THINKING ABOUT RFID

In the last year, RFID (radio frequency identification tags) have emerged as a promising and controversial technology in the worlds of commerce, health, and security. RFID tags are touted as the next stage in the evolution of supply chains and inventory management; as a replacement for optical identification technologies in packaging and passports; and as a tool for improving shopping experiences and consumer satisfaction. They are also decried as Orwellian tools for increasing surveillance of shoppers, and reducing the privacy of citizens.

It goes without saying that while both visions are compelling, they're also wrong. RFID is not a new technology. In its current form it's actually been around for 20 years, and it evolved from technologies developed during World War II. Likewise, the future of RFID could be much more interesting than either its supporters or detractors suggest—assuming we understand the technology, and the right choices are made about its design and evolution.

To understand the future of RFID, it is useful to think about the kind of technology that RFID is, and to review its history.

INSTITUTE FOR THE FUTURE

THE FUTURES OF RFID: A MEMO SERIES

Technology Horizons Program

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1 Thinking About RFID

The Futures Of RFID: A Series of Memos

To help **Technology Horizons Program** members understand the long-term potential RFID, the Institute for the Future (IFTF) has undertaken a project to map the future of RFID beyond the supply chain. Even though companies are struggling with the Wal-Mart and Tesco mandates to add RFID tags to pallets and cases of goods, it's not too early to begin thinking about how the technology could be used outside the supply chain. Our findings are presented in a series of five memos. This memo, **Thinking About RFID** (SR-926A), the first in the series, explains what RFID is and how it has evolved. The second, **Public Concerns and the Near Future of RFID** (SR-926B, analyzes consumer concerns about RFID, and discusses recent and coming controversial uses of the technology. The third, **Flashpoints and Controversies** (SR-926C), focuses on controversial potential uses of RFID. The fourth, **Smart Homes and Sociable Devices: RFID Takes Off** (SR-926D), looks at RFID's role in smart homes and a world of pervasive computing. And in the fifth and final memo, **RFID: Implications and Recommendations** (SR-926E), we discuss what the future of RFID means and how to avoid potential pitfalls posed by controversial uses and navigate to a world where businesses and consumers alike find great value in RFID.

RFID IS A TECHNOLOGICAL SYSTEM

The first thing to understand about RFID is that it is what sociologists of technology call a technological system. Such systems consist of a blend of hardware, software, institutions, regulations, and practices, all of which can influence each other. Technological systems have several important properties.

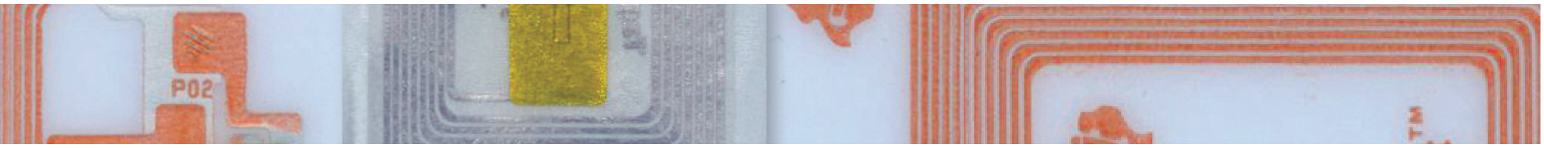
First, technological systems are made of many parts, not individual artifacts. Airplanes, computers, communications networks, and the Internet are all examples of systems. A system's components interact with and influence each other. The interactions yield behaviors or capabilities that are greater than the sum of its parts; the influences mean that a change to one part of the system will affect other component parts, and the overall behavior of the system. For example, in computer hardware, a more powerful microprocessor may draw more energy and give off more heat, forcing changes in the design of a computer's power supply, and a redesign of its layout to better circulate heat.

The boundaries of systems include anything that designers have sought to bring under their control. This means that technological systems can also include elements that we normally think of as non-technical, like businesses, technical standards, and legal regulations. Large systems, like electrical power networks, have institutions devoted to their management (electric utilities), and seek to influence the regulatory environment in which they operate. People and social institutions are also parts of technological systems, to the degree that they influence and are influenced by systems.

How does thinking of RFID as a system help us better understand the technology?

At the heart of the RFID system is the hardware, most notably tags—and readers. Each of these is itself a miniature system. Tags are a combination of computer chips, antennas, and a substrate holding them together. Readers consist of antennas; software for interpreting signals from tags; hardware to run the software; an energy source; and network connections (wired or wireless) that link readers to other computer systems.

