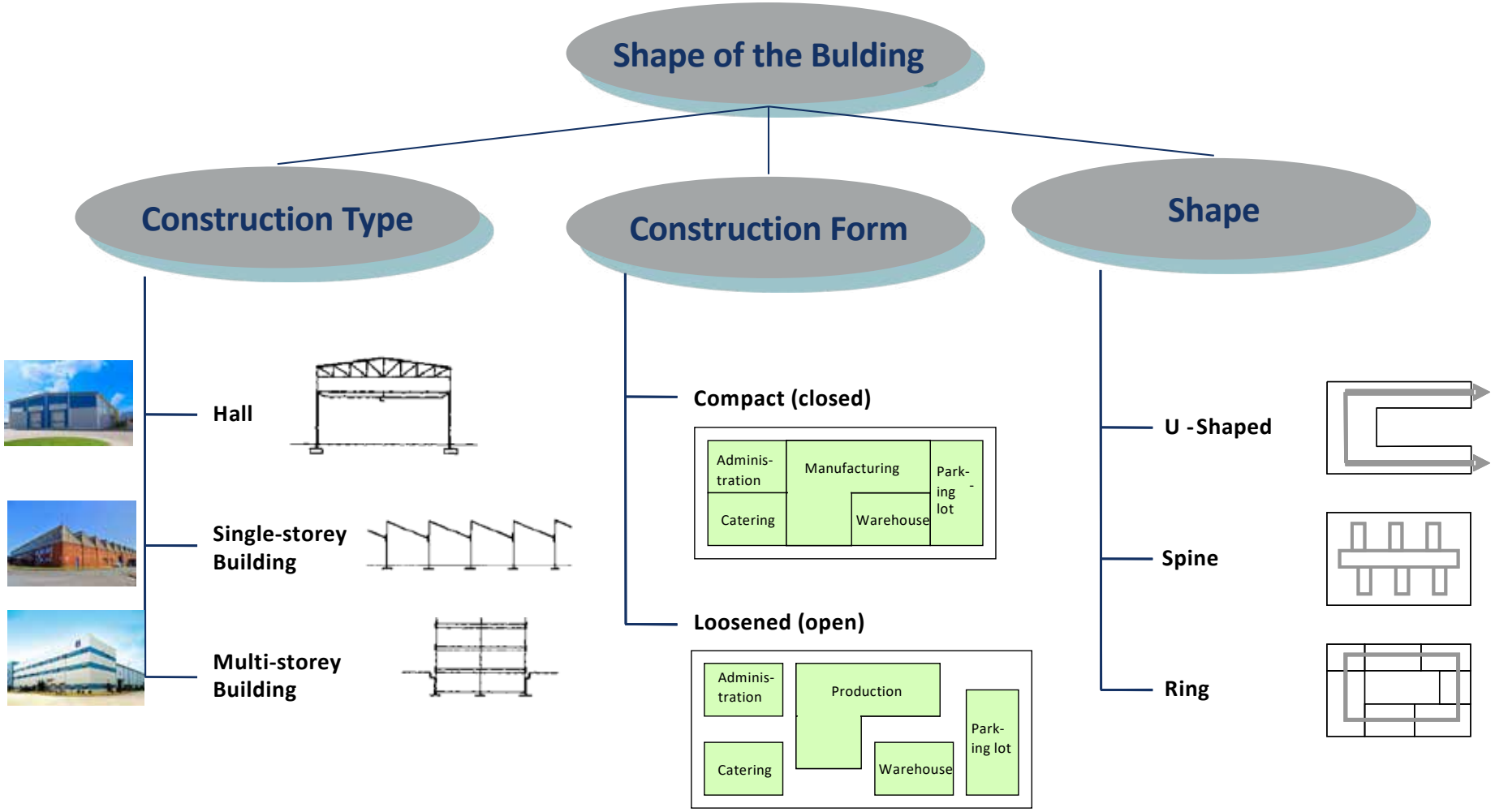
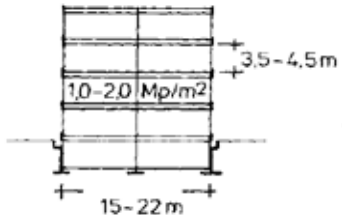
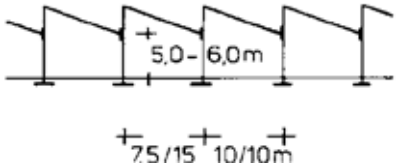
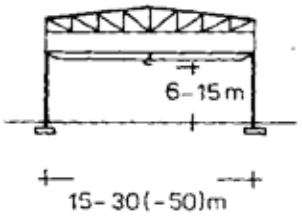


