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Survey on Status of Knowledge and Interest of Smartcard Fare Collection Systems Among US Transit Agencies

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CALIFORNIA PATH PROGRAM  
INSTITUTE OF TRANSPORTATION STUDIES  
UNIVERSITY OF CALIFORNIA, BERKELEY

## **Survey on Status of Knowledge and Interest of Smartcard Fare Collection Systems Among US Transit Agencies**

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UCB-ITS-PRR-2006-12**

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Task 3 Report

Survey on Status of Smart Card Fare Collection Systems  
Among U.S. Transit Agencies

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## **Abstract**

This study analyzes data collected from an on-line survey of U.S. transit agencies to (1) gauge current levels of interest in smart card technologies, (2) document the current status of smart card system adoption among transit agencies, the degree of planning and implementation, and levels of participation in interagency collaborations, and (3) examine factors common to agencies that have adopted smart card technology and those that have not.

Reflecting significant diversity in their goals and objectives, operating environments, financial conditions, and clients served, transit agencies have different levels of need and interest in smart card technology and interoperability. We find that: (1) the extent of consideration and adoption of smart card technology and interoperable systems varies by a number of factors, such as funding availability and partnerships with other operators for other ITS technologies, and (2) the perceptions of benefits, costs, and risks of smart card technologies vary by the extent of smart card system planning and implementation.

These findings suggest that transit system managers are often uncertain about the costs and, particularly, the benefits of moving to smart cards; this is especially the case for the often complex interoperable smart cards systems.

**Keywords:** smart cards; transit service; interoperability; on-line survey; costs, benefits, and risks.



## Executive Summary

In recent years, Intelligent Transportation System (ITS) technologies have garnered considerable attention in the transportation sector. In the public transit industry, an increasing number of U.S. transit agencies are implementing or are considering implementing smart cards as next generation fare media.

Smart card systems have the potential to improve transit service operations and planning. They can allow implementation of flexible, fine-tuned fare schedules, ease fare revenue accounting, increase the speed and convenience of fare payment, and can substantially enhance patronage and travel data collection. In addition, when smart card systems are implemented on compatible platforms across multiple transit operators, these “interoperable smart card systems” can provide seamless travel for passengers by allowing easy fare payments and transfers across transit operators.

As part of our research entitled *Designing a Policy Framework for a Statewide Smart Card System Architecture*, we conducted an on-line survey of transit agencies in the United States to gauge current levels of interest in smart card technologies and to document the status of smart card system implementation for fare media. In particular, the survey was designed to seek information on: 1) levels of knowledge among transit system managers about the smart card technology and perceptions of costs, benefits, and risks; 2) the current status of smart card system adoption among transit agencies, the degree of planning, if any, toward implementation, and levels of participation in interagency collaborations; and 3) factors common to agencies that have adopted smart card technology and those that have not. The broader objective of this survey and study is to identify obstacles to adopting smart card technology, challenges to forming interagency collaboration, and strategies used to facilitate the formation of interoperable systems.

One hundred-six agencies from 37 states, including 22 agencies from California, participated in the on-line survey. The sample represents a wide range of geographic locations, agency sizes, operating environments (though only a few rural agencies are represented), modes operated, and fare structures. Importantly, the sample also well represents transit agencies with different degrees of planning for and implementation of smart card technologies and interoperable systems.





Since transit agencies in the U.S. vary significantly in their goals and objectives, operating environment and characteristics, financial conditions, and clients served, it is not surprising that they also have different levels of need and interest in smart card technology and interoperability. Our analysis of the survey data shows that the extent of consideration and adoption of smart card technology and interoperable systems varies by a number of factors. We also found that perceptions of benefits, costs, and risks of smart card technologies vary by the status of smart card system planning and implementation among agencies.

Key findings from our analysis of the survey data include:

- Funding importantly affects agencies' decisions to adopt smart card technologies and interoperable systems.
- Agencies already in partnerships with other operators in joint ITS projects are more likely to form interoperable smart card systems; however, agencies in partnerships with non-transit organizations for special group fare programs were less likely to have formed interoperable smart card systems.
- Benefits reported include (1) customer convenience, (2) ridership data collection, (3) reduced costs of fare collection, and (4) reduced maintenance of fare collection equipment. Costs most frequently reported were the capital investments in equipment, and agencies with interoperable systems most frequently reported risks in forming complex agreements between multiple operators.
- In general, transit agency representatives tend to perceive more (and higher) benefits of smart card systems than costs or risks. At the same time, however, respondents reported that the cost of smart card systems was an important factor in evaluating the adoption of smart cards, and agencies that did not consider or that rejected smart cards cited costs as primary barriers. The finding that agencies did not perceive costs as being very high despite it being a primary obstacle, however, may reflect the agencies' uncertainty about costs and bias in the industry literature that heavily promotes (rather than evaluates) smart card implementation.
- Managers, CEOs, and agency staff members are usually the key players in planning and implementing smart card systems. Board members and the public tend to be neutral or provide only moderate support for the adoption of smart card technology.



- Regional authorities, transit operators, and metropolitan planning organizations have tended to take the lead in planning and implementing interoperable smart card systems and in revenue sharing among operators.

Collectively, our findings suggest that transit system managers – even at systems that have adopted smart cards – are often uncertain about the costs and, particularly, the benefits of moving to smart cards; this is especially the case for the often complex interoperable smart cards systems. Why have so many transit systems embraced these new technologies in the face of so much uncertainty? This question motivates the next phase in our research: detailed case studies of the motivations of managers at transit systems that have, and have not, adopted smart cards.



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# 1. Introduction

In recent years, Intelligent Transportation System (ITS) technologies have garnered considerable attention, and many applications have been implemented. Smart card systems are one ITS technology considered by many to be the next generation of fare collection media for transit systems.<sup>1</sup> In fact, public transit agencies in many other developed countries, such as England, Singapore, and Japan, have already widely adopted smart card technologies. In the U.S., an increasing number of transit agencies are considering pilot projects or transitioning to smart card systems for their fare media.

Smart card systems have the potential to improve transit service operations and planning by allowing the implementation of flexible fares and improving fare accountability. The convenience and faster processing speed of smart cards reduce boarding time, and the cards' technology can provide more comprehensive ridership and travel data than currently available. While these benefits appeal to all transit agencies, it is unclear how agencies compare these benefits to the costs and risks associated with adoption of smart cards as new fare media, and to what extent transit agencies have been planning and implementing such programs.

Interoperable smart card systems are adopted using the same platform across multiple transit operators, and can provide seamless travel by allowing transit riders to use one fare card across service areas and operators. However, the level of needs and interests that transit agencies have in interoperable systems is not known.

As part our study entitled *Designing a Policy Framework for a Statewide Smart Card System Architecture*, we conducted an on-line survey of transit agencies in the United States to gauge the level of interest in smart card technologies and the status of smart card system implementation for fare media. In particular, the survey sought to find out: (1) levels of knowledge among transit agency staff about the smart card technology and perceptions of costs, benefits, and risks; (2) the current status of smart card technology adoption among transit agencies, the degree of planning, if any, toward implementation, and levels of participation in interagency collaborations; and (3) factors common to agencies that have adopted smart card technology and those that have not. The broader objectives are to identify obstacles to adopting smart card technology, challenges to

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<sup>1</sup> The definition of smart cards and smart card systems as used in this study is provided in Appendix A.

forming interagency collaboration, and strategies used to facilitate the formation of interoperable systems.

Overall, the survey data are not always consistent with claims often made in the smart card literature. Transit agency managers often do not have a clear understanding of the relative costs and benefits of smart card technology for fare collection. This finding suggests that the sometimes booster-like enthusiasm for smart cards has not helped transit managers determine how best to measure the costs and benefits of moving to a new technology.

The following sections of this report describe the survey design and process, present the analysis of collected responses, and summarize the key findings from the analysis.

## **2. Survey Design and Process**

The survey was conducted in September and October 2005. The 2002 National Transit Database (NTD) administered by the Federal Transit Administration (FTA) was used to identify 368 potential respondents, all of which had at least one fixed-route transportation mode.

The full population was invited to participate in the survey through a letter via US post and e-mail. The text of the correspondence is included in this report as Appendix B. The first invitation explained the purpose of the survey and asked respondents to complete the survey within two weeks of the date of the request, with a clear statement that participation in the survey was voluntary. The steps of the survey process were as follows.

- First, e-mail invitations were sent to agencies' Chief Executive Officers (or equivalent position title).
- Over one hundred of the initial e-mails bounced back due to incorrect e-mail addresses.<sup>2</sup> For those transit agencies whose e-mails bounced back, we e-mailed a survey invitation letter to the agencies' Department of Transportation contact, which is primarily responsible for reporting to the NTD.
- To ensure that all transit agencies received the survey invitation letter, we also post mailed hardcopy letters to all agencies, except those that had already responded to the survey.

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<sup>2</sup> The 2002 NTD contained information from 2001. As a result, we realized that a significant number of entries were outdated. We researched updated contact information through the Internet and by calling agencies.

- We conducted the first follow-up phone calls to about 300 transit agencies that had not completed the survey. In addition, since some agencies mentioned on these follow-up calls that their mailing addresses had changed since 2001, we re-sent the survey invitation letter upon their requests.
- Several reminder e-mails were sent out as a follow-up to the survey invitation letter. A reminder e-mail was sent out to all agencies that had not yet responded to the survey.
- Finally, once the survey was closed to new respondents, we sent final follow-up e-mails to a number of respondents who had not finished the survey, and asked them to complete the survey or advise us that they would not be finishing it.
- The survey was closed in the end of October.<sup>3</sup>

Respondents to the survey logged onto the web-based questionnaire through the UCLA Institute of Transportation Studies website. The survey site provided a general overview of the project, the purpose of the survey, survey instructions, and a statement assuring confidentiality of identity and individual responses.

The survey consisted of two parts. The first part of the survey asked questions related to agency profile, such as operating characteristics, structures for joint decision-making, board composition and leadership, fare policies and fare media, and ridership demographics. The second part asked questions related to levels of knowledge about the smart card technology, current status of smart card technology adoption, and levels of participation in interagency collaborations.

Because we anticipated that agencies would be in varying stages of smart card technology evaluation and adoption (and that some agencies would *not* have smart card technology at all), we asked agencies to self-classify the current status of their evaluation and/or implementation of smart card technology.<sup>4</sup> Possible response categories were (1) agencies that have not considered smart card technology, (2) those that are in the process of considering smart card technology but have not made any decisions about their use, (3) those that considered smart card systems but ultimately rejected them, (4) those that are in the process of adopting or have adopted stand-

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<sup>3</sup> All correspondence is in accordance with the UCLA Center for the Protection of Human Subjects (CPHS) protocol.

