Ergonomics in Automotive Design
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Module – 04
Part - II
Lecture – 06
Usability evaluation of In-vehicle control and displays

Now, we are going to discuss the principle of display design. So, the first principle is related to sensory modality.

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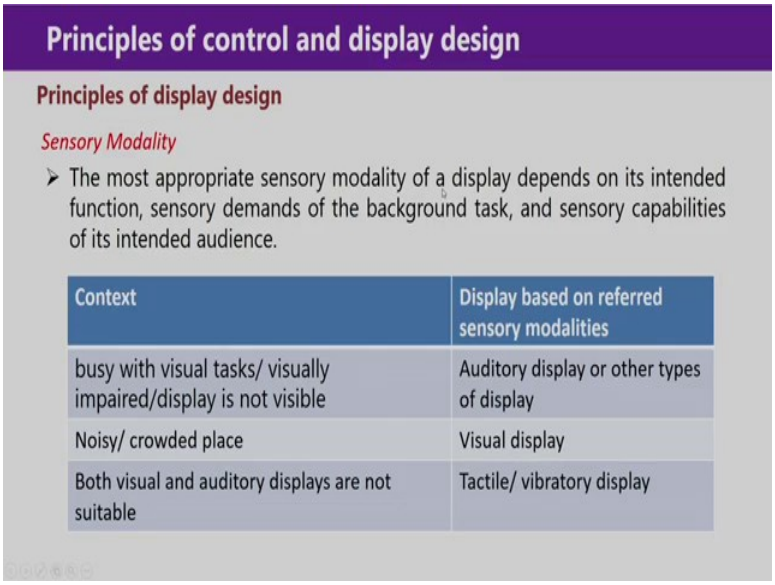

The most important sensory modality of a display depends on its intended function, sensory demands of the background task, and the sensory capabilities of the intended audience. So, based on the context; in which context, that particular display is being used; accordingly, we have to decide, which sensory modality we should consider for designing the display. For example, if the context is; the driver is busy with visual task or he or she is visually impaired or display is not visible, means, it is obscured to some extent or completely.

So, in that scenario; auditory display or other type of display is preferable. Again, if it is noisy or crowded place where there is too much noise, driver cannot hear properly. So, in that scenario; auditory display will not be useful, then it is better to go for visual display.

In another context where there is; both visual and auditory display are not suitable, then we should go for tactile or vibratory display.

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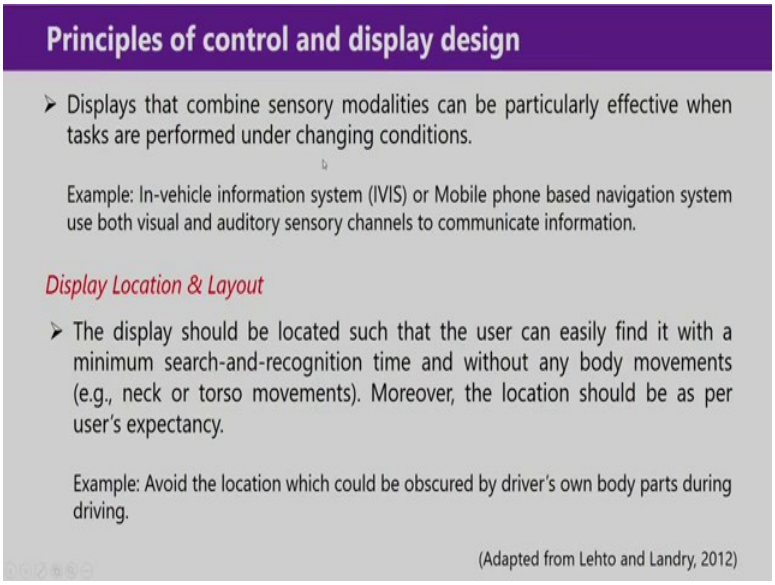

The display that combines sensory modalities can be effective when tasks are performed under changing conditions. So, it is preferable to use multi-sensory display, i.e. where the information is coming and going through different sensory channels. For example, in-vehicle information system or mobile phone-based navigation system uses both visual as well as auditory sensory channels to communicate information. So, if multi-sensory channels are used, then what happens? If driver or user is missing one of the information coming through one of the sensory channels, but he or she will definitely attend the same information coming through other sensory channels.

