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Electronic Toll Collection Interoperability Study in Brazil

Task 2 – Economic and Financial Analysis
Task 3 – Environmental/Societal Analysis

Prepared for

Associação Brasileira de Concessionárias de Rodovias

Associação Brasileira de Concessionárias de Rodovias

Prepared by

Parsons Brinckerhoff International

SET
Consultoria Ltda.

PB 100 YEARS

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Electronic Toll Collection Interoperability Study in Brazil

Task 2 - Economic and Financial Analysis

Associação Brasileira de Concessionárias de Rodovias ABCR

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TASK 2. ECONOMIC AND FINANCIAL ANALYSIS

Electronic toll collection (ETC) systems are in the early phases of operation. Information from existing ETC installations indicates that the initial costs versus derived benefits are very sensitive to assumptions. Careful analysis of all ETC factors is required to determine the total benefit.

Important to the analysis is the projected customer category (commuter, occasional user, etc.) and their utilization of the ETC system. Experience has shown that ETC start up is slow with the initial users being those "converted" from automatic and manual toll lanes. Some U.S. data shows that the majority of toll road revenues and also ETC revenues are non-commuters.(1) While this data may not be relevant to toll roads where there are no competitive alternative such as the Rio-Niteroi Bridge, it emphasizes the need to know the toll road revenue producers - not just the number of customer purchased tags.

The establishment of an interoperable toll tag system that permits and encourages customers to use multiple toll facilities helps convince existing and new ETC users that convenience is a worthwhile investment. It results in 1) an increased rate of ETC customer recruitment, 2) cost sharing in sales and customer service centers and, 3) the potential for earlier recovery of ETC capital investment costs. As more concessionaires migrate to an interoperable ETC system, financial institutions will be attracted to invest - especially with the potential to expand the tag systems to non toll road applications (parking, car washes, fueling, etc.)

The purpose of this task is to identify the ETC costs and benefits - starting with the basic ETC case and then identifying the added costs and benefits for interoperable ETC systems. Alternative benefits of standardization will be identified. ETC maintenance requirements and system maintenance support will be described. Finally, the international interoperability benefits will be discussed including a relevant prototype test in the United States.

SUBTASK 2.1. COST BENEFIT ANALYSIS

2.1.1. Costs And Benefits Of Stand Alone ETC Systems - The Case Where Interoperability Does Not Exist.

Direct Benefits Of ETC Systems

Reduction in Labor Costs: The biggest cost benefit of ETC is the savings in toll plaza lane labor and associated fringe benefit costs, etc. This benefit occurs when ETC usage increases to a point where conventional lanes (manual) can be eliminated. You will always need at least one manual lane and, when plaza design requires a maximum number of lanes for peak conditions, the ratio of ETC lanes to manual can be reduced over time as ETC usage grows. The ideal is to have only one manual lane unless peak conditions will have a large number of

non-ETC users (tourists visiting parks, sporting events, etc.). It is recommended that all lanes be ETC equipped so as to always have the option of designating the manual lane(s).

Customer Convenience/Potential for Increased Revenues: ETC provides the toll facility customers increased convenience - a long term goal is to attract more customers to use the toll roads. Commuter vehicles account for most of the initial ETC users. In many toll roads, the commercial customers are a key factor in the gross revenues. For example, busses are a major user of the Rio-Niteroi Bridge. Commercial users often follow company policy on toll road use - time saved versus toll costs, toll rate discounts, alternate routes, etc. Marketing can be the key to the expansion of ETC customer revenues.

Reduction in Customer Transaction Costs: Initially, there will be a reduced savings because of the need to have staffing and financial institution support to handle cash transactions. As the number of ETC lanes increase, savings in staff handling cash will result at the larger plazas. At smaller plazas, new operating procedures should be considered (toll takers making their own deposits at the end of the shift, etc.) to help reduce labor costs. Also relevant is the reduction in toll ticket or other media (smart cards, etc.) costs - printing, shipping and sales expenses, etc.

Increased Security and Auditibility: Since cash handling is reduced with ETC systems, the loss of revenue due to theft (plaza lanes, counting rooms, etc.) decreases. Since most Brazilian concessionaire operated toll roads employ automatic vehicle classification systems, the results can be directly correlated with toll transactions.

