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BEDTIME READING FOR TECHNOLOGISTS: ELABORATIONS ON A THEME OF MITROFF'S

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ABSTRACT

In the current issue of JITTA, Ian Mitroff takes to task a certain breed of technologists who champion a futuristic vision of humanity as cybernetic organisms. These visionaries, Mitroff argues, need to "go back to school" in order to gain a more sophisticated and sociologically-informed view of we humans and how we know. *One key thing that is missing in the thinking of these technologists, Mitroff notes, is the recognition that mind is "'distributed' in society." The current paper takes this theme as its point of departure. However, in lieu of sending the excessively narrow technologist back to school, three books are recommended as "bedtime reading." They include Edwin Hutchins'* Cognition in the Wild, *Louis L. Bucciarelli's* Designing Engineers, *and Bruno Latour's* Aramis or the Love of Technology. *A review of these works, which all tell stories about the creation and/or use of technology, support Mitroff's point that mind is social. Moreover, they show that mind is in fact* socio-technical *in nature. Knowledge is seen to be embedded in our technologies and discourses, as well as in our individual minds. What we can be said to know, in fact, arises in complex interactions among and across these domains. These books, accordingly, also shed light on the truly broad scope of our endeavor, when we undertake the development of new technologies and systems. Moreover, in the spirit of this special issue of JITTA, these books call our attention to the centrality of language and dialogue in the creation of technology and the knowledge that is associated with it.*

INTRODUCTION

In the paper by Ian Mitroff in the current issue (Mitroff 2001), the author takes to task a certain breed of technologists whose vision of one possible, and even desirable, future involves the transformation of humans into cyborgs. The basic idea behind this vision is that the so-called "super-intelligence" of computers can be joined directly and

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cybernetically to our own in order to vastly enhance our capabilities. Indeed, we are told, we must take this step in order to forestall an alternative future in which we become subordinate to a race of intelligent machines. Mitroff's critique of the proponents of this vision, then, turns on their "confusion over the nature of intelligence." There are two key aspects to Mitroff's argument. First, he notes that one hallmark of human intelligence is that people "think about thinking" – an accomplishment that currently seems impossibly remote in the realm of artificial intelligence. Second, the capabilities of an individual human mind cannot reasonably be grasped, and therefore simulated, without a consideration of "all the other minds to which it is connected and thereby inseparable." The mind, indeed, is truly " 'distributed' in society" and must be viewed as inherently social in character. Mitroff concludes, then, that computer scientists need to complete their educations:

> *"Computer scientists, who are supposed to [sic] hard-nosed and rigorous before they accept anything, are actually quite sloppy in their thinking. They literally need to "go back to school" and to get a broader education before they can accomplish their aims. They need to understand what it is to 'think about thinking with and through others.'"*

In this essay, I take as my point of departure Mitroff's recommendation that computer scientists "go back to school"; and I make the assumption that his counsel can readily be extended to certain other technologists, including members of our own information-systems community. I focus, in particular, on Mitroff's second argument about the distribution of mind in society – his point about "thinking with and through others." I will extend this point by arguing that technologists sometimes misunderstand not only the social nature of human intelligence or mind, but also the relationship of mind to technology. In short, mind in fact is best viewed as *socio-technical* in nature.

Of course, for an established technology professional or academic, literally going back to school is an expensive proposition. The tuition alone these days is staggering. And then there's the opportunity costs to consider – lost wages, neglected friends, alienated children, broken marriages. As an alternative, I will propose that the technologist start more simply with a change in bedtime reading. I will recommend three books in particular that can provide a relatively efficient, and diverting, introduction to the richer and more sophisticated view of intelligence that Mitroff demands. The books are: *Cognition in the Wild*, by Edwin Hutchins (1995); *Designing Engineers*, by Louis L. Bucciarelli (1994); and *Aramis or the Love of Technology*, by Bruno Latour (1996).

These books all involve case studies, which is to say stories, hence my claim that readers will find them diverting. And each illuminates somewhat different, yet complementary, aspects of the relationship between people, society, and technology. I will review each of these books in turn, relative to the topic at hand, and then conclude with a discussion that ties the books together around the concepts of language, discourse, and knowledge. The focus on discourse will link the current essay to the theme of this special issue of JITTA on "the importance of dialogue to the creation of and access to knowledge."

