"A project is a problem scheduled to be solved." (J. M. Juran)
Definition, Complexity and Optimisation of Projects

A project is a one-time process. Project leaders manage to cope with the unique character of each project by applying standard methods and by optimising the four steps from definition to planning, execution and completion.

1. A brief Definition of a Project

A project is by (a most simple) definition:

- unique – it therefore bears the risk of failure;
- targeted to change a system of any kind;
- limited in time and costs;
- related to a costumer.

Projectum (lat.) means **thrown forward**, just like defining a goal to be reached in the future.

2. Four major processing Steps (Phases)

Processus (lat.) means **to go forward** - like performing steps towards a goal. Thus, a project is a one-time-process. The generic process of projects consists of four consecutive steps (following [1]):

1) The **order** defines scope, duration and deadlines, costs, resources (human or machine) and organisation (how to take decisions a.o.)

2) **Planning** (≠ design) defines the schedule and therefore the allocation of costs and resources over time. It may also anticipate the communication about the project to stakeholders a.o.

3) **Execution** means actually carrying out the work (examination, design (≠ planning), construction a.o.) and controlling (steering!) of this work. It is usually the longest phase.

4) **Completion** stands for an actual statement to have reached the goal(s) and for closure of the work. Its documentation is an input for the feedback loop of optimising standard procedures (methods).

3. Project Management and fractal Geometry

Project management can be looked at as a separate process, executed in parallel during all four major processing steps and taking care of all substeps and tasks of any size during the project (fractal view).

Project management in general means: defining tasks (1), assigning resources (money, time and working force (2)), controlling (steering! (3)) and acceptance of results (4). This approach is universal with regard to any kind of environment and project objective as well as the stage or phase (step) of any project. Every step can be viewed as a project within the project resembling a fractal geometry. The result of each "project" within the project would then be:

- **definition** -> signed order or **contract**;
- **planning** -> granted **schedule** and means;
- **execution** -> actual system or **result**;
- **completion** -> **acceptance** of results / release of resources.

In addition, every step will need an (internal) order some planning of the step itself (scheduling), the actual execution and the completion of the step.

The decision making about completion of every step and releasing the next step or substep is known as **milestones**: pass, repeat or abort. This is subject to the (individual) organisation of the project.

4. Project or Process? Private or Business?

Projects and business processes can be viewed as operations to meet business needs with identical characteristics. Fig. 1 implies that goals and tasks of projects are followed outside the standard organisation a.o., e.g. from contractors or bringing together employees from different units of a company (following [1] and [2]).

Characteristic	project	process
order / mission statement *	a X y 9	↺↺↺↺
results (targeted)	a X y 9	↺↺↺↺
budget	a X y 9	↺↺↺↺
beginning and end	a X y 9	↺↺↺↺
planning and schedule	a X y 9	↺↺↺↺
deadlines	a X y 9	↺↺↺↺
responsibility / decisions	a X y 9	↺↺↺↺
team and organisation	a X y 9	↺↺↺↺
management tools	↺↺↺↺	↺↺↺↺
feedback loop (optimisation)	↺↺↺↺	↺↺↺↺

* Costumer-related

Fig. 1 Characteristics of projects and business processes: uniqueness vs. repetition.

Some business processes may be executed repeatedly every year, e.g. planning of a school timetable, budgeting of an enterprise, appraisal interviews a.o. The major difference to projects is the number of repetitions and therefore the number of (possible) iterations for optimisation.

A hybrid form would (for example) be the work of a marketing division with its ordinary business process including yearly budget and planned number of campaign and some specific projects, partly executed by contractors (outside the standard organisation) with contract accordingly.

Note: Some personal "projects" or daily, private tasks may sometimes be challenging or even constantly optimised, but this is not sufficient to characterise them as "project" or "process" in the narrower sense of the word. But borders are fluent, of course.

Note: While industrial farming undoubtedly is a business process, the growing of corn or wheat itself is a natural process, describable with biology, chemistry and physics.

