Toyota's Program for Universal Design in Vehicle Development
- Universal Design for The Toyota "RAUM"-

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INTRODUCTION

Universal design has been garnering more attention in society in recent years. It is defined as providing a service or designing an object or location in such a way that it can be easily used by many people, regardless of physical characteristics such as gender age, or disability. The concept of universal design stems from the increased participation of disabled people in society, and the expanding elderly population. Other reasons include the advent of an age in which companies are required to develop products focusing on user-friendliness in an environment where products have more advanced and diverse functions. This article will explore the universal design, design development, and product details of the Raum, which was introduced to the market in May 2003.

RAUM UNIVERSAL DESIGN PHILOSOPHY

Universal design principle

Universal design was first propounded in 1990 by Dr.Ronald L. Mace, a professor at North Carolina University., He defined seven principles of universal design. When there are many people working on the same development project, it is best to use a keyword that is easy to remember to help maintain focus on the overall design. Thus, in the development of the Raum, project members came up with the short Japanese slogan an-raku-tan, which was easy to remember and use by all members. The words composing an-raku-tan mean peace of mind, pleasure, and singularity, but also suggest the ideas of soothing, safe, affordable, easy, fun, beautiful, elemental, and simple (see Figure 1.).

Raum Universal design concepts

The universal design considered for the Raum is illustrated in Figure 2. as a conceptual diagram. The horizontal axis represents a scale of human perception that starts with (1) basic safety requirements of the vehicle, (2) easy to use, (3) easy to understand, and (4) comfort and delight. The vertical axis covers (1) height and build, (2)

people with restricted moving ability, including pregnant women, people in poor health, in addition to situations where one is carrying packages in both hands, an experience everyone has at some point, and (3) elderly people, children and people requiring a care provider. Knowledge regarding basic safety, and the dimensions and build of the human body, accumulated by researchers in the field of ergonomics for over thirty years has been incorporated in the bottom left portion of the diagram. The ergo-index and situational suitability index (to be described later) implemented in the Raum has made it possible to index a wider variety of people and the level of ease of use on the right-hand side of the perception scale. Feelings and perception are difficult to express in indices for design. The Raum design aims for the top right side of the diagram, that is, a design that inspires delight on the perception scale. The goal of the universal design for the Raum is to make mobility fun and exciting, while retaining excellent and active user-friendliness.

Figure 1. Raum Keywords

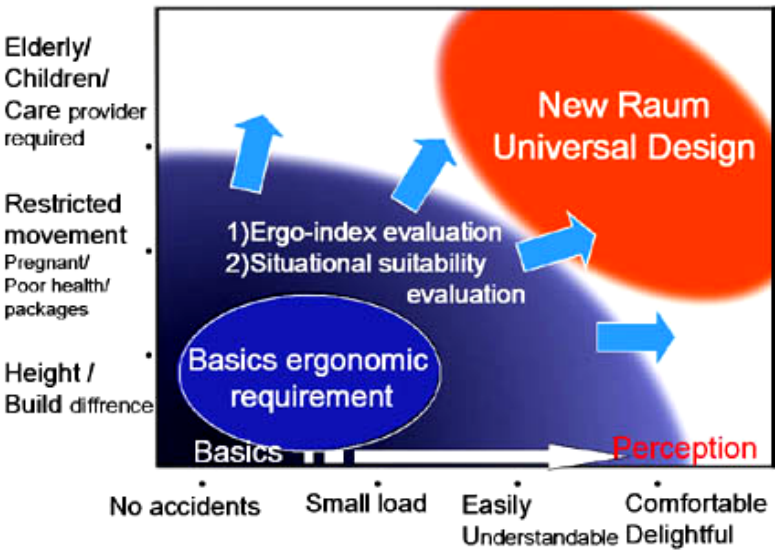


Figure 2. Universal Design Goal of Raum

Toyota Universal design indices

The two indices, the ergo-index and situational suitability, mentioned in the previous paragraph were established at Toyota as a unique criterion and method for the purpose of objectively and subjectively evaluating the level of delight and user-friendliness achieved. (see Figure 3.) Based on these two indices, an objective evaluation of hard aspects (ergonomic performance) and soft aspects (delight in usage situations) has become possible, which can also be applied to future model development.

