Cambridgeshire County Council
Integrated Ticketing
Feasibility Study

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Executive Summary

The Greater Cambridge City Deal Executive Board is looking to provide to its travel customers the benefits of an integrated ticketing solution in support of Intelligent Mobility. However the ticketing industry is at a juxtaposition where current solutions are nearing the end of useful life but the next generation integrated ticketing solutions are not mature or interoperable for full scale deployment.

The last 15 years has seen a steady increase in the potential for delivering integrated ticketing, yet the practical application of fully multi-modal integrated ticketing on a national basis is still several years away. The national context of integrated ticketing is still very fragmented and in this respect the Greater Cambridge area is further developed than many other parts of the UK.

Currently the UK transport sector is lagging behind the retail and banking sector in regard to flexible payment methods and adoption of contactless cards. Within the bus sector, cash still dominates with a limited deployment of smartcard schemes and an even smaller deployment pool of contactless payment methods (i.e. Transport for London). Within the rail sector the Department for Transport (DfT) is mandating that Train Operating Companies (TOC) implement smart ticketing in franchise renewals allowing for opportunities such as ITSO, bar codes and contactless payment to become feasible and more prevalent.

The Greater Cambridge area could be a pioneer for next generation integrated ticketing with its technology/reputational risks or consider a more risk free roadmap to build on existing investment and be ready for adopting mature solutions in a few years' time.
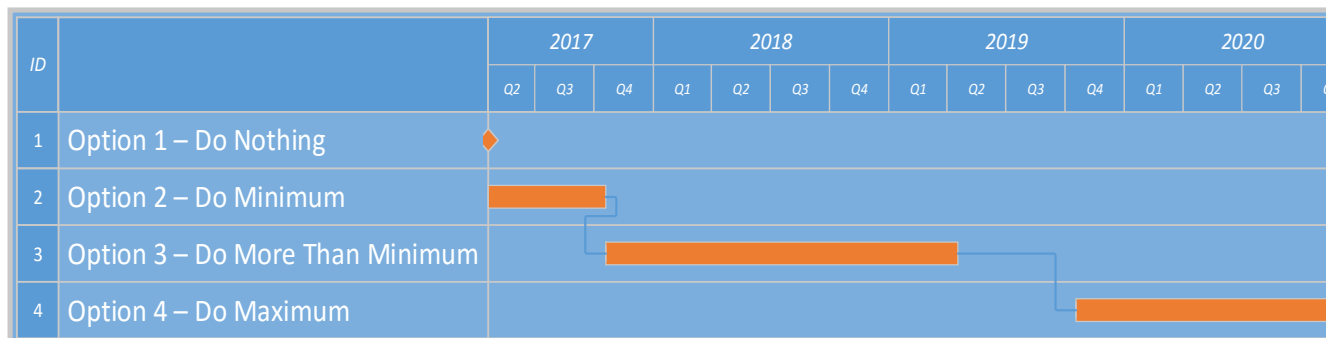
At this moment is time there are four core options summarised in the Table below:

Option	Action	Benefit	Cost	Timescale
Option 1^	Do nothing	Zero	Zero	-
Option 2	Do Minimum - further promotion of PlusBus tickets	Marginal	Low	0-6 months
Option 3	Do more than minimum - embrace forthcoming 'National Rail' smartcard and contactless payment options by others	Significant	Medium	6-24 months
Option 4+	Do Maximum - Account based ticketing	Significant	Medium	months
^ Option 1, does not support CCC's vision for Intelligent Mobility and has a high reputational risk				

+Option 4, requires work stream in 6-12 months to manage progression of Account-Based Ticketing

These options are mutually exclusive and can be delivered independently but by sequentially working through Options 2 to 4, this will introduce incremental benefits to travellers on a defined roadmap to a fully integrated ticketing solution through Option 4.

A typical timeline is illustrated below:

ID		2017			2018				2019				2020			
		Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	
1	Option 1 – Do Nothing	◆														
2	Option 2 – Do Minimum															
3	Option 3 – Do More Than Minimum															
4	Option 4 – Do Maximum															

Option 1 – Do Nothing

This achieves none of Greater Cambridge's vision towards intelligent mobility. It fails to build on the previous investment and promotion of PlusBus tickets and would likely introduce a reputational risk from travellers and residents in Greater Cambridge.

Option 2 – Do Minimum

Further promotion of PlusBus tickets – Within Greater Cambridge the PlusBus ticket offers the only multi-modal ticketing solution and despite having comparatively high uptake compared to the rest of the UK, the overall number of ticket sales is low.

Option 3 – Do more than Minimum

To be undertaken for incremental improvements:

- A National Rail branded smartcard is being developed to be utilised across Train Operating Companies (TOCs) in the South and East of England. Greater Anglia will be adopting this smartcard which provides an opportunity for a singular smartcard across rail and bus in the future.
- Contactless payment options will be available in the Greater Cambridge area by 2018, with TOCs and bus operators further developing their solutions.

Improvements made under this option will be incremental as Greater Cambridge's ticketing solutions are further developed than many other areas in the UK.

Option 4 – Do Maximum

Progress towards and implement Account-Based ticketing.

The current ticketing systems in the Greater Cambridge area are 'card centric'. This means the travel information and right to travel is stored on or in the ticket. Account-Based systems (or open loop) will allow passengers to use contactless cards, mobile phones, wearables or other identity measures to travel.

Account-Based ticketing removes the intelligence from smart cards and on street infrastructure to the back office. Whilst this provides optimum flexibility in ticketing if not managed could introduce security or revenue risk.

1 Introduction

1.1 Background

The following is an extract from the integrated ticketing brief issued on behalf of the Greater Cambridge City Deal Executive Board:

Cambridge needs to grow and there are currently plans for over 33,000 houses to be built over the next fifteen years which will see an additional 50,000 people move into Cambridge and the surrounding area. This growth presents an unprecedented challenge for Cambridge and there is an immediate need to address the pressures this will put on mobility, the Environment, Health and Social Care and the potential impacts on quality of life for residents.

Digital technology now underpins almost all aspects of modern living in every sphere across work, travel, leisure and health; and increasingly it impacts on the economic strength, sustainability and quality of life of all parts of the UK and beyond. Emerging "smart cities" technology which is set to have an even greater economic impact in the future, utilises digital connectivity, sensors and data in new and innovative ways. It will support: efficient resource management; environmental management, traffic congestion and other city management challenges and engage more directly with citizens.

In August 2015 the Greater Cambridge City Deal Executive Board approved the formation of the Smart Cambridge work stream within the overall City Deal Programme[1]

Part of this work includes investigating opportunities to move the City's transport environment towards Intelligent Mobility, including three separate studies which 'Integrated Ticketing' is one.

1.2 Purpose of Report

In principle integrated transport ticketing allows a person to make a journey that involves transfers within or between different transport modes and operators with a single ticket that is valid for the complete journey[2]. Its purpose is to encourage the use of public transport by simplifying switching between transport modes and by increasing the efficiency of the services.

In the last 15 years integrated ticketing has been made possible by the use of electronic ticketing technologies such as magnetic stripe cards and smart cards. This report will consider the current ticketing capability in the Greater Cambridge area, the barriers preventing integrated ticketing solutions being exploited and a roadmap highlighting possible future solutions. The report will focus on in-flight

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[1] *www.gccitydeal.co.uk*
[2] "Integrated Ticketing" Author Dublin Bus 2008-02-07

developments and possible developments in the transport ticketing industry over the next five years, but will also consider possible technologies beyond that.

The opportunities outlined in this report have been identified through an analysis of the following:

- Context of Ticketing in Greater Cambridge: identification of the integrated ticketing options in Greater Cambridge and plans of operators.

- Services Evolution: an overview of services that exploit or could exploit technology, trends and drivers and an assessment of their market potential.

- Technology Evolution: an analysis of ticketing technology and how it might develop to form a viable ticketing platform in the next 5 years.

- Summary & Conclusion: an outline of the timelines for developments and how the City Deal Executive Board can introduce an integrated ticketing solution.

2 Context of Ticketing in Greater Cambridge

The national context of ticketing is very fragmented with little interoperability between operators and modes of transport. In this respect the Greater Cambridge area is further developed than many other regions in the UK, where cash is still the primary source of payment for each individual journey. The national context of bus and rail ticketing as well as the advent of contactless payment facilities is discussed further in Appendixes A, B and C. The remainder of this section focuses on ticketing options within Greater Cambridge.

2.1 Ticketing Options in Greater Cambridge

Ticketing options in Greater Cambridge appears to be further developed than many other parts of the UK with various payment options available. However, there is little interoperability across operators and modes of transport. For bus and rail travel in the Greater Cambridge area there are a number of options available ranging from cash to mobile apps. For the purpose of this report the technologically feasible options for integrated ticket purchase are summarised below with the key advantages and disadvantages of further progressing these options highlighted:

PlusBus

The PlusBus ticket is already available and allows interoperable travel between rail and bus. The Rail Delivery Group (RDG) figures show that Greater Cambridge has the second highest number of sales in the Country behind Reading and the indication is that this will steadily grow with the opening of Cambridge North station. For the existing rail station, buses currently have 15% mode share compared with 43% walking, 16% cycling, 15% car and 8% taxi, with an additional 5% of passengers expected to adopt bus as their preferred method of travel upon completion of the CB1 development project. In the case of Cambridge North rail station, of the passengers who currently travel by rail and would switch to the new station, 16% would travel to the station by bus with an additional 30% of new

passengers choosing bus as their preferred method of transport to the rail station.[3] However, PlusBus is still a small percentage of overall bus ticket sales and could be further increased through advertising and promotion.

Key Advantages:

- PlusBus is already available with fares and payment channels established; and

- Marketing and promotion could be captured through existing channels e.g. Travel for Work partnership.

Key Disadvantages:

- Any increase in sales is likely to be incremental as Greater Cambridge is already achieving success in relation to UK wide sales.

Smartcard

Bus operators and Greater Anglia already have ITSO smartcards available and these solutions are widely offered to customers. Technologically, integrated ticketing on a smartcard platform between the major operators in the area is feasible. All equipment adheres to the ITSO standard and the suppliers of the on bus ticket machines for Stagecoach and GoWhippet are the same, although ticketing machine models differ between the two operators.