<sup>4</sup> Throughout this report, we refer to the classification of agencies' progress on evaluating and/or implementing smart card technology as the agency's "status" of smart card adoption.



alone smart card systems only for their own agency, and (5) those that have adopted or are in the process of implementing interoperable smart card systems in conjunction with other agencies.

Depending on the agency's smart card technology status, respondents were asked different sets of questions. This branching technique allowed us the significant advantage of being able to include both operators that adopted smart card technology and operators that did not adopt smart card technology to examine differences between the two groups. We asked all respondents about benefits, costs, and risks associated with adopting smart card technology as fare media.

Agencies that never considered smart card technology were asked the reason for not considering this fare medium, while other groups of agencies were asked for more details about the planning and implementation of smart card systems. Such questions included: the sources of information that the agency used to learn about and evaluate smart card technology; the availability of funding for smart card technology; individual champions or groups that affected policy decisions regarding adoption of smart card technology; and the interoperability of smart card technology.

### **3. Description of Respondents and Representation**

Agencies represented in this report include those that completed the survey. Although the survey was designed to test agencies that considered or implemented smart card technology as well as agencies that have *not* considered or implemented smart card technology, it is likely that our survey samples are slightly biased toward agencies that are interested in smart card technology to some degree. First, staff from some agencies that were not considering smart card technology thought their response would be irrelevant and declined to participate; others had difficulty in identifying the appropriate staff member to take the survey because there was no active effort within the agency to consider smart card technology. Second, our survey sample may under-represent small agencies that do not have enough ridership to justify substantial capital investment in new technology; these agencies may be less likely to have participated in the survey. Third, agencies that are implementing interoperable smart card systems as part of a consortium and that are not leading the joint efforts may have been reluctant to respond to our survey because staff may not be necessarily familiar with smart card technology or on-going efforts in implementation.

To gather as representative a sample as possible, however, we made follow-up phone calls to agencies that had not responded or had provided only incomplete answers, and explained that it

was equally important to hear from agencies without smart card programs as from those with programs. In this way, we increased some representation of agencies without smart card programs in our sample.

The following sections describe the geographic range of agencies represented in our sample (state and region), their operating environments, type of agency and scope, modal operations, agency size, fare revenue analysis, and fare media and structures. We also provide a description of the range of individual respondents' backgrounds and departments within their respective agencies.

Of the 368 agencies identified in the NTD with at least one fixed-route transit mode, 106 agencies responded to our solicitation and participated in our survey. This gives a fairly good response rate of 29 percent. The responding agencies offer broad geographic and institutional range. Thirty-seven states are represented, including 22 agencies from California. California agencies are disproportionately over-represented compared to agencies from other states, partly because 61 of the 368 agencies (17%) of our population universe are in California. It is also possible that agencies within the state are more familiar with UCLA and Caltrans and may be more likely to support this research as they may be the direct beneficiaries of this effort.

Table 1, next page, shows the number of total responding agencies in ten Federal Transit Administration regions. The Pacific Southwest region has 24 agencies, of which only two agencies are outside California. The Great Lakes region has 16 agencies, while three regions—Mid-Atlantic, Southeast, and Pacific Northwest—have 12 agencies each. The New England region has the fewest responding agencies (3), followed by five agencies in the New York/New Jersey and Mountain regions.

The scope (operating environment) of service offered by the agencies also represents a broad range of agencies (see Table 2 on the next page). Fifty-five percent operate local service, and 31 percent offer regional service. Ninety-seven out of 106 agencies (91%) operate in urban and/or suburban environments. The most typical environment is urban and suburban environments—half of all responding agencies operate in this type of environment. Seven agencies (7%) operate in urban and rural environments, and only two agencies operate in suburban and rural environments.

**Table 1 Number of Responding Agencies by FTA Region**

FTA Region	F	%
New England (CT, MA, ME, NH, RI, VT)	3	3%
New York/New Jersey (NY, NJ)	5	5%
Mid-Atlantic (DC, DE, MD, PA, VA, WV)	12	11%
Southeast (AL, KY, FL, GA, MS, NC, SC, TN & PR)	12	11%
Great Lakes (IL, IN, MI, MN, OH, WI)	16	15%
Plains (IA, KS, MO, NE)	7	7%
Southwest (AR, LA, NM, OK, TX)	10	9%
Mountain (CO, MT, ND, SD, UT, WY)	5	5%
Pacific Southwest (AZ, CA, NV, HI)	24	23%
Pacific Northwest (AK, ID, OR, WA)	12	11%
Total Respondents	106	100%

**Table 2 Scope (Operating Environment) of Service Offered by Responding Agencies**

Scope (Operating Environment)	F	%
City	3	3%
County	5	5%
Local	58	55%
Local/Regional	3	3%
Metropolitan	3	3%
Regional	33	31%
State	1	1%
Total Respondents	106	100%
Urban	36	34%
Urban + Suburban	53	50%
Urban + Rural	7	7%
Suburban	8	8%
Suburban + Rural	2	2%
Total Respondents	106	100%

### *Modes provided*

Most agencies in our sample operate buses (97%), and some form of demand responsive services (86%). Other modes operated include ferries (4 agencies), van pools (9), and bus service (1). Nineteen agencies (18%) provide only one mode of transit service. Of these, three agencies provide either commuter or local bus service; three agencies operate only rail service--either heavy rail or commuter rail service. Table 3 summarizes modes provided by responding agencies.

**Table 3 Modes Provided by Responding Agencies**

Mode	F	%
Bus (commuter, local, and express)	103	97%
Demand responsive service (paratransit)	86	81%
Rail (heavy, light, and commuter)	14	13%
Van (includes rail shuttle)	9	8%
Ferry boat and ferry bus	4	4%
Other	2	2%
Total Number of Respondents: 106		
Note: Respondents provided multiple answers		

### *Size of agency*

Agency sizes (as measured by vehicle fleet size) ranged from agencies with just a few vehicles to those with over 1,000 (Table 4).

**Table 4 Size of Responding Agencies (Vehicle Fleet)**

Size (Vehicle Fleet)	F	%
1-49	38	37%
50-99	26	25%
100-249	16	15%
250-499	10	10%
500-999	9	9%
1000 or more	5	5%
Total Number of Respondents	104	101%
Note: Two respondents of the total 106 did not provide fleet size.		

*Fare media*

We polled agencies on their current fare media and structures. Not surprisingly, 98 percent of all responding agencies use cash; additionally, 58 percent use flash passes,<sup>5</sup> and 46 percent use magnetic stripe cards (see Table 5). Given that all of the agencies represented in this survey that have adopted smart card systems have continued to collect cash fare payments, it would appear unlikely that transit agencies will abandon cash fares any time soon regardless of the introduction of smart card technology or any other advanced fare media.

**Table 5 Fare Media Used by Responding Agencies**

Fare Type	F	%
Cash	104	98%
Flash pass	61	58%
Magnetic stripe cards	49	46%
Tickets	44	42%
Tokens	38	36%
Other	13	12%
Total Number of Respondents: 106		
Note: Respondents provided multiple answers		

The fare policies offered most frequently are flat fares, used by over 90 percent of agencies (see Table 6 on the next page). Only 20 (19%) and seven (7%) agencies offer zone-based and distance-based fares, primarily on commuter bus and rail services, and 10 agencies (9%) have peak fare. Among these ten agencies, three agencies operate rail services, and nine agencies have commuter bus services.

Many agencies provide passes, the most popular being a monthly pass (89 agencies, 84%). A little less than half of responding agencies (48 agencies, 45%) issue a daily pass. Only 21 agencies (20%) offer a weekly pass, while seven agencies (6%) offer a semi-monthly pass. Most agencies have reduced fares for students, seniors, and disabled riders. Only 14 agencies have frequent rider discounts; these agencies include Transit Authority of River City in Kentucky; South Metro Area Rapid Transit in Oregon; Metropolitan Tulsa Transit Authority in Oklahoma;

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<sup>5</sup> Flash passes refer to any pass media that is visually inspected by the operator. Flash passes usually allow unlimited trips within a specified time period, such as monthly, semi-monthly, and weekly transit passes. Flash passes can also include identification cards (such as student or employee IDs) that, with agreement between the operator and other agencies (such as schools or employers), allow the card holder to use his or her identification card as a transit pass.

North County Transit District in California; Greater Lynchburg Transit Company in Virginia; and Lafayette Transit System in Louisiana.

**Table 6 Fare Structure / Passes / Discounts among Responding Agencies**

Fare Structure / Passes / Discounts	F	%
Flat fare	96	91%
Zone-based fare	20	19%
Distance-based fare	7	7%
Peak-fare	10	9%
Day pass	48	45%
Weekly pass	21	20%
Semi-monthly pass	7	7%
Monthly pass	89	84%
Other fare media	25	24%
Frequency ride discount	14	13%
Student fare	98	92%
Senior-fare	73	100%
Disable-fare	94	89%
Other-fare	8	8%
Total Number of Respondents: 106		
Note: Respondents provided multiple answers		

*Position of survey respondent*

The survey asked for responses from an individual in the agency who was most knowledgeable about smart card technology; the individual respondent was at the discretion of the agency. Of the 106 individuals who completed the survey, 60 respondents (63%) self-identified as holding executive or administrative positions in their organizations (see Table 7 on the next page). This is not surprising, as we initially sent the invitations to the executive director or CEO of the agencies. Fourteen respondents (15%) were in planning positions, which is also consistent with expectations, as they are often project managers or responsible for evaluation and implementation of new services. Other respondents held positions in finance/budgeting (9%), operations or logistics/scheduling (7%), and marketing (2%).

**Table 7 Job Responsibility or Position of Respondents**

Job Responsibility or Position	F	%
Executive/Administrative	60	63%
Planning	14	15%
Finance/Budgeting	9	9%
Operations or Logistics/Scheduling	7	7%
Marketing	2	2%
Other	4	4%
No Answer	10	9%
Total Respondents	106	100%

#### **4. Status of Smart Card Systems among Responding Agencies**

To gauge the extent of smart card use and adoption among transit agencies, we asked respondents to classify their agencies' progress on evaluating and/or implementing smart card projects; throughout this report, we refer to this classification as agencies' "status" of smart card adoption. Respondents categorized their agencies into five groups, and we refer to these groups using the following labels and abbreviations:

- Not Considered, or NC -- agencies that have not considered the use of smart card technology for their operations,
- Considering, or CO – agencies that are currently in the process of considering smart card technology but have not made decisions about their use,
- Rejected, or RE – agencies that considered smart card technology but subsequently rejected adoption,
- Stand-alone, or SA – agencies that are in the process of adopting or have adopted a smart card system for their agency only, and
- Interoperable, or IO – agencies that are adopting or have adopted smart card technology in conjunction with other agencies.<sup>6</sup>

As seen in Table 8, next page, a majority of the responding agencies has adopted either stand-alone (14%) or interoperable (30%) systems, or is at least considering smart card systems

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<sup>6</sup> In addition, when respondents did not provide any answer, agencies are referred as "No Answer" or NA.

