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# Humancentric applications of RFID: the current state of development

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# Humancentric applications of RFID: the current state of development

**Abstract**

Radio Frequency Identification, or RFID, is a wireless data collection technology which, through the RF portion of the electromagnetic spectrum, uses electrostatic or electromagnetic coupling to identify objects, animals and humans as unique entities. The technology first reached mass-market application in the 1980s when it was earmarked by industry as appropriate for identifying high value items moving through the manufacturing and assembly process. Successful implementation here saw RFID systems later grow to encompass supply chains, commercial goods and animals. The most recent advance in the evolutionary development of RFID has been to make humans the subject of applications. The purpose of these applications has ranged from convenience, to access, to monitoring, and to allowing for communication. We have carried the RFID devices in our hands, wallets, and our clothes. Now, potential exists to carry the technology in our bodies. This thesis examines current applications associated with the RFID implantation of humans. It aims to bridge the gap between existing technical knowledge and speculation as to future uses. Research design is based on a usability context analysis methodology with applications thematically separated into areas of control, convenience and care. This qualitative study will clarify the current state of development by investigating issues of use, nature and commercial feasibility.

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# Humancentric Applications of RFID: The Current State of Development

**IACT450 – Information and Communication Technology Honours Thesis**

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# Executive Summary

Radio Frequency Identification, or RFID, is a wireless data collection technology which, through the RF portion of the electromagnetic spectrum, uses electrostatic or electromagnetic coupling to identify objects, animals and humans as unique entities. The technology first reached mass-market application in the 1980s when it was earmarked by industry as appropriate for identifying high value items moving through the manufacturing and assembly process. Successful implementation here saw RFID systems later grow to encompass supply chains, commercial goods and animals.

The most recent advance in the evolutionary development of RFID has been to make humans the subject of applications. The purpose of these applications has ranged from convenience, to access, to monitoring, and to allowing for communication. We have carried the RFID devices in our hands, wallets, and our clothes. Now, potential exists to carry the technology in our bodies.

This thesis examines current applications associated with the RFID implantation of humans. It aims to bridge the gap between existing technical knowledge and speculation as to future uses. Research design is based on a usability context analysis methodology with applications thematically separated into areas of control, convenience and care. This qualitative study will clarify the current state of development by investigating issues of use, nature and commercial feasibility.

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## 1.1 Topic

Humancentric Applications of RFID: The Current State of Development

## 1.2 Introduction

Over the past two decades, radio frequency identification (RFID) systems have evolved to become the foundation for many vital services and complex applications. From first beginnings in tracking to today's communication architectures, RFID has been conceptualised as a breakthrough in convenience and modern monitoring efficiencies. Indeed, with supporters of RFID predicting that it will advance to providing key medical services and improved security systems, one RFID manufacturer has been led to promote the devices as "life-enhancing technology".[1]

Though these lifestyle benefits of RFID have long been touted, it is only recently that humans themselves have become both integral and interactive components in RFID systems. Where we once carried contactless smart cards or embedded devices interwoven in clothing, RFID technology has now advanced to the point where humans can safely be implanted with small RFID transponders. It is this latter stage of RFID development that this study seeks to investigate.

## 1.3 Background

### 1.3.1 What is RFID?

**R**adio **F**requency **Id**entification, or RFID, is "a wireless data collection technology"[2] which, through the RF portion of the electromagnetic spectrum, uses electrostatic or electromagnetic coupling to identify objects, animals and humans as unique entities.[3] A simple RFID system consists of an antenna and transceiver (generally combined as a 'reader') and a transponder or tag. The reader components of the RFID system scan the radio frequency and transmit any information gathered to a processing unit.

[1] Anonymous. 'Skin Deep: Human Microchip Gets Green Light For U.S. Distribution' *Wireless News* [Online] April 5, 2002. Available ProQuest, March 18, 2003

[2] C Wibberley. 'Tag, You're It: RFID Struggles For Greater Recognition' *Electronic News* vol. 48, issue 38, Sept 16, 2002, p1 (2)

[3] Webopedia 'RFID – Webopedia.com' Jupitermedia Corporation, USA, 2003 [*http://www.webopedia.com/TERM/R/RFID.html* Last Accessed: 24/03/03]

Conversely, the transponder is "an integrated circuit containing the RF circuitry and information to be transmitted".[4]

The technology is similar in theory to bar-coding. Unlike barcodes however, RFID does not require line-of-sight scanning or direct contact. Further, some industrial-use RFID signals, especially those recorded in the higher spectrum frequencies, can be measured at distances 90 feet or more away from the transponder.[5]

### 1.3.2 What is the current RFID application environment?

The current state of innovation for RFID applications can be analysed from two perspectives. The first involves looking at the subject to which the application of RFID is applied, namely, the entity to which an RFID transponder in attached. The second involves an examination of the object of RFID, or the RFID device itself.

*The RFID subject – the entity to which an RFID transponder is attached*

RFID first reached mass-market application in the 1980s when industry earmarked the technology as appropriate for identifying "high-unit-value products moving through a tough assembly process".[6] The main subjects of RFID systems at this point of development were the components of an industrial procedure. As one example, in the automotive industry RFID transponders were applied in the assembly line to verify vehicle identity and track the manufacturing process.[7] After being subject to harsh temperatures, astringent paints, cleaning agents, and other such severe industrial processes, RFID proved its robustness. The next logical step was then to move RFID outside the factory environment.

In keeping with earlier tracking rationales, RFID systems expanded their scope to embrace the supply chain. The subject entities tagged with an RFID transponder grew from the manufactured item to the transport that moved them from manufacture to sale. Application to rail is one illustration, where programmable tags attached to train carriages permitted "the full [U.S.] industry standard 12-character identification of

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[4] Ibid
[5] Ibid
[6] Association for Automatic Identification and Data Capture Techniques. 'Automatic Identification and Data Capture Technologies'. AIM Inc. Pennsylvania. 2003 [*http://www.aimglobal.org/* Last Accessed: May 01, 2003]
[7] Ibid

each car by type, ownership and serial number”.[8] Similarly, trucks became the subjects of RFID application as transponders transmitted access and egress information to and from terminal stations.

With RFID now beginning to pervade commercial environments, it was only a matter of time before products; fast-moving consumer goods in particular, were subjected to tagging. Beginning with UK and US trials, the application of RFID transponders to retail goods is now slowly moving away from its niche application. The technology is to be imposed on us all with Gillette, as one example, recently purchasing 500 million RFID transponders to tag their Mach 3 razor blades throughout England.[9]

It is not only inanimate items that have been the subject of RFID applications. Animals have not escaped the attention of technology. In fact, the application of RFID to animals has become so pervasive that it has become the subject of two ISO standards. They are ISO 11784: ‘Radio-frequency identification of animals – Code structure’, and ISO 11785: ‘Radio-frequency identification of animals – Technical concept’.[10] In this way, RFID can be used for stock keeping, tagging of meat and dairy animals, tracking during migration or racing, and identification of pets, wildlife and laboratory creatures.

From here, the next and most recent level in the evolutionary development of RFID has been to make humans the subject of applications. The purpose of these applications has ranged from convenience, to access, to monitoring, and to allowing for communication. Further, as considered in the following subsection, we have carried the transponders in our hands, our wallets, our clothes, and in our bodies. Thus, from first industrial applications, RFID has infused itself in everyday life. So much so that humans are now becoming the principal subjects of its application.

*The RFID object – the device that performs RFID operations*

Looking specifically to devices that enable humans to become integral parts of the RFID system, the first major available appliances for humancentric RFID applications

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[8] Ibid

[9] D Thomas. ‘RFID Sparks Legal Fears’ *Computer Weekly* [Online] January 14, 2003. Available Expanded Academic Index, March 18, 2003

[10] K Finkinzeller *RFID Handbook. Radio-Frequency Identification Fundamentals and Applications* John Wiley & Sons Ltd, England 2001, p. 159

were smart cards.[11] Primarily for access purposes, they have been most common in the workplace with employers requiring employees to carry their cards as both an identification measure and, through the use of card readers, as a means of opening doors or allowing entry to secure areas.

Smart cards and similar devices have been deemed "luggables"[12] as they require carrying, though to some extent they are also "wearable with the aid of an external clip or fastener".[13] More commonly however, 'wearables' refer to the generation of RFID objects that includes mobile phones, pagers and PDAs which can all be worn using clothing or a belt clip; and wristwatches, accessories and clothing which can all be embedded with small transponders.[14] These wearable devices serve functions ranging from location services, to communications and access, to emergency and medical functionalities.

With such proven and widespread applications, RFID is cementing itself as an omnipresent technology, capable of applying itself to all aspects of human life. Of importance however, is the idea that "the technology is becoming so ubiquitous [that] it's almost invisible".[15] Though such a statement may provoke philosophical debate, the literal truth of the assertion is overwhelming when we recognise that recent years have seen the evolution of human RFID implants. Beginning in August 1998 when Professor Kevin Warwick, Director of Cybernetics at the University of Reading became the first experimental human host of an RFID transponder,[16] humancentric RFID device development has since progressed to the stage where the VeriChip Corporation in the United States has begun selling implantable human RFID transponders to the mass retail market.[17] As such, RFID implants for humans are a feasible, marketable and current reality.

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[11] Ibid, ch. 1

[12] K Michael. *The Technological Trajectory of the Automatic Identification Industry* PhD Thesis, University of Wollongong, Australia, 2003. ch. 8. p. 2

[13] Ibid. ch. 8. p. 2

[14] Ibid. ch. 8

[15] Wibberley. Op cit

[16] S Witt. 'Professor Warwick Chips In' *Computerworld* Framingham, vol. 33, issue 2, Jan 11, 1999, pp 89-90

[17] Anonymous. April 5, 2002. Op cit

## 1.4 Research Proposal

This thesis aims to explore the current state of development for humancentric applications of RFID. The current state is defined by the intersection of existing practicable and proven levels of development for the subjects and objects of RFID – namely humans and implants.

The need for such a study has been identified by a gap in knowledge between where non-humancentric and technological development stands today and the future possibilities of humancentric RFID applications. Currently there is little public data that relates to existing humancentric RFID applications. Moreover, even those employed with contemporary RFID development are focused far into the future. Kevin Warwick for example, often talks of great potential applications in medical areas and, through the use of RFID technology, he "imagines paraplegics walking".[18] On the other hand, those who do not support the technology are quick to imply 'Big Brother' notions of repression and the end of the world.[19] In essence, both sides are producing emotional arguments based on prediction and forecast, greatness and doom.

This study aims to overcome opinion and forecast and provide a cohesive and impartial examination of existing, cutting-edge humancentric RFID applications. Analysis of future possibility and social implication is outside the scope of this study. Instead, discussion will be provided on existing and feasible applications, their use and benefit.

## 1.5 Aims and Objectives

The primary aim of this research is to ascertain the current state of development for humancentric applications of RFID. Its purpose is to fill a gap in the literature in the broader research area and it aims to provide a foundation for future research. Eight objectives, listed below, will aid in achievement of these aims.

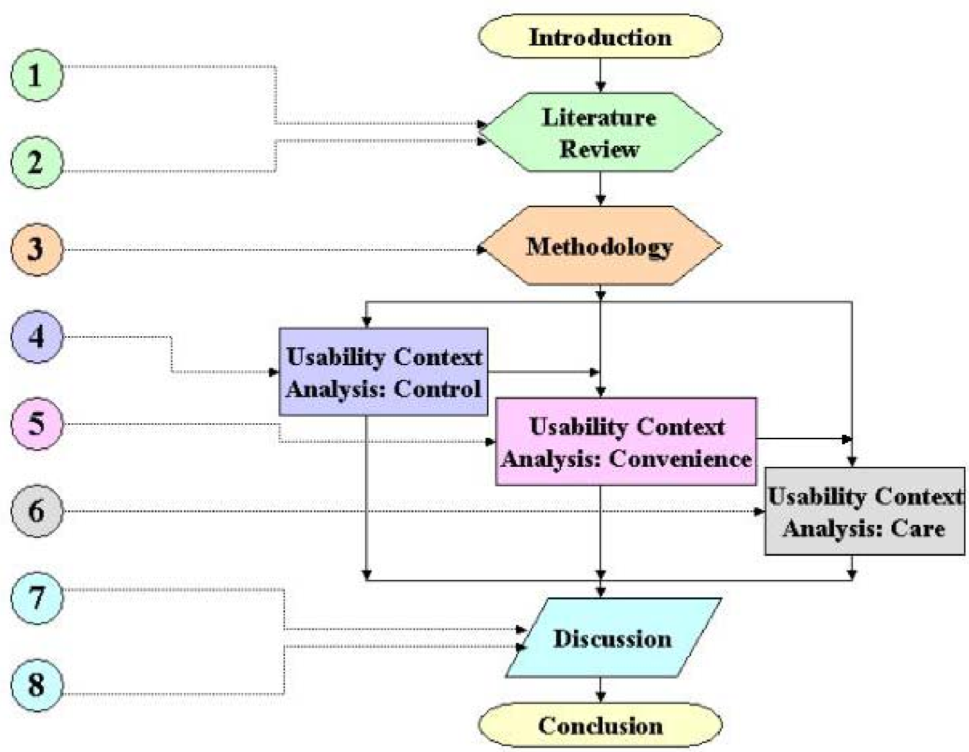
1. To conduct a thorough literature review on the current state of RFID development

[18] Witt. Op cit
[19] Greater Things. 'Chip Implants For Humans Already Here And In Use' Greater Things, Utah, 1999-2003 [*http://www.greaterthings.com/News/Chip_Implants/* Last updated March 15, 2003]

2. To expose a current gap in literature and knowledge relating to humancentric applications of RFID
3. To offer a way in which the current state of development for humancentric applications of RFID can be explored
4. To investigate the nature of those humancentric applications of RFID where function is based on control
5. To examine the improved lifestyle conveniences available via humancentric applications of RFID
6. To explore the powerful effects of RFID in areas of human care
7. To provide a discussion on the current state of humancentric applications of RFID
8. To define boundaries for the area of humancentric RFID applications

As shown in the following diagram, this thesis has been structured to aid in satisfying the above objectives. Each core chapter is linked to one or more objectives.

**Diagram 1.1: Diagrammatic Relationship of Objectives and Thesis Chapters**



## 1.6 Limitations

- The cutting edge nature of the technology in its current human-implantable form means there is somewhat limited archival documentation available
- Many current publications on the topic focus solely on ‘Big Brother’ aspects of RFID surveillance. Such reports will need to be filtered out of research in order to maintain a study not upset by emotional and conspiratorial predictions
- There are few openly contactable experts in the field
- This is a controversial area of study, provoking much public debate from civil libertarian groups

## 1.7 Outline Of The Thesis

Chapter two will review the existing literature published in the area of RFID, with specific attention given to humancentric applications. Landmark studies will be highlighted and a gap in current knowledge will be identified. Chapter three outlines the usability context analysis methodology that this study will use in attempting to bridge the identified gap in literature. Chapters four, five and six implement the methodology and present the results of usability context analyses in respective application areas of control, convenience and care. Following, in chapter seven, is a discussion of the preceding results. The discussion will illustrate the findings of the research. Finally, chapter eight closes the study and provides conclusions of the work.

# Chapter Two: Literature Review

## 2.1 Introduction

At present there is little information in public hands that relates to existing Radio Frequency Identification (RFID) applications. There is even less data which deals exclusively with more specific humancentric applications. A review of this literature is still useful however, both to qualify the current state of research and to clearly identify and confirm the gap in knowledge that this thesis aims to bridge. Accordingly, the review will satisfy objectives 1 and 2.[20]

Initially, an overview of the literature is required to show the resources currently available for research into humancentric applications of RFID. This part of the review is divided into two main topical areas. The first of these involves a minor analysis of the literature surrounding the current state of non-humancentric applications of RFID. This is because humancentric applications of RFID evolved from prior industrial, commercial and animal RFID uses. Now, as humancentric applications come into being, commercial and animal applications are continuing to develop. This analysis therefore serves to highlight the influence of non-humancentric applications on current humancentric developments and shows the prior development state in an evolutionary framework. This is followed by a larger examination of literature pertaining to the current state of development for humancentric applications of RFID. The latter analysis organises the literature into three main spheres – control, convenience, and care. In all contextual areas, literature will be reviewed chronologically.

Secondly, a critical response to the identified literature is necessary. This will include an examination of the value of the literature to proposed research, incorporating an overview of potential building blocks and identified inadequacies. By this means, a clear gap in the literature will be highlighted and the need for a thesis of this kind, exploring the current state of development in humancentric applications of RFID, will be justified.

[20] See Section 1.5

## 2.2 Summary Analysis of Literature: Non-humancentric Applications of RFID

### 2.2.1 Commercial Applications

Gerdeman conducted some of the first real research into commercial non-humancentric applications of RFID in his landmark study, '*Radio Frequency Identification Application 2000: a guide to understanding and using radio frequency identification*'.[21] Using a methodology reminiscent of a case study, Gerdeman presents a complete review of the use of RFID within transport and transport-related industries. The results of these studies are a hybrid description of devices and applications. Though a standard reference on the topic, the objectivity of the work is sometimes questionable. This is because Gerdeman, a leading expert and supporter of RFID applications in transport, incorporates into his work strong justifications and a push for RFID implementation.

Finkinzeller's '*RFID Handbook: Radio Frequency Identification Fundamentals and Applications*'[22] followed Gerdeman's work and was also a landmark study because of its newness and comprehensive summation of subject matter. Unlike Gerdeman's niche analysis however, Finkinzeller focuses on broad but fundamental physical and operating principles of RFID systems in a highly technical narrative. This is supplemented by ten small but involved analyses of applications and here, like past research, results are presented as a descriptive examination of uses containing explicit commentary on benefits.[23] Nevertheless, substantial use is derived from the study in relation to future trends.

No major studies have been recorded in the area of commercial, non-humancentric RFID development since Gerdeman[24] and Finkinzeller.[25] Only a small number of minor reports are available to complement this early research. Some, such as the RFID Journal's editorial 'Can RFID Cure Healthcare's Ill's',[26] are of questionable critical analysis, merely identifying situations that could have been avoided if RFID

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[21] J Gerdeman. *Radio Frequency Identification Application 2000: a guide to understanding and using radio frequency identification* Research Triangle Consultants Inc, North Carolina, 1995
[22] Finkinzeller. Op cit
[23] Ibid. p. 269
[24] Gerdeman. Op cit
[25] Finkinzeller. Op cit
[26] Anonymous. 'Can RFID Cure Healthcare's Ills' *RFID Journal* November 12, 2002 [*http://www.rfidjournal.com/article/view/112* Last Accessed: April 29, 2003]

systems had been used. In this way however, the editorial supports Gerdeman's push for RFID implementation. In contrast, Higgins,[27] McCullagh,[28] Thomas,[29] and Yahoo Financial News,[30] who report on recent moves by Procter & Gamble, Gillette and Benetton to place RFID transponders on their manufactured consumer goods, avoid such speculation. Also objectively written, though again containing only description and not critique, is the catalogue of common applications for RFID on the AIM Global website.[31]

Some of the most recent literature is contained within the website of the Digital Angel Corporation.[32] The company, a manufacturer of RFID devices, lists the commercial applications of their "location-enabled"[33] products to include fleet management, vehicle or equipment reporting and recovery, monitoring waste and tracking products or containers. This validates the technological means for applications outlined in prior literature and shows a working foundation for RFID applications.

### 2.2.2 Animal Applications

In the realm of radio frequency identification for animals, Geers, Puers, Goedseels and Wouters' work on '*Electronic Identification, Monitoring and Tracking of Animals*'[34] is a landmark study, significant for its collation of innovative research. Their work details RFID applications for animals where devices are either attached or implanted and, like the studies of Gerdeman[35] and Finkinzeller,[36] contains a lengthy appraisal of the expected benefits. The real value of Geers' research lies in Chapter 6: 'Existing and Future Devices and Applications'.[37] Through analysis of applications,

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[27] A Higgins. 'We're Out Of That' *Machine Design* [Online] Cleveland. November 07, 2002. Available ProQuest, March 18, 2003
[28] D McCullugh. 'RFID Tags: Big Brother In Small Packages' *CNET News.Com* January 13, 2003 [*http://news.com.com/2010-1069-980325.html* Last Accessed: May 01, 2003]
[29] Thomas. Op cit
[30] Yahoo Financial News, Press Release. 'Benetton Selects Philips to Introduce Smart Labels Across 5000 Worldwide Stores'. Yahoo, San Jose, March 11, 2003 [*http://biz.yahoo.com/bw/030311/115697_1.html* Last updated: March 11, 2003. Last Accessed: April 08, 2003]
[31] Association for Automatic Identification and Data Capture Techniques. Op cit
[32] Digital Angel Corporation. 'Welcome To Digital Angel.net'. Digital Angel. Minnesota. 2003 [*http://www.digitalangel.net/about.asp* Last Accessed: May 01, 2003]
[33] Ibid
[34] R Geers et al. *Electronic Identification, Monitoring and Tracking of Animals* CAB International, United Kingdom, 1997
[35] Gerdeman. Op cit
[36] Finkinzeller. Op cit
[37] Geers. Op cit

the uses and operations for animal identification and medical monitoring systems are detailed. Conclusions are drawn "with respect to the design of injectable electronic identification and monitoring transponders",[38] showing the technical and objective nature of this analysis.

