Optimization of In-Vehicle Information Systems

Japanese Experience w/ Navigation systems

TOYOTA MOTOR CORPORATION

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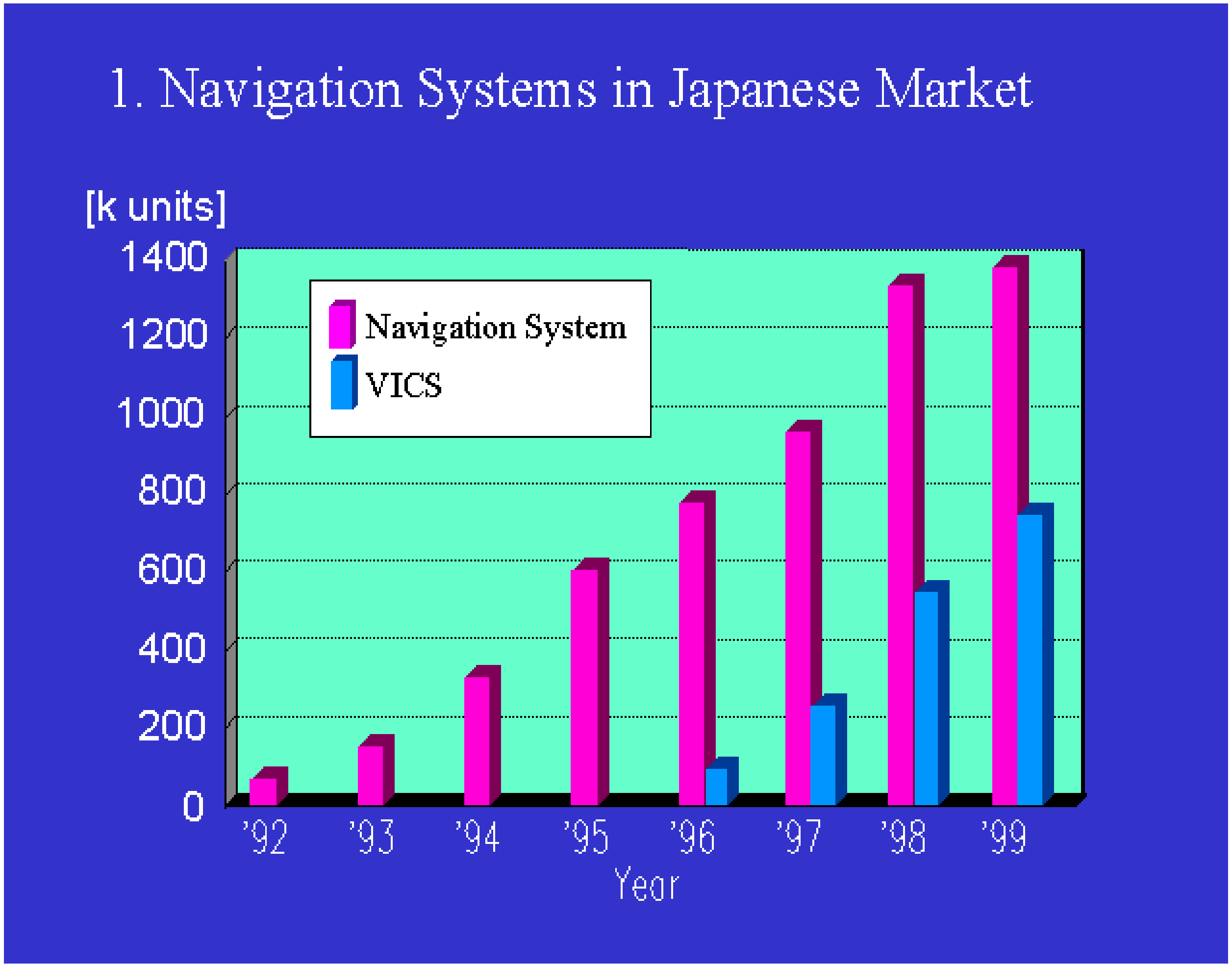
In this presentation, Toyota provides information for discussion that focuses mainly on the Japanese experience related to navigation systems.



In Japan, navigation systems with displays were first introduced in 1985.

In November of 1990, the first guidelines for safety were established, and thereafter, navigation systems sold by both OEMs and aftermarket manufacturers were being designed with safety considerations.

Also, in 1996, VICS (Vehicle Information and Communications System) was developed and introduced.

1. Navigation Systems in Japanese Market

- Sales of car navigation systems were well over 2 million in 1999.
  - ⇨ There are not many traffic accidents related to navigation systems due to JAMA's Safety Guideline. Few accidents relative to volume of sales
- VICS (Vehicle Information and Communication System) has been in service since 1996. It has been rapidly increasing.
  - ⇨ It provides dynamic traffic information directly on the map.