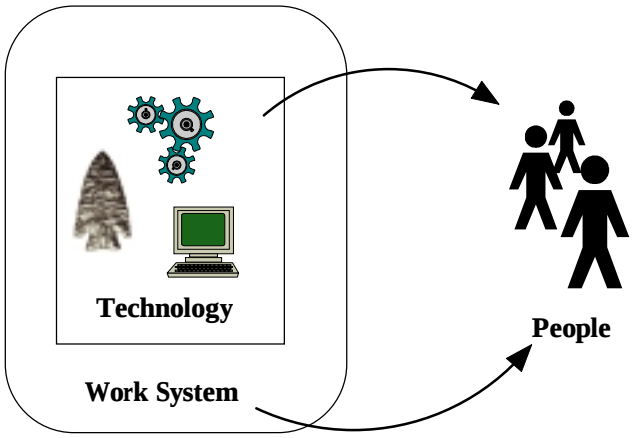
THREE RELATED QUESTIONS

In considering how these books speak to the issue of "distributed mind" and the role of technology, as well as to the technologist's need for a wider view of these things, we will entertain three basic questions (Figure 1).

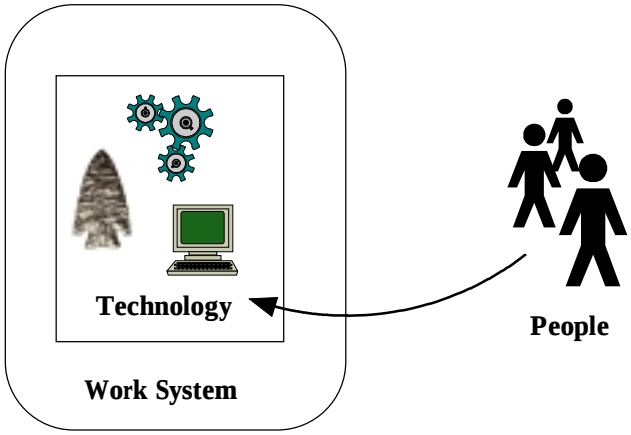
First, how is knowledge distributed among the participants *in an existing work system*? Here, we will consider the category of "participants" to include both the people and the technologies that they use. Taking the technologies and work system as a given, then, we can also ask how people and, in particular, their knowledge and associated commitments are shaped in the context of work configured around those technologies. To coin a phrase, we are asking about their *techno-socialization*. Of the three books, Hutchin's speaks most directly to this first question. Accordingly, we will examine

Figure 1: Three Related Questions

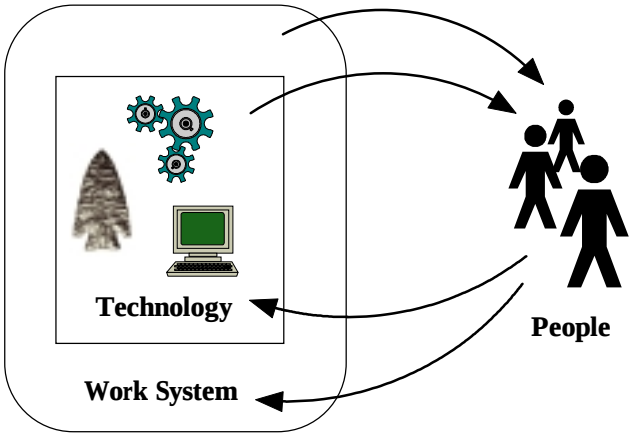
Question 1. How is knowledge distributed among the people and technologies in an existing work system? And, how are people (and especially what they know) given shape in this context?



Question 2. How are technologies created by people in work systems and how, more specifically, does knowledge come to infuse those technologies?



Question 3. How does knowledge come to be created and distributed across both the people and the technologies in a work system?



his book first.[1]

This essay will then address the second question. If technologies, as elements in work systems, help to shape the people that come to work with them, we can also ask, How do people in work systems create the technologies? We will see in particular what Bucciarelli's book has to tell us about the social construction of technological artifacts and the embedding of knowledge in those artifacts.

If our first question entertains the shaping of people in a context given by technology, and our second entertains the shaping of technology in a context given by people, then our third question brings the first two questions together. We will ask, How is the distribution of knowledge accomplished, in the creation of technologically-based systems, across both the technology in question and the people who would use, or otherwise take interest in, that technology? We will take Latour's book on the forsaken Parisian transportation system Aramis as the focus of this discussion.

