

Basic Systems Engineering concepts

Before we delve into the world of Systems Engineering, we first need to get to know some basic concepts. What is Systems Engineering? What tools does it have? And what is a market?

1 Introduction to Systems Engineering

1.1 What are Systems?

A **system** is a combination of elements. These elements interact with each other to accomplish an objective. Systems can be very big (like the Apollo Project) or very small (like a USB-stick).

There is also a distinction between closed and open systems. A **closed system** has no relationship with the environment at all. On the other hand, a **open system** does have influence on/gets influenced by the environment.

Finally, we can distinguish systems, based on their behaviour. **Deterministic systems** behave in a fully predictable way. We can always predict what they will do. **Stochastic systems**, on the other hand, have an element of chance in them. We can only estimate the probability that a certain output will occur. Finally, when dealing with **emergent systems**, we can not predict anything. Nothing is known about the behaviour of such systems.

1.2 What is Systems Engineering?

In **Systems Engineering** (SE) we examine how we can make succesful systems. There are a lot of tools that can be used for that. We will examine several in this summary.

Over the past decades, quite some good ideas have come forth from Systems Engineering. Processes like **Parts Traceability** (knowing where parts come from) and **Formal Interface Control** (making sure parts fit together) are all part of the SE toolbox.

1.3 System Hierarchy Diagram

As we just saw, a system consists of **elements**. These elements often again consist of **subsystems**. Below these subsystems, we can distinguish **assemblies**, **subassemblies**, **components** and **parts**. The parts are the lowest level of separately identifiable items. There are often also links between elements. These links are called **relations**.

The set of relations between the system, its elements, the subsystems, etcetera, is called the **System Hierarchy**. This hierarchy is often displayed in a **System Hierarchy Diagram** (SHD). An example System Hierarchy Diagram of a camera can be seen in figure 1.

2 Systems Engineering tools

2.1 The Project Objective Statement

Systems Engineering has several tools, with which systems can be evaluated. The first tool we examine is the **Project Objective Statement** (POS).

Let's suppose we're developing a system. It would be nice to know what this system should do, and how it should do this. This is where the POS comes in. The POS mentions, in about 25 words...

2.3 The Work Breakdown Structure

A Work Flow Diagram contains several tasks that need to be done. Sometimes, these tasks require further clarification. They can thus be examined more closely. A **Work Breakdown Structure (WBS)** is useful for this.

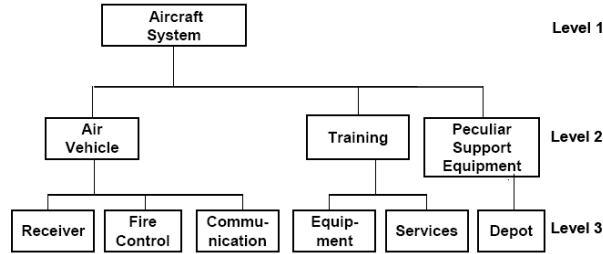


Figure 3: An example of a Work Breakdown Structure.

In a WBS, a task is split up into several ‘sub-tasks’, called **work packages**. Every single work package must be completed, before the actual task is completed. (The WBS is therefore an ‘and’-tree. Only when all sub-tasks have been completed, will the task itself be completed.) An example of a WBS can be seen in figure 3.

3 Examining markets

3.1 What is a market?

A **market** is a place where the demand and the supply of a product come together. This isn’t always a physical place. The internet can be considered a market too.

So how do we describe a market? To do that, we have to look at certain properties. Every market has certain **customers**. It also has certain **products**. We could split this up even more. Because every product also has a certain **function** and a certain **technology** in it.

Splitting up a market like this is called **market segmentation**. Every sub-group of the market is called a **market segment**. Companies often apply different marketing strategies to different market segments.

