Tutorial How to Orchestrate in Ecosystems?

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TBD

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Abstract

This tutorial discusses the challenge that societal capabilities tend be be a result of more interacting sociotchnical systems. The consequence is that we have to learn to operate in extensoive ecosystems with many different stakehodlers and considerations, where most players have limited mandate and influence. We propose Orchestrating as essential competence.

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Contents

Chapter 1

Introduction

The world around us is changing fast, technology keeps evolving much, and the solutions that we develop are increasingly a result of many interacting socio-technical systems. As a consequence, (systems) engineers need another competence profile, other methodologies, while organizations need new capabilities and better infrastructure.

In this tutorial, we will look at the trends and the consequences for the industry, research and education, how can we help the organizations to develop the systems engineering capabilities that fit the future?

Crucial competencies that we will address in the tutorial are: orchestrating across organizational boundaries, building on facilitation skills and leadership, the need for breadth (integral, PESTEL (Political, Economic, Social, Technical, Environmental, and Legal), and domain), and an agile mindset allowing to experiment, act and think, while achieving rigorous engineering.

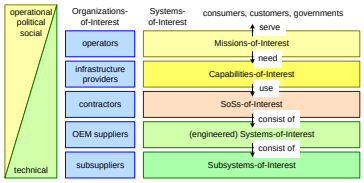
The tutorial will discuss methods and means to develop a shared vision and strategy across organizations that you need to be able to guide and orchestrate a roadmap, translating into master plans, a communication strategy, and a way to operationalize within the constituting organizations.

The tutorial will use a case where participants work on to make the offered ideas concrete and tangible.

The methods and means in this tutorial are based on work in the past 10 years in defense, health care, the energy sector, transportation, and research institutes. This tutorial builds upon the keynote at the TNO-ESI symposium 2025, see https://esi.nl/news/articles/esi-symposium-2025

Chapter 2

Introduction to Ecosystems



2.1 Introduction

Capabilities and services that we use at societal level are the result the work of many organizations. We simplify the classification of the organizations contributing to the capabilities and services to a 5 layer model, as Figure 2.1 shows. The five layers are

- operators deliverign the actual capabilities
- infrastructure providers that manage the assets that the operators are using
- contractors that build, adapt, and integrate the systems of system that together form the infrastructure
- Original Equipment Manufacturers (OEM) suppliers that develop individual systems that the contractors further integrate
- subsuppliers developing and delivering products and components to the OEM suppliers

The way of procuring from layer to layer shifts from an acquisition of solutions gradually into procurement of standardized catalogue products and components.

The focus per layer is shifting. Figure 2.2 shows the focus per layer. The higher the layers, the more operational, the deepr in the stack, the more technical

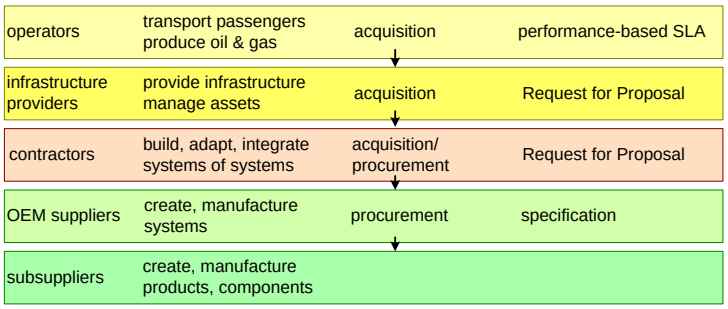


Figure 2.1: Characterization of Domain Layers

the focus becomes. The figure shows a few examples from the rail transportation domain. Operators are inherently operationally oriented. Examples are operators in The Netherlands, such as NS and Arriva. Infrastructure operators are asset oriented. ProRail is in the Netherlands responsible for the rail infrastructure with a worth of many Billions with a yearly turnover close to 2 billion Euro. Contractors are construction project oriented. OEM suppliers have a development project or product focus, while subsuppliers have a poduct or componet focus. Companies may operate at multiple levels, although these tend to organizationally fit in different silos in that company.

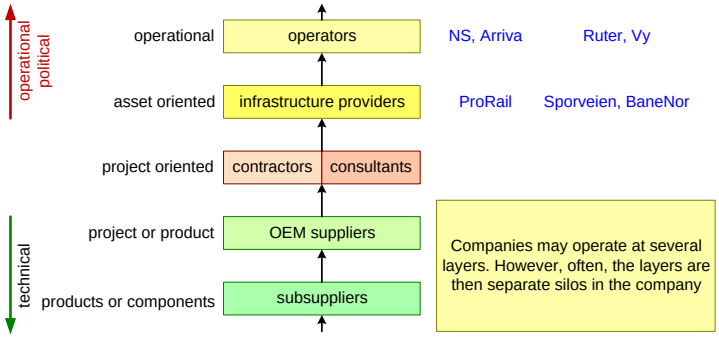


Figure 2.2: Positions in the Value Network Differ in Nature

Figure 2.3 summarizes these layers in terms of the organizations-of-interest and systems-of-interest: Operators serve consumers, customers, and governments with missions-of-interest. Operators need capabilities-of-interest that infratsructrue providers provide, using SoSs-of-interest that operators deliver. The SoSs consist of (engineered) systems and SoSs that OEM suppliers develop and deliver. Subsuppliers develop and deliver the subsystems-of-interest. High in the layers, the main concerns are

operational, political, and social, while deep in the layers, the main concern is technical. Economic and legal concerns play in all layers.

