“What people want” is not a guide to how the world actually works

Peter K. Haff in conversation with Jürgen Renn

This interview has been edited for length and clarity. It is here adapted from the German version published in Technosphäre*, edited by Katrin Klingan and Christoph Rosol (Berlin: Matthes & Seitz, 2019, pp. 26–46).*

Jürgen Renn: If I understand you correctly, you see the technosphere as a system that acts as a system on many levels. From this conception a number of questions arise: What does “system” mean here? What does the system entail? And what are the conditions for a system to exist as a system, to be something more than just the sum of its parts?

Peter K. Haff: I take “system,” in the sense that I’m using it here, as simply a collection of parts. We might not know what all those parts are. But in a system, those parts act in a way that is collective or coherent enough that we can observe and describe at some level to another person. We can recognize the collective movements of the system and mutually understand the description of it, even if we cannot articulate what each individual component is doing.

So, the description of coherence and organization gives us a handle on what we mean by the system. What I have tried to do in my research is to ask: what general physical principles apply to the system in question, the technosphere, and what do they have to say about the human condition—given that humans are "just" a particular set of system parts? This approach frames, or reframes, the debate about the Anthropocene by identifying physically-grounded guidelines and limitations, or "rules," relevant to the interactions and behavior of humans and technological artifacts and to their connections to larger-scale technospheric behavior. It ties the "social" and "geological" Anthropocenes to their common underlying physical basis, but is not reductionist, nor need it disrupt the cultural milieu or language of any group, movement, or tradition—provided that language does not contradict the underlying physical requirements. Being subject to such requirements or rules should be no more alarming to most residents of the technosphere than is their subjection, should they be aware of it, to the law of conservation of energy. Whatever their individual backgrounds might be, by recognizing these rules and acting on our knowledge of them, humans as a whole will be better positioned to exert leverage on the trajectory of the technosphere.

JR: One of my concerns, Peter, as a historian, is of course to identify at what point can we begin to talk about the technosphere as a system. There are different suggestions as to when the Anthropocene started. Proposals range from the invention of fire, the extinction of the great mammals in the Late Pleistocene, via the Neolithic Revolution, the Industrial Revolution, to the Great Acceleration of the mid-twentieth century. Is it the case that all these proposals qualify as an entry point into the technosphere? If I understand you correctly, the technosphere is about infrastructures and a new way of metabolizing with the planet. And indeed, each of these major thresholds has introduced novel infrastructures or kinds

of human interventions in the Earth system. What does this imply for the beginning of the technosphere?

You might argue that the crucial point for the birth of the technosphere is its self-organization, that is, the self-organization of large technological systems.I would say we see such self-organization in the mid-twentieth century at the earliest, at the time of the Great Acceleration, if not at some point later or even in the future. So, if you asked me when the technosphere as a system emerged, I would answer: not at any of the earlier thresholds. I think we are only now on the verge of entering it. And we may still be at a point where we can control these large technological systems. If we can do so seems to be the crucial question! Let me put it this way: do we still have the opportunity to steer the Earth system? I believe we still do, even if time is ticking. And if we do, we have not yet really entered the technosphere. In other words, the technosphere for me is not a realistic description of where we stand, but a utopian or rather dystopian vision of some not-too-distant future. So, to summarize, I very much like the concept because it captures those systematic aspects which we are subject to as human actors; I think it's a powerful concept, but I see it as only one possible option for the future state of the "human-Earth system," one that we may not have reached yet and hopefully never will. And my question to you is very simple: do you think the technosphere describes the current or even past states of the human-Earth system? Or do you agree with me, that we are just on the verge of it?

PH: I look at it a little bit differently. First of all, I don't consider the technosphere to be just a collection of technologies exclusive to humans. My conception of the technosphere is the total system of technological components. To be precise, let's call them artifacts plus humans. Because if for some reason you just had collections of technological artifacts around without humans, then you would have something very differ-

ent from the technosphere. And if you have a very large number of humans around without any technological artifacts, you'd have a very different situation; in fact, neither of those would survive without the other.