CONSTRUCTION TYPES

	Multi-storey Building	Single-storey Building	Hall
			
Characteristics	• Limited space in stacked floors • Many work places • Stairs and lifts	• At ground level	• Extensive width & hight • Less work places • cranes
Load-bearing capacity	Light to medium (<1Mp/m²)	Light to heavy (<2 Mp/m²)	Heavy to very heavy (5 Mp/m²)
Utilization	High-precision manufacturing Optics manufacturing Electronics manufacturing Food manufacturing Apparel manufacturing R&D	Machinery manufacturing Car manufacturing Textile manufacturing Paper manufacturing	Heavy machinery manufacturing Steel manufacturing
Space requirement	Small to medium	high	high
Dimensions -Length -Pillar distance -Hight	 9 – 12 (-16) m 4 – 10 m 3.5 – 4.5 m	 10 – 18 m 5 – 10 m 5 – 6 m	 15 – 30 (50) m 5 – 25 m 6 – 15 (25) m
Transportation -Horizontal -Vertical	 light floor conveyors & forklifts light cranes (=1 Mp) lift, slides, conveyors	 Forklifts, conveyors, cranes N/A	 Forklifts, cranes (>5 Mp) N/A

HALL

- Full flexibility
- Scalability (horizontally & vertically)
- No special equipment for material flow
- Easy installations of machines
- Heavy machinery and goods
- Good overview of shop floor processes

- Extensive space requirements

SINGLE-STOREY BUILDING

- High flexibility
- No special equipment for material flow
- Easy installations of machines
- Heavy machinery and goods
- Good overview of shop floor processes
- Extensive use of sunlight possible
- Additional installations on roof

- Extensive space requirements
- Limited scalability

MULTI-STOREY BUILDING

- Efficient use of given space
- Lightweight machines and products
- Additional installations on roof possible

- Low flexibility
- No scalability
- Complicated installations of machines
- Special equipment for material flow
- Hardly overview of shop floor processes

