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INDUSTRIAL ENGINEERING

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Chapter 04

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Chapter 04

PROCESS PLANNING

OUTLINE

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1	Process Theory
2	Process Mapping
3	Process-related Documents
4	Product-Process Clustering
5	Consecutive Exercise

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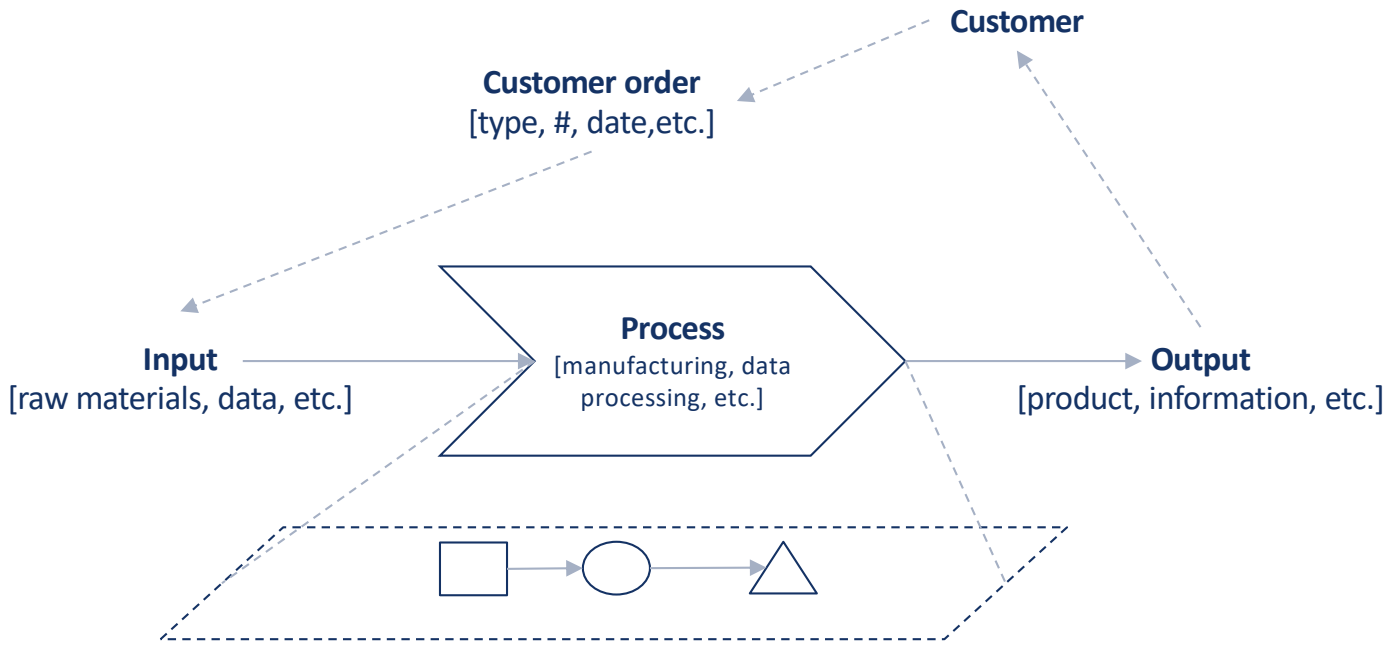
PROCESS THEORY

PROCESS DEFINITION

General view

„Operation to transform inputs in outputs“[1]



Production-related

„Sequence of tasks or operations with an internal (technological and organizational) connection to fulfil customer orders by involving several work systems.“[2]

[1] DIN EN ISO 9001:2005
[2] REFA 2017

PROCESS CHARACTERISTICS


Controlled and step-wise procedure


Interaction of humans and machines


Creating parts, components, and products


Purposeful transformation of material


Follow a sequence

Process Chain

PROCESS TYPES

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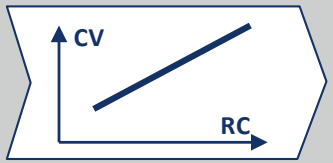
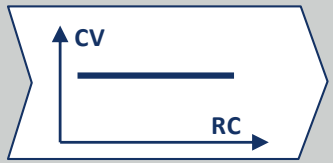
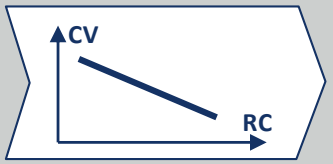
Value-adding	Supporting
planned	planned
	