Christoph sent me an excerpt from your upcoming book The Evolution of Knowledge: Rethinking Science in the Anthropocene. You talk about the technosphere as a "shell," and I had the impression that you were thinking of it as a kind of rigid, essentially purely technological shell; that humans have erected infrastructure of all kinds, like power lines and buildings, and that, who knows, maybe the whole thing is so brittle it could break under certain kinds of fairly modest stress. If that were the extent of the technosphere, then I would agree with you. But in the picture that I have, you can imagine a network with nodes on it, and the nodes are technological artifacts like transformers, and transistors, and computers, and cars, but also humans—and if artifacts and humans are the nodes of a network, then each of those nodes is connected to at least one and usually multiple other nodes. That network would be the technosphere. So, it might be fragile, I don't know—we don't know what the future will bring, so we don't know—but I don't think it's brittle in quite the sense of your technological shell metaphor.

JR: Peter, I very much like this network image that you introduce, but it seems to apply to both a Neolithic and a modern society. Even in the earlier period of humankind, there was a lot of connectivity, as we know through recent research on human origins and early migrations, and a spread all across the globe, so we can indeed speak of a sphere there as well. So, my question is: would you really apply the notion of a technosphere, as you conceive it, even to these early stages of human development?

PH: That's a good question. You have isolated tribes living today in, say, the Amazon that have had minimal outside contact with other human groups. You could make an argument that they are not even today part of the technosphere. And going back in time to when you had fairly isolated groups of humans in many parts of the world, you might think of some centers of trade and interaction that were connected by trails and pathways and trade routes, but those by no means covered every continent. Today it's different. I would say those were like baby technospheres.

JR: That raises the question of the technosphere's dynamics. You could say that it's shaped by the accumulation of ever-newer forms of interaction among its components. So every time new materials, tools, or infrastructures expand the human metabolism with the Earth system, a new stage of the technosphere is reached, beginning from some loosely-connected system that you designate as "baby technosphere." But even such a baby technosphere would be characterized by what evolutionary biologists term "niche construction," that is, interventions in the environment that shape subsequent evolutionary or historical processes.

PH: Yes, agreed.

JR: And while niche construction is already present in the biological world, niche construction has played a decisive role in the development of human culture from its very beginnings. Ultimately it is all about people and artifacts, as well as the construction of cultural archives. In that sense, any human culture has some of the qualities that you associate with the technosphere, but perhaps initially with fewer and slower interactions. But I wouldn't agree with your description of isolated communities in very early history. They may indeed have been isolated if you consider a timescale of hundreds of years, but over a timescale of thousands of years, we see

migration and interactions taking place almost everywhere, allowing knowledge to spread. In this context, one could perhaps speak of a low-temperature technosphere, to use the physical metaphor once again.

PH: Yes, I think the early technosphere was a very delicate, diffuse, extended, patchy thing—disconnected at times, at others reconnecting. I think that's a fair description. And then if you ask: well, when did this all finally cohere? At what point had it extended itself, in a way that was pretty much irreversible, into each of the major continents of the world? That was perhaps in the early nineteenth or late eighteenth century, by which time North and South America were firmly bound to the rest of the world.

Of course, there was trade going back much earlier, but not on a globally integrated scale. There's a really good description of this in John and William McNeill's book, The Human Web. The history of this web is exactly the history that you've been talking about, of these weakly connected, very dispersed societies whose connections grew ever stronger and thicker and more spread out over time until by, say, 1800, the whole world was drawn together. So, there is no precise definition of the time of origin of the technosphere, but certainly it's up and running strongly now. And, as you say, in the future it could become even more powerful.

Also, I think there's a point that's missed by most people about my own claims for the technosphere. Generally, I have given only a snapshot description of the modern technosphere, that it's basically modern infrastructure like roads and shipping lanes, and the things and people that are connected to that infrastructure. This is the network as we discussed. But this is just a sketch, so that we can start with something in mind. But this sketch is often misinterpreted and understood to mean that the technosphere doesn't include crucially im-

portant factors and features that this world system manifestly has, for example law and politics. But the technosphere is meant to include everything associated not just with technology but with humans too. I hadn't realized the extent of this misconception before and I'd like to discuss it for a moment here.