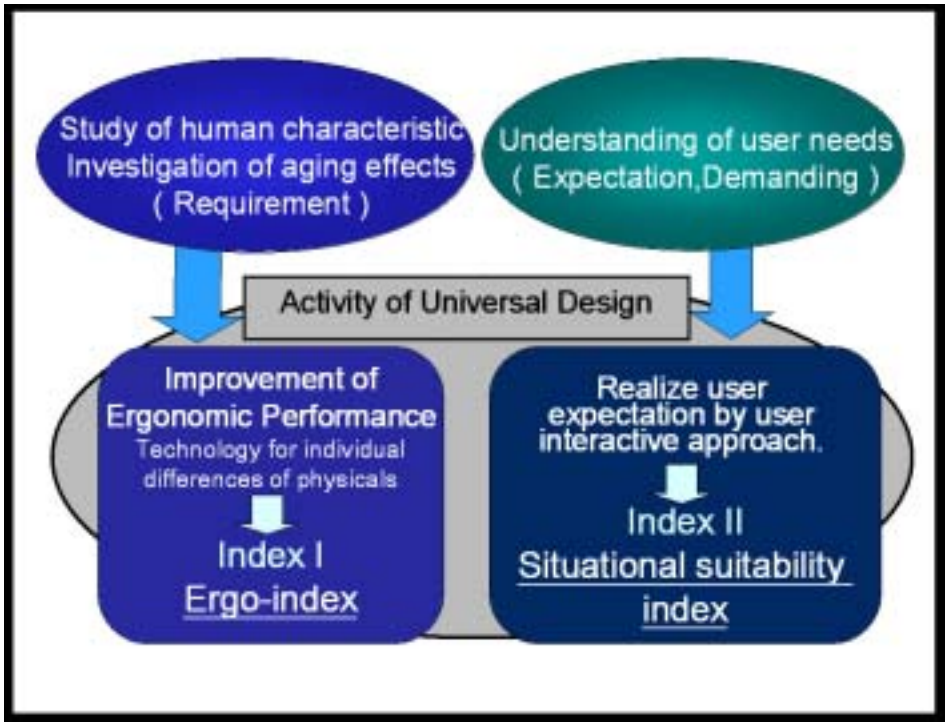
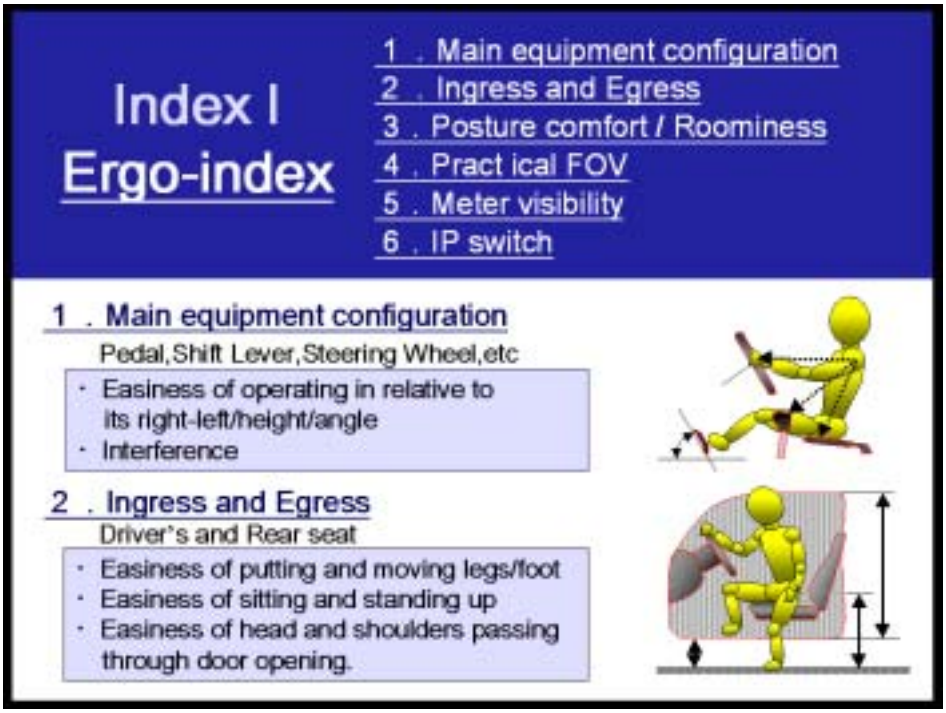


