Maintenance and Philosophy of Technology

Keeping Things Going

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Chapter 9

Maintenance of Value and the Value of Maintenance

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9 Maintenance of Value and the Value of Maintenance

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9.1 Introduction

While it's common to view maintenance practices as a means of ensuring proper functionality and usability of technology, this overlooks that technology is inherently value-laden. Technology can either facilitate or hinder the realisation of values. For example, roads and dams embody the value of safety, while artificial intelligence systems can promote transparency and fairness. Moreover, technology plays a significant role in shaping society and contributing to social development. Social media, for instance, can affect people's well-being and influence how individuals perceive and interact with each other. Maintaining our technology maintains not only technology's functional aspects but also its values.

In this chapter, we will expand upon existing discussions of value and technology by highlighting the importance of maintenance. While current discussions of value and technology typically centre on design and use, the role of maintenance is often overlooked. We can gain new insights and enrich our theoretical toolkit by bringing maintenance into the discussions of the relationship between technology and value. Looking at technology and value through the maintenance lens illuminates two crucial points often disregarded in these discussions. First, maintenance helps stabilise values by ensuring that technology continues functioning according to its intended purposes. Second, the maintenance lens reveals that technology has a life after the design stage and emphasises the importance of considering technology through time, including how embedded values may be transformed through maintenance. By focusing on maintenance, we can better understand the dynamic interplay between change and stability in technology and values.

This chapter provides an initial exploration of the intersection between maintenance and value and argues that the maintenance and value perspectives can greatly benefit from each other. While the value perspective sheds light on the role that values should play in maintenance considerations,

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it is often underdeveloped in discussions of maintenance. Maintenance can help preserve social values by stabilising the values embedded in technology. Conversely, the maintenance perspective encourages us to consider technology over time and how the embedded values are stabilised and evolve through maintenance. This long-term perspective is essential to discussions of value and technology, as it challenges the common assumption that values are fixed in the design stage based on designers' intentions and that values remain stable. We can gain a comprehensive approach to technology maintenance and value by combining the maintenance and value perspectives.

The chapter is structured as follows: we will begin by characterising the maintenance perspective, and this characterisation will provide the foundation for our subsequent discussions of technology and value. Specifically, we will highlight three crucial aspects of the maintenance perspective relevant to these discussions. First, the maintenance perspective enables us to move beyond the design paradigm that characterises many accounts of value and technology. Second, the maintenance perspective shifts the focus from value disruption to considerations of value stabilisation, recognising that the maintenance of values is an ongoing process. Finally, adopting a maintenance perspective helps to reveal how values are transformed through maintenance, emphasising the dynamic and evolving nature of the relationship between technology and value.

With this groundwork established, we will turn to the examination of socio-technical systems through the maintenance lens. The maintenance lens reveals how the components of socio-technical systems and their embedded values are maintained and possibly transformed over time.

Finally, in the last part of this chapter, we will explore the relationship between the maintenance of technology and the maintenance of value. Here, we will consider how a maintenance account of technology and value could look that takes the entire life cycle of technology into account.

9.2 Maintenance: Beyond Design, Hardware and Conservation

Viewing technology from the maintenance perspective requires acknowledging that technology is not static but evolves over time. Therefore, a comprehensive approach that takes the dynamic nature of technology seriously involves examining the entire life cycle of technology, from its creation to eventual obsolescence (later, we will delve into pre-design and end-of-use considerations). In this section, we will briefly highlight three critical aspects frequently ignored in discussions of technology and value that become apparent when considering technology from a maintenance standpoint. In Section 9.3, these three aspects and the maintenance

perspective will also guide the exploration of the relationship between value and technology in socio-technical systems.

9.2.1 Maintenance: Beyond Design

The maintenance perspective illuminates the crucial insight that there is more to technology than just design. Discussions about technology are often guided by what Mark Young calls the design paradigm (2020), which primarily focuses on a technology's design and the role of the designer's intention in creating it. This paradigm ignores the entire temporal dimension of technology, as it places design as the primary focus and views what happens to the technology afterward as secondary.

The maintenance perspective contrasts the design paradigm by inviting us to take the entire temporal spectrum of technology seriously. Technology is not finished after the design stage, and the designer's intention does not determine it. Instead, as many maintenance scholars have noted (Young, 2020; Weber and Krebs, 2021), technology has multiple temporal dimensions that require ongoing consideration. Therefore, we must recognise that technology is an ongoing process that extends beyond its initial creation and design phase. Many technologies can be considered *liminal* because they are continually reshaped, and their form must be negotiated (Suboticki and Sørensen, 2021).

Looking at technology through a maintenance lens can help us reevaluate and shift away from deeply sedimented ways of thinking about technology and value. One of these sediments is the design paradigm, which often dominates the discussions of value and technology. The focus on design and the designer's intention has resulted in approaches to value and technology that are often framed in terms of design and the intentionally designed properties of technical artefacts. For instance, some philosophers of technology, like Ibo van de Poel and Peter Kroes (van de Poel and Kroes, 2014; van de Poel, 2020), argue that technical artefacts embody values when their intentionally designed properties facilitate the realisation of these values. For instance, Michael Klenk (2020) has dubbed accounts that focus on design intentions 'intentional history accounts of value embedding'.

Furthermore, the design paradigm also influences accounts that do not focus on design intentions and their role in value. For example, although Boaz Miller (2020) recognises the long-term implications of values embedded in technology and technology's material longevity, Miller's treatment of value and technology focuses primarily on design. Although Miller briefly brings up redesign, practices of how longevity can be achieved, like maintenance, are neglected.