You mention, for example, the knowledge economy in your writing, which is obviously a critical component. Why is that nowhere to be found in my definition of the technosphere? Well, what I'm trying to do is give the fullest picture of the technosphere that's as comprehensive and at the same time as general as possible. If the technosphere is what the Earth will go through next in a four-plus billion-year history of change, then, to the scientist, the challenge is to understand its emergence and function as a physical phenomenon, that is, in a way that is consistent with what is known about prior Earth history and about the physical nature of the universe. So, I am interested in what I call a regulative description, where I avoid naming the parts of the technosphere in an overly specific way. But really the whole regulative development including the various technosphere rules that I have given elsewhere, and mentioned above can be generalized to such an extent that they can be applied not only to the technosphere, but to any system in general.

JR: I can see that in your description of the technosphere you apply a procedure you've described and designated as "coarse graining," taking an idea of statistical physics to describe large dynamic systems. Coarse graining gives us incredible insights into systems with many components. But sometimes one is interested in the microdynamics underlying such macrosystems.

PH: For sure.

JR: So let me try to take a step in that direction of microdynamics. What I see is that feedback loops and effects accumulate over the course of historical development. Perhaps one of the most obvious examples is the invention of food production during the Neolithic Revolution. In the long-run, it enhanced the possibilities for a growth of the global human population which, in turn, created new requirements for food production. In reality, the Neolithic Revolution took millennia to spread. By the early modern period, a considerable part of humanity still lived from hunting, foraging, and gathering. But once you enter this feedback loop of food production and population growth on a global scale, it is hard to escape it.

In my view, a similar feedback loop emerges when science and technology become relevant to human economies on a global scale—for instance, for industrialized agriculture, health, or systems of energy provision. These global production systems involve intended and unintended effects that require more science and technology—to mitigate the problems of climate change, global health, population growth, and so on. All of these feedback loops speed up the development of the technosphere. I therefore see the technosphere as a growingly interwoven dynamic system that absorbs all of these feedback loops. Some feedback loops may have long historical cycles, whereas other work on shorter timescales. As a whole the technosphere thus becomes ever harder to control because of the strong, non-linear dynamics that underlie the system.

PH: I agree with that. Two of the regulative rules that I have worked with I call the "Rule of Performance" and the "Rule of Provision." In a nutshell, The Rule of Performance says that most of the time, most of the components of the system have to function in a way that is conducive to the maintenance or the survival of the system of which they are a part. But for that to be the case, the parts must experience a suitable local

environment within the technosphere where such behavior is possible. And where does this environment come from? Well, the system must provide it, so it's kind of an effect of the larger system that trickles down through various pathways back to the individual components. That behavior of the system is The Rule of Provision. If the parts are humans, they may not feel it to be a very comfortable level of provision, but provision has to be at least sufficient to enable parts to perform. This relationship is the structure of a feedback loop; the Rule of Performance and the Rule of Provision are its kind of two steps. I agree with you that feedback is the central thing that's going on.

JR: That makes a lot of sense to me, but I wonder what kind of interventions are possible in such a self-organizing, or, I would say, increasingly self-organizing system, and what human actors can still control once we face the global extension of the technosphere. Human actors, in my view, are in a somewhat special category: they are more than just the elements of a computer circuit that simply operate at the lowest scale of the system without the slightest understanding of the system as a whole. Humans have a special capacity to build up in their minds an image of the entire global system. Does that not give us special possibilities of control that we wouldn't have without this capacity?, Are we not more than just elementary particles of a complex system, having our own agency within it?