Operations and Maintenance Cost Reduction: Because ETC lanes replace manual and automatic lanes and ETC maintenance is reduced on a per lane basis, maintenance cost will be reduced. Also relevant is the reduction in equipment replacement costs - automatic and manual lane equipment require more frequent replacement than ETC equipment. U.S. survey results revealed that the Oklahoma Toll Road found a 10 to 1 reduction in ETC maintenance compared with automatic and manual lanes costs.

Interest Earned on Customers Account Balance: Termed the "float" or "deferred customer revenues", interest income can be earned on the amount of the credit balance in the customers account.

Reduction in Plaza Area Requirements: because ETC lanes can accommodate more vehicles (up to 1600 to 2000 vehicles moving at road speed – the maximum safe speed in the vicinity of the plaza), additional land needs can be avoided either when plaza expansion is required or during initial plaza design.

Indirect Benefits For ETC Systems

Customer Convenience, Time Savings, Service to Patrons: A key sales factor for all customers especially for commercial vehicle users. While it may be possible to estimate the time saved by ETC, the value assigned to a minute of time saved is often the subject of debate. Commercial users are more experienced in factoring time saved into the efficiency of their fleet operations. An hour of time saved results in a savings of labor costs and reduced wear on the commercial vehicle.

Reduction in Toll Plaza Accidents: Initially, U.S. data show accidents often increase immediately after ETC operation begins with an eventual decrease after the customers become familiar with the new plaza traffic flow patterns. Clear signage and lane markings that minimize "lane weaving" should result in a long term reduction in accidents. Because Brazilian concessionaires are responsible for emergency services, the long term impact could be a reduction of these support costs.
Reduction in Time Vehicles Move at Reduced Speed: Slow average speeds - vehicles stopped, vehicles changing speeds, etc. add to vehicle wear and increased pollution. The State of Oregon, in an analysis of the savings due to electronic clearance for commercial vehicles, stated that the wear on a truck engine at idle speed is five times the road speed wear. There is also additional wear (transmission, brakes, etc.) due to starting and stopping of the vehicle at check points which equate to toll plazas.

The pollution reduction factors are described in Task 3.

ETC System Generated Customer Usage Data: Knowledge of your customer patterns of toll road usage can help improve overall marketing and management of the toll facility. For example, if there is a large percentage of infrequent ETC users, the frequency of their customer account statements can be reduced

2.1.2. DIRECT COSTS OF ETC

ETC Capital Costs

ETC Toll Lane Costs: The material and installations costs for ETC readers, RF antennas, equipment interfaces to the lane controller, patron feedback systems, ETC unique in lane signage, and plaza to lane communications. Patron feedback systems are signs/lights that control the lane, advise if tag needs to have value added, etc. ETC unique in-lane signage are signs that direct the ETC users to the proper lanes prior to the plaza (a major problem that in some cases has resulted in an initial increase in plaza accidents - commonly referred to weaving).

Plaza Costs: Computer system materials and installation costs including plaza to agency communications links, and plaza signage (dependent on number of overall lanes that have different payment methods - often a significant cost).

Vehicle Enforcement System Costs: Material and installation costs for the enforcement system (video cameras, etc.) and any additions to the plaza computer system.

System Costs: The installation and material costs for the agency or central computer including transactions costs for the video enforcement systems. Also included is the cost for the systems integrator.

Tag Costs: A key decision is whether to charge the customer for the tag or provide the tag free. U.S. survey results range from providing the tag free of charge to charging the customer

for the full marked up cost of the tag. The current practice in Brazil is to charge the customer for the tag - the full marked up including the import tax value of the tag.

Initial Marketing Costs: With ETC, the relationship with the customer is considerably different. In an automatic lane there is no customer interaction - many if not most of the ETC customers "come from" the automatic lanes. The customer must come to a tag store, learn and discuss the payment and toll rate options, install the tag, replenish the account, etc. Initial marketing must take these functions into account and help attract the customer to use ETC. Marketing material design, initial printing, advertising signs (many on toll road right of way) are key components for the ETC start up program. In the United States, the initial marketing campaign is a critical part of meeting projected ETC revenues.

ETC Operational Costs

Depreciation Costs: Depreciation of the capital costs in the United States are usually taken over a three to five year period. Brazilian survey results indicate the same time period for taking depreciation. Depreciation costs are for both the ETC lane investment costs and when appropriate, the tag costs - active tags have a projected five year battery life which also creates a replacement cost.

Maintenance Costs: Most of the U.S. toll authorities have made the decision to contract for ETC maintenance - initially with the company that installed the ETC system.

