Tech 45: Unit 2

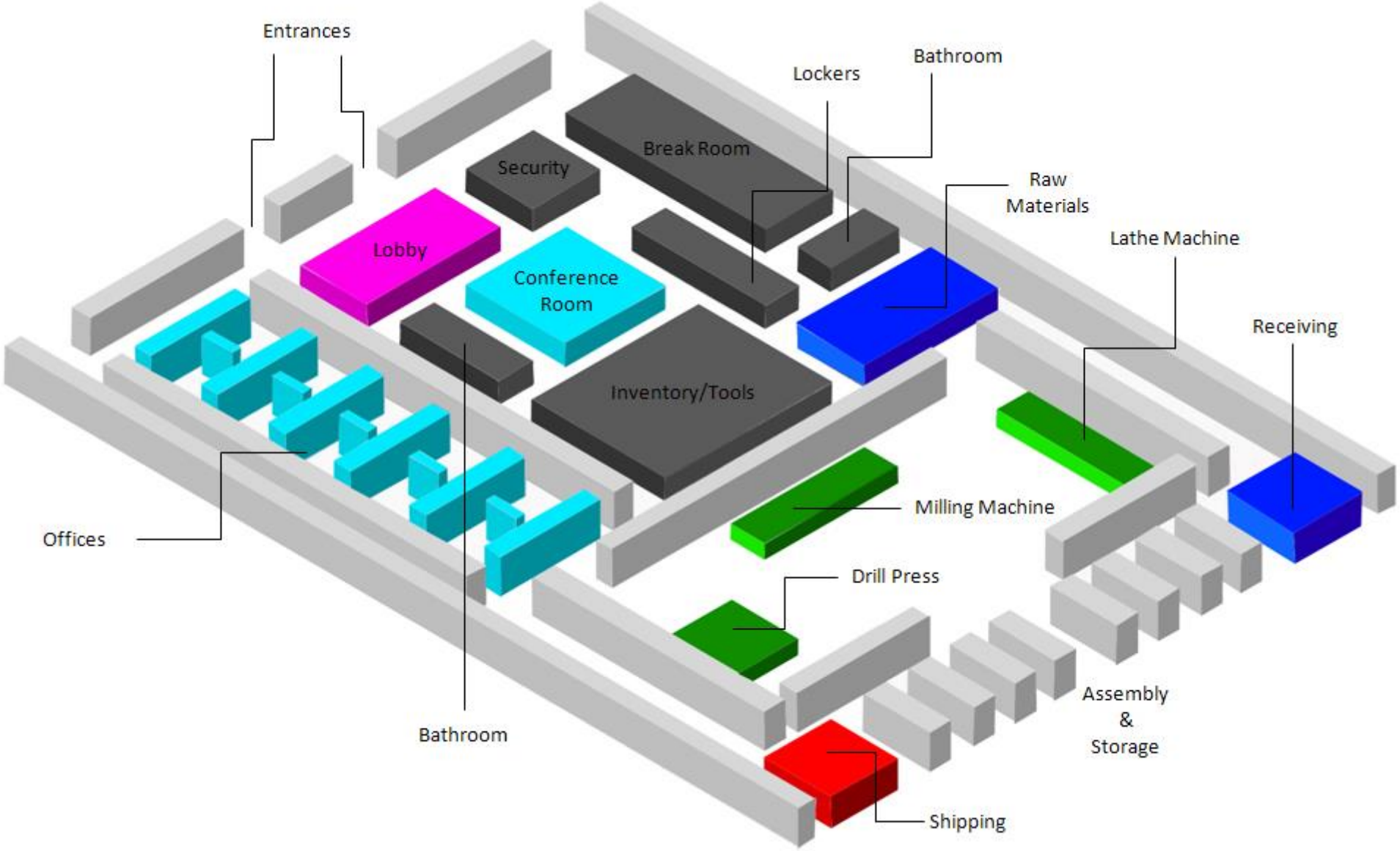
Manufacturing Facilities Design Procedures and Analysis Tools

Introduction

Like all industrial activities, manufacturing facilities design requires proper planning and coordination of critical information, tools, and associated analysis for a successful result. Without proper planning, the result will not be productive for the organization. This unit explains how such tools and information are employed.

Key Information to the Plan

1. What product will be produced?
2. How many products will be produced?
3. What types of equipment will be needed?
4. How many pieces will be needed?
5. How many workers will be needed?
6. What auxiliary services will be needed?
7. How much space will they need?


Entrances
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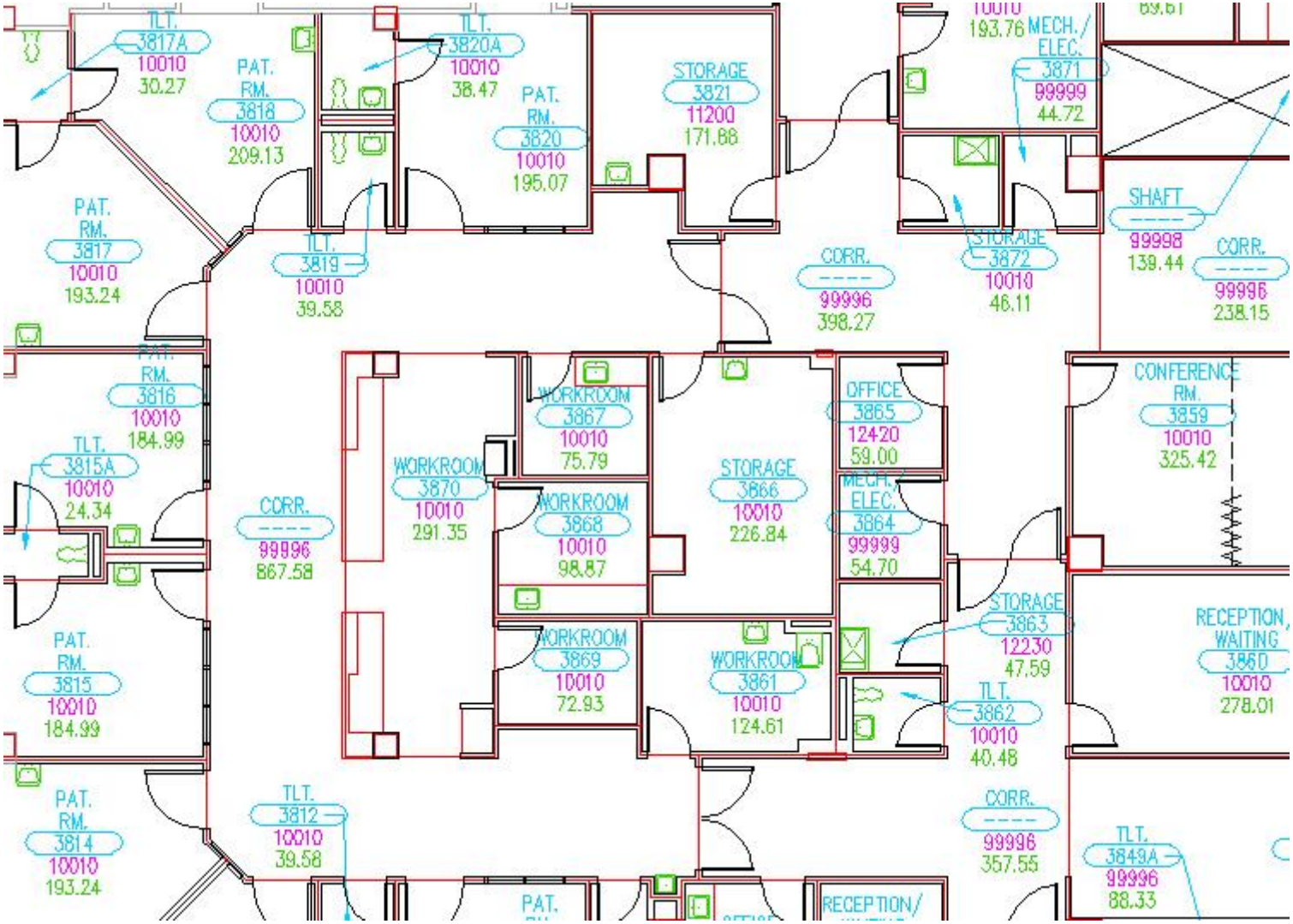
Bathroom
Break Room
Security
Raw
Materials
Lathe Machine
Lobby
Conference
Room
Receiving
Inventory/Tools
Milling Machine
Offices
Drill Press
Assembly
&
Storage
Bathroom
Shipping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Chapter 2