What can the maintenance perspective contribute to discussions of value and technology? By emphasising the longevity and stability of values, the maintenance perspective encourages a forward-looking approach that complements traditional design-focused accounts of value. Instead of thinking that design alone determines value, we must also consider the ongoing processes that maintain or transform values over the entire life cycle of technology. In this sense, the maintenance perspective challenges the narrow focus on the designer's intention that characterises many accounts of value and technology. As we will explore in Section 9.3, applying the maintenance lens to technology also has important implications for understanding socio-technical systems. But first, let us examine a second crucial aspect that adopting a maintenance perspective brings to the fore, and which will contribute to a more comprehensive understanding of the relationship between value and technology.

9.2.2 Maintenance: Beyond Hardware

Although hardware repair is a crucial part of maintenance, it is not the only aspect that deserves attention. Many maintenance scholars argue that maintenance encompasses the social dimension as well. For instance, Steven Jackson (2014) has emphasised that repair can help to maintain meaning. Maintenance and repair extend beyond material artefacts to our relationships, trust, health, honour, and status (Henke and Sims, 2020). Our desire to restore justice and repair our political system also falls under maintenance practices (Spelman, 2002). Therefore, the maintenance perspective highlights the interplay between the material and social aspects of maintenance and the broader implications of maintenance beyond the technical realm.

Maintenance studies have long recognised the symbiotic relationship between the maintenance of technology and the maintenance of social order. As Stephen Graham and Nigel Thrift (2007) suggest, it can be challenging to determine whether the focus of maintenance is the technical artefact itself or the social systems surrounding it. Andrew Russell and Lee Vinsel (2018) argue that the maintenance of technology often goes hand in hand with the maintenance and reproduction of social structures. Maintenance scholars also emphasise that the upkeep of social order requires continuous effort involving material maintenance and repair practices (Denis, Mongili, and Pontille, 2015, p. 7). Furthermore, Christopher Henke (1999) argues that while repair work fixes and maintains technology, it also repairs and restores social order in the workplace. Repair practices frequently involve reordering and fixing social relationships and beliefs, which Henke calls 'people repair' (p. 56). In their recent book, *Repairing Infrastructure*, Christopher Henke and Benjamin Sims (2020) argue that maintaining

infrastructure can sustain social and political order. They coin the term 'socio-technical repair' to describe processes of repair that involve both material and discursive interventions to restore meaning.

Expanding our thinking about values and considering how values are maintained can inspire a new perspective on value and technology. The inclusive conception of maintenance that looks beyond hardware and acknowledges the maintenance of society can help us see that the values embodied in technology are not static or fixed but are continuously negotiated and maintained.

The maintenance perspective provides a valuable complement to many approaches in the philosophy of technology that prioritise the destabilising effects of technology on values. While these discussions frequently centre around the destabilising social impacts of technology use, such as social media's impact on mental health or sustainability concerns regarding energy systems, scholars have also developed analytical tools and frameworks for exploring how technology can transform morality. One such concept is techno-moral change (Swierstra, 2013; Kamphof, 2017), which highlights the transformative impact of technology on morally salient practices. Other scholars have explored the potential for technology to disrupt morality altogether (Nickel, Kudina, and van de Poel, 2022). In contrast to these approaches, the maintenance perspective offers a crucial counterpoint by emphasising how values are maintained over time, not just how technology destabilises or transforms values.

Although it is essential to recognise the potential of technology to destabilise morality and social order, it is equally important to acknowledge technology's role in stabilising and maintaining these values. Adopting a maintenance perspective reminds us that technology has a socially and morally disruptive potential and stabilises social and moral practices, institutions and orders. Stabilising technology by maintenance, then, also stabilises and maintains a particular social and moral order. As Bruno Latour (1990) famously argued, technology is society made durable. We can extend this idea and suggest that maintaining technology makes society and values more durable.

The stabilising effect of technology is especially evident with entrenched technologies, which are deeply embedded in the social fabric and can reinforce certain values and social practices. For example, the combustion engine and the infrastructure supporting it have stabilised a value regime centred on individual independence, freedom and car ownership as a status symbol. Car use and ownership are deeply socially ingrained in many cultures and discussions about them are often highly politicised. This is evident in some countries, such as Germany, where attempts to establish nationwide speed limits on highways face significant resistance from drivers and the automobile lobby.

Adopting a maintenance perspective helps us to gain a better understanding of the relationship between technology and value. While the design paradigm focuses on the creation and innovation of new technologies and their corresponding values, the maintenance lens highlights the ongoing work of preserving and sustaining technology and value over time. This lens sheds light on often overlooked aspects of technology and value, including the maintenance of social institutions and actors. At first glance, maintenance may appear to be a conservative force that merely sustains the status quo. However, as we will explore in Section 9.2.3, maintenance can be transformative.

The maintenance perspective provides a broader understanding of technology and value by highlighting the need to maintain hardware and social relations. This raises an important question: does the maintenance of technology also involve the maintenance of values? The answer, according to the maintenance perspective, is yes. Later, we will explore how this insight helps us better understand the maintenance of socio-technical systems.

9.2.3 Maintenance: Beyond Conservation

Many maintenance activities are forward-looking and focus on the stability or continuity of some technical artefact or system over time. However, maintenance is not always about restoring the status quo or conserving something. For instance, maintenance can also involve upgrading technology to meet changing demands or technological advancements. In addition, as discussed in Section 9.2.2, the maintenance perspective opens space for thinking about how maintaining technology relates to the maintenance of value.