Tags get most of the press, but in fact they're useless without readers. Tags and readers interact when a reader sends out a burst of energy at a certain radio frequency; the tag absorbs some of it, which allows it to send out its own signal, consisting of the information on its chip. Essentially, tags are like tiny mirrors that reflect back some of the energy shined on them; or, as one MIT engineer put it, they're "bar codes that bark." However, they're very sensitive mirrors: the connection between tag and reader can be disrupted by walls, liquids, radio static, poor alignment between the tag and reader, or other environmental factors.



The RFID system also includes data and software: the data written into the tags, databases that manage information generated by tag-reader interactions, and analytical software to make sense of that information.

Finally, the system also includes social and legal elements. Foremost among these are technical standards. Standards create a level playing field for technologies, facilitate interoperability, and make it easier for new players to extend the capabilities of existing technologies. The acceptance of standards will also determine the geographical reach of the RFID system, and the degree to which the same tags, readers, frequencies, and software can be used in different places around the world. The reach of standards defines the reach of systems. Standards also reflect deeper design and strategic calculations. The standard for electronic product code (EPC) tags, which are designed as a replacement for the bar codes on consumer goods, is shaped by a belief that very cheap, simple tags can deliver value to companies and consumers, and provide a strong foundation for the growth of RFID.

Standards are not the only parts of a system that reflect values and calculations. The design of the parts of the system can encourage or inhibit experimentation, while legal rules can promote or stifle innovative behavior among different stakeholders. The Internet is a great example of how a self-consciously open system can encourage innovation: by establishing a few rules governing how devices could communicate with each other, but opening the system to any innovators and hardware, the Internet was able to both grow quickly and evolve into the immensely complex entity it is today. (In comparison, proprietary networks like Compuserve or AOL, which were "walled gardens" with their own protocols and software, either went out of business or evolved to integrate with the Internet.) Recent arguments between Hollywood and Silicon Valley over whether digital-rights management (DRM) schemes should be designed into electronic entertainment devices are essentially arguments over openness, and whether technologies should be part of DRM systems or open to consumer innovation (and perhaps abuse).

Other social rules also influence the RFID system. Federal Communications Commission (FCC) rules determine how powerful the RF antennas used on RFID readers can be, and what frequencies they can use. Corporate privacy policies or design standards are also part of the system: they set the rules for how RFID technology is deployed, and how information gathered by the system is used. Privacy laws will define how information can and cannot be used. Finally, consumer perceptions will affect how the system is used, and how widely it spreads.

The future of RFID will not be determined by hardware or software, but by the interaction of all parts of the system. When thinking about the future of RFID, it is necessary to think not just about the tags themselves. Hardware developments are important, but they do not determine the path the technology takes. Legal regulations, consumer enthusiasm or resistance, and other factors may slow or speed commercial adoption just as surely as intractable technical problems. Likewise, user-defined needs drive how a technology will evolve and diffuse. Those evolutionary paths are not determined by the technology itself.

1 Thinking About RFID

THE HISTORY OF RFID

RFID is making headlines now, but it is the product of a decades-long process of technological evolution. RFID found some of its first applications in the military. It is now being taken up by business. In the future, RFID will be adopted by individual private users.

This is a familiar trajectory for many modern technologies, from Bessemer-process steel in the late 19th century, to radio and aviation in the early 20th, to the transistor and computer in the mid-20th, to GPS at the end of the last decade. In all these cases, the military adopted these technologies for strategic or tactical advantage, with little regard to their cost. This created a situation in which companies could evolve a mature technology in the absence of strong civilian demand, develop a measure of legitimacy for their work, and escape the low demand/high cost problems and early adopter reluctance that stifle many promising technologies. Such early patronage lowers the barriers for industrial adoption of the technology; this in turn further reduces costs, leading eventually to broad accessibility and even adoption of the technology by individuals.

One way to think about the evolution of RFID is to follow the evolution of three major uses: vehicle tracking, container tracking, and object tracking (see Figure 1). Like any schema, it highlights some uses while discounting others: for example, an alternate history could be organized around object tracing, which is concerned less with locating an object than revealing its history.

