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From Radar to Reader:

On the Origin of RFID

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Abstract

Within the locative media discourse, Radio Frequency Identification (RFID) ranks as a primary technological component of the evolving pervasive computing infrastructure. RFID tags appear to constitute the flagship among the armada of ubiquitous computing devices that are about to create a shift in spatial and situational awareness. While this promise still needs to be fulfilled in the mundane realm of technological feasibility, this paper takes a different tack on this special technology. It does not deal with the future (of the supply chain, the data privacy, the "technological unconscious"), but rather the past. Never mentioned in the literature, though strikingly apparent, is the similarity between the promised, new-fashioned capabilities of RFID systems and the allegedly outdated vision of cybernetics in its original form shortly after World War II. Taking this historizing nexus up, this paper seeks to emphasize the intrinsic tie between World War II innovations in the technosciences and current performative infrastructures by unearthing the technological and cultural origin of RFID. By spotlighting the pivotal transfer mode of RFID systems and untangling the historical roots of that very mode, it hopes to achieve a new perspective on RFID's role in setting the technocratic stage of data-driven visibility, granular environments, and ambient intelligence. In this interpretation, the networked environment is not invented by current trends in information technology but has rather been continued and radicalized in a kind of *longue durée* mobilization of ambient electronic architecture.

The Past in the Future of RFID

With RFID, it seems, a cybernetic world finally becomes reality. Recent studies on ambient intelligence, informational landscapes or sentient cities draw increasingly on the envisioned capacities of RFID tags to identify—and, in the long run, to enact—things, bodies, and localities by exchanging information between them. RFID-enabled

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pervasive computing promises not only to augment but to "intelligize" environments, to create a physical world that is analyzed and governed by the digital substrates of local and remote information ecologies in the form of constantly and automatically fed-back datasets and algorithms. What strikes me as a historian of media technology is the strong resemblance of the original formulation of cybernetics to the subjects of these studies. Cybernetic thinking understands the world as being, in its very behavioral constituents, commanded and controlled by the constant and automatic feedback of information between servomechanical entities (including the human himself), particularly in order to anticipate the behavior of the "other" (Galison 1994). As if risen from the dead, Norbert Wiener's original scientific vision grins, more or less incidentally, through many of the writings on the subject.

Let me give a few examples. The "hybrid ecologies" that Eric Kabisch (Kabisch 2008) sees emerging—through tagging objects with RFID, as well as other pervasive computing technologies—derive from the synthesis of digital and embodied worlds by iterative cycles of sociotechnical practices. Yet this seems to be no more than a realization of the epistemological notion of a cybernetic system in which body and technology are merged by iterative feedbacks, including feedbacks in society, as might be seen in the works of Gregory Bateson. The shift which Nigel Thrift (Thrift 2004) detects in the "technological unconscious"—the habitual and subcognitive background of our everyday knowledge formed by the ever-changing assemblage of technologies and granularization of processes—is, when it comes to the pivotal knowledge of position and juxtaposition, heavily indebted to the "perhaps... most powerful" of innovations in changing the nature of the address, namely RFID. However, this re-formation of the

Figure 1
The locality of ubiquity is still only confined to a Glasgow restaurant (photo by author).

environment "has to be understood in the same way that we understand the growth of organisms and persons, in terms of the properties of dynamical self-organization of relational fields" (Timothy Ingold cited in Thrift 2004, 176). In other words, it has to be understood in cybernetic terms. Crang and Graham's (Crang and Graham 2007) notion of "anticipatory technologies" such as RFID systems—technologies that track and predict in the interdevicive communication process—mirrors almost exactly Wiener's initial ideas that spun off from his famous Anti Aircraft Predictor design in World War II. The only difference is that tracking targets in the "War on Terror" is becoming a function of surveillance data instead of measuring data of surveyed trajectories. What was once envisioned as an incoupling of data into servomechanical action is now applied to the data realm itself. More than that, both are basically exemplifications of statistical pattern stabilizations.

