Chapter 6
Focussing Philosophy of Engineering: Analyses of Technical Functions and Beyond

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Abstract In this chapter I elaborate on the problematic status of philosophical research on the conceptual, methodological and epistemological questions posed by engineering, and comment on the current efforts to develop this research by means of a philosophy of engineering consisting of collaboration between philosophers and engineers. I describe how recent conceptual analysis of technical functions, leading to the ICE theory of technical functions, has evolved as part of discussions in the philosophy of biology. Attempts to analyse technical functions in collaboration with engineers proved to be difficult by the engineering criteria of effectiveness and efficiency. These criteria provide room for straightforward analyses of technical functions but less so for analyses that contain philosophical detail. The ICE theory, for instance, is of limited use to engineers; a simplification of it, which I present and call the Fiat account of technical functions, is more suited to engineering but is in turn of less interest to philosophy. I conclude that profitable collaboration between philosophers and engineers is difficult and that research on conceptual, methodological and epistemological issues of engineering may better be developed by making it relevant to existing research in philosophy of technology. Philosophy of technology harbours on-going research on, for instance, ethical, social and political questions posed by engineering, and can also harbour on-going research on conceptual, methodological and epistemological questions. The current efforts to establish a philosophy of engineering should in my opinion therefore be aimed at creating an active link to philosophy of technology.

6.1 Introduction

Engineering is a rich source for philosophical analysis and it is a source that has been tapped unevenly. Engineers design and create many of the entities we are living with and as such engineering amounts to all sorts of ethical, social, political,

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phenomenological, anthropological, ontological and metaphysical questions. Many of these questions concern our way of living in a fairly direct and clear way. Possibly for this reason these questions made their way to philosophy, defining by now well-established and self-propelling lines of research that, under the heading of philosophy of technology, range from phenomenology of technology to engineering ethics. Engineering is, however, not only about entity design and creation; engineers also produce the technological tools, methods and knowledge that are used for the designing and creating. This second aspect of engineering amounts again to all sorts of philosophical questions, now conceptual, methodological and epistemological ones. Yet, even though some of these further questions made their way to philosophy, research on them seems not to be developing into self-contained research lines. In a recent encyclopaedic overview of philosophy of technology, Carl Mitcham observes, for instance, that "[e]pistemology has often been treated as a stepchild in the philosophy of technology family of philosophical interests."[1] One reason for this position is according to Mitcham that analyses of technological knowledge have regularly been conducted as part of discussions of the relation between technology and science. And even though the topic is gradually emancipating itself from philosophy of science, Mitcham describes the characterisation of basic epistemic criteria of engineering, such as effectiveness and efficiency, as a challenge rather than as something that has already been achieved. Finally the relevance of epistemological analyses of technological knowledge to ethics and politics of technology is still problematic.[2]

In this contribution I elaborate on this problematic status of philosophical research on the conceptual, methodological and epistemological questions posed by engineering, and comment on the current efforts to develop this research by means of a philosophy of engineering that consists of collaboration between philosophers and engineers. I do not consider research on technological knowledge but describe how recent conceptual analysis of technical functions at the Delft University of Technology has evolved. This analysis may be taken as a clear example of philosophical research on engineering. Yet, amplifying Mitcham's observations, I argue that it again has been conducted as part of discussions of a topic outside of engineering. Attempts to analyse technical functions in collaboration with engineers, specifically design methodologists and engineering ontologists, proved to be difficult. Precisely the engineering criteria of effectiveness and efficiency provide room for rather straightforward analyses of technical functions only and prevent mutual profitable collaboration: philosophical conceptual sophistication becomes for engineers quite quickly unproductive hair-splitting, and engineering pragmatism may become for philosophy conceptual shallowness. The analyses of technical functions, which led to the ICE theory of technical functions, was therefore primarily conducted by contrasting technical functions with biological functions. The conclusion I draw from these experiences is that if conceptual analysis is to emancipate itself

[1] Mitcham (2006, p. 548).
[2] Mitcham (2006, p. 549).

and to evolve into a viable research line, then engineers are not the best partners to focus on. This analysis better connects up with existing research in philosophy of technology. The analysis of technical functions can be made relevant to, for instance, ethical research on technology, thus opening up a large research community to this analysis, a community which is moreover susceptible to conceptual sophistication. Generalising this conclusion, I conjecture that research on conceptual, methodological and epistemological issues of engineering may best be developed by making it relevant to existing research in philosophy of technology. Philosophy of technology harbours on-going research on the ethical, social, political, phenomenological, anthropological, ontological and metaphysical questions posed by engineering, and can also harbour on-going research on the remaining questions posed by engineering. The current efforts to establish a philosophy of engineering should in my opinion therefore be aimed at creating an active link to philosophy of technology.