The sales of navigation systems exceeded 1.38 million units in 1999, and accumulated to 5 million in market.

Despite such expansion, there has not been an appreciable increase of traffic accidents caused by navigation.

After the introduction of VICS in 1996, sales further expanded. VICS provides traffic information, such as traffic congestion information, on a navigation monitor. This helps relax traffic congestion by providing timely information and allowing the driver to consider alternative routes.

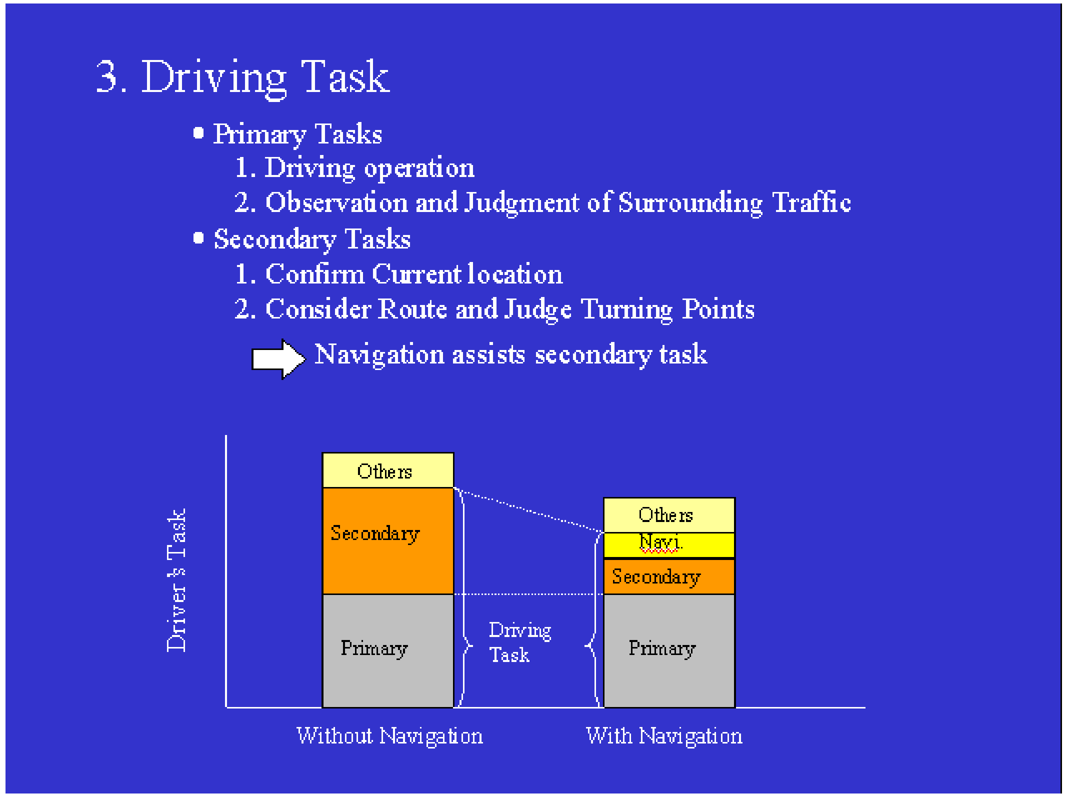
Recently, the number of vehicles with navigation systems with VICS as a standard feature have been increasing in Japan.