Sources of Information for Manufacturing Facilities Design

- Marketing
- Product design
- Management policy
- Organizational chart

Information from Marketing Department

- Selling price
- Volume
- Seasonality
- Replacement parts that an older product may require

Determining the plant rate or takt time (also called R value)

- Takt time = rate at which operation, processes, parts, components, and so on must run in order to meet the production goal
- The plant rate is used to determine the number of machines and workstations, conveyor speed, and the number of employees required to work in the facility

$$T = \frac{T_a}{D}$$

Where

T = Takt time, e.g. [work time between two consecutive units]

T_a = Net time available to work, e.g. [work time per period]

D = Demand (customer demand), e.g. [units required per period]

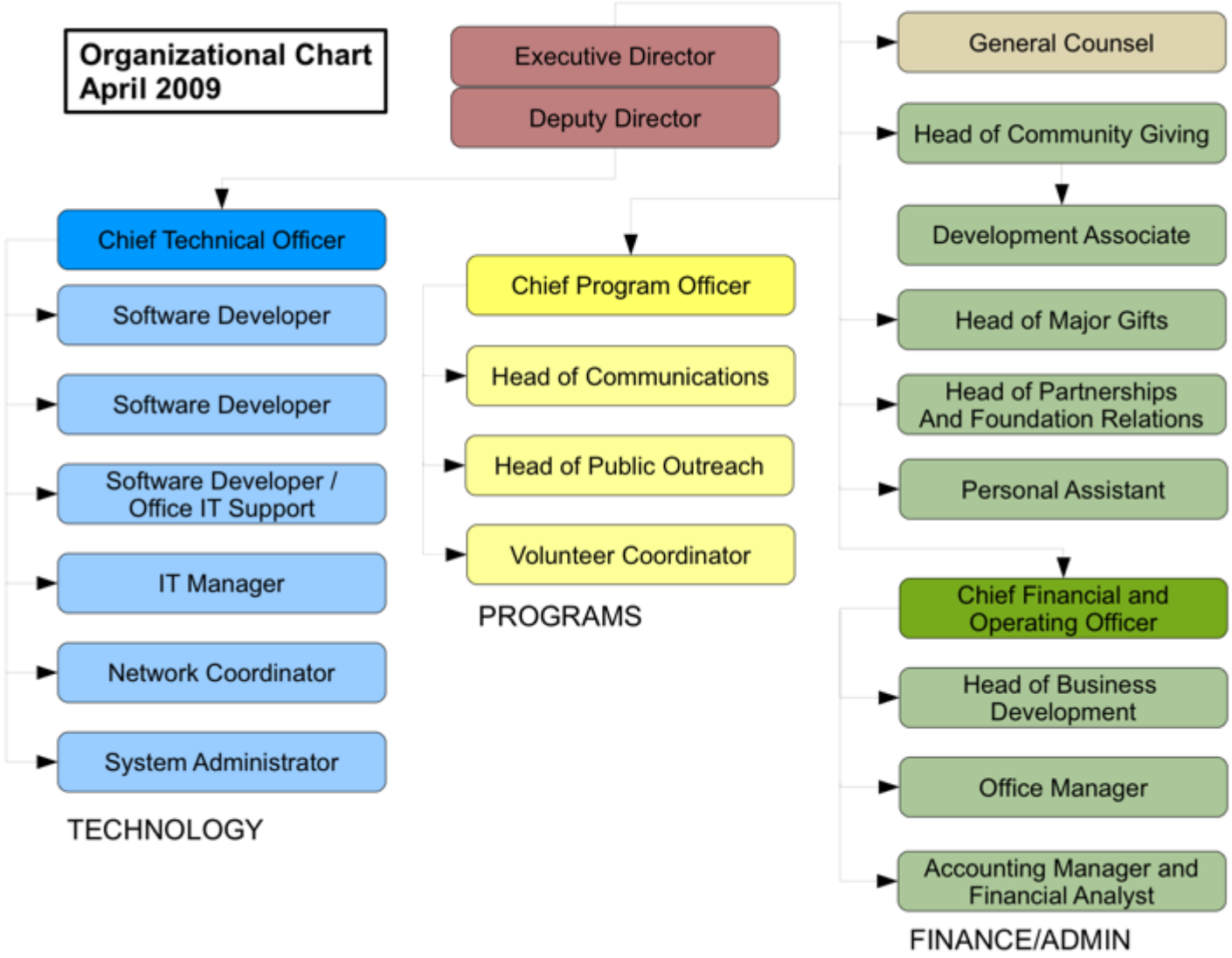
Information from Product Design Department

- Blueprints, sketches, pictures, CAD drawings, and model shop samples
- Exploded assembly drawings
- Parts list or bill of materials and indented bill of materials

Information from Management Policy

- Inventory policy
- Lean thinking and muda
- Investment policy (ROI)
- Startup schedule
- Make or buy decisions
- Organizational (chart) relationships
- Feasibility studies

Information from the Organizational Chart



Chapter 3: Time Study

- A time standard is defined as the time required to produce a product at a workstation with a qualified, well trained operator working at normal pace and doing a specific task
- The process of setting time standards is called time study

Time or labor standards are generally used for:

- Cost and labor allocation and control
- Production planning and inventory management
- Performance evaluation and incentive pay
- Evaluation of alternative methods of operation

Time standards are used for five main purposes in facilities design:

- Determining the required number of people
- Determining the required number of workstations and machines
- Determining conveyor line speeds
- Loading work cells
- Balancing assembly and packout lines

Some Facts About Time Standards

- An operation that is not working toward time standards typically works 60% of the time
- In plants that do not have time standards, employees know that no one cares how much they produce
- Operations working with time standards work at 85% of normal performance

Techniques of Time Study

- Predetermined time standards system (PTSS) or 17 Therbligs
- Stopwatch time study by Fredrich W. Taylor
- Work sampling
- Standard data
- Expert opinion standard and historical data

Sample Time Standards development

Element	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Performance rating (%)
A	1.57	1.63	1.48	1.57	1.65	100
B	2.48	2.34	2.37	2.36	2.40	90
C	1.85	3.70	1.82	1.78	1.75	95
D	1.25	1.15	1.32	1.15	1.23	115

Chapter 4

Process Design

Tasks of Process Engineer

- Sequence of operations using the route sheet
- The needed machinery, equipment, tools, fixture etc.
- Sequence of operations in assembly using the assembly chart or operation chart
- Time standard for each element of work etc.

