CIRCULAR LIFECYCLE WITH SYSTEMS ENGINEERING: THE VVVVR MODEL
A model for circular lifecycle decision-making

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The challenge
Many infrastructural works in Europe were built during reconstruction after World War II. Much of it will have to be replaced or upgraded with major maintenance in the coming decades. According to experts, in the Netherlands only there is already a need for more than 1 billion euros annually on civil infrastructure renewal and this is expected to increase to 3 to 4 billion euros per year between 2040 – 2050, excluding the maintenance costs of existing civil infrastructure (approx. €7 billion per year). In addition, many new assets will be needed to meet the challenges, such as housing, climate adaptation, green energy generation and digitalisation. On top of it, many employees are retiring in the coming years. It is therefore not surprising that many organisations have embraced Asset Management.

All these challenges demand choices and trade-offs within the context of the entire life cycle of the assets, the so-called "life cycle activities" in the 10-box Capabilities model of the IAM. See figure 1.

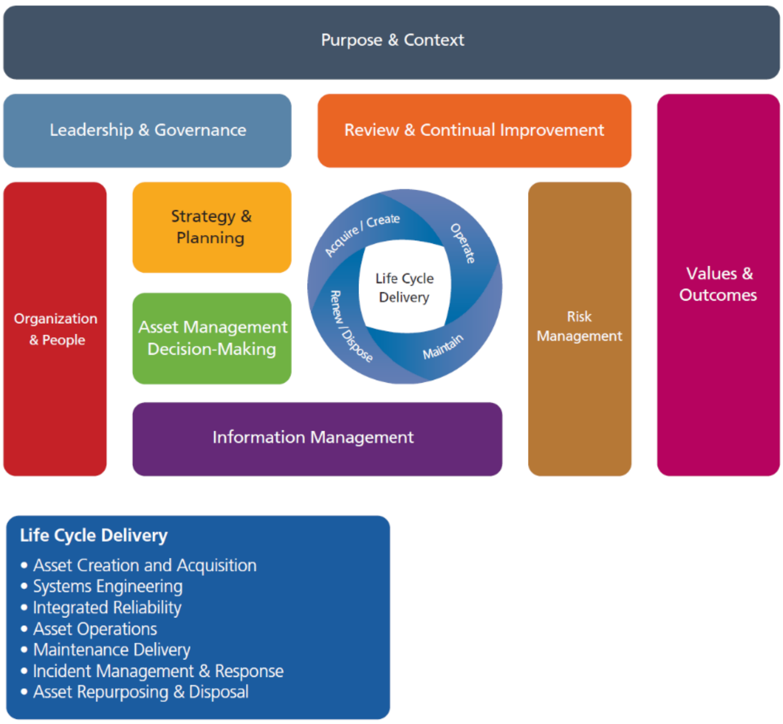

Figure 1: Lifecycle activities (The IAM, 2024).

Lifecycle activities are the core of Asset Management. Life Cycle Management (LCM) is an integrated approach to optimising the asset life cycle, starting with stakeholder requirements, through conceptual design, engineering, commissioning, operation & maintenance and end-of-life decision-making to decommissioning, disposal and reuse. Through a combination of methodologies (such as Systems Engineering, Life Cycle Costing), planning, business processes, supporting resources, analysis and reporting and timely execution, informed decision-making on asset lifecycle phases is possible and the organisation can achieve the lowest asset lifecycle cost. By looking at assets from a lifecycle perspective, organisations are able to truly embed Asset Management in the organisation. Systems Engineering is a way of thinking that can support Life Cycle Management well.

V-model

Systems Engineering is by origin an engineering discipline focused on design, development, production and operation of physical objects or products. This could include the design of a car, train or aircraft. The most well-known model in Systems Engineering is the so-called V model (see Figure 2). In many cases, the "trigger" is generally the construction of a new asset, however this involves requirements relating to subsequent life phases (e.g. maintenance requirements). As a result, important requirements from other perspectives may be missing.

