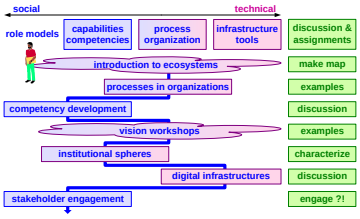
Tutorial How to Orchestrate in Ecosystems?



Gerrit Muller
USN-SE and TNO-ESI
Hasbergsvei 36 P.O. Box 235, NO-3603 Kongsberg Norway
gaudisite@gmail.com

Abstract

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

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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?

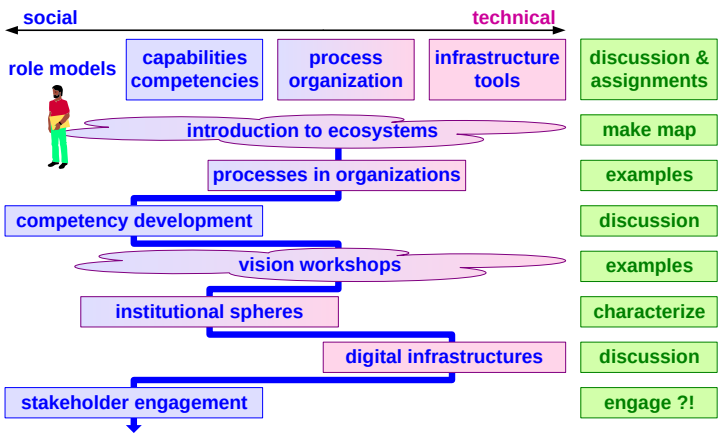


Figure 1.1: Figure of context for the tutorial

Figure 1.1 shows the flow of this tutorial, ordering the topics on an axis from social to technical. The left-hand blue-pink part is the knowledge transfer that I boradcast during the tutorial and that this reader captures in text. The right-hand green part are the interactive steps during the tutorial.

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.tno.nl/publish/pages/9347/symposiumkeynotegerrit.pdf` Figure 1.2 shows these experiences on a map with layers and application domains.

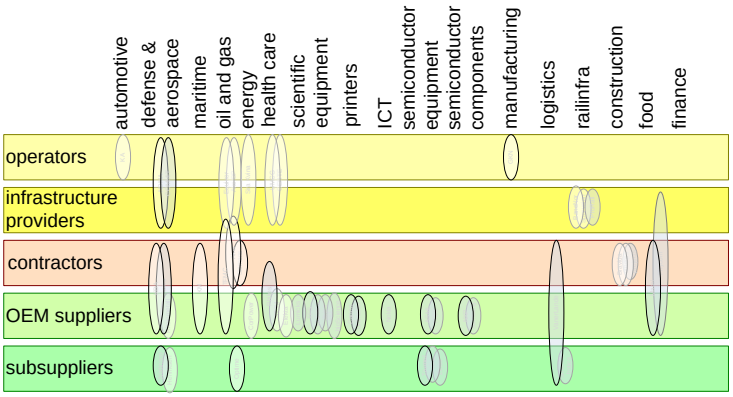
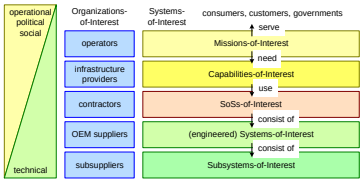


Figure 1.2: Gerrit's experiences over the past 47 years

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 delivering 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
- sub-suppliers 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 deeper in the stack, the more technical

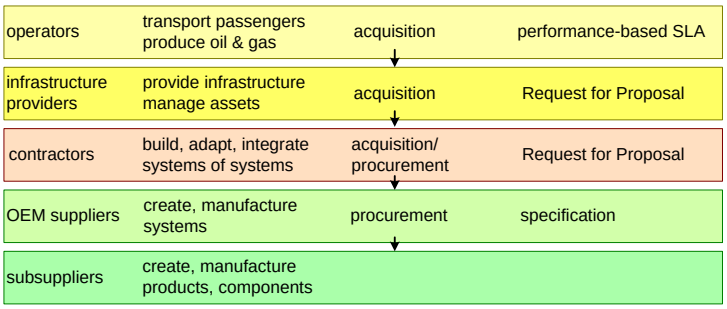


Figure 2.1: Characterization of Domain Layers

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 sub-suppliers have a product or component focus. Companies may operate at multiple levels, although these tend to organizationally fit in different silos in that company.

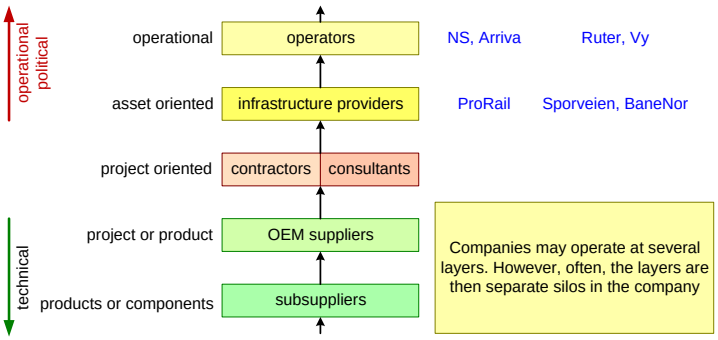


Figure 2.2: Positions in the Value Network Differ in Nature

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 infrastructure providers provide, using SoSs-of-interest that operators deliver. The SoSs consist of (engineered) systems and SoSs that OEM suppliers develop and deliver. Sub-suppliers 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.

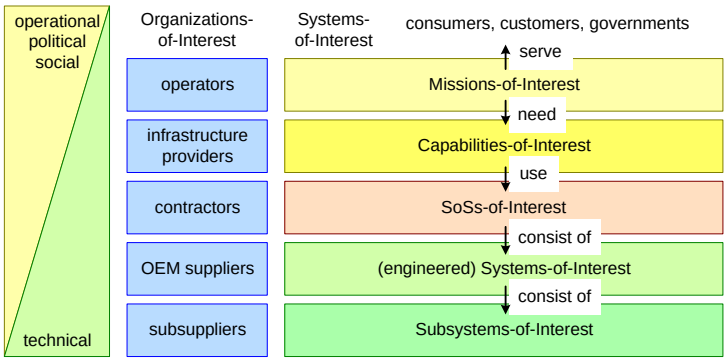


Figure 2.3: Perspective Changes from Layer to Layer

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 essential enabling system is the entire supply chain, including its supporting structures, such as contracts, second suppliers, et cetera.

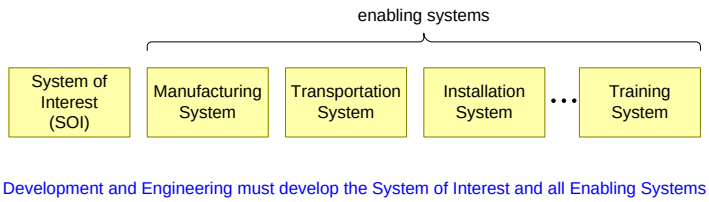


Figure 2.4: Development Has to Develop the System of Interest and its Enabling Systems

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 control 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 constituent systems in managerial sense, the lower the influence is anyone within the ecosystem has.

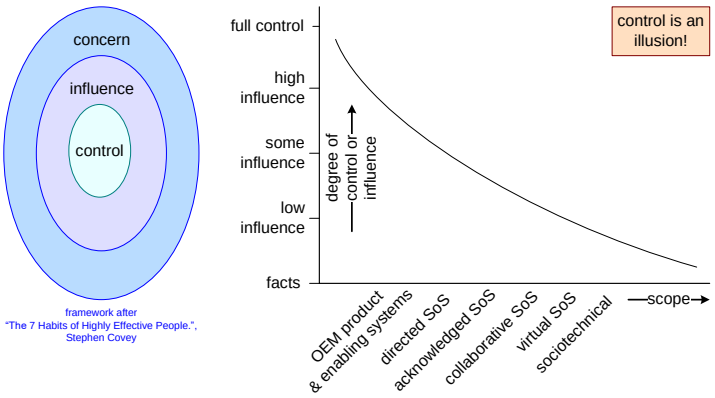


Figure 2.5: The Level of Influence Decreases with Scope

[3] provides a simple framework with a scope of control, a scope of influence, and a sphere of concern. Figure 2.5 shows the simple framework. The graph uses a more continuous scale on the vertical axis for the degree of influence. Be aware that full control is an illusion. The horizontal axis defines the system scope from small to large, also as continuum.

2.4 Layers of Ecosystems

Each layer of Figure 2.3 consists of an ecosystem itself. Figure 2.6 shows an elaboration of these layers. For example, an OEM company has suppliers (with their suppliers), partners offering complementary products and complmenting services and systems. The OEM company will have competitors. Most of these organizations will interact with the customers of the OEM company, such as the contractor.

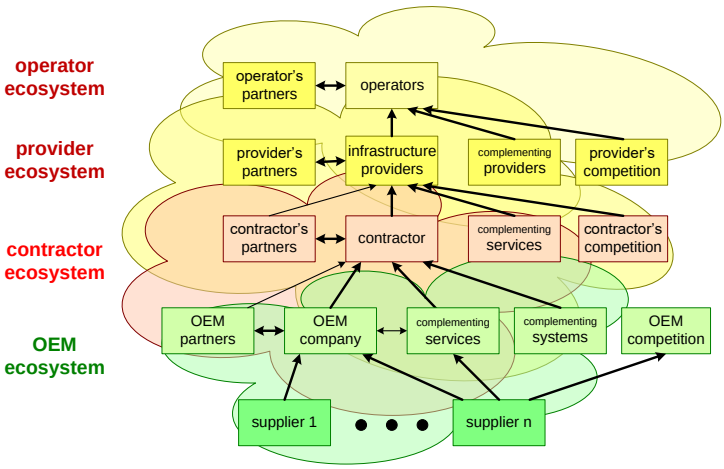
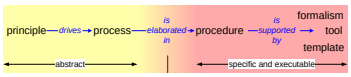


Figure 2.6: Each System and organization is part of its ecosystem

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 [4] 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 sub-processes.

