Contactless Ticketing in Paris—The *Navigo* Pass

Marc Bensimon

Introduction

Since 2000, public transport operators in the Paris Region (Ile de France) have adopted a new ticketing system based on the *Navigo* contactless pass. This project brings together the three regional transport companies: *Régie Autonome des Transports Parisiens* (RATP), which operates mostly in the capital and nearby suburbs, French National Railway Company (SNCF), and Professional Transport Organisation of Île-de-France (OPTILE), which both operate mostly in the outer suburbs. Traffic has increased steadily over the last 10 years and now reaches 2.7 billion trips every year.

These three regional public transport companies are coordinated by STIF, the Paris Region transport authority, controlled by elected councillors from the Paris Region, the City of Paris and other cities. Revenues collected by the companies from customers are complemented by funding from STIF, which manages the transport tax paid by local employers (in the Paris Region, used to support public transport), together with subsidies from local taxes.

Each company operates its own ticketing system, not relying on outsourcing or Build Operate Transfer (BOT) schemes. These systems must comply with e-ticketing interoperability and security rules regulated by STIF. Moreover, with *Navigo* in mind, the transport companies have introduced new cross-operator features, relating mostly to card issuing, customer database management, and blacklist management.

The introduction of contactless ticketing has built on the integrated fare scheme that has been in place in the Paris Region for 30 years whereby tickets (season and ordinary tickets) are accepted throughout the regional transport networks. Protecting this asset probably explains the introduction of contactless cards as a picture-perfect transposition of these integrated products to *Navigo*.

Today, nearly 3 million passengers have a *Navigo* pass containing a time-based season ticket (yearly, monthly, or weekly) valid on all public transport (metros, buses, tramways, RER, regional trains). This pass can also be used to subscribe to *Velib*, the Paris municipal bicycle self-service rental scheme. By late 2008, all season-ticket holders, or some 4 million plus users will have *Navigo* and about 80% of all trips will be *Navigo*-enabled.

Magnetic tickets still account for 20% of trips and are used for tickets valid for a single trip sold as single tickets or ticket books. They are used by over 6 million Parisians as well as millions of visitors and tourists travelling in the Paris Region every year. Migrating these tickets to *Navigo* should occur in 2010 when about 10 million *Navigo* passes will be in circulation, because magnetic tickets will have been phased out completely.

This article aims at highlighting four aspects of the *Navigo* project:

- Deployment milestones
- Reasons for 2000–10 deployment duration
- Results and prospects
- Technological options

Figure 1 Companies in the Navigo Project

Companies	Networks	Traffic
RATP	14 Metro lines, 2 express suburban train lines (RER), 4100 buses, 3 tramway lines	80%
SNCF	3 Express suburban train lines (RER), 8 regional train lines, 1 tramway line	15%
OPTILE	4100 Buses	5%

Deployment

The *Navigo* strategic plan was established in the late 1990s after several experiments.

After completing an initial R&D phase in partnership with the Innovatron Company, which holds the patents on smart cards, RATP decided to extend contactless passes to its 45,000 staff. This enabled the first manufacturing of dual-interface passes with both contactless and contact interfaces as well as development of many applications for staff, such as access to the RATP transport network, access to company premises and company restaurants, etc. This phase, which allowed RATP staff to familiarize themselves

with the technology, meant that travellers started seeing introduction of the first *Navigo* equipment for accessing the metro network and onboard buses. Subsequently, the three transport operators experimented with *Navigo* using several panels of hand-picked customers before starting the global rollout under the coordination of STIF in 2000.

The project can be broken down into three major phases corresponding to the migration of the various existing tickets from magnetic to *Navigo*.

Phase 1—Annual season tickets

These are the most loyal users who are referenced in a database and pay their tickets by standing order from a bank account. Half of annual season ticket holders are students or schoolchildren with concessionary fares. From a commercial viewpoint, starting this project with such frequent users makes sense because they can be issued quickly with a personalized *Navigo* pass with name and photograph. These travellers are enthusiastic about contactless ticketing because its convenience enhances life. This enthusiasm, which has been boosted by marketing, has translated into a big increase in the number of annual season ticket holders.

