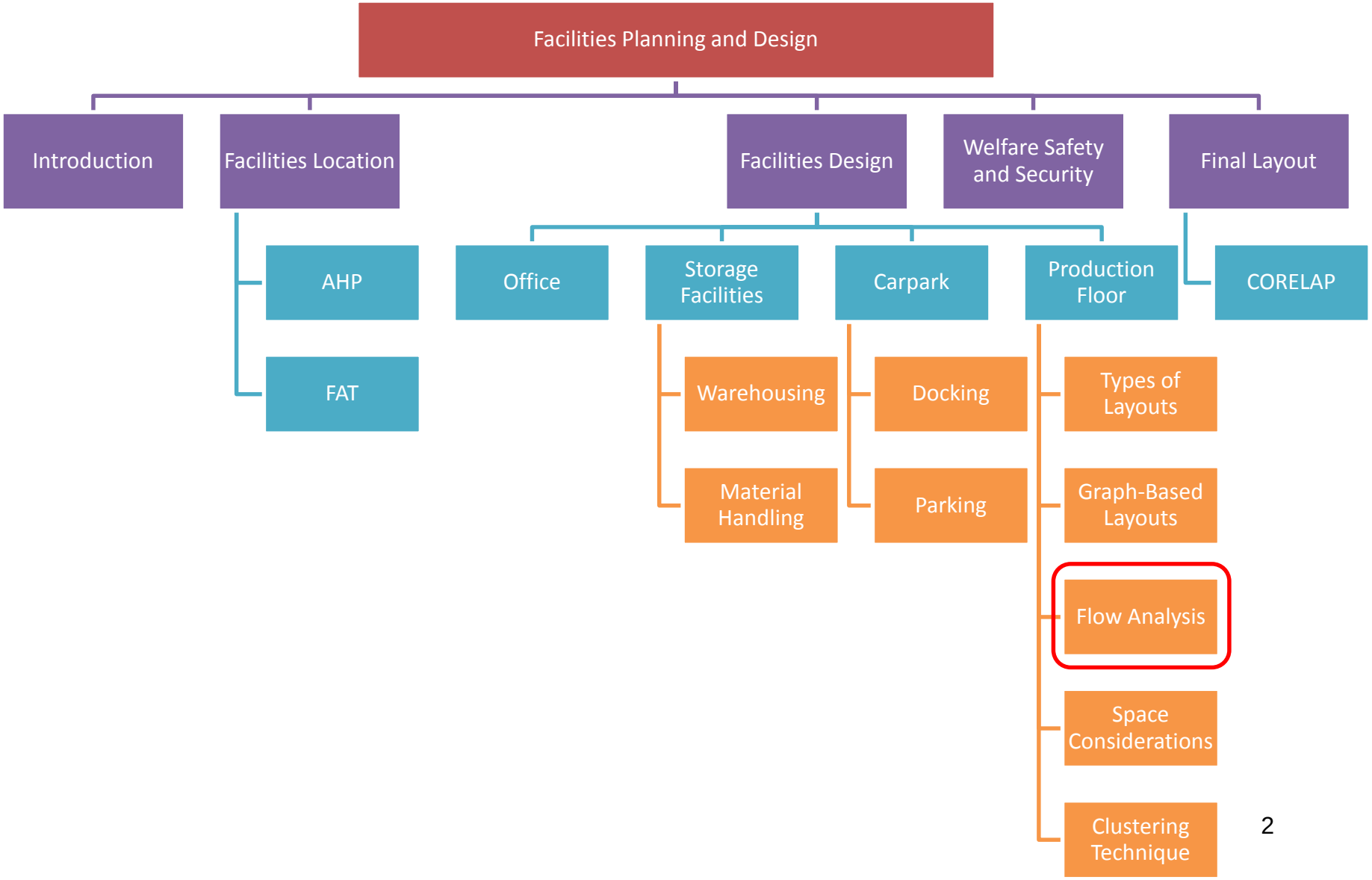
REPUBLIC POLYTECHNIC

Problem 06
The Flow

SCHOOL OF ENGINEERING

E212 Facilities Planning & Design - Topic Tree



Learning Objectives

- Calculate the total flow volume for a particular layout.
- Identify different areas of inefficiency in a facility and identify areas of changes in order to reduce the flow volume.
- Perform layout of different departments within a facility to ensure a good flow of materials and finished goods.
- Set up the process flow of a product from a flow diagram using From-To Chart.
- Calculate the equipment requirement based on production output, scrap ratio and maintenance requirement.