2. Effectiveness of Navigation System

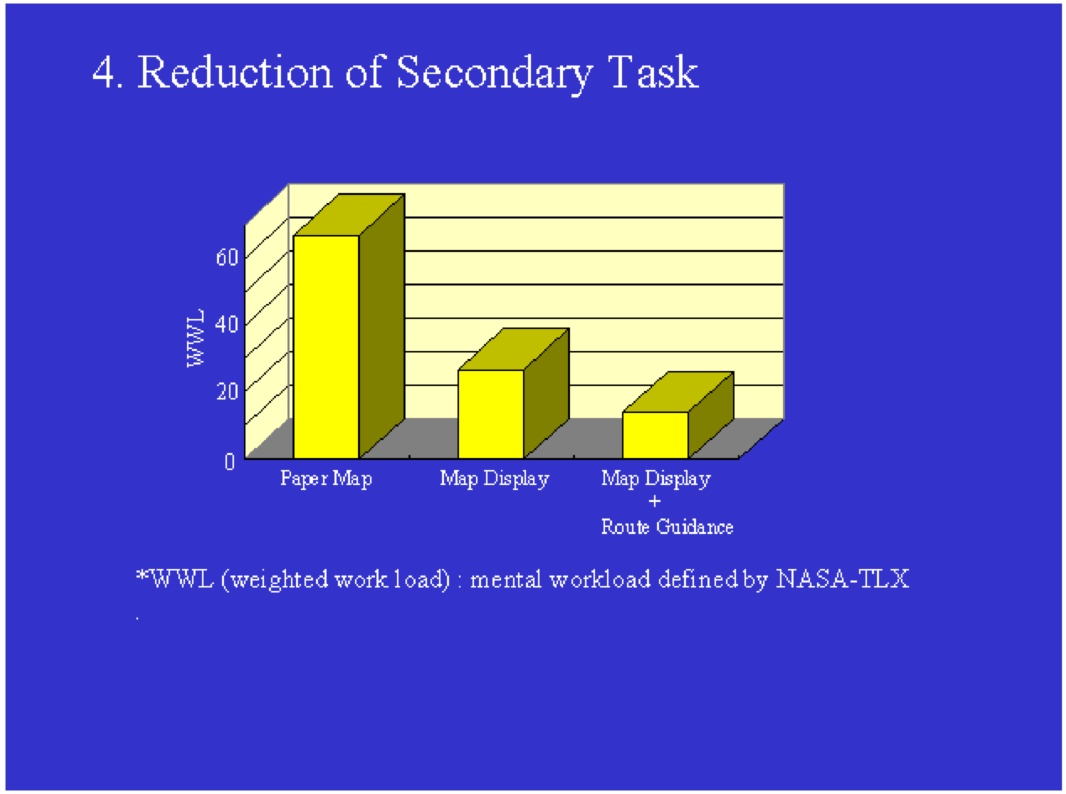
- Considered a core technology of ITS. Navigation systems communicate information with sources outside the vehicle.
- Helps relax traffic congestion by informing drivers of the congestion and allowing them to plan alternative routes.
- Reduces driver uncertainty by allowing them to recognize their current location and by making driving in unfamiliar places easier.

The following is the effectiveness of navigation systems:

- Navigation system is a core technology of ITS, and it enables communication with outside sources.
- It helps relax traffic congestion by informing drivers of the congestion and allowing them to take alternative routes, thus distributing traffic flow.
- It reduces drivers' uncertainty by helping them recognize their current location and by making driving in unfamiliar places easier.



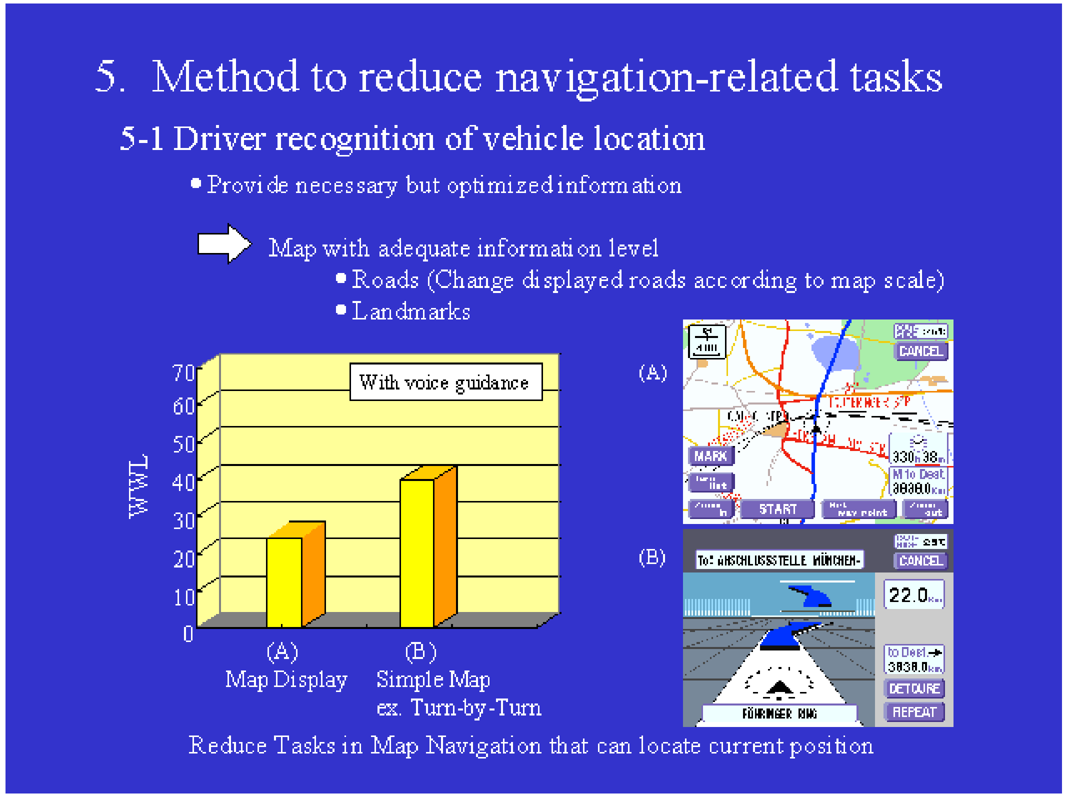
In the driving environment, a driver needs to perform driving tasks in combination with other tasks such as operating the radio, wipers, etc. Therefore, we can separate driving tasks into two main areas.
First, the primary task is driving, i.e. operation of steering, braking, etc.
Second, the secondary tasks are observing conditions in the driving environment and judging surrounding traffic conditions.
The secondary tasks also relate to navigation, which include:
1. Looking at the road environment, road signs and names, to locate oneself as to know where he/she is;
2. Making decisions based upon the environment, such as knowing when to make turns and recalling a route to a given destination.
Vehicle navigation systems can assist drivers in performing these types of secondary tasks.
The graph depicts different relative “magnitudes” of tasks when driving without navigation (left) and with navigation (right).
When we use a correctly designed navigation system, we can afford to spend additional time on other tasks by decreasing the magnitude of the secondary task even if we are adding a task to operate a navigation system.