Applications and techniques identified by Geers are given credibility by Jansen and Eradus[39] who have written a highly technical report that both outlines the international standards for animal RFID and services the opinion that RFID implantation for animals has grown to be widely accepted. The commercial reality of this is highlighted by the website of the Destron Fearing Corporation,[40] one of the world's leaders in manufacture and sale of RFID implants for animals.

### 2.2.3 Influences on Humancentric Applications

The above review of literature on commercial and animal RFID applications is important as it shows the first stage of evolution for RFID development. With Sahal noting that "the basic design of a technological innovation acts as a guidepost [for] future innovation activity"[41] it also serves as a building block for future applications and studies.

Such developmental influences can be recognised in literature. Geers for example, states that transponders currently used in animals are capable of use within a human.[42] Similarly, Eng in his journalistic script notes the potentials and current research into taking the commercial but externally worn Digital Angel GPS-tracking product and combining it with the VeriChip, an implantable RFID device for humans.[43] It is Wibberley[44] however who presents one of the most prophetic, though outdated, contentions in her opening paragraph where she says of RFID transponders that

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[38] Ibid. p. 91

[39] M Jansen. W Eradus. 'Future Developments On Devices For Radiofrequency Identification' *Computers and Electronics In Agriculture* [Online] vol 24. issues 1-2. November 1999. pp 109-117. Available ScienceDirect, March 18, 2003

[40] Destron Fearing Corporation. Electronic ID, 'Applications' Destron Fearing, St Paul [*http://www.destron-fearing.com/elect/compan.html* Last Accessed: April 10, 2003]

[41] Sahal as quoted in K Michael. *The Technological Trajectory of the Automatic Identification Industry* PhD Thesis, University of Wollongong, Australia, 2003

[42] Geers. Op cit

[43] Eng, Paul. 'I Chip?' *ABC News.com* ABC News. March 01, 2002 [*http://www.abcnews.go.com/sections/scitech/DailyNews/chipimplant020225.html* Last Accessed: May 01, 2003]

[44] Wibberley. Op cit

> "They keep track of goods. They can help reunite pets and owners. They may even reside in humans someday."[45]

It should be noted however, that these three references, two of which occur in newstype articles, merely touch on the idea of developmental influence in fleeting and speculative statements. They do not provide a real predictive analysis on the topic.

## 2.3 Summary Analysis of Literature: Humancentric Applications of RFID

### 2.3.1 Control

For the purposes of this thesis, a control-related humancentric application of RFID is defined as any human use of an implantable RFID transponder that allows an implantee to have power over some aspect of their lives, or, that allows a third party to have power over an implantee. This definition of control extends to security applications.

Substantial literature on humancentric control applications of RFID begins in 1997 with a United States patent specification for a 'Personal Tracking and Recovery System'.[46] Registered to Paul Gargano, David Gilmore, Frank Pace and Lee Weinstein, the specification outlines an invention that can track and recover (find) humans who are implanted with an RFID transponder. Though the literature shows the theoretical use of RFID in a humancentric application in objective and scientific form, no further evidence is available to ascertain whether this invention has since been manufactured and marketed by Gargano and his colleagues.

Questions as to the feasibility of use are not necessarily answered by succeeding literature. LoBaido[47] writes of an experimental program called APRIL (Army Personnel Rationalisation Individual Listings) where transponders were inserted into the necks of volunteer soldiers in the British army. Though the article contains

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[45] Ibid

[46] P Gargano et al. 'United States Patent 5629678: Personal Tracking and Recovery System' USPTO Patent Full-Text and Image Database, United States Patent and Trademark Office [*http://164.195.100.11/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=/netahtml/srchnum.htm&r=1&f=G&l=50&s1='5629678'.WKU.&OS=PN/5629678&RS=PN/5629678* Last Updated: May 13, 1997 Last Accessed: April 09, 2003]

[47] A LoBaido. 'Soldiers With Microchips: British Troops Experiment With Implanted, Electronic Dog Tag' *WorldNetDaily* October 1, 2001 [*http://www.tribulationalinstitute.com/Powerpoint/full_story_on_microchip_implant.htm* Last Accessed: April 07, 2003]

interesting information on the use of implantable devices for third-party control, only one other non-mainstream news article[48] can be found to suggest that such trials took place. The validity of this article as a news source is therefore uncertain. Eng,[49] who writes of technical obstacles, further highlights feasibility issues, or what he calls "chipping blocks", of such systems. These include problems with the miniaturisation of GPS hardware and with manufacturing safe, active RFID chips that are capable of being recharged from within the human body.

Despite concerns raised by this early literature, actual working implementations of control-related humancentric applications of RFID have been identified. Both Murray[50] and Eng[51] have documented the implantation of Richard Seelig. Seelig had one implant inserted in his hip and another in his arm in response to the September 11 tragedy of 2001. This sophisticated technology was employed to provide security and control over personal identification information. Similarly, Canadian artist Nancy Nisbet has implanted RFID microchips into her hands in order to "explore the relationship between identity and technology".[52] Scheeres'[53] article 'New Body Art: Chip Implants' explains that Nisbet's experiment, albeit occurring in the name of art and not research, was primarily about the questioning and application of control in personal environments.

Despite these descriptive analyses of current implementations, much literature in this field is of a speculative nature. Eng,[54] for example, predicts that chips melded into children's bodies will be able to advise parents of a child's location, and alert guardians in situations where children are injured. Wakefield[55] similarly predicts a future in which implanted tracking devices are common. More importantly however, she propounds the notion of microchipping for national security and advises, "You can't get a better ID card than one you can put under the skin".[56]

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[48] D Icke. 'Has The Old ID Card Had Its Chips?' *Soldier Magazine* April, 2001.
[49] Eng. Op cit
[50] C Murray. 'Injectable Chip Opens Door To Human Bar Code' *EETimes* CMP Media, January 07, 2002 [*http://www.eetimes.com/story/OEG20020104S0044* Last Accessed: April 08, 2003]
[51] Eng. Op cit
[52] J Scheeres. 'New Body Art: Chip Implants' *Wired News* Lycos Inc, March 11, 2002 [*http://www.wired.com/news/culture/0,1284,50769,00.html* Last Accessed April 03, 2003]
[53] Ibid
[54] Eng. Op cit
[55] J Wakefield. 'Chips To Fight Kidnapping' *BBC News Online* March 24, 2002 [*http://news.bbc.co.uk/1/hi/sci/tech/1869457.stm* Last Available: April 19, 2003]
[56] Ibid

Wakefield's proposal for an implantable national identification system gains credibility from Michael's work on 'The Auto-ID Trajectory'.[57] This latter study presents a summation of "the last forty years of change"[58] and offers a holistic view of the auto-ID industry where previously only fragmented perspectives had been available. This landmark study, the most recent in RFID spheres, is also less speculative than previous reporting and uses a Systems of Innovation (SI) framework to discuss results. These results are presented through case studies, one of which, 'Human Security and Monitoring',[59] predicts (through a study of evolution) a move toward more commonplace control-related humancentric applications of RFID.

### 2.3.2 Convenience

For the purposes of this thesis, a convenience-related humancentric application of RFID is defined as any human use of an implantable RFID transponder that increases the ease of performing a particular task or tasks.

The first major documented experiment into the use of implantable RFID devices in humans revolved around convenience-related applications. *Pulse*,[60] Sanchez-Klein[61] and Witt[62] all give news reports on implantation of an RFID device into the arm of Kevin Warwick, Director of Cybernetics at the University of Reading. They define results of Warwick's research in application terms of having doors open, lights switch on and computers respond to the presence of the transponder. Warwick himself gives a review of the research in his article 'Cyborg 1.0',[63] however this piece of literature is informally written and contains emotive descriptions of "fantastic"[64] experiences. His article also contains proposals for his now-performed second RFID implant experiment, seeking to empower communication between humans with similarly implanted RFID devices.

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[57] Michael. Op cit
[58] Ibid. ch. 1. p. 6
[59] Ibid
[60] Anonymous. 'GP Creates Cyberman In Surgery' *Pulse* [Online] London. September 05, 1998. Available ProQuest, May 01, 2003
[61] J Sanchez-Klein. 'And Now For Something Completely Different' *PC World Online* [Online] San Francisco, August 27, 1998. Available ProQuest, May 01, 2003.
[62] Witt. Op cit
[63] K Warwick. 'Cyborg 1.0' *Wired Magazine* [Online] issue 8.02, February, 2000 [*http://www.wired.com/wired/archive/8.02/warwick.html* Last Accessed: April 09, 2003]
[64] Ibid

Woolnaugh,[65] Holden,[66] and Vogel[67] all published accounts of the lead-up to Warwick's second experiment. These three reports were available from newstype applications and, though Woolnaugh's work involves the documentation of an interview, all three are narrative descriptions of proposed events rather than a critical analysis within definitive research frameworks. Similarly avoiding critical analysis are the future visions espoused by the authors. Holden, for example, talks of opening up a future full of miraculous benefits,[68] while Vogel draws links with science fiction.[69]

Underhill documents results of the second experiment in his journalistic essay, 'Merging Man and Machine'.[70] He notes that the outcome of the trial fell short of what Warwick predicted, leading to a critique of Warwick's visions as "fantasies".[71] Though the commotion surrounding Warwick later died down, speculative fantasies did not with Eng[72] proposing a future where credit card functionalities will be commonly contained in implanted RFID devices. The result would see commercial transactions and keeping track of your wallet made more convenient.

The idea of convenience-related humancentric applications of RFID is also touched upon in Michael's[73] landmark study. Though not specifically stating that uses are related to convenience, Michael provides an analysis of Warwick's research. These Cyborg experiments are then however related to the "Quest for Immortality"[74] and abilities to "download the mind onto computer hardware".[75] This is a vision of the future that avoids the idea of incremental advances and speculates on new applications and technologies that cannot be feasibly implemented in the current state of development.

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[65] R Woolnaugh. 'A Man With A Chip In His Shoulder' *Computer Weekly* [Online] June 29, 2000. Available Expanded Academic Index, May 01, 2003

[66] C Holden. 'Hello Mr Chip' *Science* [Online] Washington. March 23, 2001. Available ProQuest, May 01, 2003

[67] G Vogel. 'Part Man, Part Computer' *Science* [Online] Washington. Vol 295. issue 5557. February 8, 2002. p1020 (1). Available Expanded Academic Index, May 01, 2003

[68] Holden. Op cit

[69] Vogel. Op cit

[70] W Underhill. 'Merging Man and Machine' *Newsweek* [Online] October 14, 2002. p38. Available Expanded Academic Index, May 01, 2003

[71] Ibid

[72] Eng. Op cit

[73] Michael. Op cit

[74] Ibid

[75] Ibid

### 2.3.3 Care

For the purposes of this thesis, a care-related humancentric application of RFID is defined as any human use of an implantable RFID transponder that has a function associated with medicine or health. This may include applications which improve general wellbeing.

After his Cyborg 1.0 experiment in 1998, Witt[76] quoted Kevin Warwick as saying that with RFID implants he envisions paraplegics walking. Building incrementally on this notion has been the work of Kobetic, Triolo and Uhlir[77] who documented their findings of a 1 year study on a 41-year old paraplegic male who had an RFID controlled electrical simulation system implanted to deliver stimuli to his muscles. Though not allowing the mobility which Warwick dreams of, results did include greater energy and overall fitness for the patient.[78] In a similar report on research, Berger[79] provides a discussion of Micro Electrical Mechanical Systems (MEMS). Berger notes that in studies, "MEMS has successfully measured the blood pressure in a healthy dog".[80] Unfortunately, the majority of further evidence is found only in journalistic news articles such as that of Murray.[81]

Outside the sphere of research, much literature centres on the Jacobs family who were implanted with the commercial RFID device VeriChip in 2002. Murray,[82] Black[83] and Grossman[84] all comment on the family of 'volunteers' and describe the medical reasons behind their implantation in a factual manner. Streitfeld[85] and Gengler[86]

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[76] Witt. Op cit
[77] R Kobetic et al. 'Implanted Functional Electrical Simulation System for Mobility in Paraplegia: a Follow-up Case Report' *IEEE Transactions on Rehabilitation Engineering* [Online] Dec 1999. Available ProQuest, April 29, 2003
[78] Ibid
[79] E Berger. "Microchip Implants May Save Lives One Day' *CNN.com* January 23, 2002. [*http://www.cnn.com/2002/HEALTH/01/22/microchip.heart/* Last Accessed: May 01, 2003]
[80] Ibid
[81] Murray. January 07, 2002. Op cit
[82] C Murray. 'Prodigy Seeks Out High-tech Frontiers' *Electronic Engineering Times* [Online] Manhasset. February 25, 2002. Available ProQuest, March 18, 2003
[83] J Black. 'Roll Up Your Sleeve – For A Chip Implant' *BusinessWeek Online* Business Week Magazine, The McGraw-Hill Companies, March 21, 2002 [*http://www.businessweek.com/bwdaily/dnflash/mar2002/nf20020321_1025.htm* Last Accessed: April 08, 2003]
[84] L Grossman. 'Meet The Chipsons' *Time* New York, vol. 159, issue 10, March 11, 2002, pp. 56-57
[85] D Streitfeld. 'Chips To Be Implanted In Humans' *Los Angeles Times* [Online] May 10, 2002. Available LexisNexis, April 07, 2003
[86] B Gengler. 'Chip Implants Become Part Of You' *The Australian* September 10, 2002

extend on this by reporting on the other five persons in the initial VeriChip trial, one of which, an Alzheimer's patient, was also chipped for medical, care-related purposes. Due to the commercial nature of VeriChip however, the only literature found on this particular trial is contained within press releases and newstype articles which follow descriptive journalistic, rather than research-based, patterns of reporting.

Non-trivial research is found in the work of Michael.[87] Her thesis uses a case study methodology and a SI framework to discuss the adaptation of auto-ID for medical implants. Her assessment covers developments in biochips, cochlear and retinal implants, paraplegia and speech,[88] though reported applications are not all specific to RFID. Instead, the case study is conducted with regard to five main automatic identification devices.

## 2.4 Critical Response To Literature

Of all the literature identified, the vast majority is of a newstype nature. For this reason, these journalistic articles contain no clear methodology for reporting other than a narrative or descriptive discussion. Similarly, the absence of frameworks for research is evident. There are few exceptions to this, but they include Woolnaugh[89] who conducted an interview, and Murray[90] and Eng[91] who provide what are arguably small case studies.

The real value in these news articles lies in the documentation of events and advancements though many authors, including Wibberley[92] and Higgins,[93] restrict reporting to a technological study. This thesis aims to advance this literature and provide research into the applications of the technology. Also differing from proposed research, the news articles do not demonstrate technological trajectories. Instead, many follow a pattern of describing a current event, and then speculating on potential future developments rather than possible current applications. What is more, these considered future developments are often utopian implementations and are not likely to be achieved by incremental developments in the near future.

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[87] Michael. Op cit
[88] Ibid
[89] Woolnaugh. Op cit
[90] Murray. January 07, 2002. Op cit
[91] Eng. Op cit
[92] Wibberley. Op cit
[93] Higgins. Op cit

Of the landmark studies identified, the majority are concerned with non-humancentric applications. Gerdeman,[94] Finkinzeller[95] and Geers[96] all analyse implementation scenarios and hence set a precedent in methodologies, but they have not highlighted clear research frameworks that help to guide this thesis. The fourth landmark study is clearer in its theoretical framework with Michael[97] structuring her research around SI. Michael's work has a greater focus on evolutionary theory than this thesis however and as such her SI approach is much broader than the analysis to be used here. Furthermore, Michael's work contains a discussion of future applications that are beyond the scope of the current state of development. Such speculatory advances, especially those that are to occur outside the immediate future, are not within the scope of this thesis.

Content of the landmark studies also differs. Obviously the non-humancentric studies of Gerdeman,[98] Finkinzeller[99] and Geers[100] are only relevant in detailing the prior state of development and showing how humancentric applications of RFID evolved. Alternately, Michael[101] provides some of the most recent academic information on humancentric applications of RFID. It should be noted however that Michael's study is not specific to RFID and instead focuses on five automatic identification technologies. As such, it cannot contain the same depth of research as an individual thesis dealing solely with this one technology.

### 2.4.1 A Short Summation of the Gap in the Literature

Though some major studies have been conducted in the area of RFID, just one contains research specific to humancentric applications. Further, it is only news articles that largely supplement these studies. As outlined above, much of this identified literature concerns itself with descriptions of current RFID technology or with speculation and visions of the far-off future. Consequently, a gap in academic knowledge has been identified between where non-humancentric and technological

94 Gerdeman. Op cit
95 Finkinzeller. Op cit
96 Geers. Op cit
97 Michael. Op cit
98 Gerdeman. Op cit
99 Finkinzeller. Op cit
100 Geers. Op nit
101 Michael. Op cit

development stands today and the future possibilities of humancentric RFID applications.

## 2.5 Conclusion

This literature review has been conducted for two purposes. Firstly, the review aimed to qualify the current state of research into humancentric applications of RFID and, in doing so, aimed to satisfy objective 1.[102] It has done this by noting the small amount of literature available and identifying the critical studies, all of which are supplemented by a number of news articles. The worth of these studies, including their relative values, similarities and differences, were also made clear.

Secondly, in satisfaction of objective 2,[103] the review aimed to identify a gap in the literature through a critical analysis. It was recognised that most studies dealt solely with descriptions and not analyses of existing technology, or they speculated about future potentials without giving heed to current practicalities. Thus a deficiency in knowledge was identified in the current state of development for humancentric applications of RFID and in the direct, potential applications stemming from this state. The need for a strong piece of academic research into this area was further highlighted by the lack of sufficient research frameworks or reporting methodologies used in the majority of prior articles. This thesis therefore now acts to clarify research and bridge the gap in knowledge by performing usability context analyses[104] (the methodology most similar to that used by Geers[105] and Gerdeman[106]) and by using an interpretive analysis, a narrower theoretical framework than the SI approach taken by Michael.[107]

[102] See Section 1.5
[103] Ibid
[104] See Section 3.3.1
[105] Geers. Op cit
[106] Gerdeman. Op cit
[107] Ibid

# Chapter Three: Methodology

## 3.1 Introduction

A thesis cannot be successfully completed without an underlying methodology that guides research. The chosen method is crucial as it gives direction to investigation and analysis, and provides structure for the overall design. The type of methodology selected is largely dependant on the answers and outcomes sought and will vary depending on the nature of each individual topic. With this in mind, this chapter specifically seeks to detail how the present investigation into the current state of development for humancentric applications of RFID will be conducted. In doing so, this chapter will also satisfy objective 3[108] and showcase a possible research design for future studies.

As outlined in the preceding literature review, the current state of knowledge in the area of humancentric applications of RFID is limited. Documentary evidence is largely concerned with the technologies themselves or shows non-humancentric applications and speculates on human usage. Further, the vast majority of literature is news-type or journalistic in nature and real research into current applications is overlooked in favour of conjecture as to future uses. Thus, with it being the stepping-stone between current technology and future possibilities, a gap in knowledge is apparent in the area of development of current applications. The gap will be bridged by this thesis using the research methodology outlined below.

## 3.2 Research Strategy

The primary question, what is the current state of application development in the field of humancentric RFID devices, is justifiably exploratory. It entails investigation into the contemporary nature of new technology usage[109] and, because the topic is so innovative, clarifies boundaries within the research area.[110] This allows readers and future researchers to better understand the context within which applications of human-implantable RFID devices lie. As such, this is a largely qualitative study that uses some elements of descriptive research to clarify the scope of the issue.