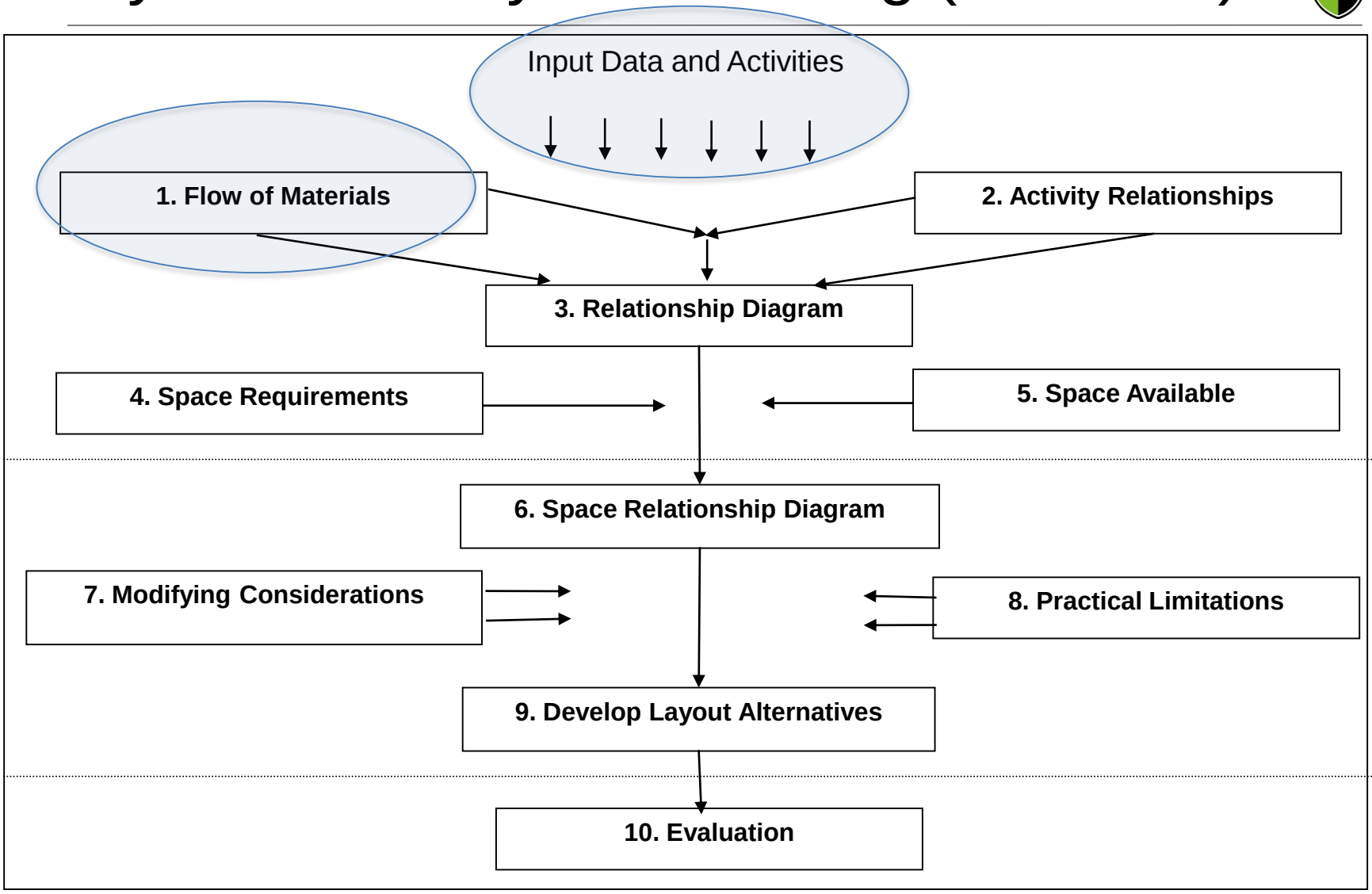
Flow Planning

- Process of arranging activities in combinations of basic flow patterns (based on flow analysis), both quantitative (from-to chart) and qualitative (activity relationship diagram).

- Types of flow
  - Materials
  - People
  - Equipment
  - Documents / Information

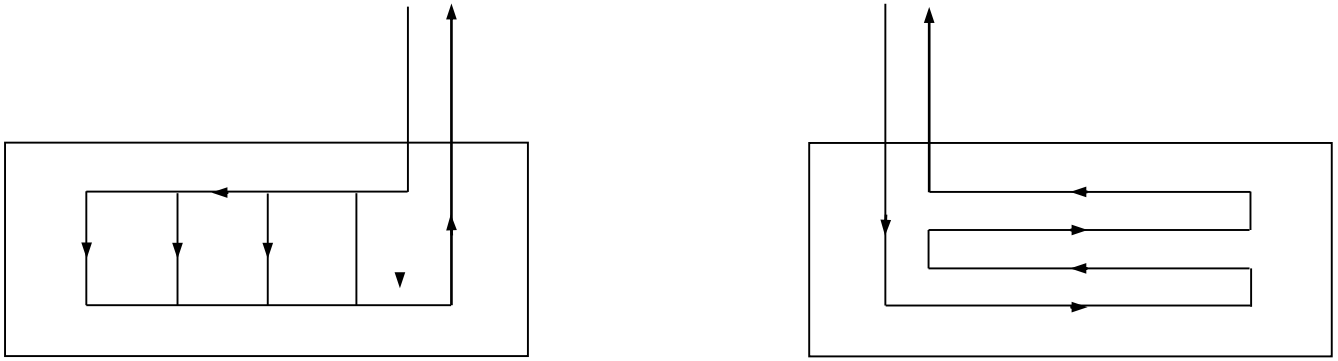
- Flow can be within workstation, within a department (intra-cell) or between departments (inter-cell)

Systematic Layout Planning (Muther's)

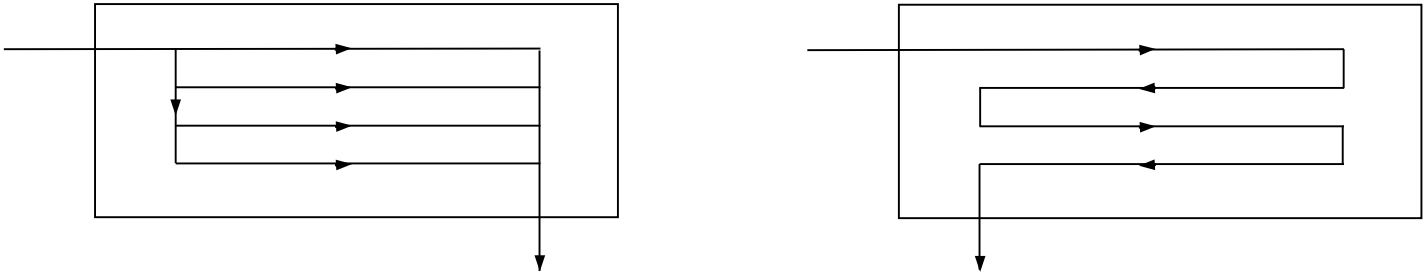


Flow within a facility considering the locations of entrance and exit (1/2)

At the same location

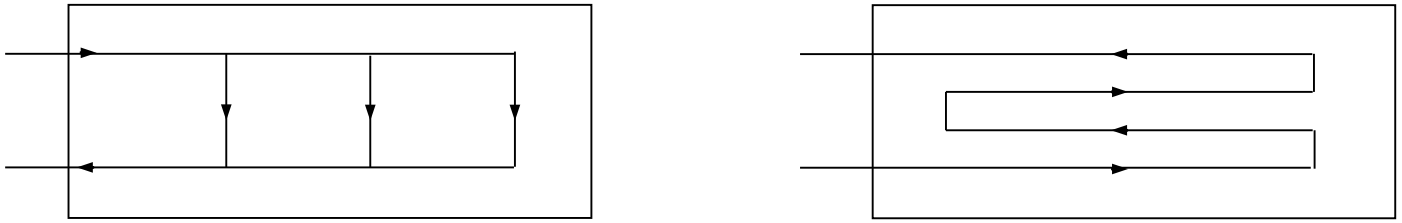


On adjacent sides

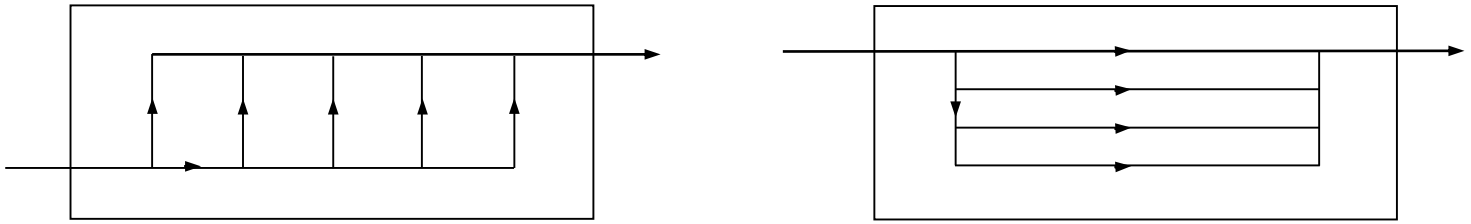


Flow within a facility considering the locations of entrance and exit (2/2)