In the literature on technology maintenance, there remains a tendency to emphasise conservation and preservation. For instance, Andrew Russell and Lee Vinsel argue that *maintenance* is all the work to preserve particular technical and physical orders (2018, p. 7). Similarly, Heike Weber and Stefan Krebs (2021) propose that *repair*, together with other forms of upkeep, is an intervention that prolongs the time that technology can stay in use. Furthermore, Gabriele Schabacher proposes that maintenance is a 'prospective routine procedure to prevent all forms of disorder' (2021). Also, Steven Jackson (2014) stresses order and proposes that repair involves acts of care that maintain order and meaning in socio-technical systems. This does not mean that these authors don't allow for transformation and change or consider maintenance exclusively in terms of conservation and preservation. Still, these aspects seem to be the primary focus.

Although there is a tendency to view maintenance as a force that conserves and sustains social order and values, scholars have pointed out that

maintenance can be a creative, innovative and transformative process (Graham and Thrift, 2007; Russell and Vinsel, 2018; Vinck, 2019; Young, 2020). Rather than exact restoration, maintenance often allows for improvisation and innovation (Graham and Thrift, 2007). Furthermore, Henke and Sims (2020, p. 21f.) distinguish between repair as maintenance and repair as transformation, highlighting the potential for maintenance to enable change in existing social orders, including power structures and social practices. While repair as maintenance conserves and restores the status quo of practices and structures of power, repair as transformation can enable changes to these power structures and social practices. Therefore, maintenance should not be seen as solely a conservative force but also as a force that can bring change and transformation.

The maintenance perspective offers a valuable framework for discussing technology and values and goes beyond the traditional focus on value disruption. Not only does maintenance help maintain and stabilise existing values but it can also be a transformative process that leads to value transformation. This perspective encourages us to pay attention to value stability and transformation through maintenance practices. We should consider supplementing existing discussions about the relationship between technology and values with what could be called *maintenance as value transformation*. This concept acknowledges that values other than those intended by the designer can be embedded in technology through maintenance practices, potentially contributing to significant changes in societal values and norms.

In this section, we have highlighted how a maintenance perspective can provide insights into important but often neglected aspects of value and technology. We have identified three key features of this perspective. First, the maintenance perspective encourages us to go beyond the design paradigm to consider how values relate to technology after the technology has been created. Second, maintenance is not just about hardware upkeep but includes the maintenance and repair of social dimensions. The maintenance perspective emphasises the importance of value stability and conservation. Third, maintenance scholars have pointed out that maintenance is not merely a conservative force but can also be transformative. This opens possibilities for thinking about how values can be transformed through technology maintenance.

In summary, adopting a maintenance lens gives us a valuable perspective for analysing the relationship between technology and values. In the upcoming section, we will put the maintenance perspective to work. We will explore how the maintenance perspective can improve our analysis of socio-technical systems and value, building upon the three aspects introduced previously.

9.3 Maintaining Technology, Maintaining Value: The Case of Socio-technical Systems

This section will explore how the maintenance perspective can enhance our understanding of the relationship between values and technology by applying this perspective to socio-technical systems.

Taking a systems perspective on technology and focusing on socio-technical systems is warranted because even singular technical artefacts are embedded in broader systems. For example, a single bicycle is not an isolated technology but is embedded in the broader socio-technical transportation infrastructure, including roads, bridges, cars and public transportation. Furthermore, most highly impactful technologies, like transport infrastructure and artificial intelligence, are socio-technical systems that integrate social and technical elements. Therefore, by applying the maintenance perspective to socio-technical systems, we can better understand how the maintenance of technology and the maintenance of value and society are related.

Maintenance scholars have long recognised the importance of socio-technical systems, particularly infrastructure. For example, in their treatment of infrastructure repair, Henke and Sims (2020) describe infrastructures as socio-technical systems. Examining socio-technical systems brings attention to the interwoven relationship between technology and social factors, highlighting the links between technology and social structures, including power and privilege. This approach offers unique insights because it connects maintenance to value considerations and emphasises the crucial role of the maintenance perspective in the analysis of technology and value. By adopting a maintenance perspective that considers socio-technical systems, we can better understand how technology and values are maintained and transformed over time.

Before we go into the details of the relationship between maintenance, socio-technical systems and values, it is crucial to understand what socio-technical systems are. According to several scholars (Kroes *et al.*, 2006; Ottens *et al.*, 2006; van de Poel, 2020), socio-technical systems have three essential components. The first component is the material elements, which include technical artefacts and other hardware necessary for the system's functioning. The second component is the agents involved in the system's operation, which are primarily human but can also include artificial agents (van de Poel, 2020). Finally, socio-technical systems consist of social, legal and economic institutions, which are required for the system's functionality.

Institutions are structures of established rules, conventions or behavioural principles that structure social interactions (Fleetwood, 2008; Wilfred Dolfsma and Rudi Verburg, 2008). Social norms are institutions because

they prescribe what to do in particular circumstances (Bicchieri, 2005; Brennan *et al*., 2013). Institutions are enforced by social sanctions that discourage non-compliant behaviour. Laws and regulations are also institutions but in contrast to most social norms they are specified in writing and enforced by formal sanctions, such as fines. Understanding these components is essential to understand how maintenance can affect socio-technical systems and values.

To illustrate how the different components of a socio-technical system work together, we can turn to the Tokyo subway system, as described in Michael Fisch's ethnographic study (2018). This massive socio-technical infrastructure integrates hardware (such as trains and tracks), agents (including passengers and conductors) and institutions (such as social norms and municipal regulations) to ensure the functioning of the system. For instance, passengers have developed efficient boarding norms during rush hour that limit train delays and keep the system running smoothly. The example of the Tokyo subway shows how the different components of socio-technical systems are tightly interconnected and must work together seamlessly to enable the system to function properly.