THE DISTRIBUTION OF MIND AND TECHNOLOGY-IN-USE

Edwin Hutchins' *Cognition in the Wild* is a report on ethnographic fieldwork with a navigation team aboard an amphibious helicopter transport in the United States Navy. It is, more specifically, a cognitive ethnography, in that it considers the functioning of navigational systems in light of the thinking that is involved. However, his analysis is not a simple, disaggregated inventory of what the individual actors know. Instead, his unit of analysis is the larger "computational system" comprising the team members and the technologies they use. His account accordingly builds up from local task systems consisting of team members in interaction with their navigational tools, to the interlinked and interdependent activities that produce the accomplishments of the larger group. Learning on the part of individual members is also examined, as is the development of new knowledge, which occurs as the larger system adapts to changes in its environment. Hutchins' inferences about cognition in this rich, practical context are couched in detailed accounts of events and performances that he observed while in the field. His book concludes, then, with an examination of the relationship between culture and cognition, and a critique of the individualized perspective of contemporary cognitive science.

Navigation on something as large and complex as a modern naval ship is a matter of teamwork. Individuals with distinctive roles and specialized (but overlapping) knowledge work together to achieve a common goal, the safe and efficient navigation of the ship. In this respect, Hutchins is particularly interested in the cognitive properties of the larger group which, he argues, are "not predictable from… the properties of the individuals" involved (p. xiii). This is so because the group's cognitive properties arise in the body of knowledge that is required to coordinate the activities of its members, a knowledge distinct from the heterogeneous task-based knowledge that those individuals possess (pp. 176-177). In this view, "culturally constructed technical and social systems… are simultaneously cognitive systems in their own rights and contexts for the cognition of the people who participate in them" (p. 287).

Hutchins observes, moreover, that cognition is ineluctably tied to the material context in which it is practiced (p. xvi):

> *"… the environments of human thinking are not 'natural' environments. They are artificial through and through. Humans create their cognitive powers by creating the environments in which they exercise those powers."*

The study of knowledge-in-practice, then, must take into account the "socio-material environment of thinking" (p. 289). An important component in that environment

[1] Each of these books speaks in some way to all three questions that will be entertained in this essay. Moreover, each book has a great deal more to say than I report here. Reading them is accordingly recommended on many counts.

comprises the technologies in use. "Physical artifacts," Hutchins observes, become "repositories of knowledge" (p. 96). In the practice of navigation, there are many such repositories – the astrolabe, the alidade, the hoey, the gyrocompass, the fathometer, the nautical slide rule, to say nothing of the innumerable charts and maps. It is in the very design of these artifacts that the observations and insights and decisions and calculations of the predecessors of today's naval navigators have become encoded or inscribed.

On the sea, then, in the hands of a diverse team of contemporary navigators these tools become the "representational media" (p. 96) that are used to understand the current state of the ship and its immediate environment and the likely effects of each upon the other. The practice of navigation becomes, to a substantial degree, an exercise in "distributed interpretation formation" (p. 241) as "the propagation of representational state" (p. 96) helps the team to build a collective understanding of the ship's situation over a succession of interlinked tasks across the team's members. Accordingly, even while there is knowledge built into the technology, as noted above, the technology also serves to externalize certain cognitive processes of the individuals for others to see (p. 236), as these are brought together in a "cascade of re-representation" (Latour 1987, cited by Hutchins, p. 132).

Such linked activities in representation naturally raise the issue of communication, a topic to which Hutchins gives considerable attention. Representations crafted by means of tools are embedded and passed along from actor to actor in streams of language. Attention to the properties of language – its potential, its limitations, and the particular shape it takes in the specific work context – is integral to understanding "the computational properties of the larger cognitive system" (p. 230).

Communication is important in daily operations; but, of course, it also has a central role in learning. Learning is a crucial function of work systems because of the need to continually replenish human expertise as the human parts of the system turn over. Hutchins recommends that learning "that happens inside an individual" therefore be seen as "adaptation of structure in one part of a complex system to organization in other parts" (p. 290).

Hutchins' account of the distribution of knowledge (pp. 264-266) in navigational teams provides a remarkably clear example of what we recognize is true of essentially all work systems, even if it may be less obvious at times. And that's that the knowledge to run the system, respond to new situations, and adapt to changes is *specialized* and *dispersed* across people and technological artifacts, which are simultaneously integrated and coordinated to work together toward common objectives. Hutchins' ethnography, then, makes tangible Mitroff's general observation about the distribution of mind in society.