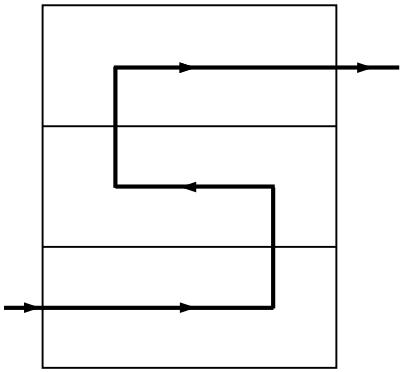
On the same side but
at opposite ends



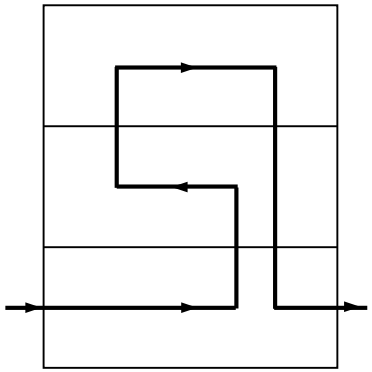
On opposite sides



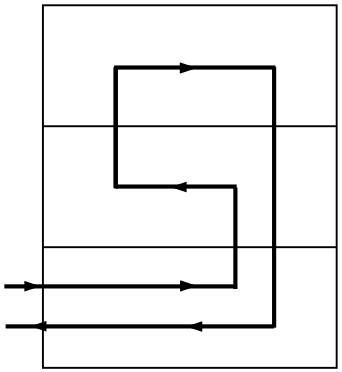
Vertical Flow Patterns



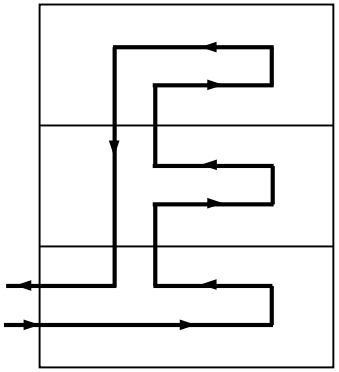
Flow between buildings exists and the connection between buildings is elevated



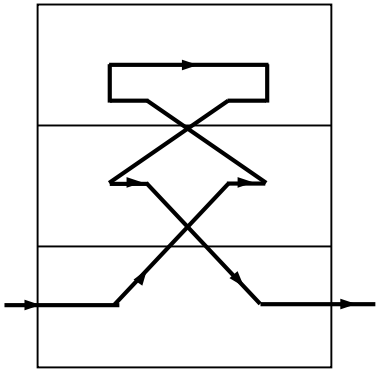
Ground level ingress (entry) and egress (exit) are required



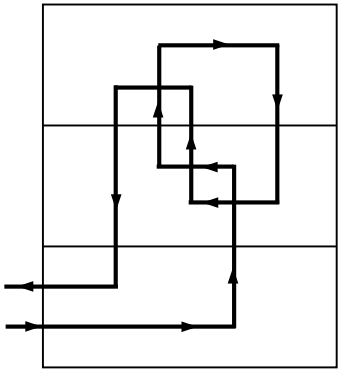
Ground level ingress (entry) and egress (exit) occur on the same side of the building