In addition, Greater Anglia provide ITSO smartcard options for season tickets from Cambridge into London and the same options are planned for Cambridge North rail station. Furthermore, National Rail are planning to deploy a National Rail branded smartcard which will be adopted by Train Operating Companies (TOCs) in the South and East and will replace existing TOC smartcards. This is expected to be available in the summer of 2017.

Although it is widely accepted that smartcards will not be the long term media upon which ticketing is purchased, they still have a significant role to play in the transport ticketing industry at present. This move away from smartcards is best highlighted by Transport for London's (TfL) approach to phasing out Oyster cards and moving to contactless payment options.

Key Advantages:

- The National Rail branded smartcard will operate across TOCs in the South and East and it is technologically feasible for this to be used for bus journeys and on Govia Thameslink Railway (GTR) services;

- All Greater Anglia stations will be smartcard enabled by the end of 2017; and

- All other infrastructure is in place to facilitate the National Rail branded or equivalent multi modal smartcard;

Key Disadvantages

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[3] Abellio Greater Anglia station travel plan

- This is rapidly becoming an old technology with TfL moving away from the Oyster card, so would only be a short to medium term fix;

- A card has to be issued and topped up which may be a barrier to casual travellers and tourists; and

- The National Rail branded smartcard will require bus operators to receive reconciliations from the RDG Host Operator or Processing Systems (HOPS).

Contactless

Stagecoach have committed to nationally delivering contactless payment functionality by 2018. This is being trialled in Oxford and will be deployed in Greater Cambridge within the national rollout timescales.

The UK Card Association has developed a framework for Contactless Europay, Mastercard and Visa (cEMV), which is designed to allow operators to consider whether to implement contactless payment options and allow delivery of a consistent customer experience across regions and transport modes. The framework includes three Contactless Transit Models:

- Model 1, Single Pay As You Go: cash replacement model where the contactless card or device is used at the start of the journey with a known fare; primarily for buses and trams.

- Model 2, Aggregated Pay As You Go: cash replacement model where the contactless card or device is used multiple times, and the fare is aggregated at the end of the day or journey leg; for multi-mode operators.

- Model 3, Pre-Purchase: paper ticket replacement model where a contactless card or device is associated with the ticket in advance and then used as a form of identity to travel.[4]

The Oxford trial is using Model 1 of the transit framework. Within this model the card is presented at the start of the journey and interactions continue to take place with the driver. The trial has been positively received by the media, politicians and general public[5]. There are a number of other contactless payment trials taking place on buses, but they are less developed than the Stagecoach trial. All five big bus operators (Arriva, First Group, Go-Ahead, National Express and Stagecoach) have committed to delivering contactless capability by 2022. This is a significant step as they cover over 70% of all bus services in the UK.

Greater Anglia already have a number of mobile apps available and are working with Google to investigate the possibilities for Host Card Emulation (HCE) as a method of ticket purchase. However, contactless payments are limited to £30 per transaction which does not lend itself to rail journeys where fares are often higher than this.

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[4] http://www.theukcardsassociation.org.uk/contactless_transport/index.asp

[5]

http://www.oxfordmail.co.uk/news/14813979.UPDATED__Contactless_payments_introduced_on _Oxfordshire_buses_by_Stagecoach/#comments-anchor

Key Advantages

- Stagecoach already have plans to implement contactless payment options;

- Greater Anglia are investing in mobile ticketing options;

- Growing percentage of people have contactless cards; and

- The contactless experience in London provides a baseline for how successful contactless can be, see Appendix C.

Key Disadvantages

- GoWhippet currently have no plans for contactless so investment would be required;

- There is currently no timeline for contactless ticketing on rail; and

- Transit model 1 is unlikely to reduce dwell time.

Account-Based Ticketing

Account-Based ticketing is defined by the Smartcard Alliance as "The transit fare collection system architecture that uses the back office system to apply relevant business rules, determine the fare and settle the transaction."

The big five bus operators are looking into the feasibility of a shared back office solution, with Transport for North (TfN) possibly being involved. This is at the development stage with a trial initially planned to take place by the end of 2017. This back office will be based on an 'open' architecture and will have ability to facilitate Account-Based ticketing, but it is unclear at this stage how this will work in practice.

The current ticketing systems in Greater Cambridge are 'card centric'. This means the travel information and right to travel is stored on or in their ticket. This is consistent of magstripe, paper or smartcard ticketing systems. These 'Closed-Loop' systems, where the fare media is supplied by the transport operator, provide a robust solution in which transactions are primarily stored on the card. However, due to the advances in communications technologies new 'Open-Loop' or Account-Based systems have been developed. These allow passengers to use contactless cards, mobile phones, wearables or other IDs to travel[6]. Some of the key benefits of Account-Based ticketing are as follows:

- Open payments – This allows customers the convenience of using pre-existing media, without the need to carry cash, smart cards or tickets. It is possible for this media to be used across transport modes and within other sectors e.g. retail.

- Dwell time – A move to Account-Based ticketing is anticipated to reduce dwell time at bus stops.

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[6] http://blog.masabi.com/blog/what-is-account-based-ticketing

- Improved accessibility – It reduces barriers for new passengers and tourists and improves the customer experience for regular users, which can be a key driver in growing passenger numbers.

- Lower costs – In the long term it will negate the need for expensive installation and maintenance of on street/on bus equipment.

- Intelligent Mobility – It falls in line with Greater Cambridge's aspirations for driving behaviour change and a reduction in car ownership as the Account-Based solution can potentially facilitate additional transport modes going forward such as, autonomous pods.

There are four major challenges to delivering Account-Based ticketing in the Greater Cambridge area:

1. It is essential that any solution has the buy in of transport operators from the start. Greater Cambridge sits within a de-regulated environment making it impossible to impose any ticketing regulations on transport operators, without their agreement and desire to share in the vision. Having these discussions with transport operators at an early stage will allow the City Deal Executive Board some flexibility into shaping the future of ticketing in the Greater Cambridge area;

2. There are cash risks which will need to be taken up by the Local Authority and/or transit operators. The Account-Based system adopts a post payment model as opposed to the current pre-payment model adopted in Greater Cambridge;

3. A fare structure will need to be established within the Greater Cambridge area; and

4. With an Account-Based solution there are additional costs in terms of transaction charges which need to be considered. In the case of TfL, the high volume of transactions means they have agreed similar merchant charges to that of Tesco.

As well as the Account-Based system being proposed by the big five bus operators, ITSO are carrying out some work into Account-Based ticketing and a system is currently being tendered in West Yorkshire Passenger Transport Executive (WYPTE).

Key Advantages:

- Big five bus operators already have plans to introduce a shared Account-Based back office;

- Possible on-going revenue savings;

- Enables a range of mobility innovations and helps to support Mobility-as-a-Service (MaaS);

- Improved accessibility as passengers are not reliant on one form of media;

- Relationships already in place with other Local Authorities which will likely reduce the cost of the system; and

- A modern future proofed approach to transport ticketing.

Key Disadvantages

- Fare structures which need to be agreed between operators;

- Capital costs of purchasing the system;

- Cash risks associated with a post payment model would need to be taken up by the Local Authority or transport operators; and

- Transaction charges are higher than those associated with cash

2.2 Summary

The current and future plans of transport operators in relation to integrated ticketing in the Greater Cambridge area have been summarised in the table below. These future plans of operators are expected to take place without any additional Local Authority funding.

Operator	Existing options which could facilitate integrated ticketing	Future options
Greater Anglia	• ITSO Smartcard (payments handled by RDG central back office) • Barcode ticketing • Mobile App • Mobile devices with Bluetooth Low Energy (BLE) have been trialled as a ticketing option, but a number of obstacles were identified including issues with customers switching off Bluetooth on their phones. As such this was not considered a viable option going forward.	• National Rail branded ITSO Smartcard • HCE
GoWhippet	• ITSO Smartcard	• Unknown
Stagecoach	• ITSO Smartcard • Mobile App • PlusBus	• cEMV • Account-Based Ticketing

In summary, there are a number of potential integrated ticketing advancements being made by transport operators in the Greater Cambridge area. Multiple smartcards are already available and the issue preventing multi modal, multi

operator ticketing on a smartcard platform is not considered technological but commercial. The advent of a National Rail branded smartcard for the South East rail region further enhances opportunities for an integrated smartcard solution for train and bus operators.

Looking forward significant work is being undertaken by both Train Operating Companies (TOC) and bus operators to facilitate mobile based payment technologies. Additionally in the longer term the industry is moving towards more Account-Based solutions which can potentially facilitate further transport modes e.g. autonomous pods.

3 Evolution of Ticketing Services and Technology

3.1 Services Overview

This section provides an overview of services relating to transport ticketing that are either nationally available now, or anticipated to be available for use in commercial products in the next 3-5 years.

The approach taken is as follows:

- A mind map has been produced to summarise all relevant services identified

- For each category on the mind map milestones have been identified (contained with Appendix D)

- Consideration is given to key drivers and barriers (also within Appendix D)

- A summary of the key findings has been provided.