Before turning to our other bedtime reading, it should be noted that Hutchins comments directly on the fans of artificial intelligence in a manner not unlike Mitroff. He faults cognitive scientists (his target) for attempting "to remake the person in the image of the computer," and argues for a striking shift in perspective (p. 363):

> *"The physical-symbol-system architecture [of AI] is not a model of individual cognition. It is a model of the operation of a sociocultural system from which the human actor has been removed."*

While Hutchins addresses change and adaptation in the larger knowledge systems that are the focus of his attention,[2] he does not give much attention to the fashioning of the technologies that are components of these systems. The other two books on our bedtime reading list, however, do make this topic their primary focus of attention. We consider Bucciarelli's book next.

[2] And in this regard he has a particularly interesting discussion of the distinction between change by evolution and change by conscious design. See pp. 345-351.

THE DISTRIBUTION OF MIND AND THE CREATION OF TECHNOLOGY

In *Designing Engineers*, Louis Bucciarelli describes and analyzes a set of case studies with the aim of uncovering empirically the nature of the engineering-design process. Observing engineering on the ground in three projects – an x-ray inspection system, a photo-print machine, and a photovoltaic energy system – Bucciarelli takes us past the hard and seemingly inevitable character of the technological artifact to witness the social and problematic process that produces the artifact. He notes that we have been "schooled to see" (p. 47) technology in a certain way, which he characterizes as follows (p. 42):

> *"Technology, as it is commonly perceived as machinery or a set of rules, is something outside of us, out there. It draws our attention to itself as a thing apart, operating in rigidly determined ways, repetitive, and usually nonnegotiable in the human encounter."*

Based on his observations in the field, he argues that real engineering-design process challenges us with a starkly contrasting image (pp. 20-21):

> *"… design is best seen as a social process of negotiation and consensus, a consensus somewhat awkwardly expressed in the final product."*

In this context, the actual things which such negotiations entertain are themselves far from the hard objects that our everyday notions of technology would take them for (p. 50):

> *"… while participants in all three accounts talk about* hardware *– batteries, photovoltaic arrays, control systems, J-tools, crystals, rollers, baffles – these things are not so solid and well defined as the word suggests. They are continually referred to, brought into question, explained, elaborated, even denigrated. There is considerable uncertainty and tentativeness about these things; the talk is about how a photovoltaic array of this or that size* might *work, how much it* might *cost, when it* might *be delivered, which one* should *be chosen. Technology defined lies off somewhere in the future."*

And later on he remarks (p. 177):

> *"… even in a discussion about hard stuff – technical apparatus, instrumental operations, and inanimate things outside of us – a healthy measure of ambiguity and uncertainty makes room for designing… In process, it is always possible to invalidate yesterday's design move because the object the language points to does not exist… Only after the fact, when design yields to artifact, do meanings appear firm and consonant. The reality of the artifact, read in retrospect, can lure you to think otherwise, but that is a* trompe l'oeil.[3] *"*

Echoing Hutchins' description of the use of technologies in an existing work system, Bucciarelli notes that "… no one participant… has complete knowledge of the myriad of events and exchanges that contribute to the ongoing design process" (p. 33). It is, once again, a case of teamwork involving the heterogeneous knowledge of a diverse group of actors. However, in contrast to Hutchins' account, in which the actors have been shaped (largely successfully) to their roles, here "differing interests and viewpoints of different parties to the design" help to produce "incoherence and uncertainty" that demand the active construction and maintenance of "networks of things, people, and interests" if the design effort is eventually to produce a successful, tangible product (pp. 49-50).

The design process itself, then, is made up of numerous "eddies of interaction" among these actors, in which "bits and pieces" of conversation add up, over time, to a design discourse that gives shape to the technology. Language is indeed central to understanding how design unfolds in real practice. Participants' contributions to the on-going discussion are, in fact, "constructed representations of purposeful things that [no one] has seen" (p. 67). Participants " 'see' the working artifact," which actually does not yet exist, "through these representations" (p. 67).

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[3] Trompe l'oeil is a style of painting that gives an illusion of photographic reality.

These are scenarios, *stories*, which are connected "to the furniture of the 'real' world through [the participants'] past experience with actual hardware and through discourse with others, who have still other stories to tell and contacts with yet others" (pp. 67-68). Thus, "different participants with different perspectives and responsibilities in the design process… will construct different stories according to their responsibilities and interests" (p. 71). This presents a situation in which "although [the participants] work on the same design, each sees the design in a way that conforms to the structure and language of his or her own object world" (p. 89) – where the *object world* is "the domain of thought, action, and artifact within which participants… move and live when working on any specific aspect, instrumental part, subsystem, or subfunction of the whole" (p. 62).