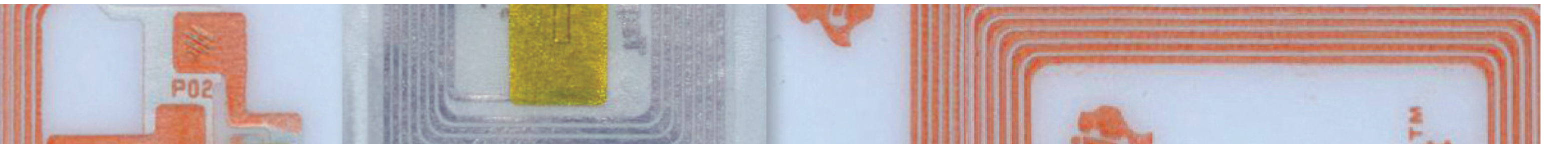
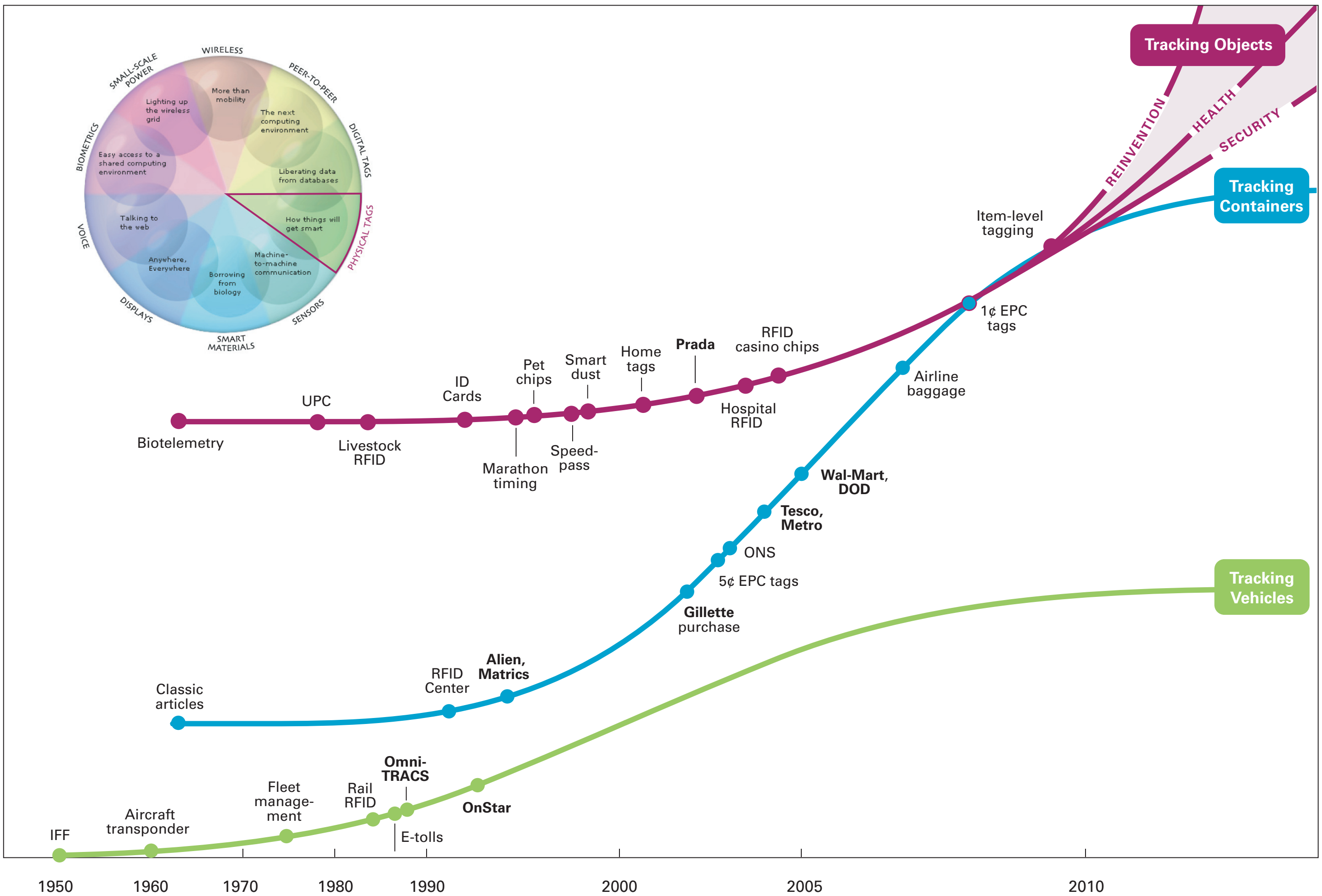