(25%). It is important to note, however, that among our respondents, those who adopted stand alone systems are about equal in number to those that have never considered the use of smart cards or who have simply rejected the idea altogether.

**Table 8 Status of Smart Card System Adoption by Responding Agencies**

Status of Smart Card System Adoption	F	%
Not Considered (NC)	15	14%
Considering (CO)	26	25%
Rejected (RE)	16	15%
Stand-alone (SA)	15	14%
Interoperable (IO)	32	30%
No Answer (NA)	2	2%
Total Respondents	106	100%

## 5. Potential Factors Influencing the Adoption of Smart Card Systems

To understand why some agencies adopt or consider adopting smart card systems, we asked in our survey questions about some likely factors influencing agencies’ decisions to evaluate and implement the programs. We hypothesized – and found true – that larger agencies as measured by fleet size and annual revenues were more likely to adopt smart card systems, possibly because they are able to achieve economies of scale. Agencies with high levels of fare fraud or that prioritize fare fraud as problematic were predicted to be more likely to adopt smart card technology, and our analysis supports this as well, though it is difficult to tell how well agencies are able to estimate or measure the degree of revenue loss.

We also hypothesized that agencies with existing ITS programs or collaborative partnerships with other agencies would be more likely to adopt smart card technology and to do so in partnership with other operators. We found that agencies that had previously partnered with other operators on ITS programs were more likely to adopt interoperable smart card systems. Contrary to our expectations, however, agencies that have partnerships with non-transit organizations or that participate in regional or multi-operator governance committees were less likely to form interoperable smart card systems.



The following sections present our analyses of factors and findings related to the adoption of smart card systems.

*Agency size*

In Table 9, we examine the agency fleet size by the status of smart card systems, and find that small agencies were more likely to have not considered (NC), or to have considered but rejected smart card technology (RE). Agencies that have adopted stand-alone smart card systems (SA) have the largest average fleet size of all groups, including interoperable agencies (IO). This may indicate that the group of interoperable agencies includes small operators that simply participate in a regional smart card program, thereby lowering the average vehicle fleet size.

**Table 9 Fleet Size by Status of Smart Card System**

Status	F	Mean	Std Dev	Minimum	Maximum
Not Considered (NC)	15	71	65	15	228
Considering (CO)	26	206	454	16	2224
Rejected (RE)	15	126	174	18	666
Stand-alone (SA)	14	401	443	16	1200
Interoperable (IO)	32	232	283	20	1300
No Answer (NA)	2	96	43	65	126
Total Respondents	104	207	336	15	2224

Note: Two respondents of the total 106 did not provide fleet size information

*Fare revenue*

Ninety-eight agencies provided us with data about their annual fare revenue (Table 10 on next page). Annual fare revenues ranged from \$80,000 to \$396 million, with one respondent reporting that his or her agency did not charge fares. Examining the average annual fare revenue by the status of smart card system adoption, agencies that never considered smart cards have the lowest average revenue of \$2.59 million, and those that rejected the technology have the second lowest (\$6.01 million). With average fare revenues far lower than other agencies that adopted or are in the process of adopting smart cards, some of these agencies likely have lower ridership and are less likely to justify the high installation cost of new technology.

Agencies that are considering smart card technology or that have implemented stand-alone smart card systems have about the same average fare revenue of \$21 million. However, the distribution is quite different between these two groups. Agencies that have adopted stand-alone

systems are more clustered—meaning that as a group, they are more like each other than the agencies that are currently considering smart card systems.

Agencies that implemented interoperable smart card systems have a slightly lower average fare revenue of \$16 million, because this group includes small agencies with low fare revenue that participate in regional smart card systems as indicated by the lower median (\$5 million) for this group.

**Table 10 Annual Fare Revenue of Responding Agencies (in \$1,000)**

Status	F	Mean	Std. Dev.	Median	Minimum	Maximum
Not Considered (NC)	12	2,594	2,949	1,325	110	9,000
Considering (CO)	26	20,881	77,779	908	80	396,000
Rejected (RE)	15	6,019	9,241	3,800	151	36,000
Stand-Alone (SA)	13	20,756	21,148	16,708	695	56,000
Interoperable (IO)	29	16,038	24,110	5,000	753	95,000
No Answer (NA)	2	1,417	684	1,416	933	1,900
Total Respondents	97	14,454	43,173	2,500	80	396,000

*Revenue loss by fraud and evasion*

When asked how much their agencies lost in revenue due to fare evasion or fraud, most respondents (70 agencies) either did not know or did not answer the question. The largest revenue loss reported by any agency, however, is \$2 million per year, or five percent of its annual fare revenue; this agency has implemented an interoperable smart card system. Three other respondents reported higher revenue loss in proportion to fare revenue – two respondents reported a ten percent loss, and one agency reported as much as 15 percent – and all three of these agencies are in the process of considering smart card technology for fare collection, but have not implemented programs yet.

Although fare fraud reduction is touted as a major potential benefit of smart card fare systems, the survey found that most respondents did not report fare fraud as a serious problem for their agencies. Twenty respondents (19%) rated fare fraud as *not important at all*, while only 14 respondents (13%) rated it as *very important* (see Table 11 on the next page). Combined with the fact that less than ten percent of all respondents provided estimates of their annual revenue loss by fare fraud and evasions, it is likely that agencies do not have reliable knowledge of revenue loss from fraud.

**Table 11 Importance of the Issue of Fare Fraud and Evasion**

Rate of Importance	F	%
Very important	14	13%
Important	33	31%
Somewhat important	35	33%
Not important at all	20	19%
Do not know/not sure	4	4%
Total Respondents	106	100%

Further analysis (not presented in a table here) also shows that there is not much variation in the importance of fare fraud between agencies that adopted and those that have not adopted smart card technology. However, all 15 agencies that adopted stand-alone smart card systems consider fraud an important issue, but only 28 percent of the 32 agencies that adopted interoperable systems reported that fare fraud was an important issue. This finding is plausible because some interoperable agencies may adopt smart card systems simply as participants in regional programs, rather than as preventative measures against fare fraud and evasion.

*Familiarity with other ITS technologies*

The survey also asked questions about the agency’s familiarity with various technologies, to test whether agencies with higher levels of technology in their current operations were more or less likely to adopt smart card technology than other agencies with no precedent in technology use. Table 12, on the next page, shows that 62 agencies (58% of all responding agencies) have implemented some form of intelligent transportation systems (ITS) programs, though most programs are unrelated to fare collection.<sup>7</sup>

Table 12 shows that in the group of agencies that never considered smart card technology there are significantly more agencies with no other ITS programs than those with existing ITS programs. This indicates that agencies with no other ITS programs are less likely to reach the point where they consider smart card technology. Although differences are noticeable in other groups of agencies in terms of the status of smart card technology, they are not strong – indicating that other factors, such as funding availability and expected costs and benefits for

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<sup>7</sup> ITS applications included automatic vehicle locators, demand responsive services, automatic voice enunciators, demand responsive services, and bus priority systems.

operators, may be more important factors in affecting agencies' likelihood of adopting smart card technology.

**Table 12 Prior ITS Programs by Status of Smart Card Systems**

Status	Yes		No		Total	
	F	%	F	%	F	%
Not Considered (NC)	6	<b>10%</b>	9	<b>21%</b>	15	14%
Considering (CO)	15	24%	11	26%	26	25%
Rejected (RE)	10	16%	6	14%	16	15%
Stand-alone (SA)	10	16%	4	9%	14	13%
Interoperable (IO)	20	32%	12	28%	32	30%
No Answer (NA)	1	2%	1	2%	2	2%
Total Respondents	62	100%	43	100%	105	100%

Note: Total number of respondents providing complete responses: 105

Although the presence of ITS technology is not a strong factor in affecting smart card technology adoption, we found that when agencies adopted ITS technology in partnership with other operators, they are more likely to adopt interoperable smart card systems than stand-alone systems (50% versus 11%) (Table 13). Agencies with partnered ITS programs (50%) are twice as likely to adopt interoperable smart card technology as agencies without partnered ITS programs (25%). However, agencies with partnerships are about equally likely to adopt stand alone systems (11%) as agencies without partnerships (18%). When it comes to forming interoperable smart card systems, familiarity with technology is less important than an agency's experience in forming collaborative partnerships around technology.

**Table 13 Prior ITS Programs with Other Operators by Status of Smart Card Systems**

Status	Yes		No		Total	
	F	%	F	%	F	%
Not Considered (NC)	0	0%	6	14%	6	10%
Considering (CO)	4	22%	11	25%	15	24%
Rejected (RE)	3	17%	7	16%	10	16%
Stand-alone (SA)	2	11%	8	18%	10	16%
Interoperable (IO)	9	<b>50%</b>	11	<b>25%</b>	20	32%
No Answer (NA)	0	0%	1	2%	1	2%
Total Respondents	18	100%	44	100%	62	100%

*Partnerships with non-transit institutions*

Partnering with other non-transit institutions for special group fare programs<sup>8</sup> is an important strategy for successfully adopting advanced fare card systems. Sixty-six agencies (65%) have partnerships with one or more of the followings: (1) universities/colleges, (2) schools, (3) employment centers, and (4) health and human services (Table 14). Other intuitions mentioned include apartment complexes, Boys and Girls Club, grocery stores, and metropolitan government.

**Table 14 Partnerships with Non-Transit Organizations**

Type of Organization	F	%
University	52	49%
Schools	30	28%
Employer	31	29%
Health	32	30%
None	35	33%
Other	6	6%

Total Number of Respondents: 106  
Note: Respondents provided multiple answers

We hypothesized that agencies that are engaged in partnerships with other organizations or agencies would be more likely to implement smart card technology particularly in interoperable systems because (1) precedent and protocols for partnerships are already established, thus providing clear avenues for other partnerships, and (2) joint programs can benefit from smart card technology applications. However, the analysis does not support our hypothesis (see Table 15 on the next page). Agencies that are involved in partnerships with non-transit organizations and institutions are less likely to adopt smart card technology in stand-alone or interoperable systems than agencies without partnerships (38% versus 58%). In fact, of all agencies without partnerships, 39 percent adopted interoperable smart card systems, versus only 26 percent of agencies with previous partnerships.

<sup>8</sup> Group fare programs offer a special fare rate for a targeted group of riders. Examples of group fare programs are U-passes, where university students and faculty pay a reduced fare for trips to and from campus; or employer programs, where an employer purchases fare cards in bulk at a discounted price and sells the reduced cost cards to their employees.

