# The Cross Israel Highway Challenge

*By Ehud Savion and Jacob Peleg*

"There are no free roads." That's the lesson three consecutive Israeli governments realized over a span of 10 years, a lesson that eventually led to the adoption of the country's first toll road. Limited land resources, along with national budget constraints and priorities, dictated the need for a new approach to addressing the country's demographic growth and road congestion, leading the government to seek alternate transportation routes that could be supported with private-sector funding. The result was the decision to begin, in 1995, evaluation of a new concept: the Cross Israel Highway Free-Flow Toll Road and, along with it, the idea of funding the road through private means and toll collection to support a return on investment (ROI), rather than via government funding and no ROI.

Today, the hundreds of thousands of commuters who travel the toll road offer undisputed testimony to the success of that decision and the process that made the concept a reality. Indeed, the Cross Israel Highway has become an inseparable part of Israeli commuters' lives. The beauty and quality of the road and its facilities, landscaping, and connecting arterials, not to mention the congestion relief the system provides, are the main reasons for the project's success.

## Highway Beginnings

The Cross Israel Highway, also known as Highway 6, is the largest build-operate-transfer (BOT) transportation infrastructure project ever implemented in Israel. The Free-Flow Toll Road, in turn, is the first of its kind in the country.

When the road was envisioned, it was expected to free up at least 15 percent of the traffic crossing the highly congested Tel-Aviv vicinity. To provide the desired bypass connection between the northern and southern regions of the country, the highway's route was directed east of the highly populated areas, with its central section covering approximately 87 kilometers and encompassing 10 interchanges, 94 bridges, 2 tunnels, 100 kilometers of agricultural service roads, and 44 kilometers of lateral roads. In addition to relieving congestion, the central section, currently undergoing expansion to the south, incorporates higher traffic speeds (110 kph as opposed to 90 kph on other area roads) and higher safety standards than older roads in the region.

The highway incorporates new asphalt technologies, high-radius turning curves, advanced crash bumpers, and textured shoulders to arouse sleepy or distracted drivers. Other features include a full-scale traffic management system with incident detection and 24/7 operator road patrollers who provide free assistance to drivers and vehicles.

## A Consortium Approach

To fund the toll road, the government contracted with the Derech Eretz Highways Consortium. The consortium's strength and success lie in its shareholder companies: Aecon/Canadian Highways Investment Corp., based in Canada; Africa-Israel Investments Ltd. (in partnership with Alon Oil Ltd.), based in Israel; and Housing & Construction Holding Co. Ltd., also in Israel. Each of these companies is involved in large-scale international projects and construction. The consortium invested more than $800 million for the current project phase of the highway, whose future expansion and major maintenance periods are accounted for in the BOT financial model.

Derech Eretz Highways Ltd., headquartered in Tel Aviv, was awarded the Cross Israel Highway project concession contract for the design, construction, and operation of the toll road for 30 years. Derech Eretz is investing $1.3 billion in private financing via shareholder equity and a syndicate of domestic and international banks.

Financial closure for the project was achieved based on a few fundamental elements: a unique toll law and related regulations adopted to legally protect the concession and the investment; a traffic forecast that substantiated the project model; and a government safety net, based on the traffic forecast, to support up to 80 percent of road use.

The project model is based on three key components: the concession contract with the State of Israel, a construction agreement with the construction joint venture (CJV) that the consortium established for the project, and an operations and maintenance (O&M) agreement with the Derech Eretz operator (DEC-Op), which is based on transportation lessons learned from around the world.

The consortium established the CJV for the sole purpose of designing, building, and commissioning the toll road on a turnkey basis. To make the toll road a reality, the CJV hired more than 150 employees and 2,000 independent workers across some 40 design and consulting firms. The entire project was successfully completed on time and on budget and met unprecedented standards of quality. Indeed, the CJV has been recognized domestically and internationally as one of the most successful organizations of its kind, mainly because of the synergy and expertise the Derech Eretz Highways venture's shareholders brought to the project.