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

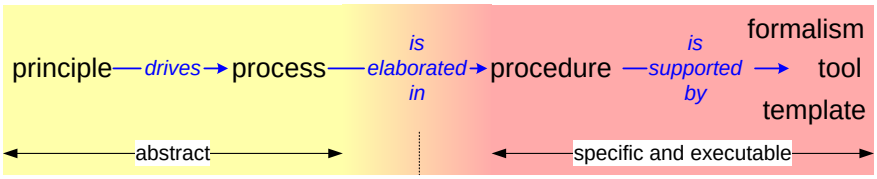


Figure 3.2: A process within an abstraction hierarchy

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.

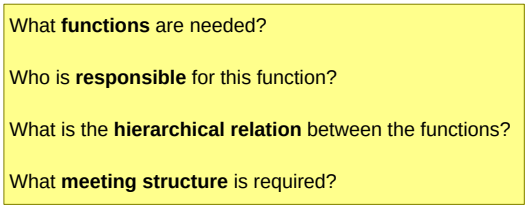


Figure 3.3: Organization Attributes

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

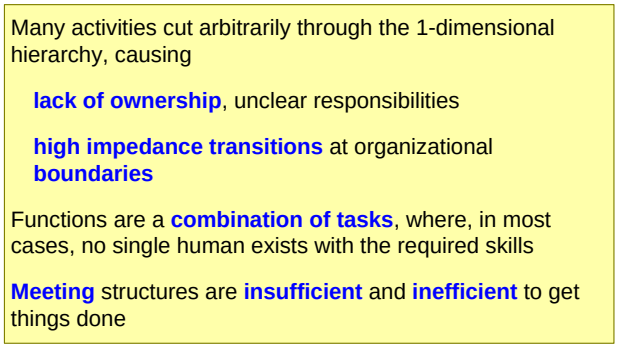


Figure 3.4: Weaknesses of the organizational view

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 a 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.

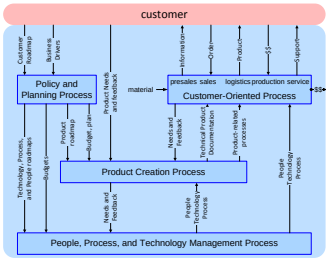
The 80/20 rule is also valid for processes: 80% of the behavior is covered by the processes, while 20% requires independent creative behavior. An organization without processes drowns in chaos, while an organization which blindly implements them will be killed by its own inertia, its inability to adapt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

For reasons of continuity and stability a 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.

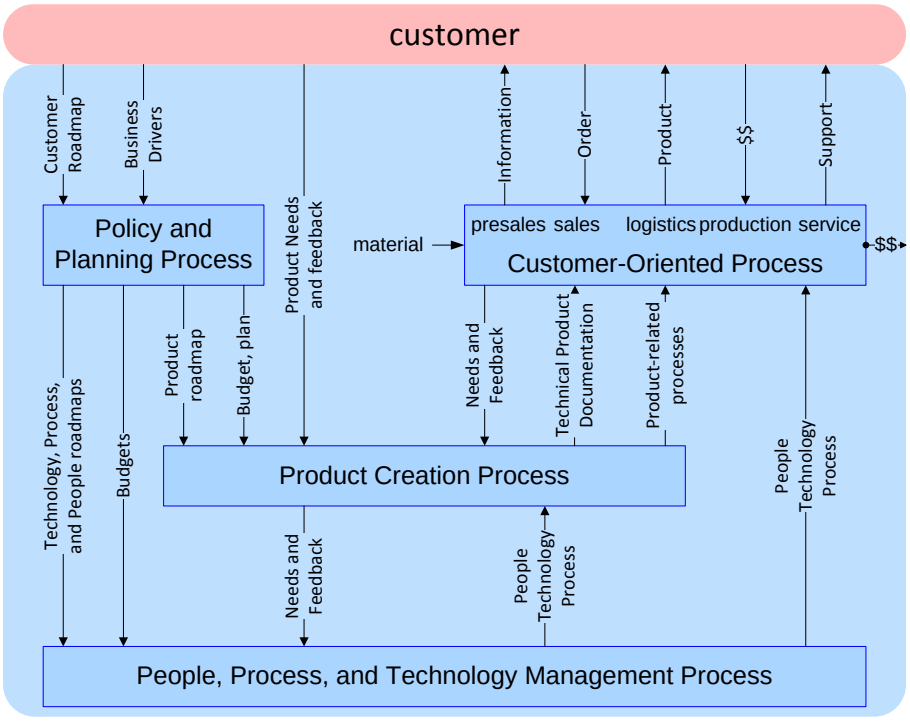


Figure 4.1: Simplified decomposition of the business in 4 main processes

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.

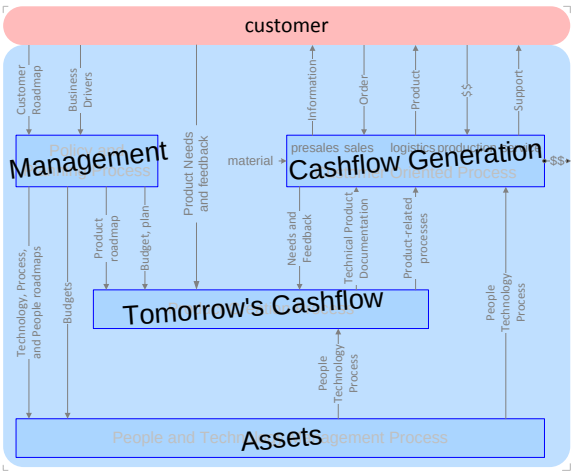


Figure 4.2: Decomposition of the business in 4 main processes, characterized by their financial meaning

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 proactive 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

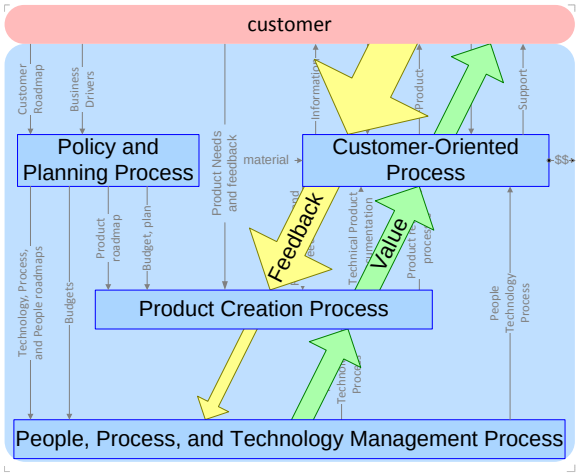


Figure 4.3: The value chain and the feedback flow in opposite direction

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.

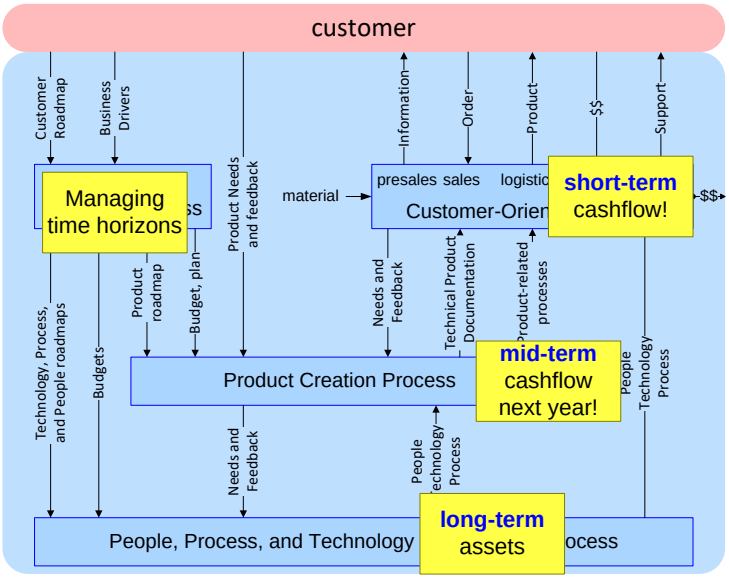
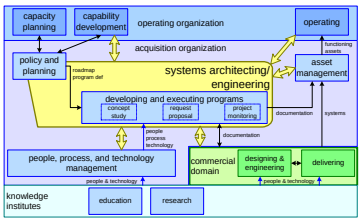


Figure 4.4: Tensions between Short and Long Term

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 capabilities and readiness of the operational organizations. Examples of such organizations are the acquisition organizations in defense, 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 organization is using assets

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

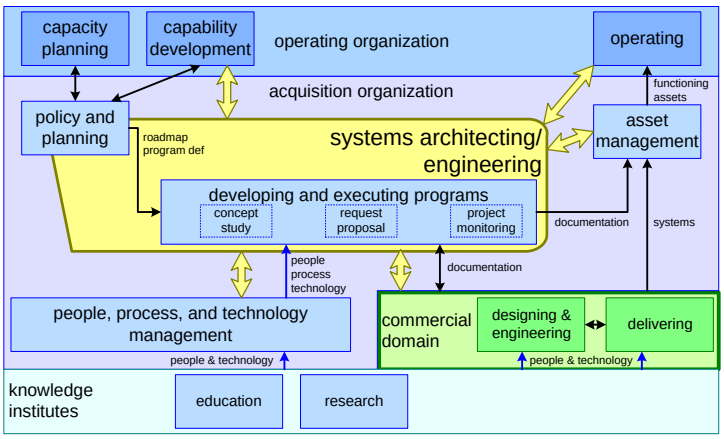


Figure 5.1: Simplified Decomposition of an Acquisition Organization

The acquisition organization itself is running various processes. The asset management process ensures availability of functioning assets. The acquisition organization acquires new assets in the developing and executing programs. It explores new acquisitions in concept studies, drives the acquisition itself through proposal requests and then monitors the acquisition projects. The acquisition primarily procures solutions from the commercial domain. The line management 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. Knowledge institutes offer education and perform research. Knowledge institutes can be governmental or commercial.