Next principal is related to display location and layout. The display should be located such that the user can easily find it with a minimum search and recognition time, and without any gross body movements; movements of the neck, torso etcetera. Moreover, the location should be as per the user's expectancy. So, while we are going to install a new display or new control, then it is very important that where the control or display needs to be positioned inside the vehicle so that it can match with the mental model of the user because user or driver is already habituated with operating different types of controls inside the vehicle.

Now, while we are inserting a new display, then it is important that it should match with the drivers or user's expectancy. For example, avoid the location which could be obscured by the driver's own body parts during driving. So, this is very important that where the display should be positioned, and how it is matching with the driver's expectancy. Display and display element should be grouped consistently with the sequences in which they are being used. So, this is also another important principle that while we are positioning different display or display elements, that should be grouped consistently.

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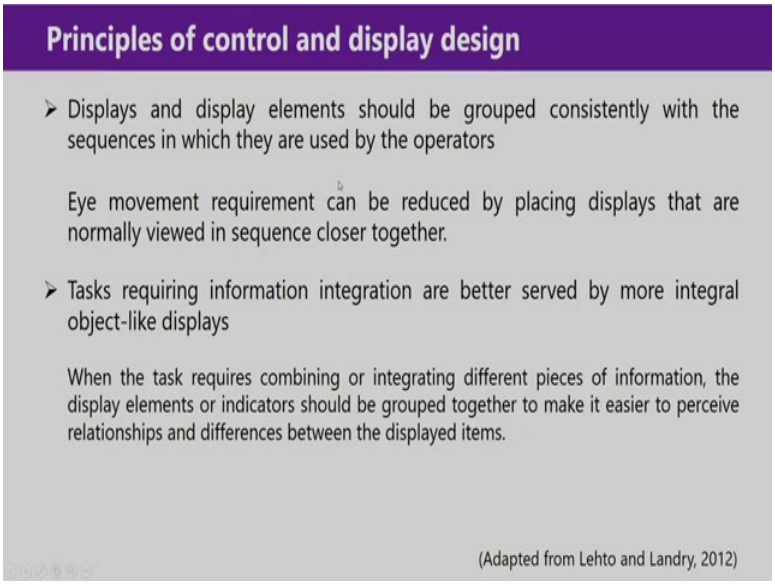

And that grouping should follow the sequence of operations for that particular task. Eye movement requirement can be reduced by placing displays that are normally viewed in sequence, and those can be kept closer to each other. Tasks requiring information integration are better served by more integral object like displays. When the task requires combining or integrating different piece of information, the display elements or indicators should be grouped together to make it easier to perceive the relationship and differences between the display items.

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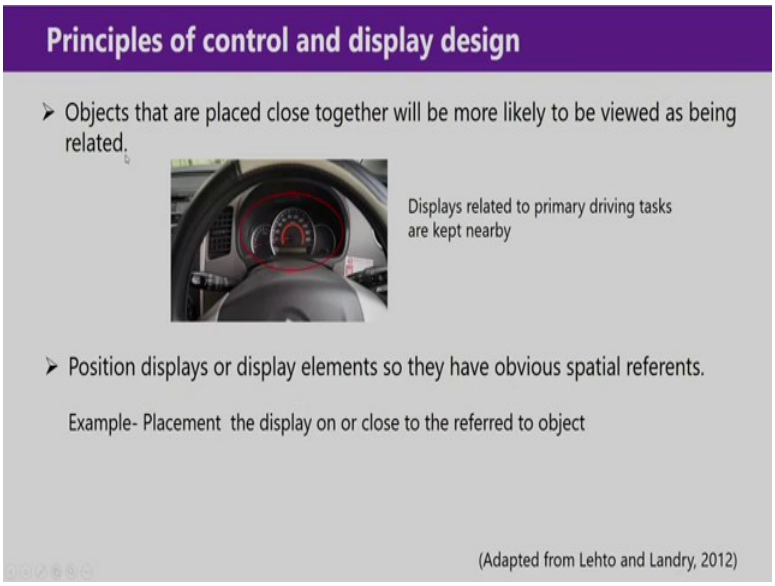