Fabricating Individual Parts

- The role of the route sheets or process chart in sequencing operations
- The role of the route sheets or process chart in determining time standards
- The role of the route sheets or process chart in determining number of machines
- The role of the route sheets or process chart in determining required tooling
- Information contained in the summary of route sheets

Determining Number of Machines Needed

- To determine the number of machines needed, the following questions should be answered:
  - ✓How many finished units are needed per day?
  - ✓Which machine runs what parts?
  - ✓What is the time standard for each operation?

Determining Number of Machines Needed

Requires that a machine requirements spreadsheet be developed

Assembly and Packout Process Analysis

- This area includes subassembly, assembly, welding, painting final assembly, and packout
- The assembly or operation process chart shows the sequence of operations in putting together the product

Assembly and Packout Process Analysis

- Assembly line balancing or time standard determination (of several assembly alternatives) is required to determine which sequence is best
- The plant rate (takt time) and conveyor speed should be determined
- Paint conveyor speed should also be determined

Assembly Line Balancing

The purposes are to:

1. Equalize the workload among the assemblers
2. Identify the bottleneck operation
3. Establish the speed of the assembly line
4. Determine the number of workstations
5. Determine the labor cost of assembly and packout
6. Establish the percentage workload of each operator
7. Assist in plant layout; and reduce production cost

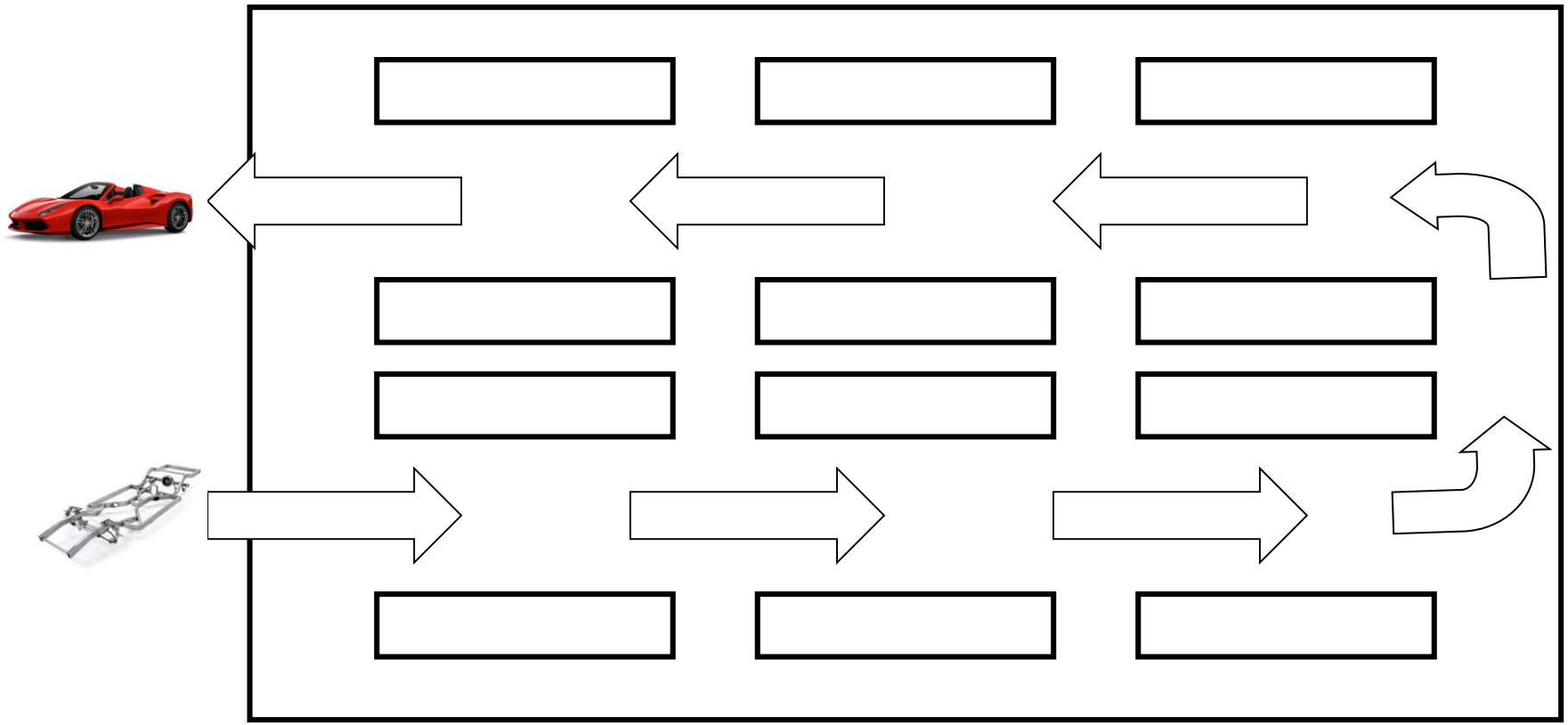
Assembly Line Balancing

- The objective is to give each operator as close to the same amount of work as possible
- This is accomplished by breaking down the tasks into basic motions required to do each piece of work and reassembling the tasks into jobs of near equal time value

Chapter 5

Flow Analysis Techniques

A Typical Flow Path



Flow Analysis Techniques

- The flow of a part is the path that the part takes while moving through the plant
- Flow analysis should try to minimize the distance in feet traveled by the part, backtracking, cross traffic, and cost of production

Flow Analysis Techniques

- A core principle of lean manufacturing is the product-oriented flow layout, as compared to process-oriented flow layouts that are planned around a group of similar equipment
- In the product-oriented layout, machines are moved and grouped according to part or product families

Flow Analysis Techniques

- Flow analysis techniques assist manufacturing facilities designer to choose the best arrangement of machines, workstations, employee services, support services, and departments
- The study of individual parts flow results in the arrangement of machines and workstations
- To accomplish this, route sheets are the primary source of information

Flow Analysis Methods

- Process chart: Used for just one part (required for Tech 045)
- String diagram technique: Can be used for multiple parts. In this, circles represent the equipment and lines between circles indicate flow
- Multicolumn process chart: Can be used for multiple parts
- From-to chart

Some Tips on Project One

Some of your required facilities are apparent while others are not. A careful study of your process charts will help to reveal the not too apparent ones. Below are some examples.

Required facilities may include:

1. Storage for raw materials (square footage to be determined)
2. Storage(s) for the 1000 products (square footage to be determined)
3. Plant manager's office (square footage to be determined)
4. Rest rooms (square footage to be determined)
5. Aisles (square footage to be determined)
6. Locker rooms (square footage to be determined)
7. Conveyor (square footage to be determined)
8. Others (square footage to be determined)

To-be determined facilities may include:

1. Machine tools	(square footage to be determined)
2. Tool crib(s)	(square footage to be determined)
3. Fork truck(s)	(square footage to be determined)
4. Cart(s)	(square footage to be determined)
5. Bin(s)	(square footage to be determined)
6. Workers of various categories	(office/workstation space to be determined)
7. Others	(square footage to be determined)

Key Analyses in Project 1

- Takt time and conveyor speed
- Number of Machines Needed
- Number of operators and assemblers needed
- Cost of operator & assembler wages
- Number of supervisors
- Total amount of space anticipated
- Total cost of the proposed project

Takt Time

Takt time or R value =

Effective minutes / Units per day

Conveyor Speed

Products per day divided by adjusted minutes times size of package

Summary of route sheet will:

Determine time standards in pieces per hour

Determine time standards in decimal minutes per unit

Summary of route sheets

Part name	Left roll	Right roll	Axle
		Time Standards in Pieces Per Hour	
Parts per unit	1	1	1
Operations			
Turning lathe	_____	_____	_____
Drill lathe	_____	_____	_____
Threading lathe	_____	_____	_____
Knurling lathe	_____	_____	_____