Because annual season ticket holders never reload their passes (or only once a year for some of them), sales terminals did not require modifications during this phase. The rollout was restricted to inspection and validation terminals, where contactless modules were added to existing magnetic modules. Maintenance staff were trained from the start and after-sales service was introduced at ticket offices and sales agencies; if a pass was faulty, reading the card using the contact interface triggered delivery of a replacement ticket. This after-sales procedure was a main reason for choosing dual-interface passes.

Phase 2—Monthly and weekly season tickets

These frequent travellers can choose between two passes: the *Navigo Personalised Pass* referenced in a database,

Navigo pass (RATP)

Navigo vending machines (RATP-Gérald Dumax)

which allows it to be replaced in case of loss, and the *Navigo Découverte Pass*, which is not referenced and offers no guarantee against loss. The former is given free-of-charge by the regional council to people living or working in the Paris Region; the latter is sold for €5. Adopting this strategy prevents the potential risk of delivering high volumes of passes in an uncontrolled manner (haemorrhage of passes).

Sales terminals have been adapted to enable contactless reloading of passes at 1300 ticket offices (including 800 for RATP alone), at 2600 automatic vending machines in the transport network (including 1600 for RATP alone), and through 1500 licensed retailers (tobacconists, newsagents), mostly registered by RATP.

Thanks to the active support of operations staff, close to 1.5 million *Navigo* passes have been distributed on a voluntary basis, out of an estimated 2.5 million potential pass users. Among several initiatives introduced to boost this figure, an Internet online service was introduced. It is currently the leading registration channel for season tickets, having overtaken all sales agencies. Public surveys show that people who have not come forward are on the whole in favour of the *Navigo* pass, but wait until the very last moment to get one. Since the Paris Generalisation Scheme does not include incentives (discounts, loyalty schemes), it was important to announce that the migration deadline is the end of 2008.

To avoid too many travellers waiting right until this deadline, it has been agreed to gradually stop selling magnetic season tickets at all metro stations—given the current take-up rate (over 150,000 passes per month), the residual number of users requiring passes by the end of 2008 will be minimal.

Phase 3—Single tickets and ticket books

These tickets account for nearly 90% of sales transactions and create high distribution costs. In future, they will be sold only on reloadable anonymous passes allowing users to load the required number of tickets. Completion of this phase

Figure 2 Three Major Phases of the Navigo Project

	Phase 1 2000 – 04	Phase 2 2005 – 08	Phase 3 2009 – 10	Total
Transports tickets	Annual season tickets	Monthly and weekly season tickets	Anonymous tickets, single or by book	
Number of passes (million)	1.5	2.5	>6	>10
Percentage of *Navigo* transactions relative to:				
– Total number of trips	33%	45%	22%	100%
– Total number of purchases	<1%	10%	89%	100%

will certainly require simplifying the existing fare structure, which currently includes various tickets that will be difficult to transpose to contactless passes.

The entrance/exit control system is best suited to contactless ticketing. However, its introduction creates implementation problems in the context of outer suburbs where many remote stations do not have contactless gates. This system should probably be limited to a fraction of users, registered in a database, following a functional scenario similar to that of Hong Kong and London (maximum debit at entrance and credit at exit) or Tokyo (minimum debit at entrance, differential debit at exit).

All other travellers will use a reloadable anonymous pass debited at entrance only for a given type of journey. Initially, this pass will replace the flat-fare Paris transport ticket books (over 30 million books sold annually). Later, it will replace the books of suburban tickets using a tapered fare structure (approximately 4 million sold annually). Visitors and tourists should also use reloadable anonymous passes, which will be microprocessor-based, fully contactless cards that could be sold to the public at a very low price and delivered by automatic vending machines with pass dispensers.

The rollout of *Navigo* up to complete withdrawal of the magnetic ticketing system will last some 10 years.