**Table 15 Partnerships with Non-Transit Organizations by Status of Smart Card System**

Status	Yes		No		Total	
	F	%	F	%	F	%
Not Considered (NC)	8	12%	7	19%	15	14%
Considering (CO)	20	29%	6	17%	26	25%
Rejected (RE)	14	21%	2	6%	16	15%
Stand-alone (SA)	8	<b>12%</b>	7	<b>19%</b>	15	14%
Interoperable (IO)	18	<b>26%</b>	14	<b>39%</b>	32	31%
Total Respondents	68	100%	36	100%	104	100%

Note: Total number of respondents providing complete responses: 104

*Participation in regional or multi-operator committees*

We hypothesized that agencies participating in regional committees or in multi-operator committees would be more likely to adopt interoperable smart card systems, because these working relationships would provide precedent for joint decision-making and cooperation in achieving shared goals and objectives. Additionally, regional and multi-operator committees would provide more opportunities for identifying smart card technology as a useful tool for myriad needs.

We found, however, that while a majority of agencies participate in some regional committee, there was no systematic relationship between this activity and smart card technology adoption. Among 106 agencies, 68 agencies participate in some regional committees with other transit operators in their region, but they were not any more likely to adopt smart card systems.

*Availability of funds for implementing smart card systems*

As we expected, funding is a central issue for implementing smart card systems. Table 16 on the next page shows sources of funding available for agencies that have at least considered smart card systems, and shows that 46% receive or are eligible to receive federal funds for smart card projects. Twenty-three agencies (26%) receive local funds, while twenty-two agencies (25%) have state sources. Regional funds are available to fifteen (17%) agencies, and 22 agencies (25%) did not have any funds available for smart card systems.

**Table 16 Available Funding Sources for Implementation of Smart Card Systems**

Funding Source	F	%
No funds	22	25%
Local funds	23	26%
Regional funds	15	17%
State funds	22	25%
Federal funds	41	46%
Do not know/Not sure	9	10%
Other (Not specified)	2	3%
Total Number of Respondents: 89		
Note: Respondents provided multiple answers		

When we examine availability of funding by status of smart card systems, we find that agencies that have some funding are far more likely to adopt interoperable systems (45%) or stand-alone systems (19%) than agencies without funding (9% and 9%, respectively). With funding, agencies are also more likely to adopt interoperable systems than stand-alone systems probably because many agencies participating in interoperable systems receive funding from a lead agency. Almost half (41%) of agencies without funding sources considered but decided not to adopt, while only ten percent of agencies with some funding decided not to adopt smart card systems (see Table 17). Eighteen percent of respondents without access to outside funding sources decided to adopt smart card systems, while sixty-four percent of respondents with access to outside funding sources decided to adopt smart card systems.

**Table 17 Availability of Funding by Status of Smart Card System**

Status	Some funds		No funds		Total	
	F	%	F	%	F	%
Considering (CO)	17	25%	9	41%	26	29%
Rejected (RE)	7	<b>10%</b>	9	<b>41%</b>	16	18%
Stand-alone (SA)	13	<b>19%</b>	2	<b>9%</b>	15	17%
Interoperable (IO)	30	<b>45%</b>	2	<b>9%</b>	32	36%
Total Respondents	67	100%	22	100%	89	100%

Further examining details of funding sources by status of smart card system, we find agencies with interoperable smart card systems receive regional (44%), state (34%), or federal (56%) funds, rather than local (31%) funding (Table 18, next page). In contrast, agencies that

adopted smart card system as stand-alone systems are more likely to have local funds, and much less likely to receive regional funds.

**Table 18 Funding Sources by Status of Smart Card System**

Status	No Funds		Local		Regional		State		Federal		Total
	F	%	F	%	F	%	F	%	F	%	F
Considering (CO)	9	35%	3	12%	0	0%	4	15%	13	50%	26
Rejected (RE)	9	56%	3	19%	1	6%	3	19%	4	25%	16
Stand-alone (SA)	2	13%	7	47%	0	0%	4	27%	6	40%	15
Interoperable (IO)	2	6%	10	<b>31%</b>	14	<b>44%</b>	11	<b>34%</b>	18	<b>56%</b>	32
Total Respondents	22	25%	23	26%	15	17%	22	25%	41	46%	89

Note: Respondents provided multiple answers

We also asked agencies that adopted smart card systems or are in the process of considering smart card systems to rate the importance of funding in their decisions. A large majority of agencies that are considering smart card systems said availability of funding is *very important* (54%) or *important* (19%) in their decision. Table 19 shows that only 12 percent of these respondents indicated that funding was *not important*. Agencies adopting stand alone systems were about equally divided between *very important* (27%), *important* (27%), and *not important* (33%); but among agencies with interoperable systems, the most common response was *do not know or not sure* (31%). This may be explained by the fact that interoperable systems are often adopted by a consortium of operators, thus spreading the cost of system purchase; or because operators in interoperable systems may have been mandated to participate.

**Table 19 Importance of Funding by Status of Smart Card System**

Status	Very Important		Important		Somewhat important		Not Important		Do not know/ Not sure		Total
	F	%	F	%	F	%	F	%	F	%	F
Considering (CO)	14	<b>54%</b>	5	<b>19%</b>	2	8%	3	<b>12%</b>	2	8%	26
Stand-alone (SA)	4	<b>27%</b>	4	<b>27%</b>	0	0%	5	<b>33%</b>	2	13%	15
Interoperable (IO)	6	19%	8	25%	5	16%	3	9%	10	<b>31%</b>	32
Total Respondents	24	33%	17	23%	7	10%	11	15%	14	19%	73



## **6. Respondents' Perceptions of Benefits, Costs, and Risks Associated with Smart Card Systems**

One crucial step to understanding barriers to implementing interoperable smart card systems is to understand how and why agencies make decisions about technology adoption and participation in collaborations or consortia. In the survey, we asked respondents how they perceive the costs, benefits, and risks of smart card systems, and their sources of information for evaluating whether to adopt smart card systems. We also asked questions about important factors that agencies take into consideration when deciding about smart card systems, and whether these factors deter or compel agencies to adopt.

We found that respondents perceive high benefits in customer convenience and data collection, but high costs in the initial equipment procurement. High risk areas included the management of a new system and the formation of agreements among multiple operators. Taken together, respondents more frequently reported the beneficial areas of smart cards than the costs and risks. This bias in perception may be due to the lack of information about actual costs of smart card systems, as reflected in the body of literature that tends to promote (rather than evaluate) new smart card technology. And, the primary reasons for not considering smart cards were lack of information and the low priority of smart cards given other competing demands on the agency. The most prominently reported barriers to smart card adoption were the cost of the system and the availability of funding.

### *Sources of information about smart card technology*

Transit agencies obtain information about smart card systems from various sources. More than 70 percent of all responding agencies mention trade journals and professional magazines, vendor/supplier representatives/literature, professional meetings and associations, and staff at other agencies (see Table 20 on the next page). Slightly more than a third of respondents indicated that they check academic literature for information of smart card systems. Other sources mentioned include American Public Transportation Association and web sites.

**Table 20 Sources of Information about Smart Card Systems**

Source of Information	F	%
Vendor/supplier representatives/literature	73	82%
Staff at other agencies	70	79%
Professional meetings and associations	65	73%
Trade journals and professional magazines	63	71%
Academic literature	32	36%
Other	10	11%
Total Number of Respondents: 89		
Note: Respondents provided multiple answers		

*Benefits*

In the survey, we asked all respondents about their perception of benefits, costs and risks of smart card systems. In each set of questions, we asked respondents to rate various aspects of smart card systems as very beneficial, beneficial, somewhat beneficial, not beneficial at all, and do not know. We used the same scale for rating costs and risks as well.

Table 21, next page, shows the proportions of respondents that rated various aspects of smart card systems (first column) as very beneficial.<sup>9</sup> The second column shows the percentages of respondents from all 106 agencies that answered these questions. The next six columns in the table show the responses of five categories of agencies with different status of smart card systems (those agencies that have never considered smart card system (NC), those that are in the process of considering (CO), those that considered but decided not to adopt (RE), those that adopted stand-alone systems (SA), and those that adopted interoperable systems (IO), and those that did not answer this question). Figures shown in **bold type** indicate that proportionally more agencies in this group (NC, CO, RE, SA, and IO) rated each area of potential benefits very beneficial, compared to the group of all agencies—showing that respondents from agencies with different statuses of smart card adoption perceive different types of benefits.

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<sup>9</sup> The survey question asked respondents to rate each potential benefit very beneficial, beneficial, somewhat beneficial, or not beneficial. The same pattern of question was asked for costs (Table 22) and risks (Table 23 and 24).

**Table 21 Areas of Smart Card Fare Collection Systems Rated as *Very Beneficial***

Area Rated As <i>Very Beneficial</i>	All	NC	CO	RE	SA	IO	No Ans.
A. Fare fraud/fare accountability	30%	7%	<b>38%</b>	13%	<b>53%</b>	<b>34%</b>	0%
B. Fare revenue	25%	7%	<b>27%</b>	19%	<b>47%</b>	<b>25%</b>	0%
C. Customer convenience	44%	27%	<b>46%</b>	38%	<b>47%</b>	<b>50%</b>	100%
D. Service reliability	25%	20%	19%	<b>25%</b>	<b>40%</b>	22%	50%
E. Flexibility in fare policies	26%	<b>27%</b>	23%	6%	<b>60%</b>	22%	50%
F. Pre-paid fares and passes	25%	13%	23%	13%	<b>53%</b>	22%	50%
G. Partnering opportunities	35%	27%	<b>38%</b>	31%	<b>47%</b>	28%	100%
H. Ridership data collection	43%	27%	<b>50%</b>	13%	<b>53%</b>	<b>56%</b>	50%
I. Farebox maintenance requirements	14%	0%	<b>15%</b>	0%	<b>33%</b>	<b>16%</b>	50%
J. Driver responsibilities for fare collection	19%	0%	<b>35%</b>	6%	<b>33%</b>	13%	50%
K. Other	1%	0%	0%	0%	0%	3%	0%
Total Respondents	106	15	26	16	15	32	2

First, examining the responses for all 106 agencies, we find that the highest expectations of smart card benefits were for customer convenience (44 percent of respondents), data collection (43%), partnering opportunities (35%), and fare fraud (30%). The high ratings given to fare fraud is a little surprising because few transit agencies appear to have accurate information about the actual fare revenue loss due to fraud. This perception of smart cards' importance in reducing fare fraud may instead be driven by vendors and the literature, which often touts fraud prevention as a primary benefit of smart card systems.