Vehicle Violation Enforcement Costs: ETC systems that are equipped with vehicle enforcement systems incur both additional maintenance costs as well as the labor, materials, and mailing costs for the infraction information. In the U. S, the toll road operator often provides the full enforcement service including getting the motor vehicle information and mailing the notice of violation and fine. In Brazil, a new law goes into effect in early 1998 that covers toll road violations. According to the concessionaires' contracts on Federal roads, concessionaires can receive a portion of the fines collected for overweight truck violations. This compensation is provided through a process by which, from time to time, the concessionaires and government officials review additional costs and income not originally anticipated in the contract. These costs and revenues are balanced to maintain the economic and financial equilibrium of the contract.

Back Room Costs: The costs of collecting the ETC cost from the customer - the cost of the clearing house, banking fees, credit card fees, etc. including labor and computer processing costs. Also included are the costs for customer account reporting. In the U.S. survey, these costs were often initially underestimated and were later found to be significant. The costs include printing the periodic report, stuffing it into an envelope, and postage. Many U.S. toll authorities are reducing the costs by providing reports on a quarterly or semi-annual basis versus monthly. The Brazilian survey revealed that most concessionaires charge a monthly tag rental fee which helps offset these back room costs.

Tag Sales Costs: The costs for selling the tag to the customer and providing customer support (help in mounting, replacing defective tags, etc.). These costs include: 1) labor, 2) customer telephone line charges, and 3) marketing and advertising costs. In the U.S. survey, these costs were often underestimated especially the continuing costs for customer support -

telephone line costs, labor, etc. In the Brazilian survey, it was too early to determine these costs but most concessionaires charge a tag purchase fee which helps offset these costs.

Toll Rate Structure: Some U.S. toll authorities have increased toll rates to offset ETC costs. This could include adding a fee for the use of the tag on a per transaction basis, establishing a minimum charge per month or adding a monthly charge. Customer charging strategies generally add "surcharges" for infrequent users and provide discounts for frequent users to attract new customers and encourage more frequent use for existing customers. Toll rate increases have the potential to deter customers from using ETC or if applied to all lanes, the entire toll road.

2.1.3. INTEROPERABLE ETC SYSTEM COSTS AND BENEFITS -

Common Toll Tags And Shared Services

Reduced Customer Costs: Combined sales activity results in a lower cost per Customer account - either opening a new account or servicing of an existing account. The economies of a common financial clearing house (back room) operation results in a reduction of customer transaction costs. For instance, the Rio-Niteroi Bridge and the Rio-Lagos toll activities have just initiated a joint sales and marketing operation.

In many cases, the existing plaza tag sales centers are closed with customers using a newly created consolidated customer service center. As the use of ETC expands, including the potential of expanding into other services, the resulting financial infrastructure (marketing, fees for service, etc.) should make the clearing house more attractive for financial institution investment thus further reducing the customer transaction cost.

Increased Return for Marketing Investments: Combined marketing programs will reduce costs and result in an increase of new ETC customers (new to toll facilities usage, existing customers adding additional toll road use, etc.)

Increase in ETC Toll Road Customers: A critical factor which increases overall revenue and leads to the labor savings mentioned above as more lanes are converted to ETC.

Increased Customer Convenience: ETC customers have the benefit of easier trips that involve multiple toll roads. U.S. survey results reveal that all toll facility users benefit because the other lanes (mixed, automatic, and manual) efficiency is improved - everyone benefits.

Commercial Vehicle Applications: A variety of related ETC system opportunities are available for commercial vehicles - when interoperable ETC tags are used for other (non-toll) purposes. Applications range from regulatory (safety certification, fuel taxes, credentials, international border crossing, etc.) to private sector fleet operations (maintenance, facility access, trip security, etc.). The potential for these applications are numerous and growing - a factor that should make any tag costs more acceptable to commercial vehicle operators.

Opportunity for ETC Systems to Provide Fee Payment for Other Services: More widespread use of ETC will open new services opportunities. In the United States and Europe, ETC tags

are used for electronic fee payment for parking facilities. A key ring "tag" is being used by Mobil Oil for service station fueling in the United States. To make this service more convenient, a window mounted tag is being marketed. While currently not compatible with the toll tag systems, it is an important part of a customer and financial institution awareness campaign. It could result in a trend toward the use of a common tag systems for vehicle electronic fee payment service transactions: parking, fueling, car wash, fast food drive through windows, etc. The wider the use of the ETC system, the lower the cost to the toll facilities because reduced marketing costs including the willingness of the financial institutions to help underwrite marketing and sales costs. Transition to the use of "smart cards" should attract additional users further reducing costs for toll facility operators. In the long term, it is likely that newly manufactured vehicles will have the "tag" integrated into the vehicles electronic systems with usage ranging to vehicle identification number, vehicle service information, and vehicle electronic fee payment activities.