Travel between floors occurs on the same side of the building

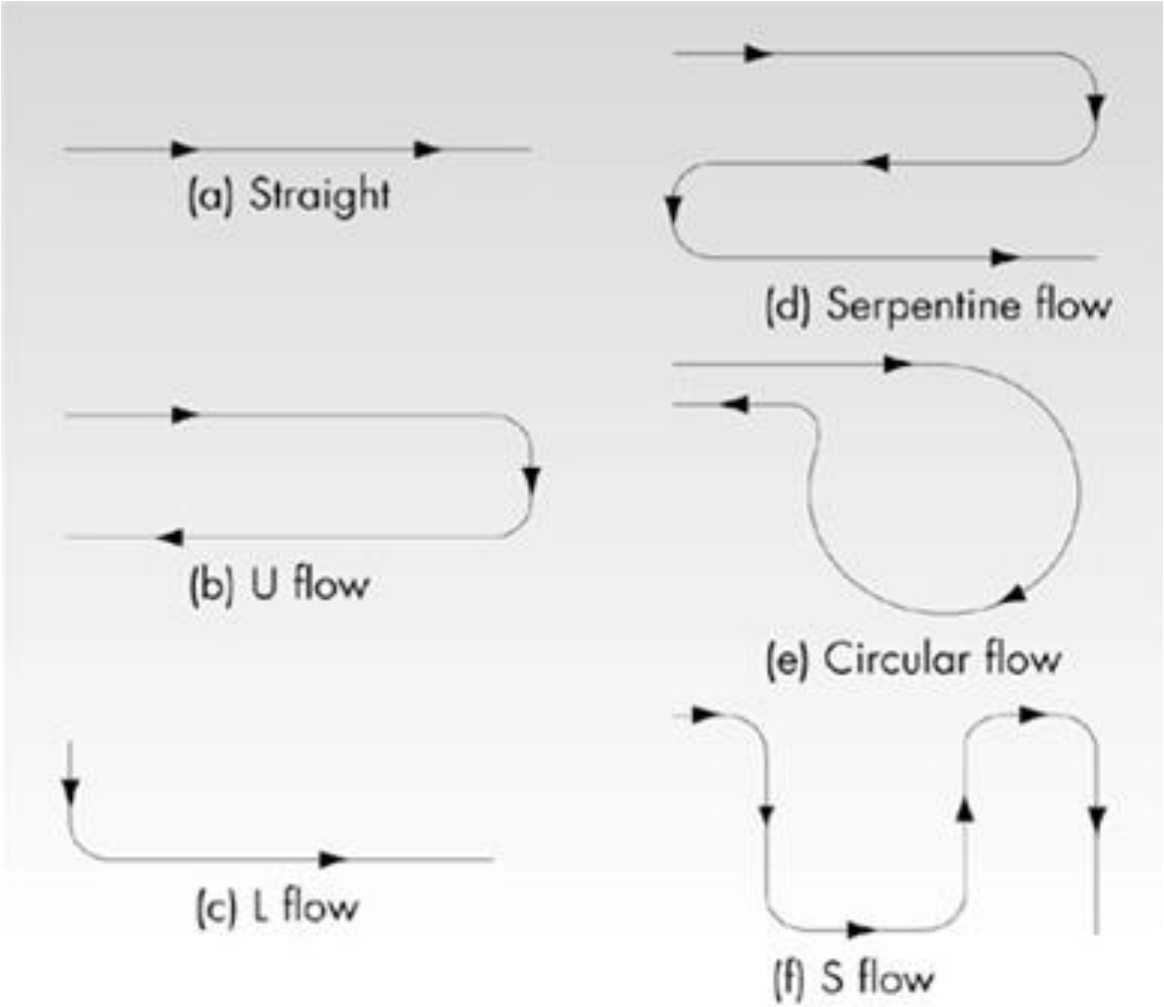


Some bucket and belt conveyors and escalators result in inclined flow



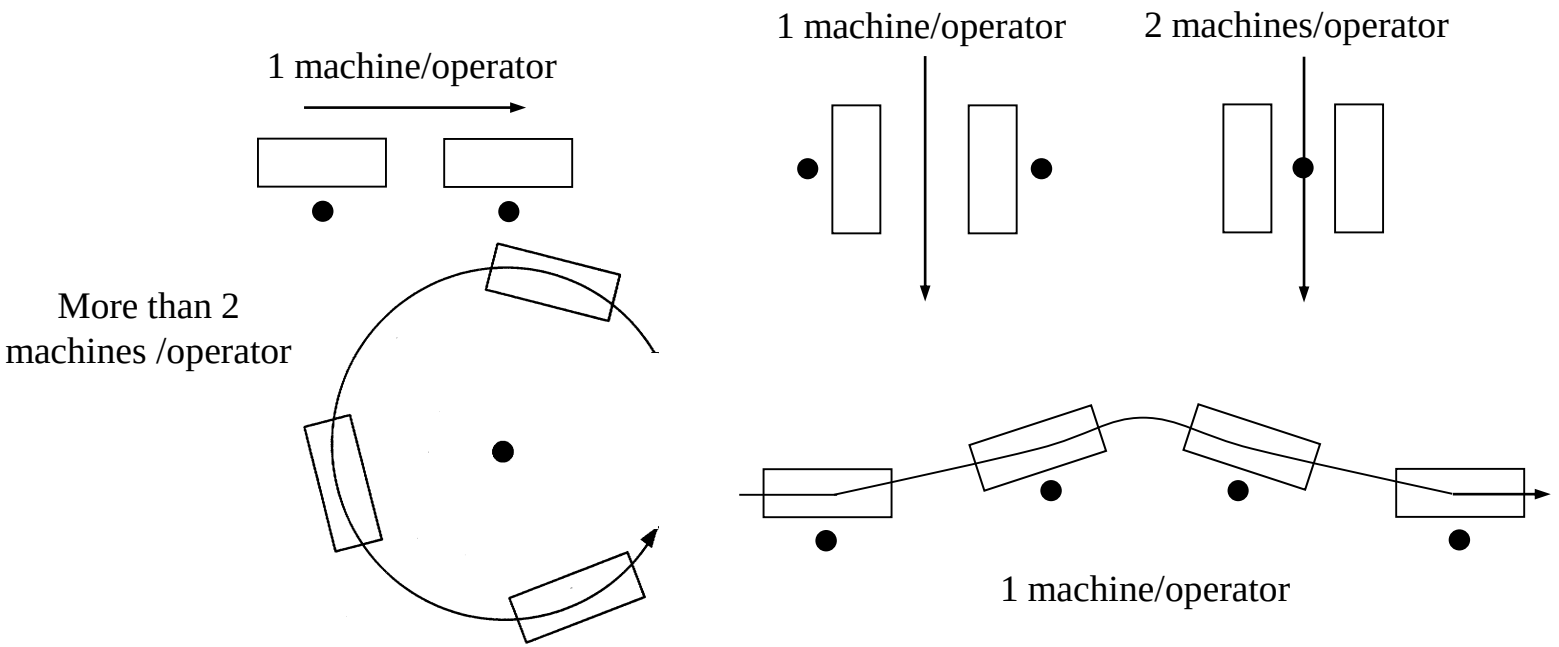
Backtracking occurs due to the return to the top floor

Flow Patterns between departments



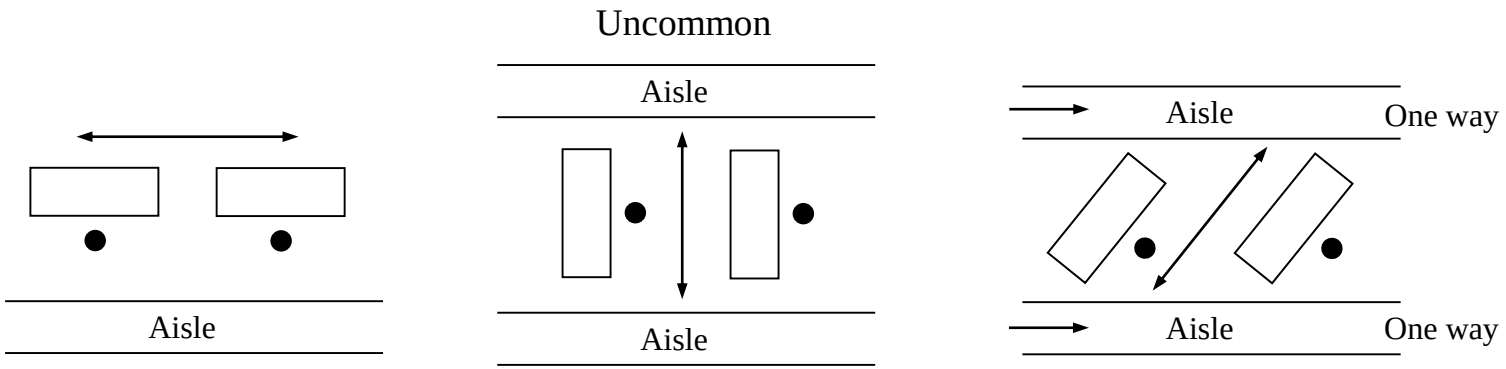
Flow Patterns within department (1/2)

- The flow pattern within departments depends on the type of department.
- In a product and/or product family department, the flow follows the product flow.



Flow Patterns within department (2/2)

- In a process department, little flow should occur between workstations within departments. Flow occurs between workstations and isles.



Dependent on: - **interactions among workstations**

- available space

- size of materials

Flow within Workstations

Motion studies and ergonomics considerations are important. Flow should be:

- **Simultaneous**: coordinated use of hands, arms and feet.
- **Symmetrical**: coordination of movements about the center of the body.
- **Natural**: movements are continuous, curved, and make use of momentum.
- **Rhythmical and Habitual**: flow allows a methodological and automatic sequence of activities. It should reduce mental, eye and muscle fatigue, and strain.