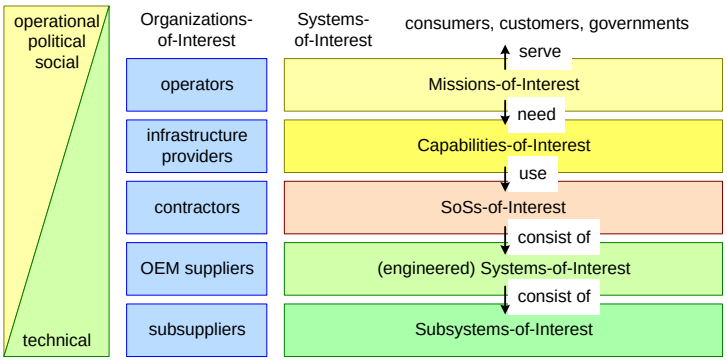


Figure 2.3: Perspective Changes from Layer to Layer

2.2 Enabling systems

Systems engineering teaches us that when we develop a system-of-interest (SoI), that we then also have to develop the related enabling systems. Figure 2.4 shows some examples of enabling systems, such as the manufacturing, transportation, installation and training systems. This list is far from complete. An eddential enabling system is the entire supply chain, including its supporting tructures, such as contracts, second suppliers, et cetera.

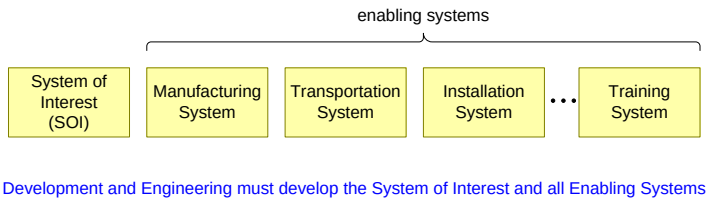


Figure 2.4: Development Has to Develop the System of Interest and its Enabling Systems

This applies recursively for each system when going down in the layers of the ecosystem.

2.3 Scope of Control

When developing products and components, the developing organization has more or less full contol over the specification and design of the product. This changes fundamentally when we enter the Systems-of-Systems domain. SoSs inherently are independent, so, the SoS constructor and users don't have full control. The less cohesion there is between consituent systems in mangerial sense, the lower the influence is anyone within the ecosystem has.

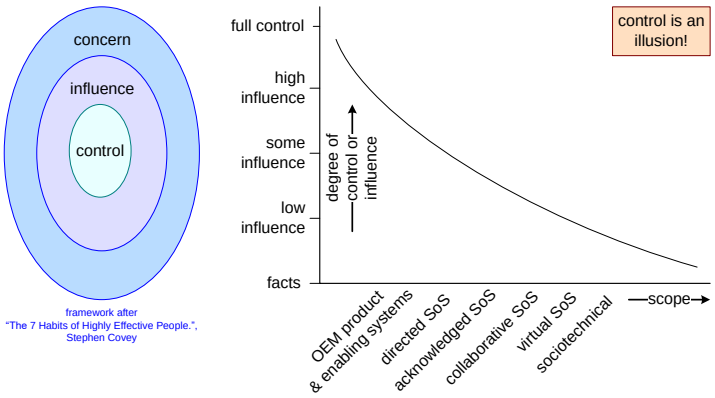


Figure 2.5: The Level of Influence Decreases with Scope

[1] provides a simple framework with a scope of control, a scope of influence, and a sphere of concern. Figure reffig:FSTEcontrolInfluence shows the simple framework. The graph uses a more continuous scale on the vertical axis for the degree of infleunce. Be aware that full control is an illusion. The horizontal axis defines the system scopefrom small to large, also as continuum.

2.4 Layers of Ecosystems

Each layer of Figure 2.3 consists of an ecosystem itself. Figure reffig:FSTEvalueNetwork shows an elaboration of these layers. For example, an OEM company has suppliers (with their suppliers), partners offering complementary products and complmemting services and systems. The OEM company will have competitors. Most of these organziations will interact with the customers of the oEM company, such as the contractor.

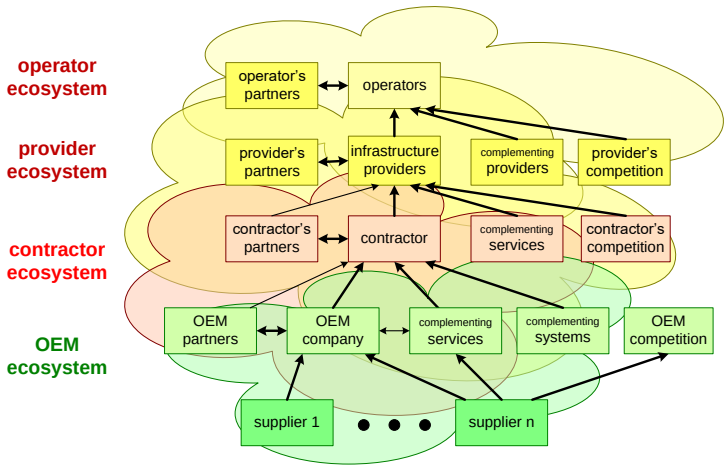
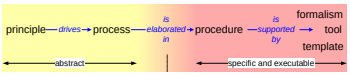


Figure 2.6: Each System and organization is part of its ecosystem

Chapter 3

Nugget: What is a Process?