The mind map below defines all the relevant services and following sub-sections provide a brief overview of each of each of these defined ticketing services. The transport ticketing services are detailed in Appendix D.
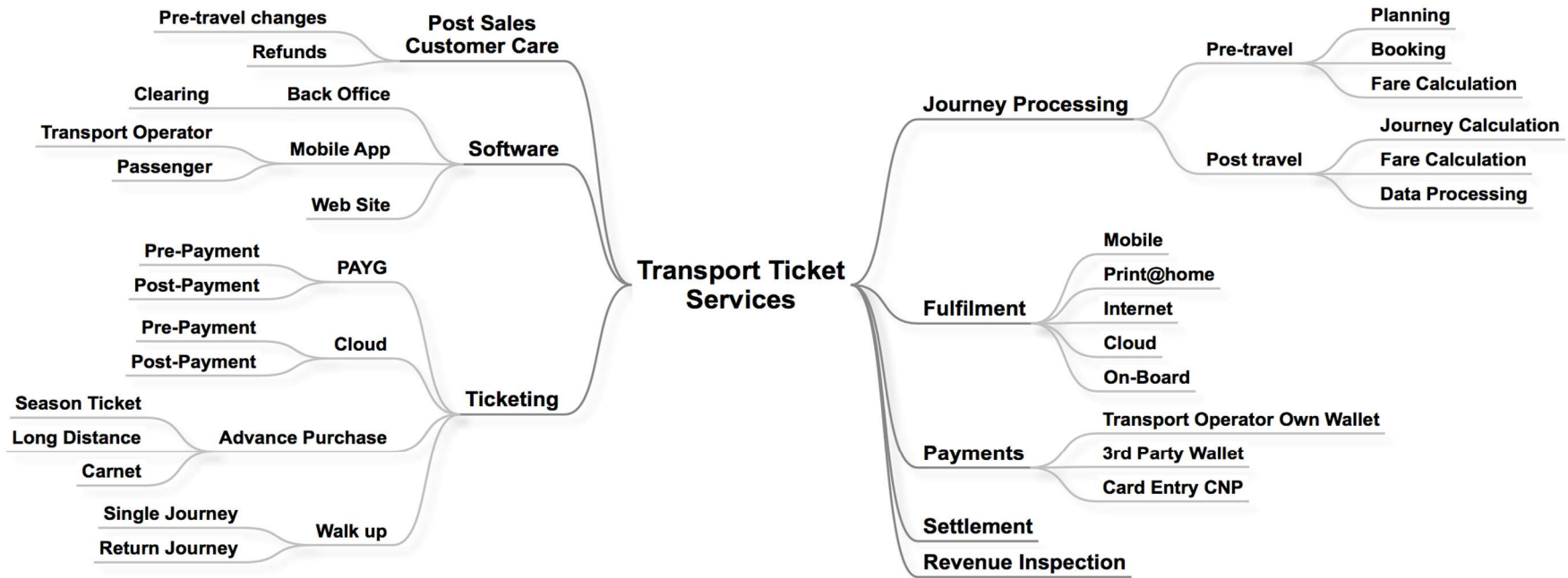

Figure 1: Mind Map of Transport Ticketing Services

3.2 Technologies Overview

This section provides an overview of technologies relating to transport ticketing that are either available now, or anticipated to be available for use in commercial products in the next 3-5 years. The approach taken is as follows:

- A mind map has been produced to summarise all relevant technologies identified.

- For each category on the mind map milestones have been identified (Appendix E).

- Consideration is given to key technical drivers and barriers (Appendix E).

- A roadmap is presented of all the technologies considered and is used to identify potential technology evolutions.

- The roadmap is used to identify the most promising combinations of technologies for further consideration in this study.

The mind map below defines all the relevant technologies and following sub-sections provide a brief overview of each of each of these defined ticketing technologies. The transport ticketing technologies are detailed in Appendix E.
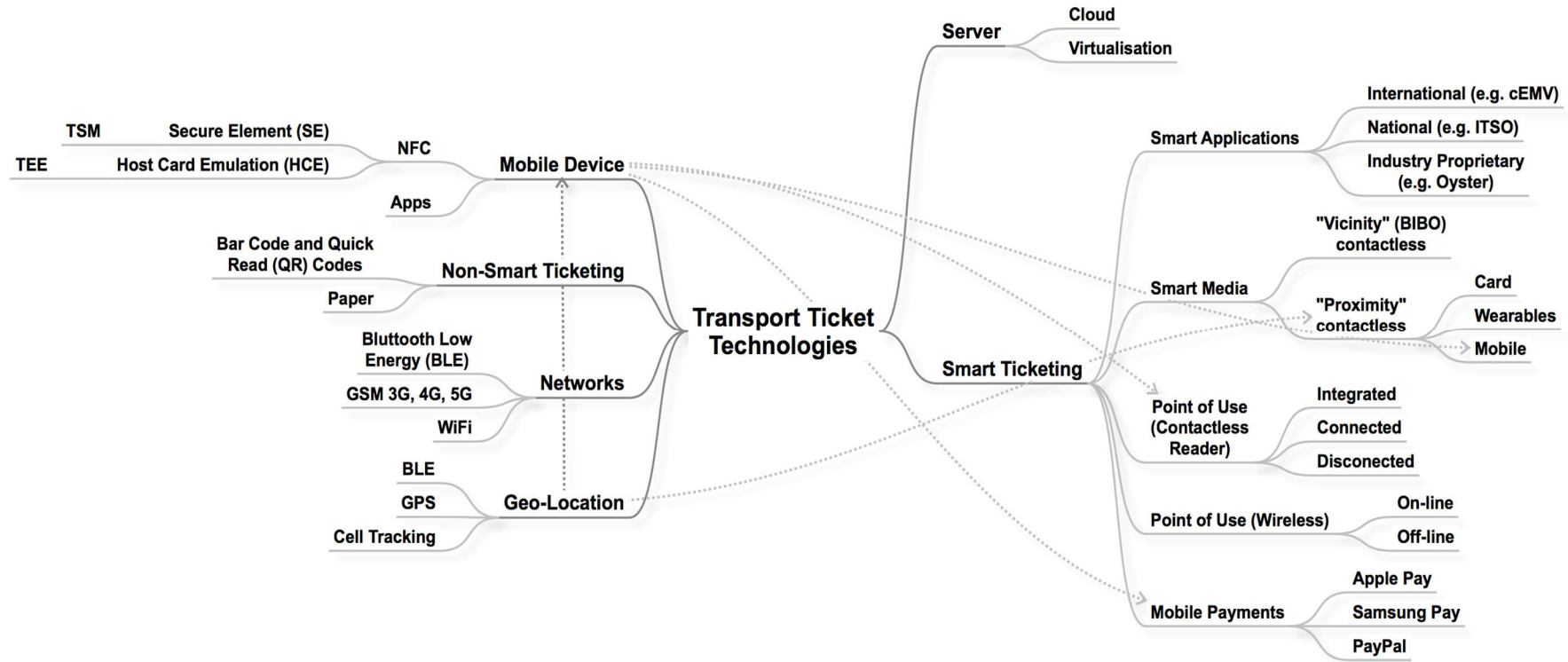

Figure 2: Mind Map of Transport Ticketing Technologies

4 Roadmap

4.1 Technology Drivers and Barriers

Technology drivers will predominantly arise from potential service opportunities and have therefore been explored in the Services section of this document. A number of potential barriers have been identified for individual technologies, but it is clear there are some common themes:

COST: Is the technology cost a barrier to exploitation?

DURABILITY: Will the technology survive everyday customer use?

INFRASTRUCTURE: To what extent can the technology interact with existing infrastructure?

PRACTICABILITY: Although it may be feasible, is it practical?

STANDARDS: To what extent can the technology be exploited using existing standards?

Standards work continues and new technologies are appearing that promise to make ticketing more flexible and therefore more appealing to customers and transport operators.

4.2 Overview

The following section shows how it is expected that the relevant technologies will evolve. This follows on from the mind maps in sections 3 (Appendix D) and 4 (Appendix E).

The following periods are represented in the roadmaps:

- Plans: up to 2 years away (2018)

- Future: up to 5 years away (2021)

- Vision: up to 10 years (2026)

Within each technology area, key milestones are shown that are described in more detail in the relevant parts of the report. Only the milestones deemed relevant to Greater Cambridge products and services are repeated on the roadmap. Account-Based ticketing is not within the roadmap as it spans across all technological areas.

It is important to note that there are disruptions in the evolution of technologies as shown in the illustration below. Each technology has a limited life of exploitation where higher productivity can be achieved with little more effort before physical limits are reached. These disruptions provide the means for unabated improvements within a technology area.

4.3   Roadmap

	Past	Plans (<2 years)	Future (<5 years)	Vision (<10+ years)
Mobile Devices	SWP SE-based, NFC stalls Android Kit Kat enables HCE Apple making NFC devices	Mobile apps primary channel for customer self-service HCE success makes NFC ubiquitous for mobile device	Greater use of wearables for payments	
Server	Cloud technology mainstream	Higher bandwidth drives uptake of cloud technology Virtualisation software in common use by enterprises driven by efficiency savings		
Displays	Smart cards have no display unless at reader Touch screens double as input devices Mobile displays not reliable enough for barcodes	Mobile displays not improve for barcodes NFC Mobile devices display smart product info	Rugged hi-res displays in all mobile devices	
Network	iBeacons used in Apple stores 3G on all UK mobile nets Wifi on buses, trains and in TfL tube stations PayPal BLE trials	4G (greater bandwidth) Multipass BLE trials Wifi across cities Apple Pay used in Transit	Wifi almost everywhere 5G (even greater bandwidth	
	2014	2016	2018	2021 2026+