All three components of the socio-technical system embody values, and the hardware of a socio-technical system comprises technical artefacts that embody values. How value embodiment occurs is subject to philosophical debate, and various accounts of value embodiments have been proposed, such as the historical-intentional account (van de Poel and Kroes, 2014) or the affordances account (Klenk, 2020). Regardless of one's preferred account of value embodiment, it is plausible that technical artefacts in a socio-technical system embody values.

Similarly, values are embedded in the institutional component of a socio-technical system. We can follow Ibo van de Poel (2020) here, who has suggested that values are embedded in the same way they are embedded in artefacts. He proposed that an institution embodies a value when it is conducive to this value because it has been designed for that value. Traffic rules are one example that van de Poel gives to illustrate his argument. For instance, the rule to drive on one specific side of the road embodies traffic safety because it was intentionally designed to facilitate this value. If all traffic participants follow it, traffic will indeed be safer.

Finally, human agents in a socio-technical system also embody values. While technical artefacts may be designed with specific values and functions in mind, human agents do not have such design features. Nonetheless, it is reasonable to say that human agents embody values because they endorse values, are motivated by them, and sustain them through their behaviour. For example, engineers who endorse the value of safety will think that safe technology is a desirable state of affairs and will consequently be motivated to design a safe product. They will feel a sense of satisfaction when they

succeed in designing a technology they consider to be safe. Different approaches have been proposed to characterise individual values, including values as conceptions of the desirable (Kluckhohn, 1951), values as abstract trans-situational goals or ideals (Schwartz, 2015; Maio, 2016) or values as patterns of relatively robust attitudes, such as emotions and desires, that provide reasons for actions (Tiberius, 2018). Despite the various accounts of values, it is widely accepted that human agents hold or endorse values.

Now let us discuss how maintenance relates to socio-technical systems and values. To ensure the proper functioning of the entire system, it is necessary to maintain all three components of a socio-technical system – hardware, agents and institutions. Furthermore, a maintenance perspective can enhance our understanding of values and technology by recognising that maintaining the components of a socio-technical system also entails preserving values embedded in them. The maintenance of these components and their embedded values are illustrated in Figure 9.1.

Let us now consider the maintenance of the components one by one, beginning with the maintenance of hardware.

When it comes to maintaining a socio-technical system, the hardware component is crucial. Technical components inevitably break down or wear out over time and thus must be repaired or replaced to ensure the system's proper functioning. Take, for instance, the complex socio-technical system of an airport. It comprises various hardware components, including airplanes, airport buildings, air traffic control equipment and runways, all requiring ongoing maintenance to keep the airport operating smoothly.

The maintenance perspective reveals that maintaining the hardware is not solely about replacing parts or repairing broken components. It also

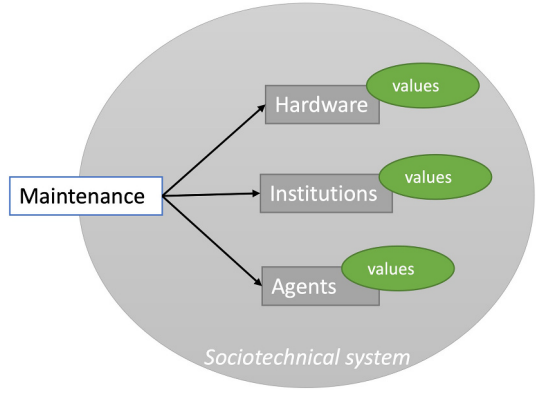

Figure 9.1 Maintenance and socio-technical system.

involves maintaining the values that are embodied in the hardware. Depending on which account of value embodiment one finds most convincing, the maintenance of values will take different forms. For example, the affordances account of value embodiment (Klenk, 2020) asserts that artefacts embody values because they have affordances, which are relational properties that create action possibilities for the agent and make some actions likelier than others.[1] Technology affords or enables some valuable actions more than others. Following the affordance view of value embedding, maintaining technology would entail maintaining its affordances and, hence, its values.

In contrast to the affordance view, on the function account of value embodiment (van de Poel and Kroes, 2014), an artefact embodies values due to the functional properties it was designed for. If the maintenance of the hardware keeps the technology function stable, then the embodied value is also preserved. Section 9.4 will explore the maintenance account for other value domains besides design values.

The debates about value in the philosophy of technology often overlook the fact that the values of technology are not static but rather require ongoing maintenance to remain stable. The predominant focus on design has led to a neglect of the role of maintenance practices in upholding values. By contrast, a maintenance perspective highlights the importance of maintaining values through active practices. This perspective provides a valuable counterbalance to the prevalent emphasis on value disruption and destabilisation in the philosophy and ethics of technology. By highlighting that values are stabilised through maintenance, it offers a fresh angle for exploring and understanding the complex relationship between technology and values.

However, the maintenance perspective recommends attending to conservation and transformation, especially focusing on transformation through maintenance practices. By applying this perspective to value and technology, we can open up intellectual space to consider how values can be transformed through maintenance. This approach challenges the implicit assumption in many debates that values embodied in technology are fixed in design. In reality, not only are embodied values maintained but they can also be transformed. Through maintenance practices, we can transform the values embodied in technology, thereby enabling it to meet new or changing requirements. For instance, to better align artificial intelligence with our value of justice, the maintenance of an algorithm may change the system components responsible for producing biased results while maintaining the rest of the algorithm.

To illustrate how maintenance as value transformation is viewed from the standpoint of different accounts of value embodiment, let's take the example of the abovementioned affordance view. According to this view,

technology embodies values by virtue of the affordances it provides, which are the potential actions or interactions it allows or invites. Hence, changing the affordances of technology can result in a transformation of its embodied values. For example, consider a social media platform designed to maximise user engagement, but it has been found to lead to negative social consequences such as addiction, polarisation and disinformation. By changing the platform's affordances, such as reducing notifications, it becomes more aligned with the value of promoting healthy social interactions. In this way, maintenance practices that modify the affordances of technology can lead to value transformation.

