

Problem 01

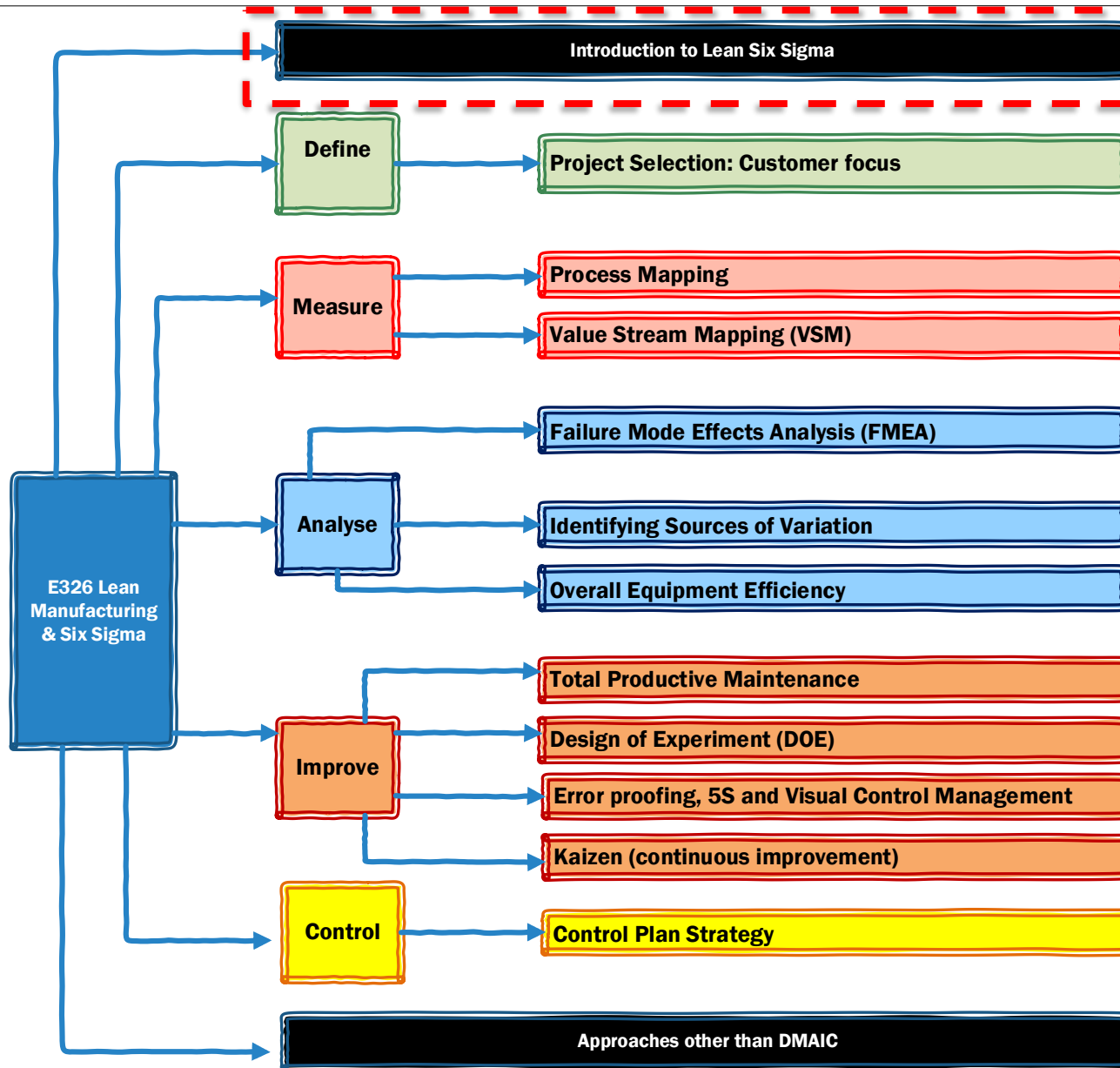
Lean or Lean Six Sigma

E326 – Lean Manufacturing & Six Sigma

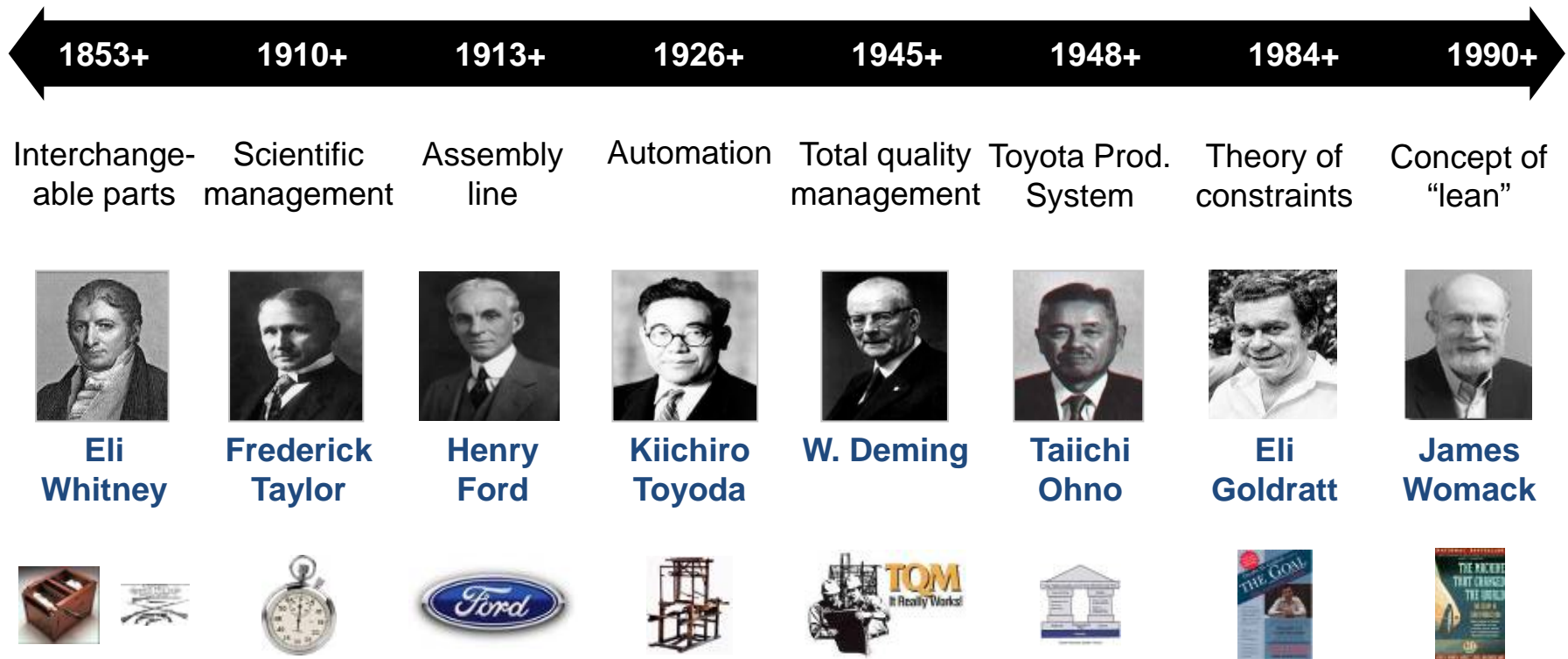


SCHOOL OF
ENGINEERING

E326 Lean Manufacturing and Six Sigma Topic Tree



Evolution of Lean



▪ What does it mean to be "lean"?

- Lean "is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination"

Lean Manufacturing Goal



The basic goal of Lean is to preserve value (a customer would be willing to pay for with less work) by

a) Reducing total cost:

To minimize cost, a company must produce only to customer demand.

b) Reducing total time:

Decreasing the time it takes to finish an activity from start to finish.

c) Eliminating wastes



It is an integrated process that makes work flow smoothly between work stations in the pursuit of perfection through ongoing improvement. The flow of individual achievements eventually became Lean Manufacturing.

Six Sigma Methodology



Six Sigma is basically a quality management system that seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimizing variability in manufacturing and business processes. It has a strong focus on the customer needs.