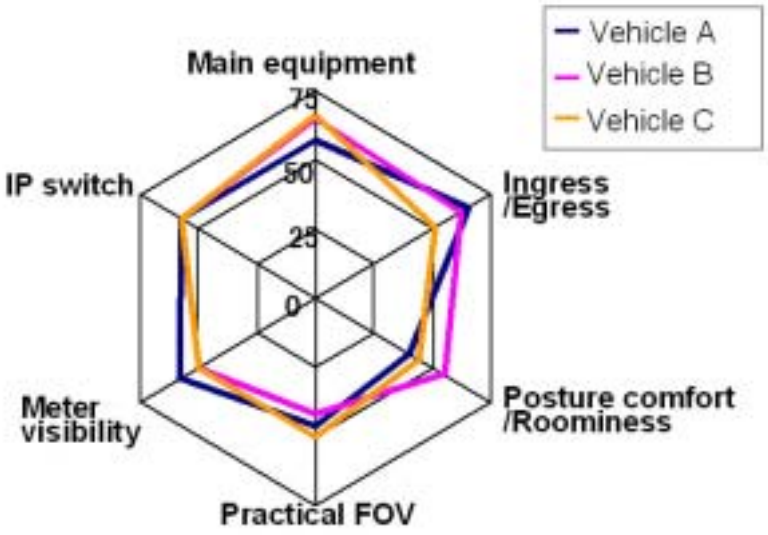
Figure 3. Indices of Toyota Universal Design

Upon introducing the Raum to the market, the two indices were announced as universal design indices, which would be applied to all future vehicle model development at Toyota.

The ergo-index* evaluates and scores 180 items in six areas based on ergonomics, taking into account differences in build and physical ability. Thus, vehicles can be graded with a comprehensive score on their performance with respect to ergonomics, making it possible to compare vehicles, as well as set target values for performance to be achieved during development. (*Toyota coined the term “ergo-index” as a combination of the words “ergonomics” and “index.”)(see Figure 4.)



A: Example of evaluation items



B: Comparison of results

Figure 4. Ergo-index

Situational suitability quantifies the degree to which items in vehicle development fulfill user needs for a vehicle (usage situations, usage methods). This index evaluates the performance of developed items in thirty situations taken from an internal database, which correspond to how the development vehicle may be used. For instance, items developed for the Raum were evaluated in terms of their effect in the situation where a person straps a child in a child seat in the back seat, then moves to the driver seat. (see Figure 5, Table 1)

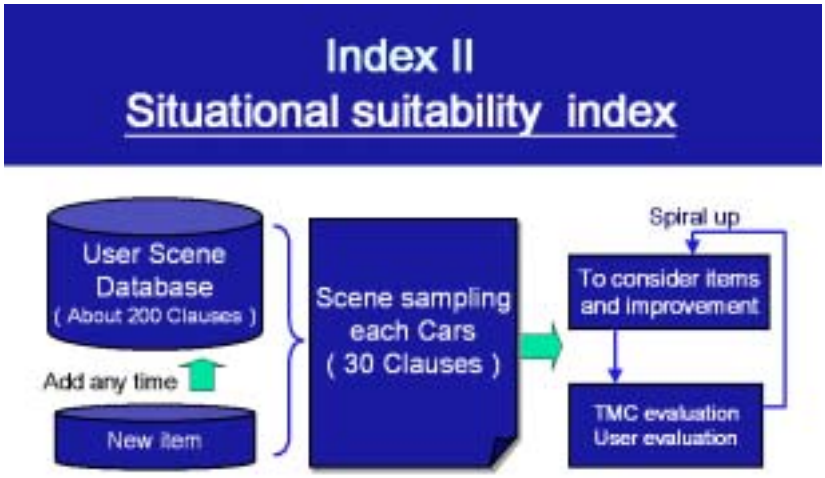


Figure 5. Approach of Situational suitability

Table1. Example of scene

Purpose	User scene	Matching Level
Shopping	• Put the child on the rear child seat and move the driver's seat • Open/close the door when both hands are occupied	◉ : 5 ○ : 4
Pick up	• Move the handicapped person from wheel chair to the passenger seat	● : 5
Driving	• Drink a can of juice • Put small articles (foods, cigarettes)	○ : 4 ● : 5
⋮	⋮	⋮