There is also a persistent focus on the overall political ramifications of RFID in the geomedia-literature, which sees identification technologies "as key components of governmentality and capitalism" (Dodge and Kitchin 2004, 1). Ruling by excessive data mining of transitory movements, or profiting by geodemographic profiling of the population, is in fact the ability to "kybernet" (the Greek word kybernētēs means "governor" or "steersman") complexities by informationizing them. For whatever reasons, however, the world that, according to Wiener, acts by the information that is being exchanged in the system, seems now effectively en route to being constructed.

Now, this bold claim that RFID is all but the continuation of cybernetic thinking laid down in the aftermath of World War II may just not feel right. Maybe I am confusing metaphorical coincidences with actual designs here. After all, RFID might indeed stratify a qualitatively new dimension of connecting nature and signature that is beyond just certain command-and-control feedback mechanisms that simply become ubiquitous. But my historical experience tells me differently. Electronic media technology is not something that is just invented from scratch and thereby alters the ecology of things and minds overnight. It is rather a hybrid assemblage of techniques and tinkerings that drags a lot of historical developments with it, and on its way gradually reshapes the behaviour of human and nonhuman actants and the relationships between them.

Thus, I would like to explore further the idea of a strong continuity in the history of electronic media—a continuity based on intrinsic design features and not just shattered by the advent of—RFID and other pervasive computing techniques. In what follows, I will try to look into the "tinkered" origin of RFID, an origin that indeed appears to date back to the days when Wiener's cybernetics was born, in the late 1940s. Moreover, I will focus on the crucial feature of RFID—namely, its wirelessness. All the expectations of RFID's ability to form an augmented digital space are in fact bound simply to its capacity to transmit data via radio signals. Thus, instead of dealing with all of the digital futurism attached to RFID, I will undertake a historical excursion into a time when sociotechnical environments were almost exclusively set by analog radio communication. No cell phones, no Bluetooth, no GPS, no GIS, no Google Maps, no Internet, no computers, not even television centering life in everyone's household. In doing so, I do not discount the possibility that this excursion might not tell anything about the future of RFID. But I aspire to show that there is a point in looking into the historical origins of an enabling technology when one discusses the current state of locative media. This paper is making a case for media archaeology as a means of investigating the historically built-in possibilities and restrictions of any kind of contemporary media technology.

RFID As We Know It

Doing a little bit of research on the history of RFID, one is sure to arrive at the name "Harry Stockman." It appears at the beginning of almost every historical overview of RFID: it is on web pages and in popular magazines, TV documentaries and company booklets, yet also in scholarly journal articles or textbooks (for example: Mohd-Yasin 2006; Garfinkel 2005a, 16). How did people come up with this name? That question is easily answered. They all simply copied the Stockman "fact" from a single short paper written by Jeremy Landt (Landt 2001), a former employee of the Los Alamos Scientific Laboratory in New Mexico, who dealt with RFID earlier in his career. In collecting material for his brief historical review of RFID, Landt searched the laboratory's library for the oldest document that would resemble the conceptual framework of what we now call RFID. He finally retrieved an article from the October 1948 issue of the Proceedings of the Institute of Radio Engineers, entitled: "Communications by Means of Reflected Power" (Stockman 1948). Crediting this "landmark paper" as "an early, if not the first, work exploring RFID" and placing it under the subheading "Genesis of an Idea," Landt spurred the erection of a virtual monument for its author, Harry Stockman.

Stunned by the fact that almost none of all the little RFID histories that draw on Landt's conclusion ever seems to have bothered to question this finding or even to have looked into Stockman's article, I was curious to find out more about this "Reflected Power Communication." I took Stockman's paper as a starting point to figure out what this was all about. Who was this man that nobody has ever heard of? What did he do that he became the "inventor of RFID"? What does it actually mean to "invent" RFID? And therefore: What is RFID?