Processing	Transportation
Assembly	Storing

extend

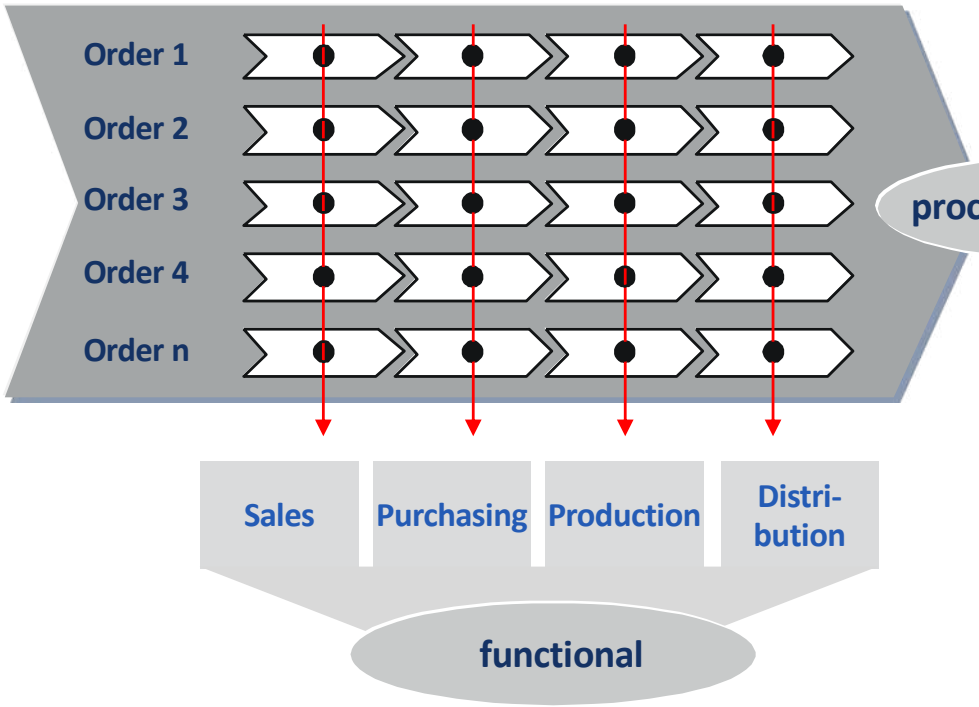
CV = Customer Value

RC = Resource Consumption

identify and eliminate

Non-Value Adding	Value-destructive
unplanned	unplanned
	
Buffering	Scrap
Searching parts	Failures

PROCESS VS. FUNCTIONAL VIEW



- Less lead time
- Higher due date reliability
- Less inventory
- Process-based calculation
- Less hierarchies
- Higher product & process quality

- Less operation times
- High capacity utilization
- Higher product quality
- Interfaces
- Higher inventory

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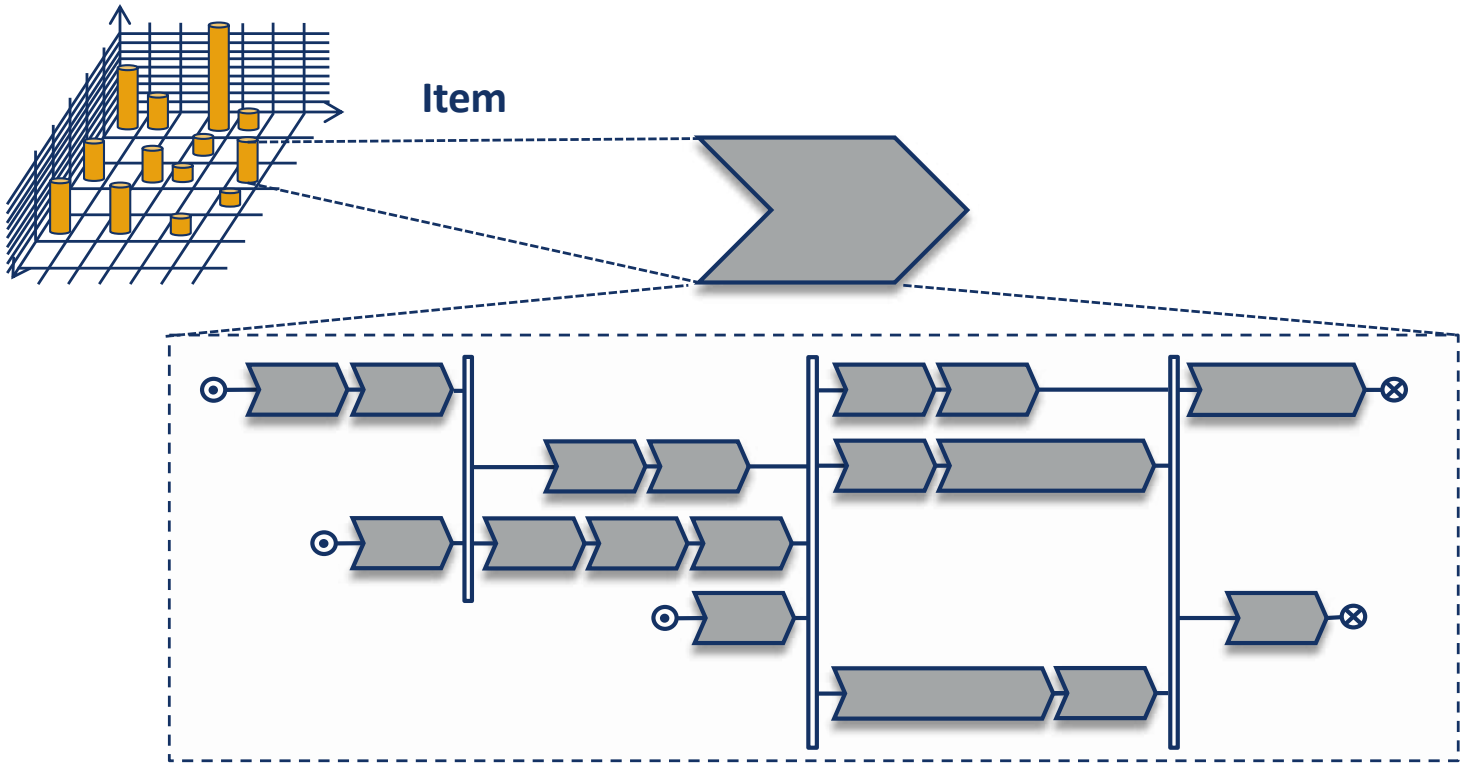
PROCESS MAPPING