While stories told about aspects of design take on the imagery and reasoning appropriate to participants' diverse and personal object worlds, these stories must be brought into coherence. Participants must be able to "communicate, negotiate, and compromise; in short, … design" (p. 81). They accomplish this by creating amongst themselves "an accepted rhetoric for describing, proposing, critiquing, and disposing that girds all design conversation, fixing what constitutes a true and useful account," and establishing a tacit understanding of "what is to be considered an honorable claim, a significant conjecture, a valid 'proof,' or a laughing matter" (p. 83). Such rhetoric and tacit understanding are neither given nor achieved effortlessly. Instead they require active construction through the concerted efforts of the participants themselves. Their work on the building of their community, the social milieu, for designing is as vital and integral as their work on the design of the artifact itself.

The technology thus emerges necessarily within a social context of design– in the same way that the meaning and purpose of a technology that has actually been put to work are necessarily defined, as Hutchins documents, in a social context of use. This is not to say that there is a lack of scientific or technical constraints, in either case: It is not true that anything goes in engineering design, "but these are not determinate" (p. 159; also see Hutchins' remarks concerning "computational constraints").

Bucciarelli's focus is on the fashioning, in a social context, of the technology itself. (Refer again to the second question in Figure 1.) Even as the technological artifact takes shape, however, Bucciarelli does remark that the artifact in turn "structures [the participants' own] thoughts, beliefs, and practices" (p. 20). Indeed, " … the object infiltrates thought" even as " thought, reciprocally, configures the object" (p. 70). As Hutchins' technologies-in-use, then, shape their users, Bucciarelli's technologies-in-creation shape their creators. This places us on the threshold of our third question (again, see Figure 1) and our review of Latour's book.

MAKING TECHNOLOGY, MAKING HUMANS

Latour's tale, in *Aramis or the Love of Technology*, recounts the history of the ill-fated Parisian transportation system named Aramis. Based on a vision of personal rapid transit, Aramis was ultimately to have been a system that could deliver passengers in individually programmed cars without intervening stops to their desired destinations. Requisite traffic volume was to be achieved through a highly innovative non-material coupling, which would bring cars together in trains without actually physically connecting them. After many years under development, spanning the period 1969 to 1987, Aramis was ultimately abandoned. Latour's book asks why. In a novel presentation that reads much like a detective story (*who killed Aramis?*), Latour weaves together a narrative around a dialog between an engineering student and a sociology professor that brings in interview transcripts, official documents, and author commentary; even Aramis is made to speak for itself.

Do Latour's investigators ultimately solve the mystery? The reader may judge for him/herself. Our interest here is in how the book, as an addition to the technologist's bedtime reading, may serve to broaden further

his/her view of technology and its relationship to the distribution of knowledge in society.

We begin by considering, briefly, how Latour's book fits in with the two we have already considered. In Hutchins' story, we are witness to a work system and its associated assemblage of technologies that have reached a point of relative stability.[4] Navigational practice and its technologies present a solid and actively reproduced network of know-how and commitments, firmly embedded in a wider organizational context that provides stability and clarity of purpose. By contrast, in Latour's story we see a technological complex struggling and failing to achieve such stability and clarity – failing, ultimately, to get its context to embrace it and cohere around it.

In Bucciarelli's stories, we hear about engineers' efforts to embed their knowledge into technological artifacts. (Like Aramis, not all of these efforts are successful.) Along the way, we learn about the plastic and problematic nature of the artifact-in-becoming, about its chimerical life in language. With his focus on the artifact and its engineers, what we do not see so clearly in Bucciarelli's tales is that such an artifact is destined for a wider life, where it will be given new, extended meaning and even re-invented in the hands of its users (Orlikowski 2000; Rogers 1995). Latour's story, then, takes a step back and shows that a technology may fail entirely to make the transition from design into use – that it may fail altogether to attain solidity and durability as an artifact – if it does not successfully engage and shape its broader context. Latour's story, then, expands our vision of what it means to "design" a technology, carrying us beyond the shaping of the artifact into a consideration of the "engineering" of the minds with which the technology must engage. In reflecting on the book itself, Latour comments, in a manner quite like Mitroff's "back to school" remark (p. x):

> *"I have sought to show technicians that they cannot even conceive of a technological object without taking into account the mass of human beings with all their passions and politics and pitiful calculations, and that by becoming good sociologists and good humanists they can become better engineers and better-informed decision makers."*