5.3 Procurement

One of the core activities of acquisition organizations 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 acquisition 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 choose. Configure to order is selecting a combination of ready-to-go solutions from the supplier. The

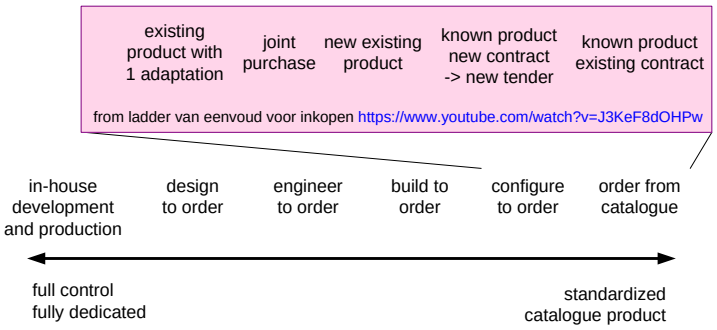


Figure 5.2: Ladder of Simplicity: Buy as Simple as Possible

supplier can also assemble the standard components, or as next step, do some 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 manufacturing itself brings full control, the ability to make it fully dedicated, at the cost of needing many specialized resources now and during the life cycle.

5.4 Value Chain

Figure 5.3 shows a simplified version of Figure 5.1, where the operating and acquisition organization are together in the highest layer. The commercial 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 knowledge of people transforms into value in each step from the supplier upwards. In other words, there are many steps from technical 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 handovers 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 lifelong learning to keep employees competent in a changing world. Lastly, they research to keep their own competency up-to-date. Figure 5.4 shows

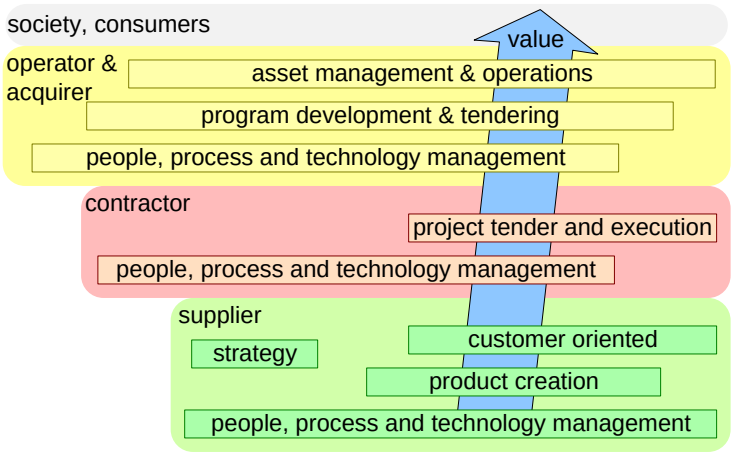


Figure 5.3: The Value Chain across the Layers

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

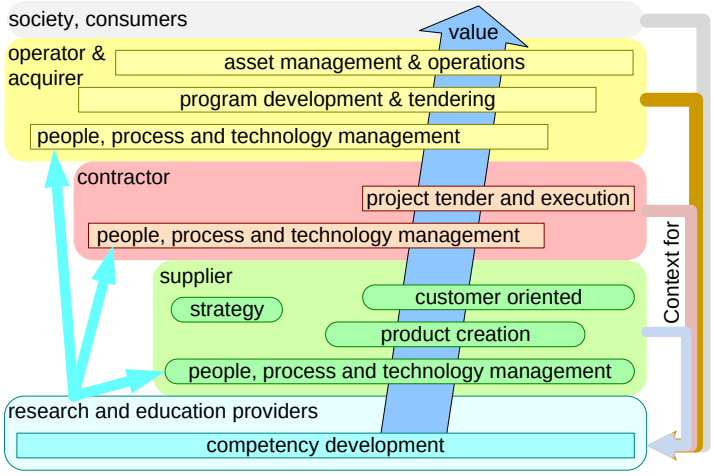
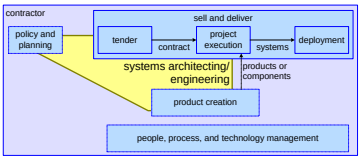


Figure 5.4: Research and Education as Long-Long-Term Process

A challenge is that competency requires context. Competency is the ability and attitude to use knowledge and skills effectively in the context of interest. In practice, research and education providers can 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 specification, 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 respond to the request for proposal, during the tendering phase. When a contractor wins the order, then the design and engineering can start. After design and engineering, the contractor can manufacture, test, and install the system(s). When the customer agrees with the acceptance test results, the customer pays the final agreed payment. Now the system is ready for use for a long period of operating and maintaining, until the system requires disposal.

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

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

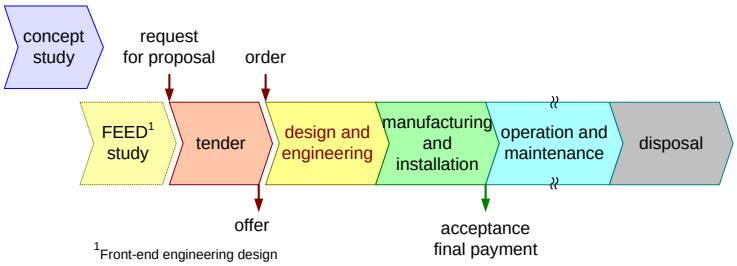


Figure 6.1: Typical Project Life Cycle

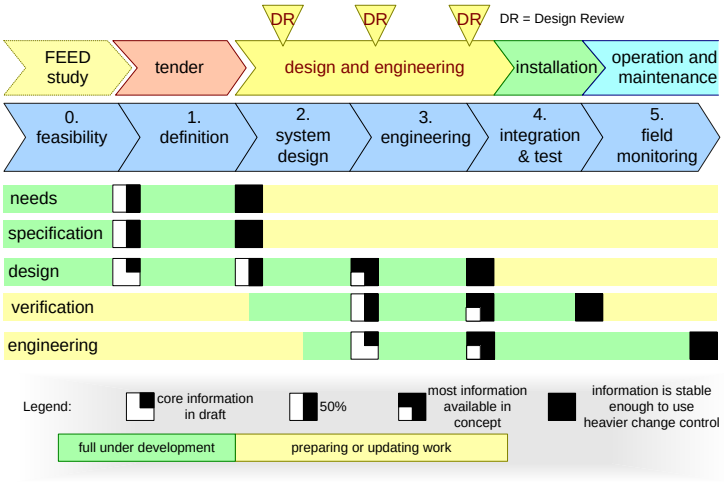


Figure 6.2: Typical Phase Gate Project Approach

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 see in this process sub-processes, such as concept study, project execution, and deployment. Figure 6.4 shows the process decomposition 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 tactical, 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

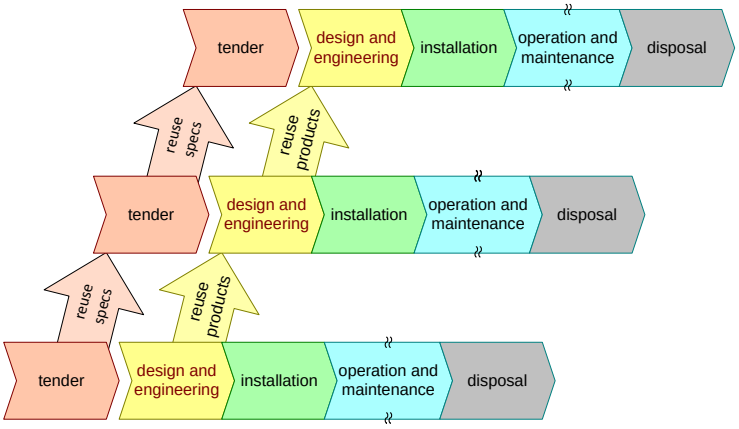


Figure 6.3: How Projects Build on Previous Projects

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

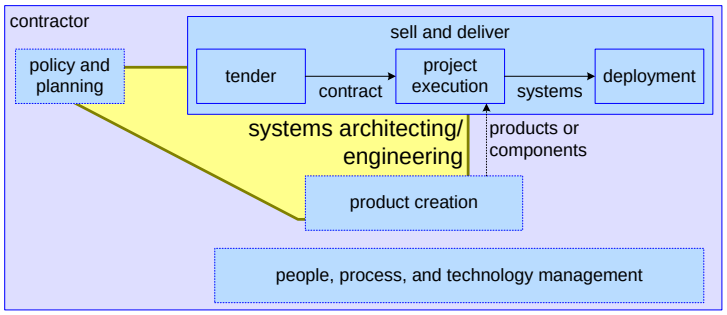
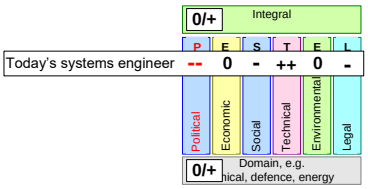


Figure 6.4: Simplified process diagram for project business

Chapter 7

Developing Ecosystem Competences



7.1 Introduction to Ecosystems Competence Development

Working in Ecosystems requires specific capabilities from organizations in the ecosystem. The people forming the organization need specific competences to enable the organization to develop the capabilities. Some of the required competences are:

- Orchestration
- Leadership
- Breadth of perspectives
- Combining agility and rigor

7.2 Orchestration

Within and between organizations there are many boundaries, see Figure 7.1. Boundaries are hurdles for communication; they hinder the information flow. They also hinder rational and emotional sharing of understanding. Orchestrators are individuals

that are able to work across boundaries. They make connections beyond boundaries. They build and maintain informal networks, By being proactive in contact across layers they make delivery across organizations effective. Orchestrators are the countermeasure for bureaucracy in and between organizations.