In short, the main goals of 'Six Sigma' are to

- reduce the number of defects created. Less defects helps minimize inventory at all stage of production.
- decreasing process variation and improve quality in the end product that the company produces, whether it is a good or service.

The Fusion of Lean + Six Sigma



- Lean Six Sigma is a methodology that maximizes value by achieving the fastest rate of improvement in customer satisfaction, cost, quality, process speed, and invested capital.
- Lean Six Sigma is mainly customer-driven approach. It is also data-driven approach which focuses on reducing process variation, centering the process and optimizing the process.
- The fusion of Lean and Six Sigma is required because:
 - Lean cannot bring a process under statistical control.
 - Six Sigma alone cannot dramatically improve process speed or reduce invested capital.

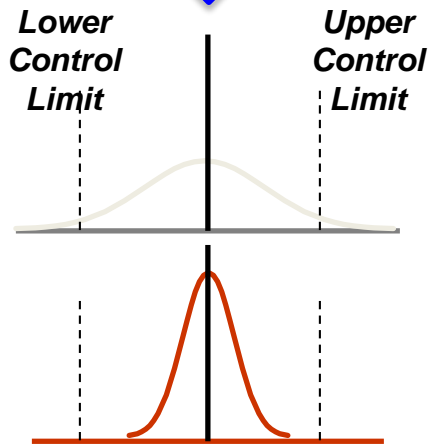
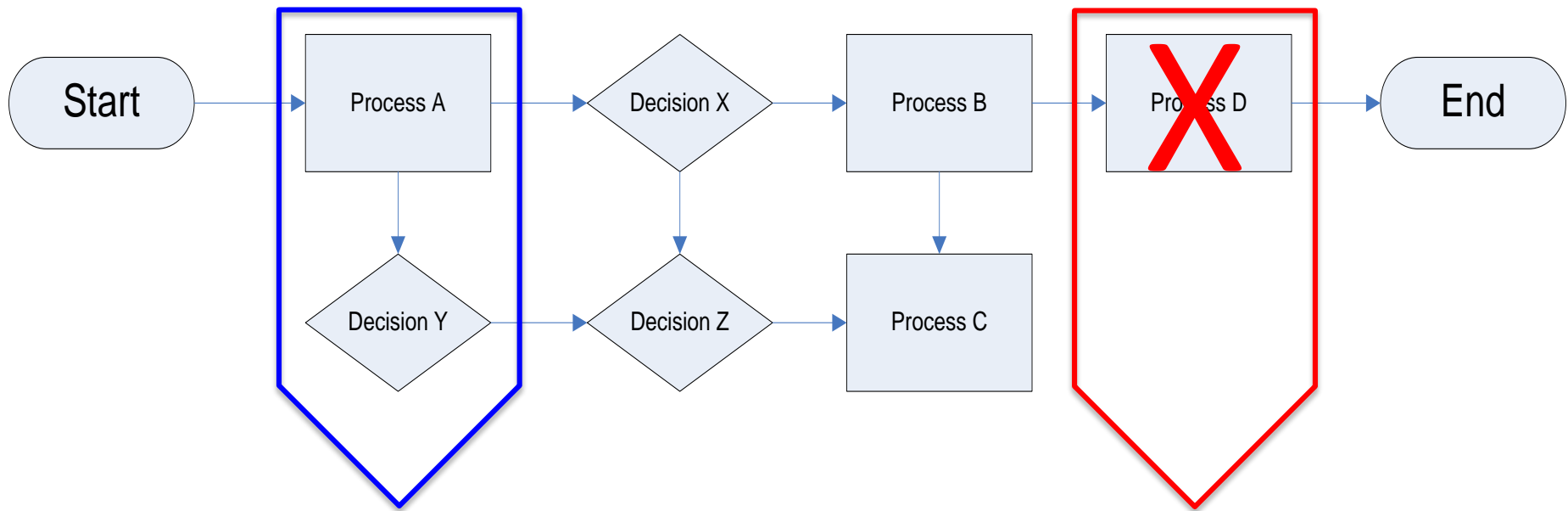
Terminologies