3.1 Introduction

We rely in this part heavily on the notion of a process. This intermezzo is defining "process" for the context of this book. We define "process", since this word is heavily overloaded in our daily world. We also discuss the relationship of processes with organizations and the drive for process improvement.

3.2 What is a process

We use process as an abstracted way of working. A process can be characterized the attributes shown in Figure 3.1

In [2] the following definition is given:

A process is an activity which takes place over time and which has a precise aim regarding the result to be achieved. The concept of a process is hierarchical which means that a process may consist of a partially ordered set of subprocesses.

This definition parallels the characterization above. It adds explicitly the potential hierarchical decomposition of the process itself.

The notion of a process can be seen as one step in an abstraction hierarchy, as shown in 3.2. The most abstract notion in this hierarchy is the "principle". A principle is a generic insight that can be used for many different purposes. An example of a principle is *decomposition*: Whenever we have something big, e.g.

Purpose What is to be achieved and why

Structure How will the goal be achieved

Rationale What is the reasoning behind this process

Roles What roles are present, what responsibilities are associated, what incentives are present, what are the criteria for these roles

Ordering What phasing or sequence is applied

Figure 3.1: Process Attributes

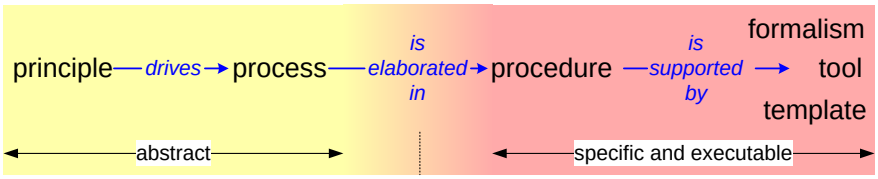


Figure 3.2: A process within an abstraction hierarchy

a problem or project, then we can decompose it in smaller pieces. These smaller pieces are easier to solve or create than the original big one.

A process is rather abstract. It describes the essentials of the purpose, structure, rationale, roles and timing, leaving plenty of implementation freedom. The power of a process is its abstraction, which enables its application in a wide range of applications, by tailoring its implementation to the specific application.

A process can be tailored and elaborated in one or more procedures that describe cookbook-like what needs to be done when and by whom. The why in a procedure has often disappeared, to be replaced by practical information for the execution.

The implementation of a procedure can be supported by tools, notations, templates and other means.

In practice managers and employees ask for tools (means) and procedures (what and how). However, without understanding of the thinking behind the procedure (why), as given in the process, these tools and procedures can be meaningless. The process captures the rationale behind procedures, tools, notations, templates, and other means.

3.3 The relation between Processes and Organizations

Traditional management is focused on “organizations”. Where organization are characterized by the attributes shown in Figure 3.3.

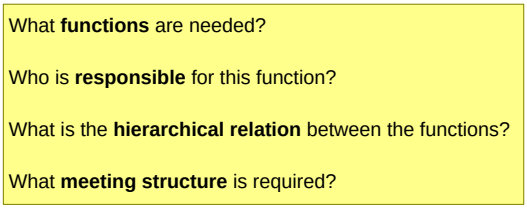


Figure 3.3: Organization Attributes

This management views is insufficient in today’s fast moving complex world. The weak spots of the organizational view are shown in Figure 3.4.

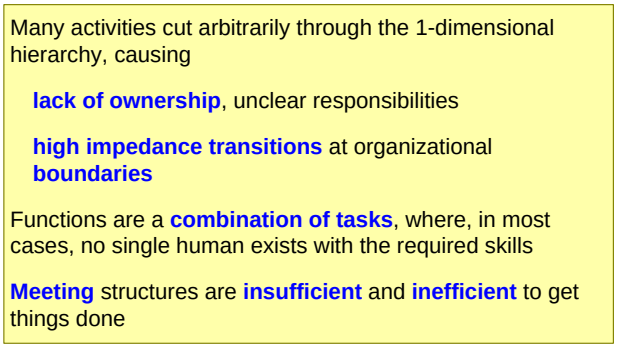


Figure 3.4: Weaknesses of the organizational view

Processes are more modern instruments for management. Many processes are required to ensure the effective functioning of an organization. These processes are interrelated and overlapping. Processes are non-orthogonal and don’t fit in a strict hierarchical structure.

Most complex product developments don’t fit in the classical hierarchical organization model, but require a much more dynamic organization model, such as the currently popular more chaotic network organization. Processes are the means which help to ensure the output of dynamic organization models such as a network organization.

Processes can be seen as the blueprint for the behavior of the people within the organization. People will fulfill multiple roles in multiple processes. The process description is intended to give them an hold on what is expected from them.

All important activities will be covered by a process, requiring the definition of ownership, relation with other processes et cetera. The allocation of roles to people is much more dynamic than in conventional hierarchies. More dynamic allocation enables a better match between personal capabilities and required skills. In practice dynamic allocation leads to more distribution of responsibilities, making it more feasible to match capabilities and skills.