5. Project or System? Complexity and Risks!

The risk of failure can be understood as a consequence of the complexity of a project. The smartspider (fig. 2) depicts the area covered by the indicators of complexity corresponding to the risk of failure. Some indicators for complexity are project-driven (in the narrower sense of the word):

- relevance to the costumer: from "nice to have" to "a question of life and death";
- importance of deadline(s): "free" – "monitored" – "immovable / high pressure to quickly meet rigorous deadlines";
- number of participants to be coordinated: 10 – 100 – 1'000 – 10'000 – 100'000;
- availability and training in project methodology: tools and decision processes: "available" – developing" – "not existing".

To compare the indicators, a scale is needed. This is the operationalisation (grey).

Complexity may also be system-driven:

- scale, visible as budget (and duration): 10 k£ – 100 k£ – 1 M£ – 100 M£ – 1 B£;

  A long duration may mean changes to cope with both for external and internal reasons (at a potentially bad time):

  - costumers' needs: additional / adapted scopes;
  - boundary conditions: modification of regulations, changes of decision makers, technical evolution, inflation a.o.
  - internal changes: new staff (loss of knowledge), modified policies due to reorganization, poor performance etc.
- technical complexity (in a narrower sense): "simple" – "many elements" – "many links" – "many uncertainties" – "complex".
- level of innovation: from "routine" to "new for us" and "pioneering act".

Project and system are related. The greater the complexity of the system, the more important the proper application of the project methodology will be.

Opposition from parties concerned or interested can be a risk as well (stakeholder). The better they are organised and funded, the more effective their opposition will be. The more emotional an issue is, the easier it will be to incite people against something. Thus, the scale could reach from "neglectable" to "of importance/to be monitored" to "dominant/threatening the projects' success".

Disastrous Failure or heroic Success?

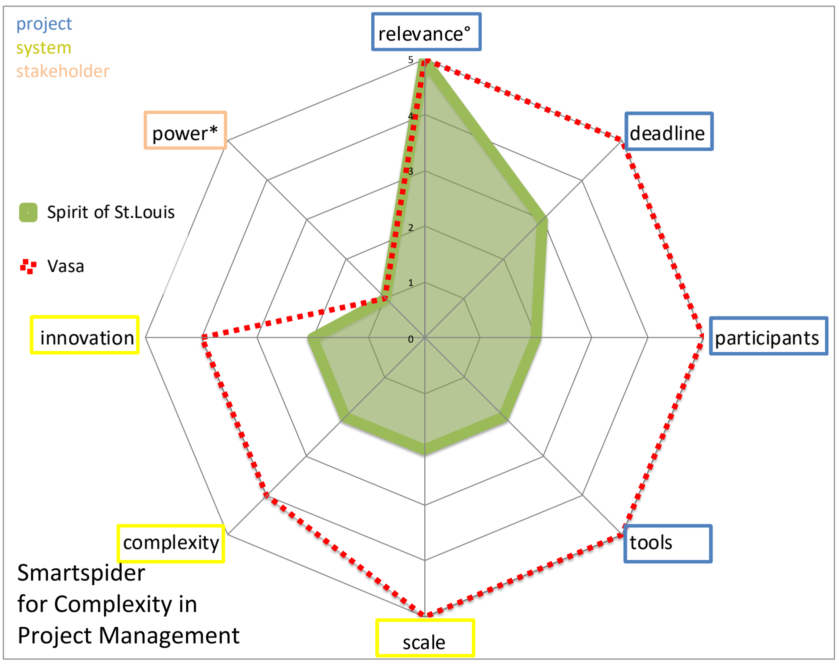

Fig. 2 shows two examples and the whole range from distastrous failure to heroic success:

- The Vasa – the biggest warship of its time – sank on her maiden voyage in 1628 – in light winds just one mile from the shore, killing some 50 people. It still is a didactic play at many anglophone universities.
- Charles Lindbergh was the first man to cross the Atlantic from west to east on a solo-flight. His secret of success with his Spirit of St. Louis in sum: "Reduce to the max!"