- Lean Manufacturing is sometimes referred to Lean or Lean Production
- Lean Manufacturing and Six Sigma are two different methodologies.
- Lean Six Sigma is the integration of Lean Manufacturing and Six Sigma.
- Many techniques used in Lean Manufacturing are applied in Lean Six Sigma.
- Lean Six Sigma can also be referred as Lean Sigma.



How Lean Six Sigma Helps?



Stabilize Remaining Steps
by Reducing **Variability**



Eliminate Non-Value
Added Steps
(Wastes)



Sigma Grading System



- The number of sigmas in the original 'Six Sigma' concept represents how close the company is to eliminating its mistakes to the necessary level.
- The number of sigmas reduces significantly as the number of defects and errors increases.
- Having a score of one Sigma is poor, while having a score of six Sigmas is the overall goal.
- In the original definition and application of "Six Sigma" Concept, a score of six sigmas represents having 3.4 defects for every million products or services the company produces. This is compared with the one sigma level which represents 691,000 defects per million products or services produced.

Examples of Sigma Value



Table 1.1 Relationship between Sigma value and faults per million opportunities and equivalent yield

<i>Six-Sigma Sigma value</i>	<i>Faults (or events) per million opportunities</i>	<i>Yield (%)</i>
1	691 462	30.85
2	308 538	69.146
3	66 807	93.319
4	6 210	99.379
5	233	99.9767
6	3.4	99.99966

Table 1.2 Effect of Sigma value on expectations of different everyday event results

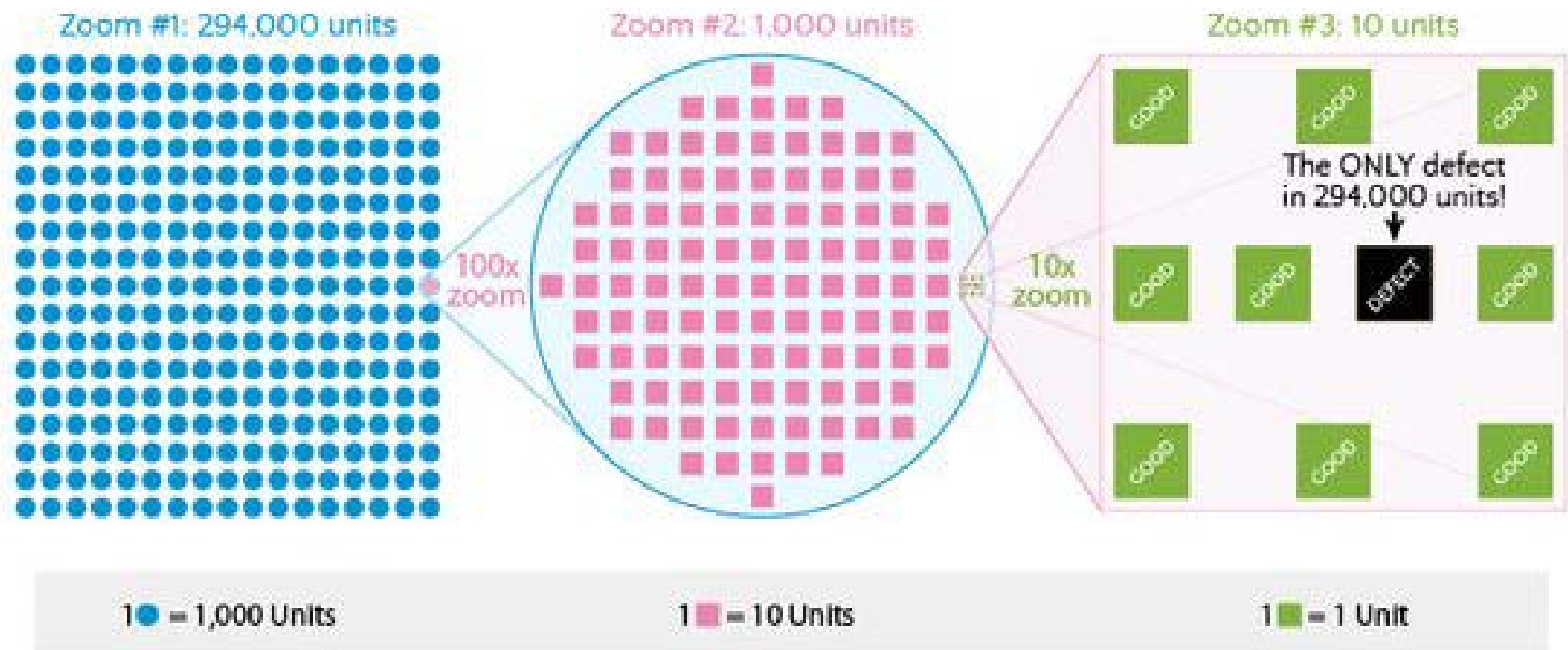
<i>Process Sigma value</i>	<i>Expectation of</i>	
	<i>time without electricity per month</i>	<i>aircraft landing/takeoff incidents in each direct return flight</i>
2	207 h	8 per 10 flights
3	45 h	24 per 100 flights
4	4 h	25 per 1000 flights
5	9 min	9 per 10 000 flights
6	8 sec	12 per million flights

