Chapter 14
Engineering as a Technological Way of World-Making

Sylvain Lavelle

Abstract In *Ways of Worldmaking*, Goodman examined the various ways of making worlds by comparing the activity of science with that of art. It is however regrettable that he did not regard the activity of engineering, thus viewed as a kind of technical art, as a genuine *way of worldmaking*. Engineering not only deals with the design and the production of technical artefacts but is also concerned with their use in as far as it tends to 'make a world' of a certain kind. One of the main problems in the philosophy of engineering is precisely to determine the nature of the relations between design and production on the one hand and use on the other. Thus the examination of the engineering way of worldmaking leads to focus on the modalities of human action (necessity, obligation, possibility, permission, etc.) in a world designed and produced by and through technology. In this respect, the constitution of some technological networks and frameworks calls for looking at the web of modalities of human agency as entailed by the engineering process.

Keywords World-making • Technical artefacts • Constitution • Modalities

Introduction

Winston Churchill once said: "We shape our dwellings thereafter our dwellings shape us" (Winston Churchill, House of Commons, October the 28th, 1948). He thus suggested that we, humans or subjects, are the actors by which things or objects are being designed and built. But then, the objects are designed and used by humans in such a way that they come to shape their daily way of living and behaving, if not their way of feeling and thinking.

One could enlarge Churchill's statement and consider the way the objects we design, produce and use are the same around the world and shape human conduct

S. Lavelle (✉)
Centre for Ethics, Technology and Society, Department of Humanities,
ICAM Paris-Sénart Engineering School, 2 Allée des Savoirs,
77127 Lieusaint-Sénart, France
e-mail: sylvain.lavelle@icam.fr

S.H. Christensen et al. (eds.), *Engineering Identities, Epistemologies and Values*, Philosophy of Engineering and Technology 21,
DOI 10.1007/978-3-319-16172-3_14

and thought in the same way. This raises the question of making the world identical in all its parts through the expansion of material and social standards applying to a set of technical artefacts. The latter at a certain level of systemic integration are assumed to be related to one another in a network but also to function as a framework on a global and local scale. The idea of a standard world that materially and socially speaking would be more or less the same in all its parts is frightening for some, or reassuring for the others. It echoes Friedman's myth of the "Flat World" and leads to ask the question of the standardisation of objects over the whole planet then leading to a single standard world (Friedman 2007).

Technology in general usually designates an activity that encompasses design and production of potentially useful artefacts, while engineering in particular designates an activity that is one part of the technology process, though an essential one. The use of technical artefacts in human business is the common aim of the technology process, while the transformation of the natural and human world can be viewed as its common end. It can be said that technology especially in the sense and in the form of engineering equals making a world or, to use Nelson Goodman's expression, is a *way of worldmaking*. Unfortunately, the philosopher who authored the expression "worldmaking" confined it to science and art in the aesthetical sense ("fine art") and he did not expand it to art in the technical sense ("useful art"). It is then valuable to examine to what extent technology in general and engineering in particular can be taken to be a way of worldmaking in Goodman's sense, or possibly in another sense.

The "making of a world" refers to the way technical artefacts as designed by engineers are arranged and connected and then form a network and a framework for humans. It is hardly disputable that engineering as a dynamic process of worldmaking concerns not only the design and the production of technical artefacts, but also their use. In addition, engineering as a creative and productive process is twofold and combines a descriptive-factual part together with a prescriptive-normative part. The classical opposition in philosophy between the "Is" ("what things are") and the "Ought" ("what things ought to be") is also relevant for the engineering way of worldmaking (Lavelle 2006). Technology as engineering indeed can be viewed as far as its ordinary process is concerned as an activity that is both science-based and society-oriented. Hence a set of questions: (1) What is it to "make a world"? (2) In what sense can engineering be considered as a "way of worldmaking"? (3) Can the notion of technological worldmaking be expressed in terms of "constitution" and "modalities" (necessity, possibility, etc.)?

Ways of Worldmaking

The "World" is quite vague a word and is commonly used in order to designate the set of things and beings that populate our environment. The question of the world definition and delineation (what it is, where it begins, and where it ends) makes it quite obvious that a world is not something very definite and delineated. A world can be my home, my garden, my family, my school, my city, my territory, my

district, my country, and possibly all of that to be viewed as a whole. A world can be natural, material, mental, social; it can also be small (a *microcosm*), big (a *macrososm*), or something in between (a *mesocosm*), depending on the scale you choose. In addition, a world is not only something that is thought over, it is also something that is made up, hence the notion of worldmaking.

What a World Is

The World as a whole is no doubt an *Idea* in the critical sense that Kant gives to this word, and certainly not a *Concept* that could be related to a set of empirical data (Kant 1787, 2008). Kant used to define the world as the set of all phenomena and in the transcendental sense as the absolute totality of the whole set of existing things. In this respect, the World is something that can be thought about, but not strictly speaking something that can be fully known, for it would exceed the capacities of human cognition and experience. Imagine if someone were to ask you to list the set of elements that exist in the World: a full life would not suffice for this Herculean task.