Let us now turn to the other critical elements of a socio-technical system. As we have seen, taking the maintenance perspective seriously involves recognising that maintaining the entire system requires more than hardware maintenance. All components must be maintained to ensure that the system functions correctly. Therefore, companies, governments or society must consider maintaining all the components to maintain a socio-technical system.

For example, to maintain a socio-technical transportation system like an airport, it is necessary to maintain social institutions like air traffic control regulations, which govern the system and enable it to operate. Similarly, to maintain a road traffic system, it is crucial to ensure that hardware components like roads and signs are in good condition, but it is equally important to maintain institutions like traffic rules.

Above, we have highlighted that institutions, like artefacts, embody values. However, the maintenance of institutions is often overlooked in discussions of technology and value. Taking a maintenance perspective requires us to consider the maintenance of institutions and how it relates to maintaining embodied values. This perspective also highlights the importance of paying attention to how institutions are maintained and stabilised over time. Maintenance scholars have stressed the relationship between maintenance and social order, emphasising the significance of institutional maintenance for the stability of values (Graham and Thrift, 2007; Russell and Vinsel, 2018; Henke and Sims, 2020). Adopting a maintenance perspective can help us to better understand how institutions maintain embodied values.

Let us briefly consider how institutions can be maintained. Institutions, such as social norms and traffic rules, can be maintained through various means, including positive and negative reinforcements. Negative reinforcement includes sanctions, which can take different forms, from public disapproval to verbal or physical discipline. In some cases, the state usually enforces physical sanctions through the police and courts. Positive reinforcement of institutions includes incentives to encourage people to adhere to norms and other means of ensuring compliance. For instance, drivers'

education ensures that drivers internalise and follow traffic rules. At this point, the maintenance of institutions overlaps with the maintenance of actors, which we will discuss below.

The maintenance of enforcement mechanisms is indeed crucial for the successful enforcement of institutions. However, it is important to note that maintaining a socio-technical system does not just mean maintaining these mechanisms but also the broader social and technical components that enable these mechanisms to function effectively. For example, maintaining a traffic enforcement system not only involves hiring and training police officers but also ensuring that the road infrastructure is in good condition, traffic signals are functioning properly and drivers are educated about the rules. All these components work together to create an effective traffic enforcement system.

Furthermore, it is important to recognise that we should not ignore the connectedness of different socio-technical systems. The maintenance of one system can impact the maintenance of another system, and the failure to maintain one system can have ripple effects on other systems. Therefore, a comprehensive understanding of socio-technical systems and their interconnectedness is necessary for a comprehensive understanding of maintenance, but we will leave this complexity aside here.

To fully embrace the maintenance perspective, we must move beyond the idea that maintenance preserves the status quo. Maintenance can be a tool for intentional change, including the transformation of institutions and values embedded in them. In the case of socio-technical systems, institutions can be changed purposefully to embed new values. For example, if there is a demand to make shipping more sustainable, the maintenance of the system may require revising shipping routes to achieve this goal. The new shipping routes will then embody the value of sustainability, reflecting a deliberate effort to transform the institution to align with new values (Künneke *et al*., 2015). This kind of intentional change of institutions is an important aspect of maintenance that is often overlooked in discussions of technology and value.

Another example of maintenance as institutional change has occurred due to the rise of sophisticated language models like ChatGPT. In response to concerns about how these models may reshape education and scientific integrity (Cotton, Cotton and Shipway, 2023), many educational organisations have sought to adapt their institutions, like policies and guidelines, to maintain specific educational values, such as scientific integrity. By revising their rules and guidelines for scientific integrity, these organisations have adapted to the new reality and ensured that their values remain embedded in the educational system. This educational change highlights how the maintenance of socio-technical systems often requires the purposeful transformation of institutions to embed new values.

Before we move on, it is important to note that the above examples of institutional change, such as the revision of shipping routes and changes to scientific integrity guidelines, involved changes in formal rules and regulations. However, not all institutions in a socio-technical system are formal. Some institutions, like social norms, are informal, and their change can often be unintentional.[2]

The maintenance perspective considers the temporal dimension and acknowledges that institutions are not fixed. In addition to focusing on the maintenance required to stabilise institutions and their embedded values, the perspective also highlights the potential for institutional transformation. By recognising this dynamic aspect of socio-technical systems, the maintenance perspective provides a more nuanced understanding of these systems.

Finally, let us turn to the maintenance of agents as components of socio-technical systems. Besides external factors like sanctions, agents follow institutions because they have internalised them through processes like socialisation and habituation (Fleetwood, 2008). Because agents likely internalise certain institutions during their education and training, maintaining internalisation processes contributes to maintaining institutions. Thus, it is crucial to recognise that the maintenance of agents involves ensuring a steady supply of agents and the continuous development and training of existing agents. This can involve providing professional development opportunities, updating knowledge and skills and promoting a culture of ongoing learning. The maintenance of agents also encompasses recruiting and retaining a diverse range of agents to reflect the diverse needs of the socio-technical system and its users.

Moreover, the maintenance of organisations that shape agents involves not just universities and vocational schools but also other institutions that support agents, such as professional associations and networks. These organisations provide resources, mentorship and networking opportunities vital for agents' ongoing development and support. The maintenance of these organisations requires a sustained effort to ensure they remain relevant, responsive and accessible to the agents they support.

The link between agents and institutions highlights the importance of maintaining internalisation processes. Agents' internalisation of social institutions, like norms, rules and conventions, underpin the socio-technical system. To maintain these internalisation processes, organisations must promote a culture that emphasises the importance of following social institutions and provides agents with opportunities to practice and reinforce these institutions regularly.