10 Years to Supply 10 Million Users

Why such a long time?

- Contactless technology saw first light in public transport and is now spreading to areas such as banking, IDs, and mobile telephony on a large scale. A controlled ramp-up, allowing operators and passengers to get to know the technology progressively was necessary.
- The complexity of the Parisian multimodal transport networks operated by several companies does not facilitate rollout, especially because each company chooses its own suppliers and the structure, density of networks, and rate of contactless rollouts varies greatly between the capital and outer suburbs.
- The project unites all players (three transport operators, STIF, and the elected local government representatives) around a functional scenario and agenda that must take their different goals into account. The benefits of interoperability for passengers are obvious. However, the benefits for public transport operators derive from back-stage coordination and negotiations for each phase, which translate into additional delays.
- The Paris transport fare structure is not straightforward—it cannot be reduced to a bank-type electronic purse with automatic revenue clearance. The fares include many types of season tickets, flat fares, zone-based, distance-based (station to station), and reduced and concessionary fares linked to local government assistance. In the current phase, reaching all travellers (including infrequent ones) with *Navigo* means simplifying fares and introducing new types of tickets, such as time-based (1, 2 hours…) where price might depend on time (peak, off-peak) that do not exist now.

Results and Prospects

Navigo is the locomotive in establishing a new service relationship with users. The goal is to introduce a mass service that can still be personalized, depending on various user profiles and situations. It builds on the high satisfaction perceived by users when it comes to the ergonomics of contactless transactions and also on new services enabled by the versatility of the processor in the pass.

The *Navigo* is convenient.

It supports loading of several season tickets (yearly, monthly, weekly) on the same card as well as tickets for destinations outside the season ticket zone. Thanks to computation of the incremental journey extension, the ticket holder only pays the

incremental price beyond the season ticket zone. Moreover, *Navigo* offers customers with personalized passes secure card replacement in case of card loss. Finally, *Navigo* is a multimodal mobility pass that opens up access to the Paris municipal bicycle self-service rental scheme, car parks, and (soon) River Seine shuttles.

Pass reloading

The pass can be reloaded through common channels (ticket offices, public transport companies' automatic vending machines, licensed retailers) and also through *new distribution channels*.

As transport tickets become electronic, remote sales are expected to expand significantly. In 2008, users with a contact card reader connected to a computer can reload tickets over the Internet. Reloading is also supported at contactless-upgraded ATMs (500 by late 2008, and eventually1500). By 2010, NFC USB keys will enable reloading of tickets over the Internet and accessing transport networks. NFC mobile phones will support purchase of transport tickets and access to transport networks in a contactless manner. If contactless mobile phone manufacturers also integrate the NFC reader mode, tickets can be transferred onto *Navigo* passes (e.g. belonging to schoolchildren) from a mobile telephone (e.g. belonging to parents).

These innovations enable proximity services and help reduce waiting times, which are traditionally long at the end of each month when season tickets are bought. They extend the reload networks while not requiring investment in or maintenance of new terminals, and encourage use of electronic payment (bank cards). They should eventually reduce distribution costs of transport tickets significantly.

Project results

Although the savings expected from the system have not fully materialized yet, the project has yielded significant results.

Systematic validation of tickets when boarding buses is impossible using magnetic tickets because it slows boarding times and bus rotation rates. Fraud is easy because season ticket holders can just briefly flash their pass (with ID photograph) at the driver. Systematic validation enabled by *Navigo* has already translated into significant reductions in bus fraud. It also provides detailed statistics on passenger traffic.

The reduction in gate maintenance costs and access equipment started with gradual removal of magnetic equipment but will only yield full results when the magnetic system has been removed completely. The same applies to fraud-related savings (thanks to the disappearance of counterfeit magnetic tickets), and distribution cost savings due to development of external sales.

Validation enabled by Navigo reduced bus fraud, and provided statistics on passenger traffic (RATP)

The convergence of transport, banking and mobile telephone

The convergence of transport, banking and mobile telephone has already started in Asia (NFC mobile telephones), in the UK and USA (contactless *Paypass* cards in London and New York). It should also contribute to the transition to a full contactless system in Paris.