"The world is the totality of facts, not of things", the "philosopher-engineer" Wittgenstein said (Wittgenstein 1998); yet the world of the engineers is a world of things, not facts (McCarthy 2010). A world is not merely something that is thought about by human beings: a world is basically something that is *made* up on the basis of some criteria that helps determine more or less precisely the bonds of a world. One can hardly imagine what a world would be without any human determination of its boundaries, aspects, elements, conditions, etc., which means that a world is always a "world-for-someone". Otherwise, if it is not a 'world-for-someone', the world is just a piece of space and time, in other words, some location as related to some duration. Nevertheless, it is not easy to clarify what "making a world" actually means when it comes to technology taken as a technical art, as compared to science and to art in the aesthetical sense.

Let us imagine that an old man, John, once an aviator on a flight tanker, creates a wonderful garden at home so nicely arranged that he spends almost all of his time in there. When he used to be an aviator on a flight tanker, he spent most of his time outside his home, and the world for him was not only his plane and his boat, his sleeping and dining rooms, his navy colleagues, but also the sky, the sea and to a lesser extent, the earth. More precisely, the world was the piece of sky and the piece of sea that he would daily fly through or over and experience in its various aspects (shape, colour, temperature,…). After he retired, the world actually meant something like his home and his garden more than his plane, his boat, or the sky and the sea in some exotic regions. Of course, since he experienced on a daily basis what flying through the sky and over the sea is about, he has kept in his memory some remainders of that time that help him figure out what and how the world is. So he is quite aware that the world is not bound to his home and his garden, and if he would not experience it, at least, he would be taught and informed about it since his very childhood. But the fact is, once retired, he has no longer experienced flying through the sky and over the sea, and what now he does experience about them are the pic-

tures and the comments he can watch and listen to on his television. This is sometimes a very good substitute to a certain personal experience of a world, but even if the TV programme is well done, it does not provide a direct active experience of it.

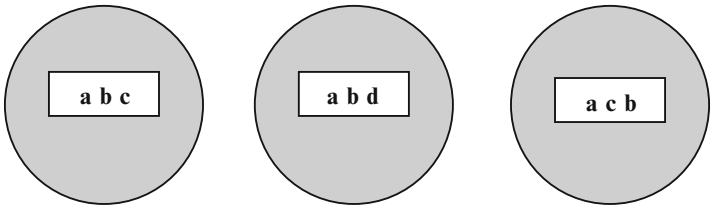
Basically, what makes one think that *a* world is *the* world (for instance, a single planet) is the common version that is given when using a map and the fact that this version is confirmed by some other versions (geography books, Internet maps, TV programmes, etc.). But *the* world is actually always *one* world, or more precisely some pieces of the world, even if one has several versions possible of his or her world at hand.

Wholes, Parts and Relations

One can propose several possible definitions of the world and insist either on the conceptual aspects or on the experiential aspects of it. The philosophical view on the world encompasses the phenomenological notion as well as the logical notion of it, alike the *lifeworld* in Husserl, or the *world of things* in Carnap (Ryckman 2007). Both insights and approaches, though supposedly opposite, refer in different proportions to the material-natural or the social-cultural immediate and ordinary environment to which humans relate and in which they live.

A world in the *logical* definition can be *in extension* the indefinitely open series of existing things and *in intension* the general shape, the overall aspect of reality. However the logical concept of "world" is in a way too formal if one considers the world as it is experienced by human beings. One can then shift to a *phenomenological* definition: a world is a set of intentional relations (beliefs, desires, expectations, affects, etc.) of humans to things and beings that constitute their experience as familiar or unfamiliar. A world can be viewed as a set of regular possibilities for cognition, volition and action enabling someone to experience certain things and events and, more broadly, to experience a certain way of life (Ihde 1990).

However, a world is not a mere set of elements, but mostly refers to the specific *connections* and *arrangements* in terms of relations, structures and situations that one can identify among those elements. For instance, *World 1* can be different from *World 2* for they have different elements (*a b c* for *World 1* and *a b d* for *World 2*), or because they have different relations between the same elements (*a b c* for *World 1* and *a c b* for *World 3*):



Worlds, elements and relations

The World as a part is possibly easier to delineate than the world as a whole. For instance, if you compare the North and the South of the Earth, you will find different worlds on the basis of their components:

- *World 1* (Europe): oaks, apples, wheat, foxes, dogs, cats, cars, boats, planes, computers,…
- *World 2* (Africa): baobabs, bananas, sorgho, lions, elephants, hyenas, cars, boats, planes, computers,…

Of course, you would find lions and elephants in the numerous zoos of Europe, and conversely, you would find dogs and cats as pets in Africa. But the important point is the population of things or beings in each area and the relationship to those things and beings as part of our world. If you take the example of bananas, you will find them quite freely in Europe, although this fruit does not grow there, and this is due to the technical organisation of collecting, freighting and distributing products. In this respect, technology has changed our world to the point that we can buy bananas, a fruit from outside Europe, every day and everywhere inside Europe, almost as if it were a local fruit. However, it is one thing to say that, in both worlds, you can find computers, it is another thing to say that, in one world, 80 % of the population uses a computer on a daily basis, whereas, in the other world, 10 % of the population uses a computer on a daily basis. In both cases, it is the same world component (a computer), but it is not the same world, for the relationship to the world component is not the same: it is an ordinary tool in one world, but it is a marginal machine in the other world.

