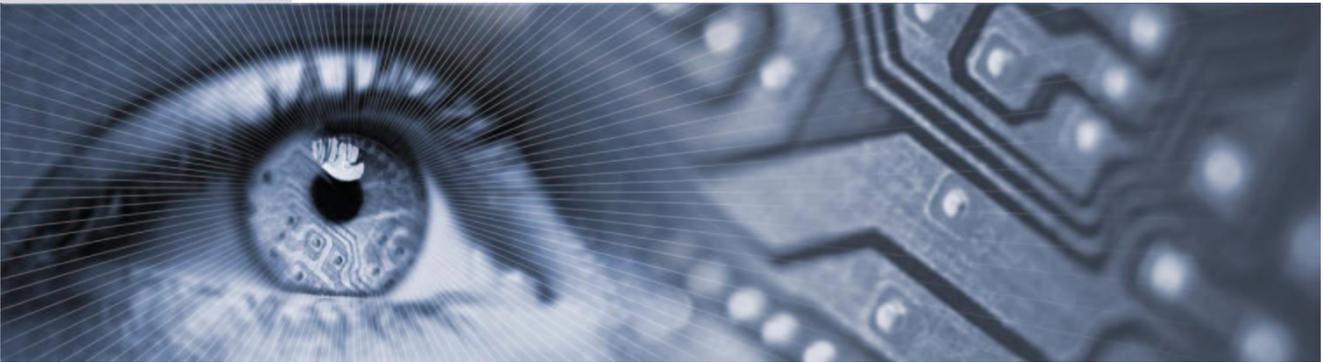


WHITE PAPER  
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Smart ticketing for mass transit

**The new global opportunity created  
by low-cost, contactless ticketing**

Innovision Research & Technology plc

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# 1 Introduction

While the advantages of smartcard-based contactless ticketing are by now well understood, the deployment of such solutions in mass transit applications has been held back by the relatively high cost of the RFID (Radio Frequency Identification) chips required. For a number of lower-value ticket types, these smartcards are too expensive, forcing public transport operators to consider the deployment of multiple technologies – a move that is widely regarded as inefficient and undesirable. In addition, some local smartcard schemes have been built using proprietary systems, creating uncertainty among transport authorities and operators about investment.

For smartcards to deliver their promise of seamless travel, reduced operating costs and improved information and planning, the transport industry needs smartcard solutions that can be rolled out economically and in a way that meets agreed international standards.

This paper sets out the current situation in smart ticketing, looks at progress in standardisation and outlines new technology developments that will dramatically alter the economics of deploying contactless ticketing solutions in mass transit applications.

## 2 Ready for take-off: the market opportunity

In the face of tight funding controls and intense competition from other methods of transport, public transport operators need to find ways of improving the customer travel experience, reducing costs and increasing revenues. Contactless smartcard-based ticketing can help the industry achieve these aims in a number of ways.

For transport operators, contactless smartcards eliminate the high maintenance costs of magnetic-stripe readers and generate data valuable for traffic management and logistics. They can also help increase revenue through the extension of operators' product ranges and by improving customer relationships, for example through more advanced customer loyalty schemes.

For transport users, contactless smartcards provide a smooth, seamless travelling experience by enabling tickets to be purchased or topped-up from one operator and used with any other operator throughout the region or country. They also provide opportunities for multi-purpose ticketing – for example, having station car park, rail travel and event entry included on one ticket – and more sophisticated loyalty/reward schemes.

As Figure 1 shows, the total available market for Limited Use transport tickets is projected to grow rapidly, from 277 million units in 2005 to 8.6 billion units in 2009 (source: *Innovision R&T/Various*).

