In today's car society, while individual freedom and mobility have been considerably enhanced, this has come at a price. Reducing traffic congestion, raising road safety, and lowering the environmental impact of our car-based infrastructure are now major issues. Intelligent transport systems (ITS), which incorporate some of the latest advances in information, electronics and communications technology, promise to offer at least some solutions to these problems, making motoring safer and more comfortable for all.

Research conducted in 1995 in Japan suggested that ITS could help cut road accident fatalities by 15% within 10 years, and halve them within 30 years. Levels of fuel consumption and environmental pollutants could be similarly reduced over 30 years, by 15% for fuel and carbon dioxide, and by 30% for urban NOx concentrations.

Toyota is conducting R&D in five basic fields associated with ITS: systems to make vehicles more intelligent; on-board multimedia systems; enhancing public facilities; logistics systems to control the distribution of vehicles on the road to avoid congestion; and alternative public transportation systems.

1. ADVANCED VEHICLE CONTROL SYSTEMS

Radar cruise control

Using steering angle sensors and a laser radar mounted in the front bumper, radar cruise control maintains a preset time interval from the vehicle ahead. If the system detects a slower-moving vehicle in the same lane ahead, it automatically decelerates the car through a combination of easing off on the accelerator, downshifting and compression braking. If these are insufficient to maintain the minimum time interval between the vehicles, an alarm sounds to alert the driver to take action. This interval is maintained until the road ahead clears, at which point the system automatically accelerates back up to the cruising speed. Radar cruise control is available on the Celsior, Progrès and Crown Majesta models marketed in Japan.

Navigation Cooperation Shift Control

The Navigation Cooperation Shift Control system (a feature of the Progrès model marketed in Japan) links gear shifting with the vehicle's navigation system to help drivers take turns more easily.

When the driver of a vehicle equipped with the system approaches a curve and steps on the brakes to slow down for the turn, the system "sees" the corner from the navigation data and automatically down-shifts from fourth to third gear. This slows the vehicle via compression braking before the driver prepares to take the curve. The transmission stays in third gear throughout the turn, then automatically shifts back into fourth gear once the vehicle has exited the bend. This intuitive system thus smoothes cornering and makes driving a more pleasant experience.

Blind corner monitoring

With this useful feature, miniature CCD cameras mounted on either end of a vehicle's front bumper monitor the road to right and left, and show the results on the EMV (Electro Multi-Vision) display in the instrument panel. At T-junctions and other blind intersections, this enables the driver to see whether traffic is approaching from either direction without having to move out into the junction too far. This feature is available on the Crown Hardtop, Crown Majesta, Progrès, Mark II, Chaser and Cresta models in Japan.

Advanced Cruise-Assist Highway Systems (AHS)

AHS help a vehicle interact intelligently with lane markings, surrounding vehicles, or other ITS infrastructure set up in the road to control its speed, direction and position relative to other traffic. They can assist the driver to make driving easier, and can also reduce driving risk by helping to provide early warning signals of danger ahead. On the highways of the future, AHS may even be able to control traffic completely, providing drivers with the ultimate convenience of fully automatic driving.

Having begun research as far back as 1968, Toyota succeeded in developing its first autonomous driving automated vehicle control system in 1992. The company has also participated in a number of projects in both Japan and the United States. Test stretches of road were completed in September 1996 in Japan, and in August 1997 in San Diego, USA.

Today, Toyota's R&D is focused on three different segments of AHS: conveying information to vehicles from infrastructure set up in the road; providing drivers with assistance in driving and controlling the vehicle; and, most complex of all, developing systems that can completely control vehicle operation.

Autonomous Automated Driving System

This system uses vehicle-mounted sensors to judge the vehicle's position by visual data on the white lane markings. It then uses this information to steer the vehicle. A CCD camera and image-processing unit detect lane position and direct the steering to maintain lane tracking. Forward-mounted laser radar is used to watch for slow-moving obstacles in the lane ahead, while more CCD cameras monitor vehicles in adjacent lanes. The system keeps the vehicle in the same lane provided it senses no obstacles in the road ahead. If it detects a slow-moving vehicle ahead, it directs the vehicle to change lanes, provided the way is clear. Once it has overtaken the obstacle, the system returns the vehicle to the original lane. If the next lane is occupied, the system slows the vehicle to maintain a safe braking distance. If a vehicle ahead has come to a stop, the vehicle is smoothly brought to a stop.

Automated Driving System Harmonized with the Infrastructure

This type of system fits the vehicle with sensors that can detect series of magnetic nails embedded in the center of highway lanes at fixed intervals. The vehicle's lane position is extrapolated from this data, and the steering controlled accordingly. In this system, obstacle avoidance is achieved through vehicle-mounted radar operating in conjunction with roadside devices. Through automatic braking and lane-changing, collisions can be safely avoided.

MONET (Mobile Network)

MONET is an online information system developed by Toyota to provide drivers with a means of getting a wide variety of useful information in real time. Initiated in November 1997, the service works through the vehicle's navigation system, together with a hands-free set and a digital cellular phone. Simple controls on Toyota's car navigation system enable the driver or passenger to call the Toyota Media Station for up-to-the-minute information on such things as traffic conditions, news, weather, or the locations of nearby filling stations. Information is displayed on the car navigation system screen, or, if the vehicle is moving, is relayed by an audible message. System upgrades introduced in June 1999 have made the system easier to use by facilitating Internet access and by allowing drivers to make verbal requests for information.