Moreover, the notion of world does not refer to a static reality, but rather to a *dynamic process* of change in which new things or new beings come into play. Thus, one can compare World 2 in its Version A and World 2 in its Version B:

- *World 2 Version A* (Africa): baobabs, bananas, sorgho, lions, elephants, hyenas,…
- *World 2 Version B* (Africa): baobabs, bananas, sorgho, lions, elephants, hyenas+*cars, boats, planes, computers,…*

There are indeed several possible versions of the world, as suggested by Goodman, and that depends upon the selection we operate regarding the world's elements and their relations.

Making a World

It is the merit of Goodman who authored the expression *way of worldmaking* to set up a perspective on how humans make a world, be this world that of science or that of art. The question of the unity or plurality of the world according to Goodman cannot be examined without considering in advance the criteria that give birth to a unique structure. For it is from these criteria that versions of the world are developed by everyone in a more or less aware manner.

In James' pluralism, the world is made of several *parts* (James, *A pluralistic Universe* 1909, 1996); in Goodman's pluralism, the world is made of several *versions*, based upon a variety of *frames of reference* (*Ways of Worldmaking*). For instance:

1. "Under frame of reference A, the sun always moves".
2. "Under frame of reference B, the sun never moves"

As Goodman (1978, pp. 2–3) suggests:

> Frames of reference…seem to belong less to what is described than to the system of description: and each of the two statements relates what is described to such a system. If I ask about the world, you can offer to tell me how it is under one or more frames of reference; but if I insist that you tell me how it is apart from all frames, what can you say? We are confined to ways of describing whatever is described. Our universe, so to speak, consists of these ways rather than of a world or of worlds.

For Goodman, there is no doubt that there is a plurality of versions of the world for there is a plurality of ways of structuring aspects of the world whose meanings are interpreted and valued in different ways for different individuals. Versions of the world that Goodman speaks about are like some unique perspectives from a framework that is specific to an individual. Goodman does not claim that it is impossible to produce any convergence between versions of the world by different individuals. But he argues that it is unlikely that these versions do not differ in at least one aspect, be it a minor one.

For Goodman, there is no neutral world prior to the human activity and language and modes of organization of our existence are not found in the world, but built to make a world (Goodman 1978, p. 20):

> The fact that there are several different versions of the world is hardly debatable. The question seems virtually empty know how there are world-in-themselves if any…We might… take the real world to be that of some one of the alternative right versions (or groups of them bound together by some principle of reductibility or translatability) and regard all others as versions of that same world differing from the standard version in accountable way. The physicist takes his world as the real one…the phenomenalist regards the perceptual world as fundamental…For the man-in-the-street, most versions depart in some ways from the familiar serviceable world he has jerry-built from fragments of scientific and artistic tradition and from his own struggle for survival. This world, indeed, is the one most often taken as real; for reality in a world, like realism in a picture, is largely a matter of habit. Ironically, then, our passion for one world is satisfied, at different times and for different purposes, in many different ways.

Thus, according to Goodman, versions of the world are symbolic systems which may have different forms and be expressed in words, sounds, images, dances and all sorts of symbols. Worlds or versions of the world are made from symbols for man is an animal whose language is flexible, who makes the world with words and who composes reality through language.

The making of a world can be achieved through several operations:

- *Composition* and *decomposition*: we gather and cut into parts by which we divide the existing worlds into sub-worlds, and we analyze their features and build new relationships until we can combine parts of it in a new way.

- *Weighting*: we weigh the differences between the worlds that can depend only on the greater or lesser emphasis, so that the relevant parts in the world cannot be in another world, and vice versa.
- *Ordering*: we order and group objects before incorporating them, and these ways are built to order the world, they depend on objects and contexts that we consider.
- *Deletion* and *supplementation*: we often remove old material, add new material and we collect and add the parts we need.
- *Deformation*: we reform the world or destroy its original form then the reformations can be viewed as corrections or corruptions.

One of the critiques of the version-based philosophy of worldmaking pointed out that Goodman oscillated between several meanings of the term "world" of which he never attempted to give a definition (Scheffler 1980). One could add to this critique a world is not only a version (a *mental-linguistic system*) but also a set of concrete connections and arrangements of things (a *material-social system*) that can be designed and produced by a technical work.

Engineering as a Way of Worldmaking

It might be that technology as an engineering process is a specific way a worldmaking in that it not only provides some intellectual or artistic *versions* of the world, but also some *fashions*, or material and social shapes. In that sense, "worldmaking" in engineering refers less to a linguistic approach like in Goodman's than to an instrumental capacity of fixing and changing the general and particular material and social shape of the world.

Minds, Matters and Acts

The version of a world as made by engineering is not just what you bear in mind alike some scientific or artistic pictures or images (*imago mundi*). It is actually more about what mind puts into *matter* through the mediation of some human acts in order to give things their structure, their function and to some extent, their significance. In this respect, as suggested by Natasha MacCarthy in her comment on Wittgenstein's *Tractatus logico-philosophicus*, the world of technology is "a world of things, not facts": "Engineering is a practical pursuit, ultimately focused on the real world, not the idealized conditions explored in the lab or the armchair. Its very nature and purpose requires that engineering deals with complexity, contingency and context" (McCarthy 2010).