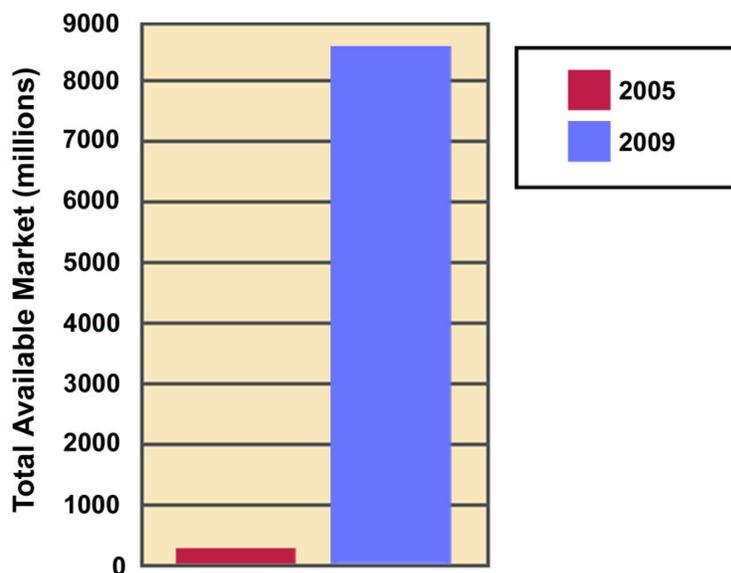


Figure 1. Growth in total available market for Limited Use transit tickets 2005–2009.

How can transport operators capitalise on the benefits of contactless smartcard technology to address this growing market?

## 2.1 Smartcard advantages

Perhaps the key benefit of contactless smartcard-based ticketing to transport operators is a significant reduction in the high maintenance costs of magnetic stripe readers. Smart media help reduce boarding times and enable valuable data to be collected for traffic management purposes, leading in turn to better allocation of resources and improved timetabling, for example. They also reduce cash handling costs and the potential for fraud.

For users, contactless smartcard-based tickets help enable a faster, smoother and more convenient travel experience. Multi-application smart tickets could enable the travel fare and entry to an event such as a concert or football match to be included on a single ticket, for example.

Many government agencies would like to see more flexible ticketing to encourage the use of public transport. Work patterns are changing – fewer and fewer people work nine to five. More sophisticated, flexible ticket types will help support these trends.

When the UK Government published its 'Transport 2010, The Ten Year Plan' paper in 2000, it recognised smartcards as an important element in improving transport infrastructure to encourage greater use of public transport. A key aim of this strategy is the development of 'seamless ticketing': the total interoperability of smartcards used by the various transport operators throughout the UK, from local buses and light-rail services to commuter and intercity train services and ferries.

## 2.2 Key challenges

There are three main challenges facing the industry in the development and deployment of contactless ticketing solutions for mass transit:

- **cost** – a DfT-sponsored business case analysis for Limited Use smartcard ticketing found that they become viable when the unit cost of the ticket medium falls below €0.25, and provided a positive return on investment when the cost of the medium falls below €0.15. The unit cost of the most widely deployed smartcards today is around €1.50. This has limited their use to high-value, multiple-use applications such as season passes and concession cards.
- **standardisation** – national and international standards are vital to the success of contactless ticketing in mass transit applications, so that local government and operators can specify and procure solutions with certainty. Standardisation efforts originally focused on high-value smartcards – only recently have revised standards for Limited Use smartcards been introduced in the UK and the USA.
- **technology** – with policies and standards falling into place, the next challenge has been for technology innovators to create workable solutions at the required price-point for mass transit applications. Driving the mass adoption of smart ticketing in transport means making low-cost, disposable smartcard tickets a viable proposition. And this requires low-cost RFID tags that can be integrated into Limited Use tickets through new production techniques, in high production volumes.

These challenges are explained in more detail in the following sections.

### 3 Bringing down the cost of smart ticketing

While current magnetic stripe-based ticketing solutions allow for low-cost paper tickets suitable for Limited Use applications in mass transit, the running costs of such systems are relatively high. For instance, the moving parts of the reader machines require regular maintenance, and the magnetic reader heads themselves need regular cleaning as magnetic deposits build up quickly in busy locations.

Contactless ticketing solutions do away with the vast majority of these maintenance costs. All that's needed to make them viable for everyday transport ticketing is for the unit cost of the tickets themselves to be brought down to an appropriate level.

The contactless ticketing schemes that have been introduced to date employ rugged, high-memory plastic smartcards that handle encrypted data. While the cost of these cards – which starts at about €1.50 – is acceptable for applications such as season tickets and concessionary passes, it is much too high for single-trip tickets, daily passes or even multi-trip carnets.

One of the first tasks of the UK's Transport Card Forum's Working Group on Low-Cost Smart Ticketing (TCF WG8) (see Section 4) was to investigate the business case for Limited Use smart cards.

Using real passenger data from its member transport operating companies, TCF WG8 was able to demonstrate a solid business case for Limited Use smartcards, albeit one that was highly sensitive to the cost of the ticket medium. The business case for the city model chosen begins to work when the medium cost of Limited Use smartcards falls below €0.25 and yields a positive return when cost of the medium falls below €0.15.

