OptimaWell

Introductory Guide to Process Management For Asset Optimization

From OptimaWell Toolbox (Toolboxes for Outperformers)

OptimaWell

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Purpose of This Document

This guide is recommended as an introduction to getting started with process modeling and simulation and its practical application in the integrated asset management of hydrocarbon production assets.

Map To Navigate This Guide

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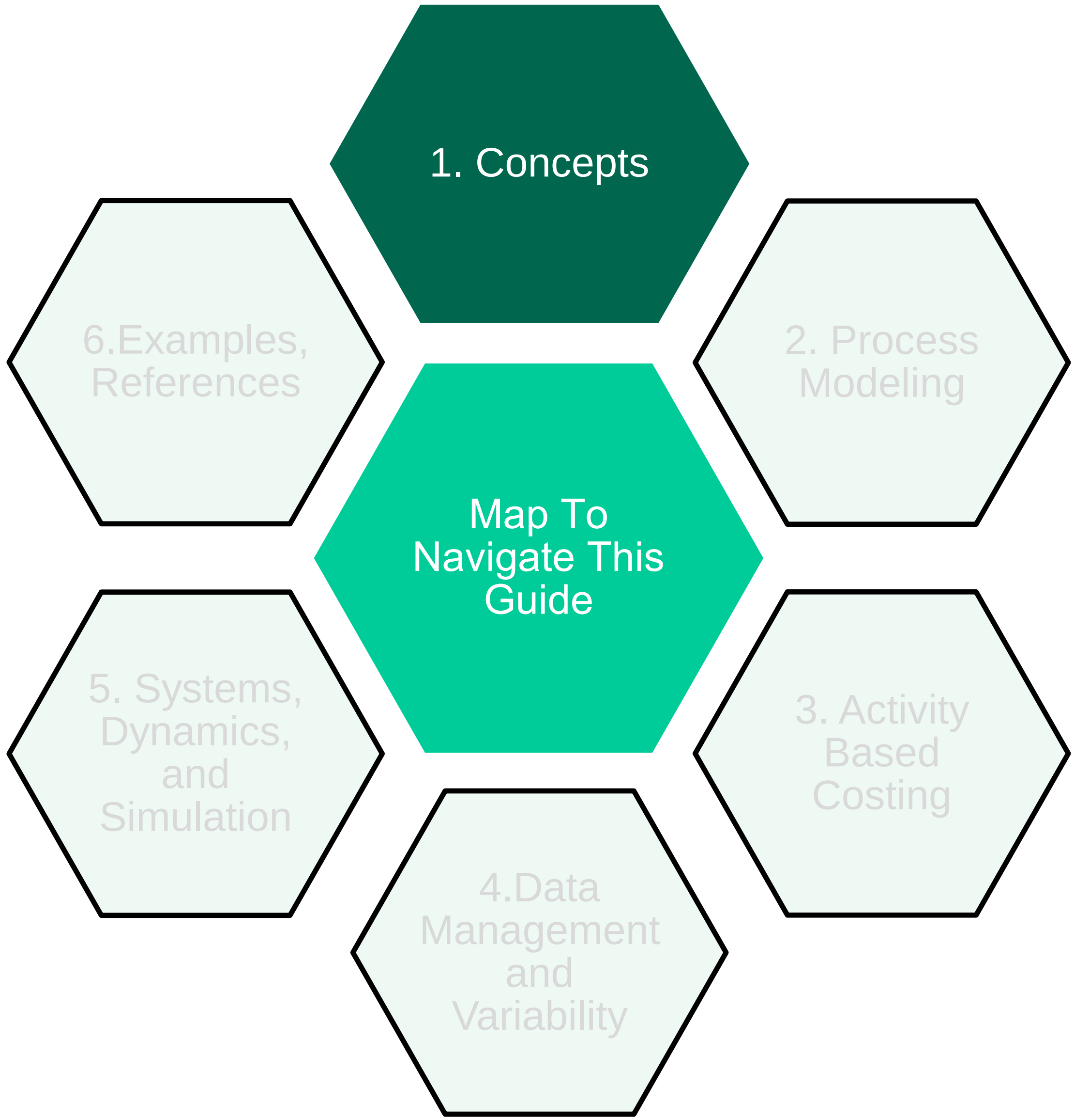
- 1.Concepts
- 2. Process Modeling
- 3. Activity Based Costing
- 4.Data Management and Variability
- 5. Systems, Dynamics, and Simulation
- 6.Examples, References

Map To Navigate This Guide



Introduction

- This guide is introductory and has two learning objectives: the first is to become familiar with the practical application of modeling and process simulation in integrated asset management, and the second is to use process modeling and simulation for the analysis and diagnosis of a system's asset health, evaluating its productivity during the production phase.

- The guide covers important processes such as data capture, review, and interpretation, as well as the closing of the loop to enable individual and organizational learning for those involved in the various activities of an asset system.

- The proper representation of processes facilitates analysis, diagnosis, and simulation, allowing for adjustments and improvements in their design, considering the specific needs of each asset system and its components (in the case of hydrocarbons, reservoirs, wells, and surface infrastructure).

- The analysis and diagnosis of productivity are part of a higher-level macro process: the sustainable exploitation of resources (e.g., hydrocarbons) by a given asset system (e.g., an oil field with one or more reservoirs).

Concepts

Integrated Asset Management and Model

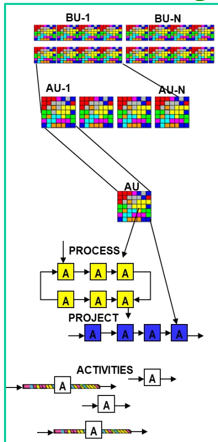
Integrated Asset Management

¿What is Integrated Asset Management?

*Method that empowers management of an organization to be **accountable** for the performance of a system of assets during its life cycle, within defined boundaries (environmental, health, safety, legal regulations, taxes, royalties) and supported by a given set of technical, commercial and financial best practices, using technologies, processes and competencies and learning methods adapted for the needs of the business.*

"Accountability for Identification and Realization of sustainable value of a system of Assets"

Asset Model Activity-Based Aggregation



BUSINESS UNIT (BU) - GEOGRAPHIC LOCATION – REGION – COUNTRY

A Business Unit is accountable for value creation from a resource base characterized and organized in asset units (Example: Upstream is accountable for hydrocarbon production to a defined market.)

SYSTEM OF ASSETS (SOA) - ASSET UNIT (AU)

The Asset Unit (AU) as an organization is the smallest primary organizational block in a region and is made up of interconnected system of assets (SOA) in which coordinated and integrated activities are managed through the Asset Reference Plan (ARP) and are executed through processes and projects. The Asset is that level of the organization above which there are no significant costs (operational and investment) associated with the final product.

ASSET

Any thing with value for the organization and that undergoes a life cycle. Assets can be classified into: Physical (wells, plants, infrastructure, data, etc), Intellectual (people, competencies, patents, etc), Financial (costs, capital, revenues, etc), Natural (hydrocarbons, oil and gas bearing rocks, Environmental, Ecosystems, Life), Social (relationships, trust, networks), Intangible (Reputation, others).

PROCESS

Rational organization of people (with different disciplines, skills or competencies), materials, energy, equipment and procedures in activities designed to produce a specific result. It is repeated many times during the life cycle of an asset.

PROJECT

Non-recurring limited duration process. It has a beginning and an end within the life cycle of the asset.

FUNCTION

Group of activities performed with common knowledge or a family of common disciplines, skills or competencies.

ACTIVITY

A set of tasks or actions performed by an individual or a team using homogeneous set of skills, knowledge and competencies, with a coherent performance from the perspective of costs and efficiency subject to improvement measures.

Asset Model Aggregation Levels

Level	Organization	Aggregation	Role	Tools	Certification
Level 1 Strategic	• Regulatory Bodies • Companies		- Select portfolio - Approve Level 1 Business Plan - Allocate financial resources	Portfolio of Opportunities for Sustainable Value Creation From Resources	Certified Fellow
Level 2 Tactical	Regions Divisions Business Units Asset Units		- Define Level 2 business plan - Evaluate Assets - Leverage Environmental, Social and Governance Variables - Formulate Asset Reference Plan (ARP)	Demand Prices; $/Bl; Value; MM$ $/Bl - Scenarios: Base (Maintain), Growth, Technological Projects - Value (Economic ,Social and environmental), Jobs - Total Life Cycle Costs, Capabilities, Milestones & Risks	Certified Senior Practitioner
Level 3 Operational	Asset Teams Process Teams Project Teams		- Formulate Operation Reference Plan (ORP) - Supply chain plan - Documentation	- Production Profile - Reserves - Total Life Cycle Costs - Supply Chain, Jobs	Certified Practitioner
Level 4 Execution	Multidisciplinary Activities		- Processes Workflows - Detailed Activities - Measure, Surveillance, Monitoring and Control	- Total Costs - Critical activities, Jobs - Time Management - HSE & Risk Mngt	Certified Associate

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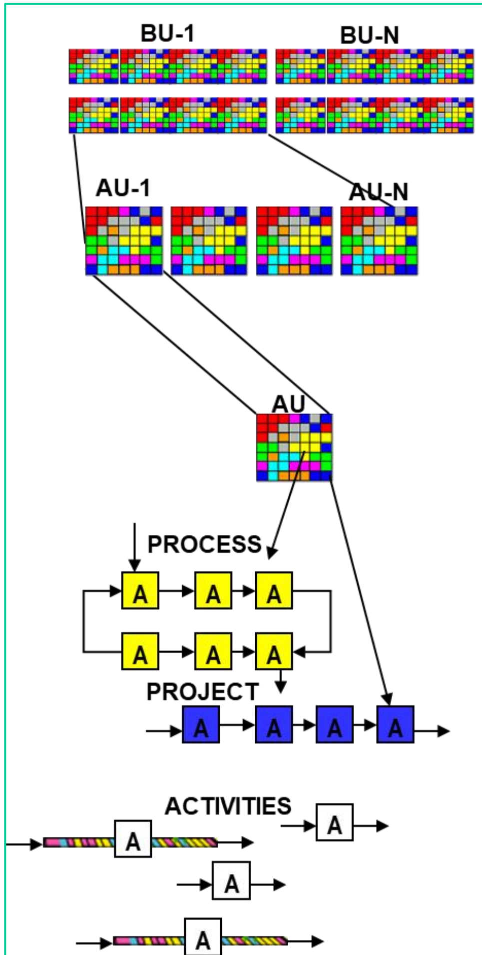
Asset Model
Activity-Based Aggregation