[108] See Section 1.5
[109] Satisfying objectives 4, 5 and 6; see Section 1.5
[110] Satisfying objective 8; see Section 1.5

The novelty of the technology and the unclear state of applications warrants that research does not fit neatly into the requirements of a common strategy. The unexplored social effects and the time frame given for this research necessitate that experiments into human RFID implantation and associated applications cannot be performed. Similarly, due to problems with sampling the small number of global citizens that have been implanted with RFID devices, and thus have experienced applications of the implanted technology, surveys of this nature are avoided.

As this thesis is exploratory in nature, and since case studies have been used by related landmark studies,[111] one might think a case study approach would be appropriate. This is a study of applications however, and the human element so commonly associated with a case study[112] is, here, only secondary. Gerdeman[113] and Geers,[114] researching RFID usage for transport industries and animals respectively; also faced this anomaly. The results were two landmark analyses of RFID usage that did not use a defined case study structure. As such, in line with precedent, this research is not undertaken in terms of case studies. Instead, 'Usability Context Analyses'[115] are used. These are defined as being similar to case studies in their use of multiple sources of evidence, but are differentiated from such a strategy on the basis of the unit of analysis. In a usability context analysis methodology, such units are not individuals, groups or organizations. Instead, units of analysis are applications or application areas for a particular product, where 'product' is defined as "any interactive system or device designed to support the performance of users' tasks".[116]

## 3.3 Research Design

The primary focus for research involves several exploratory usability context analyses. These are largely qualitative in nature and are combined, to a lesser extent, with descriptive methods used to outline the nature of the application and establish scope of context. Further, to supplement the exploration, an interpretive analysis is

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111 Case studies were used by K Michael. *The Technological Trajectory of the Automatic Identification Industry*. Op cit
112 G Bouma. *The Research Process* Oxford University Press, Melbourne, 1993
113 Gerdeman. Op cit
114 Geers et al. Op cit
115 C Thomas. N Bevan. *Usability Context Analysis: A Practical Guide* Serco Usability Services, National Physical Laboratory, Teddington, Middlesex, 1996
116 Ibid. p. 1

applied in chapter 7 where a discussion of usability context analyses and findings takes place.

### 3.3.1 Multiple Usability Context Analyses

As implied by the chosen usability context analysis methodology, units of analysis for this thesis are application areas. At the highest level, units of analysis are holistically defined by theme, or application area, to aid in qualitative analysis. These units comprise applications for control (chapter 4), applications for convenience (chapter 5), and applications for care (chapter 6). Each application selected for research was carefully chosen based on themes that became evident during the initial review of literature.[117] Sub-units of analysis within each chapter include specific examples of innovations within the area.

Similar to a case study, a usability context analysis "investigates a contemporary phenomenon within its real life context when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence[118] are used".[119] It provides a process that "helps evaluation to reflect real-world usability accurately".[120] It was felt by this thesis writer that a choice of three use analyses would allow for successful research based on this provision. The results of multiple use analyses are more convincing than a singular study, and the broad themes identified cover the major areas in which contemporary humancentric applications of RFID exist. This ensures that a thorough investigation of the phenomenon and its context occurs.

### 3.3.2 Usability Context Analysis Protocol

Each usability context analysis contains an exploration of the application area. Inclusive in each area are a number of examples of specific innovations. It was felt that the organisation of analysis by application theme, rather than individual application would sustain a better investigation and make analysis an easier task. The protocol for the usability context analyses in this thesis involves collating evidence to

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[117] See Chapter 2: Literature Review
[118] See Section 3.4.1
[119] R Yin. 'The Case Study Method As A Tool For Doing Evaluation' *Current Sociology* 1998. 40(1): 121-137, p123
[120] Thomas, Bevan. Op cit. p. 1

assess the current state of development for humancentric applications of RFID. This is supplemented by findings relating to the nature of applications, and conclusions as to overall feasibility. Table 3.1 outlines this protocol.

**Table 3.1: Protocol Structure**

| | |
|---|---|
| **The State** | What are the current humancentric applications of RFID?<br>For whom are these applications intended?<br>Have these applications been tested?<br>Are these applications in common or commercial use?<br>What are the (anticipated) circumstances of usage? |
| **Findings** | What is the nature of these applications?<br>What is the scope of these applications?<br>What are their benefits?<br>What are their disadvantages? |
| **Conclusions** | Are these applications feasible? |

### 3.3.3 Research Relevance

The findings of this research are relevant to those involved in RFID industries. It is important for manufacturers, retailers, and industry experts to be fully aware of the potential applications for technology that they push toward the market. Though it is important that professionals have a broad comprehension of technology and market placement, having an in-depth understanding of applications also aids in determining approaches to further development and harnessing market complexities.

Findings and analysis are also relevant to the community as a whole. With the general public being targeted as consumers of implantable RFID devices, they must be made aware of the capabilities of the application, its nature, benefits and disadvantages. This will allow for empowered decision making regarding such invasive technology.

## 3.4 Data Gathering

As this thesis investigates the current state of development for humancentric applications of RFID, the study is cross-sectional with data being gathered only within the period specified for research. It should be noted however, that this thesis lends itself to later longitudinal studies where future researchers are looking to compare states of development or analyse the evolution of applications.

### 3.4.1 Evidentiary Sources

The theoretical concept underpinning this thesis involves the current state of development for humancentric applications of RFID. From initial research, it was discovered that landmark studies in this area were broad across all automatic identification technologies and investigated RFID as a mere component in the auto-ID field.[121] Thus, with significant studies long completed in non-humancentric RFID disciplines, and with the human applications of RFID devices now being only loosely defined, the importance of conducting an in-depth study into the new uses of this highly invasive technology is apparent.

Three measures, or evidentiary sources, have been used to investigate the concept. These consist of documentary evidence, archival (including web-based) records, and questionnaires. Examined individually in the following sections, the use of multiple sources of evidence to clarify and investigate means that construct validity is present in the research.

#### 3.4.1.1 Documentary Evidence

As outlined in the literature review,[122] books most closely relating to this study focus on RFID applications for inanimate objects or on animal implantation. Though having no real humancentric research, they are useful in giving an evolutionary background and in establishing valid constructs for research. Offering more relevant information are journal articles and academic reports on RFID, with the added benefit of being concise pieces of literature focused on specific technical aspects or applications of the technology. Slightly more generic but in a similar vein are articles and reports that investigate the broader notion of automatic identification, the industry of which RFID is a part. These documents provide a research base and a source of ideas for more detailed study. Other useful resources include industry magazines and journals, seminars and conference proceedings. Press releases, mainly those from RFID manufacturers, are also valuable as they offer information on recent developments. Similarly, news-type articles, though written by journalists and not experts in the field, provide an up-to-date overview of applications, their

[121] See Chapter 2: Literature Review
[122] Ibid

feasibility and impact. It is here, however, that the importance of separating sensationalism from fact in documentation is essential.

### 3.4.1.2 Archival / Web Records

Archival records used in this thesis focus upon organisational reports, the majority of which are found on corporate web sites. The chosen sites, owned mainly by RFID manufacturers, contain valuable information specific to applications of the technology. As Yin notes however, an awareness of the commercial purpose of these records is crucial[123] and, accordingly, objectivity must be maintained regarding their accuracy.

### 3.4.1.3 Questionnaires

In this thesis, questionnaires have been conducted to elicit information from RFID manufacturers and experts in the field. These questionnaires were of an open-ended nature[124] and contained questions formatted to elicit unbiased information.[125] Questionnaires were sent to the intended respondents via email. Core questions within the questionnaire are outlined in table 3.2.

**Table 3.2: Questionnaire Structure**

| Section | Question |
|---|---|
| **Introduction** | Do you develop implantable RFID devices for humans?<br>Are you aware of other RFID manufacturers that develop implantable RFID devices for humans?<br>Is there currently a viable market for implantable RFID devices for humans in Australia? In the world? |
| **Lead-in** | Are human-implantable RFID devices a suitable means of identification? Explain why / why not.<br>If you answered yes to the above, what type of information could suitably be stored within the implanted RFID device? |
| **Control** | Based on current technology levels, how can human-implantable RFID devices be feasibly used for control-related purposes?<br>Are there any direct benefits or disadvantages that stem from the applications you outlined (either generally as a group, or specific to an application)? Please outline.<br>Are you aware of any humans who have been implanted for the control purposes you outlined above? Please detail.<br>What sort of control-related applications, if any, do you believe to be |

[123] Yin. 1984. Op cit. p. 80-81
[124] C Robson. *Real World Research. A Resource For Social Scientists & Practitioner-Researchers* Blackwell Press, Oxford, 1993. p. 227
[125] Thomas, Bevan. Op cit. p. 10

| | |
|---|---|
| | outside the scope of current technology levels? |
| **Convenience** | Based on the current technology levels, how can human-implantable RFID devices be used to improve convenience of lifestyle?<br>Are there any direct benefits or disadvantages that stem from the applications you outlined (either generally as a group, or specific to an application)? Please outline.<br>Are you aware of any humans who have been implanted for the convenience purposes you outlined above? Please detail.<br>What sort of convenience-related applications, if any, do you believe to be outside the scope of current technology levels? |
| **Care** | Based on the current technology levels, how can human-implantable RFID devices be used for medical purposes?<br>Are there any direct benefits or disadvantages that stem from the applications you outlined (either generally as a group, or specific to an application)? Please outline.<br>Are you aware of any humans who have been implanted for the medical purposes you outlined above? Please detail.<br>What sort of care-related applications, if any, do you believe to be outside the scope of current technology levels? |

### 3.4.2 Reliability

Foremost, reliability in research is provided through the use of multiple sources of evidence. This evidence was gathered throughout the entirety of the research and as such, represented the most relevant, up-to-date information available. In this way, support for the investigation and its outcomes is gained from cross-correlation, or "using contemporary evidence in a converging fashion to triangulate over facts".[126]

To further ensure reliability of the usability context analyses, the operations of the study (largely consisting of data collection procedures) must be able to generate the same results when repeated.[127] For use of documentary evidence, this is guaranteed by the static nature of published literature. Archival records also demonstrate this feature to some extent, however the fluid nature of the Internet as a publishing medium means that information may be randomly updated or altered. Therefore, to prevent 'loss' of research data for this thesis, each web document accessed has been saved for recording purposes. In the case of questionnaires, the replicable quality inherent in data collection is less obvious. Reliability is thus provided by unbiased questioning techniques, which ensure that earlier questions do not influence later ones, and guarantee that scope is not available for emotional responses.

[126] Yin. 1998. Op cit. p. 131
[127] Ibid. p. 36

## 3.5 Data Analysis

A number of analytic techniques are used to interpret the exploratory findings of the usability context analyses. In order to provide a meaningful analysis of data, diagrams and tables feature in the representation of information. This allows for a clear depiction of main arguments and outcomes. Following this, conclusions are drawn using comparable evidence from the usability context analyses. This involves pattern matching[128] and explanation building[129] based on the repeated observation of themes within the areas of humancentric RFID application. Further included in analysis is some descriptive discussion. This however, in satisfaction of objective 8,[130] revolves around defining boundaries for the area of humancentric RFID applications and cannot be avoided.

## 3.6 Conclusion

The exploratory study of humancentric applications of RFID has been designed to investigate the current state of application development, and its subsequent nature and feasibility. Multiple sources of evidence are employed to examine data and provide a means of assessment within a usability context analysis framework. The following chapters now employ the outlined design, data gathering and analysis techniques in order to explore application areas and gain answers to the questions proposed above.

[128] Ibid. p.107
[129] Ibid
[130] See Section 1.5

# Chapter Four: Usability Context Analysis - Control

## 4.1 Introduction

The notion of control is a powerful concept. It involves decided influence in achieving predetermined goals and ranges from the extremes of dictatorship to the subtle sway of suggestion. It is a dynamic notion, based upon knowledge of a desired outcome and, resultantly, upon the processing and distribution of information.[131] Control therefore exists in all facets of human action and this is no less true when a technological interface is present. Accordingly, in satisfying objective 4,[132] the following usability context analysis will investigate the nature of those humancentric applications of RFID where use centres upon control. This will provide an insight into the capability and nature of the technology in the current state of development.

Control, as an application area, has been previously defined[133] as those situations in which human use of an implantable RFID transponder allows an implantee to have power over some aspect of their lives, or, alternately, allows a third party to have power over an implantee. The following usability context analysis applies this definition of control when exploring the contextual application area. The usability context analysis for control-related humancentric applications of RFID is divided into three main sub-contexts – Security Controls, Management Controls, and Social Controls. Each of these includes examples of specific innovations.

## 4.2 Security Controls

| | |
|---|---|
| **Intended Users** | Mass market, persons likely to be involved in high-risk situations, persons who cannot satisfactorily identify themselves. |
| **Specific Uses** | Personal identification, location based services including wander alerts, tracking and recovery. |
| **Constraints** | Lack of widespread reading infrastructure, need for close proximity between readers and RFID tags, need for data correlation, any GPS functionality must be externally integrated with the RFID tag. |

Security, or the idea of being secure, has a wide definition that encompasses rights to safety and stability, the certainty of possession, and freedoms from anxiety and

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[131] Powerhouse Museum. 'What Is Control?' Powerhouse Museum, Sydney, 2003 [*http://www.phm.gov.au/hsc/refugee/control.htm* Last Accessed: September 03, 2003]

[132] See Section 1.5

[133] See Section 2.3.1

fear.[134] Humancentric RFID has drawn on this notion of security to allow development of several applications that purport to enhance control over well-being. With such a need being basic to every human life, the target market for these applications is generic. The two main application markets for the sub-context of security are personal identification and location based services.

### 4.2.1 Personal Identification

The most basic security application for humancentric RFID in the current state of development involves control over personal identification. Similar to an ID card, driver's license or passport, the RFID transponder contains information identifying the owner. In theory, the limit to the amount of information stored is subject only to the storage capacity of the embedded microchip or associated database and, where implantation remains voluntary, to the imagination of the implantee. Further, being secured within the body, the loss of such identifying devices is near impossible even though, as has occurred in implanted herd animals, there are some concerns over possible dislodgement of the transponder.[135] Keeping this in mind, the main usability drawback lies with reading the information. Implanted identification is useless if the information contained within the body is inaccessible.

In basic identification applications RFID transponders are considered passive, meaning that they have no battery source and remain dormant in the body until excited by a reader or scanner.[136] The reader must be within range of the RFID transponder to excite it.[137] A depiction of this process is shown in Diagram 4.1.

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[134] *Webster's Dictionary* Budget Books, Melbourne, 1988.
[135] See Appendix One
[136] M Chiesa et al. 'RFID. A Week Long Survey On The Technology And Its Potential' [Online] Harnessing Technology Project, Interaction Design Institute, Ivrea, 2002. Available IEEE, April 9, 2003
[137] JR Tuttle. 'Traditional And Emerging Technologies And Applications In The Radio Frequency Identification (RFID) Industry' [Online] Radio Frequency Integrated Circuits (RFIC) Symposium, IEEE, June 8-11, 1997. pp5-8. Available IEEE, September 01, 2003.

**Diagram 4.1: Passive RFID Transponder Reading Process**[138]

Please see print copy for Diagram 4.1

To allow personal identification applications to be successful, places where a need for human identification arises must be equipped with reciprocal RFID reading technologies. This technology commonly exists, being no different to that which has been used to read RFID tags on consumer goods, freight and access passes in recent decades.[139] The problem lies with a mass rollout of reader technology to cater for those current few who have chosen to be implanted. The present lack of infrastructure is thus likely to be the greatest technological hurdle for the application in the short to medium-term.

The Florida-based VeriChip Corporation has recognised this hurdle and, alongside its core product, a “miniaturised, implantable radio frequency identification device”[140] also called VeriChip, has implemented an Affiliate Program for transponder applications.[141] In becoming a VeriChip Affiliate, institutions including hospitals, medical centres, public safety and law enforcement organisations all agree to have personnel equipped with RFID readers so that the unique code stored on the implanted VeriChip of VeriChip “subscribers”[142] can be read. This code is a subscriber’s password for accessing, via telephone or Internet, their individual records stored within the Global VeriChip Subscriber (GVS) Registry, an online database.

One of the core application areas for the VeriChip, a device that first appeared on 19 December 2001,[143] is security. In October of 2002, subsequent to an earlier April 2002 decision and separate to its ruling on medical usage, the US Food and Drug

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[138] Earlsmere ID Systems. ‘Earlsmere ID Systems – What Is RFID?’ Earlsmere ID Systems, United Kingdom, 2003 [*http://www.earlsmere.co.uk/* Last Accessed: September 03, 2003]
[139] Chiesa. Op cit
[140] Applied Digital Solutions, Press Release. ‘VeriChip™ Successfully Launched Into The U.S. Market With Historic “Chipping” Of Jacobs Family And Nate Isaacson On May 10, 2002’ Applied Digital Solutions, Palm Beach, May 13, 2002.
[141] VeriChip. ‘VeriChip Registry – Affiliate’ VeriChip, Palm Beach, 2003 [*https://gvsregistry.4verichip.com/index.html* Last Accessed: September 03, 2003]
[142] Ibid
[143] Applied Digital Solutions Press Release. May 13, 2002. Op cit

Administration (FDA) announced that VeriChip was not to be considered a regulated device for "security [and] personal identification / safety applications".[144] This allows VeriChip a virtually limitless growth, subject to market forces and social acceptance, in the area of security applications.

Accordingly, VeriChip has been promoted for potential use within a wide variety of market spheres. One advocate for the company stated in a 2003 press release that

> "VeriChip provides an enormous opportunity for many different industries. From curbing identity theft and fraudulent access to banking, aiding control of authorized access to government installations and private-sector buildings, to future developments involving implantable GPS technology that could aid in finding missing children, VeriChip is an amazing breakthrough in identification and personal safeguard technology."[145]

Despite this marketing of VeriChip as a "technological marvel"[146] there have been a limited number of reported implantations for security purposes. Of these, several have been in response to extreme circumstances. Richard Seelig for example, New Jersey surgeon and Vice President of Medical Applications for the VeriChip Corporation, tells that he was motivated to gain a sophisticated and permanent form of personal identification when, during the September 11 tragedy, fire fighters scrawled social security numbers and identifying details onto their forearms using coloured markers.[147] Such an example highlights the need for good public record keeping. In systems where information is stored on the RFID microchip, or where the transponder contains a pointer to the 'real' information, data needs to be correlated else the application is no more valuable or feasible than current card-based, written or online documentation systems.

The above personal identification applications all operate as stand-alone RFID technologies. It is feasible however, that implanted RFID be integrated into wider identification systems, working in conjunction with biometric devices to provide

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144 Applied Digital Solutions, Press Release. 'Applied Digital Solutions' Its Exclusive Distributor Of Subdermal RFID VeriChip™ Is Launching "Solusat Medica" To Promote VeriChip's Healthcare Applications In Mexico' Applied Digital Solutions, Palm Beach, July 17, 2003.
145 Find Me LLC, Press Release. 'Find Me, LLC Named Distributor For Subdermal VeriChip™ In Louisiana' Find Me LLC, New Orleans, May 23, 2003.
146 VeriChip. Op cit
147 Murray. January 07, 2002 Op cit

several levels of identification.[148] Similarly, conjoining implantable RFID and GPS technology provides a number of humancentric applications.

### 4.2.2 Location Based Services

The most prominent of these security-based applications involves GPS tracking to pinpoint the location of a third party. Control here exists in both the ability to find and in the ability to be found. A typical implementation sees the GPS component device worn, in the form of clothing or an accessory, by the person who is to be located. When combined with an implanted RFID transponder, a sophisticated level of identification is added to the application. Suitable GPS components are currently manufactured and sold as stand-alone products by several companies including the Digital Angel Corporation[149] and Whereify Wireless.[150] An example of the Whereify product is shown in Diagram 4.2.