Figure 1

RFID as a Tracking Technology, 1945–2010



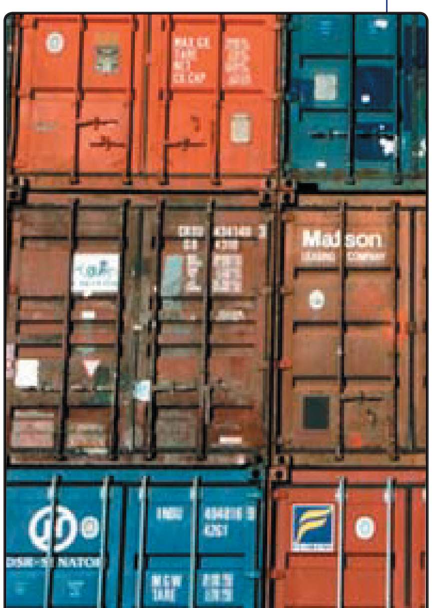
Source: Institute for the Future

1 Thinking About RFID

VEHICLE TRACKING

The first RFID-like technologies were used in World War II, in IFF (identification friend or foe) systems. These consisted of transponders installed on aircraft, which broadcast a signal that could be read by fire-control crews. In 1960, the federal government required civilian aircraft to install transponders, to help air traffic controllers keep better track of aircraft. The technology reached the ground in the 1970s, in fleet-management systems used on railroads and trucks. OmniTRACS, a leading fleet-management system company, opened in 1989.

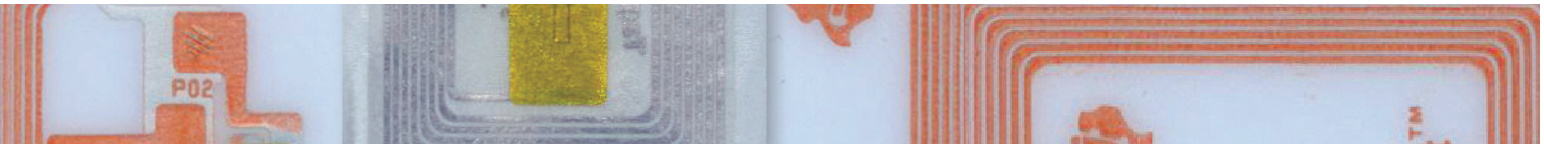
RFID begin to make its way into private autos in the late 1980s. The first electronic toll systems, used by commercial vehicles and private autos, appeared in 1988 in Europe, and spread to the United States within a couple years. In 1996, GM launched OnStar, which uses GPS and wireless technology to provide drivers with emergency roadside assistance, remote unlocking, directions, and concierge services.



CONTAINER TRACKING

Container tracking was discussed as early as 1960s, but the technology didn't take off until the early 1990s, with the opening of MIT's Auto-ID Center, and similar laboratories in Cambridge, Switzerland, Australia, Japan, and China. Container tracking is the epicenter of RFID today: and its adoption curve is primed to take off now. The ONS (Object Name Service) was opened in early 2004. In 2005, Wal-Mart and the U.S. Department of Defense will require suppliers to use RFID on pallets and cases of goods, and a number of other retailers are following suit. All these projects are focused on improving warehousing, delivery, and inventory control.

There are also container-level experiments using RFID as a security technology. The first state laws mandating use of RFID for drug safety purposes go into effect in 2005. Several airlines and airports are also experimenting with RFID-enable baggage tagging.



OBJECT TRACKING

Object tracking has been around since the early 1960s, when biologists first used radio transponders to track large mammals. (This practice really took off in the late 1960s and early 1970s.) But as with container tracking, there has been a long lag time between early adopters and the mainstream.

The 1990s saw the emergence of RFID in a variety of object tracking applications: contactless ID cards, marathon timing systems (in which RFID tag worn on runners' shoes activate an electric mat at the start and finish lines), implantable pet ID systems, and rapid payment systems used in gas stations and toll booths. Around 2000, a few companies also begin to sell keychain-sized radio-frequency tags that can be attached to PDAs, remotes, and cell phones. More recently, libraries have adopted systems that use RFID tags embedded in books to speed book checkout and shelf inventory.

