How to Create Layout for Operations Flow

Value Chain Competitiveness (VCC)

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How to Create Layout for Operations Flow

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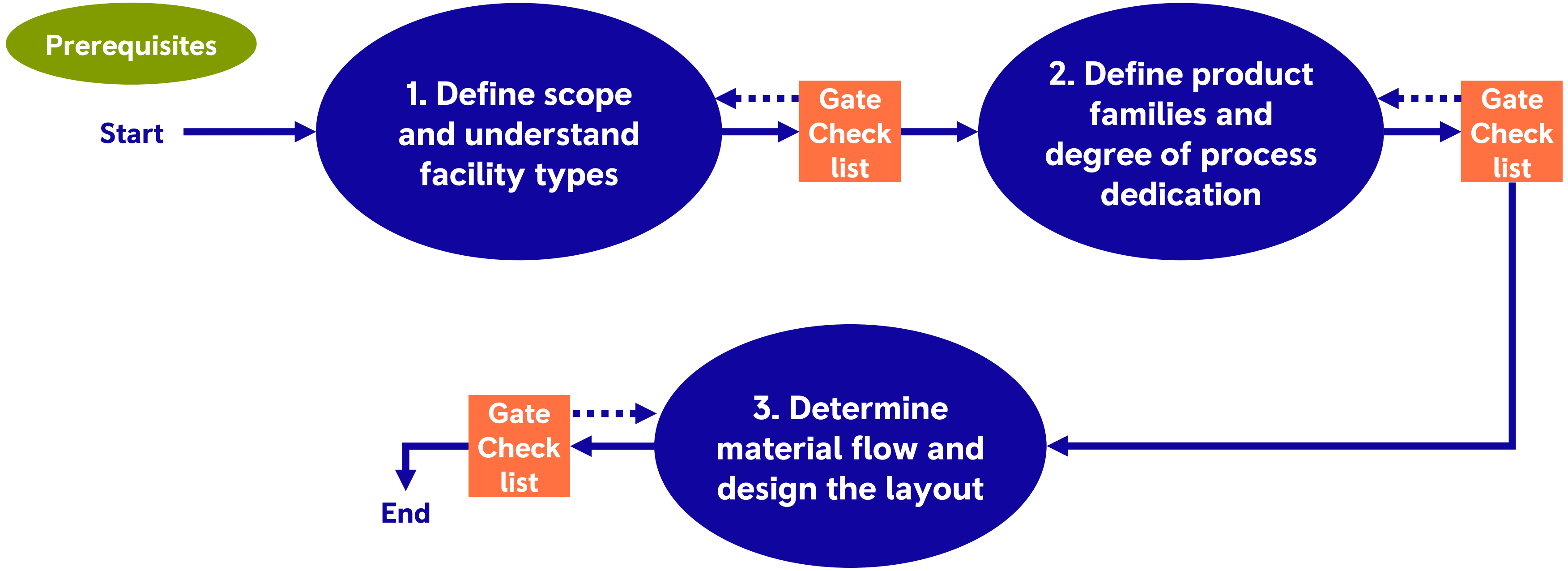
Scope

Objectives & Principles



Scope

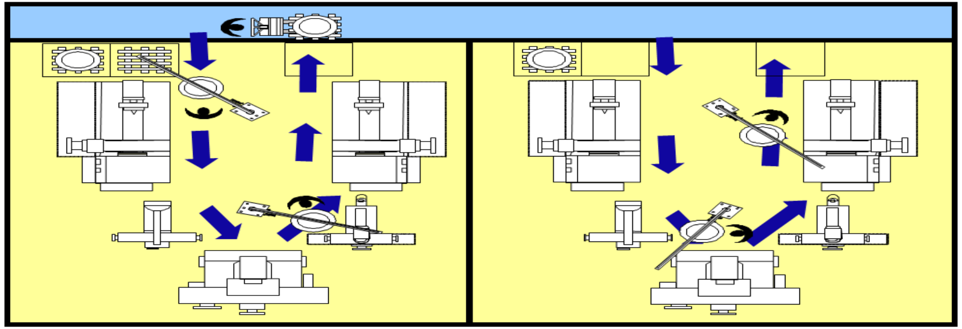
This 'How To' will enable you to:

- Understand the drivers for determining the appropriate type of facility and cell designs
- Understand and define the concept of product family groupings
- Determine current state process and identification of improvements to performance and methods
- Create a rough cut load and capacity plan to determine degree of equipment and process dedication to product families
- Determine future state material flow and cell concept layout design
- Design detail cell layout including infrastructure and other requirements to operate
- Determine high level people requirements to operate cells

Objective and Principles

Layout for Operations Flow

The arrangement of people, equipment, material and methods to create products in order of process in a continuous flow. Focussing on short lead times, low inventory and flexibility to respond to changes in mix and volume minimises the total cost of product.