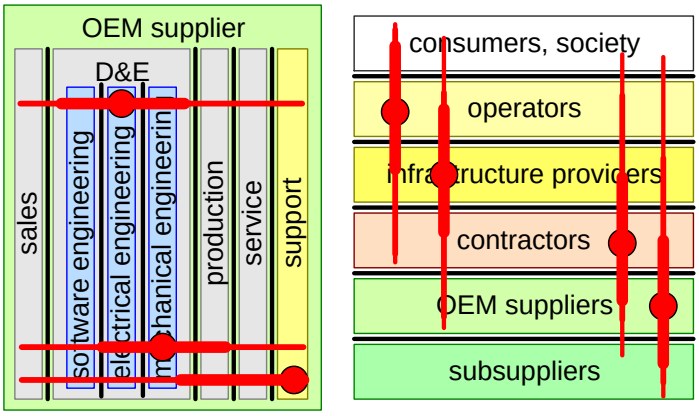


Figure 7.1: Inter- and Intra-organization boundaries trigger the need for Orchestrators

Figure 7.2 summarizes the orchestration competency. We can describe orchestrating as the competence to proactively nudge involved parties towards a fitting solution. To do this, orchestration requires the abilities:

- to relate with a wide variety of stakeholders, to understand their interests and concerns, to connect with them such that they can influence them
- to understand the problem and solution space sufficiently
- coping with ecosystem complexity, uncertainties and unknowns, and helping stakeholders to navigate them

Orchestrating requires the attitudes:

- to see the big picture, while still have an eye for the devilish details
- to own
- to be proactive
- to be genuinely interested in stakeholders

- **Orchestrating** is the competence to **proactively nudge** involved **parties** towards a **fitting solution**.
- Orchestrating requires the abilities:
  - to relate with a wide **variety of stakeholders**, to understand their **interests** and **concerns**, to **connect** with them such that they can **influence** them
  - to **understand** the **problem and solution space** sufficiently
  - coping with **ecosystem complexity**, **uncertainties** and **unknowns**, and helping stakeholders to navigate them
- Orchestrating requires the attitudes:
  - to see the **big picture**, while still have an eye for the devilish details
  - to **own**
  - to be **pro-active**
  - to be **genuinely interested** in stakeholders

Figure 7.2: Orchestrating Content and Stakeholders Across Organizations

7.3 Leadership

Since 2017, TNO-ESI has been offering an extensive competence development program, named Systems and Leadership. This program has 5 modules of in average 2 days, spread over 9 months. We strive to develop the 10 to 18 participants in architecting as well as in leadership. To do this, we have 2 teachers present continuously: one leadership teacher and one architecting teacher. Our experience is that the combination of architecting and leadership is powerful in improving systems engineers effectiveness.

The "eye of leadership" forms the core of the leadership training. Figure 7.3 shows the eye of leadership at the left-hand side. The vertical axis is self on the top and other(s) at the bottom. The horizontal axis has feelings left and ratio right. This creates four quadrants:

Own and shape denotes the leadership competence to focus by proactively owning and shaping the problem, goal, and solution.

Deliver is the competence to work with others and deliver a fitting solution together

Manage self is the competence to know yourself to such degree that you manage emotional triggers, ensuring to stay in a learning mindset.

Connect helps to build relations with a wide variety of stakeholders to effectively interact with them.

Core to the success of this program is the combination of emotional and rational perspectives. For most systems engineers, development of social skills is an essential first step for leadership skills. A major challenge for systems engineers is to open up for the emotional and social side.

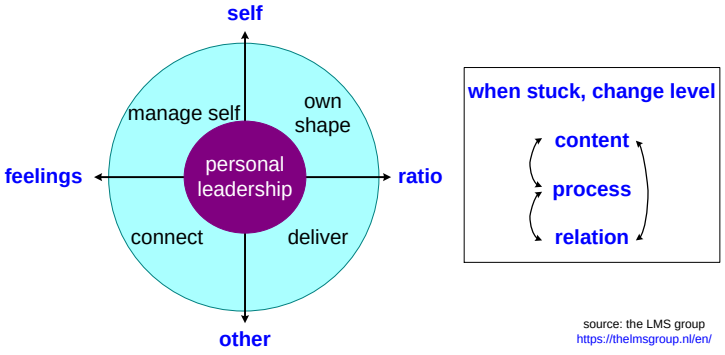


Figure 7.3: Orchestration builds on leadership, as we teach it in the TNO-ESI Systems and Leadership Program

The right-hand side of Figure 7.3 shows one of the many techniques from the program. It explains that we communicate at various levels: content, process, and relation. As systems engineers, we tend to have a major content drive. We may move to the process level. However, taking the (emotional) relation level is more challenging. The simple recommendation is that when a conversation is stuck at one level, to move to another level. The rationale is that the cause of being stuck is probably at another level as well. Changing level often helps to get unstuck.

7.4 Breadth of perspectives

A common framework for perspectives is PESTEL (Political, Economic, Social, technical, Environmental, and Legal). Figure 7.4 shows this framework with the addition of a domain specific perspective, and an integral perspective. Example domains are clinical, defense, energy, maritime, manufacturing, information technology, transportation, food, and finance. The integral perspective is the integration of all these perspectives, and especially the tensions between them.

I observe that the current generation of systems engineers are broad, however, not that broad. Figure 7.5 shows my assessment of today's systems engineers:

Technical very competent

Domain specific varies widely

Integral is the core of systems engineering. However, the limited coverage of non-technical perspectives reduces the score.

Economic is neutral. Systems engineers know that economic considerations dominate in decision making. At the same time, the majority of systems engineers that I have seen dislikes the money dimension.

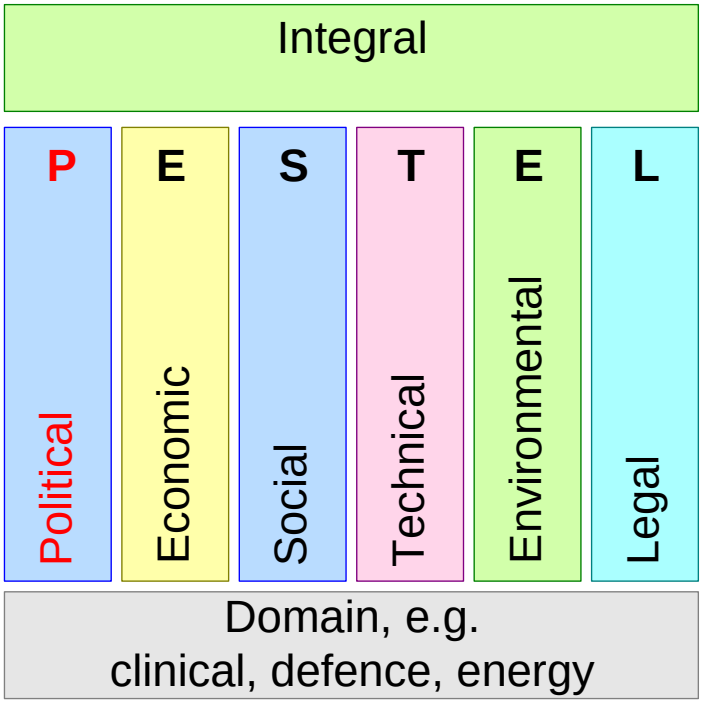


Figure 7.4: Breadth of Perspectives

Environmental seems to more appreciated, however, the lack of political priority degrades the attention and hence the score.

Legal is boring to systems engineers; a boundary condition to comply with

Social is poor in general, although it may improve with age. The nerd roots of systems engineers need complementing. This perspective will greatly benefit from social competence development of systems engineers.

Political is very dominant, certainly in the higher ecosystem layers. The power and emotion in politics is in direct conflict with the rational decision-making mindset of systems engineers. Most systems engineers I know severely dislike politics. Unfortunately, given its dominance, we have to find ways to cope with this perspective.

7.5 Combining agility and rigor

When disruptive events hit an organization or society, then the organization needs to respond fast to survive. Large and mature organization typically have lost their

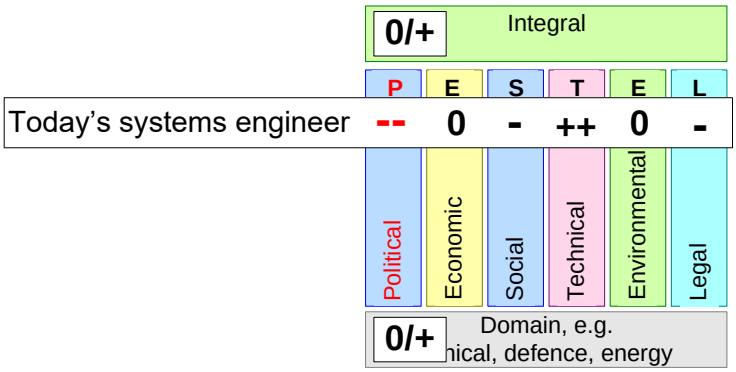


Figure 7.5: Today's systems engineers need signficant growth

ability to respond fast; bureaucracy slows down the response tremendously. The institutionalization that caused the bureaucracy is there for good reasons:

- it captures past knowledge, and in that way prevents repeating the same mistakes
- it protects against fashion grills and similar emotional upheavals

In that way, it forces organizations to work carefully, and to take time for major decisions. Hence, there is an inherent tension between institutionalization and the need for responsiveness when disruptive events occur.

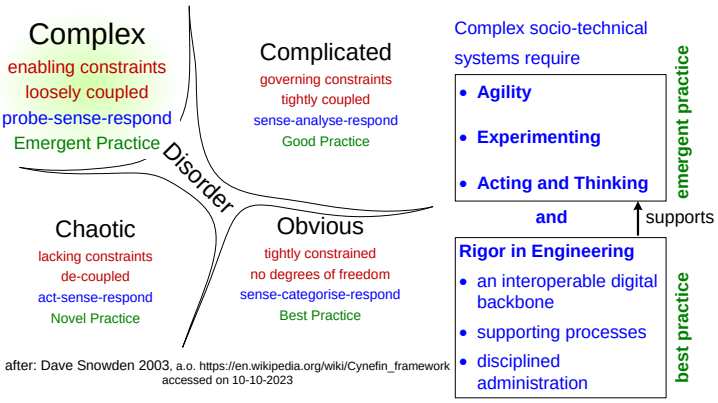


Figure 7.6: The need is responding fast to disruptive changes: Agility!

The Cynefin model, see Figure 7.6 shows that the way an organization should behave depends on the kind of challenge they are facing. Cynefin defines several classes of challenges:

Obvious or Clear where challenges are tightly constrained without degrees of freedom. Best practices work well for obvious challenges; past knowledge will do the job.

Complicated where there are governing constraints and problems are tightly coupled. These challenges require competent systems engineers that apply good practice.

Complex where there are fewer constraints, and there is less coupling. Often humans cause complexity, with their emotions, beliefs and other human properties. Complex challenges require a more open-minded approach.

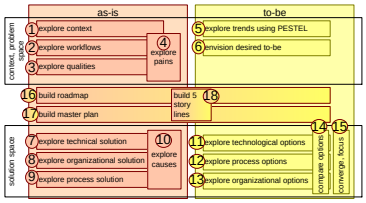
Chaotic or Wicked where we humans have problems to achieve sufficient understanding to reason about the challenge. We have to discover and learn how to address these challenges.