Six Sigma: 3.4 DPMO Visualised



A Six Sigma process has a 99.99966% defect-free rate.

This is equivalent to 3.4 DPMO (defects per million opportunities), or a single defect for every 294,000 units. How small does this look? The chart below illustrates 1 defect in 294,000 units with powers of magnification:



Seven Types of Wastes



Transportation

- unnecessary movement of materials

Inventory

- excess inventory not directly required for current orders

Motion

- excess steps taken by employees because of inefficient layout

T
I
M

Waiting

- periods of inactivity

Over-Production

- occurs when production should have stopped

Over-Processing

- rework and reprocessing

Defects

- do not conform to specifications or expectation

W
O
O
D

TIMWOOD is an acronym that represents the **7 forms of waste** found in processes, that should be reduced or eliminated.

What Is Productivity?



- Productivity and Production are not the same thing.
 - Production is the process of converting resources into products and is measure as the quantity in a given time (q).
 - Productivity is the ratio between the output of a process and its inputs and is measured as output divided by input.
- Productivity is the measure of how specified resources are managed to accomplish timely objectives as stated in terms of quantity and quality.
- Productivity can also defined as an index that measure output (goods or services) relative to the inputs (Labour, Materials, energy etc.) used to produce the output.



What Is Productivity?



- In short, Productivity is the relationship between the quantity of output and the quantity of input used to generate that output.
- It is basically a measure of the effectiveness and efficiency of your organisation in generating output with the resources available.

$$\textit{Productivity} = \frac{\textit{Output}}{\textit{Input}}$$

Output = What we have achieved

Input = What we have put in



What is Productivity?



- Technically, productivity is the ratio of output to input. It is a measure of how efficiently and effectively a business or an economy uses inputs such as labour and capital to produce outputs such as goods and services.
- An increase in productivity means that more goods and services are produced with the same amount of labour and capital. It is not about cutting costs but “doing things right” and “doing the right things” to achieve maximum efficiency and value.

Why is Productivity Important?



At the **enterprise** level, measuring productivity will help you to:

- identify areas you can improve on to increase your value added
- focus on "the right things to do" and "doing those things right"
- understand how effective or efficient your business is at any point in time
- set operational targets and strategic goals
- find out if your business practices and processes are increasing or reducing productivity
- motivate internal customers (staff) to contribute through productivity-linked incentive schemes
- engage external customers (partners, suppliers) in the process of increasing the value added of goods or services together

At the **industry** level, productivity measurements will enable you to compare your business performance against industry benchmarks.

Why is Productivity Important?