For instance, if one takes the example of information and communication technologies, on can distinguish different frames or versions, as suggested by Goodman, although the technological equipment is the same:

- In *Frame A* ("information society and global village"), the use of computers as connected and arranged in so making an information network and framework for the users is viewed as making a *world of communication*.
- In *Frame B* ("control society and global war"), the use of computers as connected and arranged in so making an information network and framework for the users is viewed as making a *world of alienation*.

Examples of frames of references

Frame A
"information society and global village"

computer systems + information networks/frameworks = a world of communication



Frame B
"control society and global war"

computer systems + information networks/frameworks = a world of alienation



In both worlds, the technological equipment is the same, but the frame on the basis of which the actors give some significance to them in terms of "worldmaking" is really different (Lavelle 2007).

The problem in this version-based approach to worldmaking as suggested by Goodman is its *idealistic tropism* that tends to neglect the realities of technical artefacts to be viewed as a set of concrete material things (Kroes 2012). A world is not just a scientific or an artistic version, it is also a material and social *fashion* not reducible to a mere worldview. Both material and social shaping of the world though technology and engineering produces some consequences on the *actions* of human beings in terms of gain and loss of capacities, in terms of knowledge, action, will, experience and significance (Latour 2005).

For example, one can take the example of what using ICT's as designed and produced with the help of engineers actually entails in terms of gain and loss of capacities for the users:

Technological shaping of human capacities in the case of ICT's

	Knowledge	Action	Will	Experience	Significance
Gain	Wide access to information	Interactive behaviour	Curiosity for the world	Open inquiry and discussion	Power and ubiquity
	Diversity of sources	Reflex of web surfing	Will to participate	Involvement in networks	Sense of the present
Loss	Lack of validation	Media-based activity	Problems with effort/desire	Reduction of reality	Anonymity and loneliness
	Patchwork culture	Less handwriting	Need to be connected	Decline of direct contacts	Loss of the past and the future

As Langdon Winner (Winner, 1986) suggests, technologies are ways of materially and then socially ordering our world and our actions in space and time:

> The things we call 'technologies' are ways of building order in our world. Many technical devices and systems important in everyday life contain possibilities for many different ways of ordering human activity. Consciously or unconsciously, deliberately or inadvertently, societies choose structures for technologies that influence how people are going to work, communicate, travel, consume, and so forth over a very long time. In the processes by which structuring decisions are made, different people are situated differently and possess unequal degrees of power as well as unequal levels of awareness. By far the greatest latitude of choice exists the very first time a particular instrument, system, or technique is introduced. Because choices tend to become strongly fixed in material equipment, economic investment, and social habit, the original flexibility vanishes for all practical purposes once the initial commitments are made. In that sense technological innovations are similar to legislative acts or political foundings that establish a framework for public order that will endure over many generations. For that reason the same careful attention one would give to the rules, roles, and relationships of politics must also be given to such things as the building of highways, the creation of television networks, and the tailoring of seemingly insignificant features on new machines. The issues that divide or unite people in society are settled not only in the institutions and practices of politics proper, but also, and less obviously, in tangible arrangements of steel and concrete, wires and semiconductors, nuts and bolts.

This view on technology and the kind of bounds they impose upon humans could also be well illustrated by a concrete situation in another space-time scale. You are an engineer working in a leading world industry: can you refuse to use a computer? "Can" here means several things: (a) Do you have the material possibility to do it? (b) Do you have the social possibility to do it? (c) Do you even have the mental possibility to do it? Technological worldmaking characteristically entails this kind of "modal" situation in which human actions are materially and socially necessary, possible or impossible (Lavelle 2009).

Technology, Engineering and Worldmaking

An overview of the technological process will hold together several stages ranging from design and production to the use of technical artefacts. However, the problem at stake is not so much the ever relative difference between each category as the

difference inside each category. Thus one can figure out that the category of designers may count some design people in the technical but also in the aesthetical sense, while the category of producers would include engineers and operators. As to the users, it could be relevant to make a difference between sub-categories such as: (a) *primary users* of technical artefacts who use them as a network but also as a framework for the action of (b) *secondary users* of technical artefacts who benefit from these technical artefacts, but who also undergo the organisation of their world and their lives on the basis of this network/framework as designed and produced by the primary users with help of designers and producers.

For instance, if you need as a secondary user to travel by plane to a country in which biometric passports and detection tests are compulsory at the airport, then you will have to walk through several control systems put together by primary users of this technology:

Ways of worldmaking in air travelling

Airport road

Airport room

Biometric passport

Security check

Outside the plane

Inside the plane

If one accepts the distinction between several types of users, namely the primary and the secondary users, then one should emphasize the way the use of some technical artefacts as elaborated by designers and producers by primary users actually shape the use of secondary users. Basically, the idea of a technological process as forming a chain of actions is on the one hand that engineers design and produce technical artefacts, while on the other hand primary users, thanks to technical artefacts, design and produce a *world* for the secondary users. In other words, you can design and produce a technical artefact, but depending on the way some users use it, you design and produce a world for the other users.