Principles of Flow Planning

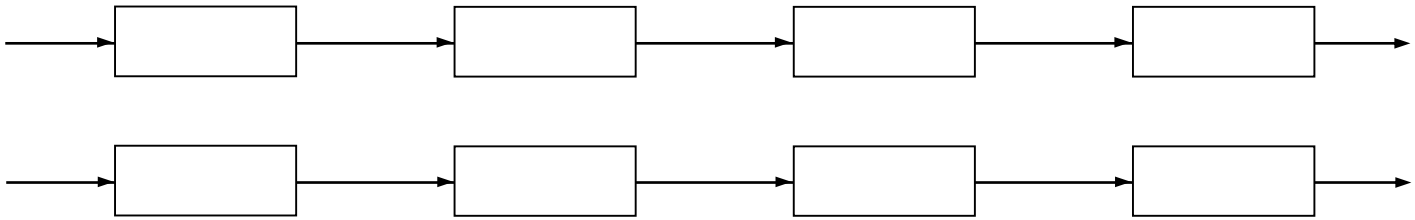
- Maximize directed flow
  - Directed flow: **uninterrupted** flow, does not intersect others
  - No **backtracking** of material

- Minimize frequencies of flow through work simplification
  - Deliver directly to the point of use - eliminate waste
  - Plan appropriate unit of load, use pallets to minimize trips
  - Combine flows and operations, e.g. Automobile assembly

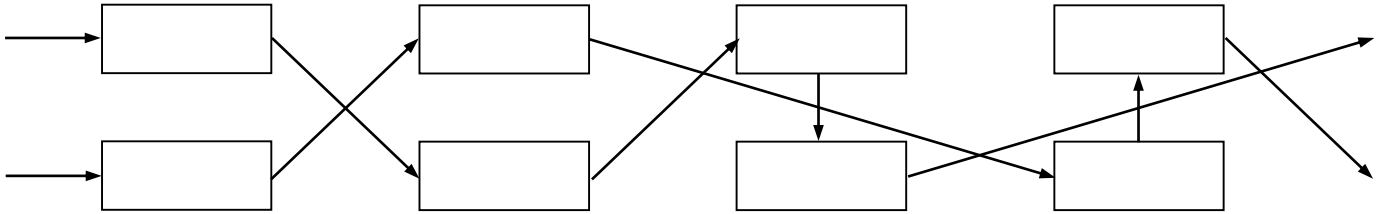
- Minimize cost of flow
  - Reduce travel distance
  - Mechanize or automate transfer

Uninterrupted Flow Path

Uninterrupted flow paths



Interrupted flow paths



Flow Analysis Information

A. Structured Product Part List

- Provides a listing of all components/parts of a product, includes part name, part number, drawing references, quantity of parts
- Product structure is a hierarchy referring to the level of product assembly: such as final product, sub-assemblies.
- Product Structure information and Structured Parts List will make up the Bill of Materials (BOM)

B. Operation Process Chart (OPC)

- Presents information on production method and assembly flow of the product
- Differentiates between in-house produced part and purchased part
- Can also include information on raw material used, operation times, inspection stations

Flow analysis information

C. From-To Chart

- A matrix that contains numbers representing a measure (unts, unit loads, etc) of the material flow between machines, departments, buildings, etc.

D. Others

- Assembly chart
- Flow process chart
- Multi product process chart
- Flow diagram

Equipment Requirements Planning

Equipment Capacity Table

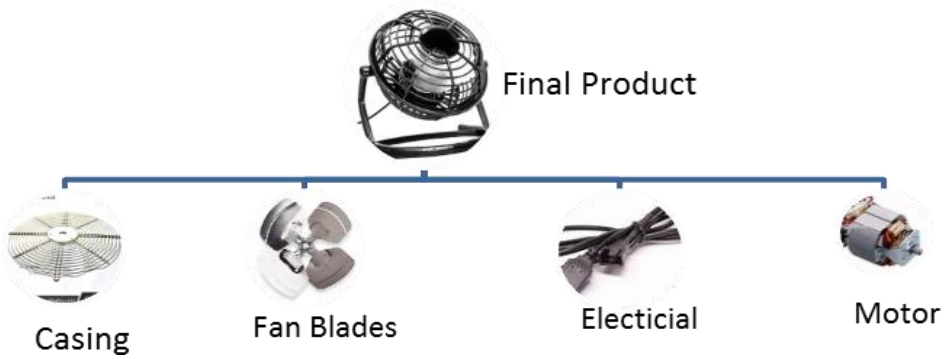
- Can have different formats

- Links product forecasted demand with available equipment to generate equipment requirements