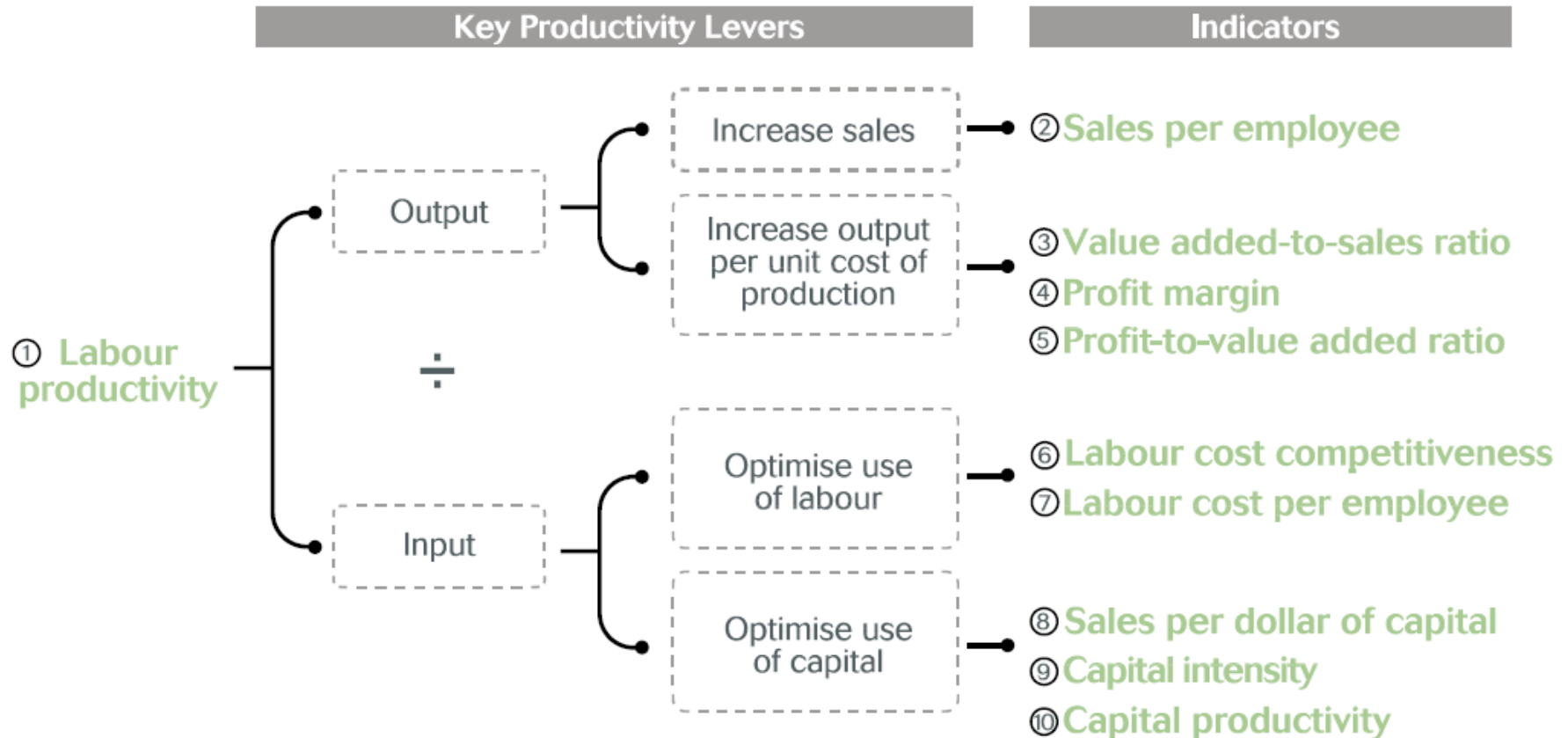
- Productivity affects **everyone** in the economy. It drives **economic growth** - a highly-productive economy means we are able to: produce **more** goods and services with the same amount of resources (new wealth) or produce the same level of goods and services with **less** resources (more wealth)
- Foreign companies may choose to set up in another country if they can obtain the same level of quality for less. If our **industries** are productive, we can remain competitive in the region.
- By adopting a productive mind-set, **businesses** can achieve higher revenue with more efficient use of resources, put in place more effective work processes and practices, leading to higher profits for the company while staff earn higher wages, enhance their skills through training, etc.

Common Productivity Indicators



- 10 commonly used indicators by management to measure the overall productivity performance of an organisation.
- These indicators should be analysed by taking into account the organisation's operation, and the performance of other indicators.

Common Productivity Indicators



Common Productivity Indicators



	Indicator	Formula	Unit	What it Measures	Significance
Productivity					
1	Labour Productivity	$\frac{\text{Value Added}}{\text{Number of Employees}^\#}$ # all categories of employees, including working directors/partners, unpaid family worker, part-time workers converted to full time equivalent	\$	Efficiency & effectiveness of employees in the generation of value added	How efficient and effective of the management & utilization of labour & other factors to generate value added
Increase Sales					
2	Sales per Employee	$\frac{\text{Sales}}{\text{Number of Employees}}$	\$	Efficiency and effectiveness of marketing strategy	How efficient or how good is the marketing strategy
Increase Output Per Unit Cost of Production					
3	Value added-to-sales ratio	$\frac{\text{Value Added}}{\text{Sales}}$	%	Proportion of sales created by the organisation over and above purchased materials and services	Efficiency in the use of purchases & prices for products and purchases, or control of Stocks
4	Profit Margin	$\frac{\text{Operating Profit}}{\text{Sales}}$	%	Proportion of sales left to the organisation after deducting all costs	Ability to generate returns from a given amount of sales
5	Profit to-value added ratio	$\frac{\text{Operating Profit}}{\text{Value Added}}$	%	Operating profit allocated to the providers of capital as a proportion of value added	Ability to generate sales and/or costs. Whether situation provided that employees are remunerated adequately

Common Productivity Indicators



	Indicator	Formula	Unit	What it Measures	Significance
Optimize Use of Labour					
6	Labour cost competitiveness	$\frac{\text{Value Added}}{\text{Labour Cost}}$	Time s	Efficiency and effectiveness of the organization in terms of its labour cost	Efficiency and effectiveness versus wage rates
7	Labour cost per employee	$\frac{\text{Labour Costs}}{\text{Number of Employees}}$	\$	Average remuneration per employee	Whether high or low remuneration to individual employees
Optimize Use of Capital					
8	Sales per dollar of capital	$\frac{\text{Sales}}{\text{Fixed assets}^*}$ <small>* Fixed assets stated at net book value, exclude work in progress</small>	Time s	Proportion of sales created by the organisation over and above purchased materials and services	How efficient is the capital utilisation or marketing
9	Capital intensity	$\frac{\text{Fixed assets}^*}{\text{Number of Employees}}$	\$	Extent to which an organization is capital intensive	Whether it is labour or capital-intensive
10	Capital productivity	$\frac{\text{Value Added}}{\text{Fixed assets}^*}$	Time s	Efficiency and effectiveness of fixed assets in the generation of value added	Efficiency in utilisation or level of investment in fixed assets