The lessons learned from both examples still are relevant and instructive today.

Fig. 2 Smartspider for complexity.

6. Lesson learned from the Vasa: Project Methodology matters

The actual reason for the Vasa-disaster (from a systems point of view!) was a lack of stability due to the centre of gravity being too high above sea level. This can be explained with some bad design decisions and an inadequate armament with an increased number of heavy cannons on the second deck (compared to the original specifications). But the bad design must be seen as a result of both not mastering the systems complexity *and* inadequate project management:

- The king frequently changed his ideas while the schedule pressure stayed high.

  But the change requests weren't neither treated as such nor properly documented. This would have been the basis for complementary contracts and revised planning, meaning to pass through the steps "definition" (1) and planning (2) of the generic process before actually applying the changes to the vasa (execution of work, step 3: redesign and construction).

  Note the difference between an idea becoming reality without questioning and an idea as bases for a change request revealing the consequences and some conscious decisions about them. A decision at the end of each step would have been necessary to accept the results and to make the revised contract and planning the new bases for project controlling as the work goes on.

  It seems obvious, that it would have been necessary to stretch deadlines and rise the budget, particularly for requests that rise the level of innovation, because it takes time to reach the next level of innovation. One must be able to design, construct, test and customize these changes.

  In short: Project methodology (tools, decision processes) probably would have been available but they were poorly applied because of the hierarchical structure a.o.
- The technical specifications and the documentation of changes were insufficient.
- The level of innovation was (too) high, because shipbuilding was based on experience rather than calculations these days. Thus, modifications in the design should have been done in small increments. The level of innovation even was increased during the execution of work by aggravating key specifications.
- Ignoring the obvious: A test conducted before launching clearly showed that the ship was not seaworthy. The test couldn't even be carried out properly because of the glaring instability of Vasa's hull. But the result of the test simply was ignored.

The last point seems to be the most surprising and annoying lesson learned from the Vasa, while the importance of (in)adequate project management and its tools seems to be the most important one.

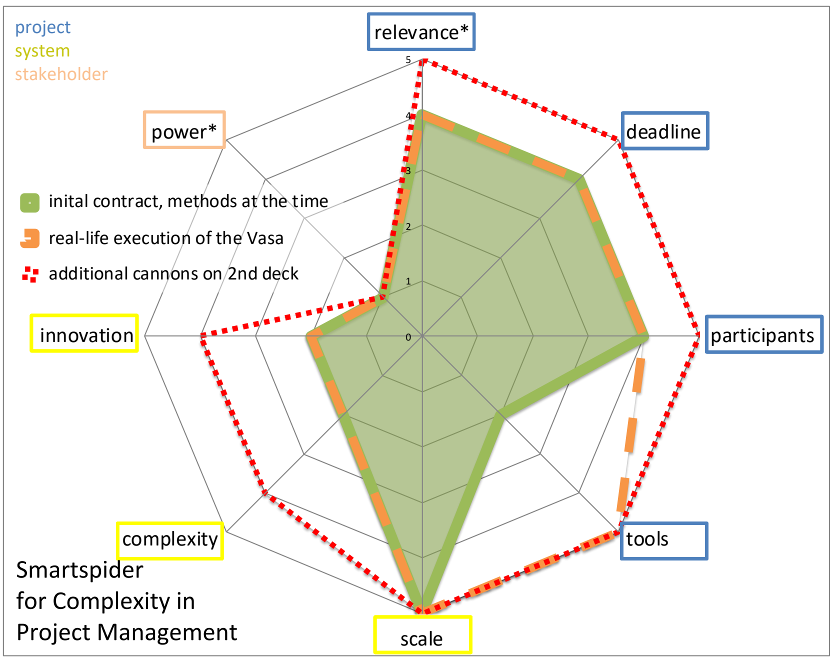

Fig. 3 Smartspider of the Vasa-disaster:
- initial order and methods at the time vs.
- real-life execution vs.
- additional cannons on the upper deck and other changes that affected the stability of the ship.