**Diagram 4.2:Wherify GPS Locator For Children[151]**

Please see print copy for Diagram 4.2

Devices such as these generally allow tracking accuracy to within a distance of several metres.[152] Variants are also available which incorporate “wander alerts”,[153]

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[148] See Appendix One
[149] Digital Angel Corporation. Op cit
[150] Wherify ‘Corporate Home’ Wherify Wireless Location Services, Redwood Shores, California, 2003 [*http://www.wherifywireless.com/corp_home.htm* Last Accessed: September 03, 2003]
[151] Ibid
[152] Garmin Ltd, ‘About GPS: What Is GPS?’ Garmin Ltd, Kansas, 2003 [*http://www.garmin.com/aboutGPS/* Last Accessed: September 19, 2003]

allowing a nominated caregiver to be notified whenever the wearer moves outside of pre-defined boundaries, and "fall-down alerts"[154] which notify a nominated caregiver when the wearer has been down for one minute or more. In situations like these, the implanted RFID tag becomes especially valuable as it allows for positive identification if the implantee is impaired, a child, an Alzheimer's patient or has been rendered unable to communicate. Many of the locator devices also provide a means for initiating emergency response. The Digital Angel product for example, will notify the nominated caregiver of a need for help[155] while, as shown in Diagram 4.2, the Wherify device will direct an emergency response request to an Emergency Services hotline such as 911. [156]

In all these applications, the RFID device and GPS technology remain divisible components. In the current state of application development, are GPS systems thus capable of being fully integrated and implanted with RFID transponders? Research suggests that they are not. Alongside the RFID and GPS transponders needed for each new device, a powerful battery and an antenna are also required.[157] Should problems inherent with storing a suitable battery inside the body be solved, questions as to battery renewal and recharging must be answered. Additionally, miniaturisation of an antenna small enough to fit inside the body and contained enough not to poison its host with radiation must occur.[158] Despite these known hurdles, press releases suggest that Applied Digital Solutions, parent company of VeriChip and Digital Angel, is researching the technology in order to provide a new breed of humancentric applications.[159]

## 4.3 Management Controls

| | |
|---|---|
| **Intended Users** | Employees, visitors to specific locations. |
| **Specific Uses** | Access control, monitoring. |
| **Constraints** | Need for employee consent, need for close proximity between readers and RFID tags, any GPS functionality must be externally integrated with the RFID tag. |

[153] Digital Angel Corporation. Op cit
[154] Ibid
[155] Ibid
[156] Wherify. Op cit
[157] Tuttle. Op cit
[158] Eng. Op cit; Sample, Ian. 'Now Find Me An Inventor For The Cameras' *New Scientist* [Online] September 14, 2002. Available Expanded Academic Index, May 1, 2003.
[159] Wakefield. Op cit

In its basic form, control allows governance of what a person effectually ‘owns’. This may be a true ownership in terms of property or intellectual property rights, or a delegated and representative ownership such as the administrative powers bestowed upon corporate management or government. In both forms, ownership can be managed or controlled by providing or restricting access, and through monitoring resources, usage and environment.

### 4.3.1 Access

*Access To Locations*

In terms of access controls, many smart-card access systems in common use today employ RFID technology to associate the cardholder with access permissions to particular locations.[160] Replacing smart cards with RFID implants alters the form of the access pass but does not require great changes to verification systems. This is because identifying information stored on an RFID microchip in a smart card can be stored on an implanted transponder and readers can similarly sense when this transponder is nearby.

In this type of control application, “reading distance is very limited due to the magnetic field type devices that are used with the high water content of the body”.[161] Scientific material suggests that feasible reading distances involve spaces of up to two metres.[162] One questionnaire respondent however, believed that “reading distances of a few centimeters are all that is practical”.[163] Hence, such applications may require implants to be placed in the hand, or in parts of the body that can be easily maneuvered in front of an RFID reader.

Though such systems could plausibly be implemented anywhere as a replacement to key or card-based access, the application would have greatest value in ‘mission critical’ workplaces or for persons whose role hinges upon access to a particular location. Examples include power stations, water treatment plants, hospitals, airports, national defence and military facilities. The implanted access ‘key’ has the added benefit of being permanently attached to its owner with minimal risk of being lost or

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[160] Association for Automatic Identification and Data Capture Techniques. Op cit; Chiesa. Op cit
[161] See Appendix One
[162] Tuttle. Op cit
[163] See Appendix One

stolen. Further, access codes or passwords stored on the RFID tag are imperceptible without appropriate reading devices. Even then, as a passive tag, broadcast of the value via data transfer between reader and transponder is less than one-twentieth of a second.[164]

*Access To Resources*

In most situations, the added cost of implantable RFID may not justify the "hands free convenience"[165] of access to locations. In terms of access to resources however, the value is slightly more generic. As Ollivier writes,

> "consider the added benefit of switching off a dangerous machine or process automatically if its supervisor moves away, or shutting down a sensitive computer terminal when the operator leaves the keyboard".[166]

Combining an implanted transponder with sensors on a given resource, the humancentric control application could permit access, start a machine or initiate a process. Further, access could be restricted or procedures terminated once the physical presence of the implantee was no longer sensed at or near the reading terminal.

### 4.3.2 Monitoring

Access provision translates easily into employee monitoring applications. In making the implanted RFID transponder the access pass to certain locations or resources, times of access can be recorded to ensure that the right people are in the right place at the right time. Control in this instance then moves away from ideals of permission and embraces the notion of supervision. This can have both advantages and disadvantages dependent upon the situation in which information gathered by the monitoring process is used. To illustrate, one scenario encapsulating this humancentric application of RFID involves doctors at a medical facility. By reviewing the location and time of access to rooms and resources, the vicinity of medical personnel can be quickly ascertained in an emergency. Known monitoring can also promote efficiency and be a deterrent to time wasting, although continual observation can conversely lead

[164] M. M. Ollivier. 'RFID – A New Solution Technology For Security Problems' [Online] *European Convention On Security And Detection* May 16 – 18, Conference Publication No 408, IEE, 1995. Available IEEE, August 31, 2003.
[165] Ibid
[166] Ibid

employees to distrust their employer.[167] Consideration needs to be given to the balance between recording clock-on and clock-off times, and recording, for instance, the number of times an employee uses the bathroom or the coffee machine. Such an example raises the common question – how much is too much? When does monitoring through humancentric RFID become an invasion of privacy?

### 4.4 Social Controls

| | |
|---|---|
| **Intended Users** | Military personnel, law enforcement officers, inmates, parolees, mass-market. |
| **Specific Uses** | Monitoring, crime prevention. |
| **Constraints** | Possible involuntary use of application, any GPS functionality must be externally integrated with the RFID tag. |

Society, through popular culture, has long toyed with ideas of dictatorial control enforced by a technologically driven government. In the current state of development however, implanted RFID is far from allowing the genetic modifications and mind control of '*Brave New World*', or the artificial intelligence of '*Blade Runner*'. Nevertheless, this does not mean that all current humancentric applications of RFID lie outside the realm of social control. As one questionnaire respondent stated,

> "Once you have an identification device, a reader would convert that into computer readable data and anything could be controlled.[168]

As such, control-related humancentric RFID can be applied in enforcing social controls, in punishing those who disregard controls, and in preventing criminal disruptions.

#### 4.4.1 Enforcement

At its most fundamental level, information from humancentric RFID can be used to identify law enforcement officers, thereby providing control similar to personal identification discussed above.[169] In the military for example, transponders may serve as an alternative to dog tags. Using this technology, in addition to the standard name, rank and serial number, information ranging from allergies and dietary needs to shoe

[167] A Contry-Murray. 'The Pros And Cons Of Employee Surveillance' *Network Magazine* [Online] vol. 12, issue 2, February, p62. Available ProQuest, March 17, 2003.
[168] See Appendix One
[169] See Section 4.2.1 Personal Identification

size can be stored. Such capacity for information, when linked to appropriate databases, can streamline processes.[170] To illustrate, *Soldier Magazine* writes

> "It would make the introduction of the Pay As You Dine Scheme much easier, allowing mess staff to swipe soldiers as they passed the hot plate. It is estimated that savings in time and administration of the PAYD scheme alone could in one year pay for up to three additional Challenger 2 main battle tanks or 27 single living accommodation upgrades."[171]

As well as streamlining, much information can be used to strategise. When linked to GPS tracking facilities[172] a complex network of individuals can be monitored in training or in battle. With the location of troops being sent to military strategists in real-time, more informed tactical decisions could be made and relayed to soldiers using standard communications devices. Similarly, it allows for services like the rapid deployment of pastors to those who have died in war, or finding of soldiers who have gone AWOL.[173] Here must be noted the consideration of timely usage however. To reduce the 'Big Brother' nature of the technology there needs to be some delineation between work and private lives and an ability to suspend the tracking functionality when appropriate. Without this, control becomes oppressive.

Whether or not such applications are in present use is a question of much conjecture. Interestingly, before his execution Timothy McVeigh, the Oklahoma bomber, accused the US government of attempting to implant such transponder devices in American soldiers during Desert Storm.[174] His allegations remain unproven. In 2001 however, two separate news sources[175] described an experimental program, the Army Personnel Rationalisation Individual Listings (APRIL) project, being conducted by the British Army. Reportedly,

> "a cross-section of soldiers … allowed themselves to be microchipped as part of a study into how new technology may be harnessed to revolutionise the bureaucracy of personal administration"[176]

The transponder was said to be implanted in the back of the neck and, while active, would send tracking information to a central Electronic Record Management System

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[170] Icke. Op cit
[171] Ibid
[172] See Section 4.2.2
[173] Lo Baido. Op cit
[174] J Kieth. *OK Bomb - Conspiracy and Cover-up* IllumiNet Press, Lilburn, Georgia, 1996.
[175] Lo Baido, Op cit; Icke. Op cit
[176] Icke. Op cit

("ERMS") in Glasgow.[177] Active RFID however, where the RFID transponder transmits information and is not simply 'read', requires a battery source and a means of transmission, usually one that is linked to GPS.[178] Common problems with implanting these additional components therefore lead to queries over the truth of the reports.

In any case, those applications that have been proven feasible can transcend military spheres and be used in other areas of law enforcement. RFID combined with external GPS devices for example, allows for location based monitoring of officers and the subsequent deployment of personnel nearest to an accident or crime scene. Thus, law enforcement becomes a complex chess game of efficient social control where the positions of all 'pieces' are known and monitored, then used to best advantage.

### 4.4.2 Punishment

Just as humancentric applications of RFID exist for law enforcement officers, so to can the technology have applications for people who have broken the law. Indeed, in 2002, 27 of 50 American states were using some form of satellite surveillance to monitor parolees.[179] Similar schemes have been used in Sweden since 1994.[180] In the majority of cases, parolees wear wireless wrist or ankle bracelets and carry small boxes containing the vital tracking technology. Substituting these devices for a combination of RFID transponder for identification and external GPS for tracking purposes is a viable concept.

Economic benefits exist as it is cheaper for parolees and minor offenders to be monitored or to serve their sentences from home, than to be tax funded members of the prison population. In Sweden for example, savings were estimated to be between 8 and 16 million US dollars for the 1997 calendar year.[181] Social benefits are also present. On one hand, because the identifying microchip cannot be truly lost or misplaced, there is a level of certainty involved in identifying and monitoring so-

[177] Lo Baido. Op cit
[178] Eng. Op cit
[179] Black. Op cit
[180] H Von Hofer. 'Notes On Crime And Punishment In Sweden And Scandinavia' *115th International Training Course Visiting Experts' Papers*, Resource Material Series No 57 [Online] United Nations Asia and Far East Institute For the Prevention of Crime and the Treatment of Offenders, 2000. pp284 – 313. [*http://www.unafei.or.jp/pdf/57-21.pdf* Last Accessed: September 03, 2003]
[181] Ibid

called 'threats' to society. On the other hand, there is privacy afforded to the parolee.[182] As questionnaire respondent Kevin Warwick writes,

> "Implants are not visible from the outside – so for a prisoner they do not have the stigma of an external tag."[183]

This notion is further extended where the GPS component is in inconspicuous form – similar perhaps to the watch-like devices manufactured by Digital Angel and Wherify - and indeed, already Digital Angel has entered into a three-year pilot program with Los Angeles County parolees to monitor their movements using wearable devices.[184]

VeriChip however, the current (and only real) forerunner in implantable RFID technology sales and manufacturing, "is backing away from involuntary identification applications, such as the tracking of prisoners or parolees".[185] This shows obvious conflicts with allowing technology to empower the wrong people. Certainly, there is no real technological difference between a democratic government implanting parolees, and a totalitarian government implanting political activists and minority groups.

### 4.4.3 Crime Prevention

Richard Seelig, one of the first persons to be implanted by VeriChip, believes that humancentric RFID is able to "function as a theft-proof, counterfeit-proof ID, like having a drivers license under your skin".[186] One proposed application involves the implantation of airline crews to ensure that terrorists cannot infiltrate airports or gain access to airplane cockpits through means of disguise.[187] Another proposed application involves taking Infant Protection systems in existence at birthing centres and hospitals and internalising the RFID devices that are worn by newborns. Such usage would aid in the correct identification of those who do not have suitable means to identify themselves. Similarly, when connected with access alarms and building

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[182] Black. Op cit
[183] See Appendix One
[184] S Tan. 'An ID idea: Microchips under your skin' *The Miami Herald* [Online] March 10, 2003. [*http://www.miami.com/mld/miamiherald/2828025.htm* Last Accessed: August 29, 2003]
[185] Murray. January 07, 2002 Op cit
[186] Grossman. Op cit
[187] Anonymous. April 5, 2002. Op cit

sensors, the technology could alert staff to the "unauthorized removal of children".[188] This latter type of usage is equally applicable to childcare facilities and schools. Nevertheless, though technologically feasible, these particular applications have not been implemented.

This example leads to more morbid criminal scenarios. In South America for example, VeriChip "is being commercialised as a way to identify kidnapping victims who are drugged, unconscious or dead. In that market, the chip is being bundled with the … GPS device, Digital Angel, so police are able to track the abduction victim's location as well".[189] One of the most vocal advocates for this application has been Antonio de Cunha Lima, a Brazilian politician.[190] With some South American countries enduring hundreds of kidnappings per year however,[191] being able to control your identity and relay your location when in danger has mass-market appeal.

Preventative humancentric applications are also realistic in areas other than crimes against the person. These applications involve the control of assets. One common non-humancentric example is the Ford motorcar "Safeguard" protection system. This is described as follows:

> "Every key is fitted with a transponder, moulded into the plastic head. In the vehicle, a small low power reader is fitted around the ignition switch, and integrates with the engine management electronics. When the driver tries to start the engine, the transponder is verified before the vehicle is started. If the transponder is missing, or has the wrong identity, starting is inhibited."[192]

Altering this system by removing the transponder from the key and placing it in the human body is viable, though untested, within the current state of development. Should the transponder be placed in the human hand and the reader located near the ignition, verification could occur in a way much like the Ford system outlined. Arguably, similar applications could be ported to any machine-type device, thus allowing control through ownership and preventing both theft and unauthorized usage.

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[188] Vxceed Technologies. 'Vxceed: RFID Technology' Vxceed Technologies, 2003. [*http://www.vxceed.com/developers/rfid.asp* Last Accessed: September 2003]
[189] J Scheeres. 'Politician Wants To Get Chipped' *Wired News* Lycos Inc, February 15, 2002 [*http://www.wired.com/news/print/0,1294,50435,00.html* Last Accessed September 03, 2003]
[190] Ibid; Black. Op cit
[191] Ibid
[192] Ollivier. Op cit

## 4.5 Conclusion

In satisfying objective 4,[193] analysing the sub-contextual control areas of security, management and social controls has allowed for insights into humancentric applications of RFID. Notably, many of the applications are adaptations of non-humancentric application models.[194] This shows an incremental development rather than technological leaps and bounds toward a future vision. Further, GPS has shown its value in location based humancentric applications of RFID. This value must be assessed however, alongside the current problems with physically combining GPS hardware and the implanted RFID transponder.

[193] See Section 1.5
[194] See, for example, Section 4.3.1 and Section 4.4.3

# Chapter Five: Usability Context Analysis - Convenience

## 5.1 Introduction

Technology has often been hailed as a creator of convenience and as a means of making chores easier, more efficient or more timely. The microwave for example, provided us with timesavings over the oven which had, at first instance, proved a more efficient and less labour-intensive cooking method than an open fire. Indeed, one may propose that every technological advancement, or ‘convenience’, builds upon old technology and provides a foundation for future development. It is interesting therefore, that when one questionnaire respondent was asked what convenience-related humancentric applications of RFID he believed to be outside the scope of current technology levels he replied “None”.[195] Accordingly, in satisfying objective 5,[196] the following usability context analysis will examine the improved lifestyle conveniences available via humancentric applications of RFID. This will aid in determining the scope of implementation and the use and nature of the technology in the current state of development.

Convenience, as an area of application, has been previously defined[197] as those situations in which human use of an implantable RFID transponder increases the ease of performing a task for the implantee. The following usability context analysis applies this definition of convenience when exploring the contextual application area. The usability context analysis for convenience is divided into three main sub-contexts – Assistance, Financial Services and Interactivity. Each of these sub-contexts contains examples of specific innovations.

## 5.2 Assistance

| | |
|---|---|
| **Intended Users** | Mass market, travellers, sportspersons, car owners. |
| **Specific Uses** | Identification of personal belongings, location based services, roadside assistance, emergency services. |
| **Constraints** | Interference during reading from other wireless systems, need for an appropriate placement of the transponder to facilitate accurate reading, any GPS functionality must be externally integrated with the RFID tag, any GPS functionality integrated with the RFID system will not work indoors. |

[195] See Appendix One
[196] See Section 1.5
[197] See Section 2.3.2

The general notion of assistance involves being helped or aided in a particular task or situation.[198] In these terms, assistance is convenient when it can be rendered at the exact time it is needed. Moreover, because assistance is a generic benefit, a potential for mass-market appeal means that convenience can arise from availability and widespread usage. This assistance can be automated or can incorporate human elements.

### 5.2.1 Automated Services

Automation is the repeated control of a process through technological means.[199] Implied in the process is a relationship, the most common of which involves linking an implantee with appropriate data. As shown in the previous usability context analysis for control-related humancentric applications of RFID,[200] this data usually exists in the form of identifying information. Such information in convenience contexts can however be extended to encompass goods or physical objects with which the implantee has an association of ownership or bailment. Convenience transpires, for both the implantee and for the greater system within which he or she may be a part, because the technological association allows for ease of identification and location of object or owner.

Illustrating this are the daily workings of an airport, where the separation and reuniting of passengers and luggage occurs frequently and consistently. Following British Airways trials in 1999,[201] media reported in June 2003 that Delta Airlines was to test the use of RFID transponders on passenger cargo over 30 days in the northern autumn.[202] As RFID does not require line-of-sight reading[203] the use of RFID tags was identified as a cost-saving measure in terms of efficiency of bag handling and in finding lost luggage.[204]

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[198] Webster's Dictionary. Op cit
[199] Ibid
[200] See Chapter 4
[201] Texas Instruments RFID 'Airline Baggage Identification' Texas Instruments Incorporated, Dallas, 2002 [*http://www.ti.com/tiris/docs/solutions/airbagid.shtml* Last Accessed: September 11, 2003]
[202] B Brewin. 'Delta To Test RFID Tags On Luggage' *Computerworld* [Online] vol.37, issue 25, June 23, 2003, p7. Available Expanded Academic Index, August 17, 2003.
[203] Tuttle. Op cit
[204] Brewin. Op cit

This airline implementation of the RFID-based convenience application did not involve the use of implants. Instead it is implant manufacturers who are taking responsibility for development of the humancentric applications. VeriChip for example, the American manufacturer of human-implantable RFID transponders, have developed VeriTag.[205] This device allows "personnel to link a VeriChip subscriber to his or her luggage, … flight manifest logs and airline or law enforcement software databases".[206] Further, at check-in, a bag is screened and considered 'cleared'. This status is used as the basis for loading and unloading passengers and luggage onto the aircraft.[207] Convenience is provided for the implantee who receives greater assurance that they and their luggage will arrive at the correct destination, and also for the transport operator who is able to streamline processes using better identification and sorting measures.[208]

The natural evolution lies with passenger collection of luggage in the arrivals hall. Although many airports employ staff to ensure that persons who collect luggage can produce a claim stub or ticket that matches the bar-coded baggage tag, this is a fallible and inconsistently applied system.[209] Humancentric RFID has the potential to rectify this in a convenient, non-labour intensive manner. Indeed,

> "Taking RFID … and expanding it to include an 'RF ticket' provided to [or in the form of] the passenger, would allow identification/matching of the person who checked the baggage upon departure, as the person who retrieved the baggage upon arrival."[210]

Such applications "virtually eliminate stolen luggage"[211] and, due to greater read accuracies and higher read-rates of RFID over optical bar-coding,[212] the need to manually handle luggage is reduced, lessening the amount of time needed to verify ownership.