The consortium started DEC-Op from the ground up. Because of the novelty of tolling in Israel, a complete operational system had to be envisioned and created. Departments for management, administration, human resources, maintenance, marketing, call centers, toll enforcement, finance, legal issues, information technology, and security all were established and personnel trained. The organization was also charged with overseeing civil infrastructure, including the road, bridges, tunnels, electrical and irrigation systems, and signage.

Over the toll road's start-up period, DEC-Op (with more than 300 employees) has become a model of success. Commuter satisfaction with the toll road's level of service and facilities, as evidenced by customer surveys and focus groups, among other means, is living proof of the group's success.

## A Free-Flowing Design

The toll road comprises 18 tollgates, 9 northbound and 9 southbound. Its core is based on a free-flow, all-electronic, main-line open system. A free-flow approach was mandatory because of Israel's limited land resources. With this setup, no toll plazas or tollbooths of any kind, or any barriers, are allowed, and registration is voluntary. Toll collection occurs at a minimum of three tollgates and a maximum of five to encourage commuters to drive long distances (tollgates six through nine are free of charge). The first section of the road was opened to the public on August 4, 2002, with tolling beginning in late December of that year. Finally, on April 28, 2004, the toll road, its supporting technology, the back office, and the operator organization were all fully functioning, right on schedule.

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The toll road now serves more than 75,000 commuters daily, and more than 350,000 users have registered to use it, with registration available via video or tag. Commuters may also drive the road as nonregistered, "casual" users. All payments are postpaid.

## The Complexities of the Israeli Toll Law

At the core of the Cross Israel Highway toll road's operation, including its system of toll collection and enforcement, is the country's toll-road law and associated regulations.

As noted above, the toll law, adopted in 1995, was created to provide the legal means to protect the project concessionaire and the consortium's investment. Adopting the law proved to be highly complex and technologically challenging, partly because, unlike U.S. and Canadian law, Israel's transportation law requires the license plates to remain with the vehicle after a change of ownership. This makes collecting tolls difficult during the billing period in which the vehicle changes hands. The toll law, however, allows the concessionaire to gain online access to the DMV database to extract vehicle ownership details for toll collection and enforcement, a provision developed exclusively for the toll-road project. The owner's identity can also be verified via his or her Social Security number, and the database can be accessed to check vehi-

cle ownership details at the back office and at the point of sale. The toll law defines the DMV-registered owner as the party responsible for toll payment and distinguishes between three basic toll classes: motorcycle, passenger car, and heavy vehicle (above 4,000 kilograms, or approximately 10,700 pounds).

The toll law also authorizes the concessionaire to block online annual license renewals upon a consecutive number of nonpayments of tolls, impound the violator's vehicle while he or she is using the toll road, and collect tolls in real time from violators. Ultimately, the law and the related toll-enforcement tools have proved to be the right mechanisms for successfully operating a free-flow toll road on which registration is voluntary.

## Overcoming Public Resistance

Adoption of a toll road meant the Israeli public for the first time would be required to pay tolls for a "product" that up to now had been free. Needless to say, this presented a significant obstacle for toll proponents to overcome. As noted earlier, during the first few months of the new road's operation, the first section of the system was opened to the public toll-free. More than 45,000 commuters used the section daily. After toll collection began, however, that number dropped by almost half. Successful marketing campaigns citing the benefits of the new system helped increase road use and registration. Additionally, as mentioned above, the policy of charging drivers for a minimum of three tollgates but no more than five gave commuters an incentive to drive long distances on the road.

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Public awareness of toll enforcement posed yet another obstacle. The new violation policy and accompanying penalties for toll debts were unheard of before the road's creation. As a result, the public initially contested the authority given the concessionaire to assess fines. Gradually but surely, however, the logic of the system sank in, and commuters came to realize the new means of toll enforcement were justified despite an escalation in penalties and enforcement on a scale previously unknown in the country.