PH: Well, I would agree that if the human mind doesn't give us the possibility to have any significant influence or control on our future then nothing else will, so it better be somewhere inside the human head that that force comes from. But let me back up a minute, and remind that my analysis of the technosphere always remains abstract, and there is no specific treatment of humans as humans. There is just an abstract system and abstract parts, plus a set of generic rules. Whatever possibilities humans may have for intervention within the

technosphere, these must be consistent with those generic rules, especially the Rule of Performance and the Rule of Provision.

JR: I think you are certainly right that there is a level of abstraction on which one can treat humans as being just as parts of a larger system without denying that they have special properties as parts. But how does that help us to assess our situation?

PH: Not really. But to answer your question about agency, I think we first would have to clarify how the technosphere, while partially dependent on humans, exhibits characteristics of autonomous behavior. All physical systems are "bound" to a condition of externality via their dependence on external sources of energy and materials. Without such resources, which they extract from their environment, they could not maintain their functionality. In this sense the technosphere is not self-sufficient. But like the other spheres, it can certainly run without direct human oversight, although of course not without the participation of its human components.

The atmosphere performs its circulations, swirls, eddies and pressure fluctuations according to its internal dynamics. Similarly, the hydrosphere, lithosphere, and biosphere each executes its characteristic dance without human design, plan, or direction. Every system, however, autonomous or not, requires a source of low-entropy energy to function. The technosphere is no exception. The atmosphere, hydrosphere, and biosphere run mostly on sunlight, while the lithosphere taps into deep geothermal energy sources. Technospheric energy requirements are satisfied largely by recent sunlight in the form of wood or food and through chemical energy derived from ancient solar radiation stored in oil, coal, or gas. Each sphere thus depends on its sister spheres and/or the sun for energy (and other resources), and each runs according to an

internal dynamic that is not under human control. And I would say that the same goes for the technosphere.

Still, going back to the question of agency, you could ask, what could one person do to affect the behavior of a nominally autonomous technosphere? Probably most people would agree that the average person doesn't have that much influence on the overall behavior of any large organization of which they're a part. Individual people can on some occasions have global influence—inventors, CEOs, what have you—but that's not really what we're talking about here. We are talking about control. But what I do think is that, if an individual, if one small part, has little influence on a large system of which it is a component of, that's not necessarily true for a large component of a system.

The wheel on your car is a pretty large component; it's smaller than the car but it's not like a transistor. If the wheel goes flat, that car stops. What about the technosphere? One kind of large component is a collective, or social movement, for example the environmental movement. At a minimum, you need a lot of people who basically are thinking the same way. And "thinking the same way," means they come into a state somewhat like a phase transition.

JR: I agree, but I would like to put the question of control a little differently. The problem is not—as one of your rules has it—that human beings are incapable of controlling systems with a larger range of behaviors than they exhibit themselves. Instead, it lies in the question of what "control" means in the first place. The stewardship of technological systems always depends on their specific material nature, in particular, their embedding in natural and cultural environments, as well as their representation by knowledge and belief systems. We know from historical examples such as sustainable forestry in Japan during the Tokugawa period that humans have been

able to manage and sustain extremely complex ecologies and infrastructures for long historical periods. The potential behaviors of these environments far exceeded those of their human components. But these were typically ecologies and infrastructures in which the relevant regulative structures of human behavior had themselves been co-evolving with those of their natural components over longer periods, including their representation by knowledge and belief systems. The effective complexity of knowledge systems does not necessarily grow in proportion to that of the technological and environmental systems steered by them. Your own imagery of a technosphere that is subject to the principles of thermodynamics is a wonderful illustration of this claim because it's so tantalizingly simple.

But let me bring in another point here: what role does politics play? The concept of the technosphere does not hold a special place for this dimension of human agency, other than the kind of collective behavior of components to which you just referred. This shortcoming was recently the subject of controversial debate. The way that humans can or cannot organize themselves is precisely the question addressed by political science. That discipline involves concepts such as power structures, inequality, and capitalism. Some scholars have even proposed to speak of a "Capitalocene" rather than the Anthropocene to emphasize the unevenly distributed responsibilities for the state in which we find ourselves. So the question is: how useful is the concept of the technosphere if it doesn't offer new analytical tools to address political and economic developments which may eventually bring the Earth system to a state in which it will be much more difficult to survive and to preserve human culture as we know it? Does the technosphere ultimately confront us with a technocratic metaphor of our predicament, and distract us from the need to learn more about the underlying social and political transformations in order to act according to that knowledge?