PROCESS MAPPING



- Graphical description and documentation of processes
- Use of process modelling languages and symbols with well-defined notations that are connected based on defined syntax
- Help identifying necessary value-added and supporting processes to manufacture a product
- Result: Process Map

PROCESS MAPPING LEVELS

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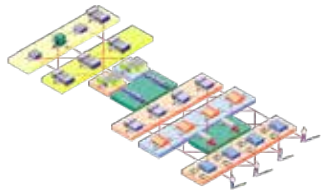
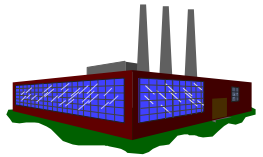
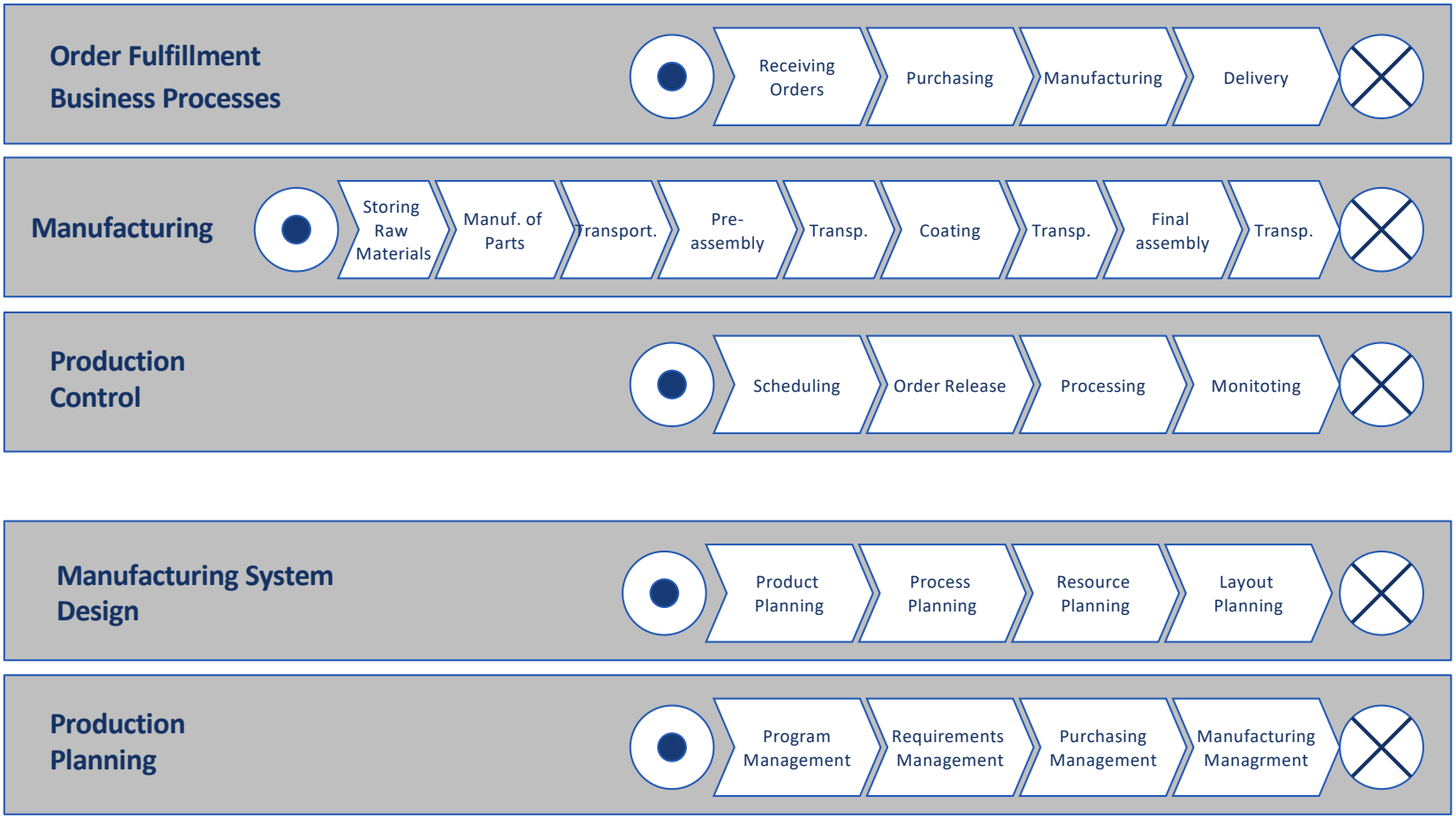
Supply Chain	• 1st level material flow processes (company A → B) • Business processes (network order fulfillment)	
Facility	• 2nd level material flow processes (system 1 → 2) • Business processes (order fulfillment)	
System	• 3rd level material flow processes (pre-assembly → final assembly) • 4th level material flow processes (work station) • Manufacturing processes • Assembly processes	