7. Lesson learned from the Spirit of St. Louis: "Reduce to the max" / "small is beautiful"

With regard to the smartspider, Charles Lindbergh tried to keep the area of project-risks small while his design decisions for the airplane aimed at a simple, reliable system optimised for the purpose of crossing the Atlantic Ocean just once.

- To judge the relevance one may ask "Who is the costumer" first? Orteig gave the idea, some people from St. Louis gave the money, but most importantly, Lindbergh commissioned himself to start defining and planning the project.

  Thus, the success or failure would have been of importance to him ("a question of life and death"), to his donors and – in the last place – to Orteig, the initiator of the award.

  Lindbergh's success pushed the boundaries of aviation one step further. This can be seen as the benefit of the project.
- Deadline(s) are contradictory: Lindbergh wanted to be quicker than anyone else, but there was no official or given deadline date of any kind.
- Project organisation was kept to a minimum and efficient, as Lindbergh acted both as project manager and pilot. He also helped adapt the design of the airplane for the mission. All the relevant people were close together. Decision making becomes much easier that way.
- Lindbergh seems to have had a clear view of how to proceed step by step: 1) financing, 2) reliable partners, 3) execution (design, construction, training and tests, actual flight).

  How much he planned into the future is unknown. He was probably unaware of the fact, that he would do shows in Europe, bring back his plane on a ship, do a lot of more shows in the States and finally leave the Spirit of St. Louis to a museum.

With regard to the system it can be said that:

- The scale of the system followed the maxim "design to cost". It was therefore reasonably small (price of the plane plus costs for the modifications). The duration of the work can also be seen this way (phase 3 according to the generic process: design and construction).
- The technical complexity (in a narrower sense) can be described as "reduced to the max". He chose a plane he basically already knew.
- The level of innovation was kept deliberately low with regard to the used technical system: Modification of an existing design by omitting unnecessary parts and adding some other parts. It was outstanding with regard to the goal of solo crossing the Atlantic Ocean, of course.

Opponents against the project are not known, just like in the case of Vasa.

8. Optimisation of Projects

To define the characteristics of an optimal system, the costs and benefits are put in relation to each other. This is both true for initial orders and change requests. There are four possible fields of change:

- Optimisation in the proper meaning of the word is a higher ratio of benefits to costs. This should always be aimed at, of course.
- Extension means both higher benefits and costs with the risk of a result too perfect for the purpose and thus a partial waste of resources.
- Reduction means lowering both benefits and costs with the risk of inappropriateness for the purpose intended and therefore a partial waste of resources.
- Deterioration would be a lower ratio of benefits to costs with the risk of the waste of resources engaged (time, money, labour force). This should be avoided, of course.

All of these need a point of reference, of course.

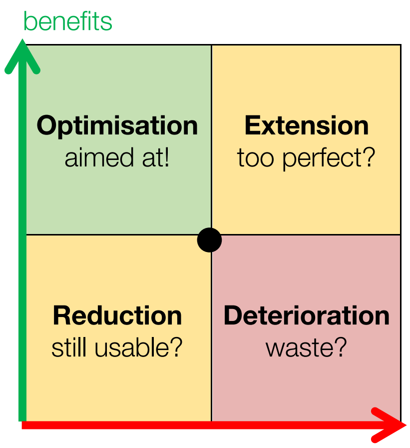

Fig. 4 Fields for "optimising" projects with the point of reference in the centre.

Defining the right Ratio of benefits/costs

To define the best ratio of benefits/costs at the beginning of a project may not always be easy:

- The risk of failure rises with the level of innovation, e.g. the decision for a highly armed warship with cannons on two decks may look like an extension (close to optimisation) compared to a ship with cannons on one deck only, but it can lead to deterioration as well.
- The Ryan NYP (New York to Paris) was based on the Ryan M-2 mail plane, the main difference being the 4'000-mile range for the purpose of a one-time-success. To achieve this, the design included both extensions close to optimisation (larger wings and fuel tanks) and optimisation close to reduction (only one engine, no front view, no fuel gauges, no radio unit to save weight). Note: These optimisations would have to be judged as a reduction in serial production.