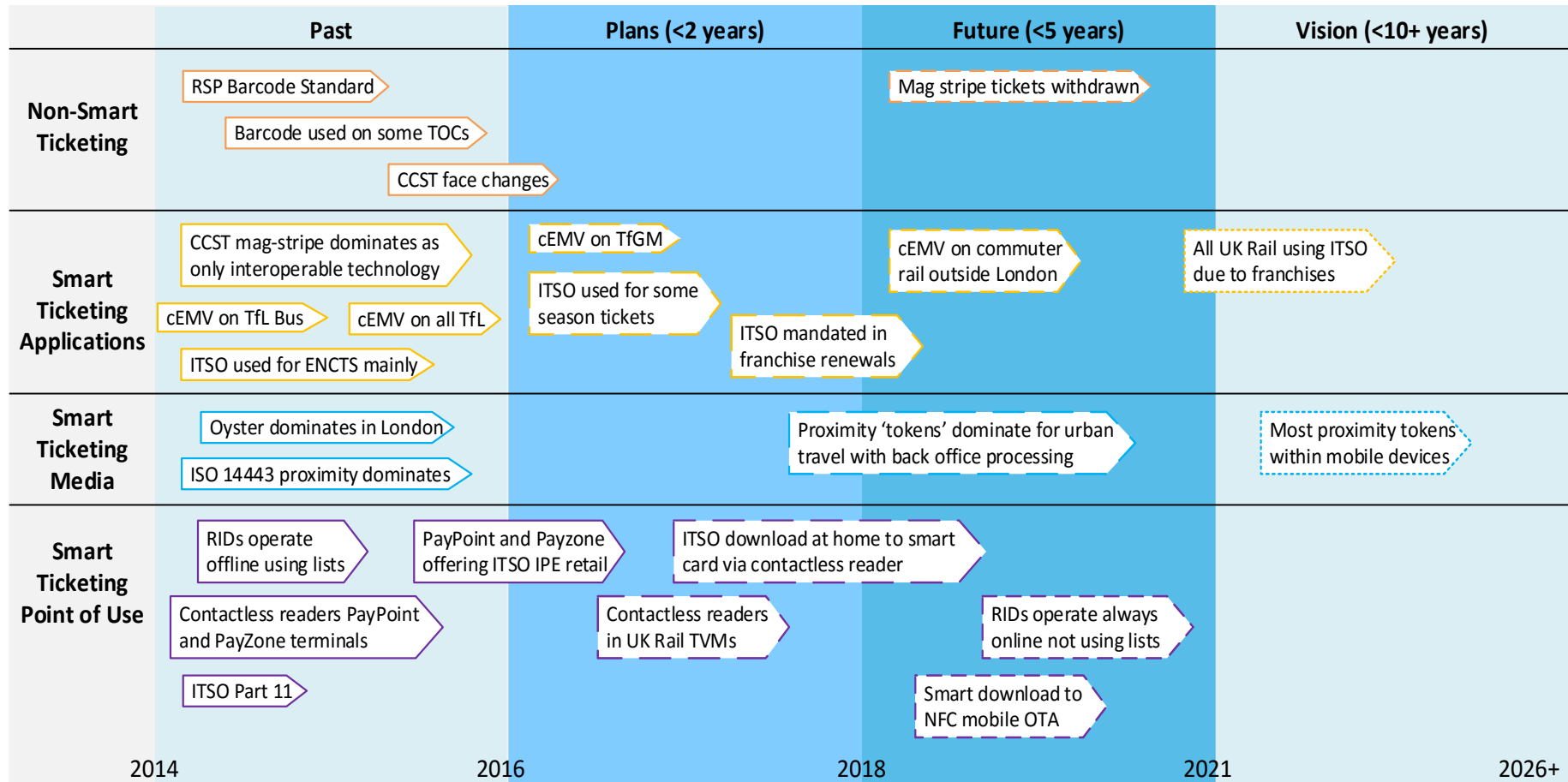|	Past	Plans (<2 years)	Future (<5 years)	Vision (<10+ years)
Non-Smart Ticketing	RSP Barcode Standard Barcode used on some TOCs CCST face changes		Mag stripe tickets withdrawn	
Smart Ticketing Applications	CCST mag-stripe dominates as only interoperable technology cEMV on TfL Bus / cEMV on all TfL ITSO used for ENCTS mainly	cEMV on TfGM ITSO used for some season tickets ITSO mandated in franchise renewals	cEMV on commuter rail outside London	All UK Rail using ITSO due to franchises
Smart Ticketing Media	Oyster dominates in London ISO 14443 proximity dominates		Proximity 'tokens' dominate for urban travel with back office processing	Most proximity tokens within mobile devices
Smart Ticketing Point of Use	RIDs operate offline using lists Contactless readers PayPoint and PayZone terminals ITSO Part 11	PayPoint and Payzone offering ITSO IPE retail Contactless readers in UK Rail TVMs	ITSO download at home to smart card via contactless reader RIDs operate always online not using lists Smart download to NFC mobile OTA	

| 2014 | 2016 | 2018 | 2021 | 2026+ |

Figure 3: Technology Roadmap

5   Summary and Conclusion

It should be recognised that in the medium term there will be no single technological solution which can be applicable to the Greater Cambridge area. Multiple solutions will need to exist side by side with all the complexity that it entails. Contactless, NFC and wearables are likely to be one form of ticket purchase, but there will be patrons who will want to top up smart cards or pay/show ticket validation through another form of media. Accessibility needs to be maintained for all patrons, indeed TfL which sits in a fully regulated environment supports magstripe, Oyster, Bank Cards, Apple Pay and even cash at TVMs.

The options available to the City Deal Executive Board have been summarised below:

Option 1 – Do Nothing

There are a number of technological developments taking place in the industry and the City Deal Executive Board may choose to allow developments to evolve on their own accord. This option involves zero additional cost, but it does not address any of the current concerns and does nothing to improve customer satisfaction in Greater Cambridge. There are significant reputational risks associated with this option.

Option 2 – Do Minimal (Marketing of PlusBus)

The Greater Cambridge area has a number of bus and rail ticketing solutions available identified under section 2, with the PlusBus ticket being the only multi modal ticket currently available. Although take up in comparison to the rest of the UK is good, PlusBus forms a small number of the bus and rail operators overall ticket sales. Surveys suggest take up of PlusBus will increase in the future especially with the completion of Cambridge North rail station. However, the number of PlusBus tickets consists of a small number of overall journeys on the bus and rail network, it is recommended that PlusBus is further marketed and advertised with suitable measures in place to monitor the marketing campaigns success.

Option 3 – Do more than Minimum for Incremental Improvements

Option 3.1 ITSO Smartcard

ITSO is being mandated in rail franchise renewals and Greater Anglia are already providing ITSO functionality for season tickets between Cambridge and London. The possibility of a new National Rail branded ITSO Smartcard being deployed across the bus and rail network should be explored. If both systems (bus and rail) adhere to the ITSO standard there will be no technological obstacles preventing integrated ticketing between bus and rail for those specific routes where it is operational. This should be facilitated and considered in the short to medium term.

Option 3.2 Contactless Payments

The technology roadmap has highlighted a number of technologies/potential technologies which could feasibly be used in the Greater Cambridge area over the next five years. Of these technologies contactless payment technologies are already

proving to be successful in other sectors and bus and rail operators have commercial plans to exploit this. Stagecoach has already committed to nationally delivering a contactless payment option by 2018 and Greater Anglia are working with Google to assess possibilities for HCE. Aiding the deployment of contactless payment methods should be considered in the short to medium term.

Option 4 – Do Maximum – Move towards Account-Based Ticketing

Considering the proposals of the big five bus operators for a single back office solution it is recommended that the City Deal Executive Board engages with bus operators and awaits the outcome of a possible combined back office trial in 2017, which the big five bus operators are currently proposing. Account-Based ticketing in the Greater Cambridge area should be considered a viable medium to long term objective.

The City Deal Executive Board may explore the potential of cross boundary integrated ticketing with neighbouring authorities, as this will provide more 'bargaining power' to reduce additional costs associated with transaction charges. Relationships already exist with five Local Authorities through the Real Time Passenger Information (RTPI) consortium and these authorities could be approached in the first instance. Additionally, Greater Cambridge (and consortium) could investigate purchasing the service from TfL or the combined operator/TfN service, which may provide savings in terms of capital expenditure.

Conclusion

This report recommends that to provide an integrated ticketing solution which fits within the wider aspirations for a seamless end to end journey within the Greater Cambridge area, the City Deal Executive Board should adopt a strategy which delivers outcomes in the short and medium term and works towards an Account-Based ticketing solution (option 4) in the long term. Account-Based ticketing solutions are not yet market ready in the UK and it is not suggested that Greater Cambridge develops their own back office as the cost of this is likely to outweigh the benefits of delivering Account-Based ticketing. As such, it is recommended that the City Deal Executive Board implement plans which work towards providing an Account-Based ticketing solution.

Option 1 is not considered a viable option so in the short term utilising options which are readily available should be considered. Option 2 and ways of promoting the use of PlusBus provides an immediate opportunity to do this.

The imminent arrival of a National Rail branded ITSO smartcard and on-bus contactless payment options opens opportunities for the City Deal Executive Board to help deliver an integrated ticketing solution (option 3). The benefits of these solutions are likely to be incremental given that Greater Cambridge already has a number of ticketing options available, however technologically they are feasible and would provide a robust short to medium term solution.

Appendices

Appendix A

Key Trends in UK Bus Ticketing

This section of the report considers some of the key trends within the UK Bus Ticketing Industry:

- Technical interoperability of ITSO cards, readers and products works well

- Many operators have implemented the "low hanging fruit" of interoperable weekly/monthly season tickets, but very few (Avon Day Rider, get me there (TfGM)) offer interoperable day tickets, which would offer most benefits to occasional travellers

- There is a surprisingly low number of people using commercial ITSO cards

- The vision of travelling across the UK with one card is still just a vision, but it is possible this will be achieved in Scotland

- Lack of attractive products and effort of purchase may be inhibitors

- The problem of "no change" has been quoted in Transport Focus as a barrier to travel, the purchase of a day pass on bus doesn't solve this issue

- Acceptance of cards, purchase locations and products varies widely from city to city

- Implementation decisions may make sense locally, but not always from the point of view of an integrated national solution

- Cash still dominates, with long dwell times, even on services offering discount for card or app

- PayPoint and PayZone offerings are not consistent across regions or even across cities.

- Many journeys made by card, paper pass and app are not recorded. They are only used as flash passes which results in a loss of data.

- Non-ITSO card schemes appear to work fast and well (starcard, Wessex, citysmart, Edinburgh)

- Only Leeds is currently using contactless Europay, Mastercard and Visa EMV (cEMV) with a retail model implementation[7]. This is discussed further in section 4.

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[7] Information provided from UK smart Transport – Mystery Shopper Project, September - December 2016

Appendix B

Key Trends in UK Rail Ticketing

The UK rail ticketing market is undergoing a significant period of change. The DfT is mandating that Train Operating Companies (TOC) implement smart ticketing in the franchise renewals, bar codes are becoming more prevalent and cEMV is being trialled on urban and commuter rail.

Several trends are beginning to appear:

- Mobile applications to plan journeys and book tickets which are usually fulfilled via barcodes due to non-availability of other technologies.

- Print Your Own (PYO) tickets which remove the need to visit a station and queue for an unknown amount of time to collect Advance Purchase tickets.

- Greater use of self-service ticket machines as a means of TOC reducing costs.

- More back office processing as e-tickets move away from card-based products to account based.

- Wider sales and distribution channels making it easier to buy tickets without having to visit a station. The Office of Rail and Road (ORR) has published a review of ticket sales and distribution in October 2016.[8]

- As fares have increased significantly over the last five years passengers are looking to advanced purchase tickets via mobile and online to save money.

In the Fares and Ticketing Review[9] there are several areas that the Department for Transport (DfT) are keen to address that will set a new direction for the industry and influence future trends:

- Offering widespread access to facilities for buying a wide range of tickets, through a choice of channels/providers, without compromising service quality;

- Providing the information passengers need to confidently choose the best ticket for their journey, and to understand the terms, conditions and any restrictions on the ticket they buy;

- Allowing them to get help and advice from a trained representative (where they cannot do so now);

- Being adaptive to modern needs and uses of modern technology to offer flexibility, convenience and minimal complexity; and

- Offering high levels of customer service and being accessible to all.