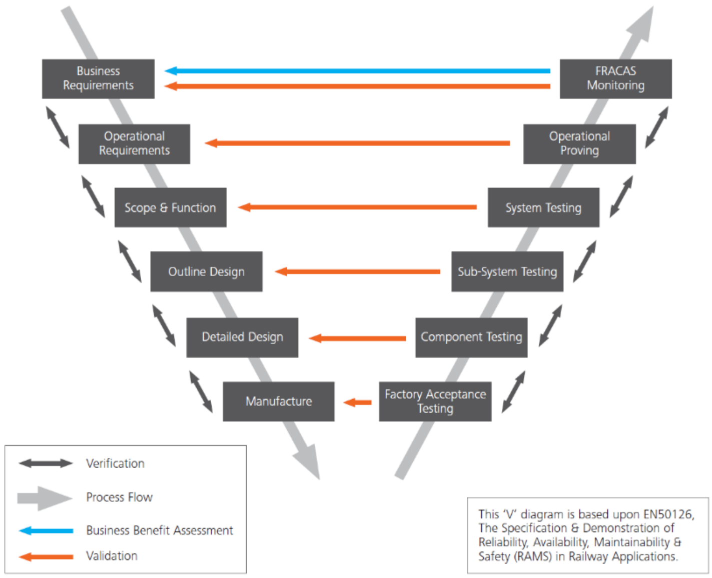

Figure 2: the V-model (IAM; 2024)

VVV model

Asset Management contributes to the organisational objectives. This contribution can be expressed in all kinds of business processes and procedures that are established within the organisation (performance areas), such as development/construction, maintenance and operation. These performance areas can be visualised separately in a VVV model. See figure 3. The advantage is that it does more justice to each phase and creates more depth.

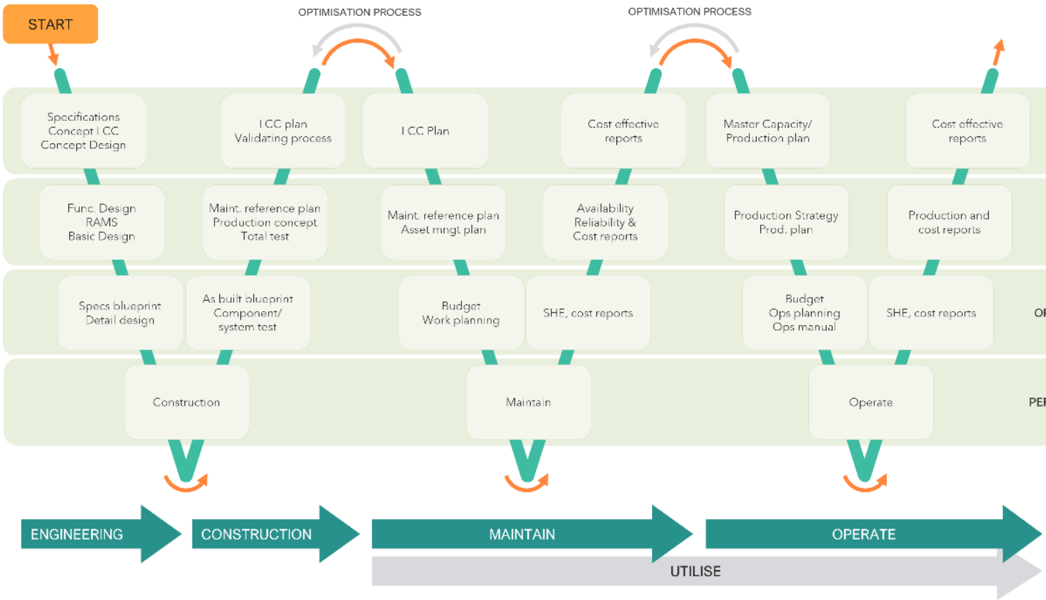

Figure 3: the VVV-model

It is important that each 'V' is well connected to both the previous and the next process, so that the applicable principles and conditions as well as feedback can be transferred. The VVV model was once developed in the Netherlands by Amsterdam Airport Schiphol, but active use of this model is otherwise unknown. And that is a pity, because it at least represents an attempt to apply the idea behind the V-model not only in the construction phase, but also in operations and maintenance. It therefor shapes Life Cycle Management more extensively. However, what is still missing is the end-of-life phase of the asset. And let this be precisely the phase many of our infrastructure assets are currently in!

VVVVR-model

Many infrastructural works in the Netherlands were built in the 1950s - 1980s and are now moving towards the end of their lifespan. This can be recognised in many other parts of the world. In short, the end-of-life phase is not only highly topical, it also presents challenges involving numerous trade-offs. These trade-offs can be visualised in a 'V' for the end-of-life phase, see the new V 'Transform' in Figure 5. Here, an extra 'V' has been added to the VVV model and the whole has been revised somewhat so that it corresponds with the life cycle delivery in Figure 1. It is assumed that all 'V's from each phase start with a shared value framework of the organisation and a SAMP, so that the same principles and objectives are applied to the different activities each time.