Latour brings language to the fore in a way that picks up where Bucciarelli leaves off. Echoing the latter when he says that "the object the language points to does not exist," Latour points out that, "By definition, a technological project is a fiction, since at the outset it does not exist, and there is no way it can exist yet because it is in the project phase" (p. 23). If a technology-in-the-making is a fiction, then engineers are novelists (p. 24):

> *"They invent a means of transportation that does not exist, paper passengers, opportunities that have to be created, places to be designed (often from scratch), component industries, technological revolutions. They're novelists. With just one difference: their project – which is at first indistinguishable from a novel – will gradually veer in one direction or another. Either it will remain a project in the file drawers (and its text is often less amusing to read than that of a novel) or else it will be transformed into an object."*

And thus in the ensuing pages, as the investigators probe the death of Aramis, we learn that Aramis (p. 24):

> *"was a text; it came close to becoming, it nearly became, it might have become, an object, an institution, a means of transportation in Paris. In the archives, it turns back into a text, a technological fiction."*

But Latour takes us beyond a consideration of the mere artifact itself: The artifact, he argues, is a text *that demands a context*, if it is eventually to become a fact, a thing with weight and solidity in the real world. "No technological project is technological first and foremost" (p. 33). Central to such a project is the fact that the technology must be *contextualized* (p. 127):

[4] Stability is always relative, of course. It would be interesting to learn about the state of naval navigation now under GPS.

> *"The only thing a technological project cannot do is implement itself without placing* itself *in a broader context. If it refuses to contextualize itself, it may remain technologically perfect, but unreal. Technological projects that remain purely technological are like moralists: their hands are clean, but they don't have hands."*

Contextualization is, to a significant degree, a matter of mobilizing the actors that must become engaged in shaping the fate of the technology (p. 126):

> *"The more a technological project progresses, the more the role of technology decreases, in relative terms: such is the paradox of development. As a project takes shape, there is an increase in the number, quality, and stature – always relative and changing – of the actors to be mobilized."*

At the same time, the context in question is not a given, so contextualization is not simply a matter of designing the artifact to fit a context – nor of finding an appropriate context. "[T]he trajectory of a project depends not on the context but on the people who do the work of contextualizing" (p. 150). All factors are thus in play, and demand the intervention of the engineer. The engineer is (p. 33):

> *"a sociologist as well as a technician. Let's say that he's a sociotechnician, and that he relies on a particular form of ingenuity,* heterogeneous engineering, *which leads him to blend together major social questions concerning the spirit of the age or the century and 'properly' technological questions in a single discourse."*

In this light, Latour takes to task (p. 137):

> *"the idiocy of the notion of 'preestablished context.' The people are missing; the work of contextualization is missing. The context is not the spirit of the times which would penetrate all things equally. Every context is composed of individuals who do or do not decide to connect the fate of a project with the fate of the small or large ambitions they represent."*

The decisions to which Latour refers get made, or do not, depending on how *interesting* the crucial individuals find the technology (p. 86):

> *"The task of making Aramis interesting never ends. For technology, there's no such thing as inertia. Here's proof: even an ordinary user can make Aramis less real by refusing to get into one of its cars; or, if she's a local official, by refusing to get excited about it; or, if he's a mechanic or a driver, by refusing to work for it."*

Reflecting back on Mitroff, the true scale of the dispersion of "mind" becomes more apparent than ever, now. Whether a technology will come into being, survive, and thrive depends on what a very great variety of people know, believe, and assume to be true, and on the commitments they make as a consequence.

This cannot be left to chance – this is one of those aspects of the context that calls for, as Latour puts it, heterogeneous engineering. The engineer must accordingly move from mere narrative, mere fiction, to rhetoric. The engineer's text that is the technology-in-discourse becomes a collection of *speech acts* (Austin 1962) meant to shape the world by shaping others' understanding and action. His/her interpretations (pp. 194-195):

> *"are performatives. They prove themselves by transforming the world in conformity with their perspective on the world. By stabilizing their interpretation, the actors end up creating a world-for-others that strongly resembles an absolute world with fixed reference points."*

The need is obvious in the case of the market, of the consumers – in this case, those who must be persuaded to understand, believe in, and therefore eventually ride, an Aramis. "Consumer demand and consumer interest," Latour remarks (p. 187), "are negotiable like everything else, and shaping them constitutes an integral part of the project." It's important not to overlook the importance of the term "shaping," here. He makes it clear that the consumer must not merely be convinced (p. 34) but, instead, substantially "invented" (p. 43).