- Contains detailed information on machine/equipment run-rates, allowances

Suggested Solution

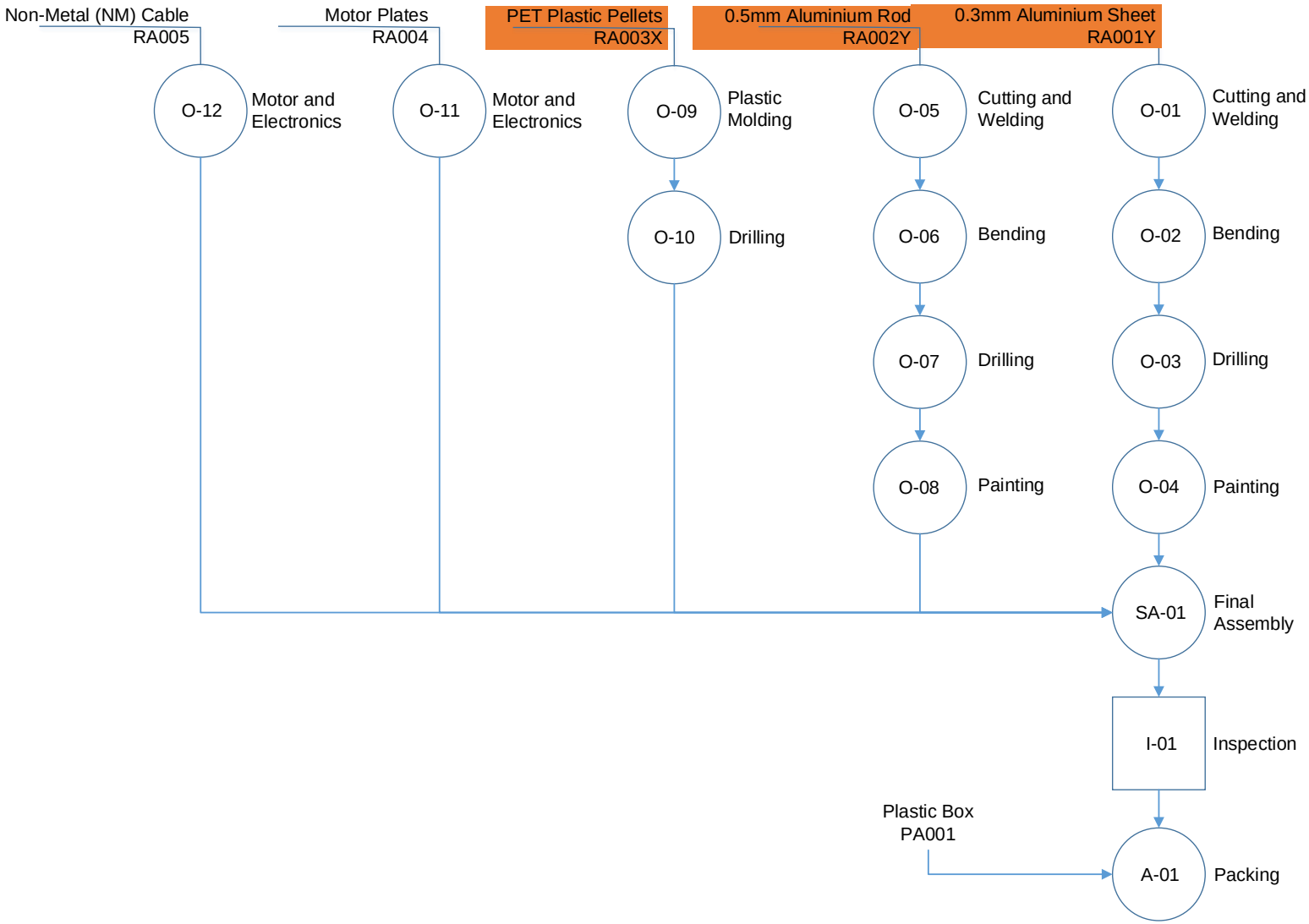
Flow Analysis Information



Part Number	Part Description
RA001	0.5mm Aluminium Sheet
RA001X	0.4mm Aluminium Sheet
RA001Y	0.3mm Aluminium Sheet
RA002	2mm Aluminium Rod
RA002X	1mm Aluminium Rod
RA002Y	0.5mm Aluminium Rod
RA003	PP Plastic Pellets
RA003X	PET Plastic Pellets
RA004	Motor Plates
RA005	Non-Metal (NM) Cable
PA001	Plastic Box
FA001A	USB Fan A
FA001B	USB Fan B
FA001C	USB Fan C