The 'Transform' phase starts with the shared value framework of the organisation and the objectives regarding the asset portfolio as included in the strategic asset management plan (SAMP). In addition, a Life Cycle Management plan of the portfolio is used. Based on this, a regular analysis can be carried out on the (remaining) lifespan of the assets and it can be examined whether the total lifespan costs or other aspects (e.g. availability of spare parts or obsolete functionality) might give cause to take an end-of-life decision. This will require an approach to be worked out in more detail (transforming) after decision-making. There will be various options for transforming, e.g. continuation (no change), life extension, modification or disposal of the asset. Disposal should prioritise reuse of the asset or (partial) recycling of materials.

Numerous international and national agreements have been made to move towards a circular economy. In general terms, the goal is to achieve 100% circularity by 2050 in the Netherlands. Clearly, the ambition is high. The aim is to curb waste and work towards sustainable and renewable building materials as much as possible. With the large replacement task as mentioned earlier in this article, huge flows of building materials are involved. It is important to get a good picture of these raw material flows and the choices that can be made. A model that facilitates this is the so-called 10R model. The 10R model is a model that is used in various sectors to visualise the flows of raw materials and thus provide insight into the choices available for the circularity of assets. Choices that can be traced back to the asset management triangle of cost-performance-risk. The "10R model" was developed by professor of sustainable entrepreneurship and former Dutch Minister Jacqueline Cramer, see Figure 4.

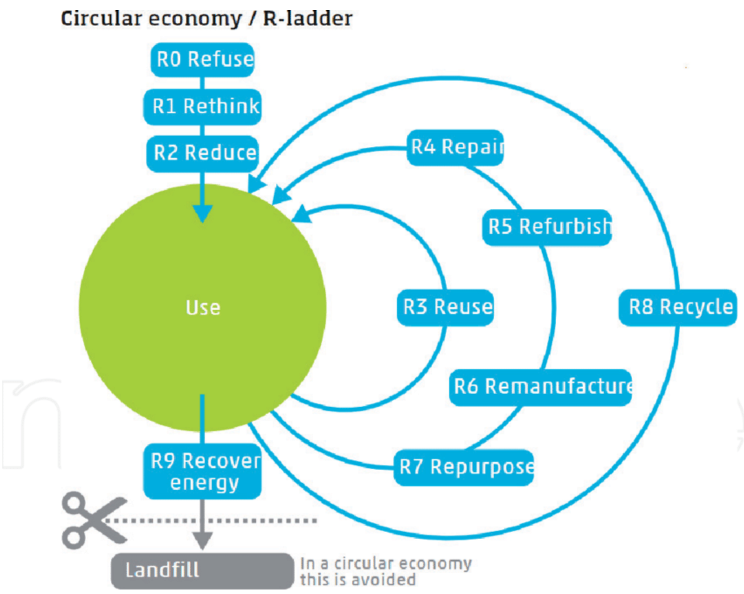

Figure 4: 10R model by PBL Netherlands Environmental Assessment Agency

Like the V-model of Systems Engineering, the question of how to deal with circularity is mostly raised at the start of a project. This is unfortunate, because a project characterises itself as a situation with various interests and often great time pressure. In other words, sufficient time is not always taken or found to have the right discussions and make trade-offs.
All R questions can easily be plotted in the developed VVVV model, see Figure 5. This makes the sustainability issues visible and tangible throughout the entire life cycle and, in particular, the time required for these types of issues is optimally used and not reduced. In addition, awareness of sustainability becomes an integral part of the organization.