Figure 7.6 shows that in the complex sociotechnical problems that arise from disruptive events we need agility, experimenting, and an attitude of acting and thinking. However, once we create solutions, we still need the rigor in engineering. Rigor exists in best practices. Effective rigor in engineering enables agility in the probe-sense phases. Examples of elements that help achieve desired rigor are:

- an interoperable digital backbone
- supporting processes
- disciplined administration

Chapter 8

Vision-Workshop How To



8.1 Introduction to Vision-Workshop How to

This presentation is the result of reflecting on facilitating workshops to develop a vision in multiple domains, such as (health) care, defense, and research. These organizations are at various levels in the ecosystems of ecosystems.

Capturing the de facto methodology that I as facilitator applied, results in this rather structured diagrams. Reality is more chaotic and the application other facilitators should use is more “organic”.

8.2 Method for Vision-Workshops

For workshop preparation and facilitation read [7] Initially participants in the workshop explore the as-is and the to-be situation, for the context (the problem space) and the solution. They use the findings to build a roadmap, master plans, and communicable storylines. Figure

The facilitator has to ensure that the participants step out far enough into the context. My experience is that most participants by default only look at their direct environment. The facilitator also has to focus the participants first on the as-is situation. A pitfall is that participants escape in a future exploration without having a baseline, nor a clear view on as-is problems and strengths.

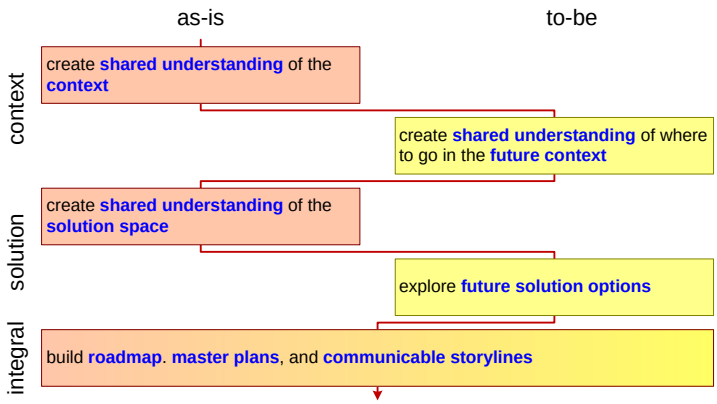


Figure 8.1: The main method for vision-workshops

When exploring the future solution, the facilitator has to build in a step to ensure that participants explore multiple solution. Jumping on the first solution is seductive for many.

The as-is and to-be for the context and the solution space form the beginning of a roadmap [5]. A roadmap is envisioning the path forward over many layers from context and solution space, to process and organization. The roadmap needs elaboration for the near-term in master plans that are more actionable and committal for the involved parties. Roadmaps and master plans can be quite overwhelming. For that reason we construct a number of simplified storylines from trigger in the context to an envisioned solution with its consequences in process and organization.

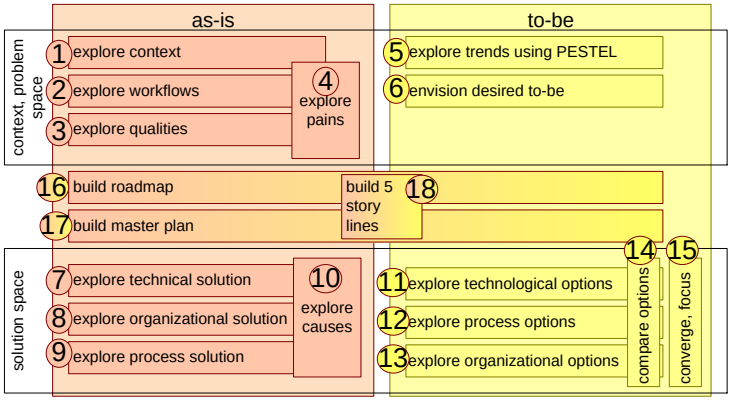


Figure 8.2: More detailed method for vision-workshops

Figure 8.2 elaborates the method in much more detailed steps.

1. Explore the context, e.g. make a stakeholder map and a systems context diagram, and identify relevant environmental aspects.
2. Explore workflows, especially the typical workflow, e.g. the primary process.
3. Explore qualities, e.g. what are the Key Performance Indicators.
4. Explore pains, e.g. where are dissatisfied stakeholders, hiccups in workflows, KPIs that the organization doesn't fulfill?
5. Explore PESTEL trends, e.g. what significant events do we foresee happening in the PESTEL perspectives?
6. Envision a desired to-be in the context and express them in a few keywords.
7. Explore technical solution through block diagrams and behavior diagrams.
8. Explore the internal organization by making an organizational map.
9. Explore internal processes by mapping the main workflows.
10. Explore causes by relating the pains in the context to the internal way of working.
11. Explore options for technical solutions.
12. Explore options for process solutions.
13. Explore options for organizational solutions.
14. Compare options using a decision matrix with criteria and scores.
15. Converge by reducing the options in a moderated discussion.
16. Build a roadmap consisting of at least 5 layers.
17. Build master plans for the near term with concrete steps that involved parties can commit to.
18. Build about 5 story lines with the purpose to ease communication to a wide audience.

Figure 8.3 maps the same steps on the roadmapping framework. Figure 8.4 elaborates the detailed method as a workflow with information entities flowing between the steps.

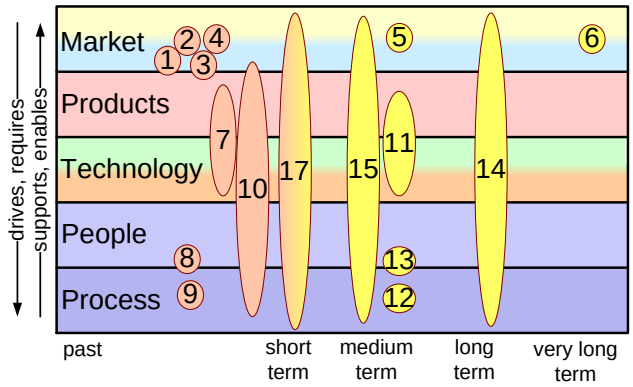


Figure 8.3: Mapping the detailed method steps on the roadmapping framework

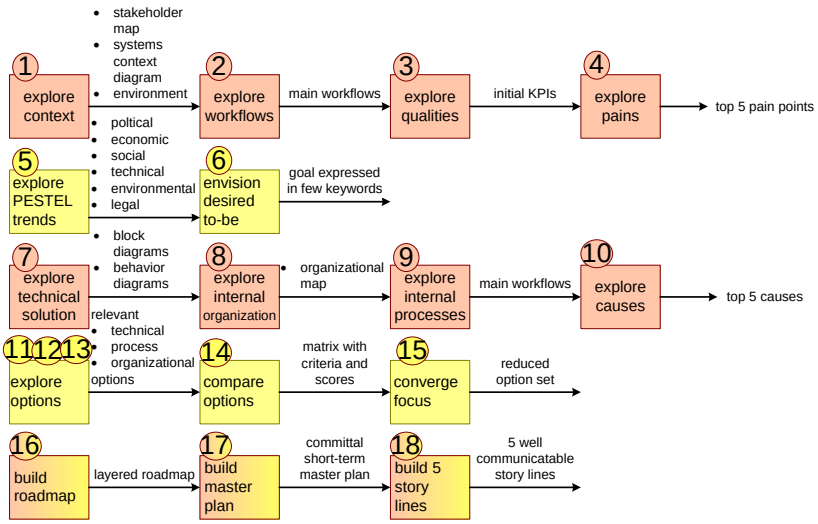
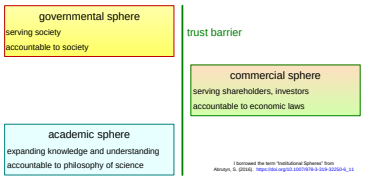


Figure 8.4: The method elaborated as a workflow with information entities flowing between the steps

Chapter 9

Institutional Spheres, Governmental, Commercial, and Academic



9.1 Introduction

The various organizations in an ecosystem differ in their way of thinking and behaving. I am borrwing the term "Institutional Spheres" from [1]. Figure 9.1 shows three main spheres:

governmental serving society and accountable to society

commercial serving sharehodlers and investors, accountable to economic laws

academic expanding knowledge and understanding, accountable to philopsohy of science

The diffrences in purpose and accountability causes generic pains. The figure shows a trust barrier between governmental and commercial, and between academic and commercial.

In the next sections, I briefly zoom in on the various spheres to show that each sphere is highly heterogeneous in itself

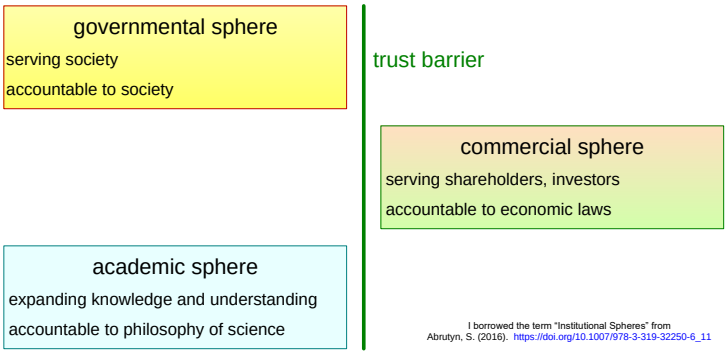


Figure 9.1: Institutional Spheres with Different Purposes and Accountabilities

9.2 Governmental Sphere

A few useful dimensions to think about the governemental sphere is the axis startegy, tactical, operational. This dimension drives the rules for roles in institunional behavior. For instance, politicians and the government set policies that civil servants operationalize. Sadly, the profiles of both roles shows reversed behavior drivers:

polticians need votes on short-term, making them short-term oriented

civil servants work over long periods at the government, giving them long-term insight

Figure 9.2 shows this dimension at the left-hand side.