A world class production/assembly facility (or cell) will draw on Visual Management principles and techniques to ensure:

- Flow of material and information is easily identified
- Performance and status of output, equipment, quality and delivery status are monitored in real time and deviation from expectation dealt with in a timely manner

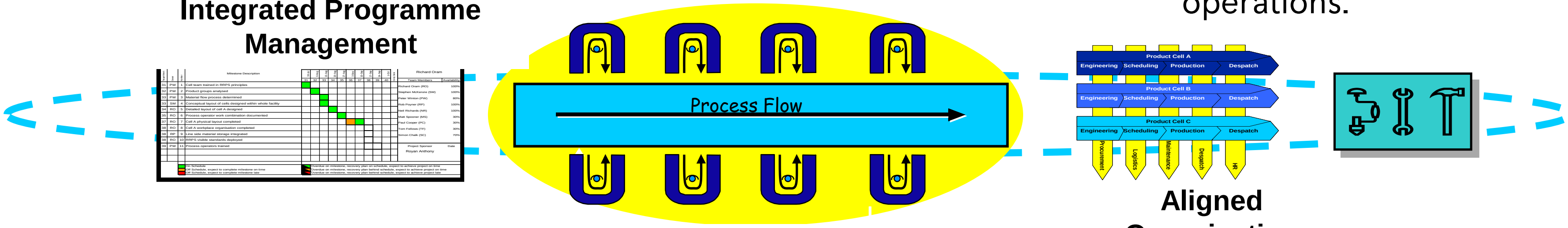
Objective and Principles

1. Implement appropriate facility type based on volume and variety of products. Flexible cells, high volume dedicated facilities or a combination.

2. Focus on products and their value streams, not processes. Group products into families that have similar process flows and takt times.

3. Minimise distance travelled, eliminate backtracking and cross-traffic of material flow for safe, productive operations.

Integrated Programme Management



Optimised Layout

Aligned Organisation

4. Build quality into the process. High process capability prevents making a defect, error proofing and over-checking prevents passing a defect on.

5. Separate machine time from human work, balance to takt time and eliminate waste.

6. Ensure flexibility of layout and response to change of requirements within the layout design.

Objective and Principles

By the end of the process we should have;

- A future state value stream map of how we will operate our flow processes
- An action plan to eliminate the barriers to creating flow processes
- A layout proposal either for a single ‘cell’ or a number of cells, including their inter-relationship. Initially this will be a rough concept and will eventually become more detailed as we test various options.
- All of the machines, workstations, material locations, tooling and fixture locations, services, material handling etc. to make the cell work
- The number of operators, their skill requirements and a standard work package defining how each task will be carried out

Prerequisites

Knowledge:

- Understanding of Lean Manufacturing principles
- Understanding of Value Stream Mapping techniques
- Planned products & volumes and bill-of-materials
- Processes, machines, routings and times (manual and auto)
- Planned level of performance required
- Current actual performance, eg. changeovers, quality, machine uptime / reliability

1. Define scope and understand facility types

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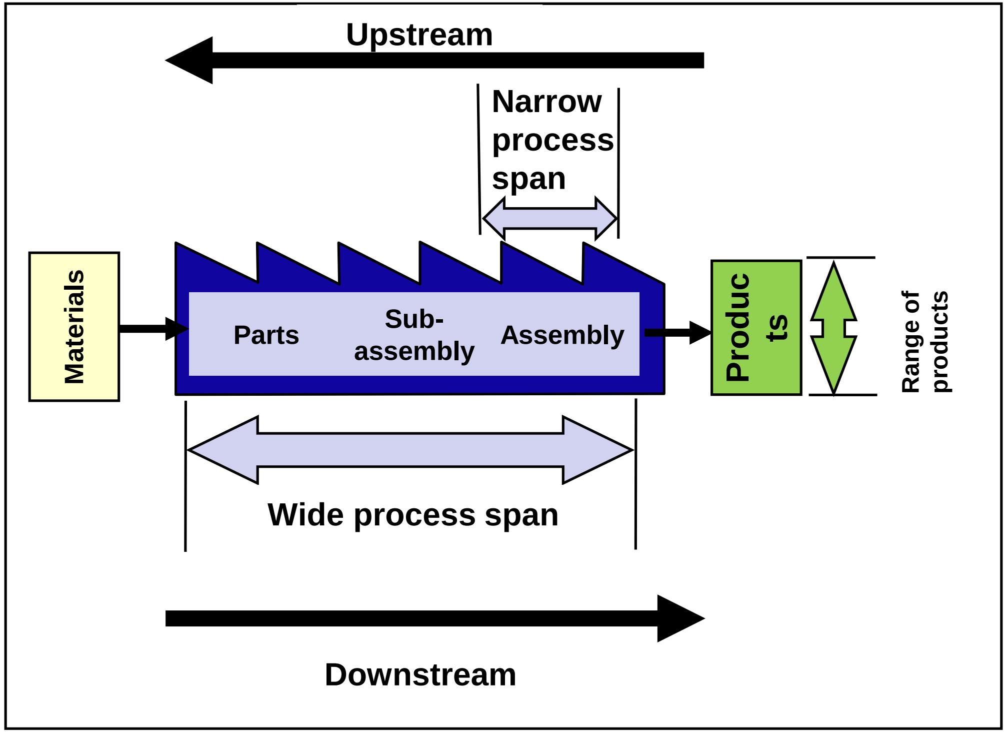
Determine scope for operations layout by selecting the range of products and process span



- The range of products is usually determined by a product 'make versus buy' strategy covering all components, detail parts, sub-assemblies, assemblies and finished products
- The scope of the factory or cell to be designed is also determined by the process span - i.e. how much of the value stream will it cover. The span can be wide or narrow (degree of vertical integration)