Tip: Match your estimated time from route sheet with those of **Time Standards in Pieces Per Hour**

Time Standards in Decimal Minutes per Unit

	Left roll	Right roll	Axle
Turning lathe	_____	_____	_____
Drill lathe	_____	_____	_____
Threading lathe	_____	_____	_____
Knurling lathe	_____	_____	_____

Tip: Divide your Adjusted Minutes by Time Standard's Pieces Per Hour

Machine requirements spreadsheet

Part name	Left roll(1)	Right roll(1)	Axle(1)	Total Machines
Machines				
Turning lathe	_____	_____	_____	_____
Drill lathe	_____	_____	_____	_____
Thread lathe	_____	_____	_____	_____
Knurling lathe	_____	_____	_____	_____

Tip: Divide your Time Standards in Decimal Minutes per Unit by Takt Time

Steps in Determining Machine Requirements

1. Complete your process charts, assigning reasonable time values (in minutes) to processes
2. Determine which minutes should be used for machine requirements
3. Convert those minutes into time standards in pieces per hour (refer to standard time table)
4. Convert the above time standards in pieces per hour to time standards in decimal minutes per unit (i.e. divide your adjusted minutes by pieces per hour)
5. Divide the time standards in decimal minutes per unit by takt time
6. Add the different rows of like machines to get the total number of machines required

Steps to Conducting Project 1

1. Design an approved product
2. Prepare make-or-buy decision BOM
3. Perform process planning (process and assembly charts)
4. Determine takt time
5. Perform workstation/machine requirements analysis/spreadsheet
6. Determine number of personnel needed
7. Determine space requirements
8. Determine total budget
9. Determine green audit scores
10. Write report

Obi, Chapter 3

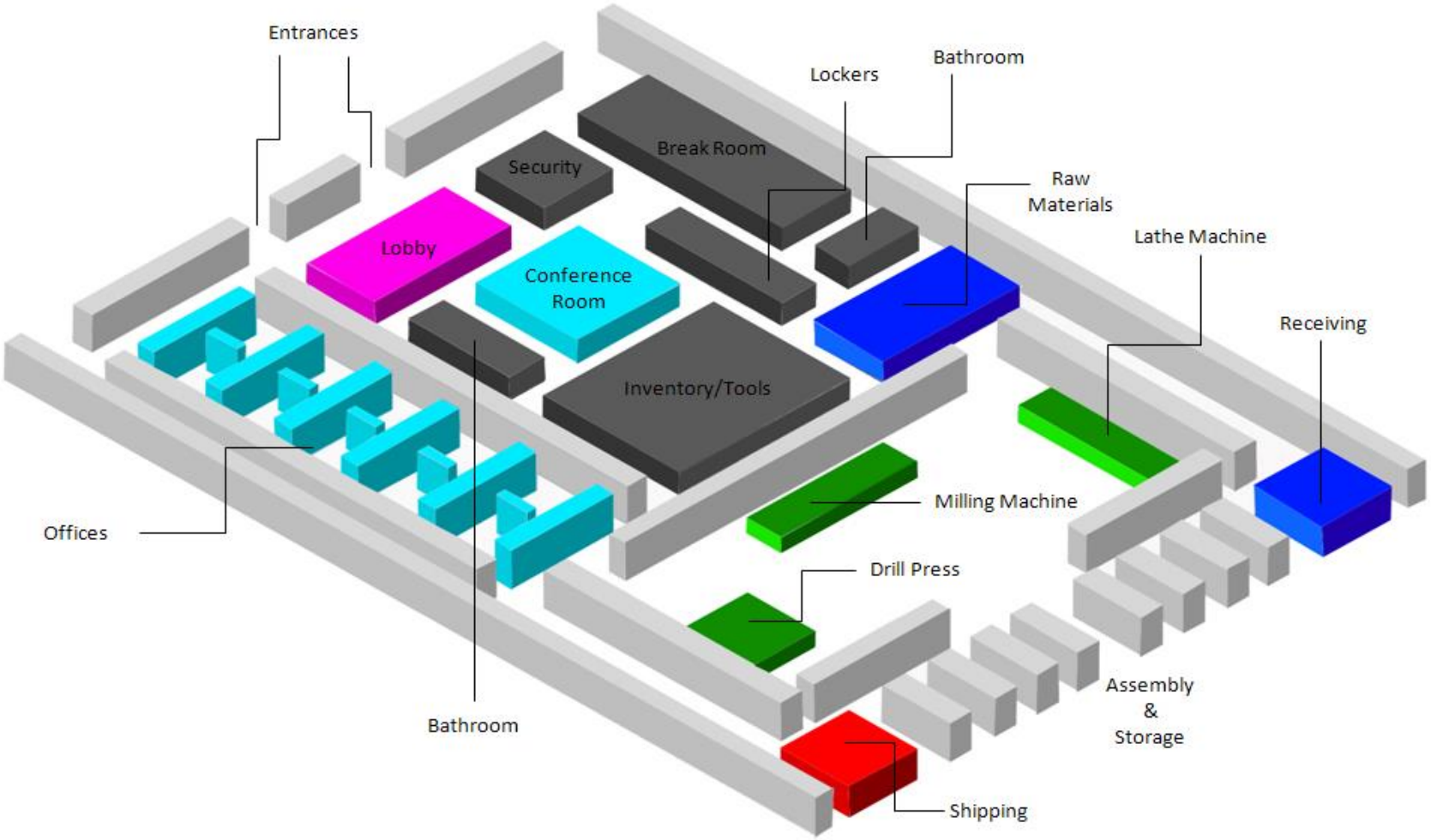
Manufacturing Plants and Facilities

A Typical Manufacturing Plant

Factory Design Goals

- Elimination of Waste
- Cycle Time Reduction
- Smaller Space
- Increased Output
- Lower Cost
- Reduction in Work In-Process
- Fewer Workers

Elements of a Factory



Elements of a Factory

Factors to Consider in Locating Factories

- Raw Materials Availability in or Near the Location
- Availability of Potential Market or Consumers
- Availability of Steady Supply of Energy or Power Source
- Good and Friendly Climate That Will Suit Both the Workers and the Facilities
- Availability of Efficient Transportation Infrastructure
- Steady Supply of Good Water for the Personnel and for the Facilities
- Availability of Efficient Waste Disposal Systems in the City
- Availability of Educated and Trained Labor Force
- Availability of Local Industry-Friendly Taxation and Legislations
- Community Amenities and Socio-Cultural Factors