Types of Technological Worldmaking

One can distinguish between several types of worldmaking in the technological process and emphasize the specificity of constitutive and modal way of worldmaking in the shaping of ordinary life practices and theories:

(TP): a *Technological Process* is a set of operations of design and production of some technical artefacts that shape their use in a certain material and social context.

(TPW): a *Technological Process of Worldmaking* is a set of operations of design and production of some technical artefacts that shape their use in a certain material and social context *by making a world* for the users.

(TPCW): a *Technological Process of Constitutive Worldmaking* is a set of operations of design and production of some technical artefacts that shape their use in a certain material and social context by *making a world that* constitutes *the ordinary life practices and theorie*s of the users.

(TPMW): a *Technological Process of Modal Worldmaking* is a set of operations of design and production of some technical artefacts that shape their use in a certain material and social context by *making a world that* modalises *the ordinary life practices and theories* of the users.

A technology as designed, produced and used respectively by engineers or producers and by users or consumers involves a process of ordinary practice-shaping and theory-shaping. It is a *practice-shaping* process in that the techniques as used within a socio-technical network – that also functions as a socio-technical framework – shape the modalities of ordinary human *action* and then bring about a set of practical conditions that the users must adapt. It is also a *theory-shaping* process in that the techniques also shape the modalities of ordinary human *thought* and carry about a set of "theoretical" options, some worldviews that the users are urged or at least incentivised to adopt. In fact, the production of ordinary theories is as much a factor of adaptation of humans to a technical system as the production of ordinary practices. For technology as a process of *modalisation* expressed in terms of necessity or obligation, possibility and impossibility, etc. not only shapes matters and acts, but also minds.

A Modal Constitution of Things and Humans

The notion of *Constitution* is used both in logical and phenomenological philosophy (from Carnap to Husserl) to designate the linguistic or mental foundation or characterisation of the world objects and of the objects' structures and relations. It is also a useful approach as regards the kind of objects that are humanly shaped and that one usually calls artefacts – especially technical artefacts, if one can distinguish them from aesthetical artefacts. I would like here to follow a sort of "third way" in between the logical and the phenomenological approaches in taking together the conceptual and the experiential analysis. In other words, I would like to suggest through the notion of *modal constitution* of things and humans – and further of human practices and theories – that the structure of relations between objects such as socio-technical artefacts can be identified as a network and a framework from a conceptual side as well as an experiential side.

Constitution of Everyday Life

The notion of Constitution that I refer to borrows from Rudder Baker's *Metaphysics of Everyday Life*, even if I rather insist on the notion of *modal constitution* which quite differs from her view (Rudder Baker 2007, p. 32):

> Constitution is a very general relation, ubiquitous in the world. It is a relation that may hold between granite slabs and war memorials, between pieces of metal and traffic signs, between DNA molecules and genes, between pieces of paper and dollar bills – things of basically different kinds that are spatially coincident. The fundamental idea of constitution is this: when a thing of one primary kind is in certain circumstances, a thing of another kind – a new thing, with new causal power – comes to exist. When an octagonal piece of metal is in circumstances of being painted red with marks of the shape S-T-O-P, and is in an environment that has certain conventions and laws, a new thing – a traffic sign – comes into existence. A traffic sign is a different kind of thing, with different causal powers, from a scrap piece of metal that you find in your garage. Yet the traffic sign does not exist separately from the constituting piece of metal. Constitution is a relation of unity – unity without identity.

The notion of Constitution also applies to technical artefacts as opposed to natural things or objects and as defined by Rudder Baker, who focuses on the technical artefacts, rather than the aesthetical (*idem*, p. 51):

> Technical artefacts (are) the material products of our endeavours to attain practical goals. Such artefacts are object intentionally made *to serve a given purpose*. Artefacts with practical functions are everywhere. We sleep in beds; we are awakened by clocks; we eat with knives and forks; we drive cars; we write with computers (or with pencils); we manufacture nails. Without artefacts, there would be no recognizable human life…Typically artefacts are constituted by aggregate of things…Artefacts have proper functions that they are (intentionally) designed and produced to perform (whether they perform it their proper functions or not). Artefacts have *intended* functions, which are obviously normative…We cannot understand the world we live in without presupposing normativity.

It can be said as regards the assumption of normativity that the nature of an artefact lies in its proper function – what it was designed to do, the purpose of which it was produced –, that is, its intended function. And the proper function of an artefact is determined by the intentions of its designer and/or producer.

If one refers to the general definition of "constitution", if *x* constitutes *y* at *t*, and *y*'s primary kind is *G*, then *x* is in "*G*-favourable circumstances" at *t*. In the case of boats, there are two kinds of "G-favourable circumstances": (1) the circumstances in which a boat may come into existence; (2) the circumstances in which an existing boat continues to exist. For (1), the circumstances are the following: (a) the aggregate must be in the presence of one or more persons who know how to build a boat from the items in the aggregate, and who either intend to build a boat from the items in the aggregate or whose activity is directed by someone who intends to have a boat built from the items in the aggregate (b) the items in the aggregate must be manipulated by such persons (either manually or by machine) in ways that execute their productive intentions or of those directing the persons; (c) the result of the manipulation must satisfy the productive intentions of the persons.