1. Define scope and understand facility types

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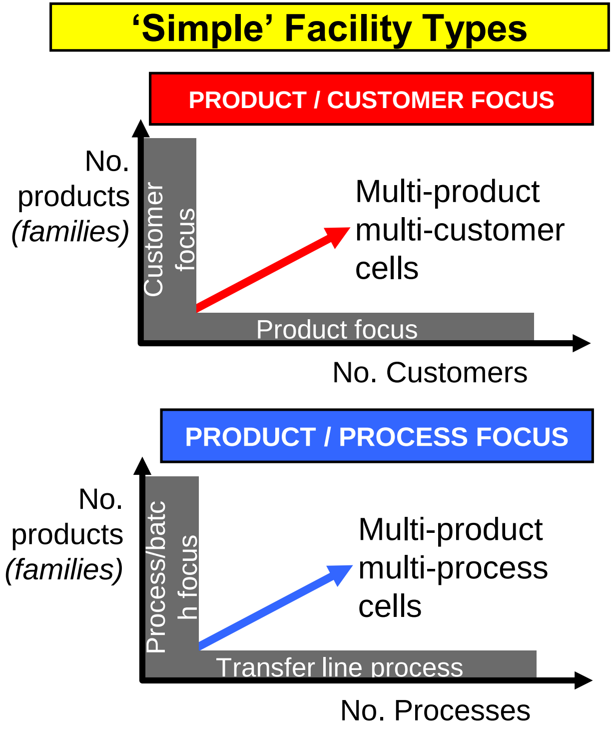
Understand appropriate facility types based on product, customer or process characteristics



- An understanding of what the appropriate type of facility may be, guides the type of analysis to determine the layout for operations flow
- A 'simple' facility type is one where the range of products, and/or processes and and/or customers is small and the focus is easy to determine
- Otherwise, common product or process characteristics dictate the type of layout

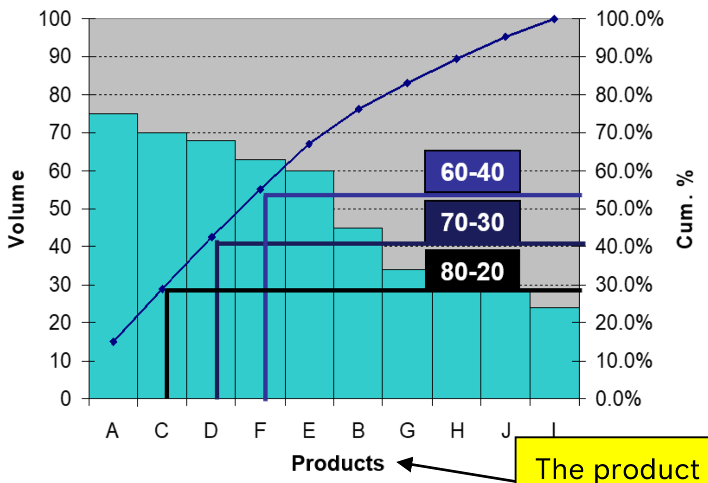
1. Define scope and understand facility types

BACK Map NEXT

Understand appropriate facility types based on product, customer or process characteristics

Product-quantity analysis indicates probable facility type

Product – Quantity Chart showing the Pareto distribution for the facility compared with curves that help define the type of facility



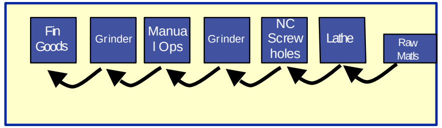
The product volume can be individual products or product families

Product - Quantity	Probable facility type	Features
80-20	Production line layout	Product-orientated, high volume, automated facility with next process in line
70-30	Cellular layout	Machines located next to each other in process sequence, minimising distance travelled whilst handling multiple products with same routings (a product family)
60-40 or less	Flexible, cellular layout	As 70-30, handling multiple products and multiple routings
Low volume	Multiple routing cell layout	Equipment laid out in cells with multiple routing embodied in the layout

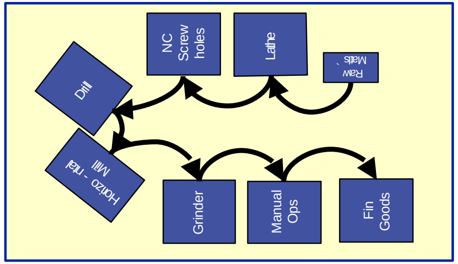
1. Define scope and understand facility types

Product-quantity analysis indicates probable facility type

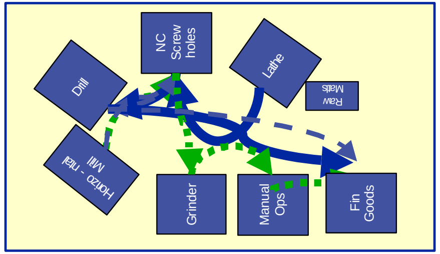
Transfer line type layout (high volume)



Cellular layout (medium volume)



Multiple routing cell layout (low volume)



- Product-Quantity (P-Q) analysis results in grouping items in three categories, based on volume:
  - High-volume items individually deserving dedicated lines.
  - Medium-volume items deserving lines dedicated to product families. Process routing or cluster analysis can then be used to define the families.
  - Low-volume items made in an environment with machines arranged to accommodate multiple routings
- This breakdown should drive the facility layout

Gate checklist 1: Define scope and understand facility types

- ☑ Initial span of processes determined for layout
- ☑ Initial range of products determined for layout
- ☑ Product volume assumptions determined
- ☑ Likely facility type determined based on customer, product or processing characteristics

2. Define product families and degree of process dedication

Workload derived from	Degree of process dedication	Efficiency focus	Facility type
Single / few high volume products	Dedicated to products	Machine	Transfer line
Families of medium volume products	Dedicated to families of products	People	Cell
Many, low volume products	Flexible, no dedication	Machines and people	Job-shop