Company Success Factors



- Focus on what the customer wants
- Know customers and try to anticipate their future needs
- Value-focused rather than cost-focused
- Constantly improve productivity and things that they do, based on the needs of customers
- Help their customers and suppliers to improve
- Constantly strive to better understand best practices of other companies
- Manage inventory levels, but always have what you need when the customer needs it.
- Manage cash flow while ensuring flexibility



Lean Six Sigma Team Member roles



- **Senior Executive:** *Senior executive sponsors the overall Lean Six Sigma initiative.*
- **Executive Committee:** *Assign champions, black belts and green belts*
- **Champion:** *Middle or senior-level executive who spearheads a specific Lean Six Sigma project, ensuring that resources are available and cross-functional issues are resolved.*
- **Process owner:** *Professional responsible for the business process that is the target of a Lean Six Sigma project.*

Lean Six Sigma Team Member roles



- **Master Black Belt:** *Highly experienced and successful Black Belt who has managed several projects and is an expert in Six Sigma methods/tools. Responsible for coaching/mentoring/training Black Belts and for helping the Six Sigma leader and Champions keep the initiative on track.*
- **Black Belt:** *A full-time change agent and improvement leader who may not be an expert in the process under study. Full-time professional who acts as a team leader on Lean Six Sigma projects. Typically has four to five weeks of classroom training in methods, statistical tools and sometimes team skills.*
- **Green Belt:** Part-time professional who participates on a Black Belt project team or leads smaller projects. Typically has two weeks of classroom training in methods and basic statistical tools

Common Productivity Indicators



Use 5 commonly used indicators to measure the overall productivity performance of the company.

- a. Valued added = Sales – Rental – Utility / Materials
= \$500,000 - \$120,000 - \$75,000 = \$305,000
- b. Labour productivity = Valued added / No. of employees
= \$305,000 / 10 = \$30,500
- c. Labour Cost Competitiveness = Valued added / Labour Cost
= \$305,000 / \$60,000 = 5.1
- d. Capital productivity = Valued added / Fixed Asset
= \$305,000 / \$100,000 = 3.1
- e. Profit-To-Value Added Ratio = Operating Profit / Valued added
= \$30,000 / \$305,000 = 0.098 = 9.8%

Conclusion: Invest in automation to improve productivity and increase output.

What is Industry 4.0

- Industry 4.0, Industrie 4.0 or the ***fourth industrial revolution***, is the current trend of automation and data exchange in manufacturing technologies. It includes ***cyber-physical systems, the Internet of things and cloud computing***.
- It originates from a project in the high-tech strategy of the German government, which promotes the computerization of manufacturing.





How Industry 4.0 Is Enabling A New Era Of MI

Industry 4.0 is revolutionizing the use of manufacturing intelligence by:

- Setting the foundation for greater optimization of overall business and control,
- Better manufacturing and operations planning,
- Greater optimization of logistics,
- More efficient maintenance of production assets and machinery,
- Using historical performance and predictive algorithms to assess future outcomes.

By better orchestrating these strategic areas, manufacturers are going to be able to attain levels of accuracy and responsiveness to customers not achievable before.

Problem 01

Suggested Solution

Possible Lean Tools



‘5S’ - It is originally a Japanese concept for house keeping.

First S - Sort (Seiri)

Put things in order and remove what is not needed and keep what is needed (good and bad, useable and non-useable)

Second S - Straighten (Seiton)

Once sorted keep systematically to have traceability. Proper Arrangement - Place things in such a way that they can be easily reached whenever they are needed.

Third S - Shine (Seiso)

Keep things clean and polished; no trash or dirt in the workplace. keep things always ready to use and in dirt-free and tidy status

Fourth S - Standardize (Seiketsu)

Make a process for the above three stages. Make standards and review them. Maintain cleanliness after cleaning.

Fifth S - Sustain (Shitsuke)

Self discipline and commitment to the standards established for the four S-²⁹ components.

Possible Lean Tools – Continued....



Value Stream Mapping (VSM)

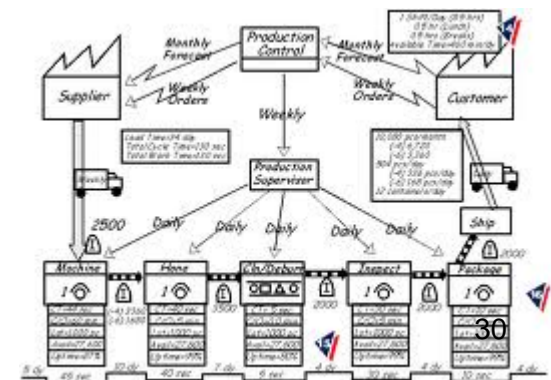
It is a method of creating a “One-page Picture” of all the process that occur in a company, from the time a customer places an order for a product, until the customer has received that product in their facility.

A value stream involves **all the steps**, both value added and non value added, required to complete a **product or service** from **beginning to end**. It helps identify areas of waste and non-value-added activity in each process.

Refs:

<http://www.nwlean.net/toolsCD/VSM/4%20steps%20to%20VSM.pdf>

<http://nursing2015.files.wordpress.com/2008/01/leanthinking.pdf>



Possible Lean Tools – Continued....