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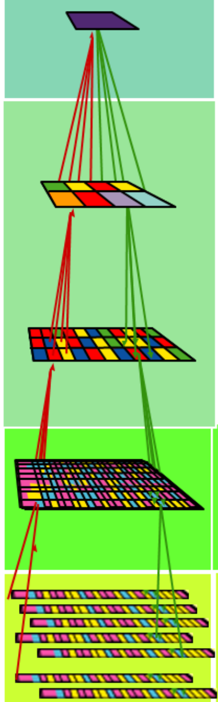
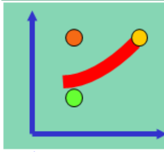
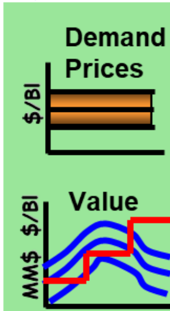
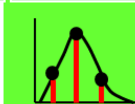
Level 1 Strategic	• Regulatory Bodies • Companies		- Select portfolio - Approve Level 1 Business Plan - Allocate financial resources	 Portfolio of Opportunities for Sustainable Value Creation From Resources	Certified Fellow
Level 2 Tactical	Regions Divisions Business Units Asset Units		- Define Level 2 business plan - Evaluate Assets - Leverage Environmental, Social and Governance Variables - Formulate Asset Reference Plan (ARP)	 - Scenarios: Base (Maintain), Growth, Technological Projects - Value (Economic ,Social and environmental), Jobs - Total Life Cycle Costs, Capabilities, Milestones & Risks	Certified Senior Practitioner
Level 3 Operational	Asset Teams Process Teams Project Teams		- Formulate Operation Reference Plan (ORP) - Supply chain plan - Documentation	 - Production Profile - Reserves - Total Life Cycle Costs - Supply Chain, Jobs	Certified Practitioner
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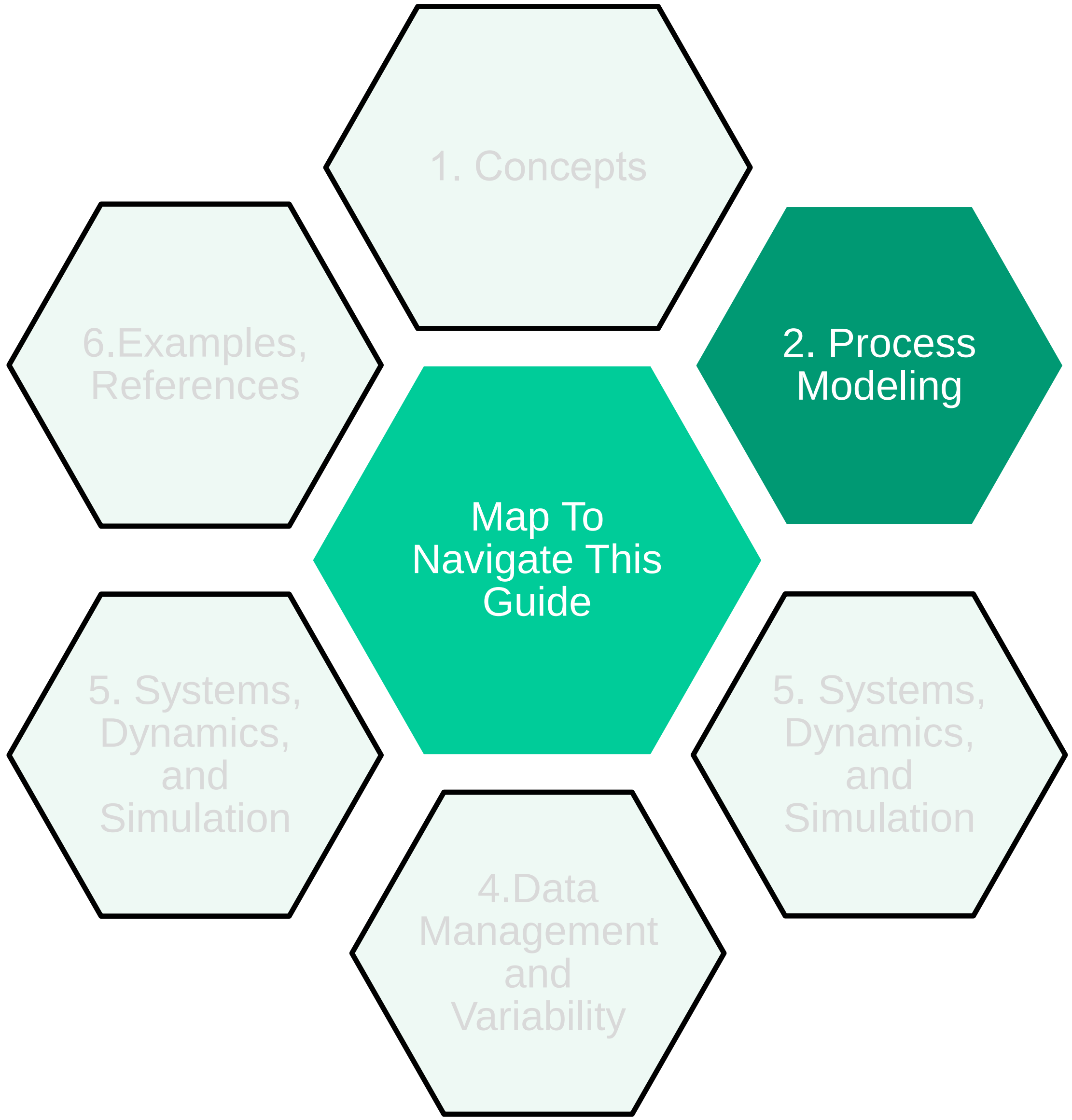
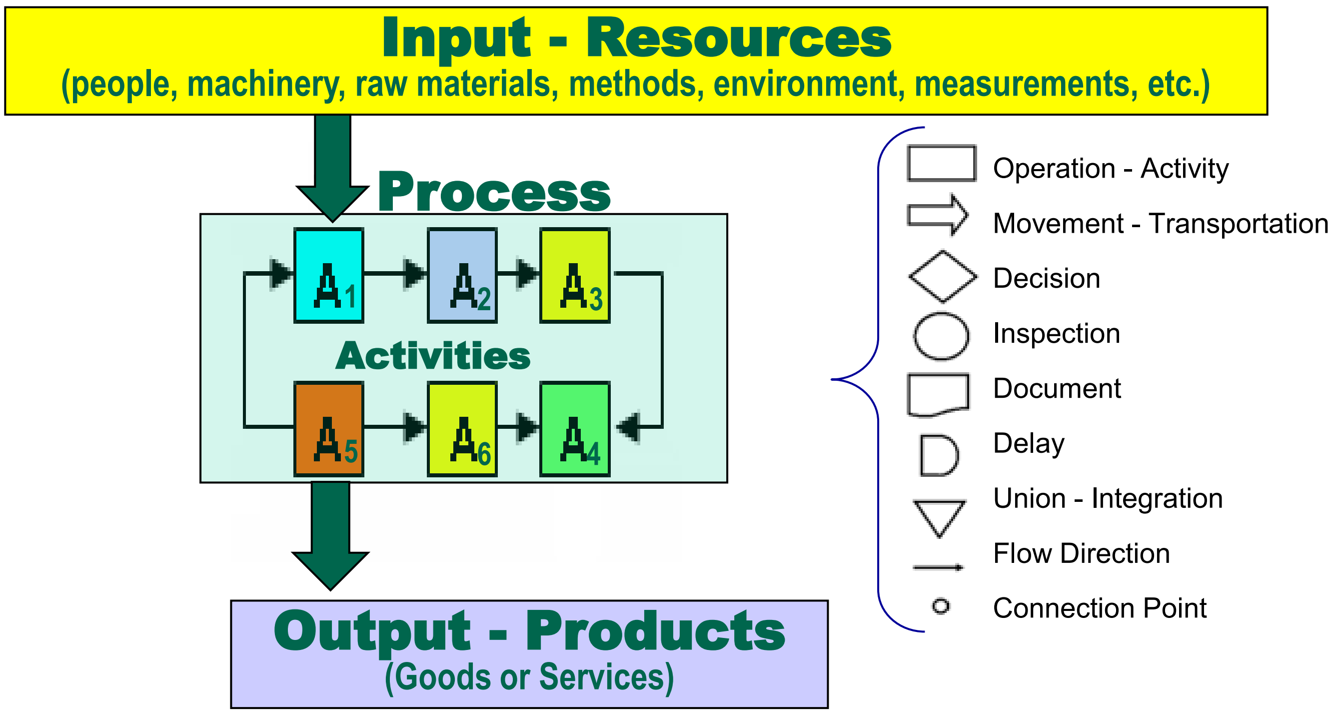


Process – Definition and Representation

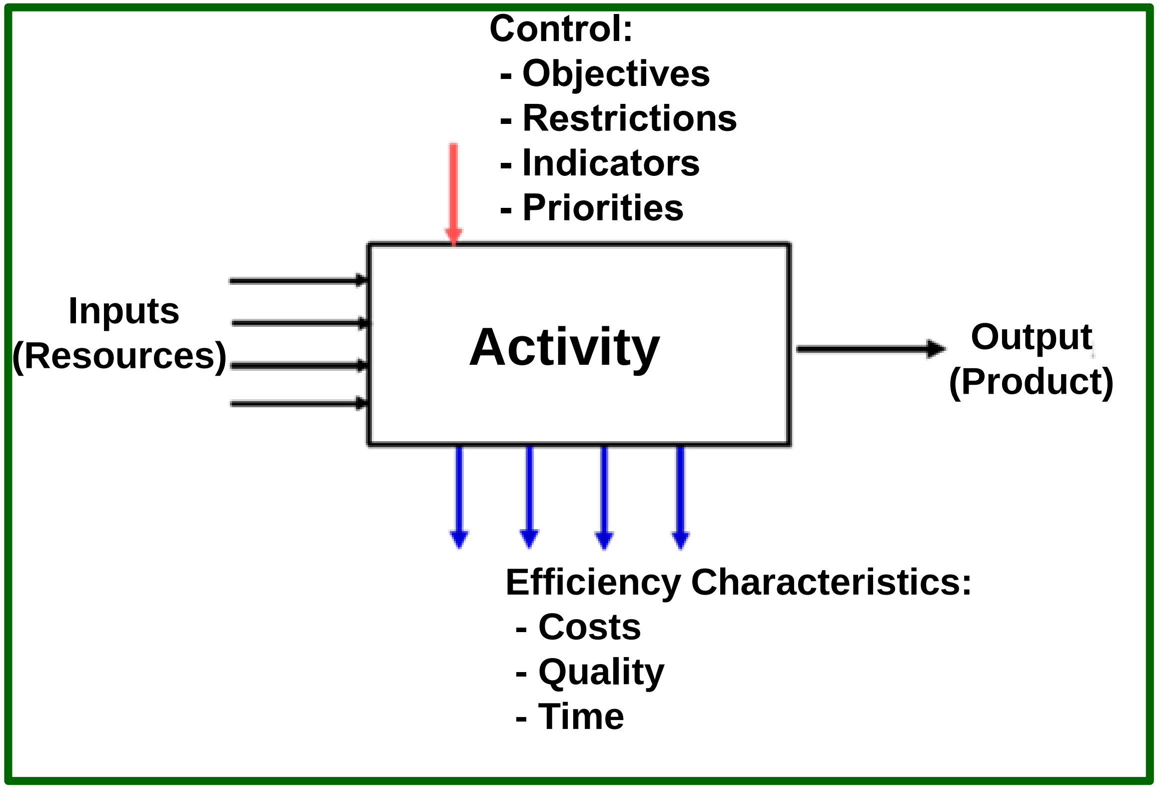
A process is defined as a logical, related, and sequential set of interconnected activities that takes inputs from suppliers or sources, adds value to them, and produces an output (product) for customers, ensuring compliance with previously established quality requirements. Each process has a beginning, an end, and a cycle time. Processes are repetitive and consist of activities, beneath which are tasks or actions (1).