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[8] The Office of Rail and Road 2016
http://orr.gov.uk/__data/assets/pdf_file/0003/22935/retail-market-review-conclusions-october-2016.pdf
[9] Department for Transport 2016
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/249001/fares-ticketing-next-steps.pdf

Appendix C

Contactless Payment

This section considers the impact of contactless payment in the UK and the likely impact this will have on transport networks.

The popularity of contactless payments is continuing to grow across the UK. Total contactless spending in 2015 was more than double the preceding seven years combined, reaching £7.75bn. By the end of the year, one in every eight card payments was contactless.

Contactless technology comes in several forms, including bank cards, smartphones and wearables such as wristbands (which host a re-loadable prepaid card chip).

Since the introduction of contactless in 2007, the number of contactless cards has grown exponentially, with the number of new cards issued in 2015 growing by 37% to 79 million, accounting for 49% of debit, credit and charge cards. The number of contactless debit cards rose to 55 million, accounting for 56% of the total number of debit cards[10]. Contactless credit and charge cards amounted to £24 million, accounting for 38% of the total number of credit and charge cards.

Significant events driving the momentum included strong growth in usage on the Transport for London (TfL) network, consistently representing 11% of all contactless payments throughout the year.[11]
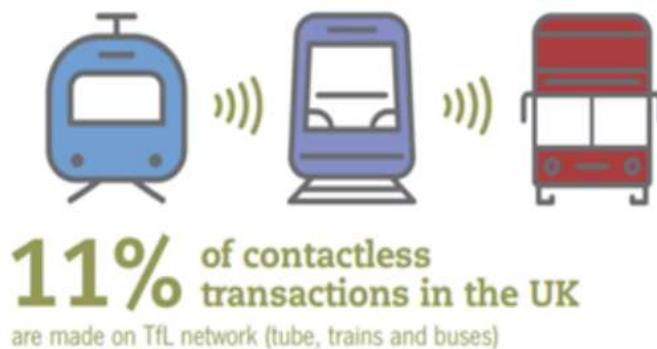
Source: The UK Card Association

The strong growth in contactless payment is expected to rise in 2017 with an increase in mobile wallets utilising Near Field Communication (NFC) technology. All the major players in the mobile device industry will have delivered their own version of the mobile wallet (e.g. Apple Pay, Android Pay, Samsung Pay), with Apple Pay alone reporting a growth of one million new users globally per week. This is likely to have a major impact on ticketing services in the UK, with no ITSO standard in place for contactless, Host Operator or Processing Systems (HOPS) are likely to evolve to facilitate account based ticketing. This is highlighted by Stagecoach in Oxford who have delivered the first on bus contactless payment facilities in the UK, outside of London.

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[10] The UK Card Association 2016, available from:
http://www.theukcardsassociation.org.uk/wm_documents/UK%20Card%20Payment%20Summary%202016%20FINAL.pdf
[11]

http://www.theukcardsassociation.org.uk/wm_documents/UK%20Card%20Payment%20Summary%202016%20FINAL.pdf

Appendix D

Ticketing Service

Service - Walk Up

Description - Tickets are bought just before the journey, either on the bus or in a railway station.

Discussion/Milestones

- Customers don't like queuing at ticket machines when in a hurry (unknown waiting time)

- Some buses still require exact fare and offer no change

- ITSO is used on bus for concessionary travel and some paid for travel

- Retail payment technologies, such as cEMV payment cards, are becoming common in public transport.

Drivers/Barriers

- Sometimes difficult to get the best value ticket for the journey

- Boarding times can be slow on buses if cash payments are made.

Service - Advance Purchase

Description - Advance purchase tickets can be bought several weeks in advance of the journey at significant cost reduction. This is typically used for yield management.

Different journey types require different ticket types:

- Long distance, high value, infrequent journey

- A regular commuter may buy all of their travel in one go via a time limited season ticket

- Frequent travellers may use a carnet of tickets purchased in advance.

Discussion/Milestones

- Problems exist when travelling across TOCs operating regions as well as across London due to non-interoperable ticketing technologies

- DfT plan to remove magnetic stripe tickets, although no date has been set.

Drivers/Barriers

- DfT Rail Fares and Ticketing Strategy [DFT_RFT] proposes to improve ways in which tickets can be purchased and distributed

- Bus companies are limited in the ways they can offer integrated fares

- Bus operators are discussing the introduction of cEMV which may pave the way to account based solutions.

Service - Cloud

Description – Dematerialisation of ticket which is stored in a central system. The passenger has a token to identify to the system that they have a valid ticket to travel.

Discussion/Milestones

- It may be possible to simplify long distance rail travel with cEMV and ticket bought in advance. cEMV card would then become the token to access the system

- Could be used for period travel

- Cards UK are working to develop a model for implementation.

Drivers/Barriers

- It moves sales of rail tickets away from stations

- Withdrawal of magnetic stripe tickets by DfT

- Allows passengers to choose their own token

- Complexity and risk apportionment being discussed with payment card networks.

Service – Pay-As-You-Go (PAYG)

Description – PAYG, which may be used in a more urban environment for short commuter type journeys. There are two ways in which this can be implemented:

- Pre-paid - stored travel rights are held on a card which is used for travel. E.g. Oyster, Octopus

- Post Paid - a card is used to identify the customer as being able to pay and payment is made via an account after travel. E.g. TfL Future Ticketing Programme (FTP), Utah Transit Authority (UTA) Salt Lake City.

Discussion/Milestones

- Oyster has led the way in the UK in this area

- Successful implementation in Holland on rail network

- Risks associated with Post Pay PAYG under discussion

- Cards UK developing model.

Drivers/Barriers

- E-Money regulations restrict value that can be stored on card

- Not necessarily suited to long distance rail due to the high cost of tickets in UK

- Better suited to urban bus, rail and tram networks.

Fulfilment Service

Service – Print Your Own (PYO)

Description – There is a move away from @counter approach to delivering tickets with customers being able to print out tickets at home (or work) with bar code technology.

Discussion/Milestones

- Has proved popular as it removes the need to go to the station to collect ticket

- Rail Settlement Plan (RSP) has produced standards for bar codes in rail

- Limited use to date on bus

Drivers/Barriers

- Bar codes will not be accepted in London by TfL for cross London travel

- TfL 'Through London' agreement might need reviewing in light of new technology.

Service – Ticket Vending Machine (TVM)

Description – TVMs allow for Ticket on Departure products to be fulfilled or traditional magnetic stripe tickets to be purchased.

Discussion/Milestones

- Passengers feel TVMs don't always offer best value tickets

- TVMs are mainly used in the Rail network

- Can result in queuing for tickets at peak hours if insufficient TVMs to meet demand.

Drivers/Barriers

- Moving away from station centric approach can reduce costs and make ticket purchase more convenient.

Service – @Internet

Description – The internet allows for a range of e-ticket products to be fulfilled, either through card readers connected to a PC or direct to mobile devices.

Discussion/Milestones

- Mobile devices would provide quicker means of distributing tickets at lower cost than TVMs or @counter

- Mobile barcodes have had some success in rail and on bus

- 2014: PayPoint/PayZone start ITSO seasons at newsagents etc.

Drivers/Barriers

- Improved convenience of a mobile solution could stimulate walk up market sales

- ORR market review identified option for 3rd parties to sell season tickets. RDG is undertaking trials.

Service – @Cloud (Ticketless Tokens)

Description – This is a means of letting the passenger have a token that identifies them to the system as having a ticket product in the cloud and the ticket is dematerialised. The token becomes necessary for revenue inspection or for accessing gate lines.

Discussion/Milestones

- The customer could use something that they already have that may be registered with the transport operator, or not, dependent upon the model implemented

- A whole new range of products could be implemented and tickets in their current form could disappear.

Drivers/Barriers

- The user may need to always be connected to the internet

- As tickets disappear into the cloud, end-to-end bundling services emerge allowing 3rd-party vendors to sell packages of tickets across the user journey from home to the events being attended.

Journey Processing Service

Service – Pre-Travel

Description – By this, we mean the traditional model for selling tickets prior to travel. In this case, processing includes:

- Journey planning
- Journey booking

Discussion/Milestones

The traditional sequence is:

- Planning
- Booking
- Payment
- Fulfilment

- Settlement

- Post-sales care

Drivers/Barriers

- Journey price is traditionally always an input; it varies with time of day and the route chosen

- Market review by ORR [2016] to consider whether tickets sales are efficient, identified areas for improvement

- End of 2014: DfT Code of Practice on provision of ticketing information at point of sale introduced to ensure passengers can confidently select the most appropriate ticket for journey.

Service – Post-Travel

Description – In this model tickets are not sold before travel and the cost needs to be calculated once the journey is completed and billed afterwards. In this case, processing includes:

- Journey calculation (based information about the legs)

- Fare calculation (based on the journey and whatever rates and capping might apply).

Discussion/Milestones

- Oyster PAYG on some rail since 2004 (balance on the card)

- Oyster PAYG on all 'London' rail since 2010 (balance on the card). TfL settles with the Train Operating Companies (TOC) later

- 2014: TfL launched cEMV distance-based model on London rail.

Drivers/Barriers

- Stations must be gated in order to be sure of passengers tapping in and tapping out

- The risk model requires being able to charge the maximum fare if passengers do not both Tap-in and Tap-out

- More difficult on bus unless there is a Tap-in Tap-out system.

Settlement Service

Service – Traditional Settlement

Description – The process of exchanging the travel service provided by the operators for money once a transaction has been executed. If a journey has multiple legs, then settlement might also involve apportionment of payment between the relevant operators.

Discussion/Milestones

- Operators may want to use their own acquirer where possible.

Drivers/Barriers

- RDG systems were designed some time ago. Making changes for current requirements can be expensive (e.g. Payment Card Industry Data Security Standards (PCI DSS))

- RDG only handles amounts in GBP and Euro. It cannot handle PayPal or other currencies which is a potential barrier to international transactions, should they be needed

- No equivalent to RDG clearing exists in the bus sector so each operator will need to develop their own.

Service – Settlement under cEMV Transit Model

Description – Under this new model, the cost of the journey is not known until it has been completed (customer taps in and out). The back office processes the taps, determines the journey taken, charges the customer's bank and then settles the funds between the relevant transport operators. TfL runs such a back office, with a similar back office delivered in Oxfordshire.

Discussion/Milestones

- It took TfL many months to negotiate with the TOCs to accept the change to this model. TfL readers are installed and the TOCs do not see the transactions.