Transition to Road Congestion Pricing: Road congestion is increasing in most urban areas. In the United States, a toll road was constructed that paralleled an existing freeway - California State Route 91 in the Los Angles area. The only way to use this new toll road is the use of an ETC tag. It is congestion priced with toll rates varied as a function of traffic and the time of day. More jurisdictions are considering congestion pricing as a way of making vehicular use less attractive and hopefully encouraging car pooling and/or conversion of users to the use of public transit. The use of ETC systems makes it much easier to "convert" the toll road to a congestion priced road.

2.1.4. COST-BENEFIT ANALYSIS

The following tables outline the costs and benefits of ETC.

Table 2.1.1. General Case - No Tag Interoperability

Capital Costs	Capital Cost Benefits
• ETC toll lane • Toll plaza computer/ communications • Central agency system (hardware/software etc.) • Toll plaza signage • Agency system computer/ systems integration • Vehicle Enforcement System (VES) • Tags (if provided at no or reduced cost to the customer)	• Increased vehicle throughput • Reduces need for additional plaza land for new lanes • Depreciation helps offset the initial ETC investment costs • Signage results in accident reduction • Increased security and financial audibility • Improvement in air quality and noise reduction

Operational Costs	Operational Benefits
• Maintenance • Vehicle Enforcement System (VES) • Financial transactions (Back room) • Tag sales • Marketing • Customer support • Emergency Medical Services	• Reduced labor costs of toll collectors • Maintenance costs are significantly reduced (compared to manual/automatic lanes) • Transaction costs are reduced due to cash/media handling • Brazilian toll rental fees offset invoicing and customer support costs • Reduction in toll plaza accidents • Interest earned on customers deposits • Additional users attracted to use toll facilities

Table 2.1.2. Toll Facility Tag Interoperability Case

Operational Costs	Operational Benefits
• Reduced tag sales costs • Reduced marketing costs • Increase in customer revenue - especially commercial • Reduced customer invoicing/account activity costs • Reduced customer support costs (labor, telephone lines, etc.)	• More return for marketing investments • Increase in toll facility customers • Increased customer convenience/efficiency • Increased commercial financial infrastructure support • Easier transition to congestion pricing • Potential to improve international commerce (borders)

SUBTASK 2.2. ALTERNATIVE BENEFITS OF AN INTEROPERABLE ETC SYSTEM

This section describes the alternative benefits of an interoperable ETC system. Alternate uses of the ETC system have been slow to develop in Europe and the United States - due primarily to the initial emphasis on getting the toll road ETC system revenue established and profitable.

Use of ETC Customer Vehicles to Develop Traffic Flow Information: Two major U.S. metropolitan areas (New York City and Houston) have installed sensors on both tolled roads and non-tolled roads to use tag equipped vehicles to develop traffic speed information - "using the vehicle as a traffic probe". The resulting information is useful in managing the toll road operations by early detection of incidents (often with the use of other sensors such as video monitoring, loop detectors, etc.). The information is usually provided to the public as

part of a display of all the road conditions in an urban area. It should be noted that public concern that the information may be used for speed enforcement is usually countered by formal statements that the information will only be used for non-enforcement purposes.

Regional Traffic and Economic Information: Travel patterns identified from toll road users are an important input to regional studies ranging from traffic flow analysis to economic development studies. Origin-destination data has been used as part of short range business decisions (motel, fast food, vehicle service, etc. investments) as well as long term regional economic development plans.

Traveler Advisory Information: Recent studies (including the U.S. National ITS Architecture Study) have made long term projections on the use of ETC in-vehicle tags as a receiver for traveler information - such as road condition warning, accident or emergency vehicle warnings, etc.

SUBTASKS 2.3 & 2.4 IDENTIFICATION OF MAINTENANCE REQUIREMENTS AND RESOURCES

Most non-ETC toll installations employ computer based management and operations systems - usually located at toll plazas and at central locations. ETC Systems add complexity to the installation and maintenance of toll collections systems. The purpose of this section is to describe the requirements introduced by ETC and preliminary experience by ETC operators in responding to these new requirements.