The *Navigo* experiments with NFC mobile phones in 2007 generated very positive feedback from users, especially for remote ticket purchase using a mobile. It is very likely that the general public will really enjoy the ability to phone, get information, pay, access public transport, and hire a self-service bicycle or a car with a single device. These new telephones should expand the reach of *Navigo*, especially among occasional users who are not interested in cards that are specific to public transport they seldom use. The *Navigo* service on NFC phones should start in 2010 with basic tickets, and will then be extended to season tickets.

Work has already started to allow travellers to access public transport with a contactless EMV bank card without needing to buy a ticket at a vending machine first, as demonstrated in London and New York. The banking transaction is carried out at gates and access equipment on flat-fare transport networks (Paris metro and buses); the ticket consists of an electronic receipt written to the card by the access equipment. The transaction is made locally by an EMV terminal in every validation equipment (or centralized in a bank server in the station, as in New York and London). During the trip, the electronic receipt (which can be read freely) can be used as proof of purchase at ticket inspection devices. Contactless bank cards could provide a smart solution for managing contactless single tickets, both from a commercial viewpoint (occasional users do not need a *Navigo* pass) and from an economic viewpoint (no issuing of specific passes).

The criteria for the Paris example

In *JRTR* 32, Jorge M. Rebelo highlighted a number of criteria (below) for '*obtaining the full benefit of non-contact smart cards*.' The Paris example has attempted to match these criteria:

- High-quality customer information and training, educating staff to answer passenger questions and assist with problems, educating the public about user friendliness—The use of *Navigo* by RATP's 45,000 staff members followed by gradual extension to the general public meets these conditions.
- Offering incentives to intermodal travel—Although there is no explicit incentive policy in Paris (no discount or loyalty schemes), the *Navigo* pass offers several additional benefits over magnetic tickets (safe replacement in case of loss, incremental journey extension, etc.)
- Overcoming resistance when customers are accustomed to flat rates or unlimited travel passes—This criterion is at the heart of the next step of the *Navigo* expansion plan targeting single tickets or ticket books, which must be migrated to contactless media to achieve simplicity and fluidity.
- High-level anti-fraud/hacking/cracking measures—The technological bases of the *Navigo* system are based exactly on these security objectives.

Technological Options

The technology must guarantee a very high level of reliability, speed and security and meet a cost level consistent with needs.

The transaction speed of around 0.1 s is a key point. Akio Shiibashi wrote in *JRTR* 32, 'Achieving high-speed high-reliability processing is an absolute prerequisite for suppressing gate error rates levels to levels that are lower than seen in conventional magnetic ticket systems. High-speed communication greatly reduces the incidence of incomplete data processing, so high-speed communication is an important precondition for actively reducing the occurrence of the problem.'

Navigo ticket gate (RATP-Sutton Denis)

Card reliability has increased significantly as volumes have increased. The number of faults due mostly to a weak mechanical connection between the chip and the antenna has been decreased. It is now possible to eliminate the contact interface for after-sales services, paving the way for reliable full-contactless cards. Moreover, as the volumes of microprocessor contactless cards in public transport and banking increases, procurement costs will drop steadily.

The architecture relies on transaction security between the card and terminal, both of which have a secure microprocessor. A combination of smart cards (mutual authentication, certification) and secret keys (DES algorithm) guarantees that transactions are not falsified. The system includes several sets of secret keys (for card personalizing, validation, reloading) and each *Navigo* pass includes a diversified secret number: if the secret number of one pass were to be cracked, the defrauders still could only clone that one pass. The central system would soon then detect the presence of clones and invalidate the cards. A period of 48 hours is sufficient to enable fraud detection and monitor pass counterfeiting. Beyond this period, the data are processed anonymously (by deleting pass serial number) in compliance with Commission Nationale Informatique et Libertés directives. Only data on the sale of personalized passes are recorded until the end of the validity period in order to facilitate pass replacement in case of loss.