In Section 6.2 I introduce the Delft analysis of technical functions and present the resulting ICE theory. In Section 6.3 the limited use of the ICE theory to engineering is sketched. It is argued that the ICE theory can be simplified to an account, which I will call the *Fiat account* of technical functions, that is more useful to engineering. Yet, this Fiat account is philosophically less interesting and thus rather a step away from a philosophy of engineering. In Section 6.4 I end with sketching ways in which conceptual, methodological and epistemological research on engineering may be established more successfully within philosophy of technology.

6.2 The Eccentric Development of the ICE Theory

The development of the ICE theory of technical functions at the Delft University of Technology may count as a research effort that falls squarely within the field of philosophy of engineering. The starting point of this effort was the *dual nature of technical artefacts*, as laid down in a research program with the same name (Kroes et al. 1999; Kroes and Meijers 2002, 2006). Technical artefacts are in this program taken as entities with a conceptually dual nature since proper descriptions of technical artefacts as "(*i*) designed physical structures, which realize (*ii*) functions, which refer to human intentionality,"[3] combine both structural and intentional concepts. The concept of technical function was taken as playing a central role in connecting the structural and intentional natures of technical artefacts, and together with the program's plea to an empirical turn to conduct philosophy with a close focus on engineering practices (see also Kroes and Meijers 2000), the goal was set to come up with an analysis of technical functions based on engineering sources. Hence, the effort, to be conducted by Wybo Houkes and myself, was defined by a philosophical question about technical artefacts and positioned at the interface of philosophy and engineering. Carrying it out led us however quickly outside of engineering and inside of the philosophical analysis of functions in biology and the philosophy of

[3] Kroes and Meijers (2006, p. 2).

mind. The main reason for this "eccentric" move away from the engineering core to topics that may be taken as peripheral to engineering and philosophy of engineering, was a general lack of consensus within engineering on how to define the concept of technical functions; existing philosophical research on specifically biological functions provided a better starting point for analysing technical functions.

In the engineering literature and specifically in the engineering design methodology literature one can find multiple sources in which definitions of technical functions are given. The precision of these definitions may vary from quite loose to more detailed, but more problematic for a philosophical analysis of technical functions is that the meanings that these definitions single out are quite diverse: authors may take functions as purposes (e.g., Gero 1990; Modarres and Cheon 1999), as intended parts of behaviour (e.g., Chandrasekaran and Josephson 2000; Bell et al. 2007) or as behaviour that contributes to satisfying needs (e.g., Stone and Wood 2000). This lack of engineering consensus is already noted by the design methodologists themselves (e.g., Umeda and Tomiyama 1997; Chittaro and Kumar 1998; Hubka and Eder 2001) but seems also a situation that they accept: they observe that the co-existence of different meanings of the term function complicates the communicating and archiving of functional descriptions of artefacts, yet individual design methodologists hardly argue that the meanings they propose are the only right ones. The engineering position seems rather to be that this co-existence of different meanings should be managed, say, by accommodating them all into overarching engineering ontologies, such that functional descriptions using one meaning can be translated into functional descriptions employing other meanings.[4]

In the philosophical literature there are also analyses of technical functions to be found. Again positions vary but by having a common starting point in the work by especially Robert Cummins (1975) and Larry Wright (1973), authors more or less are agreeing that functions are in general to be taken as capacities or dispositions of the items concerned. This philosophical literature does not focus on engineering. Typically authors (e.g., Cummins 1975; Neander 1991a,b; Millikan 1984, 1989, 1993; Searle 1995; Preston 1998) come up with accounts of a general concept of functions that they applied to and defended for the domains of biology, psychology or social reality; they apply these accounts also to the domain of engineering but typically only "in passing" and typically without spending much time on proving the tenability of the results.