PH: One of the reasons for appealing to a physical picture of the Anthropocene, as embodied by the technosphere, is to avoid the temptation to assume that human desiderata take precedence over physical laws. The technosphere concept has been criticized for not elevating commonly voiced goals, such as sustainability, to a "cannot argue with" proposition that would guide our understanding of technospheric function. "What humans want" is not, however, a benchmark for deciding how the world actually works, but simply a tentative guide to a livable future. Before committing to a strategic approach, we first need an understanding of the basic physical properties of the relevant part of the world in which we actually find ourselves, the technosphere.

This system has its own intrinsic agency and purpose, namely it acts to survive, and any given path of how that purpose plays out is not necessarily aligned with the future that we want for ourselves. So yes, there may be antagonism between human agency and the agency of the technosphere. But misalignment of purpose is something humans are used to dealing with in everyday life. With two parties at the bargaining table, humans versus the technosphere, humans can either attempt to force the technosphere to conform to their agenda—assuming a clear-cut agenda is possible on the human side, a big "if"—or, in perhaps a more productive strategy, we can try to negotiate a mutually agreeable settlement. For example, instead of pushing to dial down the rate of energy dissipation by the technosphere—a gambit likely to elicit strong pushback given the close connection between technospheric energy use and its survival—humans might support an increasing rate of energy usage in exchange for a commensurate increase in the rate of recycling of technospheric waste products (an energy-demanding process). This is not, I should add, intended as a specific policy recommendation, but as an illustration of the necessity of always keeping in mind that hu-

man desires and wants play out in an environment saturated with non-human purpose.

JR: I am a bit surprised that you now talk about a bargaining relation between humans and the technosphere while you stressed earlier that humans are an integral part of it. But anyway, apart from its indifference to the political dimension, which also seems problematic to me, let me ask you about another aspect of the technosphere concept. This aspect concerns the stability of this particular Earth sphere, which we touched on briefly at the beginning of our conversation when you alluded to my description of the technosphere as a fragile shell. Other spheres of the Earth system have undergone dramatic changes in Earth history. They may seem rather stable on the shorter historical time scales which usually concern us, but with climate change these spheres may reach tipping points at which major changes may happen. It seems to me that you treat the technosphere as if it were basically a self-sustaining, relatively stable system, whereas I would consider it as a fragile shell of culture and technology that humans have built for themselves. To see it this way does not mean such a system could not undergo similar dramatic changes, particularly as it couples to other spheres of the Earth system—such as the atmosphere, the hydrosphere, and the biosphere.

In a recent paper, Earth scientists like Will Steffen and his colleagues argue that the Earth is on a trajectory toward a hothouse Earth, which will make it difficult to have a beautiful and comfortable Anthropocene, but that we may still have a chance to avoid this development by driving the Earth back onto another trajectory. This alternative trajectory will not lead back to the familiar Holocene, but to some metastable state that we have to carefully guard by sustained intervention. This, in my view, can only be a matter of politically enhanced human agency. Steffen and his colleagues come to the same

conclusion in their analysis as I do: the technosphere, which we have built and is a major driving force of this development of the Earth system, is indeed a fragile shell. It is fragile in the sense that it will not itself guarantee, according to your Rule of Provision, that we are on a safe path. Instead, it seems we must monitor the technosphere and take corrective action to ensure we reach an equilibrium in which we can survive.