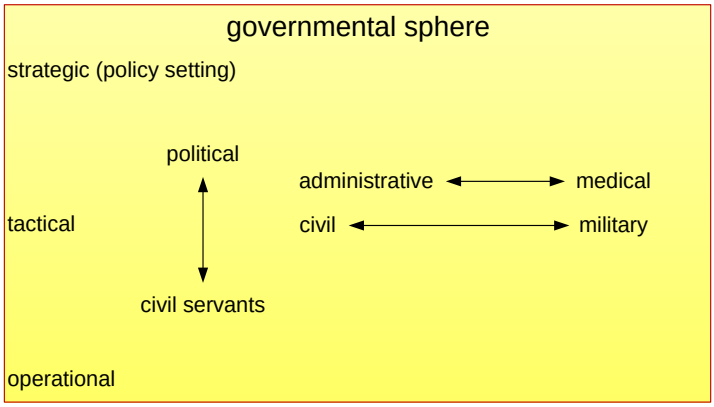


Figure 9.2: The Governmental Sphere Has Diverse Sub-Spheres

Another dimension that Figure 9.2 shows is expertise and domain related. For instance, in the defense domain, there is a divide between civilians and military

personnel. Civilians are administrators, managers, and supporting people. Military personnel, the people in uniform, experience war conditions. The defense organization trains militray people continuously to make them able to cope with these conditions, including rituals to cope with emotional consequences. Civilians and military personnel live in different sub-spheres.

Figure 9.2 shows the medical domain as a asimilar example. Here medical personnel, e.g. physicians and nurses, are the people living in the medical domain with much knwoledge and training to cope with emotional challenging situations.

9.3 Commercial Sphere

There are many ways to segment the commercial sphere. Figure 9.3 suggests a few of the dimensions:

Size in number of people, or financially, e.g. turnover or market valuation. The size of an organzation has a significant impact on its behavior.

Risk appetite and handling capability.

Dynamics of the context, e.g. market, technology, and resources.

Experience level related to the amount of knowledge and the maturity of the organization, its employees, and its relating organizations.

Business model , e.g. who pays for what, how does the organization earns its money?

9.4 Academic Sphere

The academic sphere is rather heterogeneous. Figure 9.4 uses a two-dimensional space for thiking about the variety inside the academic sphere.

Hard-soft where hard stands for the natural sciences, and technology oriented, and soft for social sciences and human oriented.

Theoretical-practical with sciences at the theoretical side and engineering and related disciplines at the practical side.

Many practical disciplines build upon theoretical sciences. For instance, medical science builds upon, physics, chemistry, biology, and social sciences. Similarly, economic sciences need natural sciences and social sciences, while it in turn serves management as discipline.

The position in this space brings natural preferences for the way of looking and thinking, e.g. quantitative or qualitative, objective or subjective, et cetera.

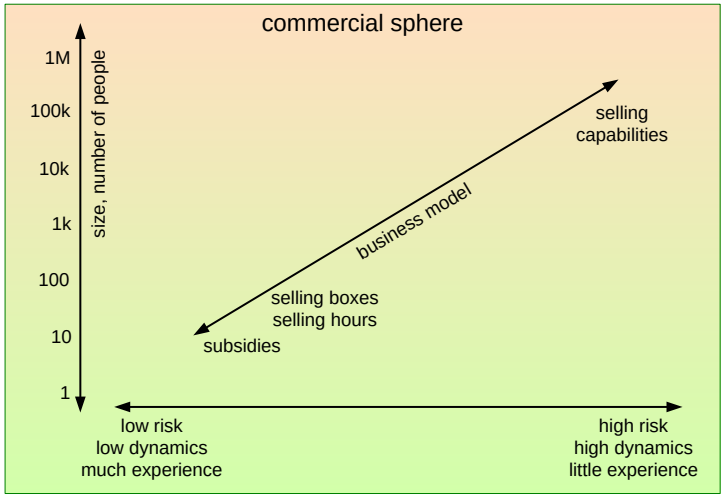


Figure 9.3: Dimensions in the Commercial Sphere

However, they all share a degree of distance to mundane aspects of every day live. Most people in this sphere believe that they should stay impartial, although some social sciences take an opposite position using the term emancipation.

9.5 Acknowledgements

Natansh Vyas helped to find relevant literature relating to Institutional Spheres, and provided feedback on figures.

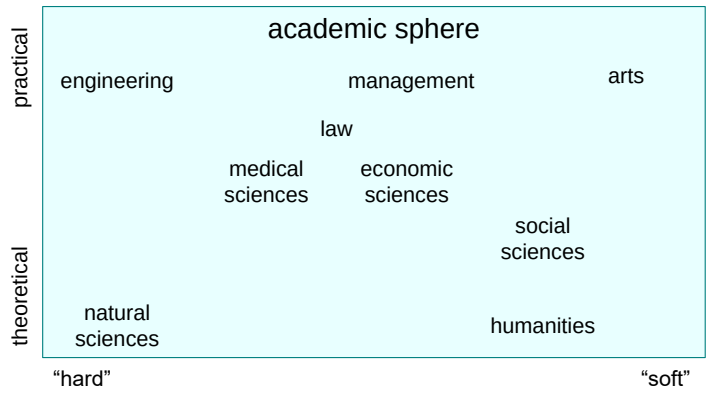
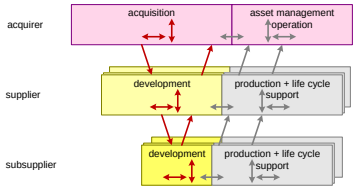


Figure 9.4: The Academic Sphere Has Multiple Dimensions

Chapter 10

Ecosystem Digital Infrastructure



10.1 Introduction to Ecosystem Digital Infrastructure

Working in Ecosystems requires a digital infrastructure that supports the communication and information access over the full lifecycle for parties involved in the ecosystem. There are many information flows between organizations. Figure 10.1 shows a schematic overview of 3 layers in the ecosystem and the information flows between and within layers.

At the top we start with the acquisition organization. The acquisition organization is often paired with an organization that takes care of the lifecycle for the systems. This lifecycle support manages the assets and operates the systems. These organizations have much internal structure, with information flows up and down and between organizational entities. The arrows in the boxes represent information flows.

At supplier and sub-supplier levels we see the same pattern with a development organization and production and lifecycle support.

10.2 Introduction to Ecosystem Digital Infrastructure

We can see the layers as a repeating pattern of producers that deliver to consuming organizations. For example from supplier to acquirer and from sub-supplier to supplier. Managers and legislators tend to reduce this relation to a hard birder with

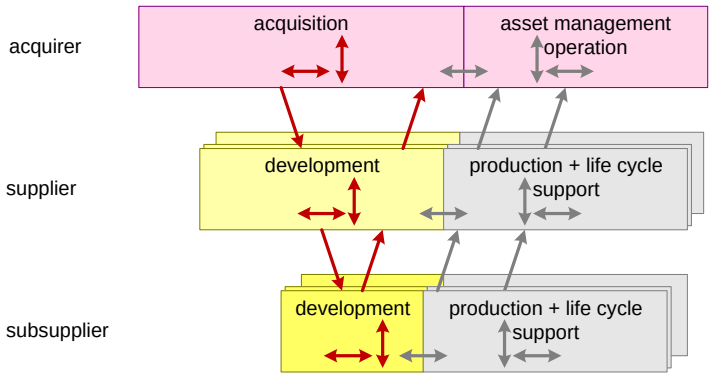


Figure 10.1: Information flows between organizations

a specification between the parties that defines the delivery. The design flow is that the consuming organization does a request for proposal using a specification. The supplier responds with an answering specification for what they will deliver. The asking and answering specification should match.

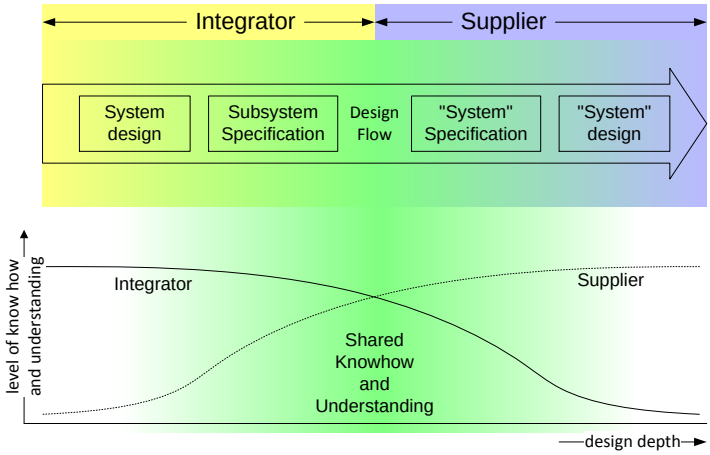


Figure 10.2: The relation between a supplier and an integrator

Figure 10.2 shows this design flow at the top. The integrator sees the supplier delivery as one of their subsystems, while the suppler sees it as their system. In the mind of many people the whole interface is this delivery specification. However, as architect, we often need to know what is at the side of the border.

Figure 10.3 elaborates this relation further. This knowledge is there to make appropriate choices and to be able to assess opportunities and risks. When producer and consuming organizations recognize each other as partners, a much more healthy

exchange of shared knowhow and understanding is possible. This requires embedding in mutually recognized processes, such as acceptance procedures and tests, and natural mapping of intellectual property. However, all overriding for success is trust between partners.

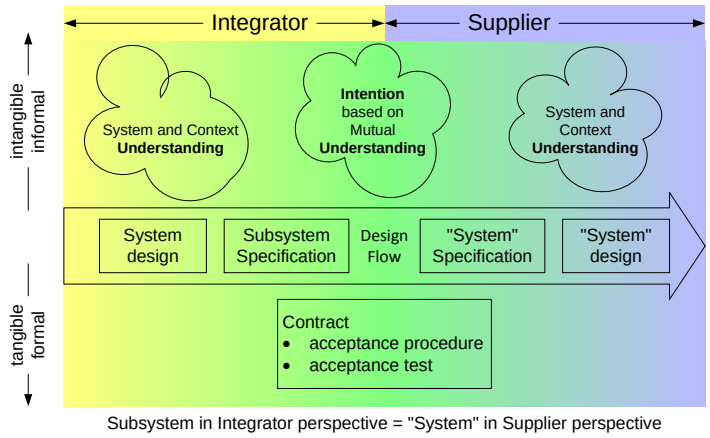


Figure 10.3: Critical Success factor between a supplier and an integrator: mutual understanding and trust

10.3 Information flows and the V-model

Figure 10.4 shows an extended V-model. The horizontal pink bars on top are the activities of the acquiring organization. Below the larger V-model a smaller copy represents the activities in the sub-supplier. Throughout the entire V-model stakeholders exchange much information. There are many borders in the flow, where stakeholders handover information. The figure indicates critical boundary transitions with numbers.