This graph is experimental data that shows that mental workload is reduced by the use of a navigation system. A higher WWL (Weighted Work Load) shows higher mental work load.

The bar on the far left is the case in which a paper map is used; the middle bar represents a navigation system that shows the current location, and the far right represents a navigation system that shows the current location and provides route guidance.

As you can see, a navigation system with information that displays the current location and provides route guidance has the lowest mental workload.



Although it appears that the use of a navigation system can help reduce driver workload, the workload for using the navigation system itself should be minimized as much as possible while maintaining necessary functionality.

We will explain the method we considered in order to reduce the workload for navigation's two main objectives, recognizing current location and confirmation of route and turns.

To allow the driver to recognize his/her current location, it is important to provide necessary and optimized information to the driver.
The graph shows the mental workload necessary to locate the current position.
(A) shows the case where the current location is displayed on the map, and
(B) shows the case where only the direction and distance to the next turning point are displayed (example given in right bottom).

Workload is less for the (A) type map since it shows the actual road, its curves, and land marks. We presume that an (A) type map gives more information on the current location and can relieve driver uncertainty by allowing a comparison of map information and the driver's actual surrounding conditions.

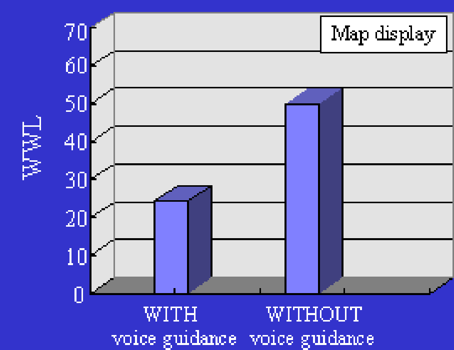
5. Method to reduce navigation-related tasks

5-2 Confirmation of route (intersection recognition)

- **Inform driver of intersection information with adequate timing**

⇨ **with voice guidance, enlarged intersection**

Ex. Voice Guidance



Voice guidance with adequate timing reduces WWL

It is important to sufficiently inform the driver of intersection information. Giving information audibly and providing an enlarged intersection maps were found to be effective.

The graph shows a comparison of driver workload when he/she is given audible guidance like “xxxx mile ahead, right turn” and when the driver is not given audible guidance.

This shows the effectiveness of voice guidance, through a substantial reduction of WWL.

6. Technical Background of JAMA's Guideline

- JAMA Guidelines - Main Items

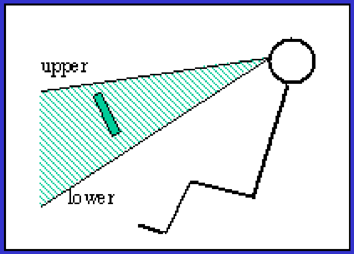
  JAMA: Japan Automobile Manufactures Association