- If a product's demand is sufficiently high, the workload may economically or strategically justify dedicated equipment or manufacturing cells that can achieve very high efficiencies (no or few changeovers)
- When there is insufficient workload to justify dedicated equipment, volume can be consolidated into product groupings or families to give required resource utilisation at lower efficiencies
- To determine whether dedicated equipment or cells is justifiable, a capacity model needs to be created to establish the workload that demand for products or families of products place on workstations

2. Define product families and degree of process dedication

Product – Work-centre matrix

	Operation							
Part no.	Lathe	Grind	Broach	CMM	Erode	Weld	Blast	NDT
ba321		x		x			x	x
ab123		x		x			x	x
cd456		x		x	x	x	x	x
ef789		x		x	x	x	x	x
yz987	x	x	x	x				x
wx654	x	x	x	x				x
							…. And so on	

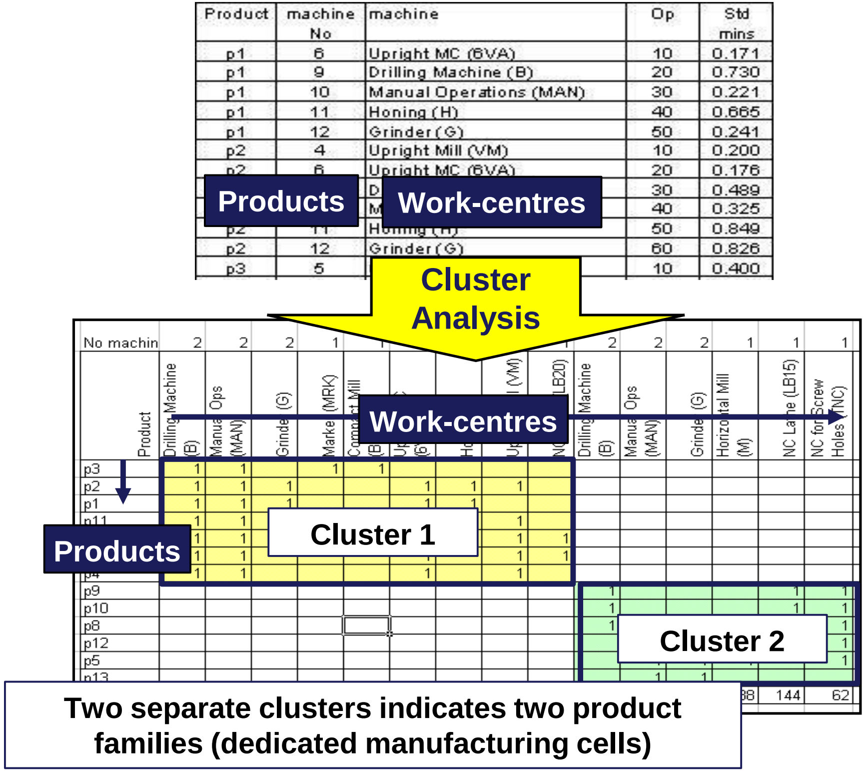
Process Routing Analysis

	Operation							
Part no.	Lathe	Grind	Broach	CMM	Erode	Weld	Blast	NDT
ba321		1		2			3	4
ab123		1		3			2	4
cd456		1		3	4	2	5	6
ef789		1		2	3	4	5	6
yz987	1	2	3	4				5
wx654	2	1	3	4				5
							…. And so on	

- A product family is a group of products that are made in an identical or very similar way.
- This is usually represented by a matrix showing the parts that are in the scope of the design for the cell or facility and the machines or work-centres that each part goes to. This is the product or work-centre matrix
- A variation on this includes a representation of the sequence of the process in a matrix. This is known as a Process Routing Analysis
- The families defined will be used throughout the design process, therefore this is a critical output.
- Some iteration throughout is likely however

2. Define product families and degree of process dedication – Cluster Analysis

Routing data



Cluster analysis output

Cluster analysis (or 'rank-order-clustering') is used where large amounts of data have to be reviewed

- The purpose of cluster analysis is to place products into groups, suggested by the routing data, such that product families are defined and process/work-centre dedication can take place
- The analysis can be carried out across different scenarios, in an attempt to better group and simplify product families enabling simpler layouts and better product flow

2. Define product families and degree of process dedication – Cluster Analysis

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Cluster analysis is easiest done using a spreadsheet to generate a matrix looking for 'clusters' of data between products and work-centres

2	No machines	2	2	1	1	2	1	1	1	1	1	1	1	
3	Product	Drilling Machine (B)	Manual Ops (MAN)	Marker (MRK)	Compact Mill (BM)	Grinder (G)	Upright MC (6VA)	Honing (H)	Upright Mill (VM)	Horizontal Mill (M)	NC Lathe (LB15)	NC Lathe (LB20)	NC for Screw Holes (TNC)	Grand Total
4	p3	1	1	1	1									3168
5	p2	1	1			1	1	1	1					1859
6	p1	1	1			1	1	1						1858
7	p11	1	1			1				1				1728
8	p7	1	1	1					1		1			1129
9	p6								1			1		1095
10	p4								1					1091
11	p9										1		1	1048
12	p10											1	1	1044
13	p8								1				1	1041
14	p12									1			1	720
15	p5		1			1				1			1	720
16	p13		1											576
17	Grand Total	8184	8135	4352					04	518	288	144	62	52
18														