IMPLICATIONS

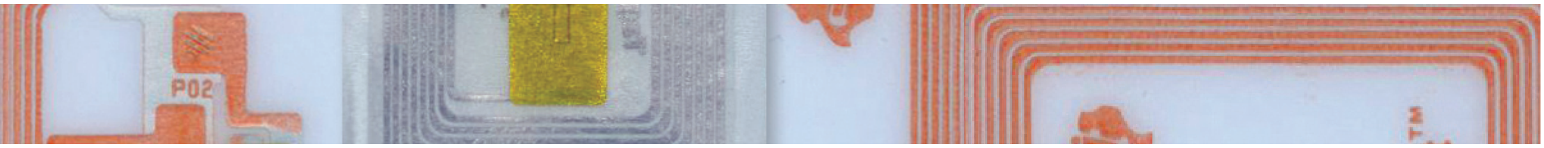
1. RFID IS A SYSTEM, NOT A SINGLE TECHNOLOGY

RFID consists of a blend of hardware, software, institutions, regulations, and practices, all of which can influence each other. New technologies enable new practices. Consumer reactions to new practices influence regulation. Regulations define acceptable practices. The future of RFID will not be determined by hardware or software, but by the interaction of all parts of the system.

2. CONSUMER BENEFIT WILL COME FROM RFID SYSTEMS, NOT JUST TAGS

Tags are the most contentious and publicly visible parts of the RFID system, but in isolation they are useless and harmless. The diffusion of RFID, and the extent of consumer contact with the technology, will be a function of the diffusion of readers, software, and applications, not just the tags.

The systems perspective also suggests that consumers will not be able to reap substantial direct benefits from RFID until they have access to other parts of the system: tags that they can write, program, and apply to their own goods; readers that they can install at home; and software that integrates RFID-generated information with other home-management and communication systems. Whether RFID remains part of a "walled garden" of commercial services that consumers can subscribe to and use but not customize or redesign, or is allowed to break free and find new uses, will determine whether RFID tags remain a curiosity, or become part of everyday life.



**3. CONSUMERS HAVE ALREADY USED RFID ...
BUT THE MOVE FROM SUPPLY CHAIN TO CONSUMERS IS A JUMP TO A NEW CURVE**

Consumers have actually had more experience with RFID than they realize; they just don't think of electronic toll passes or work IDs as RFID-enabled devices. A Cap Gemini Ernst & Young study found that while 77% of those surveyed had not heard of RFID, many of them had heard of Mobil's Speedpass or E-ZPass. It's a classic example of Paul Saffo's observation that "it takes 30 years for a technology to become an overnight success."

Today, companies are spending tremendous amounts of energy getting RFID-enabled supply-chain systems working. But thinking about item-level RFID tagging the same way you think about RFID vehicle or container tagging is a mistake: it's a jump to a new curve, not another point on the current one. Putting tags onto things that people might wear or carry constantly, for example, creates a very different kind of relationship between the user and the technology than exists when the tag is on a box—or when the tag is on a case that the user never sees. Item-level tagging is a paradigm shift for consumers, and will require technologists and companies to think differently about RFID.

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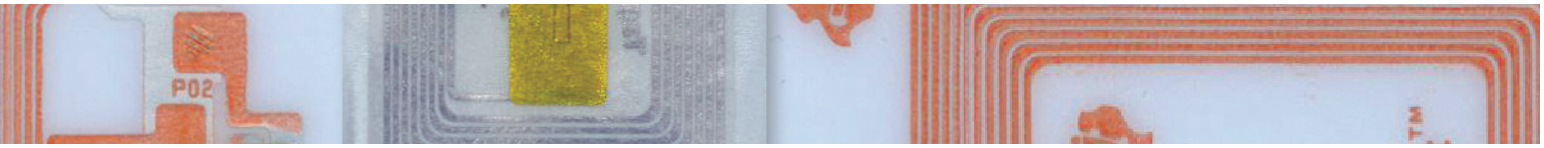

ABOUT THE ...

THE TECHNOLOGY HORIZONS PROGRAM

The Technology Horizons Program combines a deep understanding of technology and societal forces to identify and evaluate discontinuities and innovations in the next three to ten years. We help organizations develop insights and strategic tools to better position themselves for the future.

INSTITUTE FOR THE FUTURE

The Institute for the Future is an independent, nonprofit strategic research group with 35 years of forecasting experience. The core of our work is identifying emerging trends and discontinuities that will transform global society and the global marketplace. We provide our members with insights into business strategy, design process, innovation, and social dilemmas. Our research generates the foresight needed to create insights about the future that lead to action. Our research spans a broad territory of deeply transformative trends, from are health and health care technology, the workplace, and human indentify. The Institute for the Future is based in Palo Alto, California.

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