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205 Applied Digital Solutions, Press Release. 'Protected By VeriChip™ - Awareness Campaign Continues – VeriChip To Exhibit At Airport Security Expo In Las Vegas, July 17-18' Applied Digital Solutions, Palm Beach, July 2, 2002.
206 Ibid
207 A Cerino. W Walsh. 'Research and Application of Radio Frequency Identification (RFID) Technology to Enhance Airport Security' [Online] 2000. Available IEEE, August 31, 2003.
208 Texas Instruments RFID 'Airline Baggage Identification'. Op cit
209 Cerino, Walsh. Op cit
210 Ibid
211 Ibid
212 Ibid

It is important to note that the implementation of such RFID applications still cannot provide 100% read or identification accuracy in the current state of development.[213] The RFID reading process may, for instance, encounter interference from other wireless systems. Nevertheless, this does not detract from the ability of RFID to provide convenience through automated repetition of tasks. This includes, as opposed to the co-ordination of objects and relationships above, the co-ordination of people.

One co-ordinating application involves sports timing. RFID manufacturer Texas Instruments believes for instance, that with RFID "co-ordinating the times of thousands of runners during a marathon is no longer a Herculean task".[214] Their 'Championchip'[215] system begins timing when a runner with a transponder attached to their shoelace, shown in diagram 5.1, moves past the RFID reader at the start line. Timing stops when the runner moves past a second RFID reader at the finish line. This system was used in the 1999 Boston marathon and allowed Internet users to view the status of competitors in real-time.[216]

**Diagram 5.1: The external *Championchip* RFID device[217]**

Please see print copy for Diagram 5.1

Based on current technology levels it is viable that such an application could be ported to humancentric RFID. As scanners need to be within approximately one metre of the body to accurately identify a transponder,[218] the most feasible implementation may involve transponders being placed near the ankle in order to be read by scanners placed on the road. This application can assist competitors to track individual times

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[213] Ibid
[214] Texas Instruments RFID 'Sports Timing' Texas Instruments Incorporated, Dallas, 2002 [*http://www.ti.com/tiris/docs/solutions/sports.shtml* Last Accessed: September 11, 2003]
[215] Ibid
[216] Ibid
[217] Ibid
[218] Tuttle. Op cit

more accurately than when relying on stopwatches and human reflex, and can assist officials in guarding against cheating by competitors who switch places.[219]

### 5.2.2 Location Based Services

Advancing the notion of timing a period of movement leads to applications that can locate an implantee or find an entity relative to them. Similar to how external GPS can be used in conjunction with humancentric RFID for security and tracking purposes,[220] location-based services can provide convenience to the user. Integrating RFID and GPS technologies with a GPS portal such as the Internet-based mapquest.com[221] would allow users to find destinations based on their current GPS location and data regarding where they wish to be. Services have the potential to range from simple 'where am I?' assistance queries to generating convenient routes based on questions like 'where is the nearest x, y or z?' A screenshot of the mapquest.com front-end is shown in diagram 5.2.

**Diagram 5.2: The Mapquest.com Internet portal[222]**

Please see print copy for Diagram 5.2

Unlike tracking where the RFID implant was used for identification and security purposes, applications providing convenience through assistance are more likely to use the identifying implant as a type of password for access to the service. This

219 Texas Instruments RFID 'Sports Timing'. Op cit
220 See Section 4.2.2
221 MapQuest 'MapQuest: Home' MapQuest.com Inc, Denver, 2003. [*http://www.mapquest.com/* Last Accessed: September 17, 2003]
222 Ibid

provides further convenience by ensuring that access to the humancentric application of RFID is based on 'what you are'[223] and not the less tangible 'what you know'[224] or the easier to misplace 'what you have'.[225]

The nature of the application also lends itself toward roadside assistance and emergency services. In these cases, signals emitted by the GPS component are used to pinpoint the wearer's geographic location. The RFID transponder is used as an identifying link between the implantee as service subscriber, and the GPS device used to invoke the service. Convenience thus exists in the ability to be located and identified, especially when you do not know where you are.

The primary drawback of linking RFID and GPS is that the GPS component is external to the transponder. In the current state of development, manufacturers have not yet managed to produce a GPS receiver small or insulated enough to be implanted in the human body without size or radiation being a major concern.[226] Further, GPS is a potentially power hungry technology[227] which requires a line-of-sight reading.[228] Such systems are therefore of no use to, for example, roadside assistance services if they are trying to locate a person who is waiting in the basement level of a parking garage. In this way, carrying an external GPS device linked to internal RFID identification may be no more convenient than carrying a mobile phone that can be triangulated through the cell network and identified via SIM card.[229] GPS however, due to the use of satellites, has greater geographical coverage and, since the satellites use sophisticated atomic clocks for calculations, there is greater accuracy in the triangulation process.[230] The convenience benefits of GPS over mobile phones in terms of reach and efficiency are therefore evident.

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[223] H.L. Capron. *Computers: Tools For An Information Age 5th Edition* Addison Wesley Longman Publishing Company, New York, 1998. p229
[224] Ibid. p229
[225] Ibid. p229
[226] Eng. Op cit; Sample. Op cit
[227] P Dibdin. 'Where Are Mobile Location Based Services?' [Online] CM316 Multimedia Systems Paper, December 14, 2001. Available IEEE, September 12, 2003.
[228] Garmin. Op cit
[229] Sample. Op cit
[230] B Haszard. E Spalding. 'The Global Positioning System' ELEC352 Project, University of Newcastle[*http://murray.newcastle.edu.au/users/staff/eemf/ELEC351/SProjects/Haszard/GPSbasic.html* Last Accessed September 19, 2003]

## 5.3 Financial Services

| | |
|---|---|
| **Intended Users** | Mass market. |
| **Specific Uses** | Credit or debit card facilities, identification of account or transaction owner. |
| **Constraints** | Lack of widespread reading infrastructure, cannot eliminate all human interaction. |

Financial services concern the management of monies, credit and investment. Enlisting convenience in these services therefore implies a need for greater ease and efficiency in those matters that involve buying, selling or banking. The pervasive nature of global finance also suggests that these services need to have a mass-market appeal. This elicits convenience by way of access and mass-usage.

### 5.3.1 Buying and Selling

Over the last few decades, world economies have advanced from the use of physical coins and bills into increasingly cashless societies where digital transactions are affected by means of a credit or debit card.[231] Arguably, RFID is now in a position where it can be implemented as a practical replacement for cards.

In 2001 for example, Nokia tested the use of RFID in its 5100-series phone covers, allowing the mobile device to be used as a bank facility.[232] RFID readers were placed at McDonalds drive-through restaurants in New York and the technologically enabled consumer paid their bill by holding their mobile phone near a reader. The reader contacted a wireless banking network and payment was deducted from a credit or debit account. Of the trial, *Wired News* commented on system convenience by stating, “there is no dialing, no ATM, no fumbling for a wallet or dropped coins”.[233] Drawbacks exist with this particular non-humancentric application however, as if the phone is stolen “the owner must follow the same procedure as a stolen credit card and report its loss”.[234]

[231] R Griffith. ‘Cashless Society Or Digital Cash’ *Department of Economics and Finance*, Steven F Austin State University, March, 1994 *[http://www.sfasu.edu/finance/FINCASH.HTM* Last Accessed September 19, 2003]
[232] L Nadile. ‘Call Waiting: A Cell Phone ATM’ *Wired News*, Lycos, San Francisco, 2003 [*http://www.wired.com/news/business/0,1367,41023,00.html* Last Accessed September 19, 2003]
[233] Ibid
[234] Ibid

This disadvantage was also present with the American Express (AMEX) RFID trials in July 2003. In this non-humancentric application, AMEX piloted a wireless payment scheme in 175 locations in Phoenix, Arizona.[235] Consumers participating in the trial of the 'ExpressPay' service were given a key-ring containing an RFID transponder. Waving the key ring, called a "fob",[236] past RFID readers transmitted encrypted credit card details over the AMEX network and allowed consumers to pay for their goods. A signature authorizing the transaction was not needed. Despite stolen fobs generating potential credit fraud, significant statistical data was produced regarding the convenience of the application. Specifically, participating retailers recorded reductions in checkout times of between 30 and 40 percent.[237] Similarly, payments were made up to "40% faster than by using cash".[238] Moreover, according to a statement made by David Bonalle, GM and VP of the AMEX Advanced Payments group,

> "Consumers prefer using their ExpressPay key fob rather than fumbling for their wallets, while merchants enjoy the benefits of their customers' increased spending and reduced time at the checkout counter".[239]

These benefits are all similarly available when transposing the non-humancentric RFID service into a humancentric RFID application. Additionally, the weakness of the system with regard to stolen phones, fobs or other such RFID media is removed as the RFID transponder is secured within the body of the credit account owner.

Further benefits are available when the scope of the application is enlarged. In the above system, goods to be paid for must still be manually recorded. Using technology like the Trolleyponder RFID device[240] however, can allow for a shopping trolley containing goods, each with their own transponder, to be quickly and accurately

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[235] J Cox. 'Don't Leave Home Without RFID; American Express Expands Radio Payments Test' *Network World* [Online] July 21, 2003. p12. Available Expanded Academic Index, August 29, 2003.
[236] D Barlas. 'RFID For Credit Card Users' *Line 56, The E-Business Executive Daily*, July 17, 2003 [*http://www.line56.com/articles/default.asp?ArticleID=4827* Last Accessed September 18, 2003]
[237] Ibid
[238] Cox. Op cit
[239] Barlas. Op cit
[240] Trolley Scan. 'Trolleyponder / EcoTag' Trolley Scan Pty Ltd, Johannesburg, 2003 [*http://trolleyscan.co.za/* Last Accessed September 19, 2003] ; Transponder News Press Release. 'TROLLEY SCAN granted important fundamental RFID patent by US' *Transponder News*, Johannesburg, February 1, 2003 [*http://transpondernews.com/presre76.html* Last Accessed September 19, 2003]

scanned in bulk. A local display or “computer compatible data stream”[241] containing identity and cost information then becomes available. To combine this non-humancentric application with humancentric payment methods would largely decrease time spent at the register and, given the purported accuracy of RFID, can reduce needs for human intervention. In radical implementations, customer service could be eliminated entirely with consumers and their purchases being scanned upon exiting the store.[242]

### 5.3.2 Banking

Though feasible in trade,[243] is it also possible for humancentric RFID to eliminate the need to stand in line at a bank? In current development states the answer is likely no. Transactions such as depositing cash or cheques will still require human interaction in order to verify the amount of money involved. What is affected in banking spheres however is the convenience involved in identifying those who make the transactions.

Purely as a means of identification, the unique serial number or database access key[244] stored on the RFID transponder can be used to prove identity for the purposes of opening an account. Due to the implanted nature of the identifier, the potentials for identity fraud are lessened making it a more secure and viable ID source. This presents convenience by reducing the need to gather paper-based identification and ensures that, should identification ever be further questioned, the same identification used to open the account is always present with the owner.

This has similar benefits for Automatic Teller Machines (ATM’s). When such intermediary transaction devices are fitted with RFID readers, RFID transponders have the ability to replace debit and credit cards.[245] As Toni McConnel writes,

> “Tags carried by consumers for the purpose of making purchases … simply have a unique ID code that can be used by a reader to access data residing in a remote database. For the reader to access the database, it must meet security criteria that are much the same as for already existing technologies we use every day. … This is no different in principle than a credit card or ATM card number, which is nothing but a unique identifier that allows the credit card reader or ATM

[241] Trolley Scan. Op cit
[242] Transponder News Press Release. Op cit
[243] See Section 5.3.1
[244] VeriChip. Op cit
[245] See Appendix 1

> machine to look up data in a remote database. That is, we already carry cards with this kind of access to our personal information."[246]

Thus, the leap from bankcards to RFID is not great. Instead, it is merely a change of the medium on which unique identifiers for a particular bank account are stored. Implantable RFID then, being a feasible reality in the current state of development, is simply a change to where the medium is kept by the owner. Thus, the convenience of current electronic banking services is available to carriers of humancentric RFID with the added benefit that forgetting your wallet is no longer an issue.[247]

## 5.4 Interactivity

| | |
|---|---|
| **Intended Users** | Mass market, homeowners, office dwellers, car owners, owners and users of technology. |
| **Specific Uses** | Interactive homes and offices, keyless entry systems, remote control of devices, communication. |
| **Constraints** | Need for infrastructure to relay user preferences to devices, need for close proximity between readers and RFID tags, crude success in use for human communication. |

Interactivity, as a convenience-related humancentric application of RFID, moves beyond the reduction of human interaction and eliminates intermediaries completely. Where manual human action is normally required, humancentric RFID allows an absolute automation of tasks. The resulting outcome is that users of the application no longer need to perform certain acts. Instead, user preference or ownership and direct links with technology dictate what is to occur.

### 5.4.1 Interactive Locations

On August 24, 1998 Professor Kevin Warwick from the Department of Cybernetics at the University of Reading became the first human to be recorded as implanted with an RFID transponder. Using the transponder, Warwick was able to interact with the "intelligent"[248] Cybernetics building that he worked in. At the time, Warwick stated,

> "In our building in the Cybernetics department, we've got quite a number of doorways rigged up so that they pass a radio signal between the door frame. When I go through the doorways, the radio signal energizes the coil. It produces

[246] T McConnell. 'Privacy Issues In RFID' *iApplianceWeb*, CMP Media, April 06, 2003 [*http://www.iapplianceweb.com/story/OEG20030604S0*043 Last Accessed September 19, 2003]
[247] Eng. Op cit
[248] Witt. Op cit

> an electric current, which the chips use to send out an identifying signal, which the computer recognises as being me."[249]

Over the nine days he spent with the transponder implanted in his left arm, doors requiring smart card access automatically opened for Warwick.[250] Lights activated when he entered a room[251] and within his office, upon sensing the presence of the professor, Warwick's computer greeted him and gave a tally of email received.[252]

Warwick's experiment, labelled 'Project Cyborg 1.0',[253] thus showed enormous promise for convenience-related humancentric applications of RFID. The test proved that given the right infrastructure, instead of having to carry smart cards or keys, it is practical to have doors open automatically. Instead of fumbling in the dark for switches, lights will instinctively turn on. Instead of password access to a personal computer, technology will recognise human presence.

The concept of such stand-alone applications expands easily into the development of an interactive home[254] or office. With systems available to manage door, light and personal computer preferences based on transponder identification, triggering further climate and environmental changes is similarly feasible, especially considering non-humancentric versions of these applications (activated by wearable RFID) already exist.[255] As one example, based upon personal preferences related to the unique identifier stored on the transponder, humancentric RFID users could invoke opening and closing of curtains, temperature adjustments and radio station changes as they move about the interactive location. Accordingly, where one questionnaire respondent suggested limitless applications of convenience-related humancentric RFID,[256] it is perhaps within this scope that such a statement is most true.

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[249] Ibid
[250] Warwick. Op cit; Witt. Op cit; Woolnaugh. Op cit; Sanchez-Klein. Op cit
[251] Ibid
[252] Ibid
[253] Warwick. Op cit; University of Reading. 'Professor Kevin Warwick – Home' University of Reading, Reading, 2003 [*http://www.rdg.ac.uk/KevinWarwick/html/project_cyborg_1_0.html* Last Accessed September 20, 2003]
[254] See Appendix One
[255] Texas Instruments. 'Loyally Yours' *TIRIS News* Dallas. Issue 17, 1997 [*www.ti.com/tiris/docs/manuals/RFIDNews/Tiris_NL17.pdf* Last Accessed September 20, 2003]
[256] See Section 5.1 and Appendix One

### 5.4.2 Interactive Objects

It has been documented that humancentric applications of RFID can control access to physical assets.[257] Inherent in this idea of access control however, is the notion of interaction. To illustrate using vehicles, by customising locks on a car using an RFID system, doors will open when the RFID reader identifies the transponder of an allowed driver or passenger. Convenience, in addition to the security benefits outlined in chapter 4, [258] is therefore provided in timely access and keyless entry.[259]

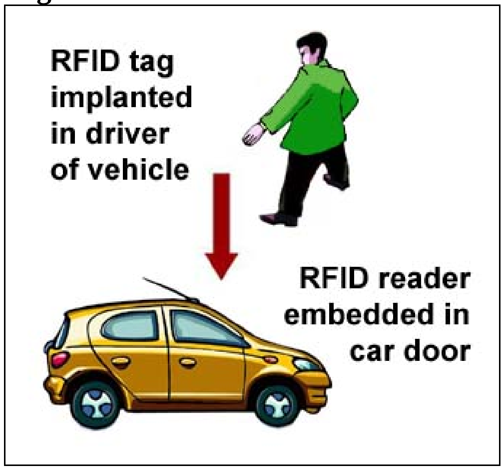
The viability of this application has been proven by the commercial availability of a non-humancentric counterpart. Manufactured by Texas Instruments RFID, the benefits are outlined in marketing material which states,

> "Imagine approaching your car with your arms full of groceries; keys somewhere in your pocket, you pull the handle and the vehicle automatically IDs you and unlocks the door… The Keyless or Passive Entry system enables this convenience."[260]

The humancentric version is pictorially represented in Diagram 5.3. As shown, the driver of the RFID-enabled vehicle is implanted with an RFID transponder. Similarly, an RFID reader exists in the door of the vehicle. When the driver comes within a recognised reading distance for humancentric transponders the driver is automatically identified and the door unlocks. Thus keyless access using a passive RFID system provides "a means for entry without the need for user interface".[261] The number of procedural steps in opening the door, compared to key-based entry, is reduced.

[257] See Sections 4.3 and 4.3.3
[258] See Section 4.4.3
[259] Texas Instruments RFID. 'Passive Automotive Entry' Texas Instruments Incorporated, Dallas, 2002 [*http://www.ti.com/tiris/docs/solutions/auto/passive.shtml* Last Accessed: September 11, 2003]
[260] Texas Instruments RFID. 'Passive Automotive Entry'. Op cit
[261] Ibid

**Diagram 5.3: Customised Vehicle Access**




Notably, reading distances for humancentric RFID systems are limited "due to the magnetic field type devices … used with the high water content of the body".[262] Humancentric RFID therefore requires transponder and reader to be merely centimetres apart.[263] This means that for applications like customised vehicle access, the implant must be inserted in the hand or in a part of the body that can be easily waved in front of a reader.

Kevin Warwick, building on research in the prior Project Cyborg 1.0,[264] had an RFID device studded with 100 electrodes inserted directly into the median nerve in his left forearm during his Project Cyborg 2.0[265] experiments in 2002.[266] Part of the scope of these experiments involved interaction with computerised devices, further showing, as originally proven in Project Cyborg 1.0, that

> "Since the human nervous system uses electrochemical signals, there's no reason it can't be made compatible with the electronic signals of a computer."[267]

In these experiments, Warwick's implant recognised neural signals corresponding to movement and sensation and transmitted them to a computer. These signals were then converted and used to interactively control other devices ranging from a wheelchair to LED jewellery worn by his wife.[268] Through the implanted device, Warwick was also

[262] See Appendix One
[263] See Appendix One
[264] See Section 5.4.1
[265] University of Reading. Op cit
[266] D Langford. 'First Person Singular' *New Scientist* [Online] London, September 7, 2002. Available: ProQuest, August 29, 2003; Underhill. Op cit
[267] Underhill. Op cit
[268] Langford. Op cit; University of Reading. Op cit

able to remotely manipulate a 3-fingered robot arm located in his laboratory and "when Warwick clenched his hand, so did the robot."[269] Here, the potential convenience in allowing remote usage or interaction with machines is apparent.

### 5.4.3 Communication

Given the success of interacting with inanimate locations and objects, the next step is to ask whether interaction between humans – communication - can be achieved through humancentric RFID devices. Such instantaneous communication would conveniently eliminate the need for intermediary devices like telephones or post. Answering this question was an aim in Project Cyborg 2.0 with Warwick writing beforehand, "We'd like to send movement and emotion signals from one person to the other, possibly via the Internet."[270]

Warwick's wife Irena was the second subject in the communications trial, being similarly fitted with an implant in her median nerve.[271] Attempting to communicate through computer-mediated signals was met with limited success. When Irena clenched her fist for example, Professor Warwick received a shot of current through his left index finger.[272] Movement sensations were therefore successfully, if primitively, transmitted.

Broadcasting emotion and thought is a much harder task and, despite research at British Telecom into mind-implantable 'Soul Catcher' chips,[273] given the results of Cyborg 2.0 such communicative technology is not feasible in the current state of development. Professor Warwick has shown possible the middle ground – a transfer of sensation – but even this needs to be medically, technologically and economically refined before the technology can advance and become a mass application.