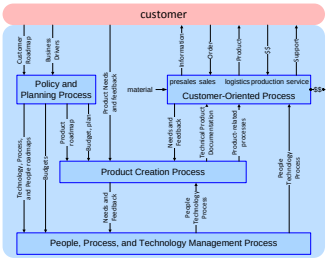
The 80/20 rule is also valid for processes: 80% of the behavior is covered by the processes, while 20% requires independent creative behavior. An organization without processes drowns in chaos, while an organization which blindly implements them will be killed by its own inertia, its inability to adapt to the fast changing world.

For reasons of continuity and stability an hierarchical organization will remain. The slowest evolving dimension is mostly used as a basis for this hierarchy. This hierarchy functions as anchor point for people in the continuously changing process world, but should play only a minor role in the entire operation.

The **Centurion** turn around operation within Philips, orchestrated by CEO Jan Timmer in the early nineties, urged the Philips managers and employees to change from an introvert organization point of view to an external result oriented process point of view.

Chapter 4

Nugget Process Decomposition of a Business



4.1 Introduction

This chapter positions the system architecting process in a wider business scope. The objective of this chapter is to provide system architects insight in the business processes and especially in the processes where system architects actively contribute.

The focus is on companies that create physical products. Other types of businesses, such as solution providers, services, courseware, also need systems architecting. The process structure will deviate somewhat from the structure presented here. See Intermezzo “Products, Projects, and Services” for a discussion on the processes in these other businesses.

4.2 Process Decomposition

The business process can be decomposed in 4 main processes as shown in Figure 4.1. We have on purpose ignored the supporting and connecting processes. This simplification will allow us to get a number of more fundamental insights in the main processes.

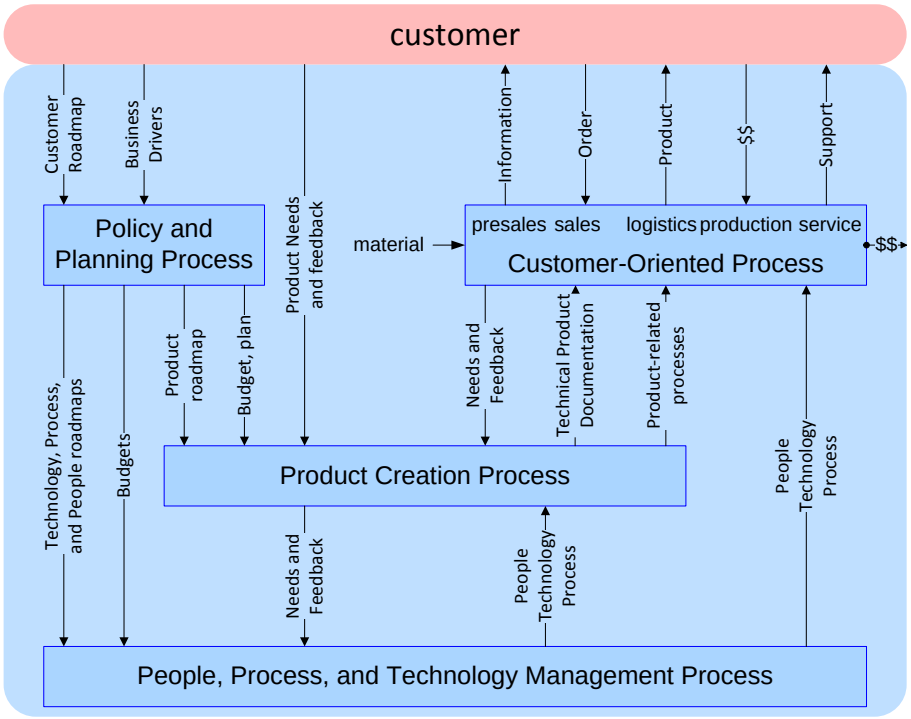


Figure 4.1: Simplified decomposition of the business in 4 main processes

The function of the 4 main processes is:

Customer Oriented Process performs in repetitive mode all direct interaction with the customer. This process is the cash flow generating part of the enterprise. All other processes only spend money.

Product Creation Process feeds the Customer Oriented Process with new products. This process ensures the continuity of the enterprise by creating products that keep the company competitive. In this way the Product Creation Process enables the Customer Oriented Process to generate cash flow in the near future as well.

People, Process, and Technology Management Process manages the competencies of the employees and the company as a whole. The competencies of the employees and the company are the main assets of a company.

Policy and Planning Process is the management process. The Policy and Planning Process defines the strategy, the long term direction of the company, and it balances the shorter term tensions between the three other main processes. The Policy and Planning Process uses roadmaps and budgets to define the

direction for the other processes. Roadmaps give direction to the Product Creation Process and the People, Process and Technology Management Process. For the medium term these roadmaps are transformed in budgets and plans, which are committal for all stakeholders.