Mayday system

In the event of an accident or an emergency, a mayday system contacts the operation center via a mobile telephone and reports the vehicle's location and the ID number of the onboard unit. It can be configured to initiate either manually or automatically. Since the system uses GPS (Global Positioning System) technology to accurately pinpoint the vehicle's location, an automatic distress signal helps to reduce the time for assistance to reach the scene quickly. In many cases, this can prove to be a difference that saves lives. Toyota is working with the authorities to boost the system's use in practice in Japan.

3. PUBLIC FACILITIES

Electronic Toll Collection (ETC)

Manned tollbooths are one of the main factors causing congestion on toll roads in Japan. In 1994, the Japanese Ministry of Construction proposed electronic toll collection for toll highways as one part of an ITS technology development plan. Toyota has been working in collaboration with other Japanese firms to create the components of this system. To facilitate ETC, vehicles are fitted with a microwave tag located internally. This device acts as an electronic ID. When the vehicle approaches a toll gate, a signal is sent between the device and the gate so that the toll is automatically debited electronically from a prepaid card or designated bank account. Since vehicles no longer need to stop, ETC promises to be several times quicker than current manual toll collection. This should significantly reduce waiting times, alleviate congestion and benefit the environment via reduced emissions. Full-scale installation covering all major highways in Japan is now under way. Toyota is working on several types of ETC systems so as to meet varying road conditions around the world.

4. ROAD LOGISTICS SYSTEMS

TIME•t (Toyota Intelligent Mobility Enhancement for Taxis)

The TIME•t system developed by Toyota monitors the location and status of taxis in a fleet using a computer located in the dispatch center. When an order is received from a customer, the computer takes note of the passenger's location and works out which taxi is best situated to pick them up. The system notified that taxi's driver of his or her next fare's location, and can also let the customer know how long it will take for the selected taxi to arrive. The system also displays the optimum route to the customer's destination on the taxi's navigation system. By speeding up the allocation of taxis to jobs and providing precise information to customers, the system promises to help taxi companies offer a higher standard of service.

Crayon

Marrying the environmental benefits of electric vehicles (EVs) with the personal flexibility offered by cars, the Crayon EV commuter system is designed for efficient, short-distance transportation. It is a practical system based on the latest technology, and is now being road-tested by Toyota for local transport between company facilities in Toyota City, Japan. Its potential uses are myriad: as well as business use in special office or commercial zones, it could be used by residents of local communities for shared use; at tourist spots, it could provide a convenient, viable alternative to rental cars.

Practical, convenient short-distance transport

Crayon is ideal for the journeys around town covering less than 30 km per day—often with only one or two occupants per vehicle—that make up the majority of urban car use. A fleet of e-com EVs, which have a cruising range per battery charge of roughly 100 km, are made available at special depots. Users can either make a reservation over the Internet or a corporate intranet to use a vehicle, or simply turn up at a depot to use any unreserved vehicle. Since the system tracks the usage of each vehicle at all times, users can easily be billed using a fee-based system based on operating time or distance traveled.

IC card technology for efficient vehicle-sharing

Drivers using Crayon have membership IC cards to access the vehicles. Upon arriving at a depot, the driver places the card onto a card reader to conduct a start-of-use procedure to use a certain vehicle. The cards then double as keys to lock, unlock and start the vehicles. Once the period of use is over, a similar card-based end-of-use procedure tells the system the vehicle is available for another user. This card system enables the fleet of vehicles to be used by many members, boosting the efficiency of vehicle use.

Zip around! Battery drain is no worry

Various features of the Crayon system ensure that the EVs in the fleet are always sufficiently charged. First, a management system at the depots tracks the battery charge status of each vehicle, and allocates vehicles to users according to this information. In addition, the car navigation system and on-board mobile telephone fitted in every vehicle keep the central management system informed about vehicle location via the MONET online information system at regular intervals. To prevent unexpected battery die-out, the central system alerts the driver via the mobile phone if they are about to go too far from a charging station or venture outside the system's designated area of use.

Charging is simple because the e-com EVs come equipped with two charging sockets. One allows the battery to be recharged overnight on household 100V current should the driver take the vehicle home. The other can be used at special charging units located at the depots to give the battery a quick 200V recharge as necessary.

Easy on the environment

Because the e-com is totally emission-free, the Crayon system provides an extremely environment-friendly alternative for short-distance commuting. The vehicles are also quiet, which reduces local noise pollution, and compact, which reduces overall energy consumption.

Intelligent Multi-Mode Transit System (IMTS)

IMTS is a public transportation system developed by Toyota that combines the advantages of railways and road systems. Currently undergoing trial runs on an experimental route at the company's Higashifuji Technical Center in Shizuoka Prefecture, Japan, IMTS uses train-like buses that can run automatically on dedicated thoroughfares, as well as being capable of normal manual operation on regular roads.

The "train routes" for these specially adapted buses are created by embedding magnetic nails in the road to create a vehicle/infrastructure automation system. The buses run on these roads automatically

using lane-tracking functions. Obstacle-detection systems prevent them from colliding with anything in the lane, while a road-to-vehicle communications system controls the buses' arrival and departure at stations along the route. In addition, extremely high-frequency radar and infrared vehicle-to-vehicle communications technology maintain the distance between vehicles, allowing up to six buses to "platoon," forming a train-like convoy.

Since there are no mechanical couplings between them, the number of buses used can be easily adjusted to meet fluctuating demand. They use a newly-developed, low-emission compressed natural gas (CNG) engine, making them highly fuel-efficient. Yet because they are based on mass-produced models, they can be maintained at normal service stations. Further, the lack of rails or overhead power lines substantially reduces the system's construction and maintenance costs.

IMTS can carry substantial numbers of people over medium distances. As such, it could be used to connect airports or train stations with surrounding cities, or provide a method of creating high-capacity bus routes between city centers and suburban areas, or even between provincial cities.