GENERAL TYPES OF LAYOUT

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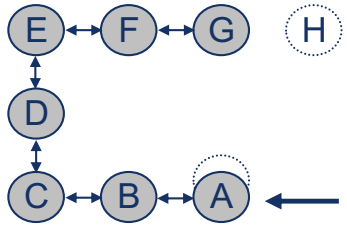
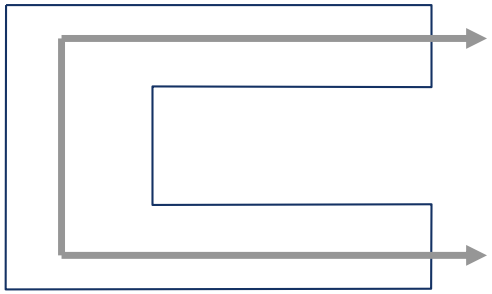
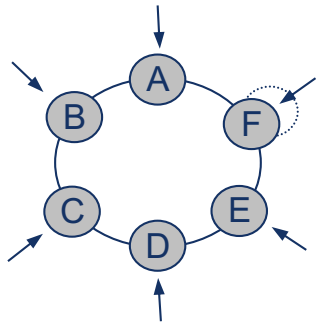
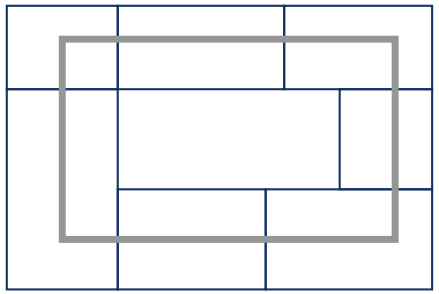
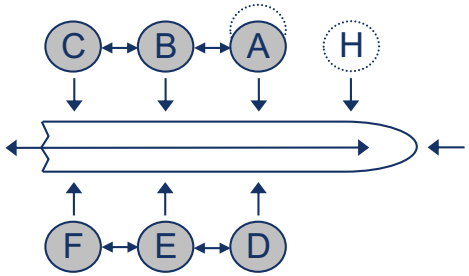
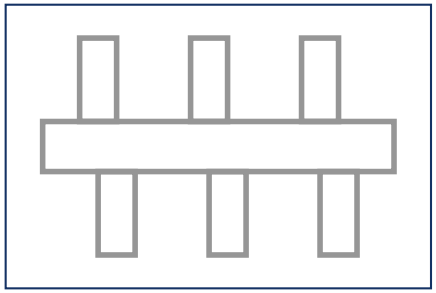
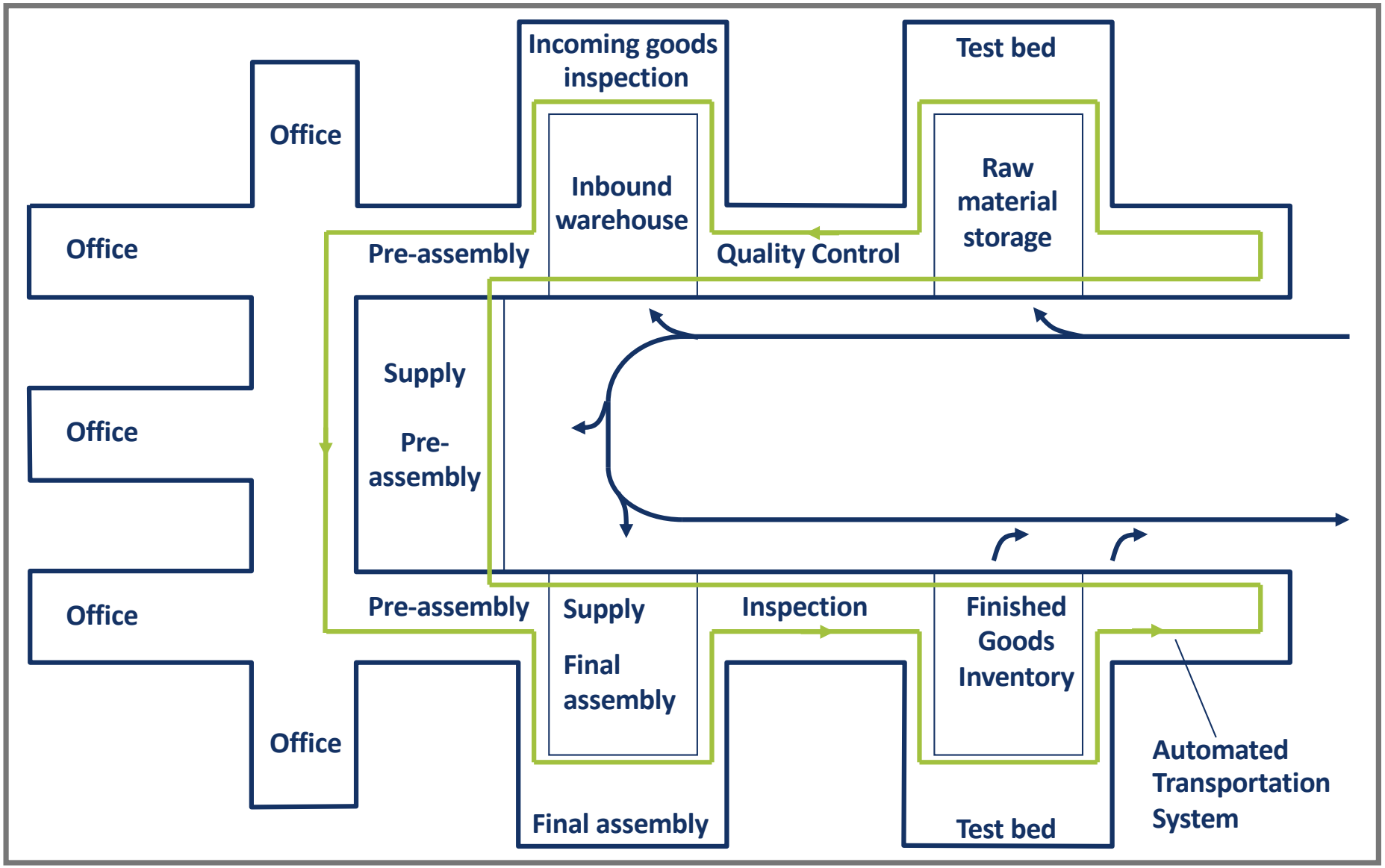
Characteristics	Principle	Structure
U-Shaped • U-shaped material flow with logistics and dispatch area at the center • Feasible with centralized logistics concept		
Ring • Coupling of different areas • Functioning of those areas only possible through true ring structure • Challenge for projects that are realized sequentially		