Factory Layouts

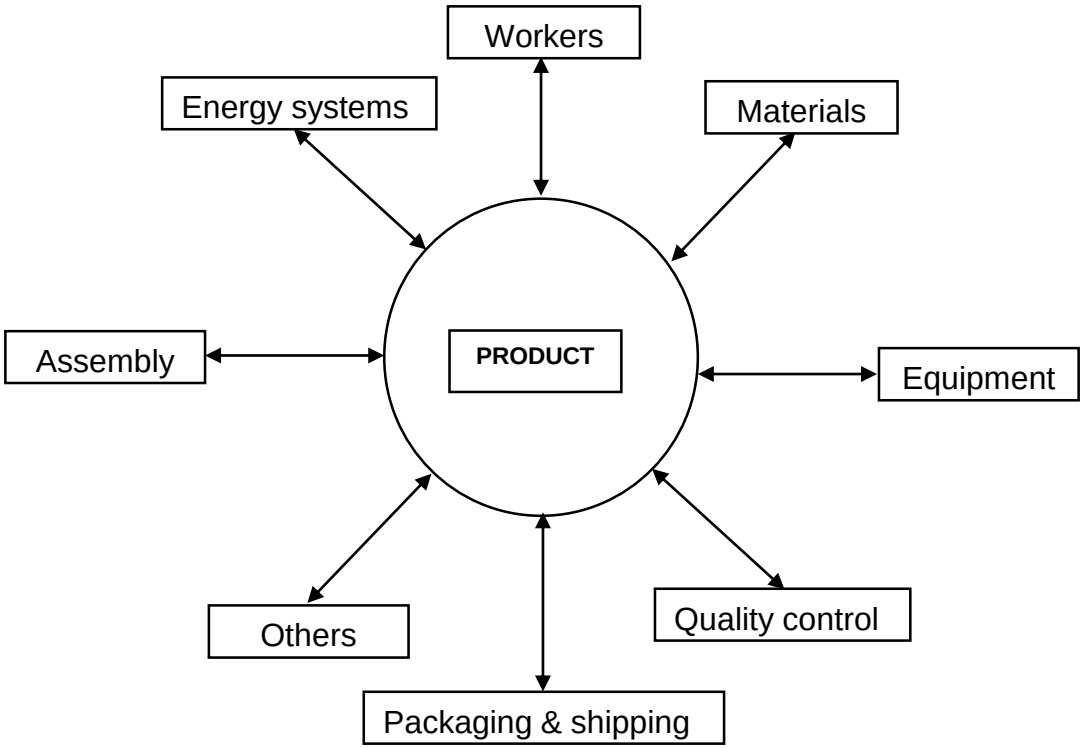
- A plant layout is the physical arrangement of equipment and other facilities within the plant.

- It can be drawn on a floor plan to show the distances between different features of the plant.

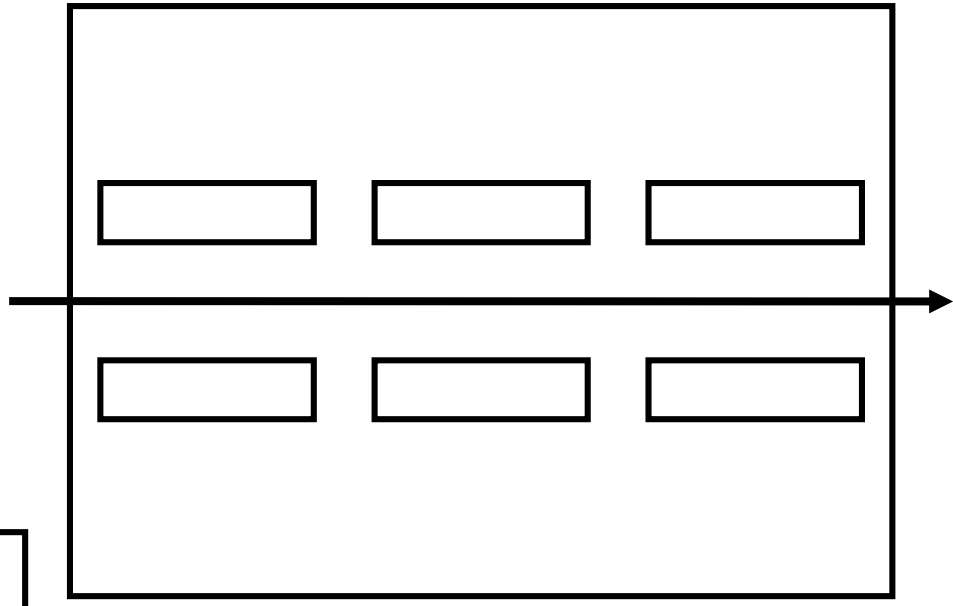
Types of Factory Layouts

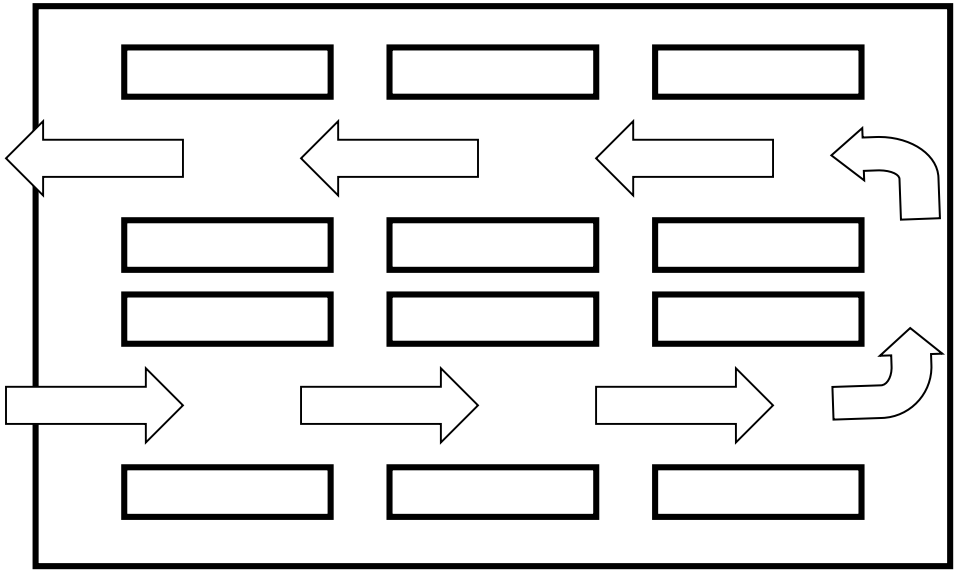
- Fixed-position layout.
- Production layout.
- Process layout.
- Cellular layout.