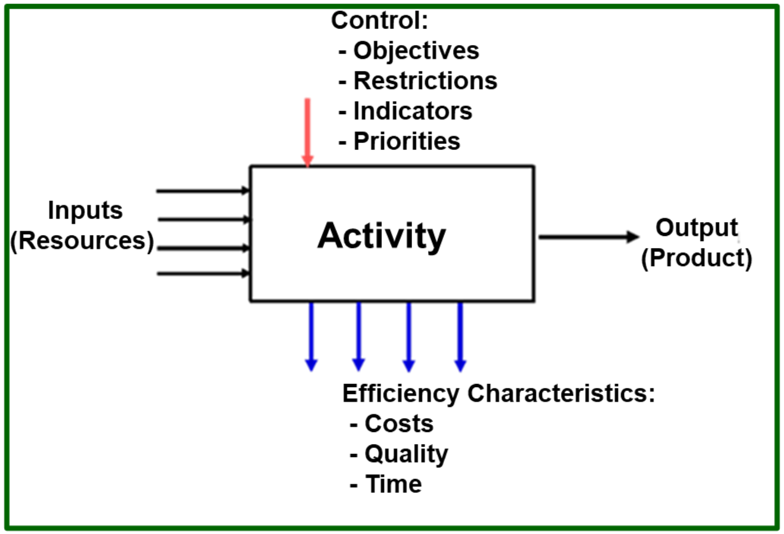
Graphical Representation of a Process according to the American National Standards Institute (ANSI)

Activity – Definition and Representation (part 1 of 2)

- An activity can be defined as a set of tasks or actions carried out within the framework or scope of a process.
- Activities are performed by a person or a group of people (integrated into functional or multidisciplinary work units).
- Activities are documented to facilitate their execution, representing them as follows:



Activity – Definition and Representation (part 2 of 2)



Activity Name

A name recognizable by everyone, expressed in the company's language. Identified with a description that is as brief and objective as possible, explicitly indicating what the activity does. The goal is to describe what it actually does, not what it should do or what might be done someday. The activity must be located within the organization(s) where it is performed.

Control

Control elements such as objectives, constraints, indicators, and priorities.

Output – Product

The main output, and if applicable, the secondary outputs, must specify the destination activity, the client or user of the destination activity, and the recipient of the main output. The unit and frequency of measurement should be defined, ensuring that the chosen unit allows for the quantitative measurement of the main output or product of the activity.

Efficiency Characteristics

Costs, quality characteristics that lead to additional COSTS on outputs (failure rates, errors, breakdowns), and time. The methodology used for efficiency analysis can be root cause analysis.

Input - Resources

The list of inputs includes both physical and non-physical ones: labor, machinery, materials, energy, data, and information. Each input can specify its description (type of component, specifications, labor qualifications, etc.). The source activity must be specified, and, if applicable, the unit of measurement and frequency for periodic inputs.

All Resources consumed by the activity are represented among the inputs. There are permanent resources and consumable ones.

Task

A **task** can be defined as an amount of work or an operation required as part of a deliverable of an activity in a project or a process.

A **task** is the smallest indivisible piece of work from an activity that can be understood and executed by a person with a discipline within a function in an organization.

Flow Diagrams (Part 1 of 2)

Flowcharts graphically present the activities that make up a process in the same way that a map represents a territory.

There are many types of flowcharts:

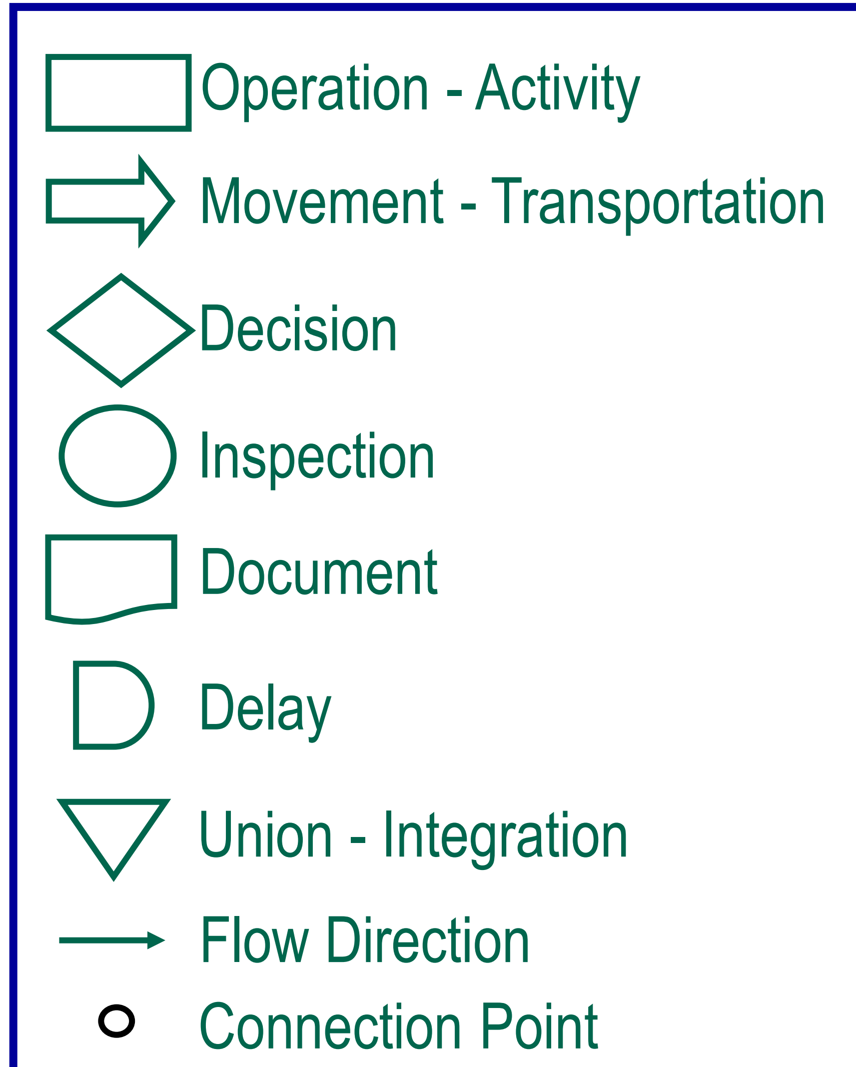
American National Standard Institute (ANSI) standard, whose symbols are shown on the right

Graphic flowchart

Functional flowchart

Chronological flowchart

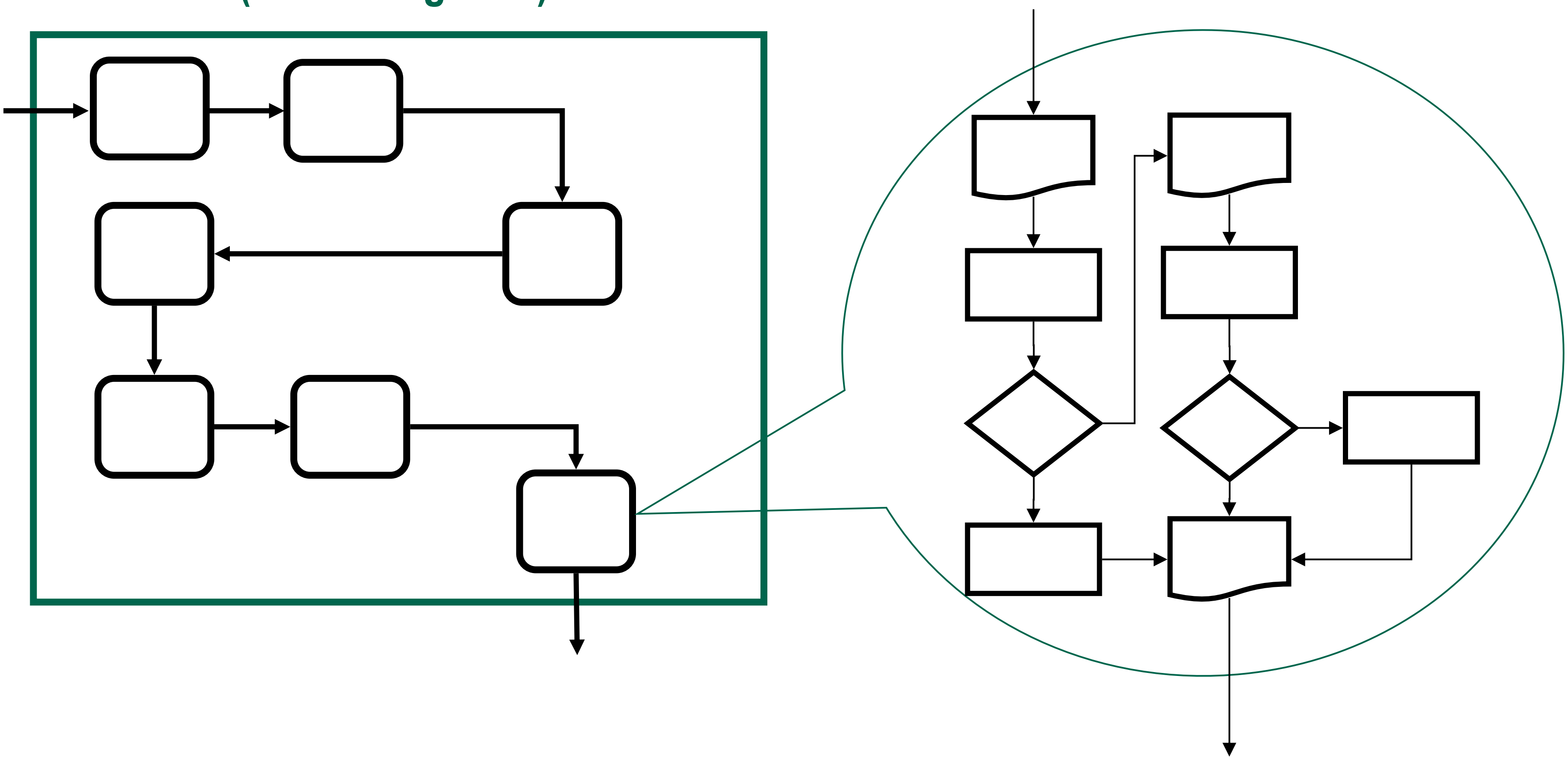
Electrical circuit flowchart



Flow Diagrams (Part 2 of 2)