Drivers/Barriers

- Operators outside London might wish to use their own acquirers, so this might be a barrier to TfL offering this service outside of London

- PCI DSS can be a significant cost barrier to any systems processing or storing cardholder data

- TfL Transit model assumes the risk is limited to a maximum journey of £8.

Post Sales Customer Care

Service – Pre-Travel Changes

Description – Customers may want to make changes after they have bought the ticket. This could include:

- Changing journey details, date time etc.

- Cancel ticket and request refund

- Change fulfilment type.

Discussion/Milestones

- If the process is simple and efficient for customers it could drive sales

- Mobile apps may help deliver this service better.

Drivers/Barriers

- Access to systems needs to be quick and easy.

Service – Refunds

Description – Customers may request refunds once they have bought the ticket in the following situations:

- They will not make the journey

- There was a service disruption and they are seeking compensation

- Changed mind about travelling either before or after planned time.

Discussion/Milestones

- Customers need to know whether they should speak to the issuer of the ticket or the transport operator regarding refund for tickets.

Drivers/Barriers

- Possibility exists for fraud if revenue inspection is not robust.

Revenue Inspection

Service – Revenue Inspection

Description – It is important that transport operators are able to manage the level of fraud on their networks to protect their revenue. Currently the key piece of technology is the biro, which is used to mark each paper ticket to prevent re-use or refund after use. With smart or bar code tickets this approach is not possible. New methods have to be developed to manage the revenue risk.

Several fraud types are possible including:

- No ticket purchase

- Fake ticket

- Cloned ticket

- Ticket touts collecting non-expired tickets and re-selling.

Discussion/Milestones

- Inconsistent approaches to Revenue Inspection between operators (e.g. ITSO seal is currently not validated by TfL handheld readers)

- In London, the move to Oyster removed much fraud 'overnight'

- For smart, the trend is away from hotlists held at all readers and Revenue Inspection Devices (RIDs), to holding the information

online while ensuring that fast connections are available (e.g. TfL looking at not holding deny list on rail gates)

- Bar code centralised checking has been introduced.

Drivers/Barriers

- TOC revenue inspection policy is driven by cost. Scheduled trains run anyway, so it may not be cost-effective to spot all fraud.

- Fragmentation of technologies means that RIDs need to be complex

- The true level of fraud is not known in some cases.

Payments Service

Service – Card Entry Card Not Present (CNP)

Description – A payment card transaction made where the customer is not physically present with the card at the time that the payment is affected. Card details have to be entered as evidence of having the card. Since the merchant cannot be sure that the customer has the card or is the cardholder, this is a major route to fraud.

Discussion/Milestones

- This has been the conventional way of paying remotely for goods and services since before the internet was available

- Introduction of the card 'security code' as some evidence that the customer is present

- Introduction of PCI DSS rules about securing and storing cardholder data

- Instant card issuance might be possible on mobile devices

- UK losses increased by 18% in 2015 over 2014, which equates to £88.5 million of losses. Some 75% (£66.7 million) of that increase was in CNP fraud and £42.4 million was down to e-commerce. Putting it simply, half of the UK increase in fraud is down to the growth in online spend and the digital revolution, as criminals exploit personal and payment details that are retained by an ever increasing connected business landscape.[12]

Drivers/Barriers

- The need to make purchases remotely drove CNP

- Entry of card details (especially the long card number) is cumbersome and error-prone, especially on mobile devices. 'card on file' can help with this

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[12] www.fico.com/europeanfraud

- Continued increase in CNP fraud

- Card issuance process can be slow due to fraud checks

- Rail retailing has not kept pace with other retailing and is currently stuck mostly with CNP payments or walk up payments.

Service – Third Party Digital Wallet

Description – Typically a digital wallet is a container for payment card numbers that gives the merchant an identifier (surrogate card number) and submits the payment transaction on behalf of the merchant. Digital wallets can be used from any online client device (e.g. Internet PC, or mobile device) providing the user with instant access to their pre-registered payment mechanisms. Some digital wallets can also contain bank account numbers or direct debit instructions that allow payments directly from bank accounts.

Discussion/Milestones

- PayPal is the most well-known digital wallet provider. June 2013: PayPal mobile digital wallet for online and in-person payments in store

- 2013: Visa and MasterCard launched a mobile wallet called V.me and MasterPass for online purchases

- 2015: The Zapp service from the Vocalink JV uses bank accounts and Faster Payments Service (FPS) in place of cards and is expected to integrate into the digital wallets of participating banks. There are already five UK banks signed up

- 2015: Apple Pay was launched in the UK. Samsung Pay and Android Pay to be launched in 2017.

Drivers/Barriers

- A barrier at present is the number of merchants accepting the new payment methods

- Passengers tell DfT and Passenger Focus that how they buy their ticket is a factor as well as cost. They want quick, easy, convenient, clear and straightforward purchases

- 3rd-party digital wallets maybe more expensive for merchants and have less favourable terms than Card Entry CNP. Direct to bank account payments may be more competitive.

Service – Merchant Digital Wallet

Description – Some merchants are issuing their own wallets motivated by providing customers with easy ways to pay. Again these can be used from any online device. The trend is toward offering customer-centric services such as relevant offers (location based) and receipts.

Discussion/Milestones

- CNP can be offered in a mobile wallet by having the card on file and perhaps requiring a PIN and a device ID to authorise

- For regular customers, where the merchant is prepared to accept credit risk, deferred payment using Direct Debit or other credit line can be used

- Integration with FPS using generated reference numbers may significantly reduce payment processing cost for specific users.

Drivers/Barriers

- As above, passengers want speed and convenience

- It enables merchants to encourage the use of the best (cheapest and most favourable terms) payment types for the best (regular or large spending) customers

- EMV Tokenisation has the potential to standardise the generation of account tokens for all card issuers, such that card on file and PCI costs are significantly reduced. This could reduce the need for 3rd-party wallets.

Software Services

Service – Back Office

Description – Functions include:

- Fares calculation including capping

- Journey calculation

- Settlement with operators

- Customer accounts

- PAYG accounts

- Management of the reader estate

Discussion/Milestones

- The back office functions are increasing in number and are becoming more complex because the back office can be more flexible than a front end card or reader can.

Drivers/Barriers

- The move to e-ticketing comes with a shift to more being done in the back office

- PCI DSS approvals can be a major hurdle if handling EMV cardholder data

- Back-office services can be re-sold to operators in UK or abroad.

Service – Website

Description – Web sites are used for:

- Customer care

- Booking journeys (Tickets, seat reservations)

- Journey planning

Discussion/Milestones

- HTML5 allows web sites through responsive design to sense client screen size and capabilities and serve up appropriate content and format

- CNP and PayPal commonly integrated for payments.

Drivers/Barriers

- Efficiency savings and customer convenience are driving interactions online where possible. Website and apps are replacing ticket offices and National Rail Enquiries

- HTML5 might remove the need for native mobile apps.

Service – Consumer Mobile App

Description – Merchants are providing mobile apps for customers to reduce the friction in their purchases and a more customer-centric experience.

Discussion/Milestones

- New payment instrument integrated with merchant apps

- More customer-centric services.

Drivers/Barriers

- Security is an issue. No assumptions can be made about the mobile platform being secure.

- Lack of standardisation at the mobile level means that most apps are separately developed for each operating system (iOS, Android; Blackberry; Windows).

- The mobile apps are used for journey planning but do not often result in ticket sales via the app. Fragmented fulfilment is a barrier.

- Host Card Emulation (HCE) could allow fulfilment of smart tickets to NFC mobile devices.

- UK Government drive towards Open Data together with Smart Cities could mean that many more open APIs allow 3rd-party apps to provide a more customer-centric experience.

Service – Vendor App

Description – Vendors can use tablets as a convenient mobile Point of Sale (mPOS) that can be easily carried around their sales locations (e.g. on rail platforms for queue busting).

Discussion/Milestones

- Tablets with NFC and barcode reading capability could be used for vending smart tickets to cards or NFC phones as well as barcode tickets to phone

- Targeting of offers and loyalty schemes to specific consumers based on their mobile device and perhaps location will become more common.

Drivers/Barriers

- HCE could allow fulfilment of smart tickets in general without an ITSO Secure Application Module (ISAM)

- ITSO Part 11 allows fulfilment of ITSO Product Entities (IPE) without an ISAM in the tablet

- Lack of NFC success in handsets has been a barrier.

Summary of UK Transport Ticketing Services

Technical Innovation in the UK transport ticketing industry is lagging behind the rest of the retail world, including other modes of transport such as airlines. Countrywide interoperability across all modes does not yet exist with smart ticketing.

The following are the main drivers for change in transport ticketing services:

Efficiency savings are being sought by DfT/ORR through the use of self-service ticket machines, web sites and apps.

- The Credit Card Sized Ticket (CCST) is the only universally accepted (including 'cross London') rail ticket currently. However, it is expensive to fulfil and open to fraud and so other technologies are being sought

- The replacement of CCSTs with PYO and other technologies that do not require printing.

Passengers are asking for ticketing to be fast, easy to use and convenient. In line with this requirement:

- DfT is committed to providing a stronger and more focussed approach to quality and customer focus in the TOC franchises

- DfT is promising further fares simplification and TfL has delivered guaranteed best fares on Oyster with capping

- DfT continues to promote smart ticketing through the rail franchise programme. However, smart ticketing has proven expensive and difficult to deploy where ITSO technology is used

The UK government Open Data programme and Smart Cities programmes are encouraging the sharing of data through open APIs, opening up the possibility of new customer-centric services.

On a global scale, the drive for greater flexibility and ease of offering new services is resulting in system intelligence moving from readers and card to the back office. This is also driven by a wish by transport operators to accept existing retail technologies and not issue transport-only payment instruments

Back office systems operators are preferring to move services online and virtualise due to the cost savings that can be achieved by not using dedicated hardware. With existing transport back office operators looking to resell their services, such as TfL.

It may appear that DfT is driving unified change across the whole of the UK, but this is not quite the case. There seems to be no clear leadership either from government or industry:

- The rail franchise scheme, nor bus deregulation encourages operators to co-operate and interoperate, but rather work in silos. It is not conducive to innovation, investment or change.

- Customer service can be inconsistent with confusion over who to contact when problems are encountered with tickets issued by third parties.

Understanding what technologies (and useful combinations of technologies) can be delivered in the short to medium term is our goal for the next stage of this report.