Given these findings, a natural first step towards a proper analysis of technical functions was to ignore the multitude of definitions given by engineers – developing an account of technical functions on the basis of this multitude would mean merely making a choice between the different options – and to arrive at an account of

[4] I return to engineering ontologies in Section 6.4 since despite their "neutral" use for translating different types of functional descriptions, they also contain new definitions of functions that are sometimes put forward as more fundamental. Compare, for instance, Kitamura et al. (2005/2006) with Kitamura et al. (2007): in the first paper the emphasis is on a separate ontological definition of function relative to which existing meanings can be positioned, and in the second the focus is on the conversion of functional descriptions based on different meanings without singling out a privileged one.

technical functions on the basis of philosophical analyses of functions that is tenable by engineering standards. The first task therefore became to define these engineering standards. Such standards could not consist of a requirement that an account of technical functions reproduces the definitions of technical functions that engineers put forward: by the multitude of engineering definitions such standards would be meaningless. What was needed were standards that capture general features of technical functions independently of specific positions in engineering. In (Vermaas and Houkes 2003) a first formulation of such standards were given and used to argue that the in philosophy popular etiological approach towards functions cannot provide for a tenable account of technical functions. These standards were presented as desiderata and formulated quite liberally in order to make them as reasonable as possible; arriving at an account of technical functions on the basis of a set of standards that engineers and philosophers do not accept in the first place, would not to work.[5] The desiderata are the following:[6]

The proper-accidental desideratum:
A theory of artefacts should allow that artefacts have both a few enduring proper functions and an unlimited number of more transient accidental functions.
The malfunctioning desideratum:
A theory of artefacts should introduce a concept of a proper function that allows malfunctioning.
The support desideratum:
A theory of artefacts should bring about that there exists a measure of support for ascribing a function to an artefact, even if the artefact is dysfunctional or if it has a function only transiently.
The innovation desideratum:
A theory of artefacts should be able to ascribe intuitively correct functions to innovative artefacts.

Having rejected by means of these desiderata the etiological approach towards functions, the second task became to give an account of technical functions that does meet them. This account was presented in Houkes and Vermaas (2004), now linking it to another philosophy project, namely the metaphysical project of defining artefact kinds by means of their technical functions. Our account is called the ICE theory and is one which deals primarily with agents ascribing technical functions to artefacts:[7]

An agent *a* justifiably ascribes the physicochemical capacity to ϕ as a function to an artefact *x*, relative to a use plan *p* for *x* and relative to an account *A*, iff:
I. *a* believes that *x* has the capacity to ϕ; and
a believes that *p* leads to its goals due to, in part, *x*'s capacity to ϕ; and
C. *a* can on the basis of *A* justify these beliefs; and
E. *a* communicated *p* and testified these beliefs to other agents, or
a received *p* and testimony that the designer *d* believes these beliefs.

[5]This strategy worked in part. In a response Preston (2003) argued for giving up the innovation desideratum within her etiological account of functions.

[6]The formulations originate from Houkes and Vermaas (2009) and are at points different to the ones in Vermaas and Houkes (2003).

[7]The formulation originates from Houkes and Vermaas (2009) and is at points different to the ones given in Houkes and Vermaas (2004) and Vermaas and Houkes (2006).

The notion of a use plan that is part of this definition is one we developed in (Houkes et al. 2002) as part of an action-theoretical characterisation of the acts of designing and of using technical artefacts. A use plan p of an artefact x is a series of considered actions that includes at least one action that can be taken as a manipulation of x. Using x can be described as the carrying out of a use plan p for x for achieving the goal associated with the plan, and designing can be described as the development of such a use plan, including the description of how to create the artefact x if it does not yet exist, and as the communication of the plan to the prospective users.

When the above definition is applied to expert designers, the first E-condition applies and the account A consists typically of experiential, scientific and technological knowledge. For knowledgeable users the second E-condition applies and A consists again of experiential, scientific and technological knowledge. For general users the second E-condition applies and the account A typically consists of experiential knowledge and testimony provided by the designers of the plans p.

With the ICE theory in place we could after the eccentric detour via peripheral topics, return to the original dual-nature question and propose how the concept of technical function relates the two natures of technical artefacts. Paraphrasing (Vermaas and Houkes 2006), technical functions may be taken as *highlighting* the structural physicochemical capacities of technical artefacts that play a role within the intentional plans by which users can attain goals. Function ascriptions may, however, also *cloak* one of these natures by allowing agents to ignore one description in favour of the other. Engineers may, for instance, focus only on the physicochemical description of artefacts by pointing out that some of their physicochemical capacities are their functions; in doing this, they highlight the capacities of the artefacts relative to a use plan that is left implicit. Users, if they ascribe functions to artefacts, may focus only on the intentional descriptions of these artefacts; by ascribing functions they describe the artefacts as having specific roles in use plans by virtue of their physicochemical make-up but ignore the explanation of how this make-up enables the artefacts to play these roles. The concept of technical functions thus connects the structural and intentional natures of technical artefacts, but also allows for separating them.