Many respondents also gave high scores for partnering opportunities, which is encouraging for the potential of interoperable systems. In contrast, the relatively low percentages of agencies rating farebox maintenance requirements and driver responsibilities for fare collection as *very beneficial* are contrary to our expectation, since both of these benefits are often promoted in the literature. This may be because the use of smart card technology does not lower maintenance

costs or driver responsibility for fare collection unless agencies can completely replace traditional fare media such as cash and tokens with smart card media.

Examining respondents' perceived benefits by the status of smart card systems in their agencies, we find that SA respondents report more *very beneficial* uses of smart cards—and report them more frequently—than IO respondents. This implies that agencies participating in interoperable systems and who are not leading the coordination may not necessarily find as many substantial benefits as agencies adopting stand alone systems. As expected, NC and RE respondents both generally have lower perceptions of the benefits from smart card systems. One notable exception is that 27 percent of NC respondents rated flexibility in fare policies as *very beneficial*.

### *Costs*

Although the costs associated with smart card systems vary by the size and specification of the system, most agencies perceive them as moderately costly. Table 22 on the next page shows the proportions of respondents that indicated a smart card fare collection system is *very costly* in each area specified in the first column of the table. Thirty-eight percent of all agency respondents rated the initial equipment (A) as *very costly* but only 13 percent rated card media as *very costly*. The view that the cost of the cards is less onerous than the equipment may reflect two things: (1) the cost of individual cards has been rapidly declining over the past few years, and (2) the cost of card media can potentially be passed on to riders. However, smart card media continue to remain more expensive than conventional fare pass media, and this may be problematic for daily passes or other infrequent uses, particularly among small transit agencies.

Among NC, CO, and RE respondents, 40 percent perceive equipment costs as *very costly*. This finding, combined with the fact that only two agencies in our survey are pursuing smart card systems without external funding, emphasizes the importance of access to capital funds for the initial investment in smart card systems.

**Table 22 Areas of Smart Card Fare Collection Systems Rated as *Very Costly***

Area Rated as <i>Very Costly</i>	All	NC	CO	RE	SA	IO	No Answer
A. Equipment costs of system	38%	<b>40%</b>	<b>42%</b>	<b>50%</b>	20%	34%	50%
B. Cost of individual cards	13%	7%	4%	<b>31%</b>	<b>13%</b>	13%	50%
C. Operating costs	10%	0%	4%	6%	<b>20%</b>	<b>19%</b>	0%
D. Maintenance costs	15%	0%	<b>23%</b>	<b>25%</b>	7%	<b>16%</b>	0%
E. Fees to data processors	13%	0%	12%	<b>25%</b>	<b>20%</b>	13%	0%
F. Staff training	8%	7%	<b>8%</b>	<b>19%</b>	7%	6%	0%
G. Ridership education	8%	7%	<b>8%</b>	<b>13%</b>	<b>13%</b>	3%	0%
H. Other	2%	0%	0%	6%	0%	3%	0%
Total Respondents	106	15	26	16	15	32	2

When disaggregated by the status of smart card system adoption, data show that agencies that rejected smart cards consistently rated them as *very costly* in all areas except operating costs (C). Among agencies that have adopted smart cards as stand-alone or interoperable systems, however, one-fifth considered operating costs to be very costly. Agencies earlier in the evaluation process or that have rejected smart cards perceive very costly startup costs, but disproportionately more agencies that have already adopted smart cards perceive very costly operating or maintenance costs. This implies that the actual operating cost may exceed agencies' expected cost. In contrast, there is a large difference in percentages for equipment costs (A) and individual card costs (B) between RE, implying that these costs are actually lower than agencies expect before adoption.

A higher proportion of CO, RE, and IO respondents than SA respondents consider maintenance costs (D) *very costly*. A similar difference can be seen for equipment costs (A). This implies that agencies may perceive significant transaction costs associated with interoperable smart card systems. If this is the case, the formation of an interoperable smart card system may require subsidies to pay the difference in costs between a stand-alone system and an interoperable system.

## Risks

Transit agencies participating in the survey appear to generally trust the reliability of smart card technology (C) and do not perceive high risks in implementing smart card systems. Table 23 shows the proportions of respondents that indicated a smart card fare collection system is *very risky* in each area specified in the first column of the table.

**Table 23 Areas of Smart Card Fare Collection Systems Rated as *Very Risky***

Area Rated as <i>Very Risky</i>	All	NC	CO	RE	SA	IO	No Ans.
A. Unused value on old passes and cards	3%	0%	0%	<b>13%</b>	<b>7%</b>	0%	0%
B. Customer interest acceptance	8%	0%	<b>12%</b>	<b>13%</b>	<b>13%</b>	3%	0%
C. Technology reliability	9%	7%	<b>12%</b>	<b>13%</b>	7%	<b>9%</b>	0%
D. Management of new systems	10%	0%	8%	<b>13%</b>	7%	<b>19%</b>	0%
E. Incompatibility of smart card systems with the current fare media	9%	7%	<b>12%</b>	<b>25%</b>	0%	6%	0%
F. Impact on fare revenue	2%	0%	0%	<b>6%</b>	0%	<b>3%</b>	0%
G. Equity related complaints	3%	0%	<b>8%</b>	0%	0%	<b>3%</b>	0%
H. Complicated agreements with other agencies	13%	0%	12%	6%	<b>13%</b>	<b>25%</b>	0%
I. Other	0%	0%	0%	0%	0%	0%	0%
Total Respondents	106	15	26	16	15	32	2

Complicated agreements with other agencies (H) are the most frequently reported risk area cited by all respondents, and IO respondents disproportionately report this area as very risky. In contrast, few of the NC and RE respondents seemed to perceive interagency agreements as a significant risk area. This may indicate that before forming actual interagency agreements, the risk of encountering these problems is often underestimated prior to actually trying to implement the agreements.

Incompatibility of smart card systems with the current fare media (E) is considered *very risky* by a quarter of RE respondents, while no respondents from SA thought so. It is possible that the issue of compatibility between smart card systems and existing fare media persists, but agencies expect a technological solution for this problem will occur within a reasonable timeframe and at a reasonable cost.

We asked respondents whether equity related complaints are a risky area for the agency when considering or implementing smart card systems. On one hand, some low-income riders may not have bank accounts or other suitable means for placing value onto electronic pre-paid cards, or may not be able to afford a lump sum value on the card. On the other hand, however, smart card systems may facilitate transactions for welfare and/or other aid recipients, since all transit users can use the same card regardless of their status. Additional research in this area may be helpful in determining whether these are the valid concerns, but our initial survey indicates that the majority of respondents do not anticipate equity related complaints (G).

*Reasons for not considering smart card systems*

In order to understand the most basic barriers that agencies face when considering smart card systems, we asked the 15 agencies that have never considered smart card systems why they have not considered the new technology (Table 24). The most frequent response was simply that agencies did not have enough information about smart card systems. The next most frequently cited reason was simply that smart card systems were a low priority given other agency needs such as replacing old buses.

**Table 24 Reasons for Not Considering Smart Card Systems**

Reason for No Consideration	F	%
Do not have enough information	5	33%
Low Priority	4	27%
Do not have enough budget	3	20%
Acceptance	3	20%
Agency is too small too invest	2	16%
No reason (no fare charged)	1	7%
No Answer	3	20%
Total Number of Respondents: 15		
Note: Respondents provided multiple answers		

*Factors considered important when evaluating the adoption of smart card systems*

To understand the motives for adopting or considering adopting smart card systems, we asked respondents from three groups of agencies—CO, SA, and IO (totaling 73 agencies)—to rate the importance of factors shown in Table 25 when considering the adoption of smart card

systems.<sup>10</sup> Table 25 shows the percentage of respondents who consider the first column factor as *very important* when deciding to adopt smart card systems. In general, CO respondents rated factors *very important* more often than other groups of respondents, such as SA and IO. This finding shows agencies in the different stages of evaluation and adoption potentially attribute different levels of importance to various factors. It is possible that after agencies complete their evaluation and subsequently adopt and implement smart card systems, their judgments change about the importance of these factors.

The cost of fare collection and maintenance (A), and availability of funding (K) are very important factors for agencies that are currently considering smart card systems, again indicating the importance of funding. The low percentages for these two factors given by SA and IO respondents, however, suggest two possibilities. First, the financial issues may be less problematic than agencies expect before implementation. Second, agencies that tend to be early adopters of either stand-alone or interoperable systems may have been able to overcome financial issues and do not consider them very important.

**Table 25 Factors Considered *Very Important* When Considering Smart Card Systems**

Factor Considered <i>Very Important</i>	All	CO	SA	IO
A. Cost of fare collection and maintenance	38%	<b>81%</b>	27%	9%
B. Service improvement	29%	<b>38%</b>	<b>33%</b>	19%
C. Fare policy flexibility	25%	<b>27%</b>	<b>33%</b>	19%
D. Fare revenues	30%	<b>54%</b>	<b>40%</b>	6%
E. Fare fraud	23%	<b>31%</b>	<b>33%</b>	13%
F. Data collection for planning purposes	37%	<b>38%</b>	<b>53%</b>	28%
G. Data collection for reporting purposes	36%	<b>42%</b>	<b>47%</b>	25%
H. Replace old system	26%	15%	<b>33%</b>	<b>31%</b>
I. Other agencies are doing it	8%	0%	0%	<b>19%</b>
J. To partner with other organizations	14%	<b>15%</b>	7%	<b>16%</b>
K. Funding was available	33%	<b>54%</b>	27%	19%
L. Demand from our riders	4%	<b>8%</b>	<b>7%</b>	0%
M. Other	4%	<b>4%</b>	0%	<b>6%</b>
Total Respondents	73	26	15	32

<sup>10</sup> For this question, 17 agencies that rejected or never considered smart cards, are not included.



Data collection capability of smart card technology seems very important for CO and SA respondents, but not for IO respondents. This may be because agencies that are only participating in interoperable systems may not be as concerned about this factor as agencies that actually lead efforts for implementation. It may also be that IO respondents are somewhat skeptical about collecting data, especially if data are viewed as sensitive and can potentially be accessed, viewed or used by other participants. It will require additional study (in this or another project) to determine if it is indeed a valid explanation.

The high rating given to replace old system (H) by IO respondents may warrant some additional attention as well. It is possible that an agency's schedule for replacement equipment influences—either positively or negatively—the agency's perceived value of entering into interoperable smart card systems.

With 19 percent of the IO respondents indicating that they were significantly influenced by the fact that other agencies were adopting smart card systems, it is easy to speculate on how this factor may have helped elevate smart card system importance for agencies considering interoperability. The respondents might want to be viewed as mainstream providers with high connectivity and enhanced service levels, and equipped with the latest tools; especially after others have adopted high visibility projects. Joining existing projects may also simply reduce the risk of adopting new technology because others have paved the way for interoperability agreements.