## The Technology behind the System

The Cross Israel's tolling-system technology is based on Toronto's 407 ETR system and lessons learned from 407 ETR during its first phase of operation. Complementary features were added to enhance system performance and reduce operational, maintenance, and life-cycle costs. One such feature, the highway's traffic management system, was tailored to the project's tolling needs as well as to the Israeli government's tender requirements for traffic monitoring in anticipation of future toll-road expansions. The government's tender committee had introduced a novel concept into the concessionaire agreement: Road expansion regarding the main line, ramps, and overpasses was designed up front, with expansion criteria based on traffic volume, speed, delays, repeatability of events, and so on. The traffic management system produces a monthly report for all road segments and ramps for the sole purpose of evaluating potential expansion.

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In contrast to the 407 ETR's closed system, in which toll gantries are located at entry and exit points for all interchanges and ramps (more than 220 gantries total), the Cross Israel incorporates mainline, open-system architecture, with toll gantries positioned only along the road (18 gantries total). Such an approach has its own

design and implementation challenges and complexities, including segment toll time-outs and trip formation.

Unlike closed tolling systems, in which one's distance between the entry and exit ramps used forms the driver's trip, the Cross Israel's open tolling system counts a transaction each time the vehicle passes under a toll gantry. Setting up predefined travel times between gantries forms the trip based on the individual gantries passed. The toll law designates that a single tollgate transaction be debited as though the vehicle drove through three individual toll sections. When three consecutive transactions are recorded, they are counted as a single trip. When a fourth tollgate is passed, a fourth toll section is debited, and when the fifth tollgate is passed, a fifth section is debited, for a maximum of five sections traveled.

Special filters and algorithms are used at the toll-processing platform for continuous validity checks. These tailored algorithms also support virtual tollgate mechanisms to compensate for cases in which a tollgate transaction is missed or truncated for whatever reason. This mechanism is supported by the back-office toll-transaction process automatically.

As a true free-flow architecture, the Cross Israel system supports both tag and license plate reading of registered tag users or video users (registered and nonregistered). To eliminate fraud, induced violations, and billing errors, the system's data-processing techniques were taken to a new level of design that was beyond the capabilities of similar tolling technologies. Part of this new design was derived from toll-law requirements regarding the use of photographic evidence in court. For example, error-detection and validation filters were incorporated to eliminate appeals from toll-road users and reduce billing errors or incorrect readings of license plate numbers or tag keys. (The fact that Israeli license plates contain only digits has aided reading accuracy.) The system also uses manual video processing to identify the jurisdiction and license plate number for those vehicles whose plates cannot be read automatically or to verify the identity of a driver who commits a violation detected by automatic image processing.

Special care was taken to provide electronic tolling and traffic management (ETTM) with high availability, minimum downtime, redundancy, failsafe modes, and data backup. Integrated diagnostics are built into all roadside and central system components, and all reporting components are integrated with a central diagnostics system.

## Innovative Enforcement Required

The Cross Israel toll road's free-flow nature and the acceptance of casual, nonregistered users required an innovative approach to tolling enforcement. The resulting system not only identifies and maintains a history of violators but also allows real-time enforcement against habitual violators using patrol vehicles that intercept the violator after being sent a dispatch once the violator enters the highway.

The real-time enforcement process is initiated when the toll revenue management and billing system identifies that a registered customer or casual user has not paid tolls incurred. If a customer's payment history is sufficiently poor, the system obtains any necessary additional identification information from the DMV and may

add the customer's vehicle to a list of those eligible for real-time enforcement.