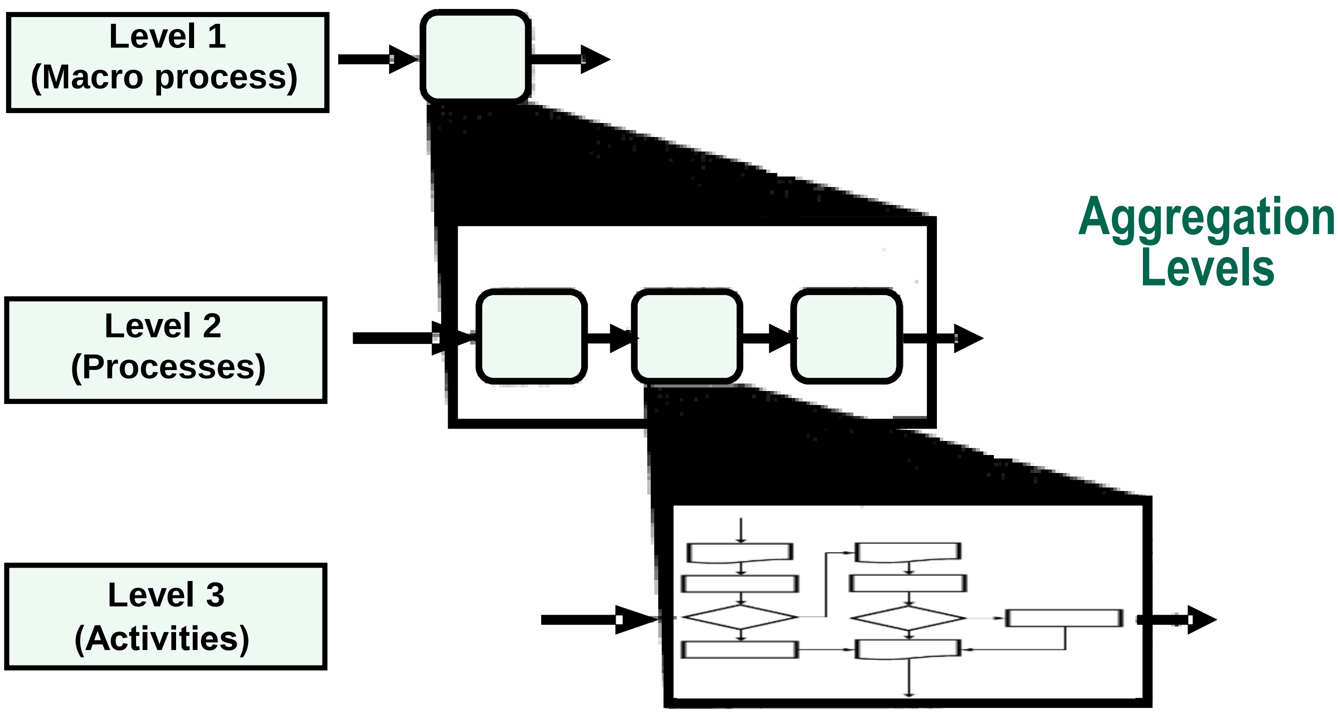
Macro Process and Process
(Block Diagrams)

Activities
(Flow Diagram ANSI)



Project, Function, Aggregation Levels

- There are two variations of the concept of process:
  - Project, which is a non-repetitive process and
  - Function, when a process has a grouping of activities carried out with specialties characterized by a common knowledge.
- When there is a very large set of processes, they are managed at various levels of aggregation and a hierarchy is used for their representation. These levels of aggregation vary for each case.



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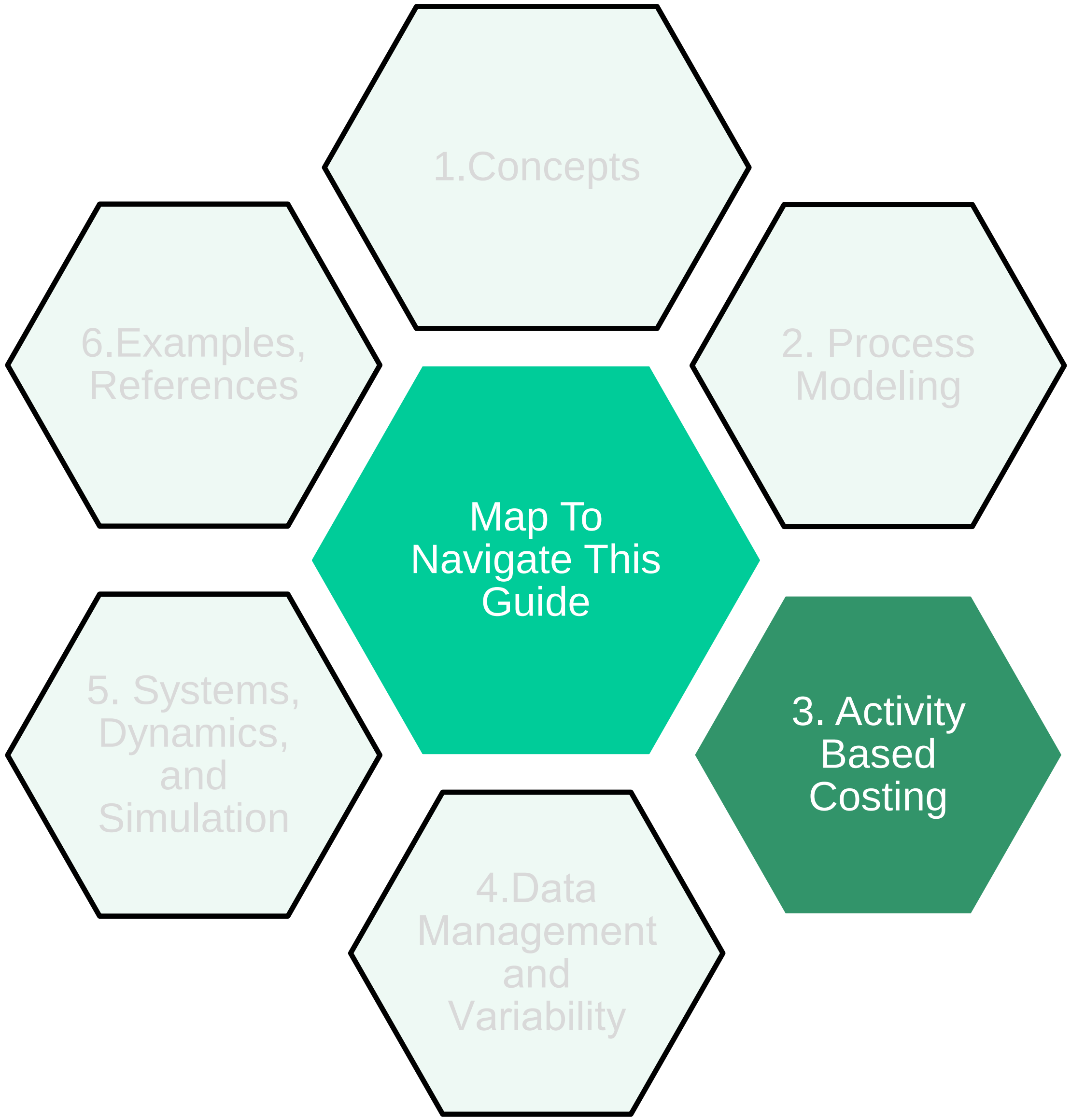
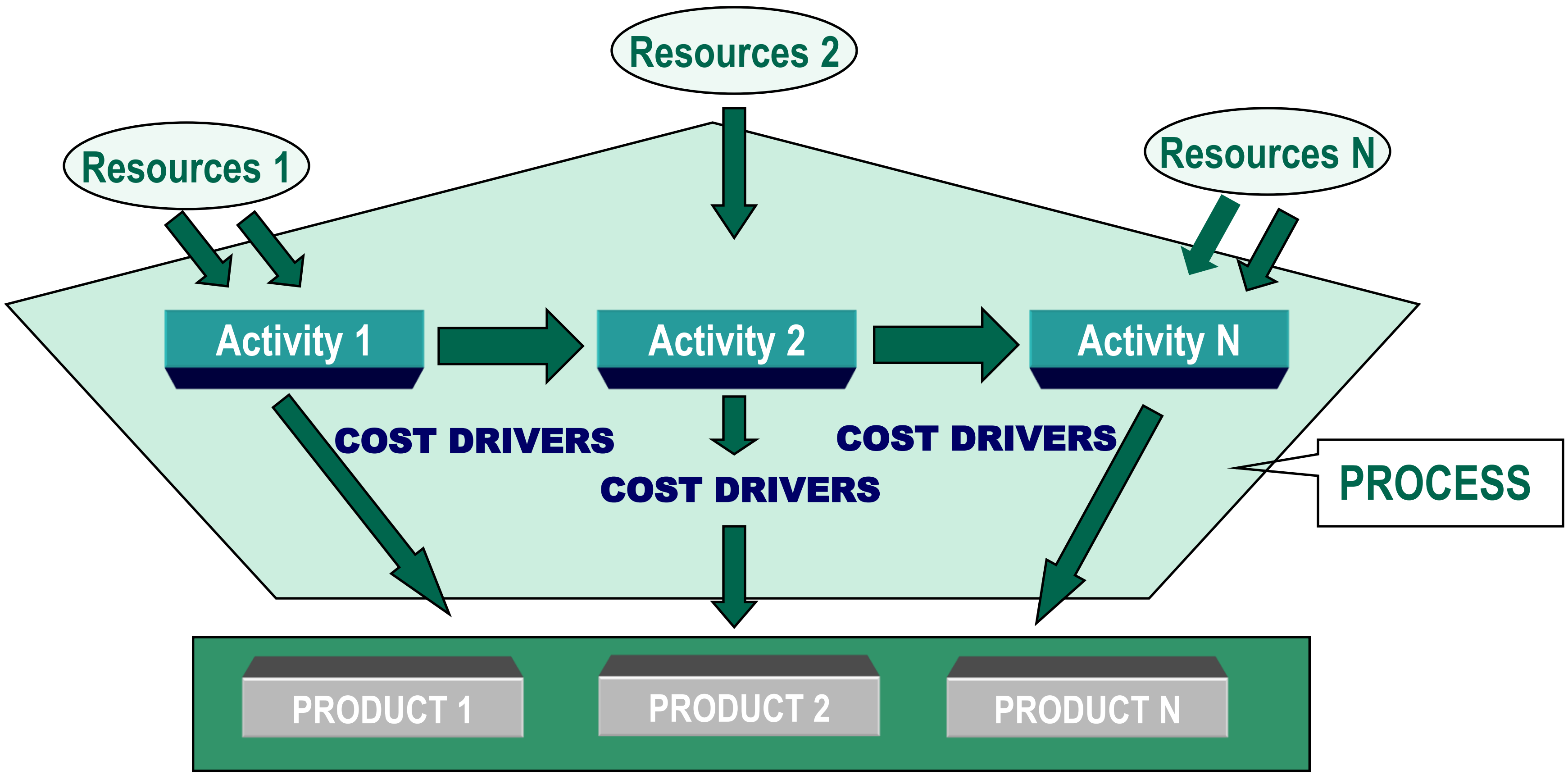


Activity Based Costing

Cost Drivers (Part 1 of 2)

Cost Drivers are indicators through which the cost of the activities performed is quantified. Cost Drivers measure the frequency and intensity of the demands made on the activities for the products to be obtained.