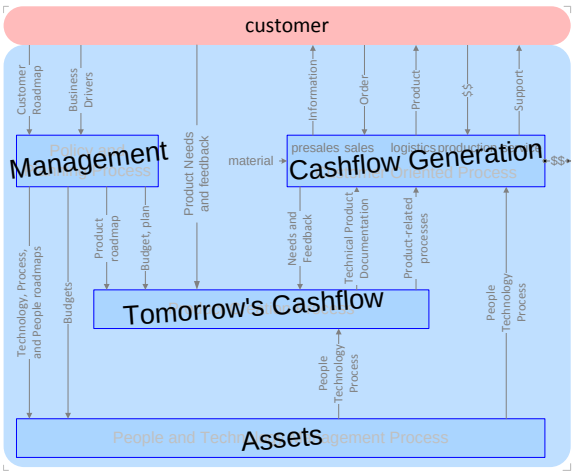


Figure 4.2: Decomposition of the business in 4 main processes, characterized by their financial meaning

The 4 processes as described here are different in nature. The Customer oriented process executes over and over a well defined set of activities. The system architect does not participate in active role in this process. However since the Customer Oriented Process is the main customer of the Product Creation Process, it is crucial that the system architect understands, or better has experienced, the Customer Oriented Process.

The system architect is in continuous interaction with many stakeholders, mostly about technical aspects. From this perspective the architect will generate inputs for the People and Technology Management Process. This might even result in participation in this process for instance by coaching, participation in the appraisal process, or participation in technology studies.

The number of instances of each process is related to different entities:

Customer Oriented Process: Depends on geography, customer base, and supply chain.

Product Creation Process: One per entity to be developed, where such an entity can be a product family, a product, or a subsystem.

People and Technology Management Process: One per “competence”, where a competence is a cohesive set of technologies and methods.

Policy and Planning Process: One per business. This is the pro-active integrating process.

The evolutionary developments of product variants and new releases are seen as individual instances of the Product Creation Process. For example the development of a single new feature for an existing product is performed by following the entire Product Creation Process. Of course some steps in the process will be (nearly) empty, which does not cause any harm.

4.3 Process versus Organization

This process decomposition is not an organization, see Intermezzo "What is a Process". A single person can (and often will) fulfill several roles in different processes.

System architects specifically spend most of their time in Product Creation Process (circa. 75%), a considerable amount of time in the Policy and Planning Process (circa 20%), and a small fraction of their time in the People, Process and Technology Management Process.

Most engineers will spend a small amount of time in the People, Process, and Technology Management Process, working on technologies and capabilities, while the majority of their time is spend in the Product Creation Process.

4.4 Value Chain and Feedback

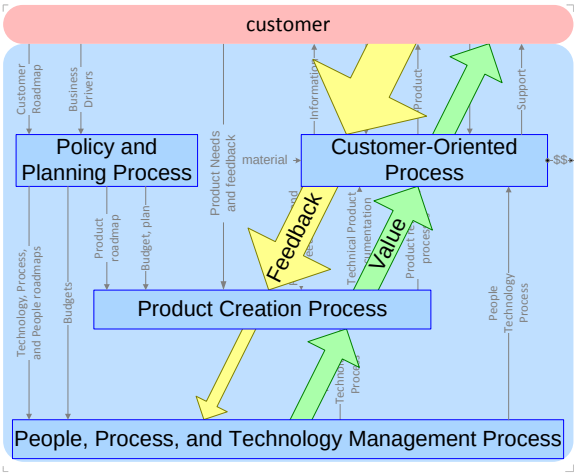


Figure 4.3: The value chain and the feedback flow in opposite direction

The value chain in these processes starts at the assets in the People, Process, and Technology Management Process. The assets are transformed into potential money by the Product Creation Process. The Customer Oriented Process finally turns it into real money. Figure 4.3 shows the value chain.

The feedback flows in the opposite direction, from customer via the Customer Oriented Process and the Product Creation Process to the People Technology and Process Management Process. Customer will communicate mostly with sales and service people. Needs and complaints are filtered by the reporting system before the information reaches Product Creation Teams. Only a small part of the customer feedback reaches the People, Process, and Technology management.

This simple model explains why the knowledge about the customer gets less deeper in the organization. The consequence is that internal technology and process provides show to little concern for urgent customer or business challenges; the sense of urgency seems to be lacking. We can take preventive measures, such as sending process and technology managers to customer sites, once we are aware of the gap caused by this natural information flow.

4.5 Time Horizon of Processes

The customer-oriented process is urgent by nature. Any problem in that process may cause a cashflow problem, which when extended may cause bankruptcy. The product creation process is medium term oriented. This process ensures the cash flow next year. The people, process, and technology management process is important on the long-term. People, processes, and technology form the assets of an organization. Organizations will survive quite some time, when they execute this process poorly. However, when doing that over a longer period, then the futrue of the company may become bleak, since it loses its competitiveness. Figure 4.4 shows these different time horizons.

Different time horizons result in tensions. When not managing the tension, then most organizations will focus on the urgent problems, satisfying the short-term. That is partially for good reasons, since ignoring larger urgent problems may cause bankruptcy. However, healthy organziations need to balance these tensions. The policy and planning process manages these different time horizons.