Objects that are placed close together will be more likely to be viewed as being related. So, while you are positioning different display or display elements, those need to be grouped in such a way, that it should give the feeling that these are related. So, for that purpose, say, if we look into this display cluster where various displays like speedometer, fuel gauge, then battery information, then wheel rotation are present. So, all these information sources, means, all these displays are positioned in a particular area, and these are related to primary driving task. Then, position displays or display elements, so, that they have obvious spatial referents; for example, placement of display on or close to the referred object.

So, for this purpose, whenever we are positioning the display, its corresponding level or signage should be nearby to that display.

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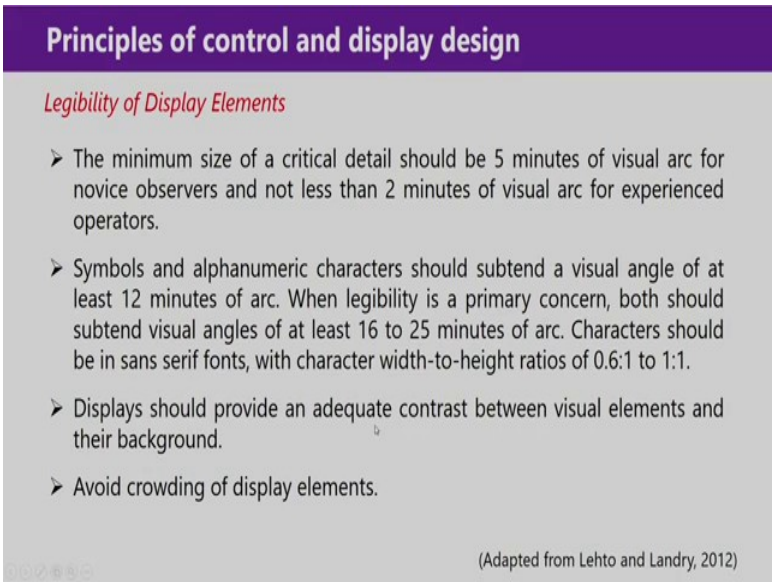

Next principal is related to legibility of the display elements. So, various strategies or various standards are followed for making the display legible and easily readable. So, for that purpose, the minimum size of a critical detail should be 5 minutes of visual arc for novice observer, and not less than 2 minutes of visual arc for the experienced operator or observer.

Symbol and alphanumeric characters should subtend a visual angle of at least 12 minutes of arc. Where legibility is primary concern, both should subtend visual angles, both means, this alphanumeric character and as well as the symbols; that should subtend visual angles of at least 16 to 25 minutes of arc. Characters should be in 'Sans Serif' font, means, there should not be any ornamentation with characters; width-to-height ratio will be 0.6:1 to 1:1.

Displays should provide adequate contrast between visual elements and their background. So, the user can easily read and easily understand that information, means, very clearly can visualize that information. Avoid crowding of display elements. So, while positioning those various display elements that should be separated and it should not be overcrowded.