Activity Based Costing

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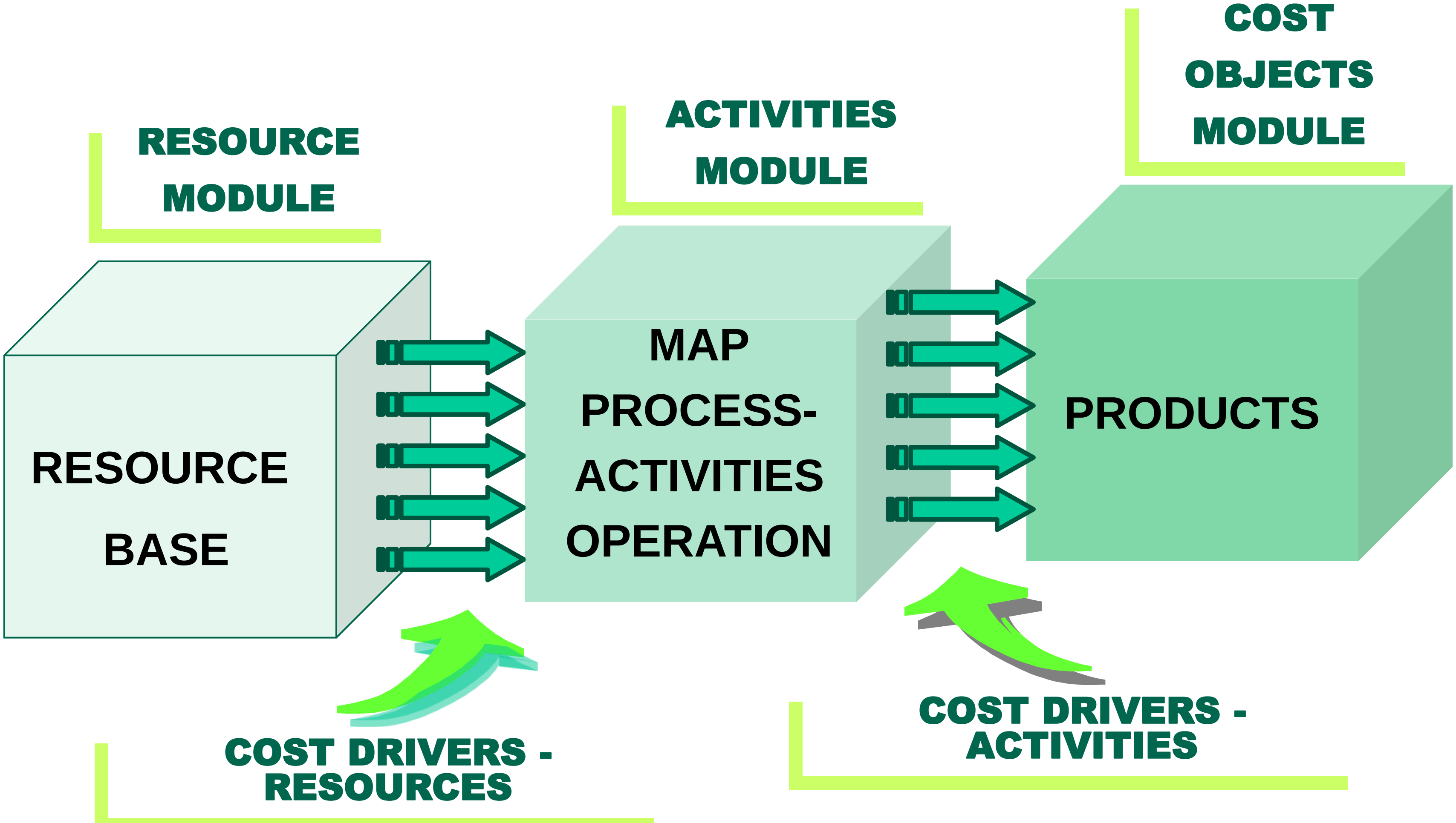

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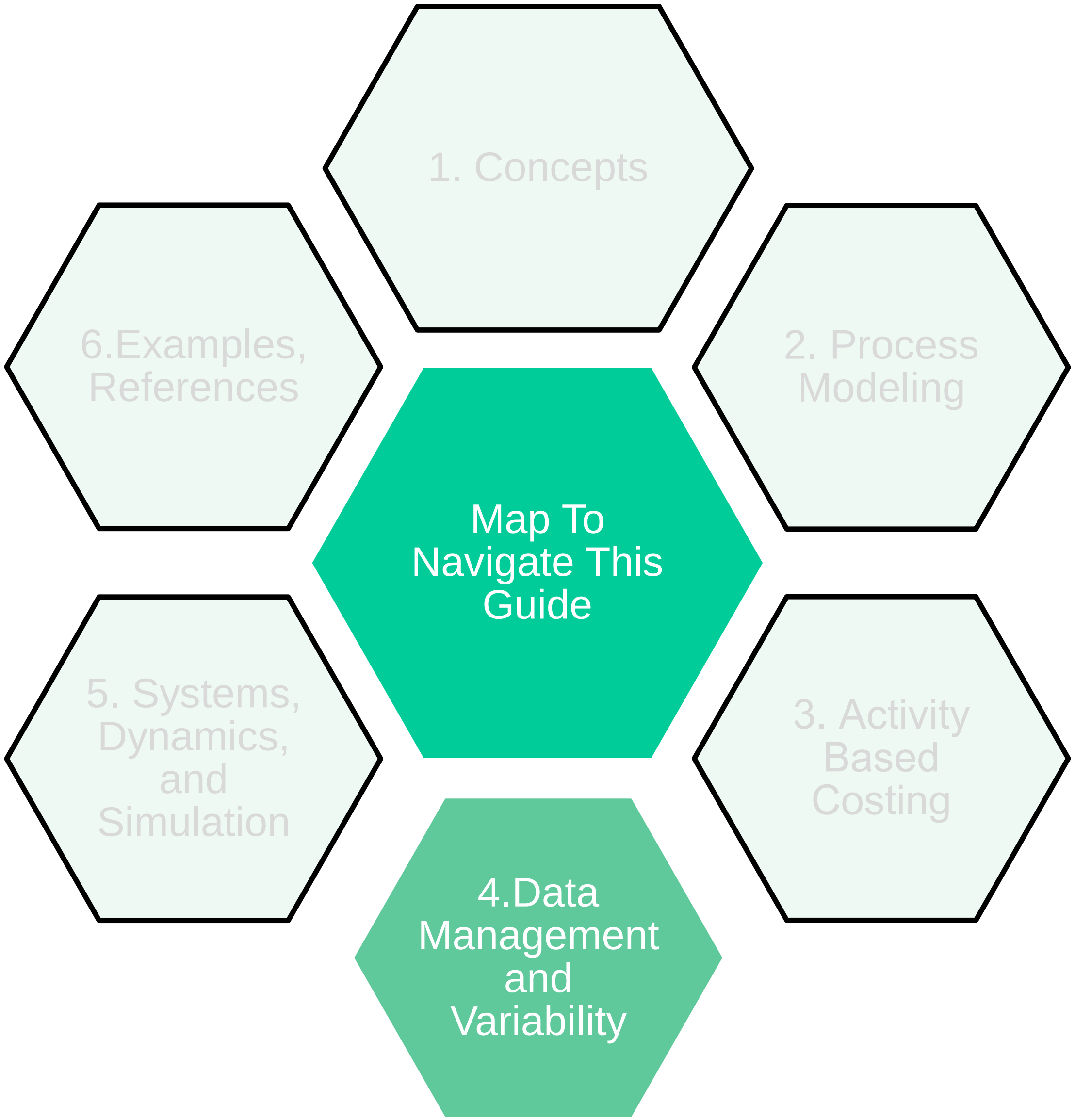
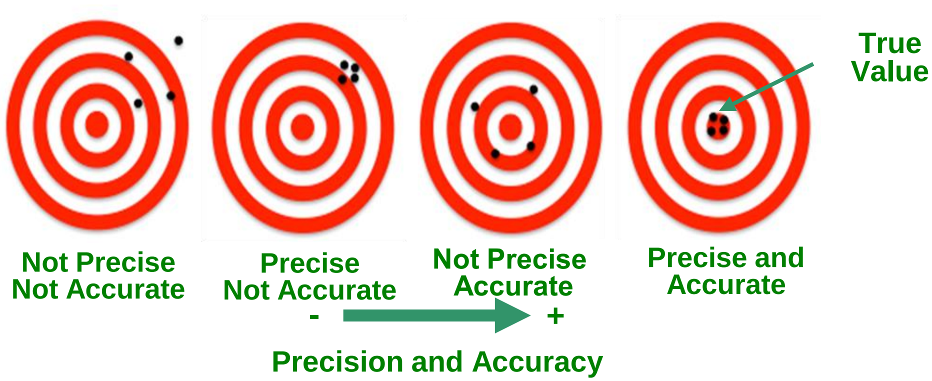


Data Management and Variability

Data Management (Part 1 of 4)

- **Data Quality**: The analysis and diagnosis of asset productivity is highly dependent on the quality of data, obtained by direct observation and classified into variables or attributes(7).
    - **Variables** are those characteristics that can be measured, such as weight, volume, temperature, etc.
    - **Attributes**, on the other hand, are those characteristics that are classifiable as conforming or non-conforming to certain specifications.
- **Continuous Variable**: A variable that can be subject to some degree of subdivision is said to be continuous. For example, the temperature of a fluid can be measured as 23ºC, 23.11ºC, 23.1156ºC, depending on the precision of the instrument.
- **Precision and Accuracy**: It is important to know that an instrument may or may not give the true value due to precision or accuracy problems. As illustrated in the following figure, a set of readings can be qualified as precise by being very close to each other, although not necessarily close to the true value. On the other hand, a set of readings whose average is close to the true value, but are far apart from each other, can be said to be accurate.



Data Management and Variability

Data Management (Part 2 of 4)

- **Data Reliability**: To increase the reliability of a process (for example, hydrocarbon production), we need readings that have both precision and accuracy. There are techniques that allow us to identify when we are in the presence of data that is not reliable and to identify the origin of the low reliability, which may be associated with the instrument or the data capture process or operation of that instrument by a person with adequate training.