Hence, given this return to the original question about technical artefacts, one can indeed argue that the ICE theory falls within philosophy of engineering. Yet, by the eccentric detour by which it was developed, research on this account of technical functions counts more as function theory as it is done in philosophy of biology and philosophy of mind, or even as action theory or metaphysics.

6.3 The Limited Use of the ICE Theory in Engineering

Accepting the eccentric genesis of the ICE theory, one may take the position that its future development can take place with a more definite focus on engineering, thus establishing research that does count as a philosophy of engineering in which philosophers and engineers collaborate. Against this position it can unfortunately be argued that the ICE theory will be of limited use to engineering. Because of the co-existence of different meanings of technical function in engineering, the ICE theory will count for engineering as just another analysis for understanding technical functions. And because of the engineering criteria of effectiveness and efficiency that Mitcham (2006) mentioned in his discussion of epistemology research on technology (see above in the introductory section), incorporation of the ICE theory by engineering in their current spectrum of options, makes sense only if it has clear benefits. It may be said that the ICE theory has the benefit of conceptual precision, and it may be the philosopher's hope that that is for that reason also appreciated in engineering, for instance, for the development of the already mentioned engineering ontologies. What, however, counts against incorporating the ICE theory in engineering, including engineering ontologies, is the wealth of additional concepts it analyses functions with, such as use plans, justifications of beliefs and communication between agents. Hence, if one rejects a strongly revisionary position that its use is that it tells engineers how they actually (ought to) understand technical functions, the ICE theory is merely one duck in the engineering pond, and one that has strange feathers. And by these strange feathers, it may be doubted that engineers will be tempted to adopt the ICE theory; by the wealth of additional concepts it introduces compared to existing accounts of technical functions, engineers will arguably more effectively and efficiently design and create technical artefacts when they stick to one of the existing accounts.

To some extent the ICE theory can be stripped from its strange feathers. As sketched at the end of the last section, engineers can cloak the intentional part of the description of technical artefacts and highlight with functional descriptions their relevant capacities while leaving their use plans implicit. The use plan for a series of components c, c', c'', ... of artefacts, for instance, may have the following form: compose c, c', c'', ... in configuration k in order to obtain an artefact x with the capacity to ψ. This plan is, more precisely, a use plan for designers that have the goal of obtaining an artefact x with the capacity to ψ. Consider now an engineer e that applies this component use plan as part of his or her designing. This engineer can now ascribe the capacity to ϕ as an ICE function to c relative to the component use plan. Substituting this use plan in the ICE definition and suppressing the goal orientedness of the use of the components, yields the following result:[8]

> An engineer e justifiably ascribes the physicochemical capacity to ϕ as a function to the component c, relative to the composition of c, c', c'', ... in configuration k of an artefact x with the physicochemical capacity to ψ, and relative to scientific and technological knowledge, iff:
>
> I. e believes that c has the capacity to ϕ; and
> e believes that x has the capacity to ψ due to, in part, c's capacity to ϕ; and
>
> C. e can on the basis of scientific and technological knowledge justify these beliefs.

[8] Vermaas (2006); the current formulation originates from Houkes and Vermaas (2009).

Notions such as use plans and communication between agents are cloaked in this formulation; only justifications of beliefs and the knowledge used for these justifications are mentioned.

Still this formulation is much too complicated to make the theory suitable for adoption in, say, engineering ontologies (van Renssen et al. 2007). In order to be applicable in engineering, it seems that more needs to be suppressed in the ICE theory, like the type of knowledge used for justifying the beliefs about the capacities of artefacts and their components, and possibly also that engineers *are* justifying these beliefs: one can take the position that engineers have the relevant scientific and technological justifications by default.