SAMPLE PROCESSES IN COMPANIES



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PROCESS-RELATED BASIC DOCUMENT

ROUTE SHEET

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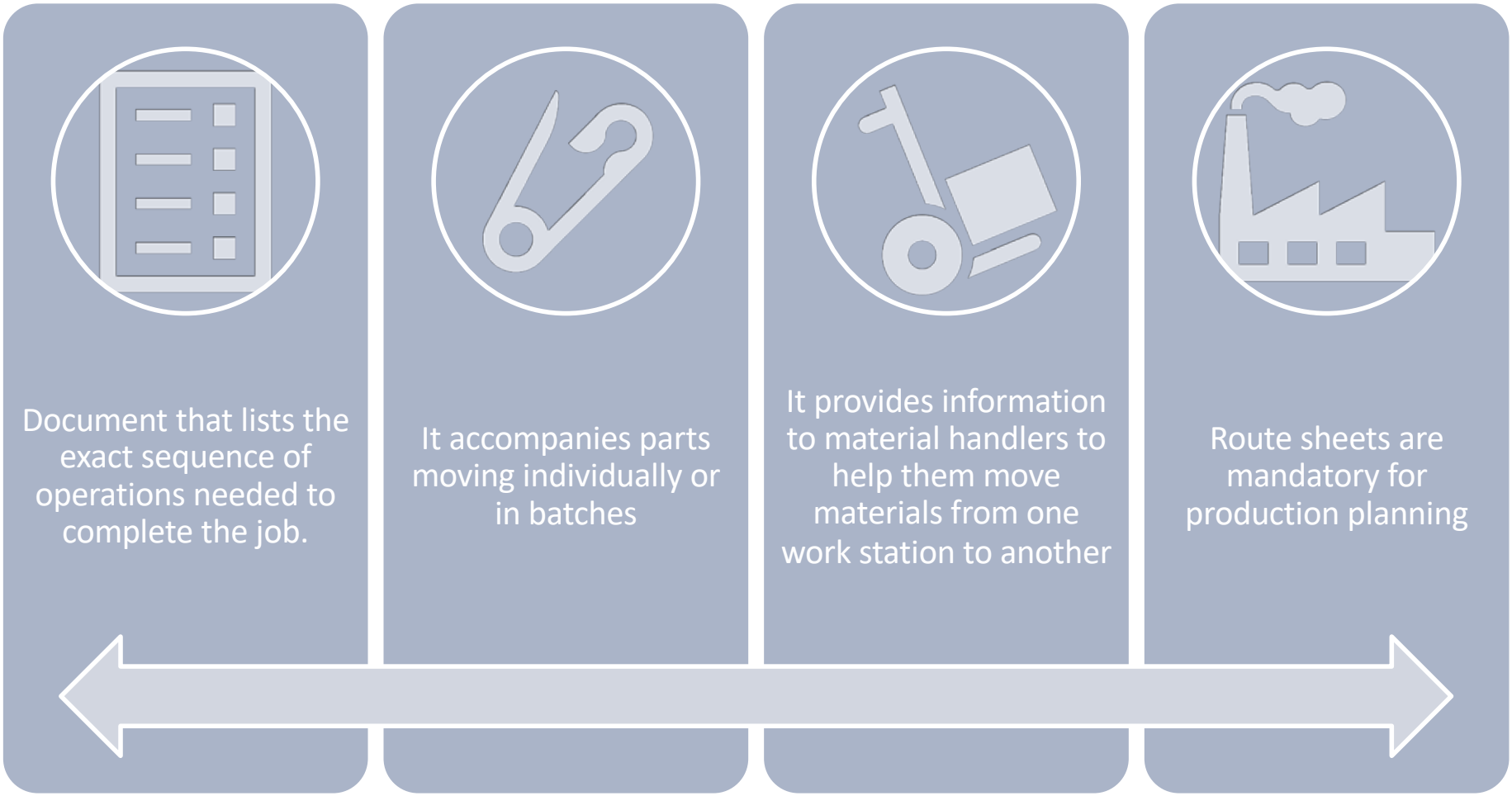

ROUTE SHEET: EXAMPLES

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Route Sheet XYZ Machine Shop, Inc.