To answer all these questions, let me start with the last one. As is fairly well known, the term "Radio Frequency Identification" refers to many varied applications, configurations and ways of transferring data between a more-or-less tiny chip (the so-called "transponder" or "tag") and an interrogating device (the "reader"). For instance, there are contactless smartcards to exert access control, there are passports with tags embedded for electronic authentification, bold tags placed in windshields for electronic toll collection, tiny tags implanted in cows and pets, there are tags put on books in libraries, other tags used for inventory management, special tags employed for pallet tracking, a different kind of tag again employed in the aerospace industry to fight counterfeiting, proximity-tags in cellphones to allow for so-called "Near Field Communication," and last but not least, there are selfmade tags employed in artistic or experimental installations to show the potential of RFID as a locative medium. To sum up, there is an endless variety of applications, spin-offs, and technical realisations of RFID, all of them defined by their own special purposes and needs, as well as their particular spatial properties and their technical and physical feasibility.

What makes this fragmented conglomeration worth summing up under a single four-letter term though is its characteristic capacity to broadcast data via radio waves. A few automatic identification technologies already exist (e.g. smartcards, OCR, language recognition, biometric-scans, and, above all, barcodes), but none of these is based upon an interface that enables computers to identify tagged objects at a range of up to several meters or inside a closed box, nor do they allow an actual two-way data exchange between identifier and identified. While the digital backend, composed of algorithms, servers and databases, is already coupled with all the customary systems of automatic identification, a digital "frontend" is only assigned to RFID.

However, there is a central problem to the sophisticated capacities of RFID chips. In order to be a mass device—like barcodes, for instance—the transponder has to be designed extremely efficiently regarding its energy consumption and size (and ultimately to a cost close to that of producing simple barcodes). At the same time, it has to maintain the advantage of a relatively wide reading range. The solution to that problem is a method of transferring the data that has been dubbed "backscatter modulation."

On a very general level, RFID systems are divided into two groups: those with active tags, and those with passive tags. While active tags come with a big and costly battery to power a signal transmission and/or more sophisticated software on the tag, passive tags are only powered by the radio waves emitted by the reader and are therefore a lot cheaper, tinier and dumber. A modulated backscatter transponder belongs to the second group, sending its data simply by modulating the carrier wave of the reader. The carrier wave is reflected by a dipole antenna attached to the tag, while the reflection properties of that dipole are controlled by the digital stream of data coming from the tiny onboard memory. In a way, the transponder engraves its information onto the echoed carrier wave. Eliminating the otherwise crucial need for a battery attached to the tag, this method delivers reliable signals up to a few meters away. Passive backscatter transponders are the one species of RFID chips that really has the potential to revolutionize supply chains or, more generally, viably to alter communication means between electronic devices.

Passive backscatter transponders are usually combined with another, more general concept to ensure a cheap chip design. Instead of putting the desired smartness into the tag, put it into the system! The typical mass transponder, one that cannot afford to host multiple functions by relying on a big memory and a complex chip architecture, simply transmits an ID number that refers to a certain dataset in a remote database, the way a license plate number links a car to its owner (and to his recorded misdemeanors). A few years ago the Auto-ID Center, an MIT-headquartered international consortium of industrial sponsors and research institutions, designated the so-called "Electronic Product Code Network," a fully integrated system of RFID-IDs (Leong 2004, Dodge and Kitchin 2004). It is based on a coding scheme that resembles the current barcode numbering. In fact, the Electronic Product Code (EPC) is supposed to become the successor to the Universal Product Code (UPC) symbology, the bar pattern that is nowadays printed on almost every product. From UPC to EPC: As with all new media, the drive to create new electronic devices seems to be the desire to outstrip universality.

By coupling masses of RFID transponders with databases via the Internet, we can wirelessly extend the Internet itself. However, this is not done by integrating fully functional computers, like laptops or cellphones, but rather by absorbing dumb ID reflectors that are put on objects. While this simple "addressing of things" might be far away from the original intention of the Auto-ID Center to create an "internet of things," there is a profound quantitative momentum in this development. The "increased granularity for identifying material objects" and the "drive towards totalising spatial knowledge at finer scales" (Dodge and Kitchin 2004, 32) seem to be perfectly matched with the wireless circuitry of RFID chips and data on the Internet. The access points of the Internet tether a so-far unset space; the tentacles of the terminals stretch out into a space that up to now has not been occupied by technical communication. And they do so in order to incorporate the license plates of trillion of outspread objects. It remains to be seen what kinds of "swarm intelligence" all this will lead to.