Idea of a Modal Constitution

One could mention many critics to this idea of Constitution as elaborated by Rudder Baker, especially concerning the notion of "favourable circumstances". I would just like to show that the idea of a *constitution of things and humans* can be expressed in modal terms and emphasize the modal conditions of human agency as related to artefacts. In fact, what counts as a world for an individual or a group is also the *web of modalities* (or modal web) that shapes his or her action in terms of necessity, contingency, possibility and impossibility ("theoretical-epistemic" terms), or in terms of obligation, liberty, permission and prohibition ("practical-deontic" terms). For instance, if I can use a car to make my daily 15 miles journey to work instead of using a bicycle, then after a few years, I will certainly take the use of a bicycle to be something impossible and the use of a car to be something necessary.

This means that we qualify the means and ends in modal terms (necessity, possibility, etc.), what we may call the *modalisation* of the world's elements and their relations. The modalisation entails that the world is not just a set of elements, but also *a set of modal relations between those elements* that shapes the modalities of human action and even of human thought in structural and situational terms as interpreted by modal judgment.

The idea of a *Modal Constitution* is the following:

(i) A constitution can be expressed in *modal terms* (necessity, obligation, contingency, liberty, possibility, impossibility, permissibility, impermissibility) regarding the scope of potential and actual human actions and thoughts as allowed or restricted by a network and a framework of socio-technical artefacts.

(ii) A modal constitution reflects the way a technology as a *network* and a *framework* of socio-technical artefacts not only equals the production of human techniques, but also entails the production of human practices and even of human theories.

One can define the classical way of articulating structures, functions and use of an artefact by using the notion of constitution in the following sense:

1. *Constitution Rule*: An artefact *A* is designed, produced and/or used for achieving a goal *G* through an action *X* in a context *C*.

If one takes into consideration the *modalities* of action, then the constitution rule can be expressed in the following way:

2. *Modal Constitution Rule*: An artefact *A* is designed, produced and/or used for modally achieving a goal *G* through an action *X* in a context *C*.

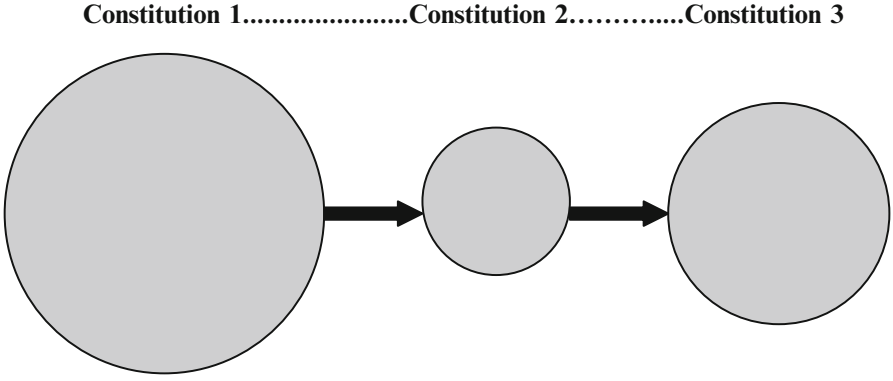
The notion of modal constitution also suggests that some elements are related to some other elements and then form a *web of modal conditions*. For example, X can travel by plane to country *C*, but provided he owns a biometric passport, otherwise he would be able to travel only to countries *non C*.

The basic model for the modal web referring to the relations between modalities can be expressed in the following way:

3. *Modal Web Constitution Rule*: An artefact *A* is designed, produced and/or used for modally achieving a goal *G* through an action *X* that modally implies an action *Y* in a context *C*.

This formal model can be translated into a less formal view that gives some kind of visual representation of the modal dynamics of human agency as long as it is concerned with actions taking place within a technological network and framework. Thus one can think of a circle that represents a modal *scope of possibilities* for a given human action the size of which varies according to the elements and the elements' relations that constitute the evolving technological network and framework.

Worldmaking technologies and modal scope of possibilities



For Constitution 1, the scope of possibilities is maximal, while for Constitution 2, due to some changes in the technological components of the network/framework, the scope of possibilities is minimal. This is the case, for instance, when a law makes a biometric passport compulsory to travel to country *C* and a user of a plane cannot sail across the ocean several weeks and so has to fly to go there.

Modal Analysis and Synthesis

One can suggest that the modal constitution of an artefact (or rather a set of artefacts) is set up in a given context in the shape of a network that also functions as a framework for the users. One can then make a modal analysis as well as a modal synthesis of the modal web of actions in order to reveal the set of implications of the artefact's material and social network/framework.