- **Discrete Variable**: Those variables that exhibit gaps for their measurement are said to be discrete. For example, the number of labels used to describe samples taken in a production process is an integer, 1, 2, 3...etc. We cannot say that there are 1.5 labels. In general, continuous variables can be measured, while discrete variables can be counted or in general, we can say that they are judged through attributes.

- **Attributes**: In a process it is necessary to manage many characteristics in terms of attributes. For example, a checklist to establish whether all requirements are being met in terms of disciplines, information, steps, compliance in the calibration of instruments, synchronization between the different measures taken to determine the quantity and quality of inputs and products handled by a process, and others that allow determining that a process is under control, will require numerous attributes.

Data Management and Variability

Data Management (Part 3 of 4)

DATA CLASSIFICATION

DATA

STRUCTURE

Collection of multiple observations, each composed of one or more variables.

The key to structure is that information is packaged into well-defined variables, e.g., the columns of a tidy data frame.

Typically, it takes lot of effort to get information into a useful structure.

UNSTRUCTURED

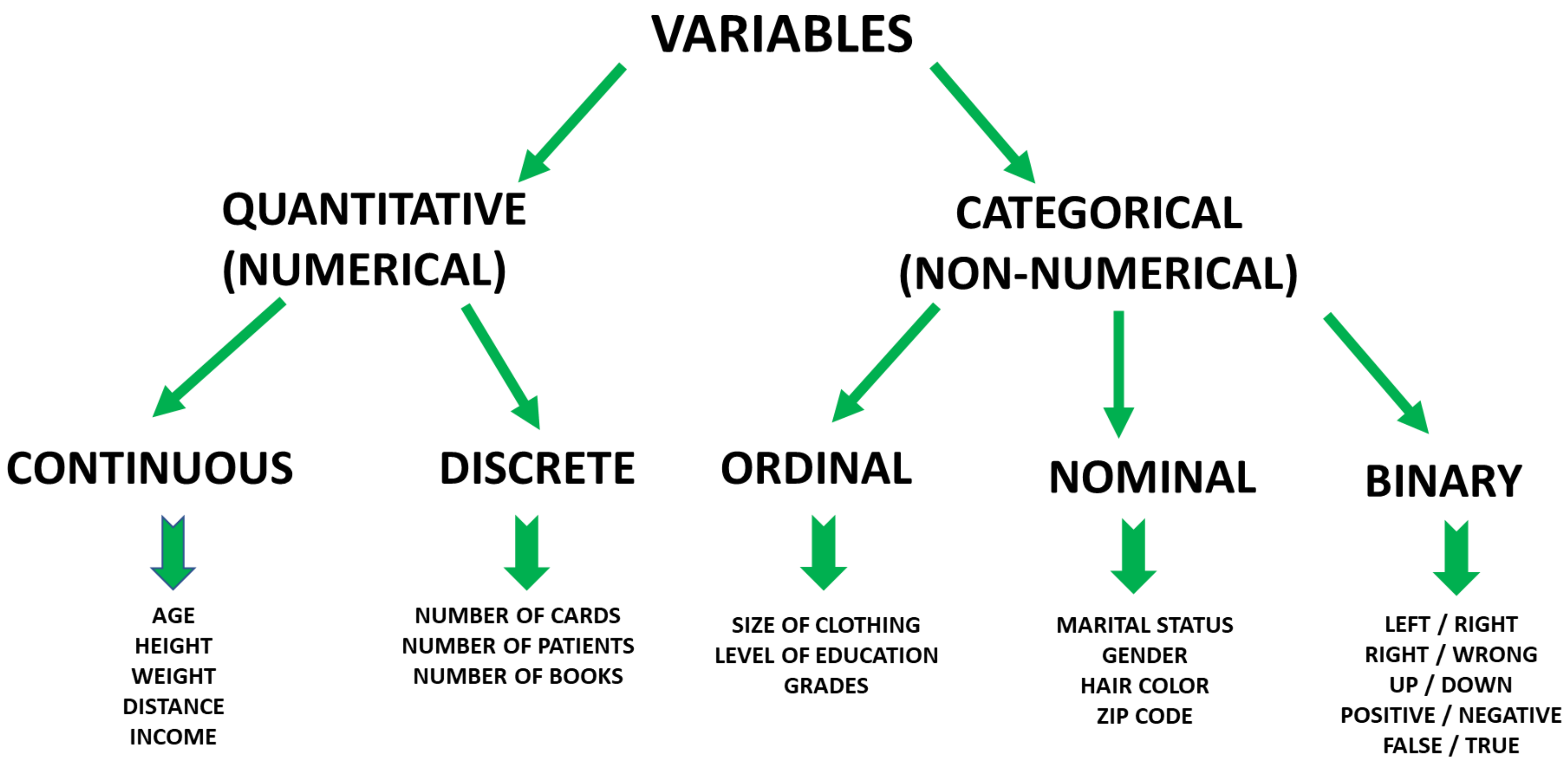
Information that has not been carved up into variables is unstructured "data"— although some say that is a misnomer.

Any field researcher knows when they are staring down raw information, and they are usually puzzling over how to collect or structure it.

Data Management and Variability

Data Management (Part 4 of 4)

VARIABLES CLASIFICATION



Data Management and Variability

Variability (Part 1 of 4)

- **Variability**: For a given object, no two characteristics are the same. For example, you can take a large number of samples of fluids produced by a production process and perform analysis of the water and sediment content in each sample. Regardless of the number of samples, you will not find two measurements of water and sediment that are exactly the same. This is more critical when the sensors through which the different measurements are made are operated, some manually and others semi-automatically or fully automatically. They are also based on different principles of physics, chemistry and other sciences.

- **Standard deviation (S)**: describes the amount of variation expected in a normally distributed data set(2). The expression for ungrouped data is given below:

$$S = \sqrt{\frac{n \sum_{i=1}^{n} Xi^2 - \left(\sum_{i=1}^{n} Xi\right)^2}{n(n-1)}}$$

S – Standard deviation

$\overline{X}$ – Average

Xi – Observed value

n – Number of observed values

For example: The standard deviation is equal to 0.35%.for 6 fluid samples whose % water and sediment readings were:6.7%, 6.0%, 6.4%,6.4%, 5.8% and 5.8%

$$S = \sqrt{\frac{6\ (231.26) - (37.2)^2}{6\,(6-1)}} = 0.35\%$$

A small standard deviation indicates that the values in the set are very close to the average. Conversely, a large standard deviation reveals that the observations are widely dispersed from the average.

Data Management and Variability

Variability (Part 2 of 4)

Chebyshev's Theorem [3] : Chebyshev's Theorem (3) : It states that three out of four values or 75 percent, must lie between the mean plus two standard deviations and the mean minus two standard deviations. Furthermore, 8 out of 9 values (88.9%), will lie between plus three and minus three standard deviations around the mean value. The theorem states that in any set of observations (sample or population), the proportion of values that lie within k standard deviations of the mean is at least 1-1/k2 where k is a constant greater than one.
If the data are grouped in a frequency distribution, the sample standard deviation can be calculated using the following expression:

$$S = \sqrt{\frac{n \sum_{i=1}^{n} (fiXi^2) - \left(\sum_{i=1}^{n} fiXi \right)^2}{n(n-1)}}$$

S – Standard deviation

$\overline{X}$ – Average

Xi – Observed value

n – Number of observed values

f – Class frequency

For example: The standard sampling distribution is 7.51 for samples taken from a production process. The results have been tabulated in 8 classes and for each class the average value of the number of samples whose results have been grouped in that class has been calculated:

Range % Water	Number f	Average % Water
30-35	3	32.50
35-40	7	37.50
40-45	11	42.50
45-50	22	47.50
50-55	40	52.50
55-60	24	57.50
60-65	9	62.50
65-70	4	67.50
Total	120	

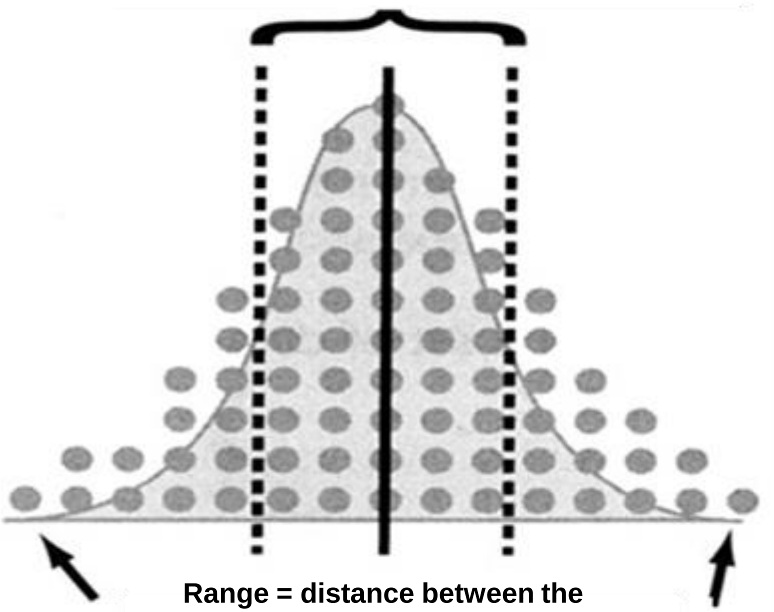
$$S = \sqrt{\frac{325500 - (6185)^2}{120\,(120-1)}} = 7.51$$

Data Management and Variability

Variability (Part 3 of 4)

- **Probability and Statistics**: : The concept of variability was established by Blaise Pascal in 1652 when he developed the non-deterministic branch of mathematics known as "probability and statistics".
- **Normal Distribution**: Friedrich Gauss established that most phenomena associated with nature and man, for example, measurement of water and sediment content, follow a pattern of behavior called a normal distribution curve, which is known as the Gaussian bell curve in his honor. The formula for the normal distribution curve f(Z) is as follows:

Standard deviation Describes amount of variation expected in a normally distributed data set



Range = distance between the largest and smallest values

$$f(Z) = \frac{1}{\sqrt{2\pi}} e^{-\frac{Z^2}{2}} = 0.3989\, e^{-\frac{Z^2}{2}}$$

$$\pi = 3.14159$$

$$e = 2.71828$$

$$Z = \frac{Xi - \mu}{\sigma}$$

Variability (Part 4 of 4)

- **Variability and Quality:** One of the objectives of asset analysis and diagnosis is to contribute to improving the quality of production processes by reducing variability.
- **Variability and Risk:** Understanding the variability of a process forms the foundation for sound risk management. As Peter L. Bernstein states in his work on the history of risk [(4)], "...the essence of risk management lies in maximizing the areas where we have some control over the consequences of our decisions, while minimizing those areas where we have no control over these consequences and the relationship between cause and effect is hidden from us..."
- **Pareto Principle and Quality:** Most events occur around the average ($\overline{x}$). Although the causes of variation may be countless, not all affect to the same degree and can be categorized into two main groups: 1) a small group of causes that have a large effect (the few vital) and 2) a second group that includes many causes with only minor effects (the many trivial). Generally, there are not many factors that truly cause variations. This fact is called the Pareto Principle, named after economist Vilfredo Pareto who discovered it in 1897[(5),(6)]. After World War II, two pioneers began applying the Pareto Principle, and today it is used in many applications. In 1951, Joseph Moses Juran (the man behind the quality revolution) established the rule of the few vital. His contribution was to combine the Pareto Principle with statistical tools to identify the root cause of quality failures and increase the reliability of industrial consumer goods.
- **Principle of Least Effort and Resources**: Using the Pareto Principle, George Z. Zipf discovered the Principle of Least Effort in 1949, which states that resources (people, goods, time, or any productive element) tend to be organized in such a way that 20-30% is responsible for 70-80% of the results associated with the activities consuming those resources.