RAUM UNIVERSAL DESIGN DEVELOPMENT MATHOD

Spiral-up development based on user dialogue

This section will discuss the development method used in designing the Raum. Design development in the past has been typically carried out based on collected information. However, in the case of the Raum, a “user dialogue-type” development method was employed. This method seeks to create more user-friendly vehicles by listening to users and reflecting feedback in the development process. To this end, developers visit sites frequented by users in order to learn how they actually use their vehicles. The opinions and expectations of users are divined through user participation in numerous discussions to confirm the impact of development ideas so that the vehicle can become more user-friendly. More specifically, a prototype is first created based on knowledge and assumptions from the design and engineering departments, which is used in hearings with users where the designers observe results. The level of development thus advances after numerous revisions and improvements followed by repeated evaluation. As such, this method is called spiral-up development based on user dialogue. While developing the Raum, over 500 user dialogues were carried out with numerous people. Confirmations with users mainly focused on functional parts (such as meter audio and heater control) related to driving and ease of ingress/egress.

Recording user dialogues

In order to maintain an environment as normal as possible during user dialogues, the camera was kept hidden as much as possible, and friends and family of the user were encouraged to ride as fellow passengers. All dialogues are recorded on VTR. Afterwards, the videos were analyzed to observe the effect of the prototypes. Figure 6 shows the confirmation of a door handle height and a prototype heater control and audio.

The top row of photos shown in Figure 7 are taken from a vehicle in which a reproduced door with a built-in pillar is used to confirm where elderly people grab for support to enter and exit the vehicle, and the ingress/egress method of children. In the bottom row of photos, a styling mock-up under development is used in the confirmation of ingress by a person in a wheelchair and a person with a guide dog. Given that guide dogs always ride with their masters, more leg space was created in the back of the Raum using a tumble seat, allowing both dog and master to relax.