Fixed-position layout

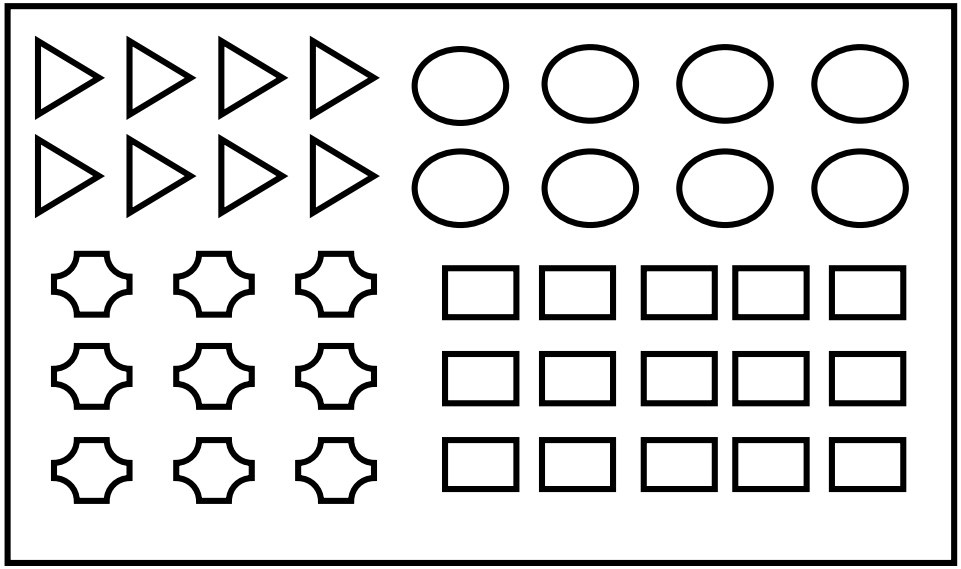


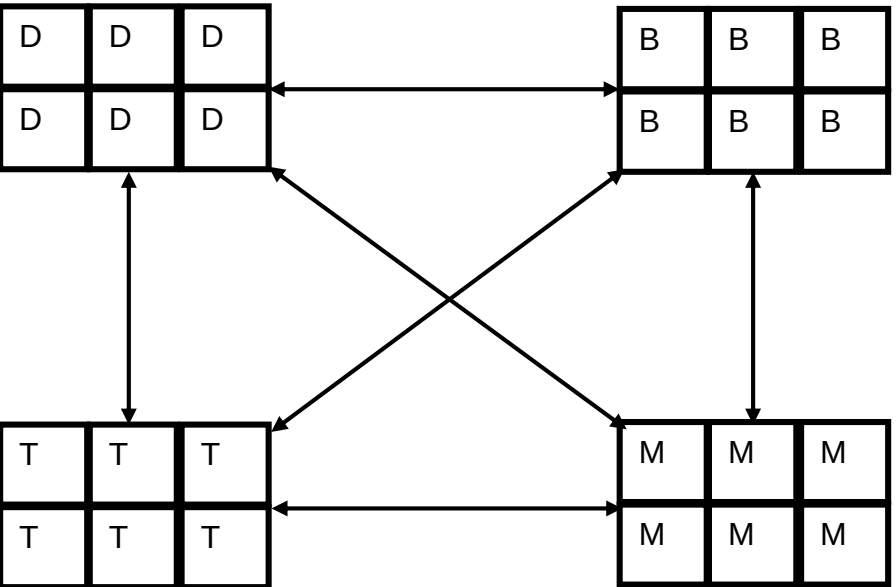
Production layout



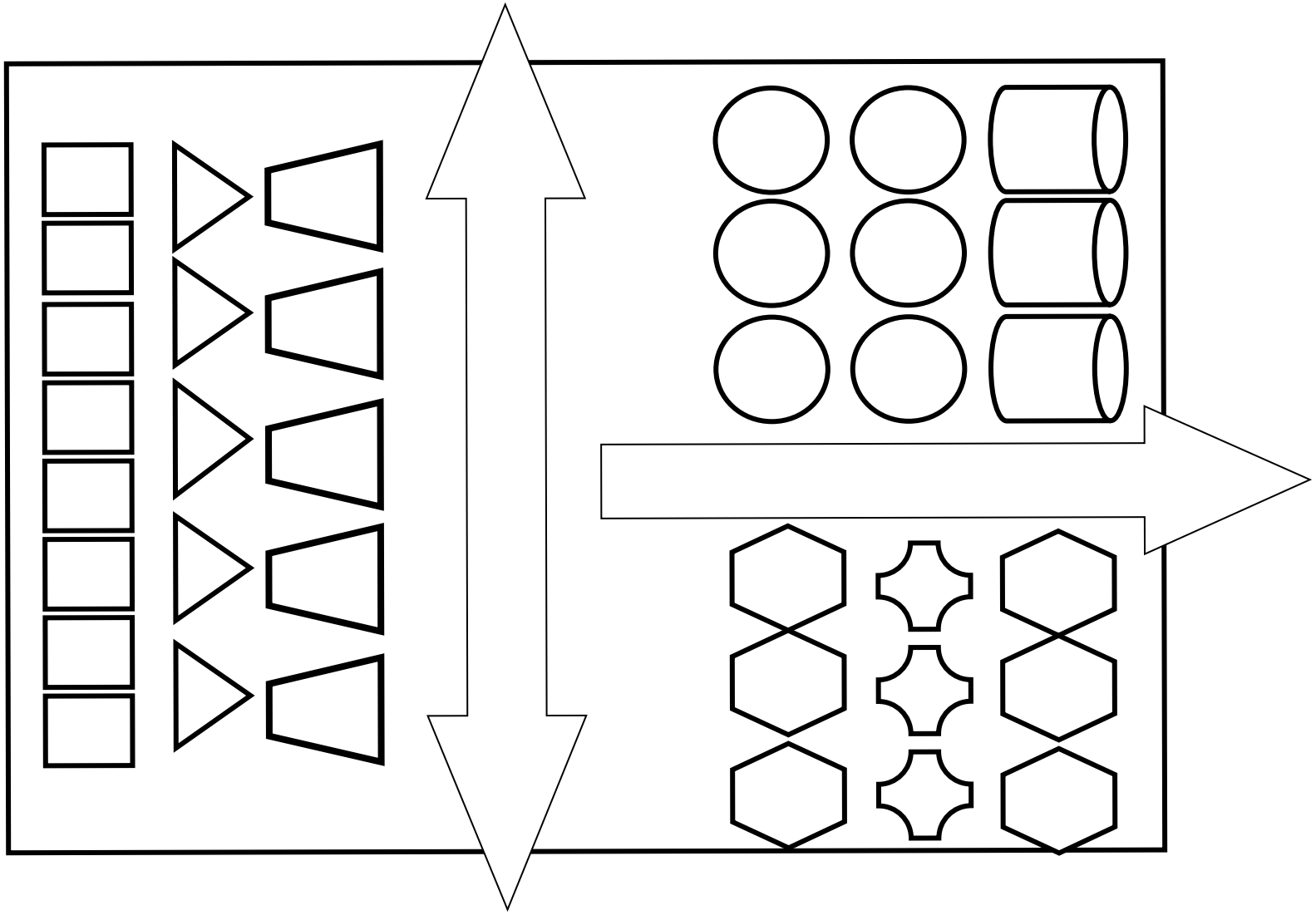


Process layout





Cellular layout



Layout Diagram for Sample Process - After - 3x

Revised: August 13, 2003; Effective: Aug 14, 2003; Expiration: Aug 21, 2003; Author: Dean Ziegler, CPIM

Process description: Bicycle frame production - Product Line B - Location 2, Staff Level 3.