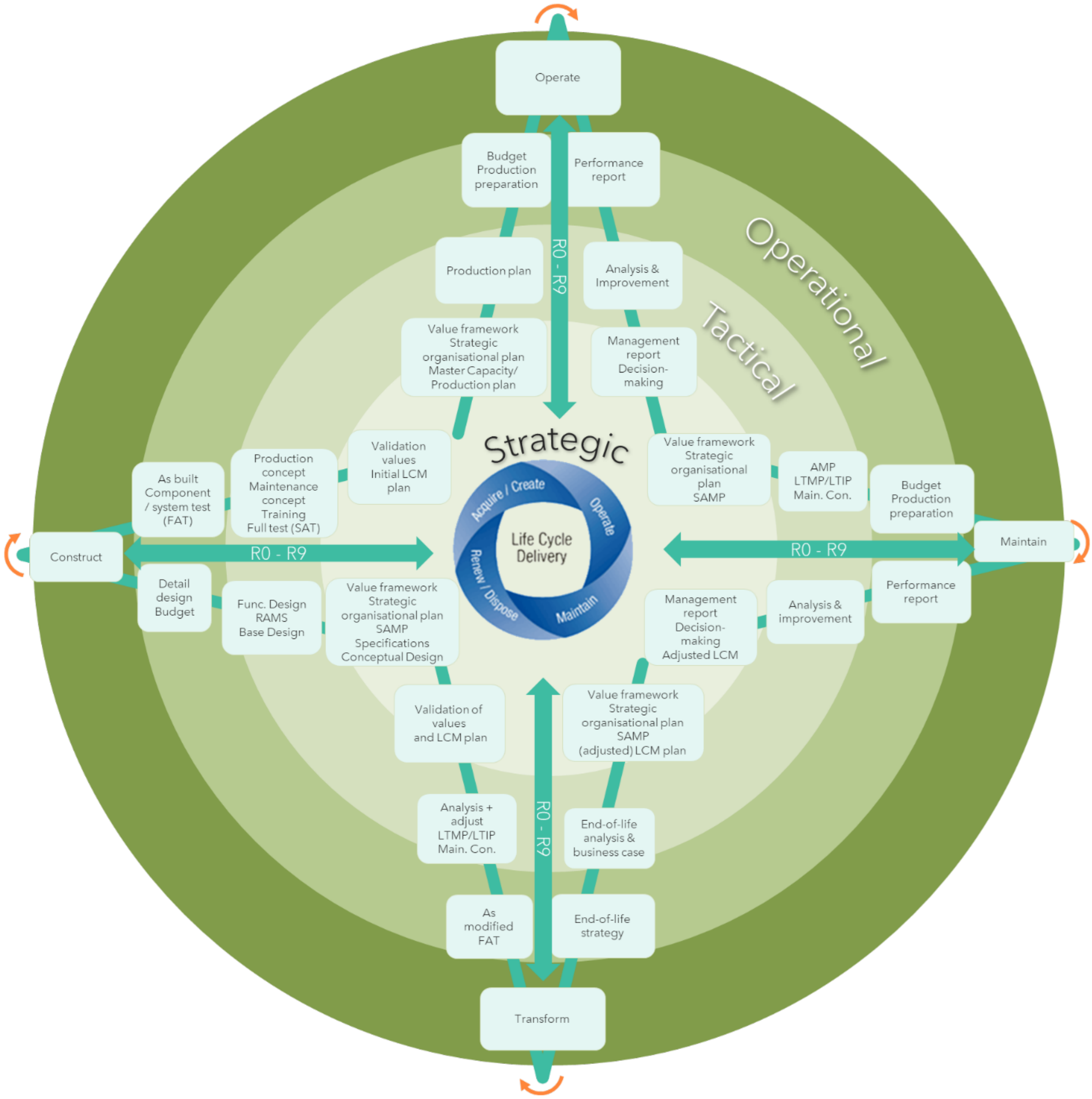

Figure 5: The 10R model plotted in the 4V model, the VVVVR model

To achieve optimal management of the performance areas a distinction is made between 3 levels:
- Strategic level: At this level, the policy is set, investments are overseen and performance indicators and cost-effectiveness are monitored.
- Tactical level: Control and optimisation of development/construction projects, maintenance and operation are among the main tasks at this level. Furthermore, reporting from tactical to strategic level on performance indicators and cost-effectiveness.
- Operational level: Preparing and executing engineering/construction, maintenance and matching operations is the main task of this level. It also focuses on aspects like cost, safety, quality and environment and reports.

Opportunities

The VVVVR model offers numerous opportunities to make a constructive and positive contribution in solving or answering the challenges as stated in the introduction, such as:

- Avoiding partly the time pressure of the project phase and addressing important questions and choices in another phase of life already. This increases the consultation of knowledge and expertise from the organisation (and third parties) and increases the likelihood of better decisions. In other words, don't start thinking when you have to, but start already when you can.
- Have the standing organisation also participate in Systems Engineering (and Asset Management in a general sense), so that it is not limited to a selective group in the project phase. Everyone starts speaking and understanding the same language and it will strengthen the integrality.
- Securing the knowledge and skills in one's own organisation (and third parties) in a proprietary system, which will give the knowledge and skills from "the heads" a place in this system. This should not be seen as a full replacement, but it will make organisations less vulnerable. In doing so, decisions will be more demonstrable and traceable, something that fits in perfectly with increasing demand for transparency and social responsibility.
- Contributing to a circular economy.

The VVVVR model is a conceptual model that can be applied and adjusted for specific conditions and situations.