  On the other hand, a design with three engines would be an extension or deterioration (e.g.)

From a systems engineering point of view, the knowledge about a system is small in the beginning, when only an idea may be existing. It is vast and well documented at the end of the process of defining, designing, construction, assembling, testing, maybe redesigning and using the system. Thus, it can be tricky to get it right from the be beginning with all the major decisions needed to define a project and the system related to it.

Adjusting the Ratio of benefits/costs

The ratio of benefits to costs often is questioned during the phase of execution of a project:

- A poorer performance than planned inevitably leads to higher costs. The same is true for unexpected technical challenges. A reduction may then be the only solution to not exceed budget contraints.

  Example: Large infrastructure programs (a series of projects related to each other) like Bahn2000 and NEAT both had some elements (projects) omitted to meet the budget goals and to give confidence to the sovereign, who had voted for them. On the other hand, such programs may also be carried out completely despite the rise of cost during execution (e.g. Stuttgart21).
- Change requests from the costumers' side maybe due to new ideas, e.g. if the decision makers change. This may lead in any direction.

  From the king's view, putting more cannons on the upper deck was an extension (close to optimisation) while from the experts view this must have been a deterioration from the moment the idea came up.
- Change requests from the contractors' side may occur as a result of poor specifications in the contract. The contractor may then try to raise the price by arguing, that the wanted quality was not clearly described in the call for tender or similar. This usually results in a hybrid extension / deterioration (higher costs to reach the benefit initially intended).

External factors have to be taken into account:

- Modifications of regulations (environmental, safety a.o.) usually lead to extension.

  The NEAT program in 2013 showed higher costs compared to the definition in 1999 of

  + 22 % (!) due to aggravated safety regulation;

  + 5 % due to improvements for the environment (renaturation a.o.) and the local population (noise protection a.o.).

  There must obviously be an optimum ratio cost/benefit for safety measures [3] and some experts question the benefit of the ongoing increase of safety standards. Thus, there seems to be is a risk of deterioration in case of new regulations.
- The economic situation may lead to higher or lower prices on the market. In this case, the estimations for the costs of certain services during the phases of definition and planning simply wasn't precise (Neat: + 13 %).
- Some boundary conditions may turn out to be other than expected like weather, geology etc. (Neat: + 7 %).

For the two last points, this can be seen as a special kind of "deterioration" or "optimisation".

In all these cases, the rise of projected costs did take place during the design of the system and not during the planning of the project.

Note the difference between:

- planning a project, i.e. schedule and allocation of costs and resources (step 2 of the generic process for projects);
- designing a system, i.e. carrying out projection work like drawing design plans a.o. (step 3 of the generic process for projects).

In German, both planning and designing are often termed as "planning". This can be misleading.

9. References in german Language

Recommended standard References

[1] Stöger, Roman (2011, 3. Auflage): Wirksames Projektmanagement - mit Projekten zu Ergebnissen. Schäffer-Poeschl Verlag Stuttgart.

[2] Stöger, Roman (2011, 3. Auflage): Prozessmanagement: Qualität, Produktivität, Konkurrenzfähigkeit. Schäffer-Poeschel Verlag Stuttgart.

References with more detailed Knowledge

Jenny, Bruno (2009): Projektmanagement - Das Wissen für eine erfolgreiche Karriere (3. Auflage). vdf Hochschulverlag ETH Zürich.

References for a brief Overview

Peipe, Sabine (2009): Crashkurs Projektmanagement (4. Auflage). Haufe Mediengruppe.

Peipe, Sabine / Kerner, Martin (2005): Projektberichte, Statusreports, Präsentationen (1. Auflage). Rudolf Haufe Verlag, Freiburg i.Br.

References

[3] Jörg Schneider (1994, 2. Auflage): Sicherheit und Zuverlässigkeit im Bauwesen, Grundwissen für Ingenieure. vdf Hochschulverlag AG an der ETH Zürich.