2.3.1. The Role of the System Integrator

Due to the introduction of new technology (radio frequency tags, etc.), most U.S. toll facility operators have made the decision to contract for system integration support - they made the determination they do not have the experienced staff to manage the ETC contracts. Only one toll authority - the New York State Thruway Authority - had the required staff to design and procure their ETC system.

The system integrator first prepares the ETC functional requirements. In some systems, the toll authority is also procuring vehicle classification systems, weigh in motion systems, and toll violator video enforcement systems which adds to the complexity of the system design. After approval of the requirements, the system integrator prepares the system design documentation - the concept of operations, design plan, acceptance test plan, etc. These are critical steps in insuring that the ETC system is integrated in the overall plaza operation and central toll management facility. After approval, the system integrator prepares the competitive system procurement specifications which is part of the Request for Proposal.

2.3.2. System Maintenance

Most U.S. toll authorities have chosen to use private contractors to either assist in or perform all the maintenance responsibilities for their ETC systems. In most cases, the contractor supplying the ETC tag system (tags, readers, lane software/hardware, etc.) has been a part of the system maintenance contract. The completion of the ETC system acceptance test is a critical phase - it insures that all the initial system performance "adjustments" have been successfully completed and the ETC lanes are certified ready for operation. Most U.S. toll authorities recommend a minimum period of three years for the ETC vendor maintenance contract.

Different ETC system vendors use customized equipment and procedures to perform periodic maintenance and troubleshoot problems. Toll authority surveys indicate that most of the difficult maintenance problems are associated with system software - versus the ETC hardware. Survey results also indicate that periodic maintenance needs are much less that those associated with manual or automatic lanes.

TASK 2.5. INTERNATIONAL BENEFITS OF INTEROPERABLE ETC SYSTEMS

This task will examine benefits of broadening the application of the ETC interoperability standard to include the movement of freight across international borders. The benefits of participating in international standard setting activities will be described.

As part of the North American Free Trade Agreement (NAFTA), the United States, Mexico and Canada agreed to examine methods to improve the movement of commodities across their mutual borders. The U.S. Department of Treasury established a new activity called International Trade Data Systems (ITDS) to negotiate, develop, install, and administer an improved process for export and import of commodities. During the Summer of 1997, the North American Trade Prototype (NATAP) system was installed at four commercial vehicle border crossing locations between the United States and Mexico and two locations between the United States and Canada. One rail crossing between the United States and Mexico was part of the test.

The NATAP system provided for advanced submission (using secure internet communications) and processing of all the documentation required for import and export of commodities. This information was provided by the shippers, freight forwarders, customs brokers who voluntarily participated in the test. Commercial vehicles were often lined up for miles at the international border crossings because their paperwork was not properly completed - it was not unusual for a truck to wait eight to twenty-four hours to get clearance to cross the border.

With the NATAP system, a RF tag was placed in the tractor unit of the commercial vehicle with a NATAP trip load number. A special lane was established at the border crossing for the NATAP commercial vehicles. The tag was "read" before it approached the Customs inspector so that when the truck reached the inspectors booth, all the preprocessed information was presented to inspector along with a picture of the driver. If the information was acceptable to

the inspector, the truck proceeded through the customs compound and out the exit - where sensors read the tag indicating the commercial vehicle had completed the process and crossed the border.

The test was a success. The three governments have agreed to continue the use of the systems operationally - the "prototype" has now transitioned to a "pilot" operation. As with many test programs, the systems were designed and installed in a hurry. As a result, different border crossing locations used different RF tags. Action is now underway to include the international borders crossing requirements in the United States lead Dedicated Short Range Communications (DSRC) standards coordination activity. Discussions are underway between the three governments on using the next generation DSRC tag as the standard for international border crossing. Successful accomplishment of this goal means that one common tag will be used by the commercial vehicle for border crossing, electronic clearance to meet the states requirements in the United States, and for the electronic payment of tolls.

Brazil could lead the way in South America in establishing a similar standardized means of expediting the flow across its international borders - a major step in the accomplishment of the Mercoursor objectives. By participating in the international activities to reach agreement on standards for a DSRC tag, Brazil could lead her neighboring countries in establishing similar programs to expedite the flow of commodities across their international borders.