Modify inputs for better clustering

Updated Analysis

No machin	2	2	2								2	2	1	1	1
Product	Drilling Machine (B)	Manual Ops (MAN)	Grinder (G)	Marker (MRK)	Compact Mill (BM)	Upright MC (6VA)	Honing (H)	Upright Mill (	NC Lathe (LB2	Drilling Machine (B)	Manual Ops (MAN)	Grinder (G)	Horizontal Mill (M)	NC Lathe (LB15)	NC for Screw Holes (TNC)
p3	1	1		1	1										
p2	1	1	1			1	1	1							
p1	1	1	1			1	1								
p11	1	1	1					1							
p7	1	1		1				1	1						
p6	1	1				1		1	1						
p4	1	1				1		1							
p9										1				1	1
p10										1				1	1
p8										1			1		1
p12											1	1	1		1
p5											1	1	1		1
p13											1	1			
Grand Tota	8184	8135	3591	4352	4096	3264	3072	2504	518	8184	8135	3591	288	144	62

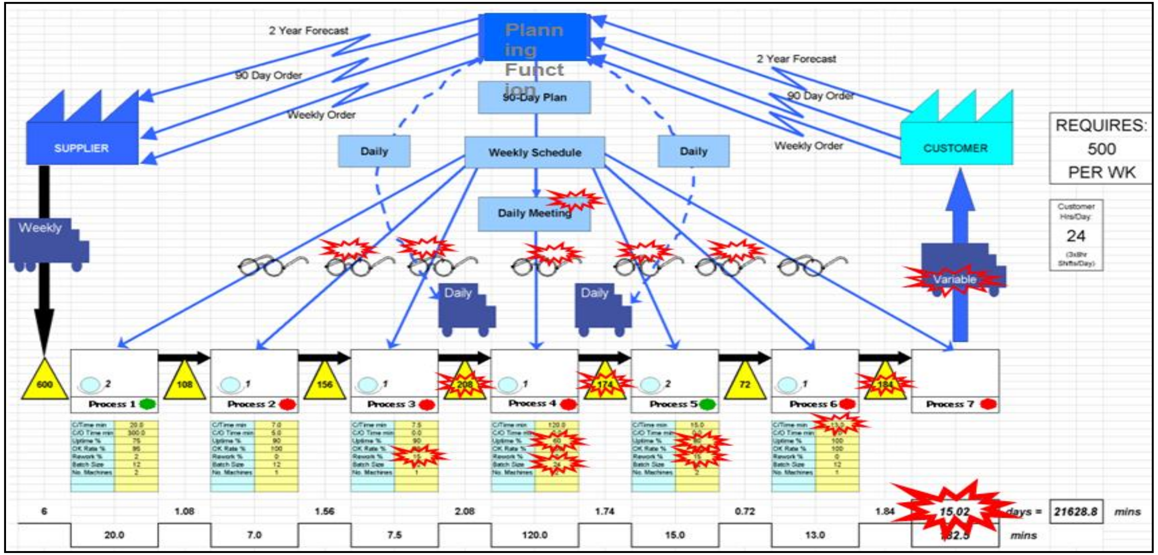
- Following analysis, there may be parts that do not 'fit' well into any particular family
  - Unique routings
  - Routings span more than one cell
  - "Exception" operations in the routings
- There are options as to how to deal with 'strangers'
  - Change routings to perform operation on an integral machine in the cell
  - Invest in / reallocate simple machines in to the cell
  - Redesign product to miss out exceptional process
  - Redefine processing method
  - Out-source manufacture of the product
  - Obsolete the product

2. Define product families and degree of process dedication

BACK
Map
NEXT

Map the Value Stream to determine ability to operate flow processing

For each Product Family, complete value stream maps to determine opportunities for continuous flow