The challenge for the industry has been to develop a low-cost Limited Use smartcard-based approach that meets these strict cost criteria.

## 4 Ensuring a mass market

One of the fundamentals for the success of contactless ticketing in mass transit applications is the creation of global standards that enable volume production and economies of scale.

For smartcards to deliver their promise of seamless national travel, reduced costs and improved resource planning, the availability of standards that enable interoperability is essential, as is the expansion of these standards to cover Limited Use ticket types.

So who is involved in the decision-making process, and where are the standards being defined?

### 4.1 The decision makers

For any new ticketing solution to succeed, it requires the buy-in of every player in the supply chain, as there are new policies, processes and investments required at every stage. The key decision makers in the transport ticketing supply chain are:

- governments and national associations, who set standards and policy and enforce them through funding support
- transport operators and authorities, who specify products and select suppliers
- system integrators, who may bundle the ticketing media as part of the initial system and ensure reader compatibility
- ticket converters, who have media supply relationships with operators
- consultants, who influence operators and authorities.

It is important that these players collaborate on the development of open standards and specifications that will provide the maximum benefit to all concerned. Only if smartcard schemes are interoperable will authorities and operators be able to procure systems with certainty.

### 4.2 The standards makers

The key international standard for interoperability of proximity smartcards is **ISO 14443**, which was published by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) in 2000.

ISO 14443 has four parts, which specify physical characteristics, radio frequency interface power and signal interface, initialization and anti-collision, and transmission protocols. All four parts are required for full ISO interoperability. Two communication protocols are recognized by the ISO standard – Type A and Type B – which provide different specifications for data transmission and a few other differences.

To conform to the ISO 14443 standard, readers must be able to read both Type A and Type B cards, and cards must support *either* Type A or Type B operation. All European Mass Transit projects are ISO 14443 compatible.

However, many existing local smartcard schemes have been implemented using proprietary data structures, without the adoption of common national – or international – standards.

In the UK, the Department for Transport (DfT)-supported **Integrated Transport Smartcard Organisation (ITSO)** was set up in 1998 to establish standards for interoperable smartcard ticketing across the country's rail and bus network. Members of ITSO include the UK's regional Passenger Transport Executives (PTEs), rail and bus operators and vendors.

ITSO is designed to ensure that developing systems are interoperable through the creation and maintenance of a specification – based on relevant international standards – for secure end-to-end ticketing transactions. The UK Government has mandated that transport ticketing projects must comply with ITSO specifications in order to receive central funding.

The **Transport Card Forum (TCF)** is a UK DfT-sponsored group of experts on smartcards drawn from local government bodies, transit authorities, operators and technology companies formed to assist the implementation of the UK Government's integrated transport policies. The work of the TCF is carried out in Working Groups, which report to the DfT. **TCF Working Group 8 (WG8)** was set up in 2001 to examine the opportunities for low-cost (or disposable) smart ticketing – also known as Limited Use smart tickets.

Low-cost smartcards were not included in the original remit of ITSO. However, having demonstrated the business case for low-cost smartcards, TCF WG8 has now developed an extension to the ITSO standard for Limited Use smartcards, with a view to setting the groundwork for the three UK demonstration projects. The DfT approved the extended standard, ITSO v2.1, in March 2004.

The ITSO standard's first major operational test is now under way with the NoWcard, an initiative undertaken by a group of county councils in north-west England covering Lancashire, Blackburn with Darwen, Blackpool and Cumbria. An expansion of London's Oyster Card scheme to Limited Use smart ticketing is being considered for 2005/2006.

In addition to ITSO, ISO now has two work items under way to expand the scope of ISO14443 for Limited Use smart tickets.

## 5 Making the technology fit

Cost is the key factor influencing the viability of contactless smartcards in mass transit applications. To derive maximum functionality and commercial benefit, it also makes sense for low-cost contactless smartcard systems to work through the interface already installed for higher-value smartcard tickets and travel passes. This requires a low-cost smart solution that is easy to issue and reliable to use.

### 5.1 Getting costs down

As outlined in Section 3, the business case for mass transit contactless ticketing begins to work when the cost of Limited Use smartcards falls below €0.25 and yields a positive return when cost of the medium falls below €0.15.

To achieve this cost level, Limited Use smartcards need to be made of thin plastic, cardboard or paper, and must dispense with the on-board microprocessor and other capabilities of high-value smartcards.

Until 2004, the best-effort manufacturing cost for Limited Use smartcards of this type was around €0.35–€0.45, as shown in Figure 2.