Part no.	Part name	Planner	Checked by:	Date	Page
081099	**Shaft, generator**	MPGroover	N. Needed	08/12/XX	1/1
Material	Stock size	Comments:			
1050 H18 Al	60 mm diam., 206 mm length				

No.	Operation description	Dept	Machine	Tooling	Setup	Std.
10	Face end (approx. 3 mm). Rough turn to 52.00 mm diam. Finish turn to 50.00 mm diam. Face and turn shoulder to 42.00 mm diam. and 15.00 mm length.	Lathe	L45	G0810	1.0 hr	5.2 min
20	Reverse end. Face end to 200.00 mm length. Rough turn to 52.00 mm diam. Finish turn to 50.00 mm diam.	Lathe	L45	G0810	0.7 hr	3.0 min
30	Drill 4 radial holes 7.50 mm diam.	Drill	D09	J555	0.5 hr	3.2 min
40	Mill 6.5 mm deep x 5.00 mm wide slot.	Mill	M32	F662	0.7 hr	6.2 min
50	Mill 10.00 mm wide flat, opposite side.	Mill	M13	F630	1.5 hr	4.8 min

Date

Planit Software Ltd

100998

ROUTING SHEET/INSPECTION REPORT

Description: Pin - Live

Part Number: JS-PIN-LIVE

Works Order: 100998

Drawing Issue: Issue A Method

Qty inc scrap	Qty exc scrap	Start date	End date	Sales Order
3000 EA	2850 EA			

Route Issue 1

Production to comply with quality standard as specified in the ISO 9000 documentation.
All Scrap and Rejected material to be returned or reported to inspection before placing in the scrap bins.

Op No	W/C	WC Description / Operation Narrative	Key Op	Set-up Time	Labour Time	Qty Prod.	Operator Sign	First off inspection	Qty Accept	Qty Scrap	Insp
10	300	Saw	N	10.00	30.00						
		Saw to length See drawing									
20	310	Machine Centre	N	60.00	150.00						
		Machine to drawing First off inspection required									
30	330	Spot Welding	Y	10.00	150.00						
		Spot weld fuse holder to pin									
40	810	Painting	Y	3 Days	240.000						
		Mask and paint to specification Do not paint last 8 mm of pin									
50	900	Inspection	Y	10.00	0.00						
		Sample Inspection									

Item No	Quantity	Material	Length / Width	Line Description	Operator
1	195.000 MT	JS-BRS-002 Brass 10mm x 6 mm			
1	3000 EA	JS-PR-002 Pressing - Live pin top			

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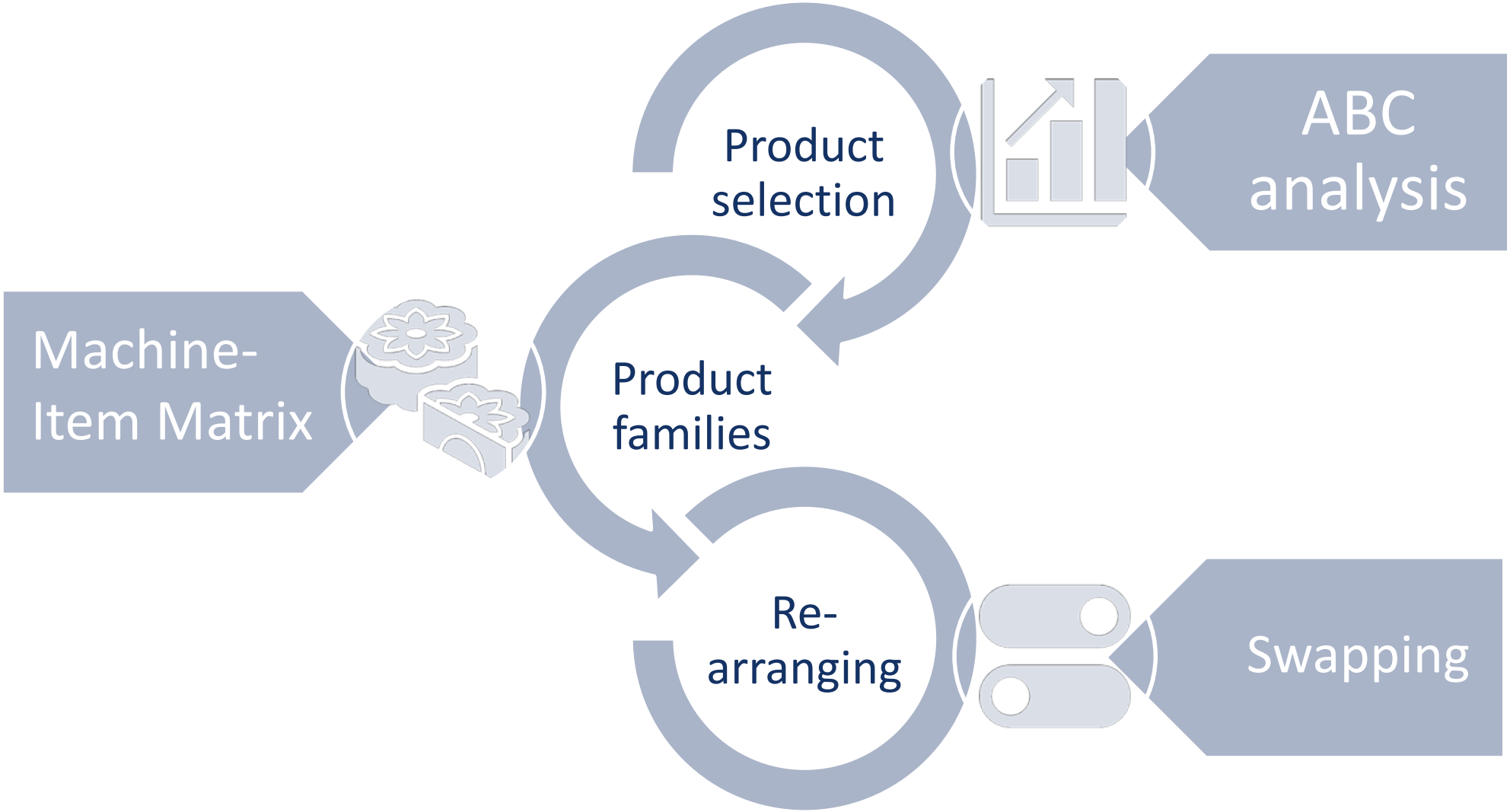
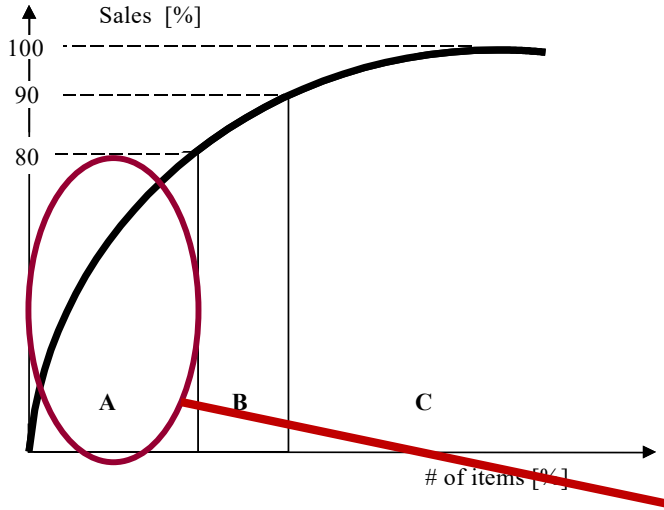
PRODUCT-PROCESS CLUSTERING