#### *Factors that may deter agencies from adopting smart card systems*

In the survey, we also asked 89 agencies that have at least considered using smart card systems to rate possible deterring factors that led to rejecting the adoption of smart card systems. We also asked agencies that did adopt smart card systems to rate the difficulty of these factors in their decisions to adopt smart card systems. Table 26, next page, shows percentages of agencies that consider various factors as *very difficult* in their decisions about smart card adoption. Overall, the two most difficult factors are cost and funding. Respondents showed moderate concern about availability of information and evaluations, benefits for agency and for riders, confidence in technology, the risk to the agency, and priority relative to other programs. Most respondents indicated that they did not encounter opposition to the adoption of smart card systems from any groups (community, unions, staff/management, and board).

Overall, about 30 percent of respondents consider cost and funding as significant deterrents to adopting smart card systems. However, when restricting our view to only those agencies that rejected smart cards, the incidence was much higher. It should be noted that 31 percent of RE respondents reported that smart cards' low priority for the agency (L) was a *very difficult* factor while less than ten percent of agencies in other groups do so. Consistent with other questions from our survey, agencies that have limited capital funding are likely to give priority to other programs, such as vehicle procurement.

**Table 26 Factors Considered *Very Difficult* When Considering Smart Card Systems**

Factor Considered <i>Very Difficult</i>	All	CO	RE	SA	IO
A. Not enough information/evaluation available	3%	4%	0%	0%	6%
B. Cost	31%	27%	<b>75%</b>	20%	19%
C. Funding	28%	<b>35%</b>	<b>69%</b>	7%	13%
D. Benefits are not suitable for our agency	4%	0%	<b>19%</b>	0%	3%
E. Benefits are not suitable for our riders	6%	4%	<b>13%</b>	0%	6%
F. Confidence in the technology	12%	<b>12%</b>	<b>19%</b>	<b>13%</b>	9%
G. Too risky for our agency	6%	4%	<b>19%</b>	<b>7%</b>	0%
H. Community or public opposition	0%	0%	0%	0%	0%
I. Union of employee opposition	0%	0%	0%	0%	0%
J. Staff or management opposition	1%	0%	<b>6%</b>	0%	0%
K. Board opposition	2%	4%	<b>6%</b>	0%	0%
L. Not a priority given our other programs and priorities	9%	8%	<b>31%</b>	0%	3%
M. Other	2%	4%	0%	0%	3%
Total Respondents	89	26	16	15	32

#### *Consideration of interoperable smart card systems*

We asked respondents from agencies that at least considered smart card systems if the agency ever considered adopting smart card systems as part of a regionally interoperable system (see Table 27 on the next page). Interestingly, 86 percent of RE respondents had at some point considered an interoperable system before rejecting smart card systems all together. Among agencies that are currently considering smart card systems (CO), however, only 23 percent are considering the interoperable system. Only seven percent of SA agencies considered interoperable systems before adopting stand-alone systems. Because only three or four of these agencies did not have potential partners (or overlapping service areas), this lack of interest in interoperable systems may be related to the agencies' operating characteristics, the timing of

their smart card system implementation, or other reasons to be explored in next stages of our research.

**Table 27 Consideration of Interoperable Systems by Status of Smart Card Systems**

Status	Yes		No		Total	
	F	%	F	%	F	%
Considering (CO)	6	23%	20	77%	26	100%
Rejected (RE)	12	86%	2	14%	14	100%
Stand-alone (SA)	1	7%	14	93%	15	100%
Total Respondents	47	35%	40	65%	87	100%

This question was asked only to CO, RE, and SA respondents, since IO responses by definition considered and adopted interoperable systems.

*Importance of interoperability of smart card systems*

We asked all agencies that adopted smart card systems about the importance of interoperability. Our goal was to ascertain whether agencies that adopted stand-alone systems perceived a real need for system interoperability, and whether agencies that adopted interoperable systems did so specifically to facility interoperability or if it was an opportunistic byproduct of implementing smart card systems.

Most respondents that adopted stand-alone systems chose not to specify their perception of the importance of interoperability in relation to their decision to adopt smart card systems. This may indicate that these respondents and their agencies adopted stand-alone systems without considering interoperability as a factor (consistent with findings presented in Table 27).

Or, it may be that respondents’ individual knowledge of interoperability somehow limited or prevented him or her from weighing on this issue. The survey result is inconclusive here. However, among respondents that adopted interoperable smart card systems, it is clear that interoperability was a very important factor in choosing to implement a smart card system. Since we received no responses on this question in the *somewhat important* and *not important at all* categories, implementing cooperative, interoperable agreement was a supporting element of agencies’ decisions to adopt smart cards (Table 28 on the next page).

**Table 28 Importance of Interoperability of Smart Card Systems**

Status	Very important		Important		Do not know/ Not Sure		No Answer		Total F
	F	%	F	%	F	%	F	%	
Stand-alone (SA)	1	7%	1	7%	6	40%	7	47%	15
Interoperable (IO)	20	63%	4	13%	3	9%	5	16%	32
Combined	21	45%	5	11%	9	19%	12	26%	47

## 7. Smart Card System Implementation and Institutional Arrangements

In the survey, we asked respondents to identify individuals or agencies that led the evaluation of smart card systems, and that sustained the efforts to adopt and implement them. We asked about public support and opposition, and contractors used for equipment and services. We also asked about arrangements for the oversight and distribution of fare revenues in interoperable systems, and whether new smart card systems were used to implement changes in fare structures and policies.

We found that agency managers and CEOs and staff members were the most frequently reported leaders in both initiating and sustaining the process of evaluating, adopting, and implementing smart card systems. Despite the benefits to riders commonly reported in the smart card literature, our survey respondents either did not know whether the public supported or opposed the new fare collection systems, or they reported that the public has been generally neutral.

While an introduction of smart card systems gives agencies an opportunity to change fare structures, it does not often lead to these policy changes. Among the agencies that did change fare policies, however, it is unclear from the survey whether these changes were in *response* to the new technology (such as fare incentives to increase smart card use among riders) or the driving motivation for smart card system adoption (advanced collection system to carry out a fare policy change).

### *Leaders initiating smart card systems*

To understand the role of individuals who may champion a project or initiate an idea, we asked agencies that adopted smart card systems to identify individual(s) who initiated the effort, and rate them based on their importance in getting these projects off the ground (Table 29).

**Table 29 Position of Individuals Who Initiated Consideration of Smart Card Systems**

Position	Most Important	Second Important	Third Important	Total	Not Important
Manager or CEO	29	15	9	53	36
Staff Member	25	27	5	57	32
Board Member	4	2	4	10	79
Vendor Representative	2	2	5	9	80
Consultant	2	4	8	14	75
Other	15	6	6	27	62

Managers, CEOs, and staff members are most frequently identified as important initiators in agencies' efforts to consider smart card systems. Respondents identified these staff members from various departments and divisions, including customer service, finance, maintenance, marketing, administration, operations, and policy and planning. Board members, vendors, and consultants are least frequently identified as important players in initiating consideration of smart card systems.

Responses in the *Other* category include regional transportation authorities (RTA), metropolitan planning organizations (MPO), state agencies, and customers.

### *Leaders sustaining smart card system adoption and implementation*

To distinguish whether there were differences between the initiation of an idea and then sustaining the project, we also asked survey respondents to identify people who were instrumental in carrying implementation forward. Again, a significant number of respondents listed the managers or CEOs and staff members, but few respondents listed board member, vendor representatives, academics, community members, and consultants. Only ten respondents listed board members as being instrumental in sustaining the efforts, and these individuals were rated low in importance (Table 30 on the next page). Responses to this and the previous question

imply that agency decisions on whether or not to adopt smart card systems are characterized more as planning decisions, rather than political decisions.

**Table 30 Position of Individuals Who Sustained the Adoption of Smart Card Systems**

Position	Most Important	Second Important	Third Important	Total	Not Important
Manager or CEO	24	9	7	40	49
Staff Member	22	19	3	44	45
Board Member	3	3	4	10	79
Vendor Representative	2	2	4	8	81
Academic	0	0	3	3	87
Community Member	0	1	0	1	88
Consultant	1	1	6	8	81
Other	11	7	3	21	68
No one individual	17	0	0	17	-
Do not know/Not sure	8	0	0	8	-

*Public support for smart card systems*

Because improving customer convenience is one of the most often cited reasons for adopting smart card systems, we asked agencies about the public’s reaction to the new technology during the planning stages (Table 31, next page). In most cases, the public has neither supported nor opposed smart card technology. Fewer respondents reported some level of support from community groups, rider groups, advocacy groups, elected representatives, and other public organizations/departments, but support has not been strong in most cases. In addition, one agency received support from major employers, and another received support from the city department of technology.

**Table 31 Public Support for Smart Card Systems<sup>11</sup>**

Group / Institution	Strong Support	Support	Neutral	Opposition	Strong Opposition	Do not know/Not Sure	Total
Community group	2	9	45	0	0	33	89
Rider group	3	14	39	0	0	33	89
Advocacy group	2	8	41	0	0	38	89
Elected representatives	1	12	25	0	1	24	63
Local business group	0	5	32	0	0	26	63
Banks/Financial Institutions	0	1	35	0	0	27	63
Other public orgs/depts.	0	9	29	0	0	25	63
Other	1	2	8	1	0	15	-

*Contracted vendors for the system*

We asked SA and IO respondents to identify their contracted vendors for smart card systems. Table 32 displays that Cubic is the most employed vendor, followed by ERG. GFI-Genfare and Ascom are contracted only by a few agencies each. Two agencies contract with multiple vendors – one agency uses two vendors, and the other agency has three vendors. Other vendors mentioned include Fare Logistics, Rising Tide, and Sheidt & Bachman.

**Table 32 Contracted Vendors**

Vendor	F	%
Cubic	11	23%
ERG	10	21%
GFI - Genfare	3	6%
Ascom	2	4%
Do not know/not Sure	12	26%
Other	9	19%
<b>Total Respondents</b>	<b>47</b>	<b>100%</b>

<sup>11</sup> Elected representatives, local business group, banks/financial institutions, and other public organizations/departments were not given as options when this question was asked of agencies that are currently considering smart cards. The total number of agencies reporting these options is therefore 63.

*Oversight and distribution of fare revenues among agencies with interoperable smart card systems*

We asked IO respondents to identify the party responsible for oversight and distribution of fare revenues for interoperable systems. Among the 32 agencies that have adopted interoperable smart card systems, 17 respondents answered this question (Table 33). We found that most agencies leave the role to either a lead operator or regional authority. The use of a third party clearinghouse for fare collection and revenue distribution seems less common, perhaps due to transaction costs of contracting out this function. Another explanation is that the proprietary nature of clearinghouse systems raises issues about whether transit agencies can readily access to their data for public reporting and planning purposes.