RFID As We Don't Know It

Now, what does Mr. Harry Stockman have to do with all this? 1948 is not well known for being a time when digital databases were abundant or when swarm intelligence was an option for the retail industry. Instead, the high tech of those days was radar, a just-recently matured concept of "seeing" things from a distance. And this is exactly where Stockman comes in.

Harry Edmond Sigfrid Stockman, a Swedish-born radio-physicist, came to the U.S. in 1940 to escape the unfolding killing in Europe and to follow in the footsteps of his famous compatriot Ernst Alexanderson, who had made a distinguished career in the U.S. radio industry. The American radio industry was extremely well established at this time. An immense amount of research took place in companies like the Radio Corporation of America, General Electric, AT&T, and Westinghouse. Meanwhile, with American involvement in the Second World War looming, another "research enterprise" entered the field: the National Defense Research Committee (NDRC). The NDRC was established by the U.S. government and led by Vannevar Bush. One of the NDRC's biggest projects is nowadays well known: the Manhattan Project, undertaken to control nuclear fission in order to build the A-bomb. But another science program, one that in its first few years was even bigger than the Manhattan Project, remains little known

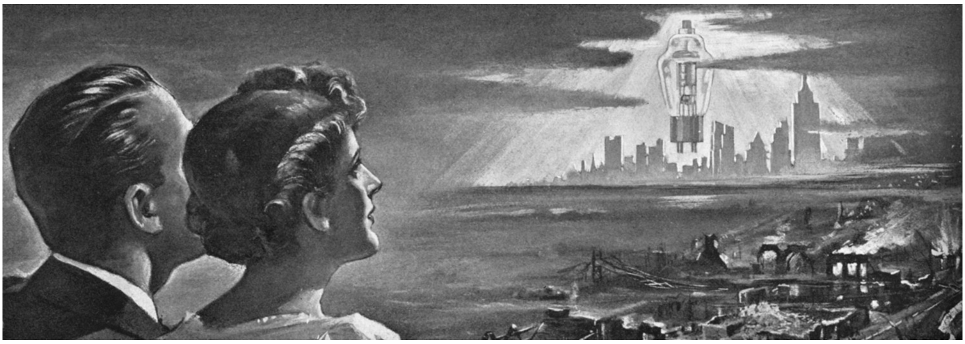

Figure 2
War of the wizard tube: a radar tube shields the homeland in peril (Anon. 1943, 6)

in contemporary culture. It was the project to control electromagnetic radiation in the region of extremely short wavelengths, in order to ensure the reliable operation of radar (Genuth 1988).

The capability of scanning sky, sea and ground where other emissions, such as sound or visible light, were not sufficient, created a dramatic shift in warfare. The introduction of radar entirely changed the perception of the battlefield. The technical feasibility of "looking through" night and fog, and even over the horizon, turned the war into a world war in every sense. Electronic warfare, as it was soon to be named, made this war of scientific expertise into the famous "Wizard War" (Figure 2).

How does radar work? A radio pulse is emitted into the atmosphere and is scattered back by reflective objects such as airplanes or ships. The distance of the object is measured by the duration of the delay between transmitting the pulse and receiving it back again, while the object's direction is determined by the radar's rotating antenna. Radar is a technology that scans space and turns that space into electronically coded spatial information. It is a "localizing" medium in a double sense: a medium that traces objects in natural space, as well as one that creates a technical space.

Now, all this requires not only high-performance equipment to transmit a strong search signal, but also very sensitive receivers, because the returning signal is just a weak blip in an ocean of noise. This called forth the counterpart of radar: radar jamming. As soon as radar became mature, a great deal of effort was put into effectively interfering with the enemy's apparatus. But radar countermeasures consisted not only of jammers (which scattered their noise-frequencies over unfriendly radar stations), but also of methods of deliberately inducing wrong information. One of these methods was the use of so-called "corner reflectors." These were metallic bodies with very good reflection properties that deceived a radar beam by inflating the retro signal—the exact opposite of current "stealth" techniques. When corner reflectors were fitted to a tiny airplane, this plane appeared on the radarscope as a huge bomber fleet, and in this way distracted the control center from the actual bomber force, which carried out its raid somewhere else.