Appendix E

Mobile Device

Technology – Apps

Description – Software applications that can be downloaded to mobile devices and installed by the user.

Discussion/Milestones

- Apple maintains tight control of loading of apps via iTunes

- Android more vulnerable to rogue apps.

Drivers/Barriers

- Potential channel to better customer service

- Security concerns due to lack of mobile platform control.

Technology – NFC

Description – A set of standards for establishing radio communications between devices which are near to each other. Includes the ISO 14443 'proximity' contactless interface standards used by transport smart cards. Three modes of NFC operation allow the mobile device to, amongst other things, act as:

- Contactless smart card

- Contactless tag and smart card reader

- Peer to peer communication devices.

Discussion/Milestones

- 2004: NFC Forum founded (now has more than 160 members)

- GSMA contributes NFC standards for mobile handsets including Single Wire Protocol (SWP) and Trusted Services Manager (TSM)

- 2010 First NFC smart-phone (Samsung Nexus S)

- 2014: Host Card Emulation (HCE) requires NFC. It might liberate NFC from SE shackles

- 2016: ITSO working to develop HCE application and pilot in West Yorkshire Passenger Transport Executive (WYPTE)

Drivers/Barriers

- Banks and Mobile Network Operators (MNO) have been reluctant to co-operate, resulting in mobile payments not taking off

- MNOs have ensured that SWP is used in most NFC handsets meaning that their SIM has to be used as the Secure Element (SE)

- 2015: Apple iPhone 6 issued with NFC, as are new iPads.

Technology – Secure Element (SE)

Description – Essentially, a smart card chip within the mobile device. Primarily for securely storing secrets such as crypto keys and PINs. This could be the SIM card, but could be other form factors such as removable secure memory cards.

Discussion/Milestones

- Ever since digital mobile phones were launched in the 1990s in Europe they have required a SIM to authenticate and connect to the network

- Provided convenience of portability between handsets by also holding contacts etc., but insufficient memory for smart phone data

- Many phones are locked to the MNO, and some SIMs are smaller in size, making portability poor in practice

- The Universal Integrated Circuit Card (UICC) standard for 3G harness the standards from multi-application smart cards (Java Card and Open Platform) to allow firewalled apps to be loaded to the UICC securely under delegated control (e.g. MNO has a SIM app and also allows a Banking app).

Drivers/Barriers

- The MNO owns the SIM card and so this is not an attractive SE for others to share

- SWP handsets can only use the SIM as SE and MNOs subsidise most handsets.

Technology – Host Card Emulation (HCE)

Description – An API that allows apps on NFC mobile devices to communicate with contactless readers while bypassing any SE in the mobile device.

Discussion/Milestones

- Jan 2014: Google deploys HCE on Android KitKat 4.4

- 2015: Apple launches Apple Pay in UK using HCE

- The MNO owns the SIM card and so this is not an attractive SE for others to share

- SWP handsets can only use the SIM as SE and MNOs subsidise most handsets.

Drivers/Barriers

- Driver to use NFC without restrictions of the SE

- Only available on some Android devices at present

- Apple still not issuing NFC hardware that is accessible to developers

- ITSO has been developing and trialling a HCE application.

Technology – Trusted Execution Environment (TEE)

Description – The Trusted Execution Environment (TEE) is a secure area of the main processor of a smart phone. It guarantees that any code and data loaded inside will be protected with respect to confidentiality and integrity. The TEE as an isolated execution environment is providing security features such as isolated execution, integrity of Trusted Applications along with confidentiality of their assets.

Discussion/Milestones

- The TEE offers an execution space that provides a higher level of security than a rich mobile operating system (mobile operating system (OS)) and more functionality than a SE.

Drivers/Barriers

- TEEs may offer Isolated Execution, Secure Storage, Remote Attestation, Secure Provisioning, Trusted Path

- Wide variety of products available which fulfill these goals to varying extent

- GlobalPlatform is working to standardise the TEE

- The development of TEE may assist in improving the security of HCE applications.

Technology – Trusted Services Manager (TSM)

Description – A TSM acts as a neutral broker that sets up business agreements and technical connections with mobile network operators, phone manufacturers or other entities controlling the secure element on mobile phones. The trusted service manager enables service providers to distribute and manage their contactless applications remotely by allowing access to the secure element in NFC-enabled handsets.

Discussion/Milestones

Typical functions of a TSM include:

- End to end security

- Activation and deactivation of services

- Remote access to applications

- Interconnect with MNO and Service providers

- Application lifecycle management

- Managing keys for a trusted execution environment.

These functions can be performed by mobile network operators, service providers or third parties, and or part can be delegated by one party to another.

Drivers/Barriers

- A TSM would be necessary to distribute tickets to mobile devices

- No commercial TSM service exists in the UK to distribute ITSO products

- The GSMA developed a set of requirements and specifications for TSM's in 2011

- Several organisations, including Gemalto, provide commercial TSM services

- Transport schemes have been implemented using NFC with TSMs in France and elsewhere.

Non-Smart Tickets

Technology – Barcode and Quick Read (QR) Codes

Description – These are tickets with journey information stored in a barcode which can be either 1D or 2D. RSP has produced a standard for rail tickets in the UK.

Discussion/Milestones

- RSP standard allows ITSO data to be included in the barcode and also includes colours for activation and inspection

- Arriva, First and Stagecoach (recently introduced) use bar codes on mobile devices

- Eurostar and other TOCs use bar codes in conjunction with PYO fulfilment.

Drivers/Barriers

- Considered cheaper to implement by some TOCs and bus operators than smart solutions

- Barcode readers not available at most rail stations.

Technology – Credit Card Sized Tickets (CCST) (cardboard printed ticket with magnetic stripe)

Description – Rail ticket form-factor for the last 20 years. Limited amount of journey data stored on magnetic stripe on back of ticket.

Discussion/Milestones

- Still the only universal ticket form-factor that is accepted universally across the UK rail network

- 2020: DfT target date for removal of mag-stripe rail tickets

- 2016: Changes to front of ticket implemented to make easier to read journey details.

Drivers/Barriers

- Mechanical readers with moving parts are high maintenance

- Failure to read rate seems high for mag-stripe, but printed ticket provides fall-back

- Can cause slow throughput of passengers

- The only form-factor that TfL can currently sell for cross-London and through London ticketing.

Networks

Technology – Bluetooth

Description – Bluetooth is a wireless technology standard for exchanging data over short distances (using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz) from fixed and mobile devices, and building personal area networks (PANs). Mobile apps can be designed to 'wake up' when within range of a Bluetooth Low Energy (BLE) beacon. Using multiple beacons within an area allows micro-location of the mobile device.

Discussion/Milestones

- 2002 Bluetooth Ratified as IEEE Standard 802.15.1.

- June 2010: BLE introduced and aimed at very low power applications running off a coin cell. Limited range (<50 m)

- 2014: Apple and PayPal use it for in store offers and payments

- 2015: MultiPass pilot includes BLE/NFC on Abellio Greater Anglia.

Drivers/Barriers

- Beacons are very low cost

- Tedipay plan to give BLE beacons out for free

- Mobile devices do not need 3G or Wi-Fi connections to use BLE

- Micro-location-based services will know when you arrive at key points in your journey, such as rail gates.

Technology – Digital Mobile Networks

Description – A cellular network or mobile network is a wireless network distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a cell site or base station. In a cellular network, each cell uses a different set of frequencies from neighbouring cells, to avoid interference and provide guaranteed bandwidth within each cell.

Discussion/Milestones

- 3G - 2003

- 4G - 2013 (EE only)

- 5G - 2023

Drivers/Barriers

- Mobile apps are becoming the norm to access services

- Data requirements are increasing as is speed

- 3G allowed users to be always online at reasonable speeds, but apps appear to be demanding more

- 4G and 5G will further improve bandwidth and transmission speeds.

Technology – Wi-Fi

Description – Any wireless local area network (WLAN) products that are based on the IEEE 802.11 standards. It allows LANs to be set up without cables. Hotspots have a typical indoor range of 46m.

Discussion/Milestones

- May 2010, the then London Mayor, Boris Johnson, pledged to have London-wide Wi-Fi by 2012

- 2014 Wi-Fi on majority of London tube stations

- Wi-Fi is available on some trains and buses in the UK either paid or free.

Drivers/Barriers

- The vision of always online might also be possible through Wi-Fi if implemented in the major cities.

Geo-Location

Technology – Bluetooth

See section 6.9.

Technology – GPS

Description – The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the earth where there is an unobstructed line of sight to four or more GPS satellites. The system provides critical capabilities to military, civil and commercial users around the world. The United States government created the system, maintains it and makes it freely available to anyone with a GPS receiver.

Advances in technology and new demands on the existing system have now led to efforts to modernise the GPS system. In addition to GPS, other systems are in use or under development. The Russian Global Navigation Satellite System (GLONASS) was developed contemporaneously with GPS. There is also the planned European Union Galileo positioning system, India's Indian Regional Navigation Satellite system and the Chinese BeiDou Navigation system.

Discussion/Milestones

- January 2010, an update of ground control systems caused a software incompatibility with 8000 to 10000 military receivers manufactured by a division of Trimble Navigation Limited of Sunnyvale, Calif

- February 2010,the U.S. Air Force awarded the contract to develop the GPS Next Generation Operational Control System (OCX) to improve accuracy and availability of GPS navigation signals, and serve as a critical part of GPS modernisation

- 2011, GLONASS reached full operational capability

- December 15, 2016 : European Commission (EC), owner of Europe's GNSS system, Galileo, formally announced the start of Galileo Initial Services, the first step towards full operational capability

- Use of GPS system has been restricted by the US government so resolutions are not as good as for US military purposes.

Drivers/Barriers

- Using GPS to track passengers could be problematic when they are indoors

- If GPS is being used to determine which train or platform a passenger is on, work will need to be done to ensure that there is a high location accuracy and passengers on the platform are not erroneously placed on a passing train

- Location could help with journey planning and remove the need for gates, as location within a station could be determined

- Location would help with post journey payment as origin destination and time information could be collected.

- 2018: Galileo will be found in every new model of vehicle sold in Europe

- 2020: Galileo will reach full operational capacity.