**Table 33 Oversight and Distribution of Fare Revenues among Agencies with Interoperable Smart Card Systems**

Responsible Organization or Party	F	%
One lead operator	6	35%
Regional Authority	5	29%
Committee of multiple agencies	1	6%
Third party, contracted services	1	6%
Other	4	24%
Total Respondents	17	100%

*Changes in fare structures and policies after implementation of smart card systems*

Smart card systems present opportunities for charging flexible fares, such as distance- or zone-based fares, or off-peak discounts. We asked agencies that adopted smart card systems if the agency changed fare structures and policies after implementing smart card systems. Table 34 on the next page shows only 15 agencies out of 47 that have adopted smart card systems answered this question. Seven respondents said their agencies changed fare structure and policies, while eight respondents said that their agencies did not. While an introduction of smart card systems is likely to give agencies an opportunity to change fare structures, it does not always lead to these policy changes. This clearly indicates that the smart card technology provides a means to carry out fare policy changes, but these policy decisions seem to be made separately from the adoption of smart card systems.



**Table 34 Changes in Fare Structures and Policies after Implementing Smart Card Systems**

Changes in Fare Structures and Policies	F	%
Yes	7	15%
No	8	17%
Do not know/Not sure	32	68%
Total Respondents	47	100%

*Lead agency in the evaluation and implementation of interoperable smart card systems*

To understand which agencies are most likely to lead the efforts in implementing smart card systems, we asked IO respondents whether a lead agency is involved (Table 35).

**Table 35 Lead Agency in Evaluating or Implementing Interoperable Smart Card Systems**

Agency	F	%
Regional Transportation Authority (RTA)	8	29%
Another transit operator	6	21%
Metropolitan Planning Organization (MPO)	6	21%
No particular lead agency	4	14%
Other institution	3	11%
RTA and another transit operator	1	4%
Total Respondents	28	100%

In most cases (86%), a lead was identified. Regional transportation authorities (RTA) were mentioned most often, followed by transit operators and metropolitan planning organizations (MPO). One respondent mentioned that an RTA and another transit operator led the effort gather, and four respondents reported no particular lead agency. Other institutions mentioned include the American Public Transportation Association (APTA), the Universal Fare System joint working group of APTA, and a regional unit.

**8. Summary and Assessment**

Drawing from web-based survey data, this report presents and analyzes information on the current status of smart card system adoption among U.S. transit agencies. We also present information about the levels of knowledge among transit agency managers about smart card technology and its costs, benefits, and risks, and levels of participation in interagency

collaborations for interoperable smart card systems. Additionally, we examine factors common to agencies that have adopted smart card systems and those that have not.

Since transit agencies in the U.S. vary widely in their goals and objectives, operating environments and characteristics, financial conditions, and clients served, it is not surprising that they also have different levels of need and interest in smart card technology and interoperable systems. Of the 368 agencies identified in the National Transit Database maintained by the Federal Transit Administration that operate at least one fixed-route transit mode, 106 agencies responded to our solicitation and participated in our survey, providing a good response rate of 29 percent. Of these 106 agencies a little less than half of them (47 agencies) have adopted or are in the process of implementing smart card systems. In addition, we found the majority of these agencies adopting smart card systems as fare media are doing so in interoperable systems (32 agencies, or 30% of all respondents) rather than stand-alone systems (15 agencies, or 14%). Of our sample, 15 agencies (14%) never considered smart card systems, 16 agencies (15%) have considered but decided not to adopt, and 26 agencies (25%) are currently considering the adoption of smart card systems. Overall, this is a nicely balanced response pool vis-à-vis smart card adoption.

### ***Principal Findings***

- *Funding availability is an important factor in agencies' decision process when considering whether to adopt a smart card system or to form or join an interoperable system.*

The often considerable up-front costs of smart card implementation are among the principal hurdles that transit agencies must overcome to adopt smart card systems. Eighty-five percent of respondents from agencies that are considering smart card systems or that have adopted smart card systems consider funding at least a “somewhat important” factor. Transit agency staff currently considering smart card systems reported funding as a more important factor than did agencies that already adopted smart card systems; 54 percent of respondents currently considering smart card systems view funding as “very important,” compared to only 27 and 19 percent of respondents from agencies that have adopted stand-alone and interoperable systems respectively.

Smart card technology is still relatively new and therefore has not yet become a “must” or a standard feature for transit operators to provide services. Without external funding to jump start

smart cards systems, transit agency managers are likely to instead prioritize the purchase of new vehicles and equipment needed for present services. In addition, agencies need enough ridership to justify the high capital investment on smart card systems. In this sense, small agencies that serve low ridership areas and that do not have external funds dedicated for smart card systems are the least likely to adopt smart card systems as fare.

Apart from respondents' ratings of the importance of funding, our analysis also shows that more than half of the 16 agencies that ultimately rejected smart card systems did not have any funds. And the availability of funding increases the likelihood of adopting smart card systems: among agencies that had some access to smart card funding, 64 percent adopted smart card systems. In contrast, among agencies that had no access to funding, only 18 percent adopted smart card systems. For interoperable systems, this pattern is even more distinct; 45 percent of agencies with some sort of funds adopted interoperable smart card systems, compared to only nine percent of agencies with no funds.

Funding sources vary between stand-alone and interoperable smart card systems. Respondents reported that the main funding sources for stand-alone systems are local. While such agencies also have access to state and federal funds, no agencies with stand-alone systems in our survey received regional funds. In contrast, agencies with interoperable systems are likely to have regional, state, and federal funds rather than local funds. Availability of regional funds for agencies with interoperable systems is understandable because interoperable systems are usually formed in a consortium of operators in a given region. In some cases, some agencies in a region may be mandated to participate with compensation of funding for equipment purchase.

- *Agencies that have partnerships with other operators on ITS programs may more easily form interoperable smart card systems. Other collaborative practices, such as partnerships with non-transit organization for special group fare programs or participation on regional governance committees do not increase agencies' likelihood of adopting smart card technology.*

While there is some indication that implementation of other ITS programs is related to the higher likelihood of adoption of smart card technology, it is not strong. However, we found that agencies that have implemented other ITS technologies in partnership with other operators are more likely to adopt interoperable smart card systems. This is probably because the precedence

of partnering provides clear avenues for negotiating and joint decision-making around interoperable systems. These findings suggest that when forming interoperable smart card systems, agencies' familiarity with technology is less important than their ability to form institutional partnerships.

Contrary to our expectations, however, the survey results show that agencies that have working relationships with non-transit agencies (such as large employers or schools and universities) and offer special group fare discounts are actually less likely to adopt smart card systems. This surprising finding may be because partnering with other organizations for special group fare programs does not necessarily require the use of smart card technology, as other fare media (such as magnetic strip cards or flash passes), can meet most required specifications. Respondents did report, however, that they expect partnering opportunities will increase with the use of smart card technology, and that they consider this advantage very beneficial.

- *Transit agency staff and managers generally reported high levels of smart card benefits, but perceived costs and risks as less significant. Most frequently reported benefits were customer convenience and data collection, while the most frequently (and highest) reported cost and risk were initial equipment procurement and complications in agreements and coordination among participating agencies.*

Our survey analysis shows a bias in perception among respondents about the benefits, costs, and risks of smart card systems; specifically, respondents frequently reported high levels of benefits, but less frequently reported high costs and risks. At the same time, respondents reported that the most significant barriers to smart card adoption are the cost and the availability of funding. The bias in perception may be due to the lack of information about actual costs and risks of smart card systems, as reflected in the body of literature that tends to promote (rather than evaluate) new smart card technology. And, the primary reason for not considering smart cards were lack of information and the low priority of smart cards given other competing demands on the agency.

The perception of benefits varies among agencies with different statuses of smart card system adoption and implementation. Not surprisingly, agencies that are currently considering or have adopted smart card systems generally perceive more benefits than agencies that never considered or that rejected smart card systems. And, as expected, agencies that rejected smart card systems

expressed stronger perceptions of costs and risks than other groups of agencies. However, agencies with stand-alone systems tended to rate benefits higher than agencies with interoperable systems, and this may be explained by the following two factors. First, agencies may implement stand-alone smart card systems with clear goals, such as improving service reliability and customer convenience. Second, some agencies in interoperable systems may be participating in a consortium without high expectations of reaping great benefits.

Although the literature on smart card systems persistently describes lower maintenance needed for smart card system equipment, it is very unlikely that smart card technology can replace all of conventional fare media, especially cash, in the near future because segments of transit users, such as low-income and infrequent riders, will still need to pay fares in cash. Empirically, we find that indeed all agencies that charge fares keep cash as a fare medium despite adoption of smart card systems.

In general, when respondents indicated high costs of smart card systems, they primarily identified the capital costs of initial equipment. The survey shows that only two agencies pursuing smart card systems are doing so without external funding. These two findings combined emphasize the importance of capital funds for the initial investment in smart card systems. Additionally, agencies that have adopted smart card systems perceive operating and maintenance costs to be more costly than do agencies that have not implemented smart card systems. This may indicate that agencies underestimate the operating costs of smart card systems prior to implementation.

- *Respondents identified various factors that are important in the consideration of smart card systems. Primary factors include the cost and maintenance of fare collection, data collection for reporting and planning purposes, and the availability of funding.*

The cost and maintenance of fare collection systems were considered very important in all agencies' decisions on whether or not to adopt smart card systems, but agencies that are currently considering smart card systems disproportionately reported this as very important, while agencies that already adopted smart cards (as stand-alone or interoperable systems) did not. This may indicate that the reduction of fare equipment maintenance and associated costs, often claimed by the literature, is not as significant once agencies have adopted and implemented their systems.

In addition, agencies with stand-alone systems viewed smart card technology's capability for data collection for planning purposes as very important, more so than agencies with interoperable systems. This implies that fewer agencies are adopting interoperable systems with the primary objective of collecting more comprehensive travel data – one of the major benefits of smart card systems often mentioned in the literature.

The ability to implement flexible, fine-tuned fares (such as off-peak discounts or distance-based fares) received relatively lower scores as an important factor in decision making than expected. In addition, less than half of the respondents from agencies with smart card systems reported changing fare structures or policies after implementing their new systems. These findings indicate that an introduction of smart card technology does not necessarily lead to changes in fare policies, probably because fare policy changes are often highly political and difficult to initiate and pass.

Among the agencies that did change fare policies, however, it is unclear from the survey whether these changes were in *response* to the new technology (such as fare incentives to increase smart card use among riders) or the driving motivation for smart card system adoption (advanced collection system to carry out a fare policy change).