The targets of persuasion are not limited to consumers, however. Latour considers the challenge confronted by one Frèque, an actor on stage in the Aramis drama (p. 172):

> *"Frèque attributes* intentions *to his CEO, to the company head, to the RATP, to nonmaterial couplings, and to variable-reluctance motors, just as he attributes rules of behavior to provincial cities, to France, to the private sector, to the public sector, and to humanity in general. He lines up the actors, humans and nonhumans alike, in a narrative; he mobilizes them in a scenario in the course of which Aramis exists for real on the Petite Ceinture; he offers them roles, feelings, and ways of playing. He creates a whole world, a whole movie, a whole opera."*

The difficulty for such a novelist, or author, is to get beyond the merely rhetorical, the mere act of "speaking for" (p. 42) these various interests. Latour continues (p. 172):

> *"Will they follow along? Will they play with him? If the actors lend themselves in large numbers to what Frèque expects of them, then his interpretation of their roles as well as the Aramis object that they're charged with creating will both be realized."*

The rhetorical engineering of a context for the technology, then, succeeds in greater or lesser measure according to its ability to convince others to become as they are represented, to engender and *translate* (Latour's term) their interests into coherence with the envisioned form, and eventually with the material fact, of the new technology.

Of course, as the details of Aramis' history are revealed, we learn that there is no single novelist attempting to author technology and context into being. A great variety of interests are engaged. And so the situation becomes a matter of the *interdefinition* of actors, implying that (p. 173) "Technological projects are deployed in a variable-ontology world," in which (p. 175):

"Actors never swim twice in the same river. As they are defining one another, as they are changing ontologies and offering each other their theories of action, there's no guarantee of their own continuity in time."

People may "start mutating as the story unfolds," leaving nothing "but the proper name that allows us to spot them" (p. 177). The work of self-definition accordingly joins interdefinition (p. 177), as actors struggle "to stabilize a certain interpretation of what they are and what they want" (p. 180). In short, the system-building that's demanded in the effort to innovate necessarily includes the shaping of the actors around the opportunity presented by the new technology, which in itself must be shaped in the context of those actors and their interests. (Refer again to the third illustration in Figure 1.)

In system-building of this kind, the system becomes saturated with intelligence, as each element is shaped to and in-formed (Boland 1987) by the role or part she/he/it has to play.[5] This is as true for the machines as for the people, even if there is no "AI" per se involved. But failure is entirely possible, as the sad tale of Aramis relates. In the end, the interdefinition of actors – human and material – may be inadequate, incomplete. The discourse that would "perform" the technology to life may fall short in the kind of argumentation, dialog, and negotiation that is necessary to bring design into rapport with the practical context of interests and actions, and to impose itself in a way that ultimately produces an everyday object – a transit system, for example, that citizens ride to work – on which people may now "have a simple point of view" (p. 79).

To return to the technology in particular and consider what Latour's story can teach Mitroff's technologist (who by now may well be suffering from insomnia!), we will close our review of Latour by pondering these remarks (p. 206):

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[5] "Humans and nonhumans take on form by redistributing the competences and performances of the multitude of actors that they hold on to and that hold on to them" (Latour, 1996: 225).

> *"Although charged by humanists with the sin of being 'simply' efficient, 'purely' functional, 'strictly' material, 'totally' devoid of goals, mechanisms nevertheless absorb our compromises, our desires, our spirit, and our morality – and silence them. "*

And he concludes (pp. 212-213):

> *"We have been mistaken. Up to now, we have believed in the existence of objects. But there are no objects, except when things go wrong and they die or rust. … If the object were lying among nonhumans alone, it would immediately become a bag of parts, a heap of pins, a pile of silicon, an old-fashioned object. Thus, the object, the real thing, the thing that acts, exists only provided that it* holds humans and nonhumans together… *"*

DISCUSSION: WE HAVE ALWAYS BEEN "CYBORGS"

The bedtime reading I have just described puts a great variety of technologies before us. None are, in the everyday sense, computer information systems, although microprocessors are indeed found in some of them. Nevertheless, readers of JITTA should find much to recommend these books. As system developers, and as teachers and researchers in systems development, we are – or we should be – *heterogeneous engineers*, as Latour puts it. In making systems out of hardware and networks and software, we certainly create technological artifacts. But when we are at our best, our work also helps shape the wider context in which those artifacts will be integrated and used. We are – or again we should be – *contextualizers*.