A. Prohibits TV and Video while vehicle is in motion

B. Limits number of continuously changing letters provided from outside sources - 30 letters max. in Japanese characters

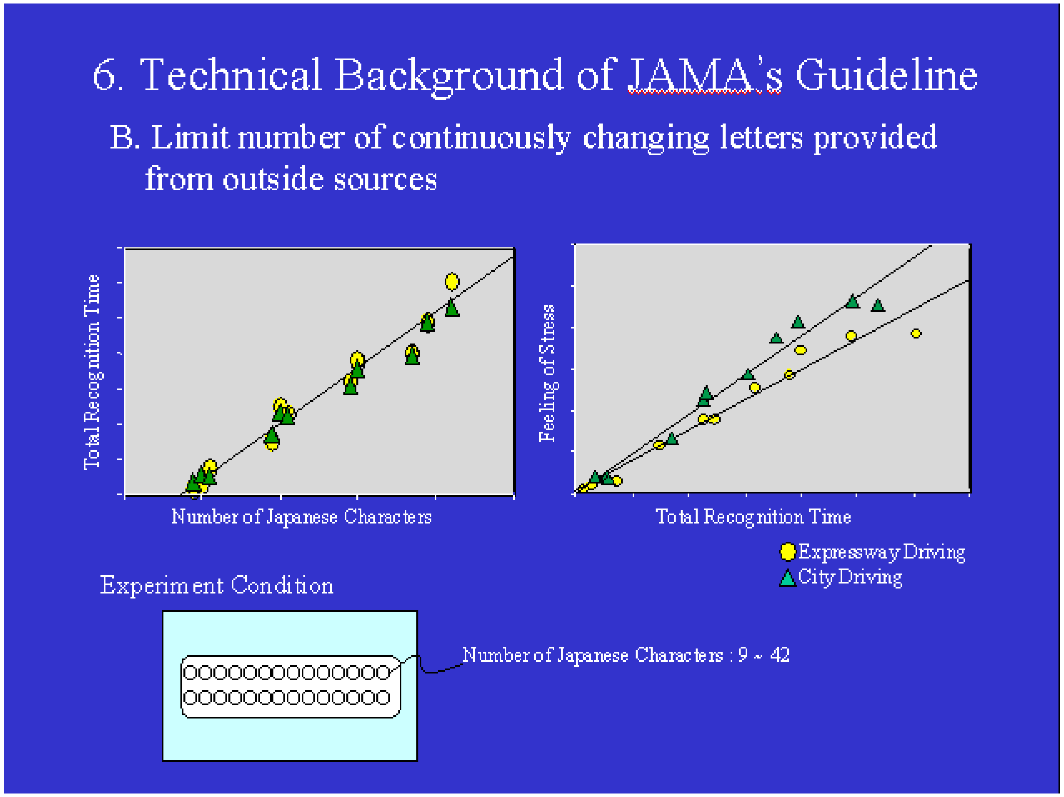
C. Prohibits complex operations while in motion
   Ex. Inputting phone numbers

D. Restrictions on display location



This shows the guidelines made by JAMA (Japan Automobile Manufactures Association) for design of in-vehicle information systems.

A. Prohibit showing TV and Video while vehicle is in motion.
B. Limit number of letters which are provided from an outside source (e.g. through broadcast or telephone system, such as E-mail) to a maximum of 30.
C: Prohibit complex operations like the input of telephone numbers using ten-keys.
D: Require placement of the display at locations where the driver can easily see and his/her forward view is not hindered.

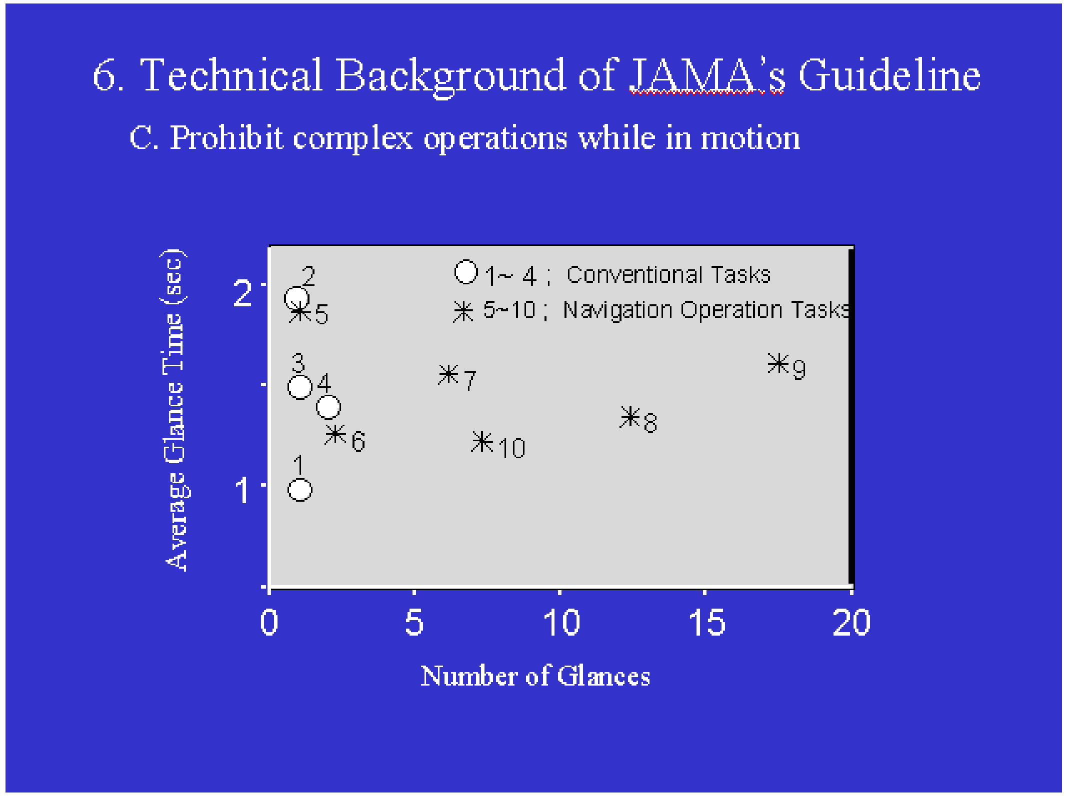


This is the technical background for these guidelines.