Figure 6. Recordings of User Dialogues 1

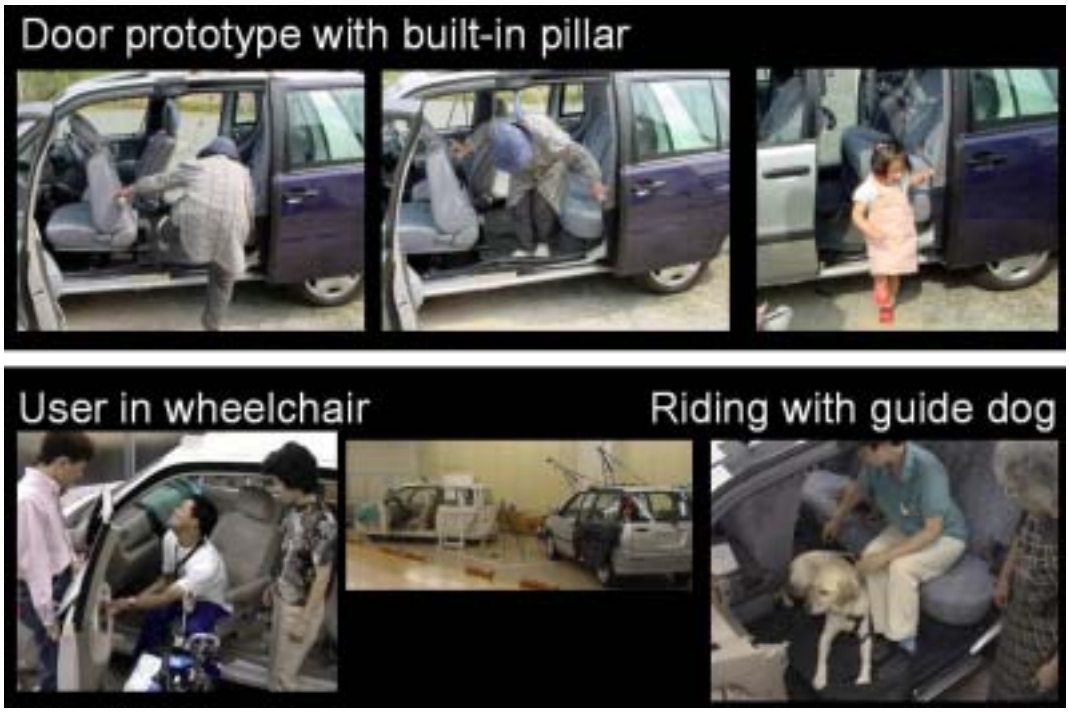


Figure 7. Recordings of User Dialogues 2

PRODUCT DESCRIPTION

Exterior design

As shown in Figure 8, the overall exterior of the vehicle is a compact, 2-box style measuring 4,045 (l) × 1,690 (w) × 1,535 (h) mm. The height of the Raum was set considering the height restrictions of multilevel parking garages. In addition, the passenger cabin space has been expanded by pushing the lower part of the front window forward and installing a roof rear edge, which achieves a well-balanced contour. The cabin dimensions allow for elbow room comparable to that in a large sedan, and the mounting point distance of the front and rear seats is 965 mm. The door handles are set 920 mm from the ground—the optimum height ascertained from confirmations with users—while the belt line feature secures a side field of vision accenting the exterior shape.

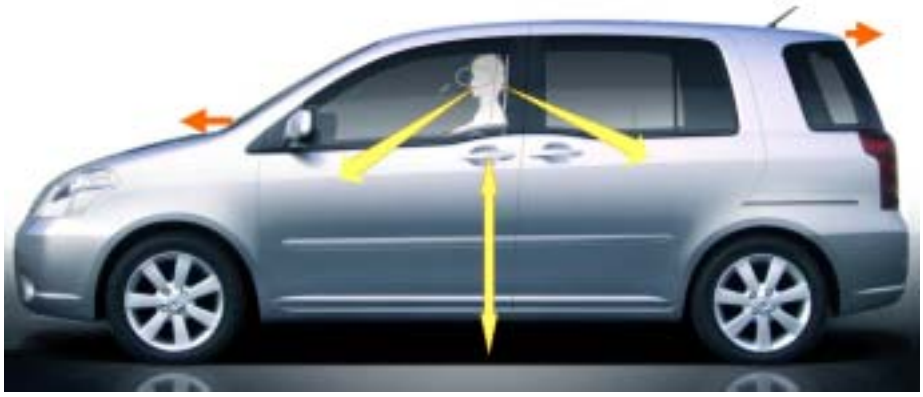


Figure 8. Exterior Design, Side

Figure 9. Exterior Design, Front and Rear

In Figure 9, consideration toward pedestrian safety is shown in the exterior front area through the use of flexible materials to improve light distribution performance with larger headlamps, and a radiator grill structured as part of the bumper. A wider field of vision is secured in the rear area by wrapping the rear window around to the sides of the vehicle, and changing the shape of the pillar on the interior side to have a sectional profile which is minimized in the direction of view. The back door opening is 540 mm from the ground, a height at which luggage can be easily loaded into the vehicle.

Interior design

As shown in Figure 10, the interior aims to reproduce the relaxing atmosphere of one's own room in the cabin space, achieving a superior design of high quality that even people who have ridden in any number of vehicles can appreciate.

The instrument panel is structured so that the heater control is placed in line with the meters to allow smooth eye movement from one to the other when driving, and the audio and heater control surfaces are separated to distinguish functions. The area from the instrument panel to the door trim was discreetly designed with user-friendly surrounding grip shapes for supporting the body when sliding the passenger seat, as well as during ingress/egress and traveling. A completely new elliptical steering wheel was also designed, because the smaller the angle of eye movement toward the meter in the center, the better the performance. Thus, the designed steering wheel has a 350 mm × 370 mm elliptical shape, and is effective for decreasing eye movement and improving ease of ingress/egress due to the reduced top and bottom portions.

Figure 10. Interior Design, Instrument Panel

Figure 11. Interior Design, Assist Grips

Figure 11 shows the various types of assist grips installed in the cabin. In particular, the grip shown in the lower left photo reduces the load on the lower back and leg muscles generated during ingress/egress, by providing a portion that also supports the hand, thus dispersing the load to the arm muscles as well. Firm assist grips were also set on the center pillar behind the driver seat, and on the back of the passenger seat to help foster a sense of security.