When put on a lake, corner reflectors simulated landmasses and therefore misguided the radar operators on board the airplanes, since they navigated by means of landmarks. This all led to an "epic of electronic warfare," as the historian Alfred Price once put it, a continuous interaction between physicists on both sides of the front line as well as between radar and jamming operators (Price 1967). So radar, I would like to argue, is also a "locative" medium. But that is a different story.

To figure out which particular frequency worked best for detecting submarines or for navigating over foreign territory and also to tinker with the best prototypes of radar equipment, the NDRC in 1940 created, in very high secrecy, the so-called Radiation Laboratory (or Rad Lab) on the MIT campus. In order to figure out how to blind or bluff the radar-eyes—not only the enemy's, but also their own—the NDRC in early 1942 also created another high-frequency lab in the same field: the Radio Research Lab. This second lab is much less well known even by historians, although in its time it was regarded both by the military and by civilian researchers as vital to the future war effort. The Radio Research Lab, located just a few miles down Massachusetts Avenue at Harvard University, was shrouded in an even higher degree of secrecy than the Rad Lab. In this way, electronic warfare became institutionalized in Cambridge, MA.

At this very location, our Swede Harry Stockman showed up. After spending his first few months in the U.S. visiting every commercial and academic radio research lab in New England, he decided not to have a career in the radio industry after all, but in academia. In the summer of 1941 he enrolled as a Ph.D. student at the Cruft Physics Laboratory in Harvard, just around the corner from where the Radio Research Lab was about to be established. But soon after his arrival, Stockman was detained from working on his thesis because he was overwhelmed with teaching obligations. For, besides the Radio Research Lab, Harvard also hosted an extensive training program for the three branches of the armed services. From 1942 until 1945, the campus was crowded with military personnel, all receiving instruction in the state of the art in medicine, geology, applied mathematics, electrical engineering, radio techniques and, of course, fundamental radar design. For the last of these, responsibility lay in the hands of the Cruft Laboratory staff. Harry Stockman spent most of the war giving Pre-Radar courses for young officers.

As the war ended, all these undertakings came to a halt. Both the Rad Lab at MIT and the Radio Research Lab at Harvard were shut down, the Pre-Radar school at the Cruft Lab was dissolved, and Stockman was finally freed to finish his Ph.D. His expertise in radar plus his connections to the military secured him his first job. The Army Air Force had taken over all the Rad Lab equipment, as well as tons of documents, drawings and notes of its research. The Air Technical Service Command then launched a new research facility on the periphery of the MIT campus: the Cambridge Field Station, or CFS. (Incidentally, the Field Station building was the same one that, during wartime, had accommodated the "Research Construction Company," an MIT spin-off that specialized in crash-producing radar equipment.) Dr. Stockman became the Head of the Cambridge Field Station's Communications Department.

In this position, Stockman devised several new communications concepts based on electromagnetic waves. One of them was the application of electromagnetic waves to stimulate the brain cells of sleeping students. Stockman seems to have worked up these traumatic experiments in the classrooms during his Pre-Radar teaching days. (Compared to the mind-control experiments of the 30s, 40s and 50s, the current debate over RFID implants and Big Brother scenarios is rather tame.)

Another of Stockman's proposals is yet of greater interest to us. Instead of a conventional communication relay line between one transmitter/receiver-station and the next one, he proposed a system where one of the stations simply modulated the carrier wave of the other: "Communications by Means of Reflected Power." With this method, Stockman aimed primarily at an economical means of point-to-point communication—a way, for example, to thin out a chain of repeater stations. The technology needed to obtain that efficiency was obvious: radar! Stockman went into the storeroom of the CFS, took the most sensitive radar apparatus he could find (an airborne radar unit developed by the MIT Rad Lab for the detection of German submarines), grabbed a couple of small corner reflectors (which particularly suitable usage on ultra-high frequencies and microwave had been studied at the Harvard Radio Research Lab), and headed towards a rural antenna station located on the Atlantic shoreline, 35 miles north of Boston.