## 5.6 Conclusion

Convenience can be provided through humancentric applications of RFID in a number of ways. Primarily, convenience benefits exist in the ability of humancentric RFID to

[269] Underhill. Op cit
[270] Warwick. Op cit
[271] Vogel. Op cit; Underhill. Op cit
[272] Underhill. Op cit
[273] K Coughlin. 'The Melding Of Man And Machine' *New Jersey Online* April 1, 2000 [*http://www.cochrane.org.uk/opinion/interviews/01-04-2000.htm* Last Accessed September 20, 2003]

automate tasks or eliminate intermediary steps in current procedures. This leads to secondary savings in time and increases in efficiency. Coupled with the convenience of the implant always present with the user, this presents a positive view of convenience applications. It suggests, as one questionnaire respondent did, that usage in this usability context area might be limitless. In satisfying objective 5[274] however, an examination of improved lifestyle conveniences available via humancentric applications of RFID has also presented some drawbacks. These include a lack of widespread infrastructure, a need for transponder-reader proximity limiting the placement of the implant within the body, and technological barriers when combining the RFID device with GPS.

[274] See Section 1.5

# Chapter Six: Usability Context Analysis - Care

## 6.1 Introduction

Throughout history, technological advances have revolutionised healthcare and medical solutions, thereby saving lives and improving the standard of living for countless people.[275] Improvements in surgical techniques have allowed for "longer, safer and more complicated operations".[276] Similarly, advances in monitoring and medical procedures have allowed for earlier detection and diagnosis of health conditions.[277] RFID is proposed to have comparable revolutionary potentials in the healthcare field. Indeed, leading pioneer Professor Kevin Warwick believes that there is enormous medical application for RFID and he "imagines paraplegics walking".[278] The question to be asked however, is how close are today's applications to these foreseen 'miracles'? The following usability context analysis now seeks to investigate the applications of RFID in areas of human care within the current state of development. This will satisfy objective 6.[279]

Care, as an application area, has been previously defined[280] as any human use of an implantable RFID transponder that has a function associated with medicine or health. This may include applications that improve general well-being. The following usability context analysis applies this definition of care when exploring the contextual application area. The usability context analysis for care is divided into three main sub-contexts – Medical, Biomedical and Therapeutic. Each of these sub-contexts contains examples of specific innovations.

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[275] S Mandel. 'The Technology Factor' Electric Perspectives Edison Electric Institute, November / December 2000 [*http://www.eei.org/magazine/editorial_content/nonav_stories/2000-11-01-factor.htm* Last Accessed: 15 October, 2003]

[276] University of Iowa Health Care. 'A History of Cardiology: The Beat Goes On' University of Iowa, Iowa, 2003 [*http://www.uihealthcare.com/depts/medmuseum/galleryexhibits/beatgoesonhistory/06surgery.html* Last Accessed: October 15, 2003]

[277] Sarasota Memorial Heart and Vascular Institute. 'Heart and Vascular' Sarasota Memorial Health Care System, Sarasota, 2001 [*http://www.smh.com/ServicesCenters.asp?Deptid=40* Last Accessed 13 October, 2003]

[278] Witt. Op cit

[279] See Section 1.5

[280] See Section 2.3.3

## 6.2 Medical

| | |
|---|---|
| **Intended Users** | Mass market, persons with allergies, persons with prior or ongoing medical conditions. |
| **Specific Uses** | Storage of medical data, patient identification, portability of medical records, emergency response services. |
| **Constraints** | Lack of widespread infrastructure, any GPS functionality must be externally integrated with the RFID tag |

The Australia Oxford Dictionary defines the word 'medical' as descriptive "of medicine in general… as distinct from surgery".[281] In this usability sub-context it describes the common practice of medicine, most notably the maintenance of patient records and accessibility to healthcare. Current technology levels show humancentric applications of RFID to exist within both of these fields.

### 6.2.1 Medical Records

With implanted RFID transponders able to store identifying information or link to identifying records in databases, the storage of medical records is perhaps an obvious humancentric application of RFID. Similar to identification for control-related identification purposes,[282] one of the primary benefits involves the RFID transponder being able to impart critical information when the human host is otherwise incapable of communication. In this way, the application is "not much different in principle from devices … such as medic-alert bracelets".[283] Unlike medic-alert bracelets however, implanted RFID likely does not have so specific a market. It is not necessary that a patient have ongoing medical conditions in order to have their medical history close at hand. As humans, we are all susceptible to accidents.

American corporation VeriChip markets their implantable RFID device for the purpose of medical identification. In April of 2002, the regulatory Food and Drug Administration (FDA) approved VeriChip for market-based distribution in the United States.[284] The implantable RFID transponder was deemed not to be a "regulated medical device"[285] and thereby became marketed as a solution for "a variety of

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[281] Turner, George [ed]. *Australian Little Oxford Dictionary* Oxford University Press, Melbourne, 1992.
[282] See Section 4.3.1
[283] M Cossolotto as quoted in Gengler. Op cit
[284] Applied Digital Solutions, Press Release. May 13, 2002. Op cit
[285] Anonymous. April 5, 2002. Op cit

security, emergency and healthcare applications".[286] In October of 2002 however, this was revised and the FDA ruled that while non-regulation was to continue over security, financial, identification and safety applications, VeriChip's healthcare applications are now subject to regulation in the United States.[287]

For VeriChip subscribers, these latter healthcare applications include giving doctors and medical staff comprehensible and emergency access to patient-supplied health information, in-facility and inter-facility patient identification, and medical facility connectivity via the implantee.[288] All these applications result from the same initial process. First, in a simple outpatient procedure lasting only a few seconds,[289] the VeriChip is implanted in a locale of the patient's choosing. Later, when scanned by a VeriChip RFID reader, a process shown in Diagram 6.1, the VeriChip excites and transmits a unique code. This code links to a secured database record in the Global VeriChip Subscriber (GVS) Registry where personal data including contact details, demographics and medical conditions are stored.[290] As such, a secondary benefit to implantation for care-related purposes is that multiple humancentric applications stem from singular preparatory and usage procedures.

**Diagram 6.1: The VeriChip Data Retrieval Process[291]**

Please see print copy for Diagram 6.1

The initial market launch of VeriChip on 10 May 2002 showcased the use of humancentric RFID for medical record-keeping applications. Eight people were micro-chipped in the televised public event and four of these were volunteers with health concerns.[292] The remaining four were company executives.[293] Of the healthcare

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286 Ibid
287 Applied Digital Solutions, Press Release. July 17, 2003. Op cit
288 Ibid
289 Anonymous. 'Eight People Get ID Chip Implants' *The Star Online*, Malaysia, May 10, 2002 [*http://star-techcentral.com/tech/story.asp?file=/2002/5/10/technology/10chip&sec=technology* Last Accessed: October 1, 2003]
290 VeriChip. Op cit; Ibid
291 VeriChip. Op cit
292 Applied Digital Solutions, Press Release. May 13, 2002. Op cit
293 Ibid

implantees, three were members of the Florida-based Jacobs family.[294] At the insistence of then 14-year-old Derek, the poor health of his father Jeff became the incentive for Derek, Jeff and mother Leslie to be implanted with an identifying RFID transponder. Here, the life-saving capability of the RFID transponder was recorded in *Time* magazine as follows:

> "Derek has allergies to common antibiotics, and Jeffrey is weakened from years of treatment for Hodgkin's disease. A few years ago, he was in a serious car accident; and when he got to the hospital, he was in no shape to explain his condition to the staff. 'The advantage of the chip is that the information is available at the time of need,' Jeffrey explains. 'It would speak for me, give me a voice when I don't have one.'[295]

The remaining healthcare implantee was Nate Isaacson, an 83-year-old Alzheimer's patient.[296] Unlike the Jacobs' who have their transponders implanted in their right arms, Isaacson's RFID tag lies in his upper back.[297] By reading this chip, medical staff can discover that Isaacson "is prone to forgetfulness, has a pacemaker and is allergic to penicillin".[298] More importantly for an Alzheimer's patient, in an emergency, the RFID transponder allows medical staff to determine Isaacson's identity.

VeriChip has proven the wide appeal of such simple care applications by successfully launching the product in non-US markets. On 17 July 2003 for example, the operation was expanded to Mexico with company Solusat Medica being named as the exclusive distributor of VeriChip products for healthcare applications.[299] These applications, whose regulatory status in Mexico differs from that of the US, are forecasted to generate $9 million in revenue for VeriChip over the next three years.[300]

Care-related humancentric RFID applications provide an unparalleled level of portability for patient medical records. Where many medical centres still keep paper-based record systems, the paper-trail problem inherent in changing doctors is significantly reduced. Implantable transponders also provide a reliable means of patient identification. Full benefit cannot be gained without an appropriate widespread infrastructure for usage however. Though the purpose of having medical data

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294 Ibid
295 Grossman. Op cit
296 Streitfeld. Op cit
297 Gengler. Op cit; Streitfeld. Op cit
298 Streitfeld. Op cit
299 Applied Digital Solutions, Press Release. July 17, 2003. Op cit
300 Ibid

accessible through implanted RFID is to save lives in an emergency, this cannot be achieved if necessary reading equipment is not available to medical staff. The problem is especially great in the early days of application rollout, as the cost of readers may not be justified until the technology is considered mainstream. Also, as most proprietary readers are only capable of reading similarly branded transponders, questions regarding monopolies in the market and support for brand names arise. VeriChip, as a technology distributor, have recognised this and, since 2002, have made considerable donations of equipment to hospitals, search and rescue units and urgent care clinics.[301] As of July 2003, discussions were also underway to donate VeriChip readers to the Red Cross and the Mexican Alzheimer's Association.[302]

### 6.2.2 Emergency Medical Response

The benefit of being able to convey medical data in emergency situations becomes clear when the implantee arrives at a medical facility where data can be read and used. Real value eventuates however, when the scope of the application is expanded and the implanted RFID transponder is able to alert medical facilities of an outside emergency. The alert given to emergency response services would contain the location of the implantee. Potentially, these transmissions could also contain the data stored on the RFID transponder, thereby giving a pre-warning of existing medical conditions and heightening the level of appropriate care given in an emergency response situation. This eclipses current telephone-based emergency response services on two levels. First, RFID sensor technology intuits the emergency, seeks help and provides indicators of medical history if the implantee is unable to do so.[303] Second, it provides emergency services with timely and accurate data. This reduces the emergency response call-taker's challenge of getting "an accurate location from the screams of disoriented, incoherent, or panicky callers".[304]

In the current state of development, the typical implementation of the above application sees an external GPS device used for location and transmission purposes. A person implanted with an RFID transponder wears it in the form of clothing or an

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[301] Applied Digital Solutions, Press Release. May 13, 2002. Op cit
[302] Applied Digital Solutions, Press Release. July 17, 2003. Op cit
[303] VeriChip. Op cit
[304] J Kauffman. 'Wireless 911 Geolocation: A New Way To Save Lives Now' *NENA News* [Online] Summer 2001. Available IEEE, September 12, 2003.

accessory.[305] Presently available GPS components, made with this type of emergency purpose in mind, can locate a user to within a distance of several metres.[306] This hinges on the ability to gain an unobstructed view of the sky, which is necessary for GPS.[307] Different products also use different response scenarios. The Digital Angel GPS device for example, manufactured by the parent company of VeriChip, will alert a nominated caregiver of the emergency situation.[308] A device produced by the Wherify Corporation however, has the ability to direct an emergency response request to the relevant Emergency Services hotline.[309]

Variants of the GPS components are available for unique healthcare situations. A GPS component with "wander alerts"[310] for example, may be useful for Alzheimer's patients. Similarly, components with "fall-down alerts"[311] may be of benefit to the elderly or to epileptics. Eng puts it best when he writes:

> "The chip will … know if your child has fallen and needs immediate help. Once paramedics arrive, the chip will also be able to tell the rescue workers which drugs little Johnny or Janie is allergic to. At the hospital, the chip will tell doctors his or her complete medical history."[312]

The primary weakness of this current application is that the GPS component is external to the body and RFID transponder. Applied Digital Solutions, the parent company of both VeriChip and Digital Angel, has been recorded in the press as working toward a prototype of a combined implantable device however.[313] They believe they have solved the question of power supply, claiming to have produced lithium ion batteries that can be charged remotely from outside the body.[314] This is yet to be publicly demonstrated. Moreover, there is no evidence to suggest that they or any other manufacturer have been able to overcome problems inherent in producing a GPS receiver (complete with antenna) that is compact and safe enough to shield the body from radiation while still transmitting through skin tissue.

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[305] Digital Angel Corporation. Op cit
[306] Ibid
[307] Garmin Ltd. Op cit
[308] Digital Angel Corporation. Op cit
[309] Wherify. Op cit
[310] Digital Angel Corporation. Op cit
[311] Ibid
[312] Eng. Op cit
[313] Anonymous. May 10, 2002. Op cit; Streitfeld. Op cit
[314] Streitfeld. Op cit

## 6.3 Biomedical

| | |
|---|---|
| **Intended Users** | Sufferers of chronic disease, trauma victims, those taking constant medication, those undergoing medical treatment, mass market for generic health monitoring. |
| **Specific Uses** | Monitoring of biological parameters for medical and health-related care purposes. |
| **Constraints** | Need to ensure human body does not reject or attack the implant, possible dislodgement of implant, need for widespread infrastructure, need for further development and human testing. |

Biomedical, as distinct from the definition of 'medical' outlined above, is here described as a branch of science dealing with human biology in a medical or healthcare setting. Already an established field in its own right, combining biomedicine with evolving humancentric RFID presents a new range of revolutionary applications in the context of human care.

### 6.3.1 Biosensors

A biosensor is a device which "detects, records, and transmits information regarding a physiological change or the presence of various chemical or biological materials in the environment".[315] It integrates biological and electronic components in order to produce quantitative results like the measurement of biological parameters,[316] or qualitative results such as the recognition of a change in biological parameters. Of these parameters, thermal, electrochemical, mass and optical changes are the most common.[317] When combined with humancentric RFID, biosensors acquire the functionality to transmit identifying information as to source, as well as the standard biological reading or result. The timesavings alone in simultaneously gathering what are, by general rule, two different data sets are an obvious benefit. Flowing from this, a combined reading of biological source and biological measurement is less likely to encounter the human error associated with manually correlating data to a data source. In the context of human care, this is especially important when for example, in a hospital scenario, patients need to be critically and accurately matched with their own biological statistics.

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[315] T Seneadza. 'Biosensors – A Nearly Invisible Sentinel' *Technically Speaking* July 21, 2003. [*http://tonytalkstech.com/archives/000231.php* Last Accessed October 15, 2003]
[316] Ibid
[317] Bioanalytical Technologies. 'Technology – Biosensors Definition' Bioanalytical Technologies, Moscow, 2003 [*http://www.biosensor.ru/eng/technology/* Last Accessed October 15, 2003]

One example of such a system relies on Micro Electro Mechanical Systems, or MEMS, devices.[318] These are small-scale implantable microsensor technologies that intrinsically monitor the biological system within which they are placed. A hand-held scanner external to the body reads the result, through radio frequency and in the form of a measurement or status, of the monitoring.[319] This reading process, occurring without the aid of batteries or wires, has the potential to alert medical staff to impending health crises in a timely fashion. Instead of a patient undertaking costly CAT scans for example, their heart condition could be monitored in a simple transponder reading. Technology to allow this particular application is currently in development. Originally adapted as a sensor for use in jet engines,

> "MEMS has been adapted to monitor blood pressure levels in the organs or blood clots of patients with heart failure or with abdominal aortic aneurysm, an abnormal widening of the aorta."[320]

In terms of testing, these cardio-MEMS have successfully recorded the blood pressure of a healthy canine.[321] As of 2003, human trials are planned but several healthcare risks have already been identified. The first of these is the possibility that the human body will have a reaction to the materials used to make the biosensor.[322] The second key health risk involves the potential dislodging of implanted chips.[323] These hazards are of particular concern, especially as one questionnaire respondent noted that

> "Even in herd animals, implantable transponders are being banned. In about 40% of the cases the transponder moved in the fat layer…"[324]

Keeping these hazards in mind, we now look to examine 'successful' applications of biosensor technology in the current state of humancentric RFID development.

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[318] L Cao. S Mantell. D Polla. 'Implantable Medical Drug Delivery Systems Using Microelectromechanical Systems Technology' *1st Annual International IEEE-EMBS Special Topic Conference on Microtechnologies In Medicine and Biology* Lyon, October 12-14, 2000. Available IEEE, August 31, 2003.
[319] Berger. Op cit
[320] Ibid
[321] Ibid
[322] Ibid
[323] Ibid
[324] See Appendix One

#### 6.3.1.1 Temperature

Implantable transponders that allow for the measurement of body temperature have been used to monitor livestock for over a decade.[325] As such, implantable biosensor technology is not novel and its benefits, in terms of the data it procures, are well known. Indeed, Geers said, when writing of implantable temperature biosensors for pigs and cows,

> "Body temperature has been proven repeatedly to be a valid parameter revealing information on the health condition or the stress situation of the animal (or human)"[326]

Accordingly, it was perhaps only a matter of time before such devices transcended into humancentric application. In February 2003 Applied Digital Solutions, a manufacturer of identification and monitoring technologies, announced the development of a temperature sensing implantable RFID device.[327] The VeriChip Corporation, a subsidiary of Applied Digital Solutions, publicly demonstrated this technology in April of the same year.[328] Of the device, promotional materials propose that,

> "This new Radio Frequency Identification (RFID) microchip has similar dimensions and performance characteristics as VeriChip, but it can also obtain and transmit body temperature data."[329]

As such, all the benefits and disadvantages of the original VeriChip, including the need for widespread infrastructure before usage can attain commercial feasibility, are present in this new RFID transponder. In addition, it gives a revolutionary new facet to human care by allowing internal temperature readings to be gained, post-implantation, through non-invasive means. The applications for this are wide and, as promoted by VeriChip, include:

- Chemotherapy treatment management
- Chronic infection monitoring
- Organ transplantation treatment management

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[325] Geers. Op cit

[326] Geers. Op cit. p44

[327] Applied Digital Solutions, Press Release. 'VeriChip™ Subdermal Personal Verification Microchip To Be Featured At IDTechex "Smart Tagging In Healthcare" Conference In London, April 28-29, 2003' Applied Digital Solutions, Palm Beach, April 25, 2003.

[328] Ibid

[329] Ibid

- Infertility management
- Postoperative monitoring
- Critical care monitoring
- Medication monitoring
- Response to treatment evaluation

**6.3.1.2 Diabetes**

An implantable transponder for use by diabetes sufferers has been proven in concept by biotechnology firm, M-Biotech.[330] The transponder itself is a small glucose biosensor, consisting of a miniature pressure sensor and a glucose-sensitive hydrogel which swells "reversibly and to varying degrees"[331] when changes occur in the glucose concentrations of surrounding body fluids. Implanted in the abdominal region, a wireless alarm unit carried by the patient continually reads the data, monitoring critical glucose levels. Data can also be automatically transmitted to a caretaker. If glucose levels are measured outside of a predetermined "safe range"[332] both patient and caretaker are alerted by an alarm. Even more importantly however,

> "A key feature of the [external component of the] monitoring system is a GPS chip which provides caretakers with the exact location of a patient should they become critically ill or incapacitated."[333]

Though not yet approved for human use, on the 23rd of September 2003, M-Biotech announced that the continuous monitor implant had been successfully tested in animal subjects.[334] This brings the development of humancentric RFID one step closer to implementing complex monitoring systems for human care. It also suggests that drastic changes may occur in common systems of medical monitoring. Diabetes sufferers using this humancentric care application can now, for example, monitor their condition continuously rather than at specified intervals. Further, though technologically invasive because of implantation, social invasion is reduced as individuals can control their own medical monitoring and remove the need for constant third-party supervision.

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330 M-Biotech. 'Biosensor Technology' M-Biotech, Salt Lake City, 2003 [*http://www.m-biotech.com/technology1.html* Last Accessed October 7, 2003]
331 Ibid
332 Ibid
333 Ibid
334 Ibid at *http://www.m-biotech.com/news1.html*

## 6.4 Therapeutic

| | |
|---|---|
| **Intended Users** | Those with previously implanted therapeutic devices, those in need of remedial care, disabled persons. |
| **Specific Uses** | Monitoring and identification of implanted therapeutic devices (e.g. pacemakers), improvement of health and fitness, muscle stimulation. |
| **Constraints** | System complexity, material constraints, computational ability, low power, needs for robustness and fault tolerance, scalability and continuous operation. |

Therapeutic devices are those used for the remedial treatment or cure of ill health and disease.[335] They are often longer-term solutions and, as such, where technology is involved there is an increased need for fault tolerance and robustness. In the therapeutic usability sub-context for care applications, humancentric RFID has two main functions. The first involves the monitoring of third-party therapeutic devices. The second occurs when RFID systems are used for remedial purposes.