Another thing these readings do for us is to bring language into the foreground in our thinking about our work with technologies and their contexts. Hutchins reminds us of the centrality of communication in the work practices of our users; it is the glue that binds together the knowledge and actions and accomplishments of the disparate participants. Bucciarelli and Latour reveal language at work in the creation of technologies; more radically, they show us that new technologies in their earliest stages exist principally in the form of language. At the same time, a language-of-innovation itself must be actively constructed, if participants are to move forward successfully. The consequences, as Bucciarelli shows us, are anything but deterministic. The seemingly inevitable artifact that appears after-the-fact is revealed, in the light of history, to be instead as much talk as substance, a problematic site for the embedding of decisions that are the result of a collectively negotiated process of design that potentially could produce any number of artifacts, or possibly none at all. In line with the theme of this special issue, we also witness the indispensability of dialogue in the creation of new technology, first in language and then progressively in material form.

Latour, then, pans back to reveal the wider role of language in contextualization. Rhetoric, we learn, is indispensable in the creation and alignment of interests around new technology. Actors must deploy language in a broader kind of system-building effort that simultaneously gives form to the human and institutional context even as it shapes the technological artifact which, these actors dream, will take its place within that context. To the extent that we, in the field of information systems, are like Mitroff's computer scientists who should "go back to school," these books help open our eyes both to the true *scope* of our enterprise as technologists and to the central role of language in constructing and maintaining that enterprise.

To return, then, to the theme of the current essay, the third thing these books serve to do for us is to sharpen our understanding of the truly distributed, socio-technical character of knowledge and intelligence. The stories in question illustrate and amplify Mitroff's call for transcending our over-individualized view of mind. We see compellingly that the knowledge required to accomplish a complex purpose is necessarily differentiated and distributed among a variety of human participants. In developing and using technologies and work systems, we depend eternally on what our contemporaries know, as they in turn depend on us. Moreover, knowledge produced by people is extended in time and space by virtue of its being built into

our technological artifacts. The resulting interdependence among people and machines is pervasive. The artifacts remain inert – mere curious, if potent, forms – without the users' and their knowledge to complete them, in some context of action. But the users' own knowledge of the tasks at hand requires completion by the knowledge that is designed into, and defines the function of, those artifacts.

As the human paleontologists have observed, deep in our prehistory our hands, brains, and tools made up a co-evolutionary complex. We became human through our work with tools. Tools, accordingly, are intrinsic to our humanity. We have been extending our discoveries, our decisions, our designs, our *minds*, into artifacts for a very long time, literally hundreds of thousands of years.

Consider a very old technology – the stone hand-ax. Its contours reflect ancient observations and judgments and choices. The knowledge of how to make one and the knowledge of how to use one were captured in memory and reproduced both by practice and by communication. When taken in a sufficiently broad frame of reference, then, the stone ax was already a "complex" technology. Even while its design encoded the intelligence of its makers, the stone ax did not "know" enough, by itself, to accomplish meaningful work. It needed a person, informed by the appropriate culture, to complete it and give it purpose – to make it truly an ax, and not just an oddly shaped rock.

At the same time, the stone ax did not provide a mere technological amplification of its user's existing, biologically-based capabilities. When this tool arrived on the scene and in our hands, it literally changed our minds. We became, in that very instance, "cyborgs."

It is an incidental and largely uninteresting point that the stone ax was in our hands and not physiologically embedded within our skin. The stone ax was inside us in a much more profound way: As it sat in our hands, so too it simultaneously occupied our minds. It changed how we think about our capabilities, about how we might make a living, how we might defend ourselves, how we might express ourselves. It changed our very concept of ourselves. Moreover, and this was equally profound, it changed the nature of our conversations. And if the paleontologists are correct, it even helped to make language and, hence, conversation possible.

To this day, we as humans continue to accomplish such transformations on our minds and our discourses through the medium of technological innovation. Our knowledge, and the learning through which we expand that knowledge, is pervasive. It is a matter of what we each know, as individuals; of what we share with one another, encoded in and carried by the on-going stream of discourse; and of what we design into the artifacts through which, and of which, we continually build and rebuild our world. Moreover, as we learn from the bedtime reading discussed here, it is about what we share with one another as we create and use our artifacts. In short, our knowledge is to a significant degree built and propagated and sustained in our discourses on technology.

Chips in our heads, if it ever comes to that, will be small potatoes compared to the profoundly deep and complex interdependencies between the knowledge that is in people, the knowledge that is in technology, and the knowledge that is in our discourses.

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