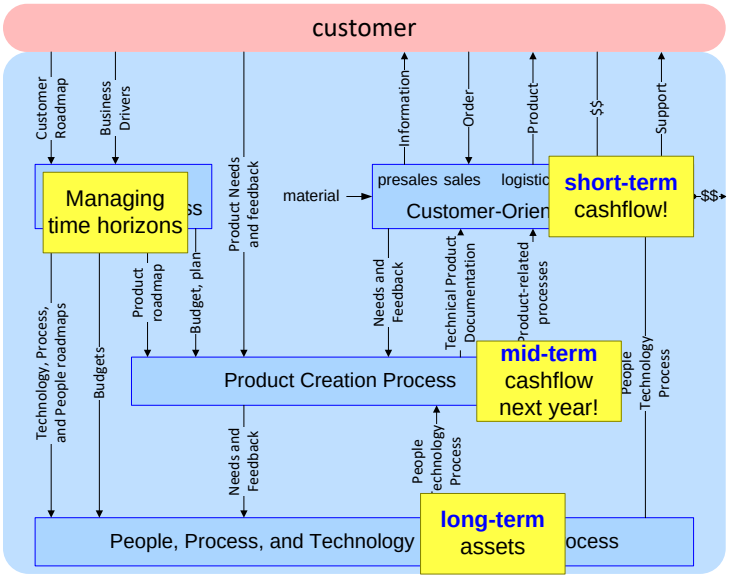
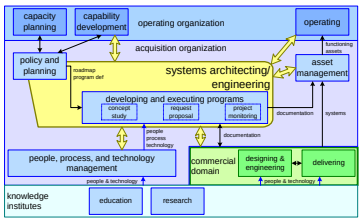


Figure 4.4: Tensions between Short and Long Term

Chapter 5

Process Decomposition of an Acquisition Organization



5.1 Introduction to Acquisition Organizations

Acquisition organizations purchase and manage the assets for operational organizations. That means that they have a large financial responsibility, since their assets tie up a lot of capital. They also determine the operational csapabilities and readiness of the operational organizations. Examples of such organzations are the acquisition organizations inde fense, e.g. the DoD acquisition in the USA, the Norwegian Defense Material Agency (NDMA), and the Dutch Materiel and IT Command (COMMIT). In the railway sector examples are ProRail in the Netherlands, and BaneNOR in Norway.

5.2 Process Decomposition of Acquisition Organizations

The customer of an acquisition organization is typically an operating organization. The operating organizations will, besides operating, look ahead and plan capacity and develop capabilities. The capacity planning and capability developments are inputs for the acquisition organization. The operating otrganization is using assets

that the acuqisition organization manages and maintains. Figure 5.1 shows these three main processes of the operating organization at the top of the figure.

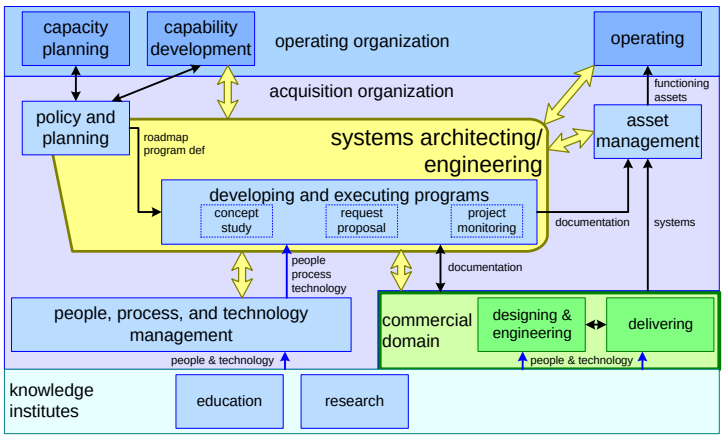


Figure 5.1: Simplified Decomposition of an Acquisition Organization

The acquisition organization itself is running various processes. The asset management process ensures availabiltiy of functioning assets. The acquisition organization acquires new assets in the developing and executing programs. It explores new acuqisitions in concept studies, drives the acqusuition itsel through proposal requests and then monitors the acqusiition projects. The acquisition primarily procures soluti0ons from the commercial domain. The line manageemnt process manages people, process, and technology. The policy and planning process balances the tensions between the asset management, developing and executing programs, and managing people, process, and technology.

Most of the design and engineering takes place at contractors and suppliers in the commercial domain. Knowldeg institutes offer education and perform research. Knowledge instituies can be governmental or commercial.

5.3 Procurement

One of the core activities of acquisition rganizations is procurement of new assets. The policy is to buy as much as possible and staying as close as possible to existing channels. The Dutch acuqisition organization calls this the ladder of simplicity. Figure 5.2 show the ladder of simplicity in the pink box. The preference is to stay as much as possible to the right side of this axis.

When there are no suppliers selling the new capabilities an operation needs, then there are again many options the acquisition organization can chose. Configure to order is selecting a combination of ready-to-go solutions from the supplier. The

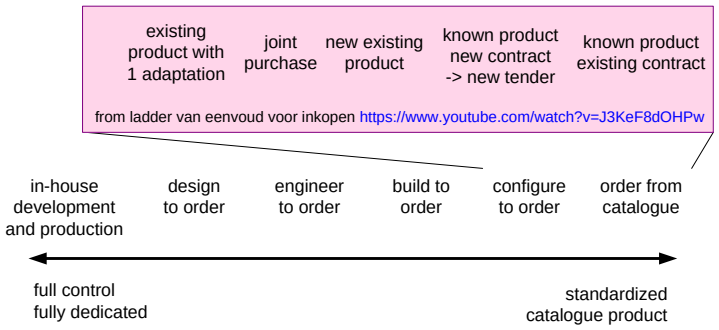


Figure 5.2: Ladder of Simpicity: Buy as Simple as Possible

supplier can also assemble the standard components, or as next step, do soem engineering work to deliver the integrated solution. When existing components don't deliver the desired solution, then suppliers may have to do design work. The most extreme option is that the acquisition organization itself develops and manufactures the solution. Developing and manufacturign itself brings full control, the ability to make ot fully dedciated, at the cost of needing many specialized resources now and during the life cycle.