At the antenna station, Stockman put up several experimental arrangements in order to tinker with implementing his new method. One of them deserves our full attention. In his article in Proceedings of the IRE, Stockman describes a so-called "Triple Turret Reflector," a self-made gadget consisting of three layers of corner reflectors, each rotating at its own speed (Figure 3). Some distance away, Stockman installed his

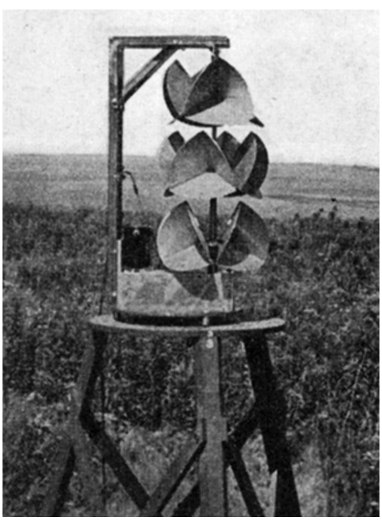

Figure 3
Stockman's Triple Turret Reflector (Stockman. 1948, 1202)

radar device together with a frequency meter, and turned the power on. Stockman then meter-read three different signal frequencies, because each layer of reflectors modulated the carrier wave of the radar beam with its own periodic change of its cross-section (strength of backscattering). In just the same way as amplitude modulation sends signals through the ether, the radar transmitted coherent waves onto the rotating reflectors, and the reflectors in turn echoed individual frequency values that were derived from their individual revolution speeds. Then the only thing left for Stockman to do was to read these three different values as a number. If layer 1 rotated with 8 rounds per second, layer 2 with 14rps, and layer 3 with 2rps, and each layer consisted of four corner reflectors side by side, he obtained an identification number for his gadget named "24 56 80." So, as Stockman himself put it, "each reflector is identified by its numberplate code number" (Stockman 1948, 1201). Instead of being duped by false bomber fleets or wrong landmarks, the corner reflectors now delivered correct information about their own identity.

With this simple experimental arrangement, the Swedish radio-physicist created no less than a crude, pre-digital form of passive backscatter modulation. By modulating numerals onto a sensitive radar beam, he devised a system of automatically identifying objects by radio waves, and along with that, he turned seeing into reading. Radar became reader.

Of course, Stockman's reflector apparatus is far from contemporary transponder design, in which signals are modulated by switching a load resistor according to binary data stored in a memory chip. We will not have rotating corner reflectors stuck on our tubes of toothpaste. But Stockman's "Number Identification Target system," as he termed his idea, demonstrated the principle of the very spectacular data transfer method that is currently celebrated (or demonized) in business meetings, PowerPoint presentations and magazine articles all over the world.

Well, Harry Stockman, at least in his lifetime, was denied any of this particular fame. Just a few months after he presented his new method at the 1948 convention of the Institute of Radio Engineers in New York City, he got into serious trouble with the Cambridge Field Station board. Eventually, he was dismissed from his post as head of the Communications Department and left Air Force research for good. A few years later, one of his former assistants filed a report about the backscatter experiments, stating: "it is hoped that the results presented herein will help to clarify some of the limiting factors present in any system of communications by means of reflected power" (Bishop 1951, 3). Stockman spent some years working for different electronics companies around Boston before returning to academia as a teacher at various Tech colleges. He kept his passion for developing new methods and apparatuses and founded a small enterprise that designed and constructed display models for classrooms. He died on 18 May 1991 at his home in Cape Cod—right where the waves of the ocean have been modulating the waves of their own sound for millions of years.