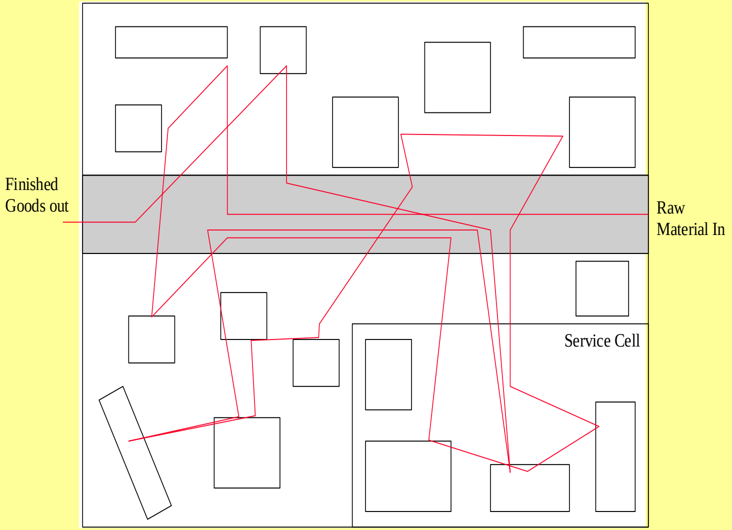


Use 'How to: Value Stream Mapping' to map the current state and opportunities

2. Define product families and degree of process dedication

Collect additional information to get a full picture of the current state

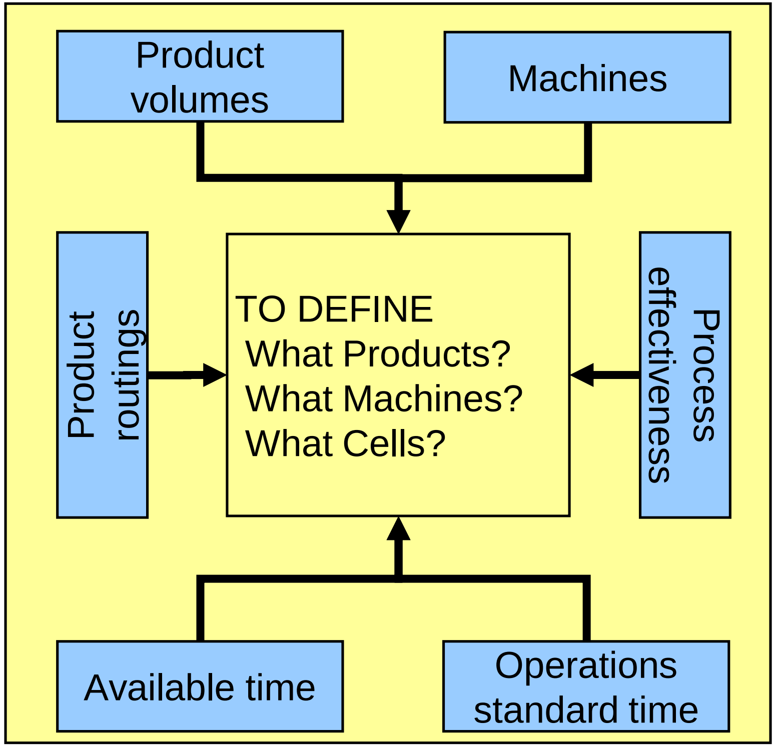
Example of a 'Spaghetti Chart' flow diagram



- A detailed floor plan of facility gives the physical boundaries of the factory, the size of facilities and cells
- A flow diagram analysis (Spaghetti Chart) assesses work movement and distance travelled, indicating transportation waste
- An equipment survey (type, capability, component, condition, space envelope) establishes the availability of equipment
- Determine constraints that exist to establish what cannot be done or moved (challenge later)
- Skills matrices assess the readiness of the workforce to move to a multi skilled work team
- Existing infrastructure requirements (services, craneage, IT) to establish what layout options are possible

2. Define product families and degree of process dedication

Create a rough capacity model



- Creating a rough capacity model helps to determine the products and machines allocation in cells and the rough loading of those cells
- Workload for the model uses
  - Product volumes
  - Product routings
  - Machine allocation
  - Operation times
- Loading time for the model uses
  - Available (or shift operating) time
  - Process effectiveness (or OEE)
- Analysing the workload with loading time establishes the cells required and machines required in each cell
- Scenarios can be tested, including challenging the assumption on OEE, changeover times etc.

Gate checklist 2: Define product families and degree of process dedication

BACK Map NEXT

☑ Product families have been determined using relevant techniques

- Cluster analysis
- Process Routing Analysis
- Other common characteristics

☑ Value Stream Maps has been created for each product family

- Barriers to operating continuous flow in the value stream have been assessed, issues highlighted and actions identified

☑ Additional current state information has been collected

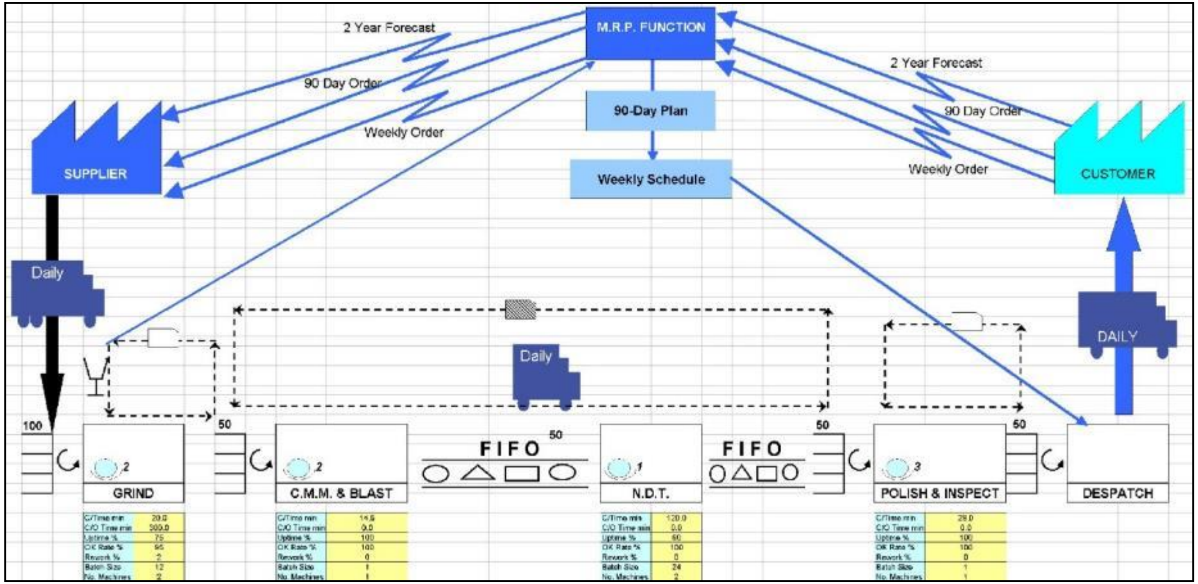
- Existing floor plans
- Machine availability, condition and constraints
- Infrastructure and services
- Skills matrices