Let us take the example of Ivan Denissovitch, the famous hero of Solzhenitsyn's novel (Solzhenitsyn 1962, 2000), and let us suppose that Ivan managed to escape the Soviet Goulag and then managed to join the "Free World":

> Ivan Denissovitch is very happy to escape the Soviet Goulag and to join the Free World that he views as a kind of promised land. After arriving in the Free World, Ivan is trying to get directly to a plane in an airport, but he is biped when walking around a detection system. He is harassed by the police asking for his biometric passport, whereas he can just exhibit his paper-made and hand-written documents. Then, Ivan cannot find a telephone functioning with coins, or ask the people around; they are all running and escaping, talking alone and holding their hand on their right ear. He wants to hire a room in a low-cost hotel, but he is requested by an answering machine to send a confirmation by the Internet. When arriving at the hotel with a taxi, which displays road information seemingly coming from space, he intends to discuss with someone in order to explain his poor situation. But he finds nobody in the hotel: everything is automatic…provided you have a credit card, and so a bank account. Hopefully, Ivan Denissovitch remembers the Goulag, and can enjoy the freedom of sleeping outside, without money, in the Free World.

If we have a look at the table below, it appears that Ivan Denissovitch uses technical means that belong to Worlds 1, 2 or 3, but not to World 4:

Functions	World 1	World 2	World 3	World 4
Locomotion L	Walk	Boat	Train, Car	Plane
Communication C	Voice	Telegraph	Telephone	Mob. phone
Identification I	Name	Identity card	Passport	Bio. passp.
Reservation R	Mail	Telephone	Fax	Internet
Payment P	Coin	Note	Cheque	Credit card

Worlds and Technologies

We can now express this specific modal constitution as related to a specific network/framework and to a specific worldmaking process in using a modal analysis and a modal synthesis. In the presentation of the modal analysis and the modal synthesis,

I will not use some logical symbols as required in modal logic, such as ◇ for "Possibility" or □ for "Necessity". I will use the terms as expressed in ordinary language, but I will keep mainly to the terms as used in *epistemic* and *deontic* logic (Necessity/Obligation, Possibility/Permissibility, Impossibility/Impermissibility, Contingency/Liberty).

(I) **Modal analysis**

In the *modal analysis*, one makes an analysis of each modality in order to explicit the range of modal options at stake for one type of action:

Locomotion (L)
Necessity/Obligation: X has to take the plane to travel to country C.
Possibility/Permissibility: X can take the car, the train or the boat if he/she needs not to travel to country C.
Impossibility/Impermissibility: X cannot walk if he/she travels across the sea or the ocean to country C.
Contingency/Liberty: X can take the plane or the boat to travel across the sea or the ocean to country C.

Communication (C)
Necessity/Obligation: X has to use a mobile phone to be able to call from anywhere.
Possibility/Permissibility: X can use a telephone if he or/she can access it in some public or private locations.
Impossibility/Impermissibility: X cannot use a telegraph.
Contingency/Liberty: X can use a mobile phone or a telephone if he/she does not need to be able to call from anywhere.

Identification (I)
Necessity/Obligation: X has to use a biometric passport to travel to country C.
Possibility/Permissibility: X can use a classical passport or an identity card to travel to some countries non C.
Impossibility/Impermissibility: X cannot use a mere name as such.
Contingency/Liberty: X can use a passport or a biometric passport in some countries non C.

Reservation (R)
Necessity/Obligation: X has to use an Internet reservation for hotel H.
Possibility/Permissibility: X can use a fax or telephone for hotel non H.
Impossibility/Impermissibility: X cannot use a paper mail reservation for hotel H.
Contingency/Liberty: X can use an Internet, a fax or a telephone reservation.

Payment (P)
Necessity/Obligation: X must use a credit card for payment.
Possibility/Permissibility: X can use notes for the payment of hotel H.

Impossibility/Impermissibility: X cannot use cheques for the payment of hotel H.
Contingency/Liberty: X can use credit card or a cheque for the payment of hotel H.

(II) **Modal synthesis**

In the *modal synthesis*, one makes a synthesis of all the actions implied for each modality:

Necessity N (or Obligation O)
Locomotion: X has to take the plane to travel to country C.
Communication: X has to use a mobile phone to call from anywhere.
Identification: X has to use a biometric passport to travel to country C.
Reservation: X has to use an Internet reservation for hotel H.
Payment: X must use a credit card for payment for hotel H.

Possibility P (or Permissibility P*)
Locomotion: X can take the car, the train or the boat if he/she needs not to travel to country C.
Communication: X can use a telephone if he/she can access it in some public or private locations.
Identification: X can use a classical passport or an identity card for some countries non C.
Reservation: X can use a fax or telephone for hotel non H.
Payment: X can use notes for the payment of hotel H.

Impossibility I (or Impermissibility I*)
Locomotion: X cannot walk if he/she travels across the sea or the ocean to country C.
Communication: X cannot use a telegraph.
Identification: X cannot merely use his/her name.
Reservation: X cannot use a paper mail reservation for hotel H.
Payment: X cannot use cheques.

Contingency C (or Liberty L)
Locomotion: X can take the plane or the boat to travel across the sea or the ocean to country C.
Communication: X can use a mobile phone or a telephone if he/she needs not to call from anywhere.
Identification: X can use a passport or a biometric passport in some countries non C.
Reservation: X can use an Internet, a fax or a telephone reservation.
Payment: X can use credit card or a cheque.

The modal analysis and synthesis explicit the web of modalities as conceptualised and as experienced by some human beings in terms of their actions and as regards their modality in the context of a worldmaking technological network and framework.