Spine
• Supporting (material supply) and processing (manufacturing) areas
• Possibilities for expansion:
  • Macro expansion (extension of the spine)
  • Micro expansion (extension of manufacturing areas)
		

U-SHAPED-FACTORY



U-SHAPED LAYOUT

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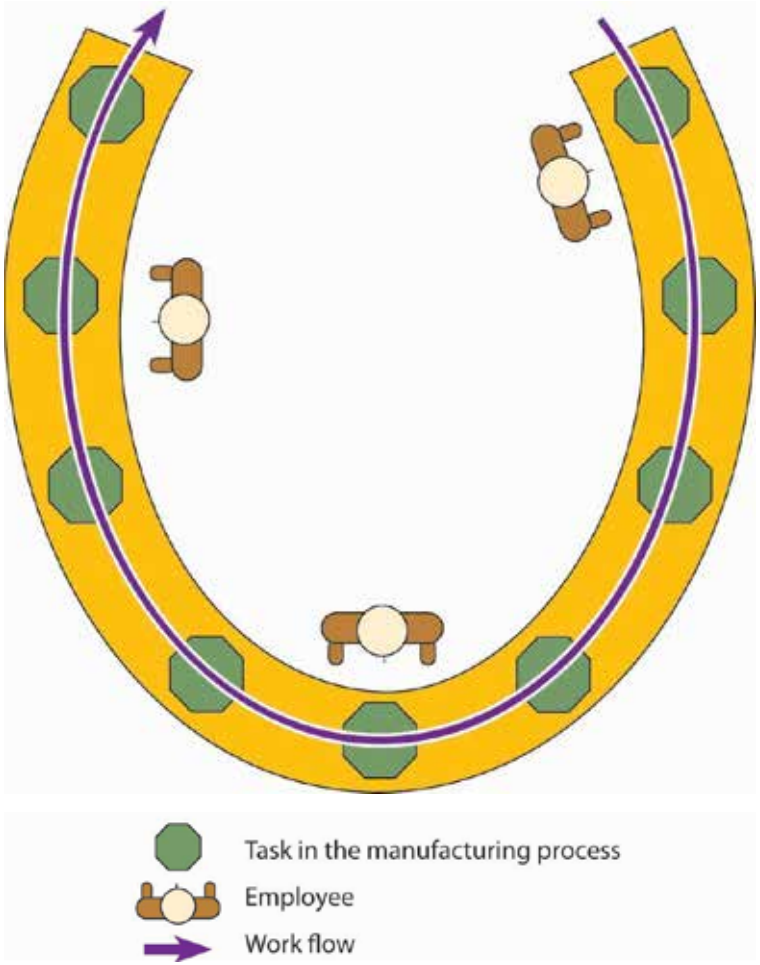
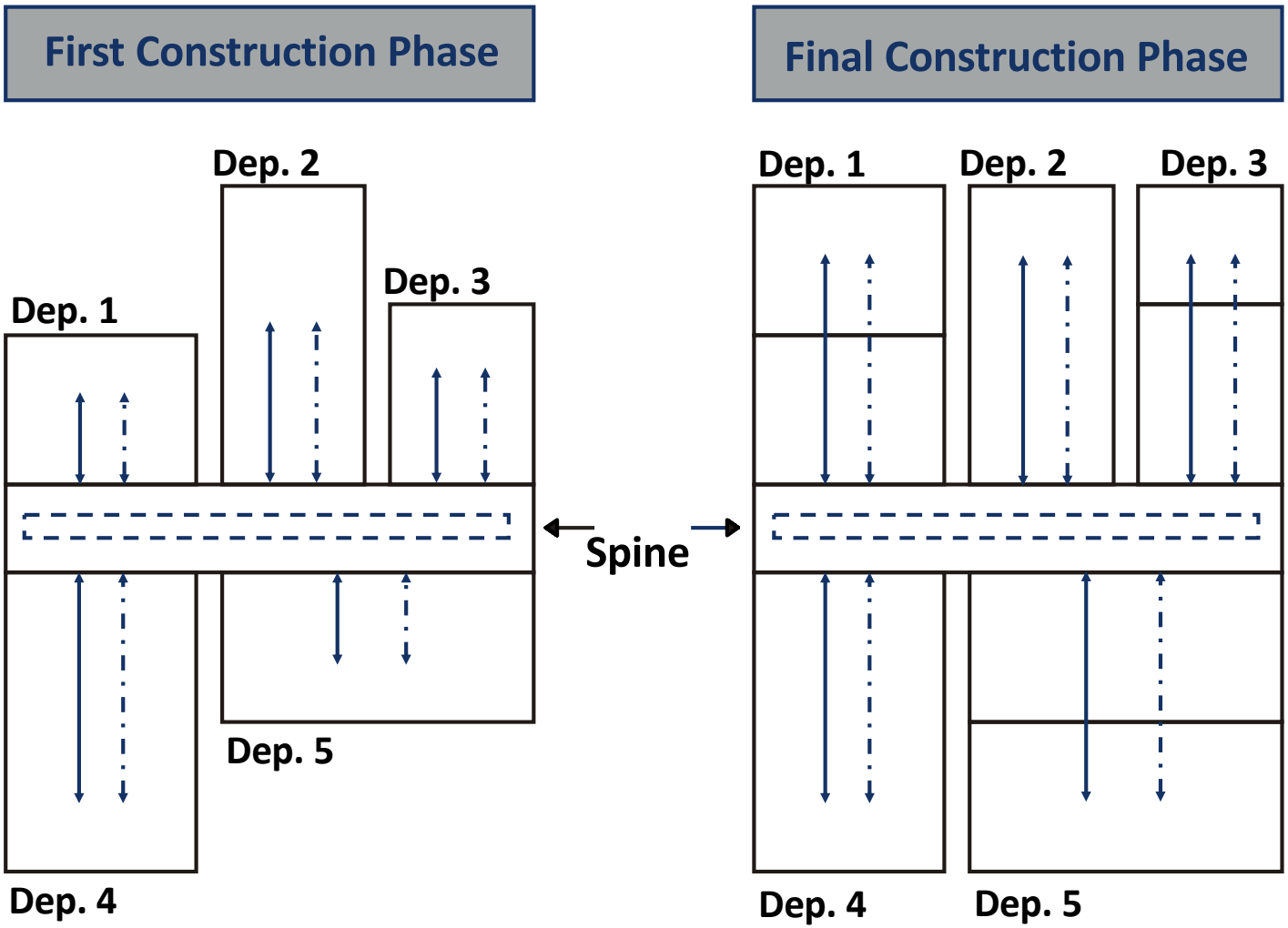
- Efficient use of given space
- Lightweight machines and products
- Additional installations on roof possible