The parts of the speedometer and other gauges shown in Figure 12 were confirmed with users over thirty times and considerable time was spent in their development. The speedometer is placed most prominently in the center of the panel, in which the displays are white bands for easy recognition, and the meter numbers use a typeface with superior readability even when viewed slightly blurred, such as in the case of slightly far-sighted elderly drivers. Figure 13 shows an example used in confirmation with users. Furthermore, investigations regarding the warning indicators showed that many people do not understand the meanings of indicator symbols, nor notice when an indicator is lit, or if noticed, often do not understand what action should be taken. As a result, a master caution light was installed in the speedometer to alert the driver, and directions are displayed in the warning indicator panel. Adding easy-to-read wording to each warning indicator has also made it easier to describe the content of the warning when contacting a repair person or the like by cell phone, which are now often used in such emergencies (see Figure 12).

Figure 12. Speedometer, Gauges, Warning indicator

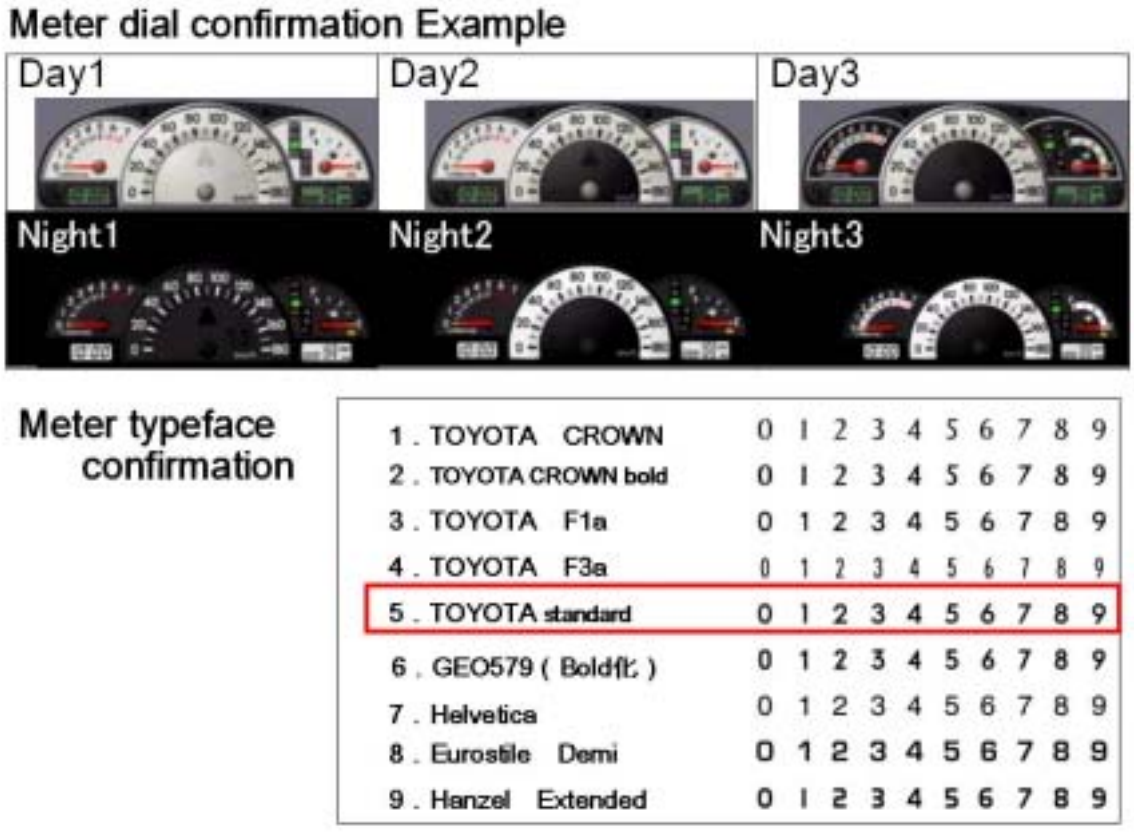


Figure 13. Meter Confirmation Examples

Figure 14 shows the audio panel. There are 22 buttons used in the standard Toyota multi-purpose audio system, but in the Raum, this has been reduced to just 12 buttons by narrowing functions down to only basic operations. These include mode selectors, a source adjuster (for CD track selection, cassette tape fast-forwarding and rewinding or the like), sound volume knob, and CD/tape eject button. Buttons have also been placed on the steering wheel, which have the same basic functions. Unfamiliar English were written in Japanese, because these notation and symbols for transportation information found to be less common and not widely recognized based on investigation results