5.4 Value Chain

Figure **??** shows a simplified version of Figure **??**, where the operating and acquisition organization are together in the highest layer. The comemrcial domain combines a contractor layer and a supplier layer. The figure shows the main processes in each layer, where the top process delivers the value to the next layer.

Value from technology and knwoledge of people transfoms into value in each step from the supplier upwards. In other words, there are many steps from techncial components and the introduction of technologies to assets that deliver value to consumers and society. A consequence of this long value chain is that technology innovations take time to get from the beginning to the end (benefits in the real world). Another consequence is that many parties and individuals are involved, with many ahndovers on the way. Any handover is a point where losses occur with the risk of introducing mistakes.

5.5 Competency Development

Research and education providers deliver competent people to all layers. They also provide life long learning to keep employees competent in a changing world. Lastly, they research to keep their own competency up-to-date. Figure 5.4 shows

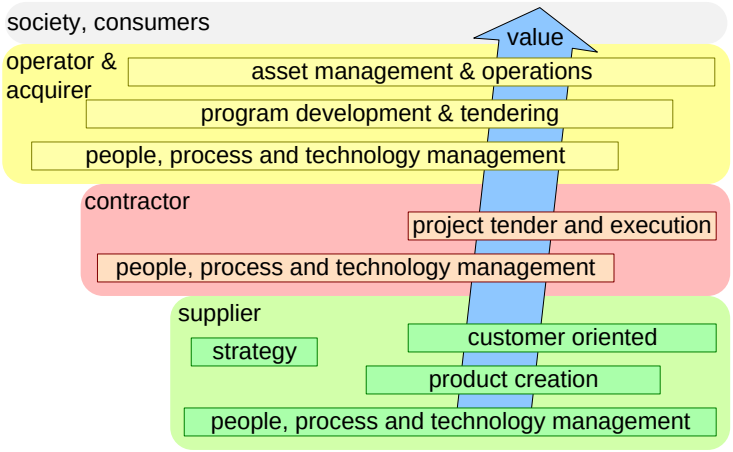


Figure 5.3: The Value Chain across the Layers

the research and education providers at the bottom of the figure. The value chain actually starts with competent people.

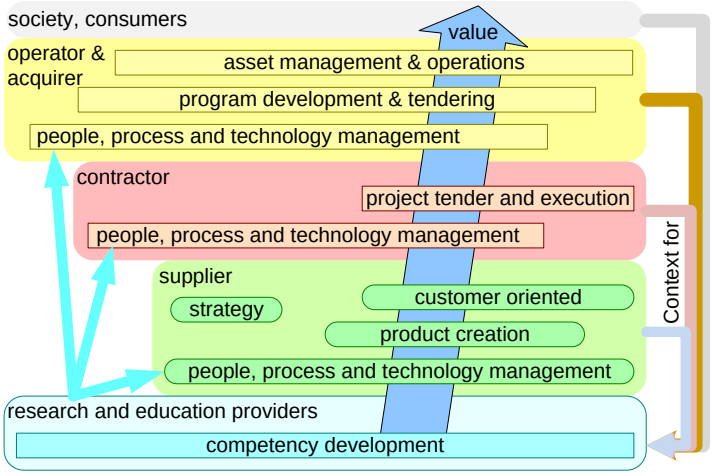
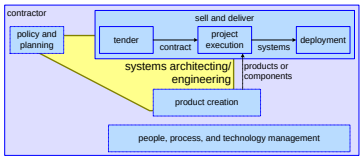


Figure 5.4: Research and Education as Long-Long-Term Process

A challenge is that competency requires context. Competency is the ability and attitude to use knwoledge and skills effectively in the context of interest. In practice, research and education prodviders cna be too far away from the relevant context. Hence, researchers and educators have to ensure that they connect with the relevant context.

Chapter 6

Process Decomposition of a Contractor Organization



6.1 Introduction

Contractors are program and project focused. Projects are temporary organizational structures that deliver a result according to an agreed specifciation, time, and budget. Programs are overarching organizational structures for multiple related projects.

Projects have their own life cycle. Figure 6.1 shows a typical project life cycle. Concept studies often provide the information for proposal requests. A Front-end engineering and design study uses the available information, often in a relatively brief period, to define the proposal. Several companies repsond to the request for proposal, during the tendering phase. When an contractor wins the order, then the design and engineering can start. Afetr design and engienering, the contractor can manufacture, test, and install the system(s). When the customer agrees with the aceptanc test results, the customer pays the final agreed payment. Now the ssytem is ready for use for a long period of operating and maintaining, until the system requires disposal.

Most contractors use a phase gate proces to manage their projects. Figure 6.2 shows a typical phase gate proces for projects. Design reviews are interaction moments between acquirer and contractor.