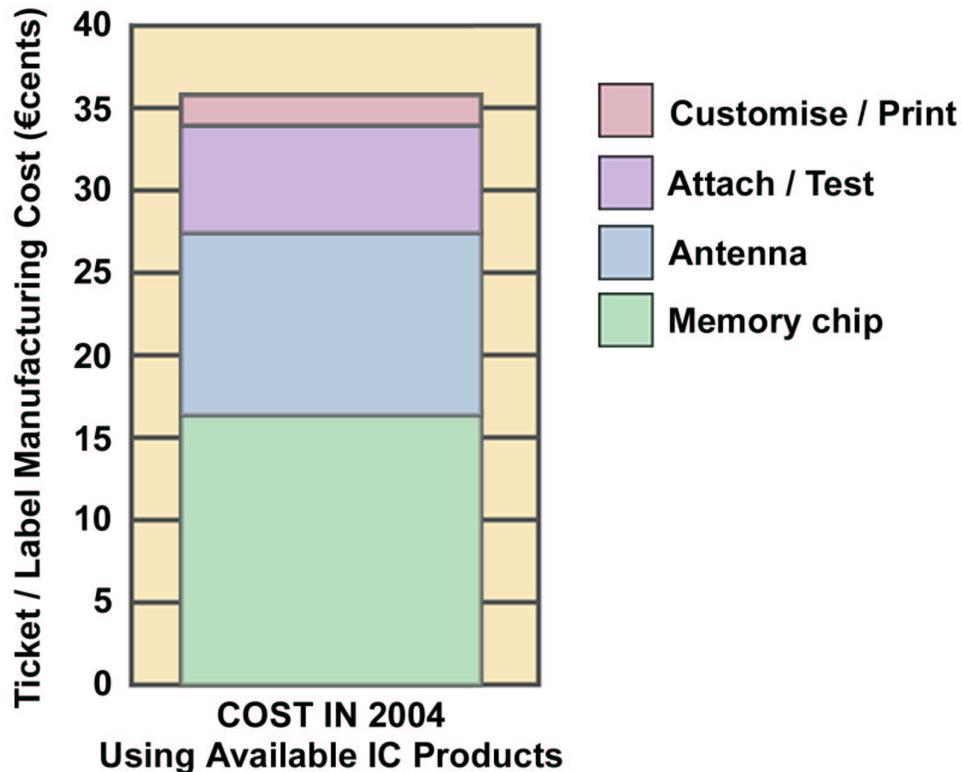


Figure 2. Best-effort manufacturing cost for RFID tickets using existing chip products.

The memory chip had been a substantial cost component in low-cost RFID tickets to this date – bringing down the cost of the chip, therefore, had a significant impact on the overall cost of the ticket.

## 5.2 Memory needs

The amount of memory needed on the smartcard varies according to the application it must fulfil. For example, a single-use ticket that only has to let someone through a turnstile may need just a single bit of memory. A one-day travel card, on the other hand, would require sufficient memory to store a serial number to allow for revenue apportionment and to store time and date validity.

For many transport applications, it is also an advantage if the chip has read/write capabilities. This enables the stored value of a ticket to be cancelled in stages, for example as each trip is taken, or as each separate product on the ticket is used.

This means that there needs to be a balance between keeping the RFID tag cost as low as possible and providing sufficient memory to handle a range of disposable ticket applications. This includes the possibility of having two ticket products on the same ticket, for example 'park-and-ride', or a bus trip with stadium entrance.

## 5.3 New chip on the block

To meet the transport industry's needs for contactless smart ticketing, Innovision R&T announced its Jewel<sup>®</sup> RFID chip in early 2004. Measuring just 0.59mm x 0.59mm and costing up to 50 per cent less than the nearest competing product, Innovision R&T believes that Jewel is the world's smallest and lowest-cost RFID chip that is compatible with ISO 14443 Type A, as well as regional standards including ITSO and RIS.

Jewel is designed to meet the criteria developed by TCF WG8, and enables the ticket manufacturing cost to be reduced to around €0.15, as illustrated in Figure 3 – enough to provide a positive return on investment in low-cost disposable ticketing applications.

The Jewel chip is a two-terminal integrated circuit designed for connection to a loop antenna to produce a passive RFID tag operating in the 13.56MHz frequency band. Its EEPROM memory is configured with 7 bytes of unique ID data, 96 bytes of user read/write data arranged in blocks of 8 bytes that can be individually locked to be read-only, and 48 bits of One-Time Programmable memory, which can be used as single-use tokens. There are also 2 bytes of fixed ROM for version identification purposes.