If one proceeds in this way, one ends up with an account of technical functions that may be called the *Fiat account*. By this account it are the engineers themselves who *by decision* determine technical functions, since as experts in technology and science their decisions are implying the right justified beliefs. Return to the above components. If engineers indeed compose the components c, c', c'', ... for obtaining an artefact x with the capacity to ψ, because c has the capacity to ϕ, c' has the capacity to ϕ', et cetera, then one may argue that the I and C-conditions in the above engineering version of the ICE theory are satisfied, and that c thus can be ascribed to ϕ as a technical function, c' can be ascribed to ϕ' as a technical function, et cetera. Generalising this to artefacts as a whole and taking engineering ascriptions of technical functions as statements that artefacts *have* functions, the Fiat account becomes:

> An artefact x has the physicochemical capacity to ϕ as a function iff engineers decide that x has to ϕ as a technologically useful physicochemical capacity, and lay down this decision in engineering documentation such as design documents, patents and technical handbooks.

This Fiat account is a clear *intentionalist* account of technical functions: the beliefs of engineers about technical artefacts fix their technical functions. The reference to engineering documentation is now added to avoid a well-known problem for intentionalist accounts, posed by beliefs of would-be, crackpot engineers: in order to rule out unrealistic function ascriptions, say, perpetual motion machines that get the function to provide infinite energy, it is required that the decisions that ground function ascriptions are laid down in engineering documentation and thus are meeting the standards that apply to such documentation. The Fiat account is thus also a *social-expert* account of technical functions: the beliefs of engineers fix technical functions only if these beliefs are accepted within the professional discipline of engineering.

This Fiat account lacks the philosophical subtleties part of the ICE theory. With the Fiat account the dual-nature question of how technical functions are connecting the structural and intentional natures of technical artefacts cannot anymore be answered straightforwardly: it becomes, for instance, unclear in the Fiat account how technical functions are related to the goals for which users manipulate technical artefacts. Yet, it fares relatively well when evaluated against the four desiderata given in the previous section. If within the Fiat account the proper functions of artefacts are taken as the technologically useful physicochemical capacities of those artefacts that engineers "canonise" for longer periods by laying them down in their more enduring patents and handbooks, and if accidental functions are taken as the technologically useful physicochemical capacities that engineers occasionally lay down in their design documentation but do not canonise for longer periods, then the proper-accidental desideratum is by and large met. The Fiat account allows also for malfunctioning: if engineers decide that an artefact x has to ϕ as a technologically useful physicochemical capacity and lay this decision down in their documentation, then the artefact has to ϕ as its (proper) technical function in the Fiat account, even if it (temporarily) does not have to ϕ as an actual capacity. The account provides support for the ascriptions of technical functions, since engineers have the status of technological and scientific experts. Only with respect to the innovation desideratum one can raise some doubts. The Fiat account ascribes intuitively correct functions to innovative artefacts in so far engineers have themselves come up with the innovation: such functions are laid down in the design documents about the innovative artefacts. Yet, users can also come up with innovation, say when using artefacts in ways that are not anticipated by engineers, or not accepted by engineers. Such innovation may be captured in terms of technical functions as well, say, when cars are described as having the function to let crying infants fall asleep and coins as having the function to open tins. Such innovative functions typically will not make it to engineering documentation, and thus do not count as technical functions in the Fiat account. Whether engineers mind that such innovative user functions cannot be taken as true technical functions, may be doubted.[9]

The upshot of this digression is that the ICE theory may be stripped from its wealth of concepts – use plans, justifications of beliefs, communication between agents – in order to make is more useful for engineering. The Fiat account one then may end up with is acceptable within limits, and may be used to, for instance, develop engineering ontologies: the Fiat account suggests including functions in such ontologies as physicochemical capacities that are reported in engineering documentation as technologically useful capacities of technical artefacts. Yet, this stripping can hardly be taken as a development of the ICE theory or as furthering philosophy of engineering. Assuming that the ICE theory does meet the four desiderata for accounts of technical functions[10] and given that the Fiat account cannot answer straightforwardly the dual-nature question about technical artefacts, the transition to the Fiat account seems rather a step backwards. The for engineering less useful concepts part of the ICE theory, which may be taken as due to its origin in philosophy of biology and action-theory, are rather elements to hold on to in a philosophy of engineering.

6.4 Focussing the ICE Theory on Philosophy of Technology

The above discussion of experiences with developing the ICE theory suggest that philosophical research on conceptual, methodological and epistemological questions can better not be established with a focus on engineers. In this final section I

[9]Examples of functions that are determined by users only, may also be used to argue that the Fiat account does not fully meet the proper-accidental desideratum.

[10]See Houkes and Vermaas (2009).

briefly elaborate on this suggestion and end with conjecturing that a focus on existing research in the philosophy of technology is for now the best way to proceed.