DEFINING PRODUCT FAMILIES



DEFINING PRODUCT FAMILIES

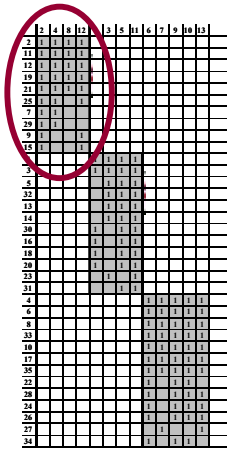


Route Sheet

Article #	Zyx123		
Lot Size	1.000		
OP	**Machine**	t_e	T_r
10	B1	...	...
...	...	...	...
...	...	...	...

Machine-Item Matrix

	B1	B2	B3	B4	B5	B6	B7	...
I-1001	1		1		1	1		
I-1002	1	1	1	1		1		
I-1003				1	1	1		1
I-1004				1	1	1	1	1



	Machine						
Item	B1	D1	P1	D2	B2	P2	P3
1	30	10	20				
2	20	10/30	40				
4		10	20				
3				10	40	20	30
5				20	30	10	
6				10	20/40	30	
7				10		30	20
8				10	20	30	

	Machine						
Item	B1	D1	P1	D2	B2	P2	P3
1	30	10	20				
2	20	10/30	40				
4		10	20				
3				10	40	20	30
5				20	30	10	
6				10	20/40	30	
7				10		30	20
8				10	20	30	

	Machine						
Item	B1	D1	B2	D2	P1	P2	P3
1	30	10			20		
2	20	10		30	40		
3			40	10		20	30
4				10	20		
5			30	20		10	
6		10	20/40			30	
7		10				30	20
8		10	20			30	

Rearranging & Clustering

MACHINE-ITEM MATRIX

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Machine ID

Item ID	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1		1		1						1		
2		1		1				1				1	
3	1		1		1						1		
4						1	1		1	1			1
5			1		1						1		
6						1	1		1	1			1
7		1		1									
8						1	1		1	1			1
9		1										1	
10						1	1		1	1			1
11		1		1				1				1	
12		1		1				1				1	
13			1		1							1	
14			1		1							1	
15		1										1	
16	1				1							1	
17						1	1		1	1			1
18	1				1						1		
19		1		1				1				1	
20	1										1		
21		1		1									
22						1			1	1			1
23			1								1		
24						1			1	1			1
25		1		1								1	
26						1		1		1			1
27							1						1
28						1			1	1			1
29		1		1			1						1
30	1			1	1					1	1		
31					1						1		
32					1						1		
33	1				1	1	1		1	1			1
34						1			1	1			
35						1			1	1			