### 6.4.1 Monitoring of Implanted Therapeutic Devices

Implanted therapeutic devices are not new, having been used in humans for many years. Alongside the use of artificial joints for example, "radical" [336] devices such as pacemakers have become commonplace. The combined use of RFID with these therapeutic devices however, has re-introduced some novelty to the remedial solution. This is because, while the therapeutic devices remain static in the body, the integration of RFID allows for interactive status readings and monitoring, through identification, of the medical device.

The VeriChip Corporation has been one advocate of such an application, with plans to market the VeriChip RFID transponder as a "pacemaker helper".[337] In this application, the transponder is "attached to the outside of the heart device or implanted nearby in the body"[338] and provides information, in addition to standard medical details, regarding the pacemaker's manufacturer and settings. Medical staff can then gather data regarding an implanted therapeutic device by simply scanning the relevant area of the body with a handheld RFID reader.

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335 Turner. Op cit
336 Michael. Op cit
337 Murray. January 07, 2002. Op cit
338 Ibid

For this application to provide adequate human care, it must be ensured that radio frequency scanning does not in any way affect the electromagnetic workings of the pacemaker. Testing has been performed to assess this risk with results as follows:

> "The power output of these [reading] devices has been found to be below that which would cause interference with pacemaker operation. There is no scenario in which the operation of an RFID device could turn off or shut down a pacemaker."[339]

Accordingly, with interference not an issue, VeriChip are recorded in the media as being in discussion with pacemaker manufacturers to have the VeriChip incorporated with the medical devices during the assembly process.[340] By having the RFID transponder embedded with the pacemaker (or indeed, with an artificial joint or other therapeutic device),[341] only one invasive procedure is then required to implant the two components. The downside in the current state of development lies with the lack of widespread infrastructure and limited knowledge as to use. Indeed, the question remains, even if a patient was to have an RFID transponder implanted how would medical staff recognise that it was there? How can medical staff know to scan for an implanted transponder, and how can they know what specific area to scan?

### 6.4.2 Treatment

The use of RFID systems in remedial or therapeutic situations is a research area attracting much attention in the current state of development.[342] Due to the human care element and the grim consequences of failure, both benefits and risks have life-altering potentials. On the one hand, a working solution can improve the standard of life for individuals. On the other, the complexity of systems means limitations regarding power, materials used in manufacture and computational ability are more likely to be encountered. Similarly, the need for robustness, fault tolerance, continuous operation and scalability are heightened.[343]

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[339] Idesco Secure Identification. 'Frequently Asked Questions' Idesco Secure Information, Oulu, 2003 [*http://www.idesco.fi/faq/faq.htm* Last Accessed October 14, 2003]
[340] Murray. January 07, 2002. Op cit
[341] Raza, Nadeem. Bradshaw, Viv. Hague, Matthew. 'Applications of RFID Technology' Microlise Systems Integration Limited, Institute of Electrical Engineers, IEE [Online] London, 1999. Available IEEE, May 1, 2003.
[342] L Schwiebert. S Gupta. J Weinmann. 'Research Challenges in Biomedical Networks of Wireless Sensors' [Online] ACM, Rome, 2001. Available IEEE, August 17, 2003.
[343] Ibid

There are very few proven applications of humancentric RFID in the treatment-related usability sub-context at current, and fewer still have generated a proof of concept involving human implantation. Further, of those demonstrating proof of concept, benefits to the user are generally gained via an improvement to the quality of living, and not a cure for disease or disability. None of these applications are in commercial development.

One of these applications demonstrating proof of concept in research-based development is an electrical stimulation system. In a step toward Professor Kevin Warwick's vision of seeing paraplegics walking,[344] a 41-year old sedentary male patient carrying a spinal cord injury was implanted with two eight-channel radio frequency controlled "receiver-simulators".[345] The RFID system was used to deliver stimuli to muscles attached to the implanted device via electrodes. After one year, the implant had caused "no adverse physiological effects, and the individual reported health benefits such as more energy and greater overall fitness".[346]

Though promising, such therapeutic applications still have a long way to go before they reach the revolutionary heights proposed by RFID proponents. With applications to restore sight to the blind[347] and re-establish normal bladder function for patients with spinal injuries[348] already in prototyped form however, some propose that real innovative benefit is only a matter of time. Arguably the technology for the applications already exists. All that needs to be determined and proven is a correct implementation. Thus, feasibility is perhaps a matter of technological achievement and not technological advancement. In any case, in the current state of development, this achievement has not yet been made on a commercially viable scale.

## 6.5 Conclusion

Care, as a context of humancentric RFID, showcases applications in medical, biomedical and therapeutic spheres and an investigation of these applications has shown results of use to range from remedial benefit through to life-saving capability.

[344] Witt. Op cit
[345] Kobetic, et al. Op cit
[346] Ibid
[347] Schwiebert et al. Op cit
[348] Arabi, Karim. Sawan, Mohammed. 'A Multiprogrammable Microtstimulator Dedicated To Bladder Dysfunctions' [Online] Department of Electrical and Computer Engineering, Montreal, 1994. Available IEEE, August 31, 2003.

Despite these profound gains however, humancentric RFID applications in this context are in an early stage of the technological lifecycle and still face many barriers. These include material constraints, computational ability, increased need for robustness and fault tolerance, and the need for low power but continual operation.

In satisfying objective 6,[349] the context of care has shown itself to be an area which is more complex in terms of technology, and, in the current state of development, less open to commercial usage than its fellow context areas. This is likely due to the extreme life-altering risks of failure that are not present (to the same degree) within other contextual applications.

[349] See Section 1.5

# Chapter Seven: Discussion

## 7.1 Introduction

The usability context analyses for control, convenience and care were performed to determine the current state of development for humancentric applications of RFID. For each application area, specific innovations were showcased in order to investigate humancentric RFID as a "contemporary phenomenon within its real life context".[350] By this means, a broad range of applications were determined as feasible though many of these are untested and even less are in common or commercial usage.

As outlined in chapter 3,[351] this chapter applies an interpretive analysis to the results of the three usability context analyses. First, an overview of common themes is needed to ascertain the links between contexts and the ideas that underpin the technological application as a whole. This is necessarily followed by an evaluation of the nature of use. This includes analysis of application quality and support for service, and the commercial viability of the technology. Objective 7,[352] to provide a discussion on the current state of humancentric applications of RFID, and objective 8,[353] the definition of boundaries for the area of humancentric RFID applications, will be satisfied.

## 7.2 Usability Contexts

Applications for control, applications for convenience and applications for care were all assessed as usability contexts for humancentric RFID. The choice of contexts stemmed from the emergence of separate themes within the literature review,[354] however the context analyses themselves showed much congruence between application areas. In all usability contexts for example, identification and monitoring are seen as core applications. For control,[355] this functionality exists in security sub-contexts and in the management of access to locations and resources. For convenience,[356] identification is necessary to provide assistance and monitoring is

[350] Yin. 1998. Op cit
[351] See Section 3.3
[352] See Section 1.5
[353] Ibid
[354] See Chapter 2
[355] See Chapter 4
[356] See Chapter 5

prevalent in supporting interactivity with locations and objects. Care,[357] as the third context, requires identification for medical and therapeutic purposes and highlights the monitoring of biological parameters as basic functionality.

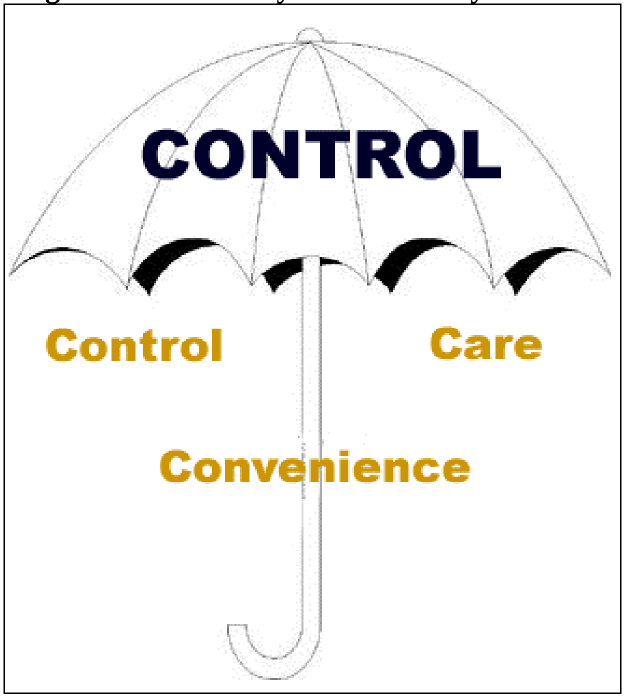
With standard identification and monitoring systems as a base for activity, it is logical that so many core humancentric applications of RFID are espoused as having a mass target market. Medical identification for example is not restricted to those with prior or ongoing illness because, as humans, we are all susceptible to accident or illness.[358] Similarly, security and convenience are generic wants. Combined with the cross-correlation of core innovation outlined above, this mass-market appeal leaves the way open to combining applications across context areas. One potential combination would be in the area of transportation and driver welfare. Here the transponder of an implanted driver could be used for keyless passive entry (convenience), monitoring of health (care), location based services (convenience), roadside assistance (convenience) and, in terms of fleet management or commercial transportation, driver location (control) and monitoring (control).

Despite the outlined parallels and the potential creation of cross-contextual application systems, it is wrong to suggest that all context areas for humancentric RFID are equal in stature. Indeed, in the current state of development control appears as the dominant usability context. Though care can exist in third party control and medical convenience is present in care-related applications, it is control which filters through other contexts as a central tenet. In convenience-related applications for example, control exists in the power of automation and mass management, in the regulation of interactive environments and in the authority over interactive devices. On the other hand, for care-related applications, medical identification is a derivative of identification for security purposes and the use of biosensors or therapeutic devices extends control over well-being. Accordingly, as shown in Diagram 7.1, control is the dominating ‘umbrella’ theme that encompasses all contexts of humancentric RFID in the current state of development.

[357] See Chapter 6

[358] See Section 6.2.1

**Diagram 7.1: Usability Context Analysis Themes**




Alongside contextual theme, defining the usability contexts further are the benefits and disadvantages recognised in each application area. When taking a narrow view and analysing a sub-context or specific innovation, it becomes clear that many benefits of humancentric RFID are application specific. Therapeutic implants for example, have the benefit of the remedy itself.[359] Also within this narrow view however, particular implementations of applications are largely given to social disadvantages including the onset of 'Big Brother' mentalities, religious objections,[360] and specific privacy fears. This thesis sought to avoid such social concerns however and a high level view of benefits and constraints has therefore been constructed. A summary can be seen in Table 7.1.

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[359] See Section 6.4.2
[360] Greater Things. Op cit

**Table 7.1: High Level Benefits and Disadvantages for Humancentric RFID**

| Scope | Benefit | Disadvantage |
|---|---|---|
| **Humancentric Application (Use)** | ▪ Means of identification – a theft-proof, counterfeit-proof ID<br>▪ Means of access control<br>▪ Means for monitoring resources (including employees)<br>▪ When combined with GPS – means of location, means of emergency alert<br><br>▪ Enhance control over well-being<br>▪ Enhance convenience of performing tasks<br>▪ Allows interactivity with locations and devices<br>▪ Provide care-related functionalities<br>▪ Biosensing abilities<br><br>▪ Streamline processes<br>▪ Portability of data<br>▪ Time savings<br>▪ Economic benefits (especially re: monitoring of parolees)<br>▪ Privacy in application usage as implant is invisible to human eye<br>▪ Transponder cannot be 'forgotten' or left at home | ▪ Lack of widespread reading infrastructure<br>▪ Need for data correlation<br>▪ Need for an appropriate placement of the transponder to facilitate accurate reading<br><br>▪ Possible involuntary use of application<br>▪ Crude success in human-to-human communications |

| Scope | Benefit | Disadvantage |
|---|---|---|
| **Humancentric RFID (Technology)** | ▪ Secured within the body, thus reducing theft and loss<br>▪ Access codes, serial numbers or passwords on the transponder are imperceptible to the human eye | ▪ Material constraints<br>▪ Computational ability<br>▪ Low power<br>▪ Potential interference from other wireless systems<br><br>▪ System complexity<br>▪ Need for robustness and fault tolerance<br>▪ Need for continuous operation<br><br>▪ Human body may reject or attack the implant<br>▪ Close proximity between reader & transponder<br>▪ Possible dislodgement of implant<br><br>▪ GPS functionality must be externally integrated with the RFID transponder |

Table 7.1 divides the results of the usability context analyses into benefits and disadvantages associated with the usage of humancentric applications, and benefits and disadvantages placed on applications by humancentric technology. As can be seen, compared to the numerous benefits associated with application usage, the underlying technology weights itself toward being disadvantageous. In the current state of application development this is of no great concern for application uptake and indeed, devices like the VeriChip have already gained regulatory approval for use.[361] What will be affected however is future growth in development as visions of "paraplegics walking"[362] and thought-to-thought communication[363] will be hindered by technological constraints.

## 7.3 Application Quality and Support for Service

For humancentric RFID, an assessment of application quality is dependent on commercial readiness. Applications being researched raise different concerns to those being sold in the marketplace. Of the former application state, the usability context analyses suggest that the technology used in humancentric applications presents the largest hurdle. In his Cyborg 1.0 experiments for example, English Professor Kevin Warwick kept a transponder implanted in his arm for only nine days.[364] A direct blow to the transponder would likely have shattered the glass casing, doing irreparable damage to surrounding nerves and tissue.[365] Similarly, research in the area of location based services faces technological hurdles as combining GPS with humancentric RFID involves challenges of radiation shielding, miniaturisation and power supply.[366]

Once technological difficulties are overcome however, and an application moves from being a proof of concept into a commercial product, market-based concerns are more relevant to application quality. Quality of data for instance, is a key issue in commercial contexts. Where many applications rely on correct data for identification, security or medical purposes, ensuring accuracy of data is a high priority. In VeriChip applications, users are given the ability to control the personal information that is

[361] Applied Digital Solutions, Press Release. May 13, 2002. Op cit
[362] Witt. Op cit
[363] Michael. Op cit
[364] Woolnaugh. Op cit
[365] Witt. Op cit
[366] Eng. Op cit; Tuttle. Op cit

accessible, though stored in the Global VeriChip Subscriber (GVS) Registry, through their implanted transponder.[367] The system does not appear to account for data correlation however, and there is a risk of human error in the provision of information and in data entry. Thus, who pays for errors? Who is liable if and when things go wrong? Such questions indicate the need for an establishment of industry standards. This would allow a quality framework for humancentric RFID applications to be created and managed.

Industry standards are also relevant to support for service. In humancentric applications of RFID they are especially necessary as much usability, adjunct to the implanted transponder, centres upon peripherals such as GPS devices.[368] Even the accepted need for RFID readers can increase the complexity of the system, as the interoperability of devices becomes an issue. Most proprietary RFID readers can only read data from similarly proprietary RFID transponders. This is known to be true in the case of VeriChip.[369] In medical applications however, where failure to harness the available technology can have life altering results, a humancentric RFID user with a non-compatible, and therefore unreadable, implant is no better off for use of the application. Accordingly, for humancentric RFID to realise its promotion as "life-enhancing technology",[370] standards for compatibility between differently branded devices must be developed.

Lastly, the site of implantation should also be subject to standards. It was observed in the usability context analysis for care that even if the existence of an implanted transponder were known, difficulties would arise in knowing where specifically to scan.[371] Indeed, of those widely reported incidences of implantation, the Jacobs' family were implanted in their right arms[372] while Kevin Warwick was implanted in his left.[373] Nate Isaacson has his transponder in his upper back,[374] while British soldiers in the alleged APRIL trials carried transponders in their necks.[375] Therefore, without a common site for implantation, and where scanning an implanted

[367] VeriChip. Op cit
[368] See Section 4.4.2
[369] VeriChip. Op cit
[370] Anonymous. March 18, 2003. Op cit
[371] See Section 6.4.1
[372] Gengler. Op cit
[373] Holden. Op cit; Witt. Op cit
[374] Streitfied. Op cit
[375] Icke. Op cit

transponder requires a reading distance of no more than a few centimetres, attempting to find the RFID device can be time consuming or ineffective. This is a great disadvantage in medical, location-based or other critical implementations where time is a decisive factor in the success of the application. It is also a disadvantage in more general spheres because the lack of standards suggests that though technological capability is available, there is no social framework ready to accept it.

## 7.4 Commercial Viability

### 7.4.1 For the Consumer

A humancentric application of RFID must satisfy a valid need in order to be considered marketable. This is a heightened requirement for humancentric RFID as the source of the application, the transponder, requires an invasive procedure for installation and cannot be easily removed. Add to this that humancentric RFID is a relatively new commercial technology with few known long-term effects, and we see that participating in an application is likely to be a considered and not a spontaneous decision. For these reasons, despite many applications having a mass target market, the value of the application to the individual will determine boundaries and commercial viability.

Value is not necessarily cost-based. Indeed, with the VeriChip sold at a cost of $US200 plus a $US10 per month information storage fee,[376] it is not being marketed as a toy for the ultra-rich. Instead, value and the associated scope of the application is assessed in terms of life enhancements. Therapeutic devices for example, provide obvious remedial effects; but the viability of a financial or medical identification system may be limited by available infrastructure. Similarly, is implanting for ‘just in case’ kidnapping or terrorism purposes[377] really worthwhile if it simply serves as a means of identification after death?

Arguably, commercial viability in these instances is increased by the ability of one transponder to support multiple, yet similar, applications. Identification-related applications for example, all supported by a standard VeriChip, are available in

[376] Streitfeld. Op cit
[377] See Section 4.4.3

control, convenience and care usability contexts.[378] Likewise, one humancentric RFID GPS system can support multiple location-based services. The question arises however, as to what occurs when different manufacturers market largely different applications? Where no real interoperability standards exist for humancentric applications of RFID,[379] it is likely that users of the technology must be implanted with multiple transponders from multiple providers. Given that the idea of unique multi-application transponders in the current state of development is met with power and processing constraints, the lack of transponder portability reflects negatively on commercial viability and suggests that each application change or upgrade may require further implantation and bodily invasion.

### 7.4.2 For the Manufacturer

Taking VeriChip as a case study, one is led to believe that there is a commercially viable market for humancentric applications of RFID. Indeed, where the branded transponder is being sold in North and South America, and has been showcased in Europe,[380] a global want for the technology is suggested. It must be recognised however, that in the current state of development, VeriChip and its parent, Applied Digital Solutions, have a monopoly over those humancentric RFID devices approved for use. As such, their statistics and market growth have not been affected by competition and there is no comparative data. The difference between hype and reality is therefore hard to discern.

Looking beyond VeriChip, all questionnaire respondents have a different view on the current commercial viability for humancentric applications of RFID.[381] Kevin Warwick for example, believes that there is viability in the emerging market, though ethical concerns are slowing growth in some locations. Alternately, a second respondent emphasises that there is “definitely not”[382] a viable market, while the third leaves the question open to conjecture. This inconsistent opinion suggests that humancentric applications of RFID have not yet cohesively proven themselves to the

[378] See Sections 4.2.1, 5.2.1 and 6.2.1
[379] See Section 7.3
[380] Applied Digital Solutions, Press Release. April 25, 2003. Op cit
[381] See Appendix One
[382] Ibid

market. A commercially viable fad perhaps, the long-term feasibility remains to be seen.