- *Managers, CEOs, and agency staff members are key players in planning and implementing smart card systems. Board members and the public are generally neutral or provide only moderate support for the adoption of smart card systems. Where smart cards have been implemented in interoperable systems, regional authorities, transit operators, and metropolitan planning organizations have tended to take the lead in revenue sharing among operators.*

From the survey, we found that agency managers and CEOs, and staff members were the most frequently reported leaders in both initiating and sustaining the process of evaluating, adopting, and implementing smart card systems. Despite the bevy of rider benefits commonly reported in the smart card literature, our respondents either did not know whether the public supported or opposed the new fare collection systems, or they reported that the public has been generally neutral.

In most cases, leadership in evaluation and/or implementation of interoperable smart card systems is taken by a regional authority, a particular lead transit operator, or a metropolitan

planning organization. It is unclear from our survey, however, which agency (and what level of governance) is most effective for leading and coordinating multiple transit operators. The fact that regional (rather than state) agencies are currently leading the charge means that interoperable smart card systems have been planned and implemented at the regional level in most cases.

We were surprised to find in our survey that only one respondent mentioned the use of a contracted clearinghouse. Our survey data do not allow us to determine whether this means that transit operators in interoperable smart card systems are satisfied with the present arrangement of revenue sharing administered by a regional authority or one lead agency. Instead, public agencies may simply be reluctant to contract out this function to the private sector due to concerns about large transaction costs and/or public accounting issues.

## **9. Next Steps**

Because survey analyses presented in this report are limited to descriptive statistics, we can draw only preliminary conclusions about the relationships between operating characteristics and the adoption of smart card systems. Consequently, we are unable to infer the direction of causality, the nature of interoperable agreements between agencies, or the processes of decision-making around smart card system evaluation and adoption. Next steps of our research include exploration of the following related questions:

- Are there characteristics that make some operators more or less likely to adopt smart card systems?
- Do perceptions of smart card benefits, costs, and risks affect whether agencies adopt smart card systems, or does the adoption of smart card systems influence the perceptions about project benefits, costs, and risks?
- What are the motivations for smart card system adoption, and how do agency staff members manage the uncertainty of the associated costs and risks?
- How are decisions made around the adoption of smart card systems either as stand-alone systems or as interoperable systems?
- What are institutional arrangements, barriers and catalysts to the formation of interoperable systems?
- What are the short- and long-term applications of smart card technology?

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## Appendix A: Definition of smart card technology

### *Basic definitions of smart cards and smart card systems*

In this report, we define **smart cards** as the fare media, specifically referring to the credit-card sized ISO cards that transit riders use to pay fares. Smart cards contain a microprocessor and are machine readable like commonly used magnetic stripe cards, but are capable of multiple applications and data storage. In other sectors, smart cards are used to speed payment transactions,<sup>12</sup> have applications in data management,<sup>13</sup> and are commonly used for employee identification, security, and facility access.<sup>14</sup>

In contrast, **smart card systems** are the package of components necessary for the functionality of smart cards as fare media. For example, smart card system refers to the collection of smart cards and readers (hardware), as well as the mechanisms for data transfer and processing (software). In transit applications, the potential advantages of smart card media fare payment systems over current fare media payment systems are significant. The processing power of smart cards and smart card systems allows the storage and processing of large amounts of data. Cards also can be easily and quickly reprogrammed, similar to personal computers.<sup>15</sup>

### *Card options*

Smart card technology is available in three basic styles: (1) contact-based, (2) contactless, and (3) hybrid. **Contact-based smart card technology** is used in the same way as credit cards, and is read by sliding or inserting them in a reader head. These cards have limited value for transit as the required action of swiping or inserting them offers no speed advantage over cash

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<sup>12</sup> Maxey and Benjamin; Fleishman, Schweiger et al. (1998). "Seamless Fare Collection: Using Smart Cards For Multiple-Mode Transit Trips," in APTA 2001 Rail Transit Conference Proceedings, Vol. 2005 McDonald, N. (2000). "Multipurpose Smart Cards in Transportation: Benefits and Barriers to Use." *UCTC Research Papers*: 27.

<sup>13</sup> Blobel, B., P. Pharow, et al. (2001). "Securing interoperability between chip card medical information systems and health networks." *International Journal of Medical Informatics* 64: 401-415.

<sup>14</sup> Messmer, E. (2004). Feds eyeing one access model for all. *Network World*. 21. Holcombe, B. (2005). *Government Smart Card Handbook*. US General Services Administration. Washington, D.C., US General Services Administration: 262.

<sup>15</sup> Zandbergen, A. (1994). *IC Cards in Transport: Applications and Standards*. Towards and Intelligent Transport System, Paris. Christian, F. (1997). What makes the smartcard smart? *Mass Transit*. 22. Christian, F. (2003). Introduction. *The Parking Professional*: 43-47.

transactions.<sup>16,17</sup> **Contactless cards** – sometimes referred to as tap or proximity cards – operate with a radio frequency (RF) wireless signal with a range of about 10 cm or less.<sup>18</sup> These cards are much faster in payment transactions than cash, and are viable alternatives as fare media for transit operators. **Hybrid or combination cards** have two embedded processing chips, but true hybrids cannot transfer data between one chip and another because the cards are designed to operate with two distinct processing environments. These cards can be swiped, and they can be used by a contactless reader, but the data stored by each processor, including pre-paid transit fares, can only be assigned to one processor or the other. This is an important point because contact-based and contactless transactions use different processors, meaning a contactless card cannot be read by a contact-based reader and visa-versa. This has implications for interoperability across transit agencies and transportation modes. Hybrid cards that solve the problem of two incompatible processors in a single card are called “**combi-cards**” or **dual interface cards**. These cards are designed to be used with contact and contactless readers. They have either a single chip (with a dual processor) or two chips, each with a microprocessor that can transfer value between contact-based functions (such as banking) and contactless functions (such as transit).

#### *Stand-alone vs. interoperable systems*

The range of smart card applications available to a user can include single uses such as fare collection for one transit operator, to multiple uses such as one fare card used across multiple transit operators within a region, or across multiple modes (for example, a transit card that can also be used for electronic toll collections,<sup>19</sup> or parking fees.<sup>20</sup>) Multi-purpose applications can even extend into the use of one smart card across many sectors (such as transit, employer and

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<sup>16</sup> While the speed of the transactions may not increase with contact cards, there may be advantages over cash by reducing fare fraud. Unfortunately, fare fraud is not easily estimated and the effects are not well understood. This is further explained in the fare policy section.

<sup>17</sup> Zandbergen, A. (1994). *IC Cards in Transport: Applications and Standards*. Towards and Intelligent Transport System, Paris.

<sup>18</sup> Multisystems Inc., Mundle and Associates Inc., et al. (2003). *Fare Policies, Structures and Technologies: Update Report 94*. Transit Cooperative Research Program. Washington, D.C., Transportation Research Board: 184.

<sup>19</sup> Libbrecht, R. and T. Oy (1999). *Area Report 1998-Fare Collection and Integrated Payment*. E. C. DGXIII.

<sup>20</sup> Shoup, D. (2005). *The High Cost of Free Parking*. Chicago, Planners Press. Smart Card Alliance (2003). *Transit and Retail Payment: Opportunities for Collaboration and Convergence*. S. C. Alliance. Princeton Junction, New Jersey: 30.

university services,<sup>21</sup> retail transactions,<sup>22</sup> or banking), or across geographic regions and jurisdictions. Obviously, multiple-application systems allow many more partners in the system, greatly enhancing the potential usefulness of the cards, especially for occasional transit users.<sup>23</sup>

The system applications (single or multiple) have implications for the selection of card technology. Although contact cards are often the lowest common platform for multiple agencies and uses,<sup>24</sup> they may not be suitable when handling transactions for multiple modes that demand different operating parameters. For example, highway toll collection may require cards to operate over a longer distance between transponder and receiver so that drivers may pass under a gantry without slowing down,<sup>25</sup> while transit fare collection may require that cards be read only within close proximity of the fare box to prevent inadvertent charges when a cardholder passes near a fare box.

Despite these issues around multiple uses, our survey and report is limited to the use of smart cards for fare collection on transit agencies only, and throughout the report, we describe single-operator smart card systems as **stand-alone systems**, and multiple-operator systems as **interoperable systems**.

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<sup>21</sup> Foote, P. and D. G. Stuart (2000). "Impacts of Transit Fare Policy Initiatives Under an Automated Fare System." *Transportation Quarterly* 54(3): 15. Giuliano, G., J. E. Moore, II, et al. (2000). "Integrated Smart-Card fare System: Results from Field Operational Test." *Transportation Research Record* 1735(1735): 138-146.

<sup>22</sup> Michael, S. (2005). Experts say culture hinders single smart card. *Federal Computer Week*: 2

<sup>23</sup> Smart Card Alliance (2003). *Transit and Retail Payment: Opportunities for Collaboration and Convergence*. S. C. Alliance. Princeton Junction, New Jersey: 30.

<sup>24</sup> Fleishman, D., C. Schweiger, et al. (1998). *Multipurpose Transit Payment Media Report 32*. Transit Cooperative Research Program. Washington, D.C., Transportation Research Board.

<sup>25</sup> Chapman, B. (2001). *White Paper on Establishing Interoperability of the Caltrans FasTrak Electronic Toll Collection System with Regional and Local SmartCard Transit payment Systems now being Deployed within the State of California*. Caltrans. Sacramento.

## Appendix B: Survey invitation letter

Dear Colleague,

We are writing to ask you to participate in a survey of transit agencies about smart card systems for fare collection. On behalf of the California Department of Transportation, researchers at UCLA are studying the extent to which transit agencies have considered (or are considering) the use of smart card technology for fare media. Our aim is to better understand why some transit operators are choosing to move to smart card systems, while others are not.

This survey of U.S. public transit operators is a central part of that research. As such, we are interested in learning more about that status of smart card systems at your transit agency. Deciding whether your agency will respond to this survey and, should your agency choose to respond, who from your organization is the best person to complete the survey is entirely up to your agency.

We ask that you complete our online and very user-friendly survey by Friday, October 14. The survey is located at: <http://www.spa.ucla.edu/its/smartcard/index.cfm>. From the front page of the survey, you will need to create a log in identification. Once the log in is complete, you will be directed to the first page of the survey.

The survey contains both multiple choice and open-ended questions, and should take about 20 minutes to complete. Because it is conducted on-line, if you do not complete the survey today, you can save your responses without submitting them and return to it at a later time. However, you are under no obligation to complete the survey once you have started it.

Again, your participation in this survey is voluntary. Individual responses by your agency will be viewed only by the UCLA researchers working on this project and will not be shared with the California Department of Transportation, or any other individuals or organizations. Further, none of your agency's responses will be presented in any publications or other materials produced from this research in a way that identifies the person responding or transit agency without your explicit authorization.

Should you have any questions about this research or your participation in it, feel free to contact:

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