However, the agents in socio-technical systems include more than just operators. Users are another significant group of agents. For instance, when focusing on travel infrastructure, train passengers and pedestrians

should be considered. A maintenance perspective should pay attention to this group because, as we have seen, it looks beyond design and considers what happens after technology leaves the factory. For example, in the case of the Tokyo subway discussed previously, how commuters use a transportation system, including norms of smooth entry and exit, can significantly impact the system's operation.

Earlier, we discussed how agents embody values. However, the question of how agents' values are maintained is often overlooked in the literature on technology and values. This is a critical oversight because the maintenance of values is relevant to technology's smooth functioning and stability. Adopting a maintenance perspective can help correct this oversight by emphasising the importance of maintaining values in addition to other components of the system.

To illustrate the role of values in the maintenance of a system, let us consider the example of traffic infrastructure. Drivers who endorse the value of safety will behave in a way that does not harm the material parts of the infrastructure. For instance, in certain countries with colder climates, valuing safety means changing tyres between winter and summer, which avoids damaging the road[3]. Similarly, a plane passenger who values efficiency will likely behave in a way that contributes to quick boarding, which helps with the smooth operation of the flight.

Now that we have established that the values of agents, operators, engineers and users are relevant for maintaining technology, we must ask how the values embodied in agents are maintained. A part of the answer lies in considering organisations that shape agents and their values. First, let us briefly consider the organisations that shape operators and engineers and then turn to the topic of maintenance of users' values.

To fully understand the maintenance of values in socio-technical systems, it is important to consider the role of various organisations in shaping the values of the agents involved. While it may not be possible to provide an exhaustive list of all the factors that influence the values of these agents, certain organisations, such as universities and vocational schools, play a particularly significant role in shaping the values of operators and engineers. During their education and training, these agents internalise values crucial for maintaining the socio-technical system, such as efficiency, safety and sustainability. These values, because they translate into behaviour, like designing an efficient product, are conducive to maintaining the socio-technical system. Organisations play a key role in shaping and maintaining the values of users because they influence the internalisation of norms. For instance, a driver's education program is mandatory in many countries, and drivers must pass a test before receiving their license. This education likely instils values such as safety and responsible driving in the prospective driver. In addition, formal rules and regulations and official

sanctions, like fines, help maintain drivers' values and keep their behaviour in line with established institutions crucial for maintaining the socio-technical system.

The interdependence of the components of a socio-technical system is an essential feature of such systems. As we have seen, agents' values are closely related to institutions and maintaining one component can contribute to maintaining the other. However, it is also important to note that the components can be maintained independently, and the intention to maintain one component does not necessarily imply the intention to maintain the whole socio-technical system. For instance, a government may wish to maintain certain rules and regulations regarding the use of technology without the intention to maintain the entire socio-technical system. For example, a government may enforce strict data privacy laws without the intention to maintain the entire digital infrastructure. Similarly, the European Union may wish to maintain its rules about the use and design of cars without the intention to maintain the socio-technical traffic system in its member states.

So far, we have examined socio-technical systems from a maintenance perspective, which proved to be a powerful tool for identifying key components of the connection between technology and value previously overlooked. However, our treatment was more like a snapshot view. For this reason, our considerations were not entirely faithful to the dynamism embraced by the maintenance perspective. To fully align with the maintenance perspective, we must consider technology through time, particularly how values are maintained throughout a technology's lifespan. Section 9.4 will focus on technology and maintenance over time.

9.4 Technology through Time: Maintenance and Value Domains

The maintenance perspective shifts our attention from the initial design of technology to its ongoing trajectory through time. It encourages us to focus on how technology is stabilised and transformed. In contrast to accounts that emphasise the importance of design, the maintenance perspective highlights the ongoing importance of maintenance, repair and adaptation. While design is crucial, it is only the beginning of technology's life cycle. In this section, we will see how adopting a maintenance perspective can give us insights into how values are maintained in different domains throughout the life cycle of technology.

At this point, it is crucial to introduce how a maintenance account of value and technology would consider the whole life cycle of technology. To provide such an account, let us revisit the concept of embodied values we discussed earlier. We previously noted that some philosophers argue that values are embodied in technology through design. However, it is essential

to recognise that design is only one of many domains that contribute to shaping the values embodied in technology. Many philosophers of technology also emphasise the importance of the use domain and its associated values[4] (van de Poel and Kroes, 2014; van de Poel, 2020).

The values related to design are *intended values*, which are the values that designers or developers aim to embody in the technology they create. For instance, the designers may intend for the technology to embody values such as sustainability or safety. In addition to intended values, we can distinguish *realised values*. These are the values that are actually realised in the use of technology. Notably, intended values and realised values may not always align. For instance, it may turn out that the technology is not sustainable or safe once people use it. Finally, there are *embodied values*, which we have previously discussed. Embodied values are intentionally embedded in the technology and realised in use because the technology has been designed for these values (van de Poel, 2020). Let us now turn to a maintenance account of value and technology, which can provide a broader analytical perspective than existing accounts of value and technology.

Distinguishing between design and use is a good start, but to fully capture the relationship between technology and value, a maintenance account would emphasise the full temporality of technology. Adopting a maintenance perspective means looking beyond just design and use and considering the value domains that span the entire life cycle of a technology.