Real-time enforcement commences when the system detects that a listed violator has entered the highway and passed a tollgate. At that point, an alert message including the violator's license plate number, vehicle description, owner information, and summary account information is sent to a network of mobile toll-enforcement terminals via a dedicated cellular communication network. Each enforcement terminal is assigned an "area of interest." Alerts are sent to all terminals but are displayed on only those units with an area of interest overlapping the violator's location at the time of detection. Enforcement notification starts within eight seconds after the violating vehicle or tag passes through the tollgate. If the violator fails to stop for the patrol vehicle, he or she is perceived as breaking the law, and hired highway police officers are sent out. This method of enforcement has proved highly successful despite the significant public controversy it initially provoked. Toll-collection leakage is minimal, and casual as well as registered users are paying their invoices or debits on time to avoid fees and sanctions.

## The DSRC Component

The system's tollgates provide transaction data but also act as integrated entities to monitor travel time along a toll section to calculate time-outs and update the trip formation process as required. Each toll segment is also divided into links with the use of dedicated short-range communications (DSRC) readers. By time-stamping the tag, the readers can measure, average, and uplink travel times for central processing by the system's toll-transaction processing platform and traffic management system. These data are then used to calculate travel times and speeds as well as incident-detection algorithms.

One of the biggest problems with the DSRC protocol and the adoption of the 900 megahertz domain was complying with a very tight spectrum domain for use by cellular companies and other applications. An extensive effort to comply with the frequency regulator resulted in a workable change to the uplink and downlink frequencies and a considerably narrower band, as well as a very low noise floor to other users of the spectrum. Meanwhile, tags were designed to comply with the North American DSRC standard. The design took into account future applications and interoperability; therefore, the tag allows for software and protocol updates. In addition, a great effort was made to preserve battery life beyond eight years of operation.

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Project contract requirements dictated implementation of a traffic management system designed for highway management as well as for integration within the open-architecture tolling system. The resulting system consists of a traffic management center, a CCTV system, vehicle detection stations (to track volume, speed, and occupancy), traffic signals, electronic signs, and a tunnel management system. It provides highway surveillance, detects traffic abnormalities such as accidents and congestion, manages incidents, monitors ramps, generates traffic statistics, and provides traffic and

travel information to commuters. It also interfaces with external organizations such as police, other traffic management centers, and emergency services. Traffic statistics are extracted periodically or on demand and submitted to government representatives for review and evaluation of traffic patterns and potential road expansion. The government's safety net for comparison with the traffic forecast is based on the tolling system's highly accurate data.

## Billing System Helps Smooth the Road

The toll road's revenue management and billing system was tailored to comply with Israel's toll law and free-flow environment regulations. It establishes and maintains the customer's account, handles tag distribution and inventory control, and provides financial accounting and reporting. As a multi-interface unit, the system interacts with credit-card clearinghouses, banks, DMV offices, Web and call centers, and other entities. The DMV interface was developed jointly by the Ministry of Transportation and Derech Eretz Highways. The result is an online, secured interface that supports either batch jobs or online data queries, including the blocking or approval of annual license plate renewals as required in handling toll violations.

In the two years the Cross Israel toll road has been operating, the back-office operation center has gained a valuable core of knowledge. As many toll operators have discovered, defining how a billing system should look like in a free-flow environment is a complex job, as many independent variables (including account types, vehicles, drivers, and violations) come into play. Operational back-office issues surfaced during the first phase of our system ramp-up, reflecting the fact that free-flow tolling requires a high degree of flexibility. We also learned another important lesson: Unless back-office operations are designed based on a proven, configurable product, the system will control the operator rather than the other way around.

Because the revenue management and billing system initially was designed to meet a predefined set of rules and guidelines rather than to operate in a dynamic tolling environment (which had not previously existed in Israel), the need to enhance and upgrade the system emerged gradually during the toll road's initial operational phase. The system, including its customer relationship management (CRM) operation and call center, is undergoing an innovative redesign that will yield a parallel production facility so that the current and new systems will work side by side until full compliancy is validated.

Together, the Derech Eretz Highways Ltd. concession, the CJV, the Derech Eretz operator, and the Cross Israel Highway Free-Flow Toll Road have set new standards in the international toll industry in construction, technology, and operation. With the success the system has enjoyed thus far, surely the best is yet to come.

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