The actual sentences are displayed as shown in the bottom.

The left graph shows that total recognition time becomes longer as the number of characters increase.
The right graph shows a driver's stress measured by subjective evaluation.
The higher on the graph means higher mental stress.

City driving causes more stress than highway driving, and naturally drivers feel higher stress when total recognition time becomes longer.

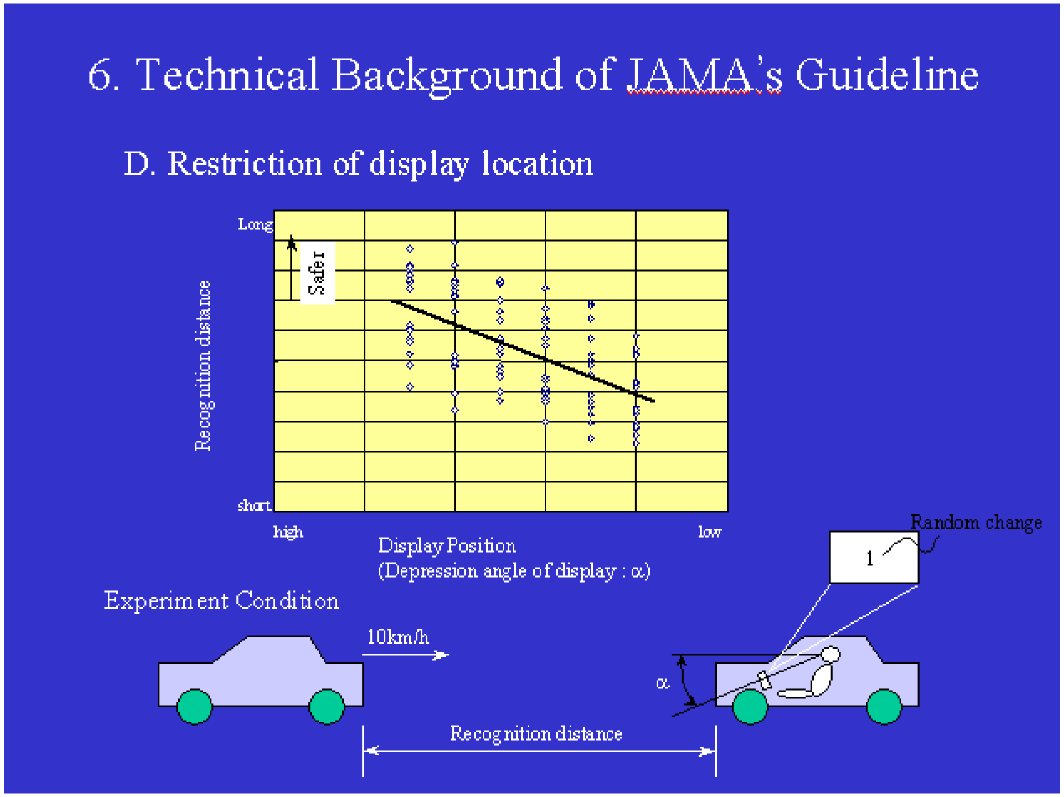


This is an example of an experiment to study the average duration time and the number of glances for each task while driving.

These are conventional tasks;
1:reading speedometer
2:operating dimate control
3: reading the clock
4:selecting a radio station

Navigation Operating Tasks include;
5:map reading
6:changing map scale
7:adjusting location on map
8:selecting the destination
9:entering phone number
10:searching address in the list

The Average Glance Time for all the tasks were less than 2 seconds, but it is necessary to reduce to complexity of the operational tasks to reduce the number of glances.



This is an example of a study on display location showing the viewing angle of the display location and the forward distance within which the driver can recognize objects in front of him/her.

In this experiment, the driver looked at randomly varying numbers displayed on a monitor located a degrees downward from the drivers forward point of view. We measured the forward distance for which the driver noticed another vehicle approaching him/her, while the drivers looked at the random numbers.

The general trend was that a higher located display results in a longer recognition distance, therefore giving the driver more time to notice any event in front of the vehicle, even while looking at the display.