The life cycle of technology involves more than design and use; it also includes a domain that could be called *discard*. While discard may appear simply as a form of use, it is prudent to distinguish between use and discard because what happens to technology after it becomes obsolete may not necessarily affect how people use it or how creators intend it to be used. For instance, how to discard technology may not even be considered in the use plan. A use plan describes an intended use of technology, including a set of manipulations of the technology so that it can adequately fulfil its function (Houkes *et al*., 2002). This is not to say that discarding a technology is never part of a use plan or that designers cannot translate their intentions regarding how technology is discarded into design requirements. For instance, if designers and engineers intend technology to be recyclable, they can make devices that are easy to disassemble. Nevertheless, an outlook that focuses on design and use, like the predominant paradigm in the philosophy of technology, invites us to do, risks ignoring the entire life cycle of technology. Adopting a maintenance perspective, which means focusing on technology over time, helps to prevent this limited view of technology.

It is important to acknowledge that discarding technology is not a value-free process because it is connected to value-sensitive issues such as sustainability, justice and safety. For example, many discarded clothes and

computer technologies end up in markets or landfills in the Global South, where they are often disassembled or repurposed. Therefore, the discard domain can realise specific values like the use domain. The values realised in the discard domain are related to the intended values designers aim to achieve when the technology is discarded. Designers can significantly promote sustainability, safety and other values during the discard phase by making the technology easy to disassemble and break down into recyclable parts.

Besides the domains of design, use and discard, there is yet another domain that we should consider. In taking the social embeddedness of use and design seriously, our thinking needs to reflect that the intended values of design do not arise from a social vacuum. Therefore, adding pre-design as a fourth domain to our analysis is crucial.

The pre-design domain encompasses the social and cultural factors that contribute to the values intended by designers. For example, the values that engineering students internalise during their education play a crucial role in shaping the intended values of the technology they develop. However, the values they learn in their education are influenced by larger social contexts, such as cultural norms and expectations.

Additionally, the domain of pre-design includes the demands of employers and purchasers of technology. These demands are not isolated from larger social values and expectations and are often shaped by them. For instance, a company may demand that its technology be designed to minimise environmental impact or prioritise user safety.

A maintenance account of value and technology requires us to adopt a comprehensive perspective that considers the entire social life of technology. To achieve this comprehensive view, we must focus on the four domains introduced earlier, namely design, use, discard and pre-design and examine how maintenance relates to values in each domain. The central idea is that maintaining each domain helps maintain the associated values. The relation of maintenance, domains and values can be illustrated in Figure 9.2, which I adapted from van de Poel and Kroes (van de Poel and Kroes, 2014; van de Poel, 2020).

In the remainder, we will elaborate on the maintenance of pre-design, design, use and discard. It should be noted that there may be an overlap between the types of maintenance, and my analysis is not exhaustive. Furthermore, maintaining one domain can contribute to the maintenance of multiple values.

To elaborate on the *maintenance of pre-design*, it is important to consider the various social domains that shape the intended values that go into the design of technology. As mentioned, engineering education plays a significant role in shaping students' values and beliefs. In their courses, students are often confronted with tasks, materials and projects highlighting the importance of instrumental values related to efficiency and cost reduction.

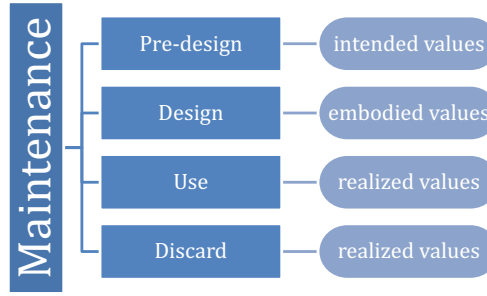

Figure 9.2 Maintenance of value domains.

Students internalise these values, later shaping their design decisions about intended values. Maintaining the status quo of engineering education that features courses and curricula that mainly focus on some values and not others, the university contributes (unintentionally) to maintaining some intended values and not others. This need not be the case, however, and universities may opt for what Henke and Sims call 'repair as transformation' (2020, p. 21), which means finding ways to repair while changing some practices, instead of simply repairing to conserve the status quo. For instance, by including ethics education, students may also internalise moral and social values that can inform the design of their future projects.

To further illustrate the maintenance of pre-design, consider the impact of social and cultural norms on the intended values of technology design. For example, gender roles and stereotypes may be deeply ingrained and could influence the intended values of technology design. Maintaining a status quo that perpetuates these norms would likely result in technologies that reinforce and perpetuate gender biases and inequalities.

Maintenance of design relates to the maintenance of social factors that influence the design of technology and its embodied values. Embodied values are the values for which technology is intentionally designed to facilitate. To illustrate, let us consider a previous example of rules and regulations that prescribe which values should be intended and promoted in technology design, such as rules concerning safety and sustainability standards. By motivating designers to create technology in a certain way, these institutions make it likely that the technology furthers specific values. Maintaining institutions that ensure the technology is adequately designed then maintains embodied values.

Recall that intended and embodied values can misalign, for instance, when the technology is not designed correctly, is misused or has unintended consequences. Some practices, such as the tendency or even requirement to choose the cheapest design option to save costs, can contribute to

this misalignment since designing affordably may come at the expense of other values, such as the health and well-being of users. Thus, maintaining these practices through economic incentives perpetuates the mismatch between intended and embodied values.

Maintenance of use concerns the conservation of factors that affect technology use, thereby maintaining realised values. Like pre-design and design, social institutions such as customs, laws and regulations are crucial in maintaining specific technology use. Maintaining certain norms of technology use through incentives or sanctions can ensure that technology is used according to its intended purposes and values. For example, laws that govern the use of vehicles and organisations that enforce sanctions, like the police and courts, aim to ensure that cars are used safely. The government may also reward specific technology use by providing tax breaks.