Interestingly, in non-humancentric commercial markets, mass rollouts of the technology have been scaled back. In July 2003 for example, Wal-Mart stores in America cancelled their "smart shelf" trial – an experimental use of RFID transponders and systems to track individual Gillette razor-blade products.[383] Similarly, problems have arisen in non-humancentric animal applications. The original implementation of the 1996 ISO standards ISO 11784: 'Radio-frequency identification of animals – Code structure' and ISO 11785: 'Radio-frequency identification of animals – Technical concept' were the subject of extensive complaint.[384] Not only did the standards lack a need for unique identification codes, they violated the patent policy of the International Standards Organisation.[385] Further, owing to "the existence of three conflicting patents affecting ISO 11785",[386] the standards also infringed the antitrust law of several countries. Even after the ISO standards were returned, by vote of the ISO Council, to the SC19 Working Group 3 for review,[387] a general lack of acceptance by authorities meant for limited success. Moreover, in recent times, moves have been made to ban the use of implantable transponders in some herd animals.[388] One questionnaire respondent estimates that,

> "In about 40% of the cases the transponder moved in the fat layer and there was concern that someone might eat the transponder by accident. There also was a degradation in the meat quality due to antibodies sensing the presence of the foreign body … Lastly there is the issues [sic] of long term irritations causing cancer."[389]

As noted in the literature review, humancentric applications of RFID have been influenced by and built on non-humancentric applications.[390] This includes both commercial and animal uses. The cessation of non-humancentric trials, and the prohibition of implantable devices, is therefore not a positive sign for the

[383] D Ewalt. 'Wal-Mart Cancels RFID Trial As Companies Get Realistic About The Technology' *InternetWeek* [Online] July 14, 2003. Available Expanded Academic Index, August 17, 2003.
[384] RFID News. 'International Standards Organisation Returns RFID Standard For Animal Use To Working Group For Major Revisions' *RFID News*, 2002 [*http://www.rfidnews.com/returns.html* Last Accessed: October 22, 2003]
[385] Ibid
[386] Ibid
[387] Ibid
[388] See Appendix One
[389] Ibid
[390] See Section 2.2.3

humancentric industry. It instead draws boundaries and shows a belief in the niche functionality of the technology. This suggests that gaining long-term commercial viability will be fraught with problems.

## 7.5 Conclusion

The results of the usability context analyses for humancentric applications of RFID showed a number of parallels between identified applications. Control however, is the dominant application area; with thematic influences appearing in convenience and care-related contexts. This influence ranges from control over self and identification, to third party control in location-based services. In any case, a number of benefits and disadvantages are identified for the use of applications as a whole. Notably though, benefits are largely associated with application use, and disadvantages with application technologies.

In further assessing the nature of humancentric applications of RFID, attention has been drawn to the need for industry standards. This is relevant to both accuracy of data and support for service, and sustains the need for value in applications. Indeed, it is this notion of value that is central to commercial viability in the current state of development and the worth of an application to consumers is what defines boundaries for humancentric RFID applications. Considering this in light of recent, perchance influential, developments in non-humancentric areas, it is well to suggest that humancentric RFID is a niche application of technology whose commercial viability will be questioned outside the short to medium-term.

# Chapter Eight: Conclusion

## 8.1 Introduction

Recent developments in the area of RFID have seen the technology expand from its role in commercial and animal tagging applications, to being implantable in humans. With a gap in literature identified between current non-humancentric and technological development, and future humancentric possibility however, little has been previously known about the nature of contemporary humancentric applications.[391] This thesis, in satisfying the eight objectives outlined for research,[392] has attempted to bridge this gap. In doing so, by means of multiple usability context analyses, it has provided a cohesive study on the current developmental state of humancentric applications, detached from the emotion and prediction which plagues this particular technology.[393] A final summation will now be given.

## 8.2 Principle Conclusions

Humancentric applications of RFID are incrementally being built on the foundations of non-humancentric commercial and animal applications.[394] In the current state of humancentric development, stand-alone applications exist for control, convenience and care purposes, but with control as the dominant context, its effects can be seen in other application areas. Applications are also influenced by power and processing confines, and accordingly, many functions have simple bases in identification or monitoring.[395] Application usage is made more complex however, as the essential nature of peripherals (including readers, information storage systems and, in some cases, GPS) is coupled with a lack of industry standards for interoperability.[396]

Though the technology has been deemed feasible in both research and commercially approved contexts,[397] the market for humancentric applications of RFID is still evolving. Initial adoption of the invasive technology has met with some success but any real assessment of the industry is prejudiced by the commercial monopoly of the VeriChip Corporation. Assessment of feasibility is also constrained by the limited

[391] See Chapter 2
[392] See Section 1.5
[393] Greater Things. Op cit
[394] See Section 2.2.3
[395] See Section 7.2
[396] See Section 7.3
[397] Applied Digital Solutions, Press Release. May 13, 2002. Op cit; Warwick. Op cit

research into long-term effects of the implanted technology and, where use in applications for herd animals has seen the transponders dislodged or attacked as a foreign body by the immune system,[398] this presents a negative view of humancentric RFID. As such, even without taking into account social responses, the long-term commercial viability for humancentric applications of RFID is questionable.

In the short- to medium-term, adoption of humancentric RFID technology and use of related applications will be hindered by a lack of infrastructure and a lack of standards, not only as to the aforementioned interoperability, but also as to support for service and transponder placement.[399] Further, in the current state of development, though much research is occurring in the area of humancentric applications of RFID, the market is still too niche for truly low-cost, high quality application services. As such, the current state of development is not one that will allow for the mass generation of a Cyborg race. Any such visions of the future, alongside curing the incurable and thought-to-thought communication, remain predictions.

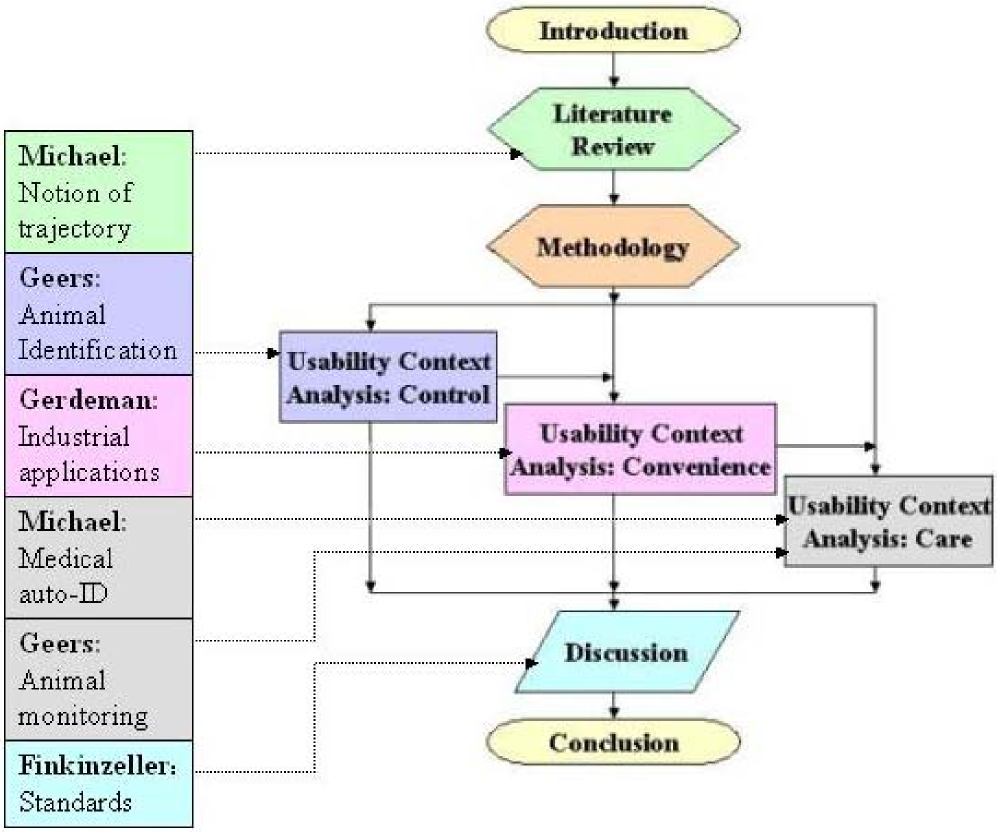
## 8.3 Links To Earlier Findings

Though this thesis has filled a gap in the current state of knowledge surrounding humancentric applications of RFID, links to earlier research in the wider RFID field are evident. Foremost, Michael's notion of trajectory[400] gained support as the literature review, and subsequent usability context analyses, showed humancentric applications of RFID to be largely influenced by non-humancentric commercial and animal applications. Indeed, Geers' work on animal identification,[401] Gerdeman's investigation into non-humancentric industrial applications,[402] and Geers' evaluation of animal monitoring[403] can all be seen as pre-cursors to applications in the contexts of control, convenience and care respectively. In the latter context of care, Michael's assessment of medical automatic identification[404] technologies is also paralleled. Finally, links may be drawn between Finkinzeller's investigations of non-humancentric RFID standards in his study, *RFID Handbook: Radio-Frequency*

[398] See Appendix One
[399] See Section 7.3
[400] Michael. Op cit
[401] Geers. Op cit
[402] Gerdeman. Op cit
[403] Geers. Op cit
[404] Michael. Op cit

*Identification Fundamentals and Applications*,[405] and the need for the development of standards for humancentric applications identified in Chapter 7. A diagrammatic representation of these identified links can be seen in Diagram 8.1.

**Diagram 8.1: Diagrammatic Relationship of Thesis Chapters to Earlier Research**




## 8.4 To Whom Do Findings Apply?

The results of this thesis have wide-ranging relevance for the RFID community. Not only does it raise awareness and investigate the nature of applications, actual and potential, being pushed toward the market by manufacturers, retailers and industry experts, but it explores the effects of doing so. These effects, in terms of benefits, disadvantages and commercial viabilities, provide an in-depth comprehension of what is a relatively new and unexplored application of technology. Such understanding, when applied, allows both researchers and industry to move in more appropriate directions.

[405] Finkinzeller. Op cit

This study is also applicable to the wider community. By identifying mass target markets for many humancentric applications of RFID,[406] the potential of science to impact on all our lives has been shown. Where the technology is as invasive and controversial as humancentric RFID, it is thus critical that factual and cohesive research is available in the public domain. Such research reduces stigma attached to the technology and its applications, and empowers decision-making surrounding use.

## 8.5 Recommendations

In the current state of development, humancentric applications of RFID remain an evolving technology. As such, in order to maintain a positive focus for advancement, a primary recommendation of this thesis is the development of global standards. Regulation of these standards, something greater than simple commercial approval, is also necessary. This may help to overcome some barriers to social acceptance and should provide a technologically feasible framework within which applications can operate.

Without this development of global standards and regulation, it is recommended that a critical view be taken of the commercial viability of humancentric RFID products and services. In the short-term, commercial data must be assessed against the backdrop of a market monopoly. With the VeriChip Corporation as the sole entity responsible for manufacture and sale of commercially-available humancentric RFID devices, their success can too easily be attributed a mass want for the technology, rather than a niche need that would be suffocated by new market entrants.

At the very least, research into humancentric applications of RFID should continue. Primarily, the long-term effects of implantation for humancentric RFID purposes need to be ascertained. This will determine whether the downfalls associated with animal implantations also exist for humans, and will provide a more solid base for assessment of commercial viability. Research into humancentric RFID devices also needs to persist. With a disproportionate number of application disadvantages stemming from the technology itself,[407] overcoming technological barriers could widen the conditions of use and provide a greater power of applications. Lastly, because this thesis focused

[406] See Section 7.2
[407] Ibid

upon use and nature of humancentric applications of RFID, social concerns that would contribute emotional argument to the research were avoided. As such, the gap in literature for the current state of development has been recreated in the area of social acceptance. It is therefore recommended that this thesis be used as a foundation for examinations of social need, social want, freedom of information and security and privacy issues. In this way, a more holistic view of humancentric applications of RFID can be presented.

# Appendix One

## A1.1 Questionnaire Response One

**PART A**

*Name?* Kevin Warwick

*Organisation?* University of Reading (Cybernetics Dept)

*Job Title / Role?* Professor of Cybernetics - Teaching + Research

*Does your organisation develop implantable RFID devices for humans?*

No, but we have tested a number of devices in human experiments

*Are you aware of any organisations that develop implantable RFID devices for humans? If possible, please list them.*

The only one that I am aware of (where a simple ID device is used for humans) is the Digital Angel - VeriChip

*Is there currently a viable market for implantable RFID devices for humans in Australia? In the USA? In the world?*

I think it is just emerging. South/Central America, because of kidnappings, is a good base. In USA + UK ethical concerns still slow the market.

*Are human-implantable RFID devices a suitable means of identification? Please explain why / why not.*

Depends what you want it for. If you need to find someone within a few minutes, without anyone knowing that they have such a device, then yes.

*If you answered yes to the above, what type of information could suitably be stored within the implanted RFID device?*

Technically just about anything you want. As it is also poss to link (by radio) the device with a computer, the amount of stored information is just about infinite. Health info is obviously poss, as is bank card type details. For tracking purposes though only a simple code is required.

**PART B**

*Based on current technology levels, how can human-implantable RFID devices be feasibly used for control-related purposes? (Examples of 'control-related purposes' include personal identification, security, tracking and management, law enforcement.)*

Tracking children/people if abducted/kidnapped - using the mobile phone network.
Prisoners
Security in buildings

*Are there any direct benefits or disadvantages that stem from the applications you outlined (either generally as a group, or specific to an application)? Please outline.*

Implants are not visible from the outside - so for a prisoner they do not have the stigma of an external tag
Implants do not get lost

*Are you aware of any humans who have been implanted for any of the control purposes you outlined above? Please outline.*

No

*What sort of control-related applications, if any, do you believe to be outside the scope of current technology levels?*

Prisoner tracking under all circumstances

**PART C**

*Based on the current technology levels, how can human-implantable RFID devices be used to improve convenience of lifestyle?*

Replace credit cards
Interactive home

*Are there any direct benefits or disadvantages that stem from the applications you outlined (either generally as a group, or specific to an application)? Please outline.*

For an older person, who loses things !, an implant could become essential.

*Are you aware of any humans who have been implanted for the convenience purposes you outlined above? Please outline.*

No

*What sort of convenience-related applications, if any, do you believe to be outside the scope of current technology levels?*

None

**PART D**

*Based on the current technology levels, how can human-implantable RFID devices be used for medical, therapeutic, emergency response and similar care-related purposes?*

Info on a person who needs treatment - past medication, particular problems

*Are there any direct benefits or disadvantages that stem from the applications you outlined (either generally as a group, or specific to an application)? Please outline.*

If the person is ill they might not be able to tell the doctor of their condition. Could save their life.

*Are you aware of any humans who have been implanted for the care-related purposes you outlined above? Please outline.*

Appears to have been quite a few in Mexico recently.

*What sort of care-related applications, if any, do you believe to be outside the scope of current technology levels?*

If it is simply RFID then babies in intensive care - simply due to the implant size.

**PART E**

*Do you wish to make any extra comments?*

Interactive (not just ID) implants open up a much wider potential usage.

*Do you consent to the information you have given in the above questionnaire being published in this thesis? No identifying names will be used in the final publication.*[408]

Yes

*Thank you for your time.*

[408] Permission was gained from Professor Warwick to publish his name alongside his questionnaire response

## A1.2 Questionnaire Response Two

**PART A**

*Name?* [Withheld]

*Organisation?* [Withheld]

*Job Title / Role?* [Withheld] – Industry Expert

*Does your organisation develop implantable RFID devices for humans?*

No

*Are you aware of any organisations that develop implantable RFID devices for humans? If possible, please list them.*

Have heard of one operation in the US but do not remember their name

*Is there currently a viable market for implantable RFID devices for humans in Australia? In the USA? In the world?*

Definitely not!!!

*Are human-implantable RFID devices a suitable means of identification? Please explain why / why not.*

Even in herd animals, implantable transponders are being banned. In about 40% of the cases the transponder moved in the fat layer and there was concern that someone might eat the transponder by accident. There also was a degradation in the meat quality due to antibodies sensing the presence of the foreign body and generating antibodies. Lastly there is the issues of long term irritations causing cancer. The potential lawsuits for a class action against the suppliers and legislators by a large number of the population who believe it causes harmfull effects could be very discouraging.

*If you answered yes to the above, what type of information could suitably be stored within the implanted RFID device?*

[No answer given]

**PART B**

*Based on current technology levels, how can human-implantable RFID devices be feasibly used for control-related purposes? (Examples of 'control-related purposes' include personal identification, security, tracking and management, law enforcement.)*

Once you have an identification device, a reader would convert that into computer readable data and anything could be controlled

*Are there any direct benefits or disadvantages that stem from the applications you outlined (either generally as a group, or specific to an application)? Please outline.*

[No answer given]

*Are you aware of any humans who have been implanted for any of the control purposes you outlined above? Please outline.*

I have heard of the inventor and his child in the US company being implanted, but not any others beyond those two.

*What sort of control-related applications, if any, do you believe to be outside the scope of current technology levels?*

Reading distance is very limited due to the magnetic field type devices that are used with the high water content of the body. Hence reading distances of a few centimeters are all that is practical.

**PART C**

*Based on the current technology levels, how can human-implantable RFID devices be used to improve convenience of lifestyle?*

RFID is just one of a number of biometric technologies that can be used for identification. Obviously RFID could be less intrusive than others, such as fingerprints, retina scan, etc.

*Are there any direct benefits or disadvantages that stem from the applications you outlined (either generally as a group, or specific to an application)? Please outline.*

[No answer given]

*Are you aware of any humans who have been implanted for the convenience purposes you outlined above? Please outline.*

See above

*What sort of convenience-related applications, if any, do you believe to be outside the scope of current technology levels?*

Applications requiring long reading distances.

**PART D**

*Based on the current technology levels, how can human-implantable RFID devices be used for medical, therapeutic, emergency response and similar care-related purposes?*

The RFID data can identify the bearer with or without their consent, accessing a database which holds the necessary information needed, such as medical records.

*Are there any direct benefits or disadvantages that stem from the applications you outlined (either generally as a group, or specific to an application)? Please outline.*

[No answer given]

*Are you aware of any humans who have been implanted for the care-related purposes you outlined above? Please outline.*

See above

*What sort of care-related applications, if any, do you believe to be outside the scope of current technology levels?*

Applications requiring long reading distances

**PART E**

*Do you wish to make any extra comments?*

The backlash from the public, and the possible long term cancer effects, will kill this application of the technology. There further are the religious aspects from the Bible about marking people.

*Do you consent to the information you have given in the above questionnaire being published in this thesis?*

Yes

*No identifying names will be used in the final publication.*

*Thank you for your time.*

## A1.3 Questionnaire Response Three

**PART A**

*Name?* [Withheld]

*Organisation?* [Withheld] – A manufacturer of (non-humancentric) RFID devices

*Job Title / Role?* Customer Service

*Does your organisation develop implantable RFID devices for humans?*

NO

*Are you aware of any organisations that develop implantable RFID devices for humans? If possible, please list them.*

NO

*Is there currently a viable market for implantable RFID devices for humans in Australia? In the USA? In the world?*

I don't  know

*Are human-implantable RFID devices a suitable means of identification? Please explain why / why not.*

Not for identification of the human being

*If you answered yes to the above, what type of information could suitably be stored within the implanted RFID device?*

Only for identification of implanted medical device.

**PART B**

*Based on current technology levels, how can human-implantable RFID devices be feasibly used for control-related purposes? (Examples of 'control-related purposes' include personal identification, security, tracking and management, law enforcement.)*

I don't know

*Are there any direct benefits or disadvantages that stem from the applications you outlined (either generally as a group, or specific to an application)? Please outline.*

[No answer given]

*Are you aware of any humans who have been implanted for any of the control purposes you outlined above? Please outline.*

NO

*What sort of control-related applications, if any, do you believe to be outside the scope of current technology levels?*

[No answer given]

**PART C**

*Based on the current technology levels, how can human-implantable RFID devices be used to improve convenience of lifestyle?*

I can't find any

*Are there any direct benefits or disadvantages that stem from the applications you outlined (either generally as a group, or specific to an application)? Please outline.*

[No answer given]

*Are you aware of any humans who have been implanted for the convenience purposes you outlined above? Please outline.*

No

*What sort of convenience-related applications, if any, do you believe to be outside the scope of current technology levels?*

[No answer given]

**PART D**

*Based on the current technology levels, how can human-implantable RFID devices be used for medical, therapeutic, emergency response and similar care-related purposes?*

Perhaps for identification of implanted devices

*Are there any direct benefits or disadvantages that stem from the applications you outlined (either generally as a group, or specific to an application)? Please outline.*

You can see how old and what type of device that is implanted. New batteries needed? Exchange Needed?

*Are you aware of any humans who have been implanted for the care-related purposes you outlined above? Please outline.*

No

*What sort of care-related applications, if any, do you believe to be outside the scope of current technology levels?*

[No answer given]

**PART E**

*Do you wish to make any extra comments?*

I have not any experience of this type of RFID

*Do you consent to the information you have given in the above questionnaire being published in this thesis? No identifying names will be used in the final publication.*

OK

*Thank you for your time.*

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