Current Matrix

Machine ID

Item ID	2	4	8	12	1	3	5	11	6	7	9	10	13
2	1	1	1	1									
11	1	1	1	1									
12	1	1	1	1									
19	1	1	1	1									
21	1	1	1	1									
25	1	1		1									
7	1	1											
29	1	1											
9	1			1									
15	1			1									
1					1	1	1	1					
3					1	1	1	1					
5						1	1	1					
32						1	1	1					
13						1	1	1					
14						1	1	1					
30					1		1	1					
16					1		1	1					
18					1		1	1					
20					1		1	1					
23						1		1					
31							1	1					
4									1	1	1	1	1
6									1	1	1	1	1
8									1	1	1	1	1
33									1	1	1	1	1
10									1	1	1	1	1
17									1	1	1	1	1
35									1	1	1	1	1
22									1		1	1	
28									1		1	1	1
24									1		1	1	1
26									1		1	1	1
27										1			1
34									1		1	1	

Clustered Matrix

REARRANGING & CLUSTERING

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	Machine						
Item	B1	B2	D1	D2	P1	P2	P3
1	10		20		30		
2		20		10		30	
3			10		20		
4		20		10		30	40
5	20		30	10	40		
6	40	20		10		30	
7				10		20	30
8		20		10		30	

	Machine						
Item	B1	D1	P1	D2	B2	P2	P3
1	10	20	30				
2				10	20	30	
3		10	20				
4				10	20	30	40
5	20	30	40	10			
6	40			10	20	30	
7				10		20	30
8				10	20	30	

	Machine						
Item	B1	D1	P1	D2	B2	P2	P3
1	10	20	30				
5	20	30	40	10			
3		10	20				
4				10	20	30	40
2				10	20	30	
6	40			10	20	30	
7				10		20	30
8				10	20	30	

	Machine						
Item	B1	D1	P1	D2	B2	P2	P3
1	10	20	30				
5	20	10 30	40				
3		10	20				
4				10	20	30	40
2				10	20	30	
6				10	20 40	30	
7				10		20	30
8				10	20	30	

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CONSECUTIVE EXERCISE
PROCESS PLANNING

CONSECUTIVE EXERCISE – PRODUCTS & SERVICES

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- Machine Parts Manufacturer offering a wide range of products and items that need following operations
  - Milling
  - Turning
- Other secondary processes like
  - Sawing
  - Drilling
  - Grinding
- Heat treatment
- Warehousing

MAKE-TO-STOCK MANUFACTURER

Characteristic		Attributes			
1	**Order Placement**	Manufacturing based on individual orders	Manufacturing based on blanket orders	Anonymous pre-manufacturing w/ customized finishing	Make to stock
2	**Product spectrum**	Products according to customer specification	Standardized products w/ customer specific versions	Standard products w/ versions	Standard products w/o versions
3	**Product structure**	Multi-part products w/ complex structure	Multi-part products w/ simple structure	Products w/ less parts	
4	**Determination of Material Requirements**	Demand-based	Order-based	Anticipatory	Consumption-based
5	**Determination of Dependent Requirements**	Order-based	Order-based & periodic	periodic	
6	**Procurement Type**	Extensive external procurement	External procurment to a greater extent	Insignificant external procurement	
7	**Inventory**	none	Inventory of items at lower structural levels	Inventory of items at higher structural levels	Inventory of products
8	**Production Type**	One-off production	Small-batch production	Series production	Mass production
9	**Way of Manufacturing**	Jobshop manufacturing	Work-cell manufacturing	Line manufacturing	Flow manufacturing
10	**Way of Assembly**	On-site assembly	Work-cell assembly	Line assembly	Flow assembly
11	**Structure of Manufacturing**	Manufacturing w/ a high degree of structuring	Manufacturing w/ a medium degree of structuring	Manufacturing w/ a low degree of structuring	
12	**Change Requests**	Extensively	Occasionally	insignificant	