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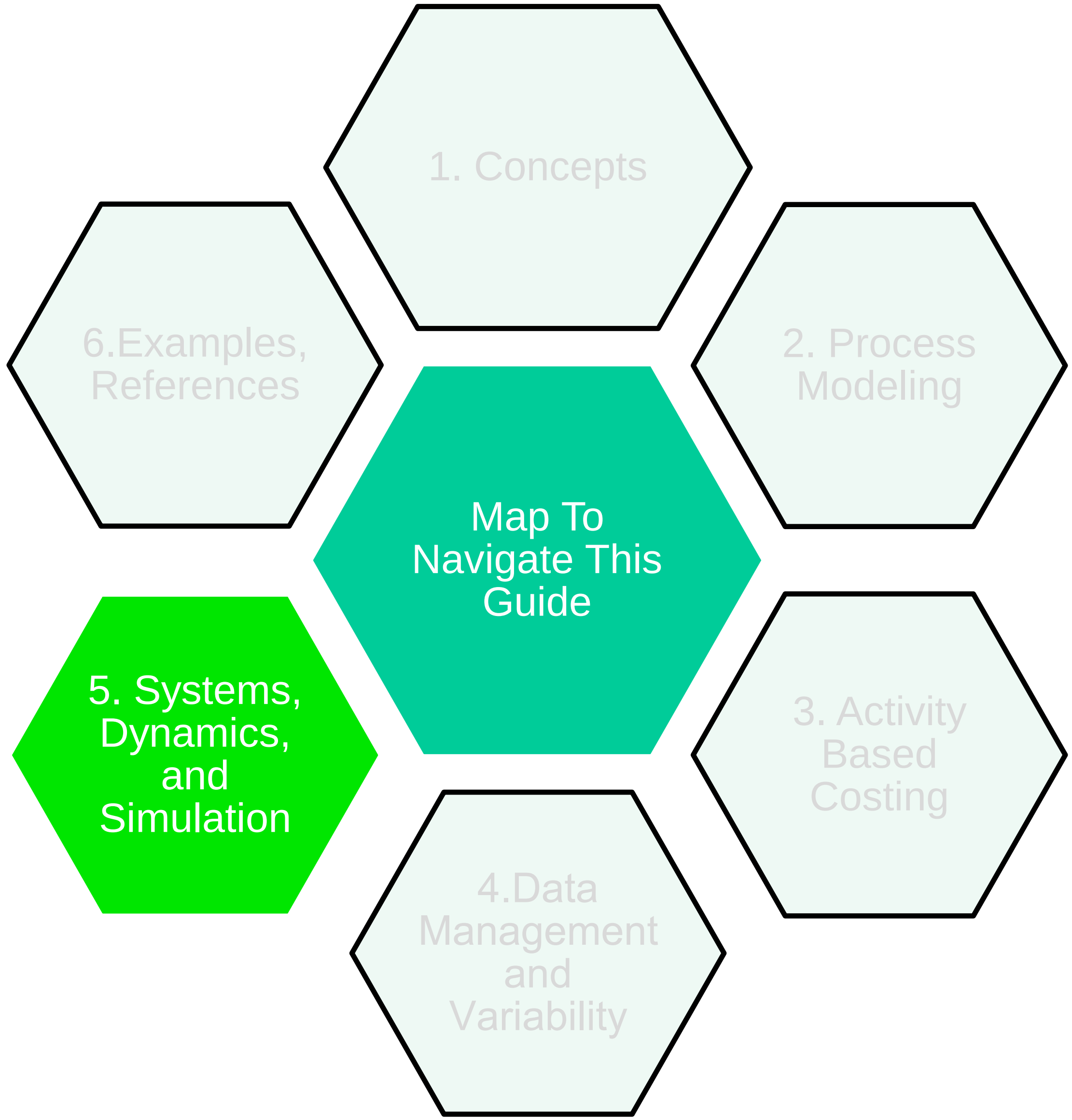
Mapa



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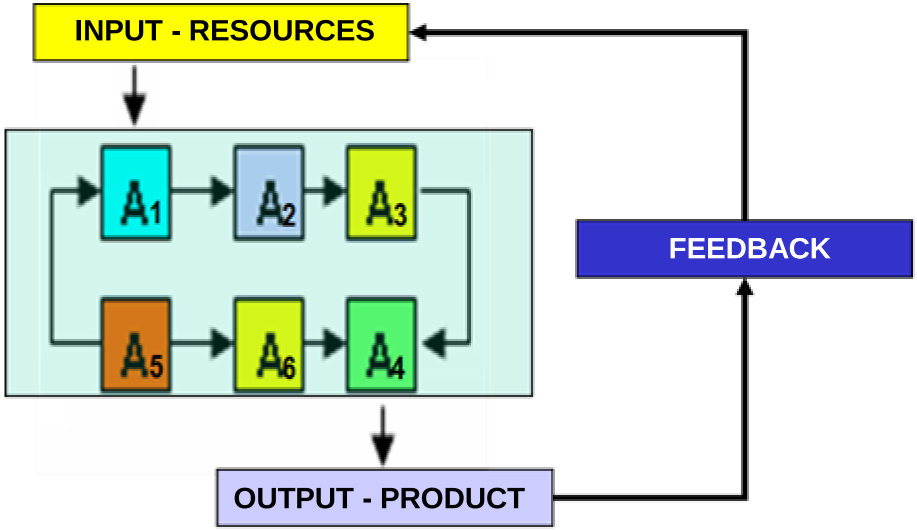
Systems, Dynamics, and Simulation

Systems and Their Dynamics (Part 1 of 3)

- **System**: is a network of interdependent components (set of things, processes and people) that work together towards achieving a goal or purpose [8]. Without a goal, a system cannot be defined. We live in a world of systems. Our body is a system, a company is a system, an electric power plant is a system.

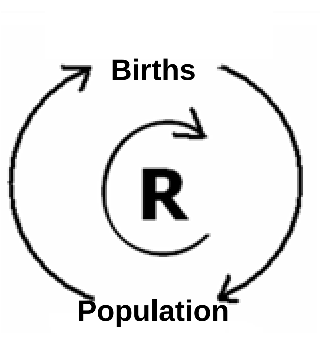
- **Systems Dynamics**: Systems dynamics [9] was developed by Jay W. Forrester, professor of systems at the Massachusetts Institute of Technology (MIT) during the 1950s. Systems dynamics helps us understand that there are no isolated situations of the cause-effect type. We live in a circular, moving world, where each action is based on present conditions and affects the future, so that the modified conditions become the basis for future conditions. The process has no beginning or end, but rather infinite feedback loops that interconnect people and events.



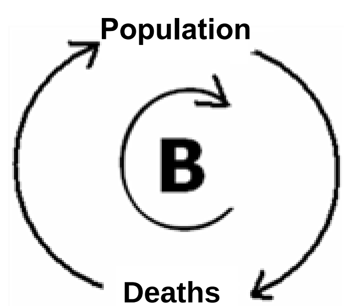
Systems, Dynamics, and Simulation

Systems and Their Dynamics (Part 2 of 3)

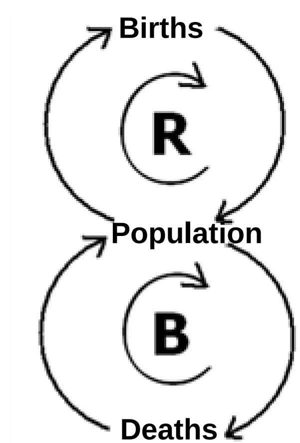
- **The diagram of a reinforcing (or feedback) causal loop** is the basic graphic tool of system dynamics (10). This system diagram helps us understand the evolution of an event in a circular way, as opposed to traditional linear thinking. Within reinforcing processes, we can identify two types: reinforcing processes and compensating processes.
- **Reinforcing processes** are those that involve an increasing force, either positive or negative, meaning a process in which each movement generates more movement. The symbol used to identify them by convention is an R enclosed in a circle. For example, if we take a specific population and observe the number of inhabitants, we can know that this population will grow over time due to the effect of births that occur.
- **Compensating processes** are forces that try to bring the system to a state of equilibrium or balance. The symbol used to identify them is a B enclosed in a circle. An example is deaths that tend to decrease the population. We can also have combined processes where the population does not grow indefinitely, among other reasons, due to the effect of deaths. Thus, the reinforcing process is affected by the compensating process.



Reinforcing processes



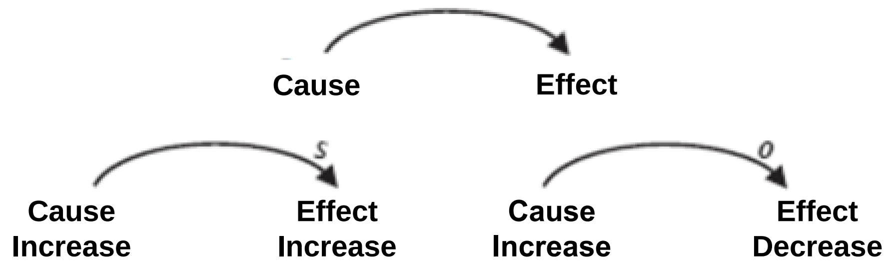
Compensating processes



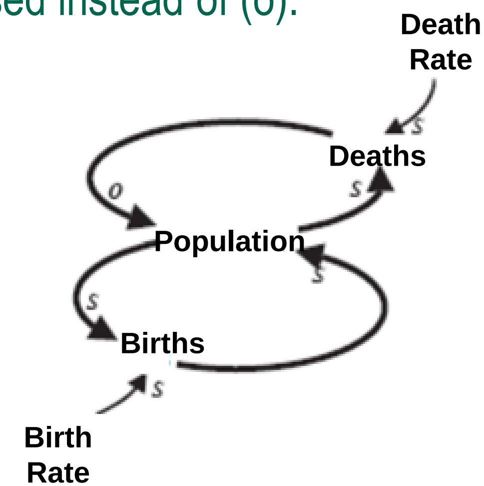
Combined Processes

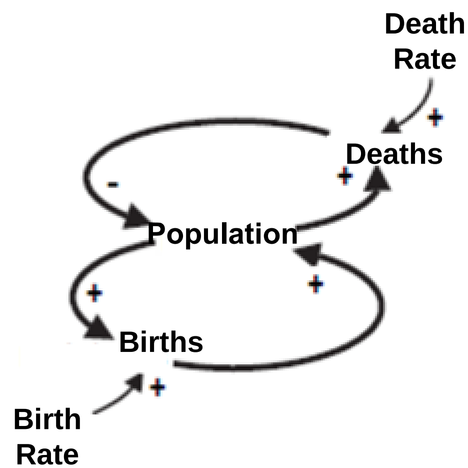
Systems and Their Dynamics (Part 3 of 3)

- **Cause-Effect Diagrams or Causal Diagrams** are system diagrams with the cause-effect relationships that underlie the systems, also known as causal diagrams are represented by a curved arrow. An increase in the cause can generate an increase in the effect (s – for the same direction) or if an increase in the cause can generate a decrease in the effect (o – for the opposite direction).