Many contractors reuse past project knwoledge for future projects. Figure 6.3

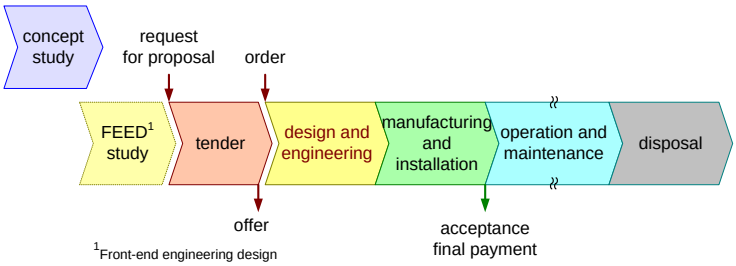


Figure 6.1: Typical Project Life Cycle

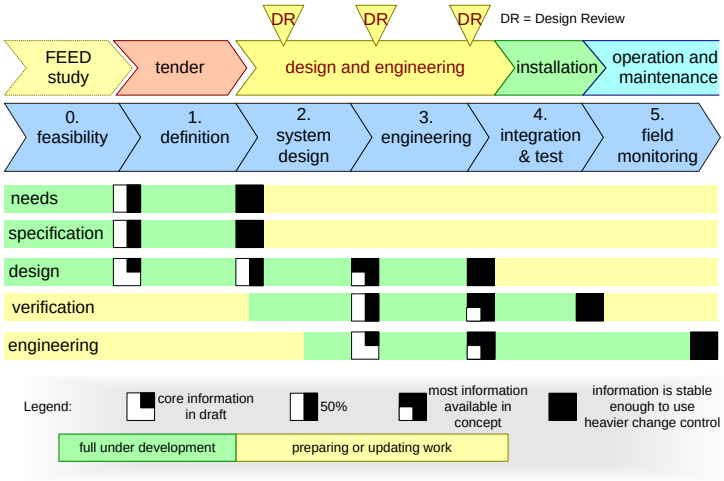


Figure 6.2: Typical Phase Gate Project Approach

shows how they reuse information from tendering and design and engineering.

6.2 Contractor Process Decomposition

The core process of contractors is the process to sell and deliver. When we zoom in, we can se in this process subprocesses, such as concept study, project execution, and deployment. Figure 6.4 shows the process decompositiion for a contractor business. The sell and deliver process may use products or components. Contractors often try to reuse past projects in the form of products that they can reuse in future projects. The line management process manages the people, process and technology for use in the sell and deliver and product creation processes. Selling and delivering is an urgent process, product creation is more tactial, while line management is a long-term process. These processes have tensions, where urgent, shorter term, will always win, unless leadership has a clear policy and manages

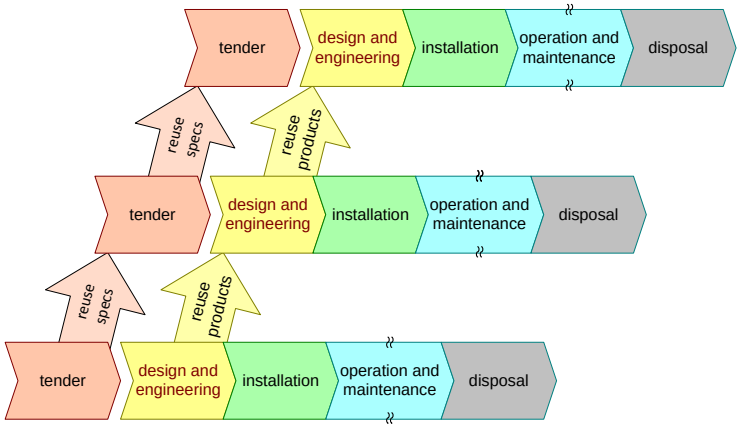


Figure 6.3: How Projects Build on Previous Projects

these tensions. The policy and planning process is for lookign ahead and managing these tensions.

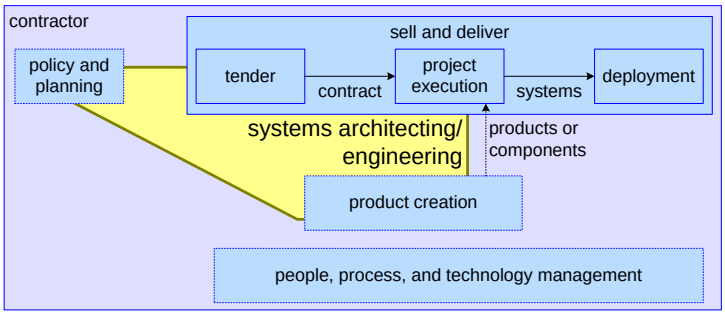


Figure 6.4: Simplified process diagram for project business

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[2] Klaus Kronlöf, editor. *Method Integration; Concepts and Case Studies*. John Wiley, Chichester, England, 1993. A useful introduction is given in Chapter 1, The Concept of Method Integration.

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History

Version: 0.1, date: April 26, 2026 changed by: Gerrit Muller

- exchanged ProcessDecompositionOfBusiness for ProcessDecompositionOfBusinessNugget

Version: 0, date: April 5, 2026 changed by: Gerrit Muller

- Created, using material from IntroductionToEcosystems, DevelopingEcosystemCompetences. VisionFutureSystemsCapability, SystemsAndLeadershipProgram