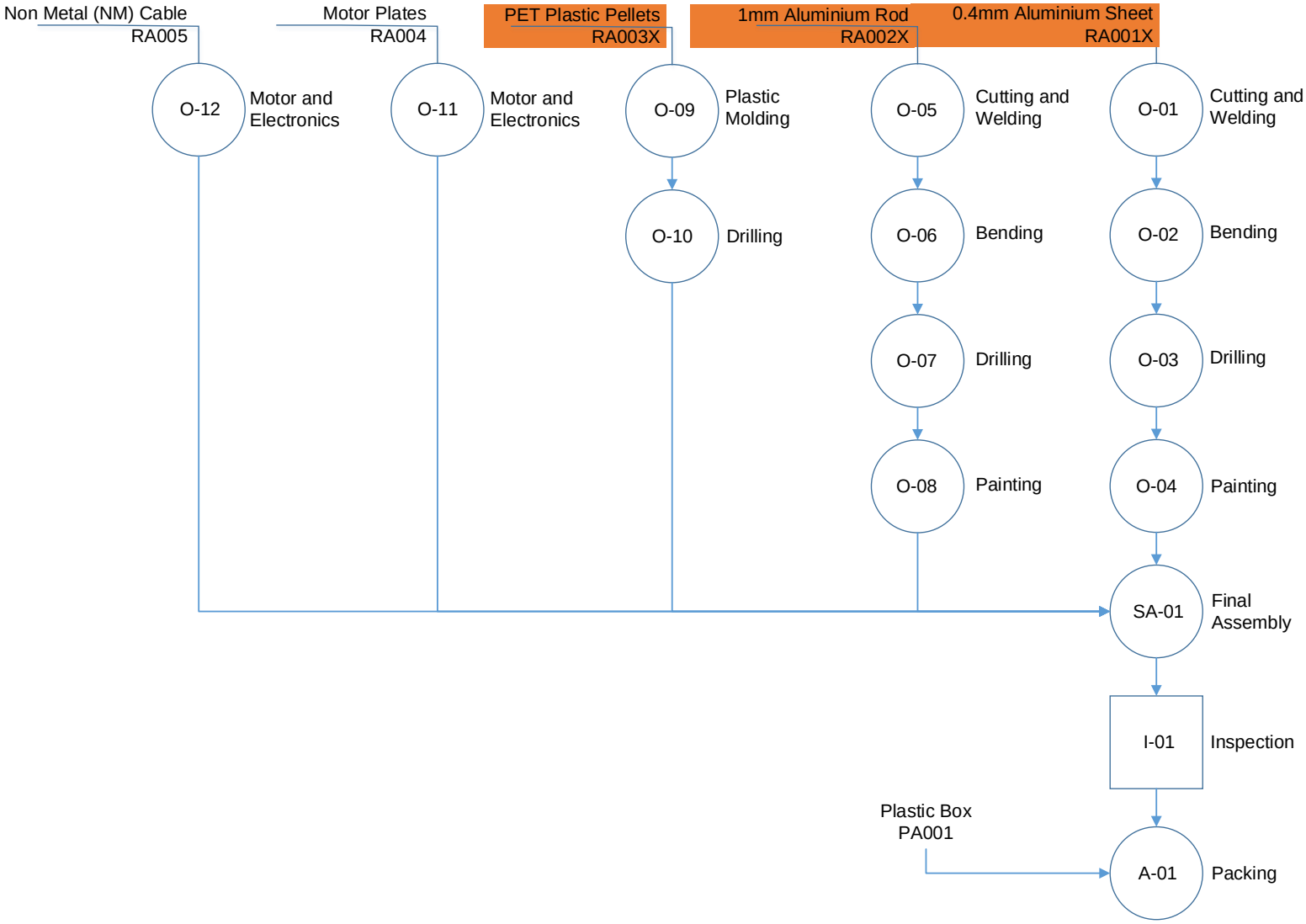
Flow Analysis Information

Operations Process Chart (OPC): USB Fan A



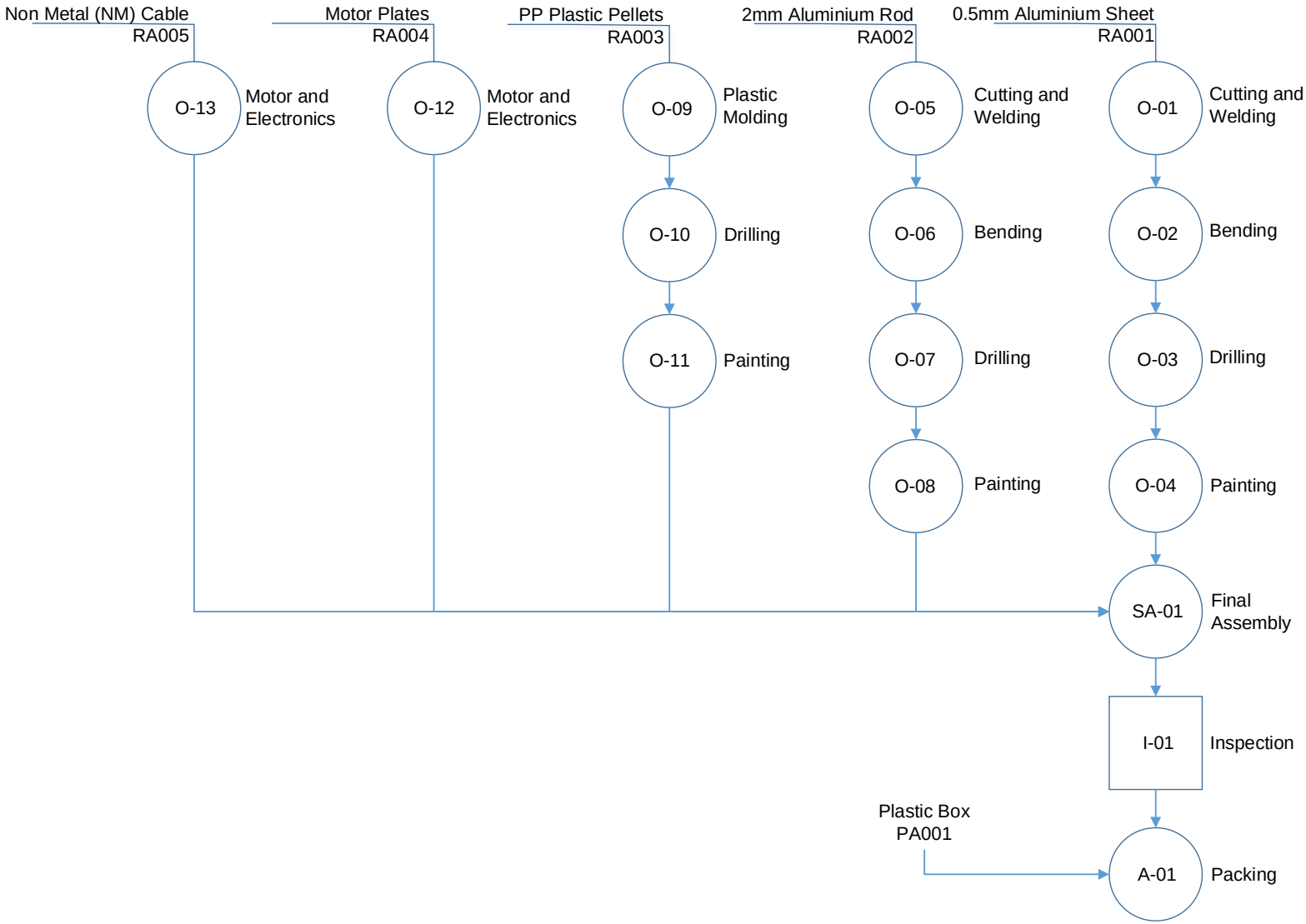
Flow Analysis Information

Operations Process Chart (OPC): USB Fan B



Flow Analysis Information

Operations Process Chart (OPC): USB Fan C



Flow Analysis Information

Forecasted Demand & Equipment Involved

Item	Planned Production Capacity (unit per hour)
USB Fan A	540
USB Fan B	240
USB Fan C	180
Motor Plates Only	180
Non-Metal (NM) Cable Only	180

Station ID	Station Description
A	Drilling Station
B	Bending Station
C	Plastic Molding Station
D	Spray Painting Station
E	Cutting & Welding Station
F	Motor & Electronics Station
G	Final Assembly, Inspection, and Packaging Station
H	Raw Material Area
J	Finished Good Area

Flow Analysis Information

Equipment Routing , Flow Quantity, Batch Size, and Number of Trip

Part Number	Part Description	Equipment Routing						Quantity Required (in unit)	Batch size	Number of Trip
RA001	0.5mm Aluminium Sheet	H	E	B	A	D	G	180	80	3
RA001X	0.4mm Aluminium Sheet	H	E	B	A	D	G	240	80	3
RA001Y	0.3mm Aluminium Sheet	H	E	B	A	D	G	540	80	7
RA002	2mm Aluminium Rod	H	E	B	A	D	G	180	40	5
RA002X	1mm Aluminium Rod	H	E	B	A	D	G	240	40	6
RA002Y	0.5mm Aluminium Rod	H	E	B	A	D	G	540	40	14
RA003	PP Plastic Pellets	H	C	A	D	G		180	75	3
RA003X	PET Plastic Pellets	H	C	A	G			780	75	11
RA004	Motor Plates	H	F	G				960	15	64
	(spare parts)	H	F	J				180	15	12
RA005	Non-Metal (NM) Cable	H	F	G				960	100	10
	(spare parts)	H	F	J				180	100	2
PA001	Plastic Box	H	G					960	400	3
FA001A	USB Fan A	G	J					540	20	27
FA001B	USB Fan B	G	J					240	20	12
FA001C	USB Fan C	G	J					180	20	9

From-To Chart:

Some Notations:

N_{ij}: number of different types of items moved between activities i and j.

f_{ijk}: flow volume between i and j for item k (in moves/time period).

h_{ijk}: equivalence factor for moving item k with respect to other items moved between i and j (dimensionless)

[all h_{ijk} = 1 if assumed equal ease of movement]

w_{ij}: equivalent flow volume specified in From-To Chart (in moves/time period),

$$w_{ij} = \sum_{k=1}^{N_{ij}} f_{ijk}\, h_{ijk}.$$

From-To Chart (Step 1)

(Showing only the flow volume between i and j)

From \ To	A	B	C	D	E	F	G	H	J
A				41			11		
B	38								
C	14								
D							41		
E		38							
F							74		14
G									48
H			14		38	88	3		
J									

Working example:

There are 180 units of PP Plastic Pellet and 780 units of PET Plastic Pellets that move from Raw Material Area (H) to Plastic Molding Station (C) per hour.

Since both of them move in a batch size of 75, the total number of trips = RU(180/75) + RU(780/75) = RU(2.4) + RU(10.4) => 3 + 11 = 14

**RU = Round Up*

From-To Chart (Step 2)

(Showing the flow volume with consideration of the level of difficulty in moving the parts)

From \ To	A	B	C	D	E	F	G	H	J
A				41			11		
B	38								
C	14								
D							41		
E		38							
F							106.0		20.0
G									48
H			14		38	126.0	3		
J									

Working example:

We know from the worksheet that it is 1.5 times more difficult to move the motor plate. We also know that the motor plate's equipment routing is H-F-G and H-F-J. So only flow H-F, F-G, and F-J will be affected.