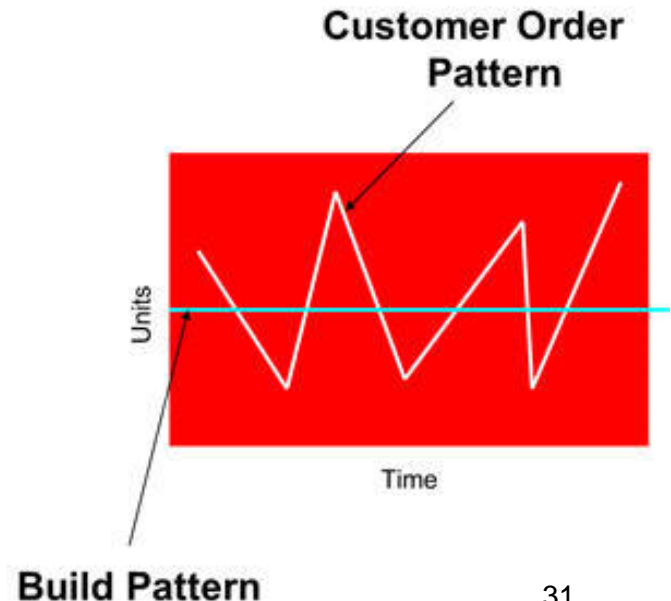
Workload Levelling (Heijunda)

Levelling work, a concept known as *heijunka* from Toyota Production System. It is working on improving material flow, information flow, or other flow (such as patient flow in a hospital).

Workload Levelling is based on the fact that customers may not give production orders in a stable, predictable way in the vast majority of cases. In reaction to shifts upward in customer demand and changes in the average demand, the production rates should be increased; if customer demand drops on the average, the production rates should be decreased. In either case, a steady mix and volume should be built over a fixed period of time

Ref:

<http://nursing2015.files.wordpress.com/2008/01/leanthinking.pdf>



Possible Six Sigma Tools



- Brainstorming, fishbone diagram to identify all causes of error.
- Pareto chart to narrow problem to it's primary cause.
- Design of Experiment (DOE) to identify key factors that will reduce errors the most.
- Failure Mode & Effects Analysis (FMEA) to design a new process & employee training.

Today's Problem: How to Improve?



- It is often advantageous to begin with Lean projects.
 - These are easier to understand and implement.
- Begin with streamlining processes and Rapid Improvement Events and use the “7-wastes” to check against the problem faced.
 - This gets the operation in good order.
 - Chronic problems are now easier to deal with.
 - “Low Hanging Fruit” is eaten.
- Next, select Six Sigma projects



Today's Problem – New Factory



Potential areas of improvement



Meeting product/customer specifications



Good 5S

Possible Lean Six Sigma Tools

- Voice of Customer
 - Quality Function Deployment
 - Critical to Quality
-
- 5S, Visual Management tools (Lean)
 - Kaizen

Today's Problem – New Factory



Potential areas of improvement



Good inventory management

Possible Lean Six Sigma Tools

- Value stream mapping (VSM)
- Just in Time
- Kanban



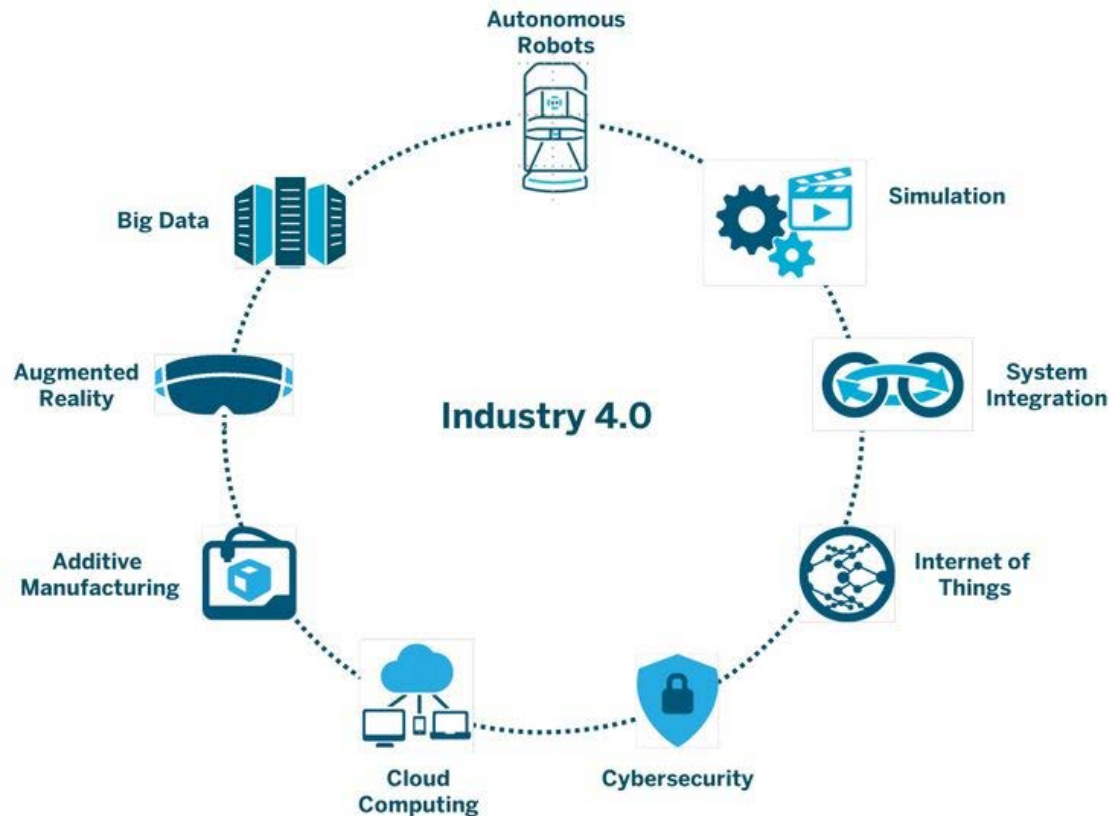
Optimal Productivity

- Process mapping, VSM to see the possibilities to reduce waiting time.
- Workload levelling of the equipment and the operators.
- Brainstorming, fishbone diagram to identify all causes of error
- Pareto chart to narrow problem to its primary cause (Lean / Six Sigma)

Industry 4.0



9 Pillars of Industrial 4.0



“When robotics, 3D printing, data analytics, the Internet of Things, and digital fabrication are joined together, they integrate the physical and virtual worlds.”