Electronic Toll Collection Interoperability Study in Brazil

Task 3 - Environmental/Societal Analysis

Associação Brasileira de Concessionárias de Rodovias ABCR

PB 100 YEARS

TASK 3 ENVIRONMENTAL/SOCIETAL ANALYSIS

This task addresses the environmental and societal benefits of ETC systems. As the information collection phase for this task progressed, it became evident that quantitative environmental information from existing toll facilities is not available. The cost and complexity of data collection is the prime reason for the lack of good benefits information.

Air Quality - Two methods for projecting air quality benefits were found in a literature search. Both methods use the same procedure for estimating toll plaza conditions. Video cameras are used to estimate the motorist driving cycle - deceleration while approaching the toll booth, idling while paying the toll, and then accelerating back to normal highway speed. Congestion added to the number of these cycles including waiting time at idle. ETC estimates were made for the different plaza lane configurations - vehicle speed reduction for plaza safety and with no speed reduction.

In the first air quality projection method described by Lampe and Scott, the Clean Air Action Corporation (CAAC) collected video data at New Jersey and Massachusetts toll plazas in 1992 and developed vehicle profiles for the manual and ETC lanes. The next step involved dynamometer testing of ten vehicles of different size, model and vintage (1982 to 1992) matching the different driving cycle profiles. The CAAC results, projected for toll facilities in New Jersey and Massachusetts, have been the subject of much discussion and debate. Discussion points included the choice and maintenance condition of the test vehicles, the stated assumption that all lanes would use ETC, the projection of reduction in oxides of Nitrogen (NOx), etc. Specific results in the reference paper are not included in this section due to the uncertainty surrounding the data and assumptions.

The second projection method is described by Al-Deek et al in a unpublished September, 1997, paper submitted to the Orlando-Orange County (Florida) Expressway Authority (OOCEA). Data was collected in 1994 and 1996 at the Holland East Plaza - a fourteen lane plaza that is the busiest of all the OOCEA plazas. Data collection was more rigorous including the use of probe vehicles in improve the quality of the recorded video data. Vehicle emissions were then derived from a computer model. The conclusions in the report describe reductions in Carbon Monoxide (CO) and HydroCarbons (HC). An increase in NOx was reported due to increased speeds at the toll plaza due to ETC - "it is difficult to reduce CO and HC without increasing NOx". Again, the specific results are not included in this report because several variables were introduced in the analysis including the fact that "emission reductions are also due in part to the new tail pipe (government) standards".

The results of these analyses have indicated that ETC will improve air quality in the vicinity of the toll plaza. The reduction in number of vehicles accelerating and/or waiting at idle coupled with vehicles moving at increased speed are the primary contributors to these improvements. Most of the above analysis involves passenger vehicles. As evidenced in visits to Brazilian toll plazas, the large number of busses and

trucks that will potentially use ETC will increase the ETC contribution to air quality improvement.

Noise - Noise levels were measured and modeled in the vicinity of the New York State Thruway Tappanzee Bridge. The analysis indicated that morning peak period noise levels are lower with ETC because of the substantial reductions in the number of vehicles accelerating from stop. During the evening period, noise levels were unchanged with or without ETC - due primarily to an extended rush hour period. As stated above, increased bus and truck use of ETC would increase the benefit contribution.

Energy Analysis - ETC equipment is powered by electricity. A New York State Thruway consultant performed an energy assessment to quantify both the energy consumed by ETC equipment and the energy saved through a reduction in motor vehicle fuel consumption. Their results indicated "that ETC would produce a net decrease in energy use at the toll plaza.

Electromagnetic Radiation - The New York Thruway Authority consultant analyzed an existing study that investigated the electromagnetic radiation produced by AMTECH AVI tags to determine its relevancy to the Tappanzee Bridge. The evaluation indicated that the study is directly relevant and demonstrates that "there is adequate safety margin for the public and toll collectors. The operation of ETC equipment at the Tappanzee Bridge would not create a hazard to human health."

In summary, studies of the environmental benefits confirm what we would believe - that ETC does make a contribution to improving the environment. Unfortunately, the cost of instrumenting ETC tests has not permitted the collection of quantative data to help substantiate the contribution. Also, conditions over time have changed for before and after ETC case studies - an increase in the number of vehicles in use, changing emissions standards, etc. It appears that we will have to wait to get hard information that will permit a definitive estimate of the specific contributions.