7. Driving Environment Comparisons with US

1. Higher driving speed (US vs. Japan)
2. Many lanes in roads (US vs. Japan)
3. Name of roads in US vs. name of intersections in Japan

[Response to US environment]   ex. Toyota's Navigation System

1, 2: Earlier guidance timing to next turn

Highway :	US	2 mile ahead
	Japan	2 km (1.25 mile) ahead
Surface road:	US	0.5 mile ahead
	Japan	700 m (0.44 mile) ahead

3: Guidance based on street name

US ,xxxx street right turn,
Japan ,xxxx (intersection name) right turn,

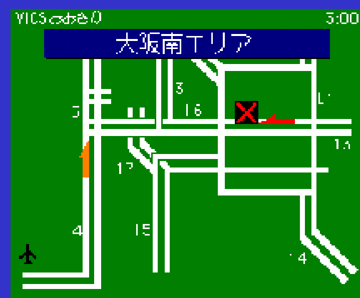
This is a comparison of road or traffic environment in the US and Japan.

Although there is not a big difference, driving speed is higher and there are more lanes on roads in the USA. Also, in Japan intersections are named whereas in the US streets are named.

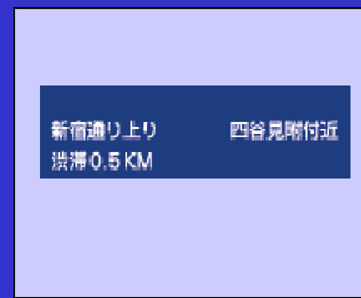
Toyota adjusted its navigation system design for these differences. In the US, guidance instructions are made earlier to adjust for higher speeds, and were modified to include street names.

8. Further information

8-1 VICS: Traffic Information in Japan (Congestion, etc.)



Highway Congestion Map



Text Information for Congestion, Traffic Control, Accidents, etc.

Here is some additional information relevant to in-vehicle information systems in Japan.

There are systems which display traffic information on the monitor, which is transmitted from the traffic control center.

The left picture shows traffic congestion. Traffic is slowed in the direction of the red arrow by a blocked road at the "X" point.

Texts in the right picture tells of congestion, traffic control or an accident on the vehicle monitor.

Both are adjusted so that they can be seen while driving.

Using this type of information, the driver can adjust his planned route to determine an alternative route around the congestion.

8. Further information

8-2 Regulation

Conversation using a mobile phone and staring at pictures displayed on a monitor are prohibited except when the vehicle is in park.

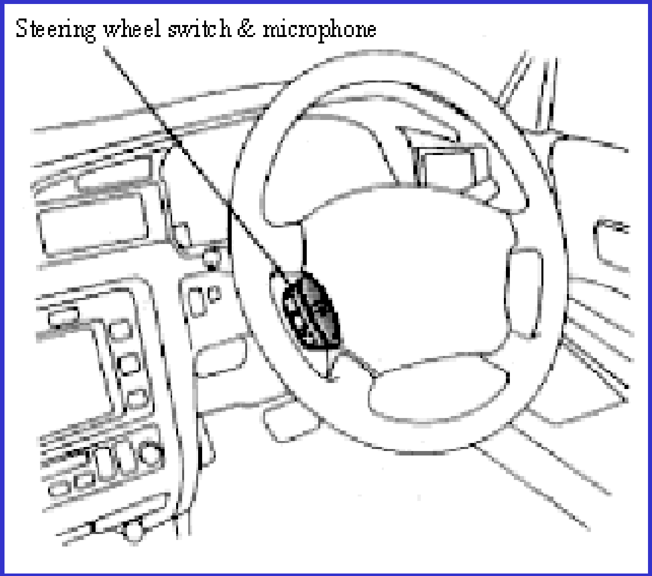
This is not applicable to phone conversations with a hands-free mobile phone.

It is prohibited to use a mobile phone, except for a hands-free type, and to stare at pictures on a monitor while driving (e.g. TV screen, etc.)

This regulation was in effect in 1999 in Japan.

8. Further information

8-3 Hands-Free Mobile Phone



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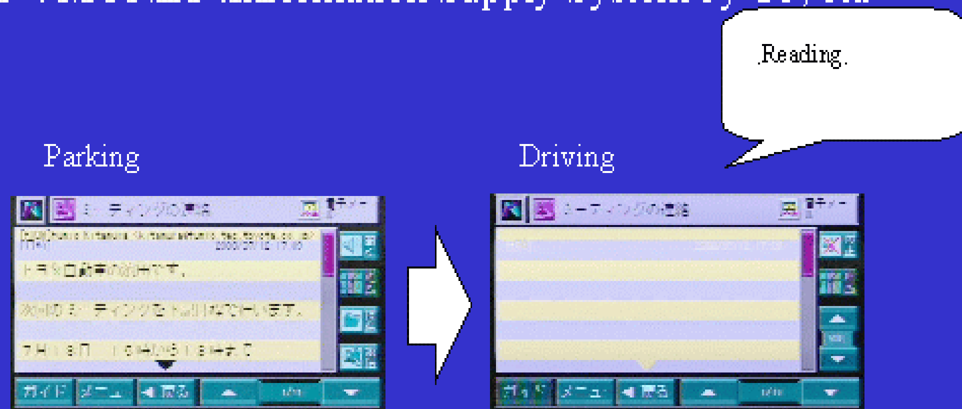
8. Further information

8-4 MONET :Information Supply System by Toyota



Text information is not displayed while the vehicle is in motion.
Rather, information is .read. to the driver by the system.