It may be argued that my negative conclusion about doing philosophy of engineering in interaction with engineers is due to a focus on the existing engineering community at large. Doing interesting philosophy of engineering in collaborating with mainstream design methodologists or engineering ontologists may indeed be difficult, but that does not rule out that individual engineers are willing to consider philosophical subtleties without an immediate demand to technological usefulness. Walter G. Vincenti's (1990) book on technological knowledge in aeronautical engineering, for instance, and the work by Louis L. Bucciarelli (1994) and Billy V. Koen (2003), prove that such engineers exist.

This response is valid and one indeed can argue that within engineering a less pragmatic interest in philosophy is present and may be growing. Firstly, returning to the ICE theory and engineering ontologies, it may be argued that engineers have to eventually become interested in more elaborate accounts of technical functions as provided by philosophy. As said in Section 6.2, engineering ontologies may on first sight be aimed at translating different types of engineering functional descriptions into one another, yet, in order to achieve that, engineering ontologies themselves have to incorporate a precise notion of technical function. Kitamura et al. (2005/2006), for instance, are introducing such a precise notion. Secondly, in a recent assessment of the state of the field, Kees Dorst (2008) argued that design methodology has up to now been concerned mainly with the design *process*, and ignored three other aspects of designing, being the *object* of this designing, the *designer* itself and the *context* of design. Moreover, research on the design process makes, according to Dorst, often a too quick jump from description to prescription, ignoring the, in Dorst's view, intermediate phase in which (the courses of) design processes are explained. Dorst announces a Kuhnian revolution in design methodology that will transform it to a field in which all four aspects are studied in a more encompassing and analytic way. Clearly, when such new research emerges in engineering, it will provide ample means for collaboration between philosophers and engineers. Yet, Dorst calls this revolution also *a-revolution-waiting-to-happen*. Hence, despite the promises that may exist for a philosophy of engineering that focuses on engineering, the current state is still that there exists in engineering only a limited number of points of contact for philosophical research on conceptual, methodological and epistemological questions. For propelling this research one better can look – also – at other partners in academia.

In my view these other partners can be found in existing research on topics that traditionally have been subsumed under the heading of philosophy of technology. Ethics seems to me a prime candidate. In the ethics of technology the design process is increasingly becoming part of the analysis as a locus at which ethical considerations are at play and should be made manifest, as is, for instance, exemplified in the emerging interest in the notion of value-sensitive designing (e.g., Friedman 1997; van de Poel 2001). An ethical analysis of the design process presupposes understanding how this process in carried out by engineers and this defines a common interest with research on the conceptual, methodological and epistemological questions of engineering. Moreover, collaboration with the ethicists in research on engineering may be expected to lead to further conceptual, methodological and epistemological questions about engineering and thus to broadening and deepening this research rather than to simplifying matters. Finally, collaboration would immediately make clear the relevance of this research. In this volume on philosophy of engineering a first example of what such an interaction may result in is given by the chapter by Auke Pols, in which parts of the ICE theory of technical functions are used to consider the ethical responsibilities of engineers. Another example could be research on the first conceptual phase of design, in which engineers are by a number of design methodologies, advised to analyse their design tasks in terms of functional requirements. The required overall functions of the product-to-be are in this conceptual phase to be decomposed into series of subfunctions, instead of to be immediately linked to existing design solutions for the overall functions, in order to increase the innovation and flexibility of the design. Analysing the ethical values in play in this first conceptual phase defines a joint research effort of both ethicists and philosophers of engineering.

Beyond collaboration with ethicists of technology one can also envisages a convergence of research on conceptual, methodological and epistemological questions and of research on the politics of technology. Technical artefacts are increasingly analysed as parts of socio-technical systems, which are amalgams of artefacts, agents and social objects. The understanding of such socio-technical systems poses all kinds of new conceptual questions for a philosophy of engineering, an understanding that at some point may contribute to more political studies of technology as exemplified by Langdon Winner's (1980) analysis of the politics of technical artefacts.

To sum up: engineering is a rich source for philosophical analysis, and a source that can establish a self-contained and viable philosophy of engineering if it is tapped with a focus on existing ethical and political research in philosophy of technology. Developing philosophy of engineering with a focus on engineering and in collaboration with engineers may at this point hamper its viability because of the current engineering interests in research that is fairly immediately useful. A direct focus on engineering may prove viable in the (near) future; for now the future of philosophy of engineering lies, to my mind, within the discipline of philosophy of technology.

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