Figure 14. Interior Design, Audio Panel

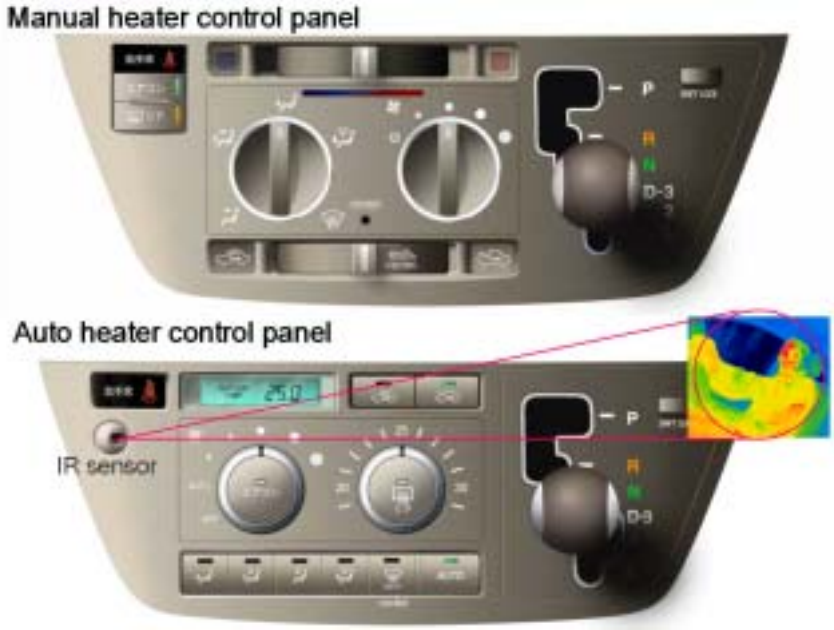


Figure 15. Interior Design, Heater Control Panel

The heater control panel shown in Figure 15 has a simple construction consisting of two dials placed adjacent to the shift knob within range of the driver's hand (approximately 650 mm to 720 mm from the shoulder). Since it was discovered in user surveys that some did not know what to do when the windows were fogged over, Japanese were written near by defroster symbol. In this mode, the windows are cleared by drawing in outside air and eliminating moisture with the air conditioner.

The auto heater control includes a user-friendly function that measures the temperature of the window glass and occupants with an infrared (IR) sensor to control the cabin temperature, thereby maintaining a comfortable environment that does not feel colder than the temperature setting.

Panorama door

Figure 16 shows the main selling point of the Raum: a panorama door (as named in the Raum). Building the center pillar into the door allows for sufficient strength during travel, while also creating an opening that is 1,500 mm wide when both the front and back doors are opened. In addition, the panorama door was also designed for use in combination with the tumble seat installed as the front passenger seat. Various panorama door and seat arrangement combinations greatly expand the variety of situations in which the Raum can be used, thus promoting the maximum amount of delight.

Figure 16. Panorama Door and Tumble Seat

Figure 17. Panorama Door and Mobility Vehicle

A tumble seat comes standard with the panorama door shown in Figure 17, however, the seat can be customized for the user in the Welcab (mobility vehicle), taking advantage of the wide opening. A front passenger lift-up seat facilitates ingress/egress by electronically moving the seat outside the vehicle and lowering to the ground. In addition, a rear swivel seat allows users to exit the vehicle while keeping their legs comfortably extended.

CONCLUSION

In 1997, the first-generation Raum was introduced to the market with reviews praising its user-friendliness, and received the Good Design Award (G-mark) of the Universal Design Prize from the Ministry of International Trade and Industry. Upon the start of development to create the new Raum around 2000, a project began that aimed for a return to the basics, in which designers studied the essentials of user-friendliness for commercial application. During this period, other industries (such as electronic appliances, stationary goods, and housing) also saw increased application of universal design concepts.

In the ergonomics evaluation and design departments, development progressed toward the commercialization of a universal design brimming with fun and delight from the user's point of view, which was researched through dialogues with users. As a result, the Raum was highly reviewed and awarded the Universal Design Prize again in October 2003. The gathering of user opinions was started once more after the new Raum went on sale in May, as such feedback is essential to advancing universal design. In closing, the author wishes to express his appreciation to the many people who provided feedback during development, as well as the companies involved in development for their support.

REFERENCES

Toyota Motor Corporation. 2003. “RAUM Press Information”. 3-9.

Toyota Motor Corporation. 2003. “News from Toyota: Toyota New Raum Announcement.”