RFID As We Should Get To Know It

That's it. No more, but also no less, is behind all of the Stockman buzz. It was a simple but ingenious experiment that "misused" military apparatus to configure a new principle of retroreflective communication. That certainly does not elevate Stockman to the heights of being the inventor of RFID. Too many physical principles, too many pieces of scientific gadgetry, too many scientists, engineers and tinkerers, too many published as well as hidden drafts, experiments, and institutional agendas had their influence on what later became the actual components of RFID systems. The development of a hybrid composition such as RFID has no single event to base itself on. Stockman is rather a piece, a storybook character, in the developing years of the electronic age. Nevertheless, his inventive demonstration of a new method of communication was indeed a "landmark." By applying the state of the art in radiation engineering to communications engineering, it sparked the very crucial transfer mode that—when the prophecy fulfills itself—we will employ in the near future when we address the multitude of things that we produce, ship, wear, use, own, and play with.

What does this little story (or legend, if you will) tell us for our purpose? It tells us that RFID, as a technology that enables locative media, carries a certain prefiguration, a kind of operant conditioning. It tells us that the very concept of backscatter RFID is created and based on an architecture of seeing and jamming. The massive research undertakings in the field of radar during the Second World War turned the electromagnetic spectrum into a controlled environment, penetrated by an armada of newly designed electronic apparatus. This led to several innovations that we still draw upon now when we talk about locative media.

Let me show how. Two days after Harry Stockman was given a mere twenty minutes to present his ideas on retroreflective communication at the convention of the IRE, a special session called "Advances Significant to Electronics" was held in the morning. Invited speakers were Norbert Wiener, Claude Shannon, John von Neumann, Isidor Rabi and Maurice Deloraine. The talks given were titled "Cybernetics," "Information Theory," "Computer Theory," "Electronics and the Atom," and "Pulse Modulation." That same morning, the session was already recognized as "destined to become known in future years as one of the more important IRE sessions ever to be held" (IRE 1948, 366). What came together there is as historical as it is intertwined with the state-of-the-art equipment that Stockman used for his identification experiments. To begin with my introductory nexus: in the same year when Stockman presented his retroreflective communication, Norbert Wiener's celebrated book on cybernetics came out, spawning that new information science which had originally started with the attempt to aim anti-aircraft fire automatically by reinserting radar measurements into the trajectory equations of an airplane. Claude Shannon's "Mathematical Theory of Communication" was also published just a few months after the convention (although it was written earlier). In many ways, the fundamental quantification of information he presented therein resulted from his own work on the extraction of signals from noise in radar operations. 1948 was also the year when—under the consultancy of John von Neumann—the assembly of Whirlwind began. Whirlwind was the first computer capable of processing data in real time—radar data, of course! Isidor Rabi, a nuclear physicist, was associate director of the MIT Rad Lab, where he conducted basic research into the fundamental physics of radar before he went to Los Alamos. And last but not least, Maurice Deloraine's pulse-code modulation is the very basis of today's data media such as CDs, DVDs or even digital TV and radio broadcasts. Stockman's analog data transfer method was, at the very same conference, surpassed by the fully-fledged dawn of the digital. Yet the most important event might not be the talks of the protagonists of this paradigmatic shift. Instead, it might be the moment just a few weeks earlier in wintry New Jersey, when a plastic triangle wrapped in gold foil established contact with a plate of germanium. This point contact transistor became the starting point of the famous exponential trend in miniaturization that now allows us to put tiny microchips on tubes of toothpaste.

Setting sail in the backwash of World War II, the striking concomitance of all these developments is no plain coincidence. All in a fundamental way shaped by the scientific engineering efforts to get radar working reliably—and therefore to control radio frequencies in the higher bandwith—these developments mark the beginning of the electronic age. And RFID, in its most mass-compatible conceptualization of transponders scattering information back to an interrogating device, is right in the midst of it all. While RFID as such would never have had become an idea without radar, without radar it also would not bear its intrinsic antagonistic cultural design. It comes as no surprise when Crang and Graham notice a "war-like architecture of self/other" (Crang and Graham 2007, 814, following Louise Amoore) in the combination of technologies such as RFID to identify and track targets in the "War on Terror."