Learning Objectives

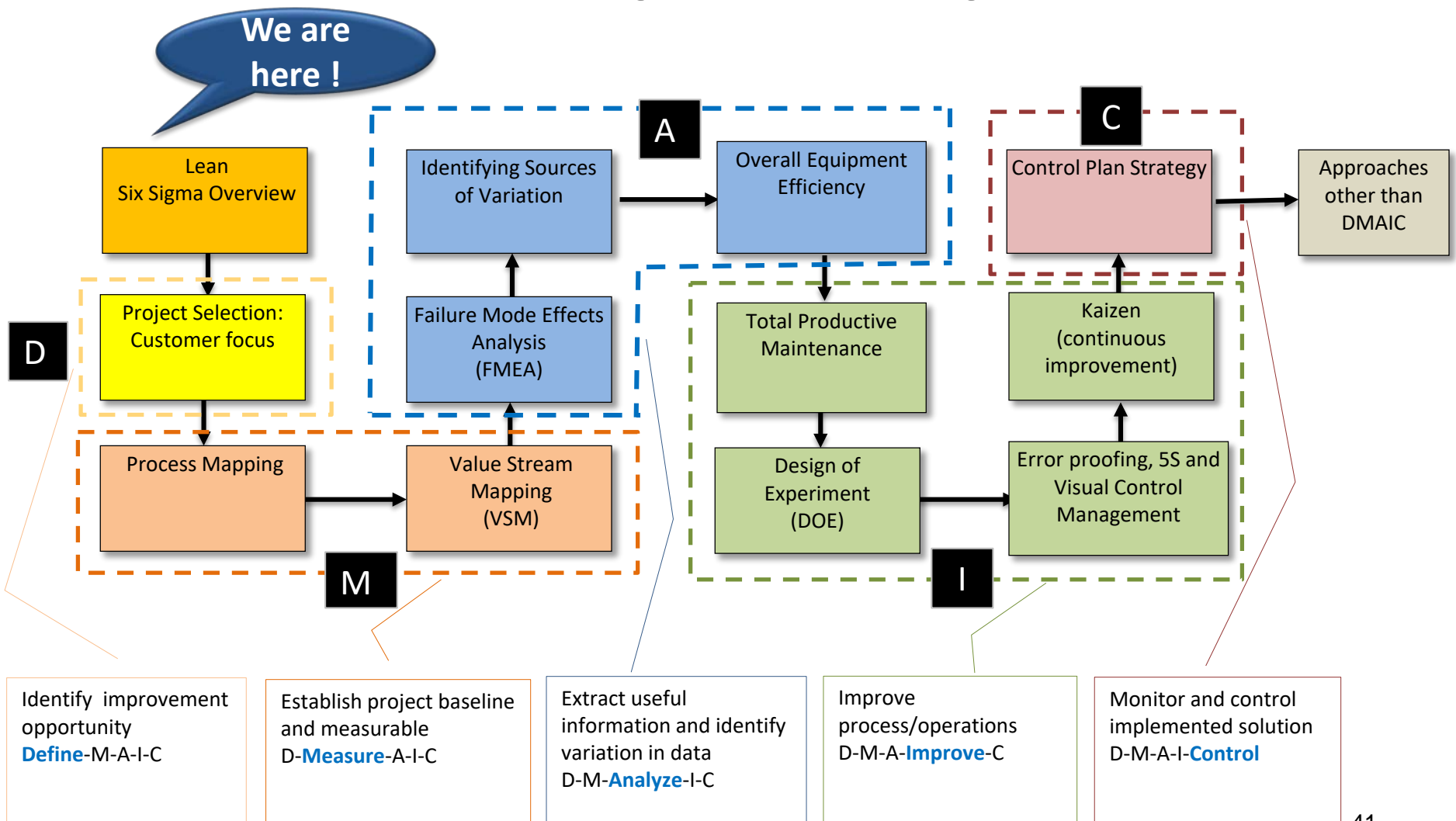


- Describe the importance of Lean Manufacturing, Six Sigma and Lean Six Sigma.
- Distinguish among “Lean Manufacturing”, “Six Sigma” and “Lean Six Sigma”.
- Differentiate Lean Six Sigma team roles and responsibilities.
- Explain what productivity is, its importance and some common productivity Indicators

Overview of E326



Lean Manufacturing and Six Sigma



Before you go...



- Install “[Minitab 17](#)” and “[Quality Companion 3.2](#)” from “Run Advertise Programs”.
- Try launching the program after installing to make sure the program can run before next lesson by below path:

[Start/Startup > All Program > Minitab Solutions > Minitab...](#)

[and](#)

[Start/Startup > All Program > Minitab > Quality Companion..](#)