As in other countries, when it comes to trips, the privacy issue is taken to heart by a significant part of the French population. Unlike most online architectures, this distributed architecture limits centralized collection of data, assuring better privacy.

One of *Navigo*'s main assets deals with reducing forgery, which has been estimated at about €15 million per year for magnetic tickets in the Paris Region in the late 1990s. A public electronic transaction system has inherent risk of exposure to fraud. A key quality is the ability to detect an attack and react quickly, which means always being one technological step ahead of defrauders. The last evolution in this area relates to triple DES contactless components, which will soon be used in season tickets. For occasional users, disposable contactless tickets could represent a system security flaw; to reach a minimum cost, which is still high with respect to that of trips, this solution uses basic wired memory chips. Other solutions addressed earlier that are consistent with the security level of microprocessor chips (incremental journey extension for season tickets, reloadable anonymous passes, NFC mobile telephones, EMV contactless bank

cards) could be chosen over disposable contactless tickets for single tickets.

Generally speaking, the convergence of uses between the worlds of transport, banking, and mobile telephone advocates using acknowledged and shared standards such as:

- ISO 14443, NFC and EMVCo proximity transmission
- Public security algorithms (triple DES for public transport)
- Multi-application GlobalPlatform for JavaCard objects

France has chosen Calypso as the preferred transport application. It is the specification for secure contactless transactions between a microprocessor card and terminal derived partly from the RATP work. The specification was designed by transport operators, brought together within the Calypso Network Association—a not-for-profit organization based in Brussels—and licensed to suppliers. Several generations of masked chips and downloadable JavaCard Calypso-compliant applications are available in Europe (France, Portugal, Italy, Brussels), Montreal, and Israel. Owing to its versatility, the technology is suited to local needs whilst complying with standards.

Unlike magnetic ticketing, which has remained static for 30 years, contactless ticketing is evolving in line with innovations and standards. The *Navigo* system, which was designed in the late 1990s, uses a proximity transmission method designed before publication of the ISO 14443 standard (but remains close to the type-B standard) and standard DES security. Starting in 2008, the Paris network will be upgraded to support new chip technologies (ISO transmission, triple DES security and JavaCard software).

Conclusion

The *Navigo* project shows that while the public is enthusiastic about contactless ticketing, a lot of effort is still required to phase out magnetic ticketing. So far, the project has focused on migrating the range of tickets to a contactless medium. But to be a complete success, the technology change must involve fare restructuring. At the same time, the convergence of mobility-related services (public transport, mobile telephony, payment) enables a wide spectrum of complementary applications, which are already plentiful in Asia, such as real-time information, location and navigation, entertainment, games, safety, etc. Naturally, the Japanese and European markets are different and sometimes they are actually opposite. For example, broadband Internet for personal computers has become widespread in France, whereas use of mobile telephones remains more voice-centric than data-centric. Innovation must therefore adjust to the specific technical environment, but success also depends on acceptance by the public.

However, some French citizens fear that the convenience provided by new technologies might be at the expense of lost privacy. For example, some people fear *Navigo* will allow personal movements to be tracked. Thierry Rousselin writing in *Le Monde* said, 'Can one avoid being traced?' He explained that tracing would not be due to Big Brother seeking to know everything about our life, but rather due to our own taste for convenience, starting with the Internet and mobile phones. He noted that many Internet users gladly leave considerable amounts of data freely on Internet web sites, blogs, etc., and suggests that individuals must take responsibility for privacy. This aspect must be taken seriously to help the public to embrace the technology confidently, and enhance it by inventing new leisure uses (peer-to-peer data exchange, games, etc.) that engineers have not yet recognized. ■

Marc Bensimon

Mr Marc Bensimon is Navigo Assistant Project Manager for Ticketing at RATP. Prior to his current position, he was in charge of the multi-service applications of the contactless transit pass in the Department of Information and Telecommunication Systems (SIT). He has an Advanced Master's Degree in Economics from Paris X—Dauphine University.