While the Department of Defense's call for a "Manhattan Project"-like program for total surveillance, mentioned by Crang and Graham, is in fact just a hyperbolic dystopian fantasy, the first large-scale employment of RFID was indeed executed in the run-up logistics of the war in Iraq (Rosol 2008). Pervasive computing technologies are war architectures of self/other, only that the other does not need (yet) to be an insurgent but just the evil chaos of losing track of artillery shells and armored vests in unexpectedly hostile countries (Figure 4).

The "ontology of the enemy," as Peter Galison (Galison 2004) called Wiener's cybernetical thinking, is a militarized configuration of the self/other in the process of the visualization of a remote pilot (radar) or prospective consumer/terrorist/disordered mind (RFID) by computing its transitory behaviour. According to Crang and Graham, "hybrid spaces [do] enable visibility" (Crang and Graham 2007, 791). Enabled, among others, by the itself-extremely-hybrid technology RFID, the visibility in such spaces is based on reading (signals, code, ID-numbers) that, in turn, is based on seeing by means of electromagnetic radiation in a spectrum where visibility fails. Since RFID was forged in a time when the primary aim was to get ahead of the enemy in the continuing interaction between detecting and jamming, we ought to wonder how fragile and vulnerable an RFID-networked world and its alleged control over things, bodies and localities might eventually be. Since it was forged in a time when the outstanding goal was to connect (and to disrupt connections between) machines, rather than connecting (or disrupting connections between) people, we ought to wonder about what actually defines, or mounts, the room for social interaction when employing this locative media technology.

References

Anonymous. 1943. Radar – wartime miracle of radio. *Radio Age* 2 (4): 3–7.

Bishop, W. B. 1951. *The practicability of retrodirective reflectors for communications purposes*. Technical report no. E4081. Cambridge, MA: Air Force Cambridge Research Center Laboratories.

Crang, M., and S. Graham. 2007. Sentient cities: Ambient intelligence and the politics of urban space. *Information, Communication & Society* 10 (6): 789–817.

Dodge, M., and R. Kitchin. 2004. *Codes of life: Identification codes and the machine-readable world*. Working paper, Centre for Advanced Spatial Analysis, University College London.

Galison, P. 1994. The ontology of the enemy: Norbert Wiener and the cybernetic vision. *Critical Inquiry* 21 (1): 228–266.

Garfinkel, S. and H. Holtzman. 2005. Understanding RFID technology. In *RFID: Applications, security, and privacy*, ed. S. Garfinkel and B. Rosenberg, 15–36. Upper Saddle River, NJ: Addison-Wesley.

Genuth, J. 1988. Microwave radar, the atomic bomb, and the background to U.S. research priorities in World War II. *Science, Technology and Human Values*, 13 (3, 4): 276–288.

IRE. 1948. IRE National Convention Program. *Proceedings of the Institute of Radio Engineers* 36 (3): 365–369.

Kabisch, E. 2008. Datascape: A synthesis of digital and embodied worlds. *Space and Culture* 11 (3): 222–238.

Landt, J. 2001. *Shrouds of time. The history of RFID*.

Leong, K. S., M. L. Ng, and D. W. Engels. 2004. EPC Network Architecture. *Auto-ID Labs*, Research Workshop. (last accessed 30 October 2008).

Mohd-Yasin, F., M. K. Khaw, and M. B. I. Reaz. 2006. Techniques of RFID systems: Architectures and applications. *Microwave Journal* 49 (7): 62-74.

Price, A. 1967. *Instruments of darkness: The history of electronic warfare*. New York: Charles Scribner's Sons.

Roberti, M. 2004. RFID Upgrade gets goods to Iraq. RFID Journal, 23 July, (last accessed 30 October 2008).

Rosol, C. 2008. *RFID. Vom Ursprung einer (all)gegenwärtigen Kulturtechnologie*. Berlin: Kulturverlag Kadmos.

Stockman, H. E. 1948. Communications by means of reflected power. *Proceedings of the IRE* 36 (10): 1196–1204.

Thrift, N. 2004. Remembering the technological unconscious by foregrounding knowledges of position. *Environment and Planning D* 22: 175–190.