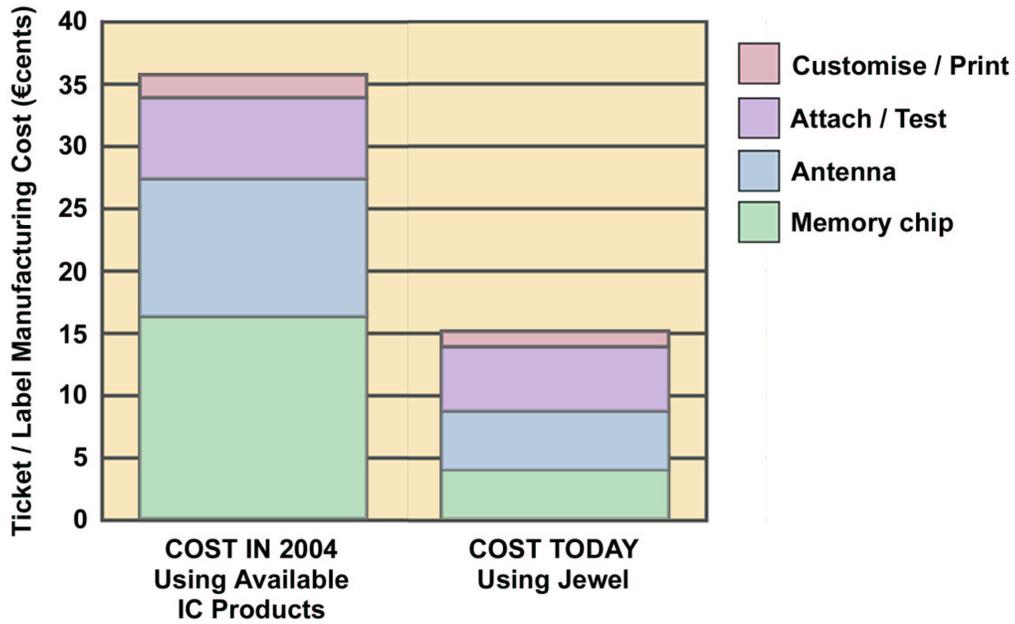


Figure 3. Manufacturing cost for RFID tickets using Jewel chip.

Interestingly, the cost-saving design of Jewel means that the memory chip is no longer the main cost element in the ticket. Ticket converters are now working to reduce the cost of converting a chip into a ticket, including printing an antenna, attaching it to the chip and encapsulating the resultant 'inlet' into a printed paper or polyester ticket. To achieve the cost targets, these steps must be done at high speed in an automated process, which requires substantial investment on the part of the companies involved.

The potential of a 'chicken and egg' situation (whereby manufacturers need volume orders to justify the investments that will reduce ticket costs and operators want to see ticket costs reduced before placing volume orders) can be averted through a step-by-step, partnership approach. This risk is further mitigated by the predicted future growth of RFID across all sectors – enabling manufacturers to amortise costs further through an increased global demand for the technology.

## 6 Summary

Smart ticketing offers the mass transit industry a significant opportunity to reduce costs, improve efficiency and enhance the travelling customer experience. Low-cost contactless ticketing will fill the gap between the current high-end smartcard-based solutions and traditional Limited Use ticketing, without the high running costs associated with magnetic stripe-based solutions.

Innovision R&T's developers have risen to the challenge of creating a technology solution that meets industry requirements for cost and standards compatibility. What's more this new solution can be deployed as a complement to existing smartcard travel schemes – making use of the already installed contactless ticketing infrastructure.

It is now up to the transport operators and authorities, system integrators and solution vendors to grasp the opportunity presented by contactless ticketing technologies. This process is being initiated through pilot trials around the world aimed at proving the commercial and passenger benefits. The first steps towards a future of totally contactless mass transit ticketing are well underway.

## 7 Glossary

DfT	Department for Transport
ISO	International Organization for Standardization
ISO 14443	ISO standard governing proximity smartcards
ITSO	Integrated Transport Smartcard Organisation
LoCoST	Low Cost Smart Technology
PTE	Passenger Transport Executive
RFID	Radio Frequency Identification
RIS	Regional Interoperability Specification
TCF	Transport Card Forum
WG8	Working Group 8 of the TCF

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