☑ A rough cut capacity model has been created, machine and equipment requirements have been identified

3. Determine material flow and design the layout

The Future State VSM

For each Product Family, complete value stream maps to determine the future state

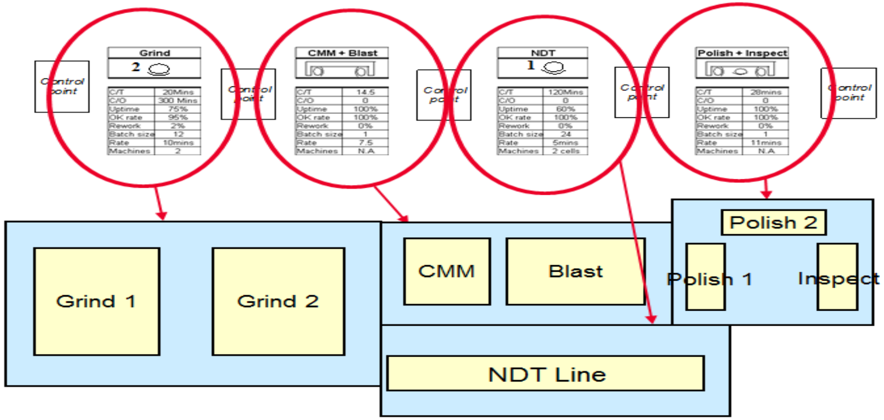


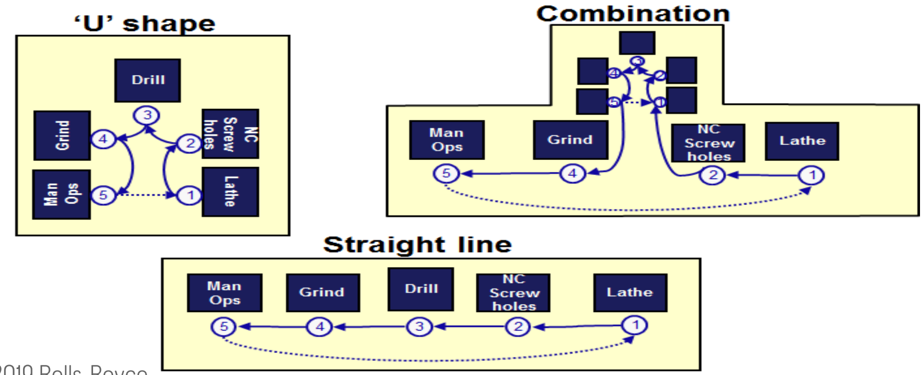
Use 'How to: Value Stream Mapping' to map the future state

3. Determine material flow and design the layout

BACK Map NEXT

Work Centres and material space





- Estimate cell floor space required for the work stations, considering the working envelope
  - Estimate addition space for material handling in the cell
- Estimate cell floor space required for stock
  - The future state VSM gives stock required
- Estimate space required for bought out parts
  - Stores and line-side material

- Consider the 'shape' of cells to best create flow
- Cell layouts consider flexibility and continuous flow
  - Flexible multi process handling and response to volume change
  - Good visibility of activity and progress
  - Minimal travel distance at start and finish of process

3. Determine material flow and design the layout

Key layout considerations include:

- **Safe working**: Safe and quick access around the equipment and facility (aisle ways). Access and ease of maintenance. Height of equipment and visibility / lighting in work areas.
- **Visual Control**: Information centre(s) and visual management board(s) locations. Visually managed stock location footprints.
- **Short Conveyance / Transportation**: Minimise distance between 'supplier' and 'customer' and work stations. Ease of delivery to the work area considering size, weight and frequency of use.
- **Layout Flexibility**: Layout change flexibility with minimal costs / disruption. Flexibility of services (air, power, water) and material handling system to change.
- **Build-in Quality**: Layout supports the principle of 'not accepting, making or passing on poor quality'. Mistake proofing in the processes wherever possible.
- **Ease of Quick Changeover**: Layout supports quick changeover (pre-set tooling and equipment at point of use) support smaller batch production.
- **Ease of Team Working**: Layout support multi-machine working and relocation of team members to alternative processes. Ease of rebalancing for changing demand.

3. Determine material flow and design the layout

Simulate the design concept options

Simulation is a method of analysing and verifying concepts and running different scenarios quickly. It is a visualisation of the shop floor layout, looking at production flow, control and aspects of industrial engineering. For example:

Full-scale mock-up simulation

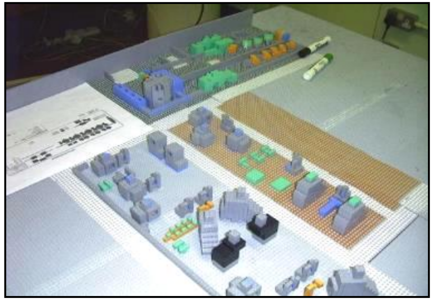
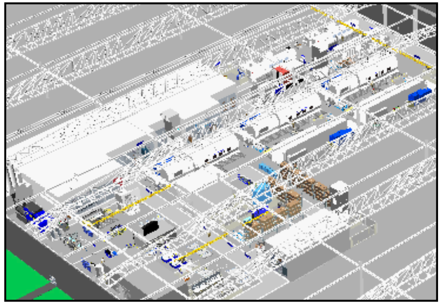
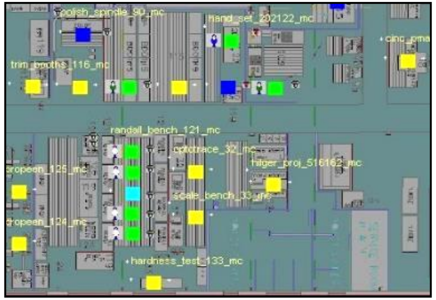