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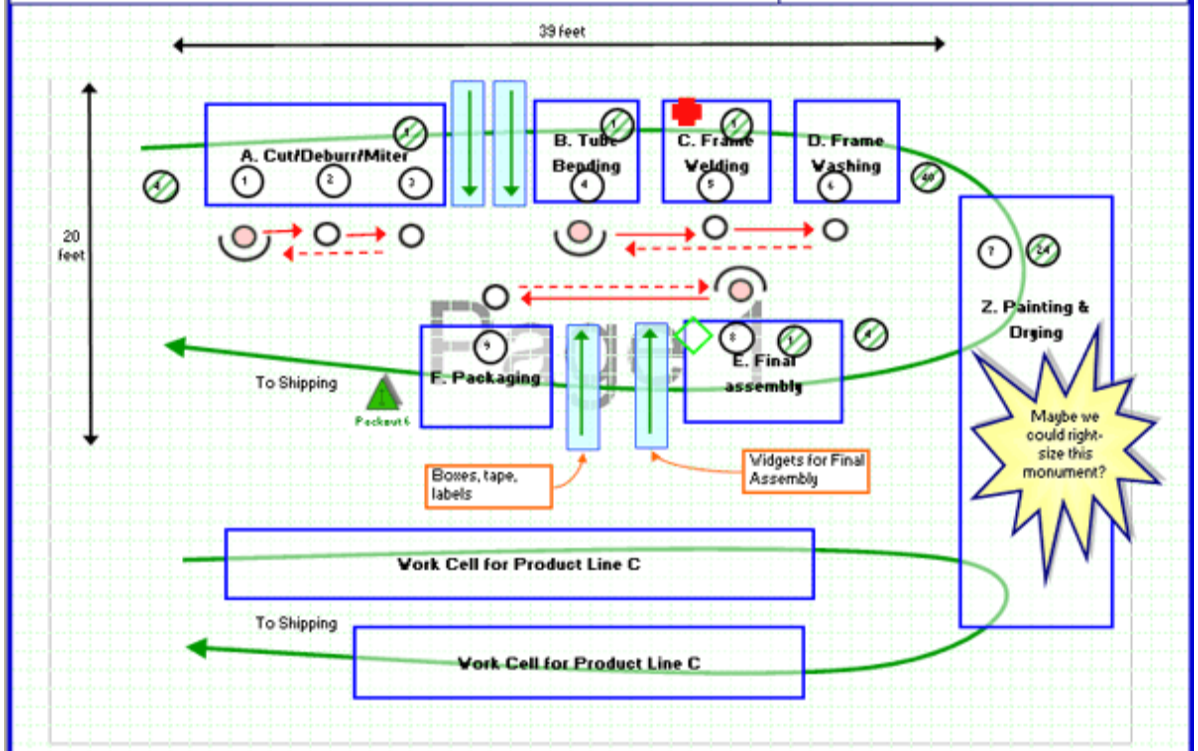
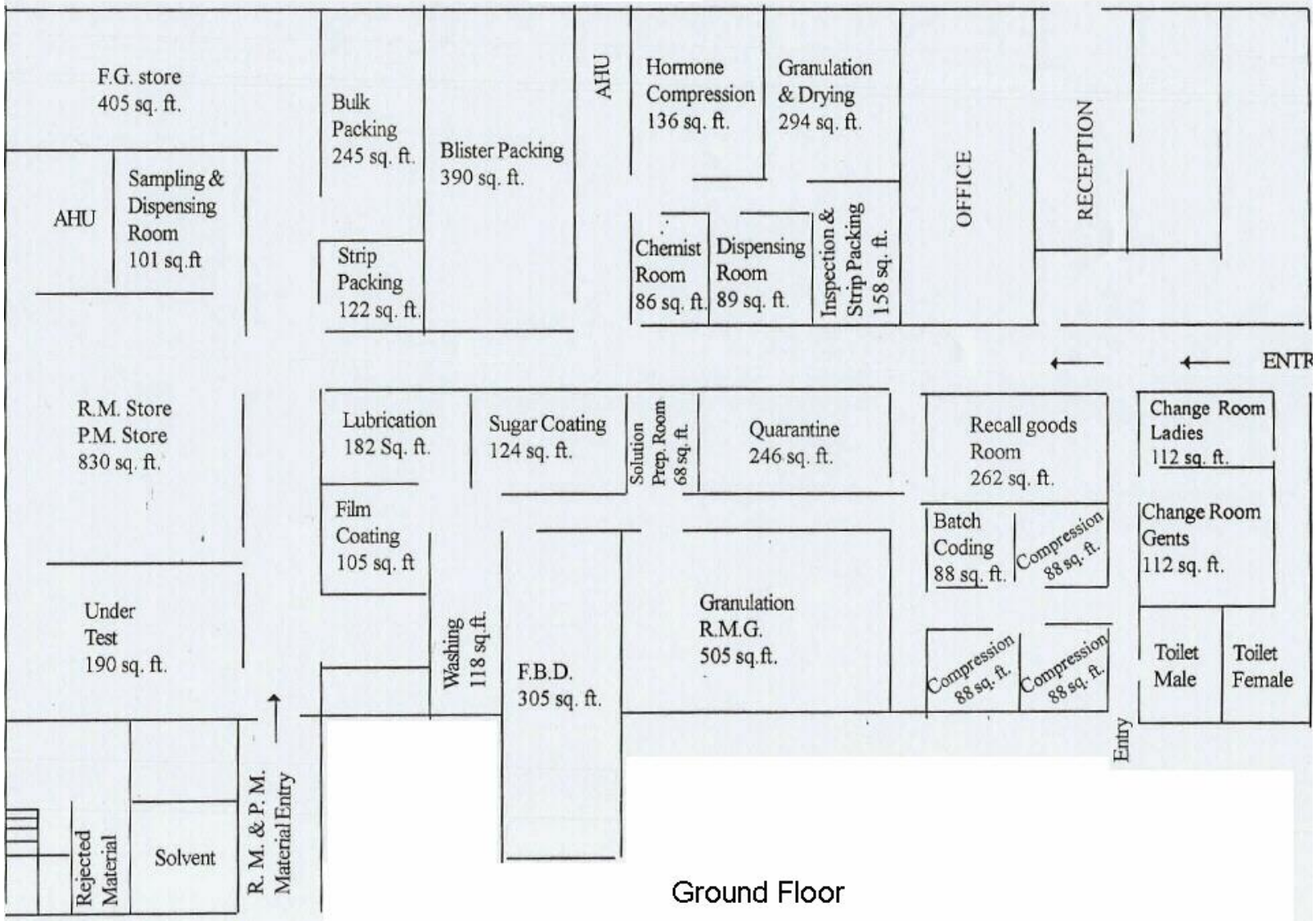


Drawing Scale	Staff Level	Takt Time	Cycle Time	Lead Time	Total Std WIP
1 foot per square	3 people	11.5 mins	11 mins	< 8 hrs	40 units