This is an example of an information service being provided by Toyota in Japan, called “MONET”.

E-mail is displayed in text while the vehicle is parked, but when in motion, the system reads the text to the driver and the text is not displayed on the monitor.

9. Necessary Study and Action from now

- Make guidelines suitable for the US traffic environment
  i.e. guidelines for operation while driving, hands-free phone, etc.

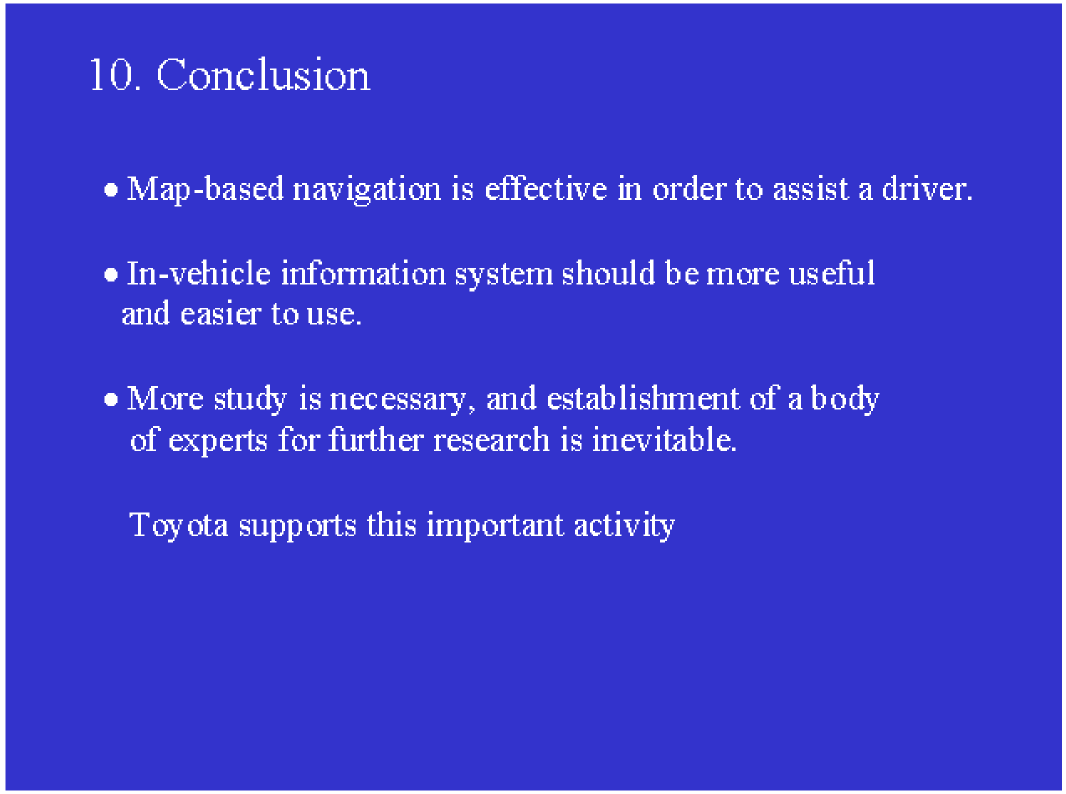
- Develop metrics to better evaluate driver distraction

  (Measure effectiveness in reducing distraction by voice operation
  Measure effectiveness in reducing visual work load by voice reading of Email, etc.)

Through our experience in Japan, and in order for consumers to use this kind of demanding product more safely, Toyota recognizes the need for additional studies.

The industry needs to have certain guidelines suitable for the traffic environment in the U.S., such as prohibition of complex operations and manual-type mobile phone use while driving.

Also, the industry needs to establish measures to better evaluate the magnitudes of driver distraction. There may be metrics other than those described in this presentation, such as measures to evaluate the effectiveness of voice commands and measures to evaluate the effectiveness of reducing driver workload involved in watching a monitor when reading E-mail, etc.



Conclusions are as follows:

First, map-based navigation can help reduce driver workload.

Second, in-vehicle information systems should be adequately designed to be more effective and easier to use.

Finally, additional research programs are necessary, working jointly with government agencies, industry, and research consortiums, to develop realistic, objective metrics which can be implemented industry-wide. Toyota is willing to support such important activity.