- **Examples of Causal Diagrams**, another example related to population is shown below using causal diagrams. As indicated in the example, the (+) sign is also used instead of the (s) symbol. Likewise, the (-) symbol is used instead of (o).

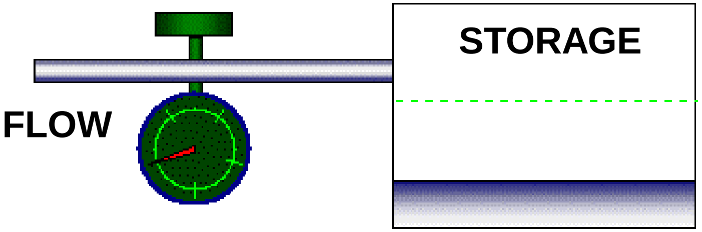




Systems, Dynamics, and Simulation

Dynamic Process Simulation (Part 1 of 4)

- Forrester [11] established a parallel between dynamic (or evolving) systems and a hydrodynamic one, consisting of reservoirs, interconnected by channels with or without delays, varying their level through flows, with the help of exogenous phenomena.



- System dynamics allows us to go beyond case studies and descriptive theories. System dynamics is not restricted to linear systems and can make full use of the non-linear characteristics of systems. Combined with computers, system dynamics models allow for effective simulation of complex systems. Such simulation provides a way to determine the behavior of complex non-linear systems, such as in the analysis and diagnosis of the productivity of hydrocarbon production assets, for example, wells with water production problems.
- There are numerous trading simulators, which are described below:

Company	Tool	Webpage
CACI	SIMPROCESS, MODSIMIII	www.caci.com
Edge Software Inc.	WorkDraw Design/Analyst	www.workdraw.com
isee systems	ithink, Stella	https://www.iseesystems.com/
Andritz (Imagine That, Inc.)	extendsim	https://www.andritz.com/newsroom-en/automation/2023-03-22-extendsim-group
Rockwell Automation	Arena Simulation Softwre	https://www.rockwellautomation.com/en-us/products/software/arena-simulation.html
Symix, Inc.	AweSim!	https://www.awesim.org/
Scitor Corporation	Scitor Process	https://www.saic.com/
Process Model Corporation	ProcessModel	https://www.processmodel.com/
ProModel Corporation	ProModel	www.promodel.com
iGrafx	iGrafx	www.igrafx.com

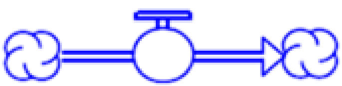
Systems, Dynamics, and Simulation

Dynamic Process Simulation (Part 2 of 4)

- The commercial software iThink® and Stella® are products of High Performance Systems, Inc. In this simulation environment there are four basic elements that will be described below:

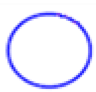
Accumulator

The accumulator or level is used to represent something that is being accumulated or drained. These are states of some material resource that can be quantified. For example, the way water accumulates in a tank. At any given time, the water in the tank represents the accumulation (level) of water, that is, the amount of water that has entered through the inlet valve, minus the water that has left through the pipe.



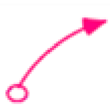
Flow

It is the rate of change of an accumulator. In the water tank example, the flow isthe water coming into the tank through the inlet valve and the water coming out through the pipe. Physical flows are what can change at a level. In particular, we as actors can only intervene in the flows, never in the levels.



Converter

It is used to perform manipulations on input data or convert that input data into some kind of output signal. For example, if one closes the water inlet valve to the tank, the converter will take that action as an input signal and convert it into a signal reflecting the flow of water. More generally known as auxiliary variables, a converter transforms information coming in from different sources into new information.



Connector

It is an arrow that allows information to be passed between converters, between accumulators and converters, between accumulators and flows, or between converters and flows.

Systems, Dynamics, and Simulation

Dynamic Process Simulation (Part 3 of 4)

In the development of a simulation model, three major stages or steps are identified [12]:

First step – Conceptualization:

1. Select Scenario →
2. Define Model Purpose →
3. Identify critical variables and limits of the model →
4. Establish Time Horizon →
5. Establish Relationships Between Variables →
6. Develop Causal Diagram (conceptual model)

Second Step - Formulation:

1. Develop the block diagram (Forrester diagram) →
2. Determine the mathematical Equations of the model (formal model) →
3. Estimate and select The parameters Of the model

Third step – Evaluation:

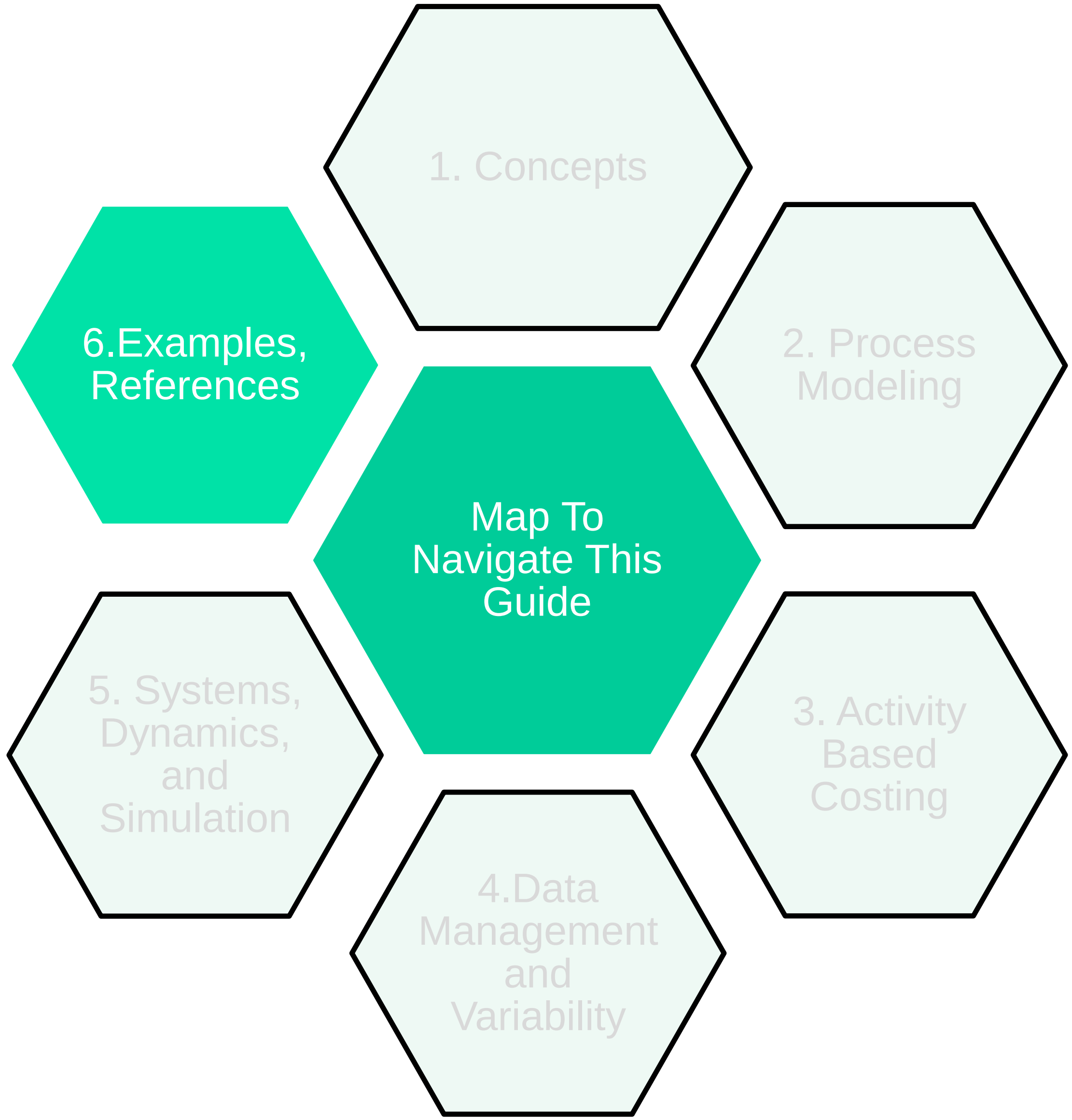
1. Simulate the model and test the dynamic hypotheses →
2. Testing the model Under assumptions →
3. Response of the Model with Sensitivity analysis

Dynamic Process Simulation (Part 4 of 4)

Once the model is finished, it is used to determine, through the relevant simulations, the following:

- Cycle times, processing times and waiting times (delays).
- Costs of each activity and total cost of the process.
- Flow of activities that present bottlenecks, critical paths, queues.
- Use of resources (personnel, equipment, etc.).
- Inventory levels of inputs necessary for the sustainability of the processes.
- Variation in inputs and outputs.

Map To Navigate This Guide



Mapa

Examples, References

References (Part 1 of 2)

In this guide, five examples have been selected that can serve as a basis for developing the dynamic simulation model for the process of analysis and diagnosis of the productivity of hydrocarbon production assets. These examples are:

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2. “System dynamics model of Hubbert Peak for China’s oil”. doi:10.1016/j.enpol.2006.07.009 – Link: https://www.sciencedirect.com/science/article/abs/pii/S0301421506002989

3. “An Alternate Simplified Approach For Selecting Enhanced Oil Recovery Technologies Using Analogs And Hubbert Peak Oil Theory”. Paper SPE-144982. SPE Enhanced Oil Recovery Conference held July 2011 in Kuala Lumpur, Malaysia. Link: https://doi.org/10.2118/144982-MS . Ortiz-Volcan J.L., Ronelba Blanco, Diane Djotaroeno.

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Examples, References

References (Part 2 of 2)

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    Link: https://ocw.mit.edu/courses/15-988-system-dynamics-self-study-fall-1998-spring-1999/
12. H. James Harrington & Kerim Tumay.: "Simulation Modeling Methods To Reduce Risks and Increase Performance". McGraw-Hill. 1999.