Add columns here



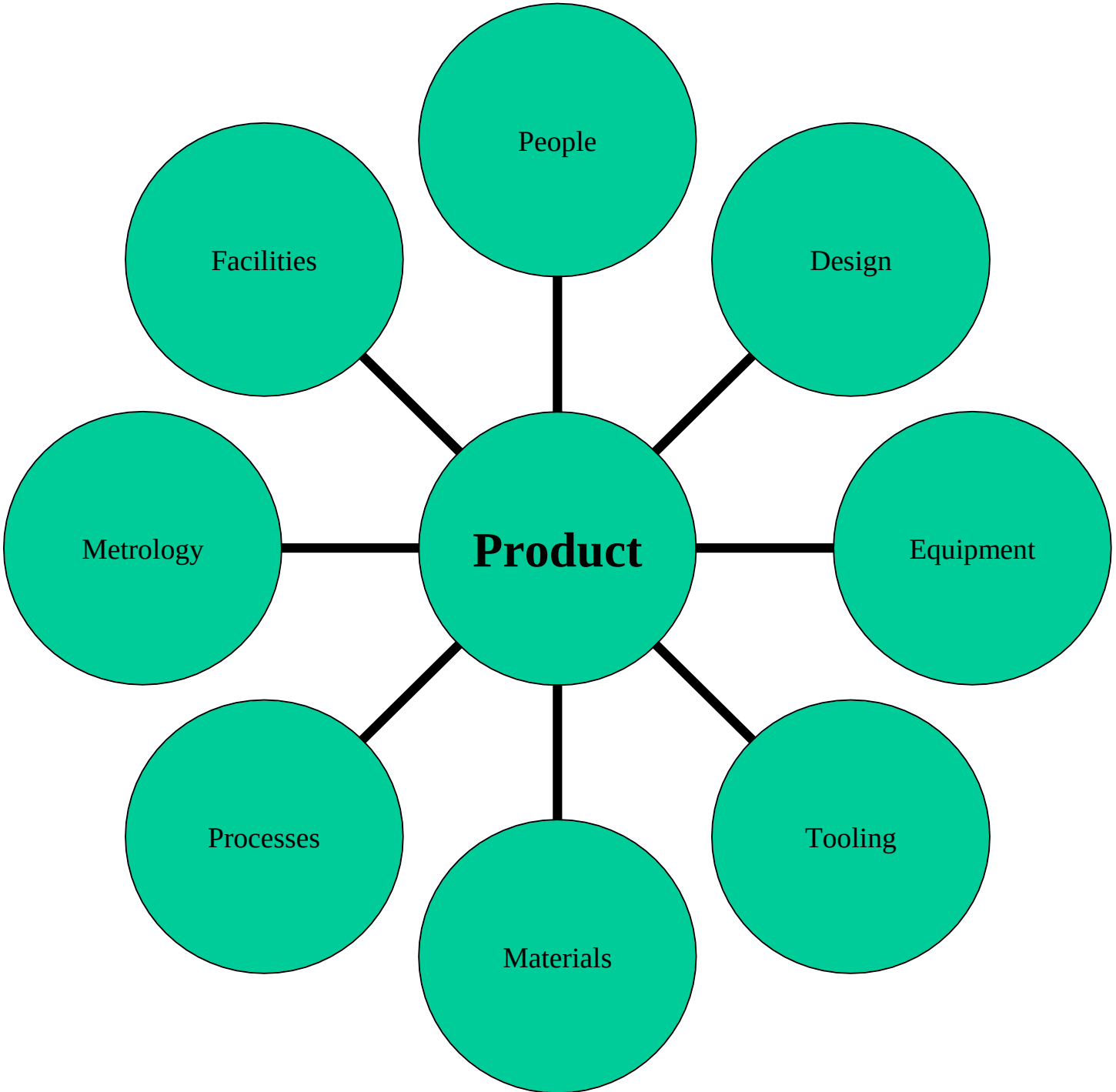
Ground Floor

3-D

Green Manufacturing Audit

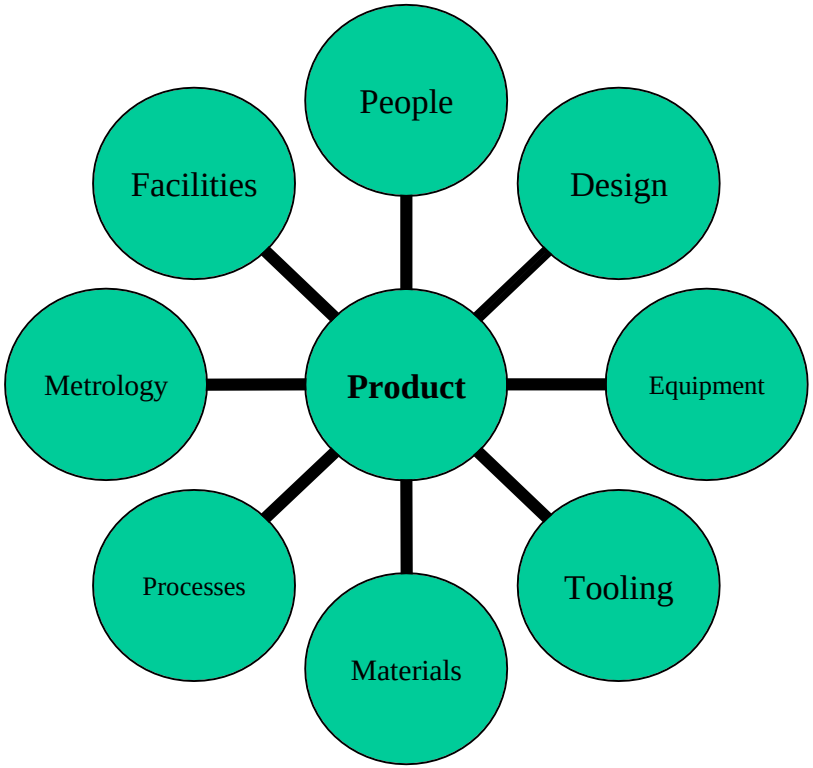
“Green Manufacturing Audit” means an evaluation of a manufacturing system to determine its environmental impact or carbon footprint.


Jiangsu Zhuodi Machinery Co.,Ltd


People
Facilities
Design
Metrology
Product
Equipment
Processes
Tooling
Materials

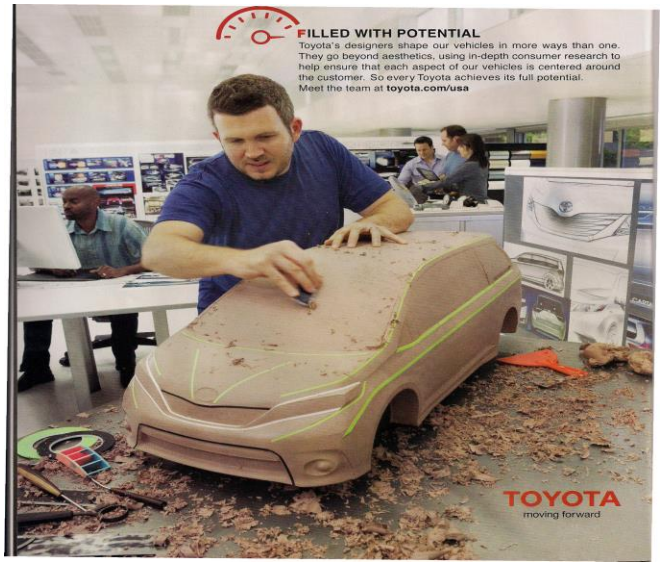
Components of Green Manufacturing Audit

- People and company policy
- Materials
- Energy usage
- Processes
- Facilities and equipment
- Public opinion survey
- Product life cycle



Materials Green Audit Factors

Steel	85%
Aluminum	90%
Zink	85%
Chromium	40%
Wood	80%
Degradable plastics	100%
Non-degradable plastics	80%
Water	100%
Glass	80%
Sand or silica	100%
Recyclables	90%
Lead	40%
Copper	85%
Brass	80%
Others	80%



Energy Green Audit Factors

Gasoline	80%
Diesel	80%
Coal	75%
Wood	70%
Hydroelectricity	100%
Wind	100%
Solar	100%
Algae	100%
Ethanol	100%
Geothermal	100%
Biodiesel	100%
Other	80%

Equipment Efficiency Audit Factors

Regular systems	80%
Old systems (polluters)	60%
Hybrid engines	90%
Biodiesel engines	90%
Biofuel systems	90%
Others	

Processes Audit Factors

• Manual	100%
• Power-driven cutting tool	85%
• Shearing & punching machines	90%
• Laser welding	95%
• Sand casting	80%
• Other casting processes	85%
• Arc welding	85%
• Gas welding	80%
• Extrusion molding	95%
• Injection molding	90%
• Other molding processes	85%

Design Technique Audit Factors

100% solar powered	100%
100% wind powered	100%
100% water powered	100%
100% coal powered	75%
100% gasoline powered	80%
100% diesel powered	100%
100% biodiesel powered	90%
100% biofuel powered	90%
100% electric powered	80%
Other	80%

Company Policy Green Audit Factors

Highest and enforced standards	100%
Fairly standard requirement	80%
Just enough to get by	60%
Not readily identifiable	30%
Clearly non	0%

Public Opinion Green Audit Factors

Highly liked by the public	100%
Company OK but can improve in some ways	80%
Company needs to do serious improvement	60%
Company has traditionally not cared but is willing to help	40%
Company is a 600 lbs. gorilla and cares about no one at all	0%

Green Manufacturing Audit Sheet

Manufacturing Systems Components	**Green Scores**	**Comments (Good, Poor, or Approve)**
Machine tool	_____	_____
Manufacturing methods and processes	_____	_____
Materials	_____	_____
Energy source	_____	_____
Company policy	_____	_____
Public opinion about company	_____	_____
Design technique	_____	_____
Average Score	_____	_____