CONSECUTIVE EXERCISE - MACHINES


Milling Machines


Turning Machines


Drilling Machines


Grinding Machines

Sawing Machine


Tempering Furnace

EXERCISE 4.1

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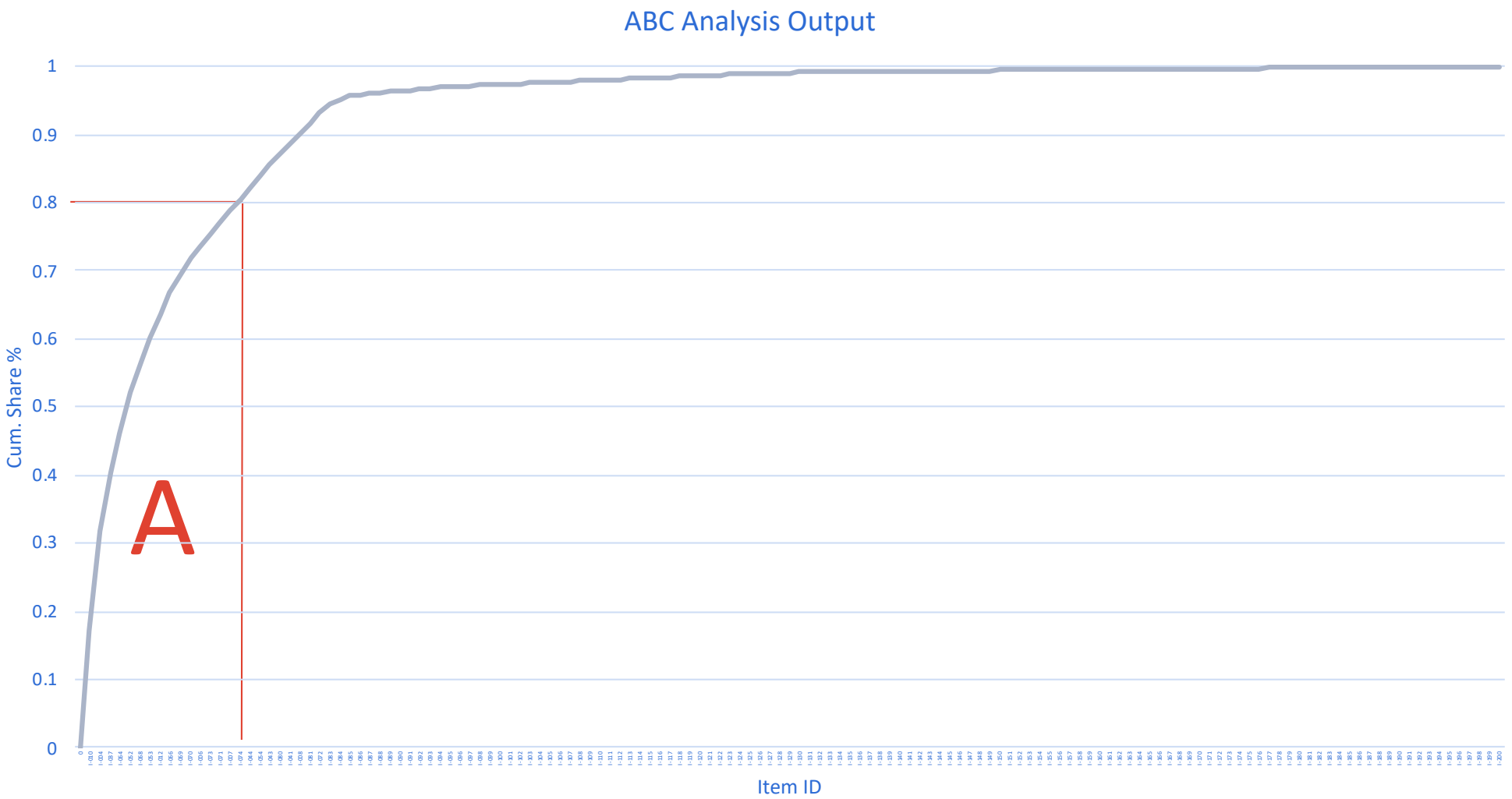
- Conduct an ABC analysis based on the annual output of item in spreadsheet S08
- Create an appropriate diagram for this ABC analysis
- Interpret the results

EX 4.1: ABC DIAGRAM BASED ON ANNUAL OUTPUT



EXERCISE 4.2

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- Develop a standard routing for the previously identified A items
  - Use spreadsheet S13
  - Consider operations spreadsheet S12
- Cluster those items based on similar operations
  - Use spreadsheet S14
  - Rearrange the table until you find feasible clusters (=product families)
- Develop a standard routing after clustering using spreadsheet S15

VBA CODE FOR SORTING THE MATRIX (ADVANCED)

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```
Sub Sorting_Matrix()

    Dim pos() As Long, ws As Worksheet, Rank() As Double, col(2) As Long, dif As Long
    Dim i As Long, j As Long, Temp

    Matrix_Ent = 16
    ReDim pos(Matrix_Ent - 1)
    ReDim Rank(Matrix_Ent - 1)
    col(0) = 0
    col(1) = Application.WorksheetFunction.Count(Range("C22:C37"))
    col(2) = col(1) + Application.WorksheetFunction.Count(Range("D22:D37"))

    Set ws = Sheet14
    p = 0

    For k = 0 To 2
        For i = 1 To Matrix_Ent
            If ws.Cells(21 + i, 3 + k).Value <> "" Then
                Rank(p) = Application.WorksheetFunction.Rank(ws.Cells(21 + i, 3 + k), Range(ws.Cells(22, 3 + k), ws.Cells(37, 3 + k)), 1)
                dif = CLng(Right(ws.Cells(21 + i, 1).Value, 3))
                Rank(p) = Rank(p) + 0.001 * dif + col(k)
                pos(p) = 21 + i
                p = p + 1
            End If
        Next i
    Next k

    For i = LBound(Rank) To UBound(Rank) - 1
        For j = i + 1 To UBound(Rank)
            If Rank(i) > Rank(j) Then
                Temp = Rank(j)
                Rank(j) = Rank(i)
                Rank(i) = Temp
                Temp = pos(j)
                pos(j) = pos(i)
                pos(i) = Temp
            End If
        Next j
    Next i

    For i = 0 To Matrix_Ent - 1
        'ws.Rows(pos(i)).Copy ws.Rows(3 + i)
        ws.Cells(3 + i, 1).Formula = ws.Cells(pos(i), 1).Formula
    Next i

End Sub
```

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THANK YOU!