PH: There is another level that I think comes in here and that is the sheer acceleration in the current trajectory of the technosphere. Because technology accelerates but biology does not, the technosphere also surprises us on a daily basis. Slow classical ecology is now under challenge by fast modern technology, as is the slow human brain. In my view no long-term solution to ecological problems generated by the technosphere, such as the coming hothouse Earth or the high rate of extinction, is possible without explicit consideration of technological acceleration. Because we ourselves are parts of the accelerating technosphere, our own work and intellectual environment, as well as the environment affecting classical ecological systems, are subject to the resulting stress. Because there is no control panel on the technosphere, humans cannot simply dial back its speed on demand. Instead, under an accelerating regime we have less and less time to understand what is happening as the technosphere changes or to respond accordingly.

Meanwhile, new and transformative technologies continue to arrive at an increasing rate. This means that technological "solutions" to ecological problems can never be more than temporary fixes. Perhaps the most fundamental contribution that the concept of technosphere offers to the modern ecological debate is the realization that the fate of the biosphere involves not just human response to an ecological emergency but requires a parallel reckoning with the fact that humans are not independent agents, but captive parts of an accelerating

global system that, being autonomous, operates with first allegiance its own internal necessities rather than to human goals.

JR: Here I completely agree with you. I would just like to recall that, while it is quite conceivable that the sum total of the unintended consequences of our actions has developed its own accelerating dynamics, escape routes may still be open to us. It appears to me that the dynamics underlying the Anthropocene might well enhance both the challenges with which we are confronted and our possibilities to react to them, for example by developing a knowledge culture that is orientated towards global challenges. However, I am also unsure whether theses developments for understanding the human-Earth system and adapting our behaviour will ultimately be sufficient to meet its challenges.

It is at this point that I would like to introduce a terminological distinction that may help to differentiate between two different states: one in which the self-organizing power of the technological systems we have built overpowers us as human agents, and another in which we still have an opportunity to intervene and to steer the Earth system onto a safer path. For the first state I would reserve the designation "technosphere." I would prefer to call the cultural component of an Earth system in the second state (where intervention remains possible) the "ergosphere." Just like your technosphere concept, the concept of the ergosphere generally refers to the material culture, technologies, infrastructures, and the human agents, which over millennia have produced the peculiar metabolism between humans and their environment, at the center of which, according to Marx, is human labor. The ergosphere, in other words,describes a sphere of human "work" which is characterized by the transformative power of human labor with regard to both the global environment and humanity itself. The Greek word "ergon" means work in this trans-

formative material and open sense, referring not primarily to effort and suffering like the word "ponos," but also not primarily to the procedural, goal-oriented capability captured by the word "techne." In contrast to your technosphere concept, by its evoloutionary logic the ergosphere is still open to different ways of shaping the relations between humanity and its planetary home in terms of the cumulative effects of human interventions embodied in our "works."

The ergosphere has a plasticity and porous texture. Materials and functions are not so tightly interwoven as to exclude innovations and the repurposing of existing tools for new applications. In principle, each aspect of the ergosphere can be transformed from an end into a means for new intentions and functions. Thus, the responsibility for using and developing technical systems must always be assumed anew. On the other hand, nothing rules out the possibility that the ergosphere quickly transforms into a technosphere in the sense of a self-organizing system that can no longer be steered by human intervention. In any case, as long as this transformation is still possible, we should try to maintain ourselves within an ergosphere, preventing it from a phase transition in which it will transform into a technosphere beyond the reach of our interventions.

PH: The challenge is that the human ergon is so effective that new technologies constantly come on line, but we don't know what they really mean. We don't understand what their long-term consequences will be. I believe this ignorance is fundamental. The future is not predictable. It lies behind a veil of complexity woven of human, technological, and natural threads. Under these conditions, our future seems destined to be one of technological fixes continuously applied to the unexpected consequence of earlier technologies, until latent feedbacks revealed by continued acceleration cause too much disorder, or turbulence, for business as usual. That is

likely a fundamental datum of the world—that there is no final endpoint of comfortable equilibrium at which everyone can rest and say "job well done." Is there a way out? If there is, and humans are to be part of the solution, it will require the deceleration of technology toward a constant rate of technological change.