Table-top simulation



3D CAD model



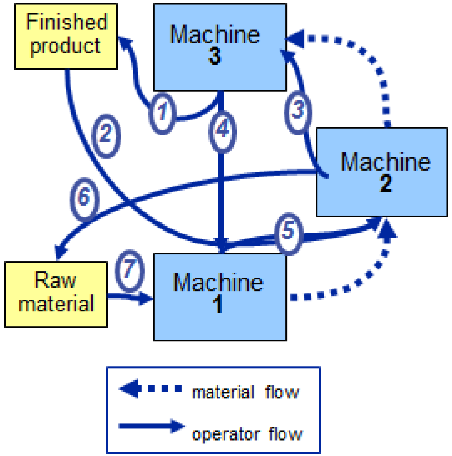
Computer based simulation

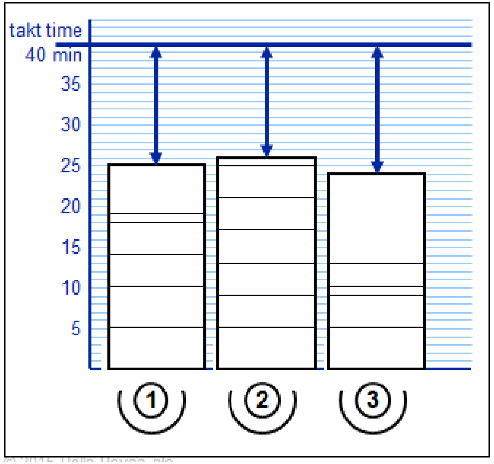
3. Determine material flow and design the layout

BACK Map NEXT

Analyse operator work in relation to the layout

Determining operator work combinations will ensure that the layout design supports the future state operation.

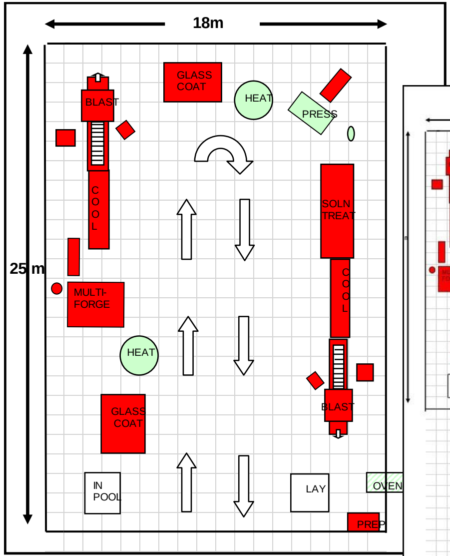




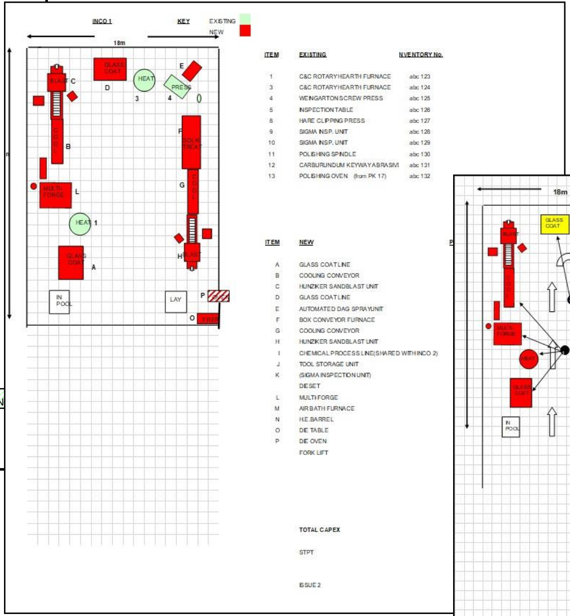
See 'How to Determine Optimal Manning Configuration'.

3. Determine material flow and design the layout

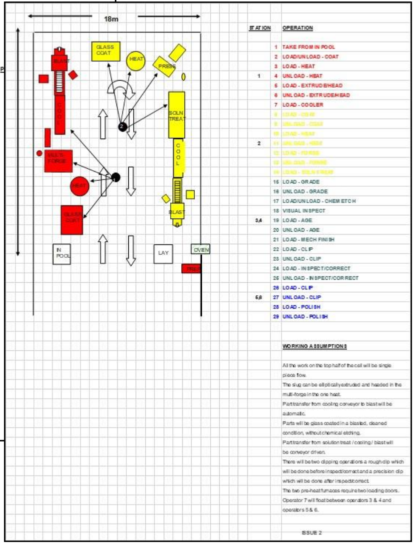
Create standard design pack



Cell layout



Finance requirements



Operator standard work

Gate checklist 3: Determine material flow and design the layout

BACK Map

- ☑ The future state value stream has been determined for each product family
- ☑ Machines and equipment have been allocated to meet the future state
- ☑ Space requirements for machines, materials and materials management processes have been estimated
- ☑ Layout relationships have been determined
- ☑ Options for concept design of layout created and modelled. Optimal solution selected considering business objectives
- ☑ Operator work has been analysed in relation to the layout
- ☑ Standard packs have been created for the layout design