0 Life cycle stakeholders - acquisition in the acquisition organization tend to be separate organizational entities with different cultures.

1 Acquirer - supplier are different economic and legal entities with own interests, typically each with its own digital infrastructure.

2 Marketing, architect - engineer within the supplier have different cultures, habits, and responsibilities, often in separate organizational entities.

3 Supplier - sub-supplier , often a primary interaction between purchasing and sales with a negotiation attitude.

4 Sub-supplier - supplier where documentation can be extensive during engineering, however also during the entire lifecycle. These are different economic and legal entities with own interests, typically each with its own digital infrastructure.

5 Engineer - industrialization within the supplier, however, sometimes separate organizational entities using different digital infrastructure because they have different applications and needs.

6 Engineering - lifecycle support within the supplier, however, separate organizational entities using different digital infrastructure because they have different applications and needs.

7 Supplier - acquirer During the entire lifecycle. These are different economic and legal entities with own interests, typically each with its own digital infrastructure.

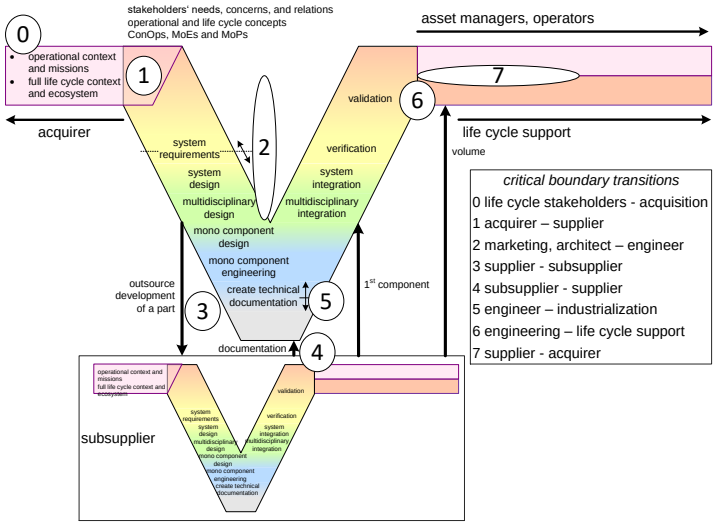


Figure 10.4: Critical boundary transitions in the V-model

10.4 IT-tools and infrastructure

When we go deep into the engineering organizations in suppliers and subsuppliers, there are specialized digital infrastructures for the various technical disciplines. Such infrastructure has repositories and dedicated computer assisted tools. Figure 10.5 shows these digital engineering environments.

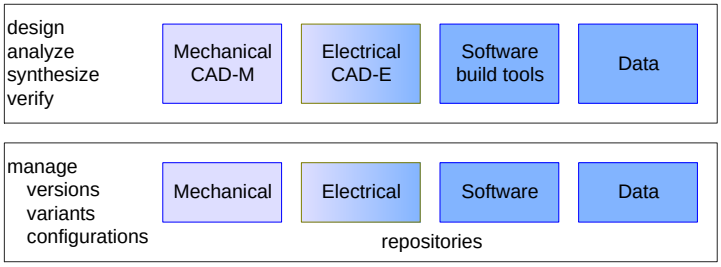


Figure 10.5: Digital mono-engineering environments

Figure 10.6 extends the map of tools for a supplier. In development, there is a rich variety of IT tools at system and organization level. For all repositories, version and configuration control is essential. Unfortunately, many organizations have hybrid infrastructures with less structured stores, e.g. shared drives, up to fully functional repositories. In the product and life cycle support, there are also many IT applications. Here ERP is often a central repository connected with most other applications.

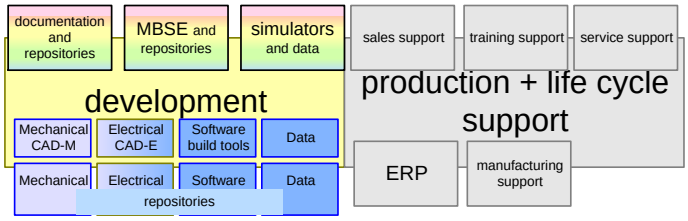


Figure 10.6: IT-tools at a supplier

Figure 10.7 completes the map to the same layers as Figure 10.1. The multitude of tools, handovers, and organizational boundaries explains why the current digital infrastructure in ecosystems is functioning partially at best. Be aware that this pattern extends to many ore parties in the ecosystem.

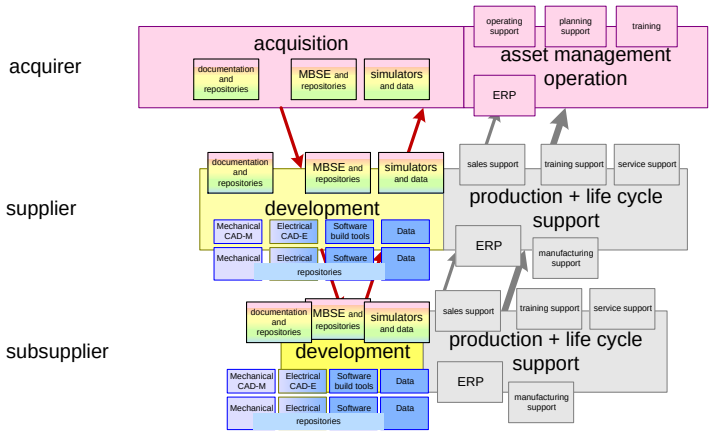
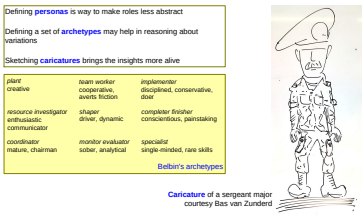


Figure 10.7: IT-tools across layers

Chapter 11

Stakeholders, from Abstract to Individual Humans



11.1 Introduction to Stakeholders from abstract to humans

Any system of interest is interacting with its context. We distinguish several elements in the context:

- humans and organizations
- natural environment
- man-made artifacts

Figure 11.1 shows that all these elements interact within itself between them, and with the system of interest

Figure 11.2 elaborates the elements further. Stakeholders can be individual humans or organizational entities. Social, political, and psychological characteristics drive their behavior. That means that emotions play a significant role, which triggers a risk of ill-behaving stakeholders. This is in contrast with man-made artifacts, which are often engineered systems. Technical

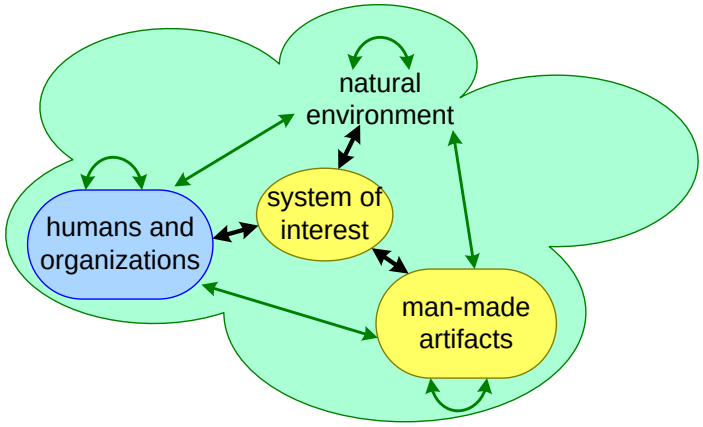


Figure 11.1: The context of a System-of-Interest

characteristics primarily determine the behavior. We assume rationally designed systems that will behave well when the engineers do their job well. Question is whether complex systems, systems of systems, and sociotechnical systems will behave well. Do we understand our man-made artifacts well enough?

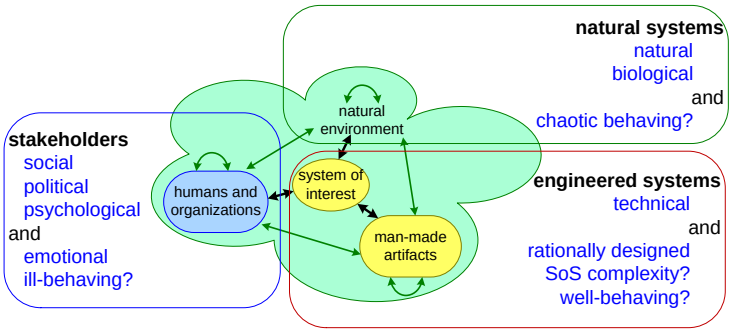


Figure 11.2: The context of a System-of-Interest

Natural systems in the environment may be biological. Nature and biological systems may behave chaotically from our perspective.

The overarching question is how well do we understand the context, so, how well can we understand the behavior of our system of inertest in its context? This paper focuses on the stakeholders.

11.2 Abstracting Stakeholders

[8] explains that we can view a system at many levels of abstraction, e.g. without details or with more details. It visualizes this by using an exponential scale. Then it shows that you can do the same with the system context. Figure 11.3 takes this one step further and shows stakeholder related aspects at the various abstraction levels.

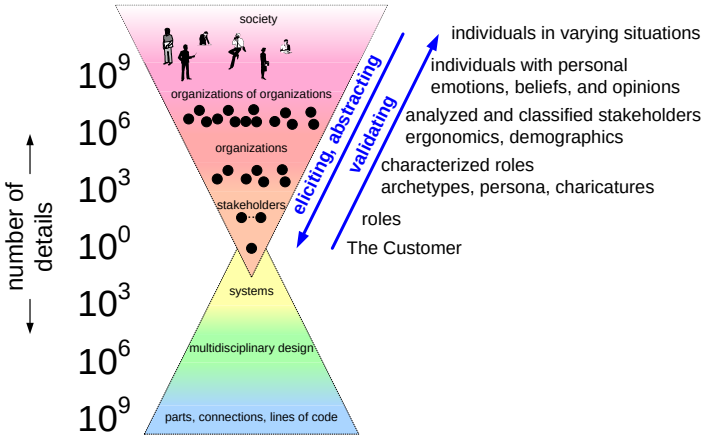


Figure 11.3: Abstraction from humans to roles

Figure 11.4 elaborates the upper pyramid further. When we start at societal level, we have billions of people with many relevant behaviors and characteristics. These are individuals in varying situations, where we can observe behaviors, pains, interests, concerns, patterns, with many variations, and exceptions. In a first abstraction step, we reduce variations and exceptions, by looking at the common patterns. In that way we get individuals with personal emotions, beliefs, and opinions.