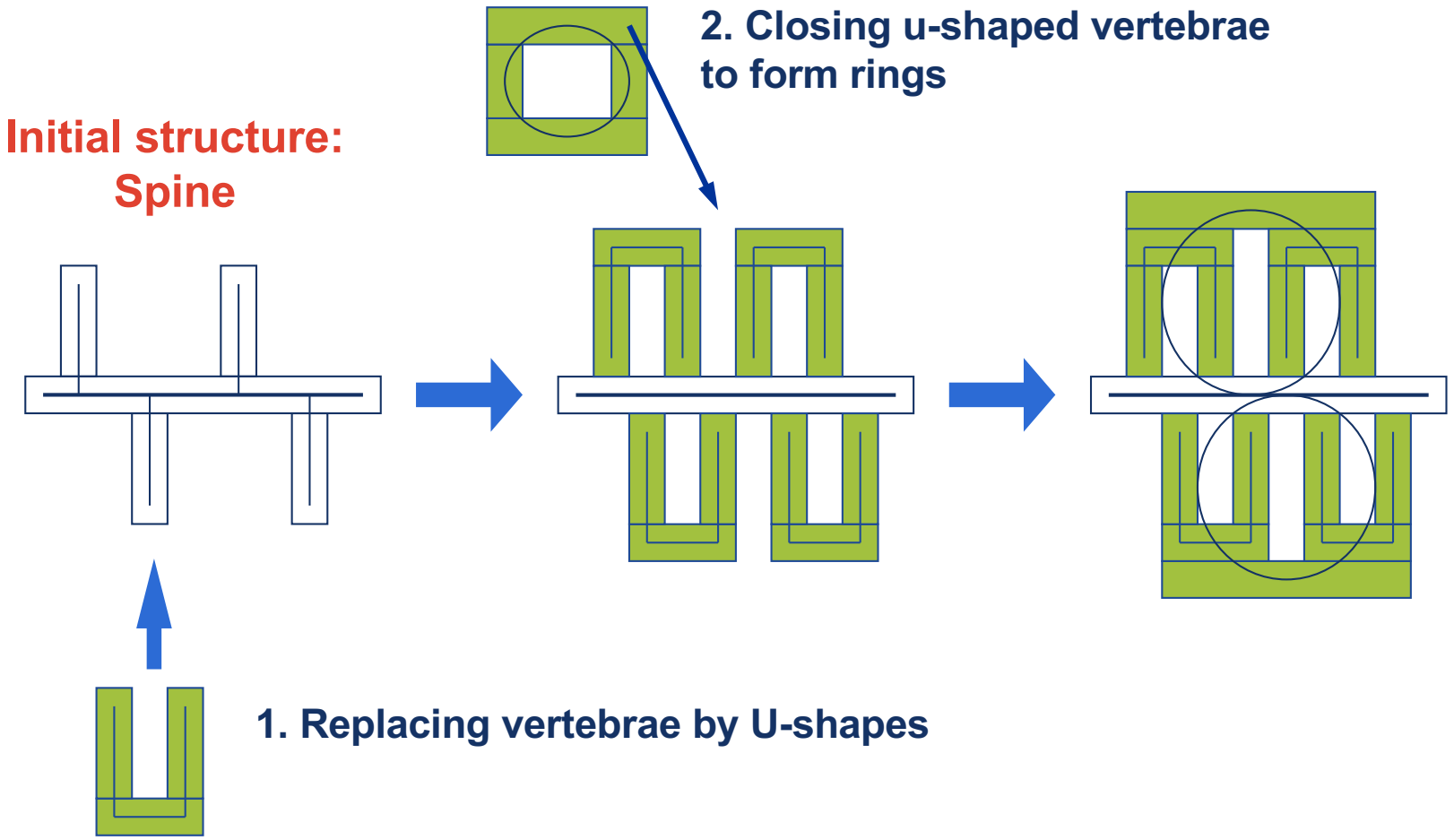
- Uneven workload for employees possible



SPINE SHAPE DEVELOPMENT



COMBINATION OF SHAPES



CONSECUTIVE EXERCISE

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- Calculate the space requirements for the needed machines
  - Use spreadsheets S25 & S26

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THANK YOU!