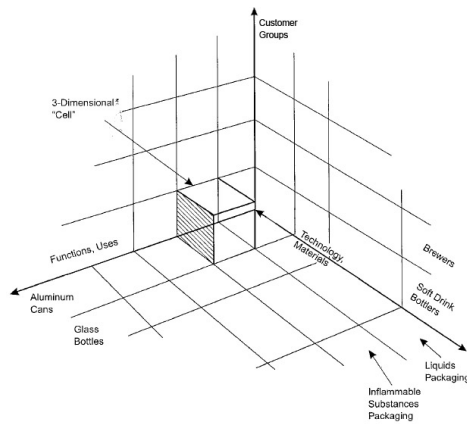


Figure 4: An example of a Multidimensional Market Definition.

There is a nice method to visualize market segments. It is called the **Multidimensional Market Definition** (MMD). It consists of a 3D graph. The three axes of this graph indicate the customer, the function, and the technology/material of the product. An example of an MMD (applied for the bottling market) can be seen in figure 4.

Let's take a closer look at the MMD. The positions in the graph are so-called **cells**. Each cell indicates a certain combination of customer, function and technology. A cell, or a combination of cells, thus indicates a market segment.

3.2 The Supply Chain

Products don't just arrive at the market. They have to be supplied to it. This supplying can be visualized by a **Supply Chain**. An example of such a Supply Chain can be seen in figure 5.

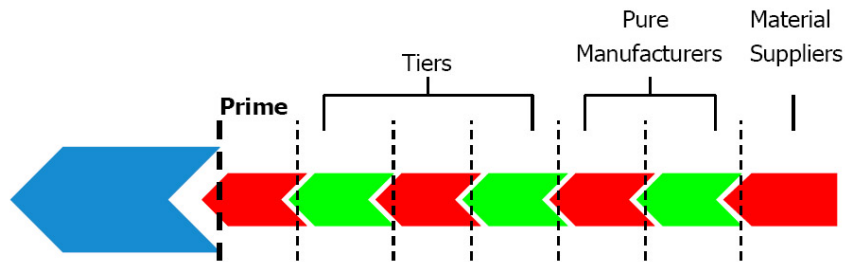


Figure 5: An example of a Supply Chain.

In a Supply Chain, the steps a product goes through, before it reaches the market, are displayed. First we start at the **raw material suppliers**. The raw materials are then turned into basic parts by **pure manufacturers**. These basic parts are eventually assembled, and ready to be supplied to the market.

3.3 Market Analysis

Let's suppose we know what our market looks like. Now we want to position our product onto the market. To do that in an optimal way, we need to perform a **Market Analysis**.

An important tool to perform a market analysis, is the **SWOT analysis**. We want to give our product a certain position on the market. In a SWOT analysis, we look at the **Strengths**, the **Weaknesses**, the **Opportunities** and the **Threats** caused by this. If we know these four things, we might be able to improve the position of our product on the market.

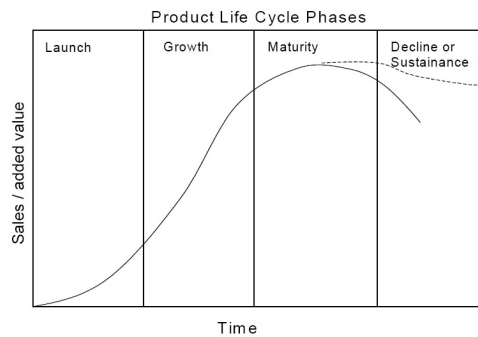


Figure 6: The general shape of the Product Life Cycle graph.

There is another way to examine the position of our product in the market. We can also look at the **Product Life Cycle** (PLC). This cycle describes the sales of the product, while it is on the market. An example of a Product Life Cycle graph can be seen in figure 6.

Let's take a closer look at the PLC. Initially, in the **introduction/launch stage**, sales are low. However, growth is accelerating, and soon we reach the **growth phase**. When this growth is starting to halt, we reach the **maturity phase**. Finally, the product either leaves the market (**decline**) or will have a steady sale level (**sustenance**).