- 2020: BeiDou (the Chinese GPS) will reach Full Operational Capability

Technology – Mobile Phone Tracking

Description – Mobile phone tracking refers to the ascertaining of the position of a mobile phone, whether stationary or moving. Localisation may also occur either via multilateration (MLAT) of radio signals between (several) radio towers of the network and the phone, through association with a Base Station or simply via GPS. To locate the phone using MLAT of radio signals, it must emit at least the roaming signal to contact the next nearby antenna tower, but the process does not require an active call. Association assumes the mobile phone location to be the same as the cellular Base Station or the Wi-Fi Access Point that the mobile phone is connected to. While this is a simple approach, its accuracy depends on the coverage range of the Base Station/Access Point which can range from 50m in indoor and dense urban areas to ~30Km in rural areas.

Discussion/Milestones

- Several vendors have produced commercial products

- Google Latitude

- Find My Friends (Apple)

- Nearby (Microsoft)

- Other applications such as Foursquare, Facebook etc. allow for location to be recorded and shared

- Location information could be integrated with ticket sales app to provide origin destination information

Drivers/Barriers

- Data protection issues will need to be addressed for any commercial solutions

- Issues relating to ownership of subscribers location and movement data

- Privacy Enhancing Technologies (PET) can limit amount of data that is shared.

Smart Ticketing Point of Use (Reader)

Technology – Integrated

Description – Built in card reader capability in devices such as TVMs, PayPoint and PayZone terminals etc.

Discussion/Milestones

- ITSO Part 11 allows readers without ISAMs

- Contactless EMV accepted as transit payments

- NFC should become available in all mobile devices eventually.

Drivers/Barriers

- ISAMs traditionally needed in readers to hold secret crypto keys, depending on the application being used on the cards

- There is a cost in upgrading the acceptance infrastructure to meet the new specifications.

Technology – Connected

Description – Connected, devices such as PC plug in smart card readers, USB tokens etc. ITSO products could be download at home.

Discussion/Milestones

- USB contactless form factor could allow download at home via USB to be used as contactless form-factor when travelling.

Drivers/Barriers

- ISAMs traditionally needed in readers to hold secret crypto keys, depending on the application being used on the cards (but see ITSO Part 11).

Technology – Disconnected

Description – Offline card interaction, such as one-time password cards. Both Visa and MasterCard have standards for using EMV cards in offline devices to display one-time passwords.

Discussion/Milestones

- 2011: Visa experiments with credit smart cards with keypads and display embedded

- 2012: MasterCard follows suit.

Drivers/Barriers

- Standalone devices – cheaper integration cost in short term

- Not currently being considered for transport but an ITSO card that can display the products it contains is feasible

- MultiPass technology recently tested which contains a touch screen which can both display and take input

- RIDs might need to operate in this mode if they cannot always be online.

Smart Ticketing Media

Technology – Proximity cards contactless interface: ISO 14443

Description – These are the smart cards commonly used for transport, such as Oyster, ITSO and EMV. The usual read distance is less than 10cm. Readers conforming to this interface standard will be able to talk to these cards if they also have the necessary application and cryptographic keys for each.

Discussion/Milestones

- 2013: TfL launches bus readers that accept Oyster and cEMV

- 2014: TfL plans to launch a reader that can accept Oyster. ITSO and cEMV on the whole Oyster estate

- 2016: ITSO rolled out on Rail network as new franchises awarded.

Drivers/Barriers

- Significant cost associated with putting infrastructure in place (especially if ITSO)

- Allow for fast throughput at gated stations.

Technology – Vicinity cards contactless interface: ISO 15693

Description – The contactless smart cards are similar to proximity cards, but they operate over larger distances. They could be a candidate technology for Be-In Be-Out (BIBO). The idea is that the customer is detected as being on the vehicle or not and so the fare that they owe can be calculated.

Discussion/Milestones

- Pilot on Swiss Railways ~2009 to demonstrate concept

- DfT study into BIBO technology for transit payments in the UK in 2009, concludes that it is expensive to implement and confusing for customers as well as easy to defraud. Seems unlikely to be used in the near future.

Drivers/Barriers

- High cost of antennas

- High power output of antennas raises some health & safety concerns. Technology is immature

- Not a popular paradigm in the UK since it has connotations of tracking the customers.

Smart Ticketing Schemes

Technology – ITSO (UK National)

Description – A national transport smart media specification part-funded by DfT and not used outside the UK.

Discussion/Milestones

- ENCTS mandated by DfT as ITSO cards for all transport concession cards on buses

- ITSO Part 11 allows readers without expensive ISAMs

- 2016: Rail Franchises include ITSO requirements.

Drivers/Barriers

- The small market place of UK only makes international suppliers reluctant to invest

- The standard is not a complete end-to-end solution, therefore getting implementations to work has been extremely hard

- Designed for an offline world in the 1990s. It has taken over 10 years to start to be adopted

- Adoption by UK operators has been slow due to lack of business case in their environments and the fact that ITSO is not a complete solution

- ITSO readers on buses in England driven by Bus Service Operators Grant (BSOG) grants

- ITSO currently working on developing an approach to NFC/HCE.

Technology – cEMV (International)

Description – TfL has worked with the payment schemes over the past 6 years to establish a new transit payment model with acceptable risk using contactless EMV cards. The cards are standard bank cards with a contactless interface. Therefore, they can only perform standard EMV protocols. Nothing can be written to the card chip (unlike Oyster or ITSO).

Discussion/Milestones

- Initial implementation on bus as cash replacement using retail model

- 2013: Transit Payment model agreed with Visa and MasterCard (and Amex) by TfL. Integrated into the international scheme specs.

- Payment schemes planning to issue (charged for) tokenisation services

- 2016: Cards UK is working on UK national models for open payments

- 2016: Stagecoach planning to implement cEMV model 1 (retail model) across UK bus network.

Drivers/Barriers

- The lack of international transit ticketing standards provides an opportunity for cEMV

- Contactless EMV payments in the UK currently limited to £30 max per transaction. This is set to rise in the near future and other countries allow considerably more (e.g. Australia)

- Back office cEMV use in transit is not standardised beyond the transit (risk) payment model. E.g. TfL will not be the same as TfGM and their reader will not be interchangeable

- Proprietary nature has restricted the supply market to mainly Cubic at TfL

- Payment schemes require all infrastructure to be PCI DSS approved which is expensive. For example, TfL is using the Cubic tokenisation service.

Technology – Oyster (London, Proprietary)

Description – A proprietary transport smart card application from the 1990s 'offline' world which therefore stores balance information in the smart cards and fares information on all the readers.

Discussion/Milestones

- Oyster offered for sale to DfT for use in the whole of the UK but this was declined

- Proprietary MIFARE Classic cards in use were hacked by academics and shown to be easily cloned. Migration to proprietary DESFire cards

- 2014: plans to phase out Oyster, but it is still being supported by TfL.

Drivers/Barriers

- The initial main driver for TfL was increasing passenger throughput without the expense of re-architecting London Underground Limited (LUL) stations built in Victorian times

- Secondary drivers of saving time boarding buses and commuters through rail gates

- Proprietary nature has restricted the supply market to solely Cubic

- 2016: Oyster acceptance extended to Gatwick and other areas outside M25

- No obvious strategy in place for future rollouts.

Server

<u>Technology – Cloud</u>

Description – Cloud Computing is a paradigm in which information is permanently stored in servers on the Internet and cached temporarily on clients that include laptops, handheld devices, etc. This technology has become popular with end users over recent years in the form of Dropbox, Google Drive, etc., but is also used by enterprises.

The majority of cloud computing infrastructure currently consists of reliable services delivered through data centres that are built on computer and storage virtualisation technologies. The services are accessible anywhere in the world, with The Cloud appearing as a single point of access for all the computing needs of consumers.

Discussion/Milestones

- Costs can be cheaper than using specific transport ticketing technology. The utility model allows paying for what you need now, rather than guessing what you will need in the future

- High-speed bandwidth makes it possible to receive timely responses from the cloud from anywhere

- Device and location independence

- Security can be improved (due to centralisation) but can be a concern (due to access from anywhere)

- A barrier is that ticketing in the cloud requires online access at the time of inspections, otherwise the unwieldy lists at readers and RIDs will be required, like TfL currently does for FTP.

Drivers/Barriers

- TfL is considering the use of server virtualisation software (e.g. MS Azure) to allow them to run multiple back office for multiple cities in the cloud without having to purchase all the servers

- TfL is considering what they call "ticket in the cloud". By this they mean an advance purchase long distance rail ticket is associated with a token such as a bank card. When necessary (e.g. Inspection) the token can be used to access a cache in the cloud to confirm the ticket details

- In FTP Phase 4, TfL would like to be able to access a cache in the cloud, rather than maintain lists of approved tokens at readers and RIDs.

Appendix F

Technology Potential

This section provides recommendations about which combinations of technologies seem promising and therefore CCC should remain alert to and which seem unlikely to progress further and therefore should not be considered.

Ones to watch

- Connected point of use: USB contactless readers for home fulfilment to transport smart cards or contactless smart chips in USB format could be used for fulfilment of smart tickets at home before the NFC mobile device market takes off.

- ITSO Part 11 and ISAM farms in the cloud: Allows ITSO terminals (POSTs) for the first time to operate without containing an ISAM provided they have online to (a farm of one or more shared) ISAMs.

- NFC mobile devices with HCE: Freedom from the tyranny of the SE might mean that mobile NFC takes off soon for payments and lots of other transactions including transport ticketing. Both fulfilment (say with ITSO part 11) and for customer ticket carrier in place of smart cards. This is already happening.

- Mobile apps with Barcode: Already happening. Improvements in screen quality might improve performance of successful barcode presentation to readers without customer training.

- cEMV and post-pay PAYG: The use of cEMV is taking off in London as cash and Oyster replacement, saving TfL money on card issuance. Non-standardised back offices might hamper interoperability across the UK (e.g., TfL and TfGM). The cost model needs to be considered as this works for many transactions.

- Account Based Ticketing: This is not on the roadmap as it spans across multiple sections and is facilitated through the other technologies e.g. cEMV. Account Based Ticketing is moving at a swift pace and is becoming more prevalent as consumers needs change.

Ones not to be considered

- Vicinity smart cards and BIBO: Seems to be a long way from finding technical solutions so that it could work well enough in the UK transport environment.

- Mobile devices with BLE: interacting with Beacons allowing apps to be 'woken up' and present the appropriate form of ticket for the present environment: ITSO on NFC; Barcode; or something else. Trialled by Greater Anglia identified a number of issues.