We can abstract the individuals into stakeholders, by observing workflows, processes, problems, needs with its variations and exceptions. The result is analyzed and classified stakeholders with ergonomics and demographics. Further observation of behaviors, interests, concerns with its variations and exceptions, resulting in characterized roles archetypes, persona, caricatures.

Once more abstracting results in the main workflows, processes, problems, needs, tasks, artifacts, locations, interactions, relations, and events. We then have simplified stakeholders in a limited set of roles (such as project leader, electrical engineer, marketing manager, etc.). Figure 11.5 shows an example of roles in acquirer and supplier, relevant for the acquisition and delivery of systems in a business-to-business setting. A common (over)abstraction is

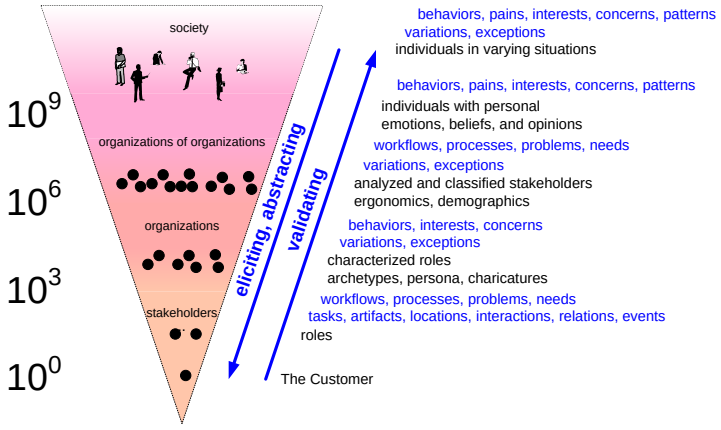


Figure 11.4: Elaborating what to observe

"the customer".

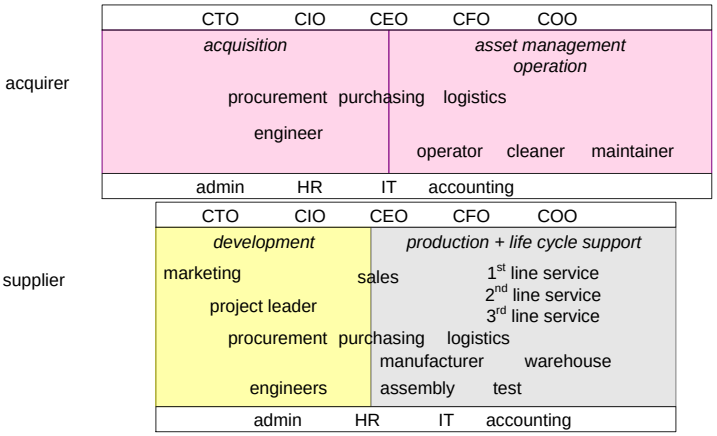


Figure 11.5: Elaborating what to observe

This description is from detail to abstraction, which requires eliciting of insights and capturing abstractions through interaction with stakeholders. Reversely, we need to validate our abstractions by testing them in the real world, also through stakeholder interaction. Once we have an initial set of roles, we can make them more specific again (moving upwards) to increase insight.

Figure 11.6 shows a few ways to make roles more specific in an insightful ways. A common technique, among others in software engineering, is defining personas. Another technique is defining archetypes. The Belbin roles are

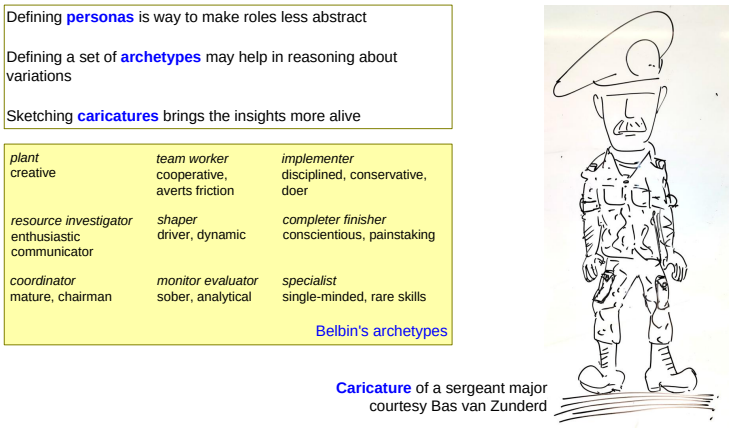


Figure 11.6: Making roles more specific using personas, archetypes, and caricatures

actually kind of archetypes. In discussions, it may also help to sketch caricatures.

11.3 Introduction to Stakeholders from abstract to humans

Figure 11.7 shows a suplier company in its ecosystem with many stakehodelrs of systems engineers. There are many stakholders within the engineering departments, in the broader organization including all lifecycle support functions, and the again broader ecosystem, and the customer ecosystem. Many roles in the organziation have a responsibility for a subset of stakeholders. The black dots in the figure, denoted as proxies engage such subset. For example, the sector director for service will represent service stakeholders.

Systems engineers will engage these proxies frequently. However, their challenge is to sample the stakehodelrs these proxies represent as well. The systems engineers need to understand the various stakeholders sufficiently to engage effectively with the proxies. For example, knowing what to look for and what to ask.

Figure 11.8 elaborates for several roles what stakeholders they represent, and hence where they focus when engaging. The challenge for systems engieneris is to know how much to sample and who to engage directly.

We see that systems engineers know that they need to engage stakeholders. However, probably handicapped by limited social skills and introversion,

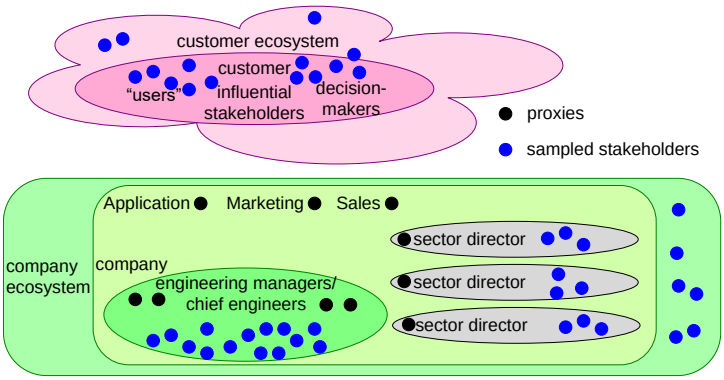


Figure 11.7: Multiple people engage stakeholders; creating context understanding is team effort

- Sales: customer stakeholders with decision power or big influence
- Marketing: customer stakeholders and the wider customer ecosystem
- Application: customer stakeholders that actively work with the system
- Sector directors: (manufacturing, customer support, etc.) life cycle stakeholders and the wider life cycle ecosystem
- Systems engineers: sampling enough relevant stakeholders to work with their problem and topic of interest

How can systems engineers know what is enough sampling and what stakeholders are relevant?

Figure 11.8: Who engages stakeholders?

they tend to contact stakeholders way too little. Figure 11.9 shows kind of maturity model for engaging stakeholders.

- The most basic level is listening and observing stakeholders in their environment.
- This allows them to start understanding what they do, how they do it, what they use, whom they communicate with.
- The next step is understanding stakeholder pains, concerns, interests, and needs.
- Which then allows them to empathize with stakeholders in a genuine way.
- Ultimately, systems engineers need the competency to engage more effectively with stakeholders and building a network and trust

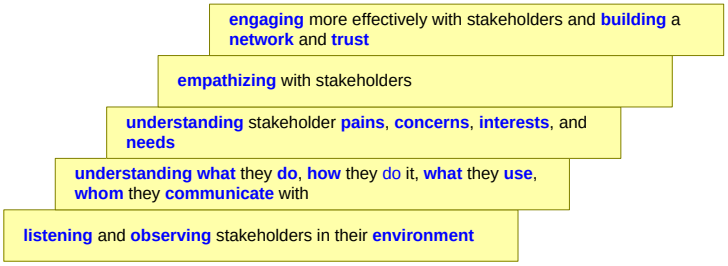


Figure 11.9: Increasing competence levels to achieve a trusful network

11.4 An approach to engage stakeholders

Figure 11.10 shows an approach to engage stakeholders.

- Analyze the field of stakeholders, discuss them and make a map capturing the stakeholders, their positions, and their relations.
- Select a subset of stakeholders to contact them.
- Prepare by reading, searching, discussing, sketching and making diagrams.
- However, engage early and do not postpone that. That requires time-boxing of the initial steps, especially the preparation.
- Capture and communicate insights somewhat more structured, e.g. using A3 architecture overviews [2].
- Keep repeating these steps!

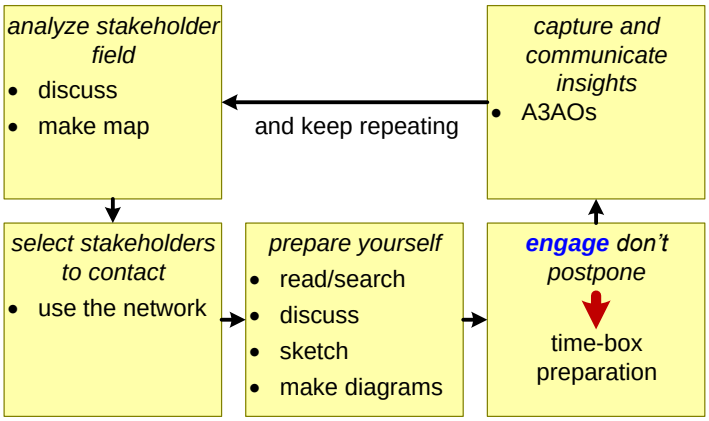


Figure 11.10: An approach to engage stakeholders

11.5 Acknowledgements

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- added PLSElayerCoverage and TOESlogo to the introduction

- changed status to concept

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- added logo, exercises, and questions
- changed status to draft
- defined logo

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- added DevelopingEcosystemCompetences, VisionWorkshopHowTo, EcosystemDigitalInfrastructure, StakeholdersFromAbstractToHumans, InstitutionalSpheresGCA

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- added TOESexerciseLandscape

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- exchanged ProcessDecompositionOfBusiness for ProcessDecompositionOfBusinessNugget

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