So, example for H-F we should multiple 1.5 to the motor plate's flow quantity (other parts' flow quantity remains the same): 1.5*RU(960/15) + RU(960/100) + 1.5*RU(180/15) + RU(180/100) = 1.5*RU(64) + RU(9.6) + 1.5*RU(12) + RU(1.8) => 96 + 10 + 18 + 2 = 126

**RU = Round Up*

From-To Chart (Step 3)

(Rounding up the numbers, if there is any decimals)

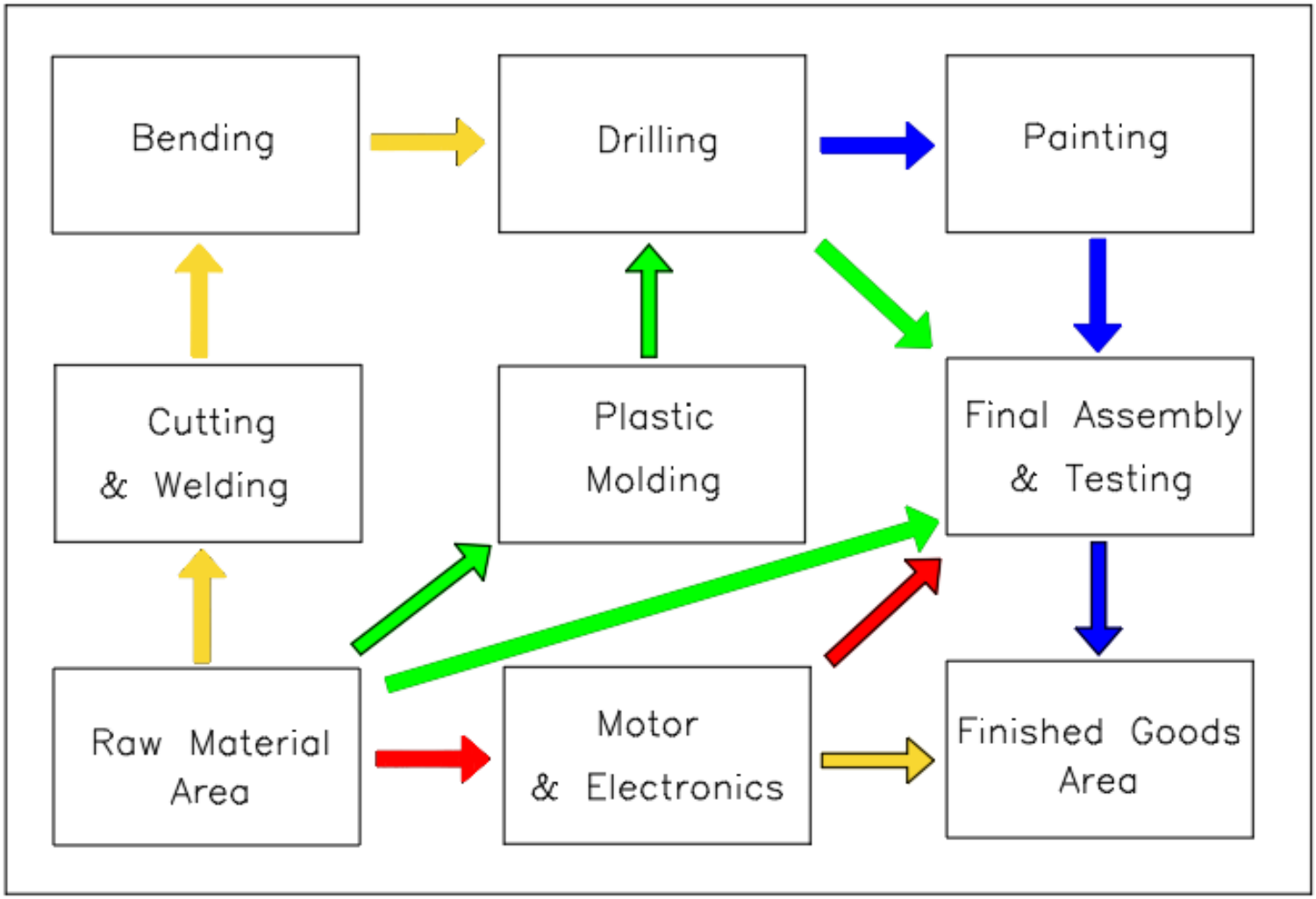
From \ To	A	B	C	D	E	F	G	H	J
A				41			11		
B	38								
C	14								
D							41		
E		38							
F							106		20
G									48
H			14		38	126	3		
J									

Intensities of Flow between Equipment/Stations

From \ To	A	B	C	D	E	F	G	H	J
A				41 (B)			11 (D)		
B	38 (C)								
C	14 (D)								
D							41 (B)		
E		38 (C)							
F							106 (A)		20 (C)
G									48 (B)
H			14 (D)		38 (C)	126 (A)	3 (D)		
J									

A	Very High Flow (> 100)
B	High Flow (41 - 99)
C	Medium Flow (16 - 40)
D	Low Flow (0 - 15)

Proposed Layout of Equipment (in AutoCAD)



Minimum Equipment Requirement

Station ID	Station Description	Gross Output (units per hour)	Equipment Efficiency	Net Output (units per hour)	Demand (units per hour)	Number of Equipment Needed	Number of Equipment Needed (Rounded Up)
A	Drilling Station	400	95%	380	2880	7.58	8
B	Bending Station	360	95%	342	1920	5.61	6
C	Plastic Molding Station	180	95%	171	960	5.61	6
D	Spray Painting Station	400	95%	380	2100	5.53	6
E	Cutting & Welding Station	300	90%	270	1920	7.11	8
F	Motor & Electronics Station	720	85%	612	2280	3.73	4
G	Final Assembly, Inspection, and Packaging Station	300	95%	285	960	3.37	4
H	Raw Material Area	-	-	-	-	1	1
J	Finished Good Area	-	-	-	-	1	1

Sample Calculation for Drilling Station:

Net Output = Gross Output * Efficiency = 400 x 95% = 380

Minimum number of equipment needed = Demand / net output = 2880 / 380 = 7.58 = 8 **(rounded up)**

Learning Objectives

- Calculate the total flow volume for a particular layout.
- Identify different areas of inefficiency in a facility and identify areas of changes in order to reduce the flow volume.
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- Set up the process flow of a product from a flow diagram using From-To Chart.
- Calculate the equipment requirement based on production output, scrap ratio and maintenance requirement.

Overview of E212 Facilities Planning and Design