Conclusion

Technology and engineering are certainly alike art and science one of the several possible ways of worldmaking in that they shape our material and social environment as well as our daily lives at home, at work, in transportation or on vacation. The technological making of a world through engineering can be viewed as a socio-technical process that counts several stages, namely those of design, production and use of technical artefacts. It is important to understand better the extent to which a set of technical artefacts are arranged and connected so that they come to constitute a network as well as a framework for the actors or the agents who use them. One can say that, at a certain level of integration of technical artefacts, what is at the very beginning a mere combination of artificial things becomes at the end a genuine artificial system that bounds the actions of the users for better or worse.

The idea of constitution suggests that the distribution of technical artefacts in space and time to form a network/framework is not a matter of chance but the result of a series of plans and scripts. One can support the idea of a *contextual* constitution of things and humans and argue that for an object to be a technical artefact it depends upon some criteria to be satisfied and upon some "favourable circumstances" to be met. This view is not wrong, basically, although it appears insufficient mainly for reasons of contextual indeterminacy, but also, so to speak, for reasons of *modal indeterminacy*. The modal approach to constitution makes it explicit that the relations between the elements of a network that otherwise functions as a framework is not only situation-sensitive but also structure-productive.

The *modal constitution* of things and humans requires a "model of modalities", an analysis and a synthesis of the modalities of human actions in a material and social context shaped by a web of connections and arrangements. These modalities refer to the classical modal terms (necessity/obligation, possibility/permissibility, impossibility/impermissibility, contingency/liberty). But they are not just some formal concepts, they are also meant to reflect some informal experiences of human beings who produce some situated judgments as lived and expressed in modal terms. Moreover, this view is not a static picture, but refers to a dynamic process in which the scope of possibilities of the users can vary depending upon the variation of the elements and their relations that make a world.

Contrary to what Goodman suggested, a world is not a mere scientific or artistic version: it is also a complex material and social organisation of things that is *made* by humans and that *makes* their lives.

References

Friedman, T. L. (2007). *The world is flat: A brief history of the twenty-first century*. New York: Picador.

Goodman, N. (1978). *Ways of worldmaking*. Indianapolis: Hackett.

Ihde, D. (1990). *Technology and the lifeworld*. Bloomington: Indiana University Press.

James, W. (1909, 1996). *A pluralistic universe*. Lincoln: University of Nebraska Press.
Kant, E. (1787, 2008). *Critique of pure reason.* New York: Cosimo.
Kroes, P. (2012). *Technical artefacts: Creations of mind and matter*. New York: Springer.
Latour, B. (2005). *Reassembling the social*. Oxford: Oxford University Press.
Lavelle, S. (2006). *Science, technologie et éthique*. Paris: Ellipses.
Lavelle, S. (2007). Technology and engineering in context. In S. H. Christensen, B. Delahousse, & M. Meganck (Eds.), *Engineering in context*. Aarhus: Academica.
Lavelle, S. (2009). Politiques des artefacts Ce que les choses font et ne font pas. *Cités, 39*(3), 39–51.
McCarthy, N. (2010). A world of things, not facts. In I. Van de Poel & D. Goldberg (Eds.), *Philosophy and engineering: An emerging agenda* (pp. 265–273). New York: Springer.
Rudder Baker, L. (2007). *Metaphysics of everyday life.* Cambridge University Press: Cambridge, UK.
Ryckman, T. (2007). Carnap and Husserl. In R. Creath (Ed.), *The Cambridge companion to Carnap*. New York: Cambridge University Press.
Scheffler, I. (1980). The wonderful worlds of Goodman. *Synthese, 45*(2), 201–209.
Solzhenitsyn, A. (1962, 2000). *One day in the life of Ivan Denisovich*. Penguin Modern Classics: London, UK.
Winner, L. (1986). Do artifacts have politics? In L. Winner, *The whale and the reactor: A search for limits in an age of high technology* (pp. 19–39). Chicago: University of Chicago Press.
Wittgenstein, L. (1998). *Tractatus logico-philosophicus*. Mineola: Dover.

Sylvain Lavelle Ph.D. in Philosophy, University of Paris-Sorbonne, 2000. Degree in Political Sciences from University of Paris and Bordeaux, and in Natural Sciences from University of Paris and Aix-Marseille. After 2 years as an assistant at Sorbonne 1998–2000, he has taught philosophy, epistemology and ethics in the department of humanities of an engineering school, ICAM Lille. He is currently working at ICAM-Paris and is Director of the Center for Ethics, Technology and Society (CETS) in Lille and an associate researcher at the Ecole des Hautes Etudes en Sciences Sociales (EHESS-GSPR). Sylvain Lavelle has been involved over the past years in several research projects funded by the European Commission (TRUSTNET, COWAM, EGAIS) and the French National Re-search Agency (PARTHAGE). He is an author and/or an editor of several books and of many articles, chapters and research documents, including *Science, Technologie et Éthique* (Ellipses, Paris, 2006), *Ethical Governance of Emerging Technologies Development* (IGI Global, New York, 2013) and *La Société en Action*, (Herman, Paris, 2013).