When technology is not used as intended, and intended values and realised values misalign, society and designers must find ways to maintain specific technology use. Municipalities, for instance, may create new regulations to increase the safe use of E-scooters by restricting where they can be ridden. Besides social maintenance of use, there is also technical maintenance of use. Designers have tools to maintain specific technology use, such as apps needed to operate the scooter, which can restrict where the scooter can be parked or limit the maximum velocity in certain areas of the town, realising the value of safety in traffic. Designers can also achieve technical maintenance of use by designing technology with specific affordances (Klenk, 2020; Steinert and Dennis, 2022), which makes particular forms of technology use more likely, thereby maintaining realised values.

There is some overlap between the different forms of maintenance, which means that maintaining one domain, and its accompanying values, can contribute to maintaining other values. This is particularly evident in the maintenance of use. When social institutions or affordances maintain a specific use of technology, it maintains the realised value and embodied value because the latter is intended by the designers and realised in use. In other words, by maintaining a specific use of technology, designers and society can ensure that the technology's intended values are realised.

Finally, the *maintenance of discard* concerns the factors that influence how technology is treated after it loses its usefulness and hence, which values are realised in this treatment. Discard shares many similarities with use and could be viewed as a form of use. Therefore, the aforementioned points about the maintenance of use applies equally to the maintenance of discard. Social institutions, such as norms and laws concerning recycling, contribute to how technology is discarded, and maintaining these institutions maintains the accompanying realised values, such as sustainability. Providing the necessary infrastructure to discard technology can also be a way of maintaining the values associated with discard. For example,

providing convenient opportunities for people to discard their old electronic devices so that they can be collected and appropriately recycled facilitates the realization of values like sustainability and safety.

9.5 Conclusion

The chapter's main purpose has been to demonstrate how examining technology and values from a maintenance perspective can enhance discussions of the relationship between value and technology in the philosophy of technology.

We have explored three fundamental aspects of a maintenance perspective, which have helped us to understand the relationship between maintenance and value more fully. First, taking a maintenance perspective enables us to move beyond the design-centric approach and ask how value stability is maintained after the initial design. Second, the maintenance perspective on technology and value allows us to recognise that technology can sustain values rather than merely destabilise them. Third, maintenance is not limited to preservation but can also be transformative. Adopting a maintenance perspective allows us to consider how the maintenance of technology can contribute to the transformation of values.

The maintenance perspective offers a novel lens to examine technology and value. To demonstrate the usefulness of this perspective, we applied it to socio-technical systems, highlighting how maintaining such systems preserves the values embedded in their components and the relationships between social and technological maintenance. The maintenance perspective also allows us to explore value considerations in the whole life cycle of technology, thereby opening up new avenues for philosophical inquiry into technology and value.

An upshot of a maintenance account of value and technology is that extant perspectives on technology and value should be expanded. Adopting a maintenance perspective can also inspire new investigations within philosophy and ethics of technology. For example, if maintenance practices contribute to the stability of values, then responsible maintenance should supplement responsible design approaches, such as value-sensitive design or design for values (van den Hoven, Vermaas, and van de Poel, 2015; Friedman and Hendry, 2019).

Responsible design aims to facilitate responsible practices of technology design by considering technology's impact on people, the environment and society. As a supplement to responsible design, responsible maintenance would extend these value considerations to technology maintenance.

Responsible maintenance differs from frameworks like design for maintenance and maintainability approaches (Dhillon, 1999). Design for maintenance aims to anticipate and plan for future maintenance needs to ensure

that the technology remains in good condition or continues to promote safety and health (Martinetti and Singh, 2019). Design for maintenance refers to processes during the design phase of technology, while responsible maintenance focuses on the impact of maintenance. Although design for maintenance is relevant and can include important value considerations, responsible maintenance supplements design for maintenance in that it infuses maintenance with value considerations by considering the impact of maintenance on people and society. For instance, by questioning what is maintained and by whom and which values are sustained and transformed through maintenance?

Furthermore, to further develop a maintenance account of value and technology, a possible next step is to investigate the mechanisms of value stability and transformation. For instance, it would be valuable to consider when and under which conditions maintenance practices contribute to stabilising or transforming values. This could involve analysing specific case studies of technology maintenance and their impact on values or developing theoretical frameworks to guide such analyses. Additionally, exploring the ethical implications of maintenance practices and their effects on values could be a fruitful area for further investigation.

One motivation for the chapter was to convince readers that the maintenance perspective can make valuable contributions to the philosophy of technology. A maintenance account of value and technology, which highlights the crucial role of maintenance in sustaining and transforming values, helps to shake loose common assumptions in the field. More work is necessary to establish a complete maintenance account of value and technology. It is key that we maintain our efforts to develop and deepen our understanding of the relationship between maintenance and value in technology.

Notes

1 The idea of affordances originated in ecological psychology and was developed by psychologist James Gibson. According to Gibson, affordances are what the environment 'offers the animal, what it provides or furnishes, either for good or ill' (1979, p. 127). Affordances can be characterised as the relation between the abilities of the organism and the features of the environment (Chemero, 2003). As relational phenomena, affordances depend on the properties of the environment and the features of the agent interacting with it. Design scholar Don Norman applied the idea of affordances to human–technology interactions. Norman proposed that affordances are '[…] perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used' (1988, p. 9). For instance, a doorknob affords grasping whereas a computer mouse and a trackpad afford particular ways of handling. The idea of affordance helps to analyse what technology does and how it does it. Recently, Jenny Davis (Davis, 2020) has presented

mechanisms of affordances that help to discern how technology shapes social behaviour and its political implications.

2 Further discussion of these types of norm changes can be found in Brennan *et al*. (2013, p. 107ff.).

3 I would like to thank the editor for suggesting this example.

4 This is an oversimplification and the phases need not be strictly compartmentalised. There are feedback loops, and the use can inform the design (see, for instance, van de Poel (2020)).

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