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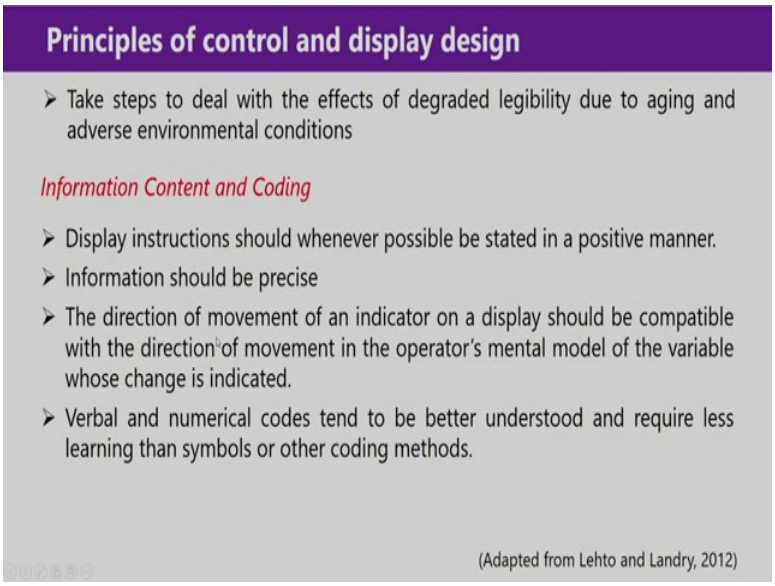

Next; steps to deal with the effects of degraded legibility. So, there should not be degraded legibility and for that legibility; say, for example, this type of degradation of legibility may happen due to aging, due to adverse environmental condition, like low illumination level or high glare. So, in that situation, we have to design the display in such way, so, that it can be compatible with different drivers; with varying age group as well as various other having vision-related problems.

Information contents and coding; so, in this principle, a display instruction (whenever possible) should be stated in a positive manner; then information should be precise as much as possible, it should be highly precise. The direction of movement of an indicator of a display should be compatible with the direction of movement in the operator's mental model of the variable whose change is indicated. Next is; verbal and numerical codes tend to be better understood and requires less learning than the symbols and other coding methods. So, for that purpose, it is better to use verbal and numerical codes in place of symbol and other coding methods.

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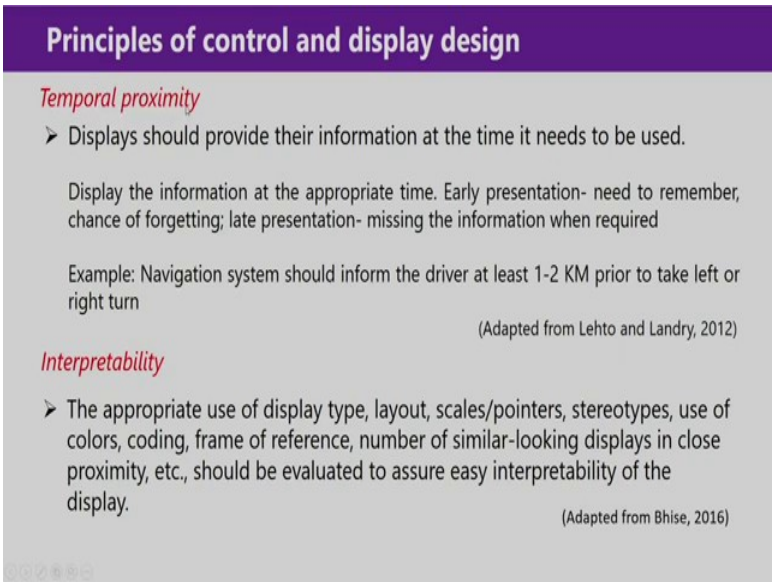

Next principle is related to temporal proximity, means, related to time. So, display should provide their information at the appropriate time, when it is required. So, it should display the information at the appropriate time; if it is presented early, then there is need of remembering that information or there is also a chance of forgetting. If the information is presented late, then there is missing of the information at the time of requirement.

So, for this purpose, the navigation system should inform the driver, at least one to two kilometers prior to taking a left or right turn. So, it should convey that information, display that information at least sometime before the actual task is being performed. Next principle is related to interpretability. So, the displayed information; its content should be such that it should be very easy for understanding by the users.

So, in the case of automobile displays, its design should be such that drivers can easily decode that information and can make the decision. The appropriate use of display type, layout, scale or pointers, stereotypes, use of colors, coding, frame of references, number of similar-looking displays in close proximity, etcetera should be evaluated to assure easy interpretability of the display. So, these are the various aspects which should be taken care of, for developing a good display, which is very easy to interpret.

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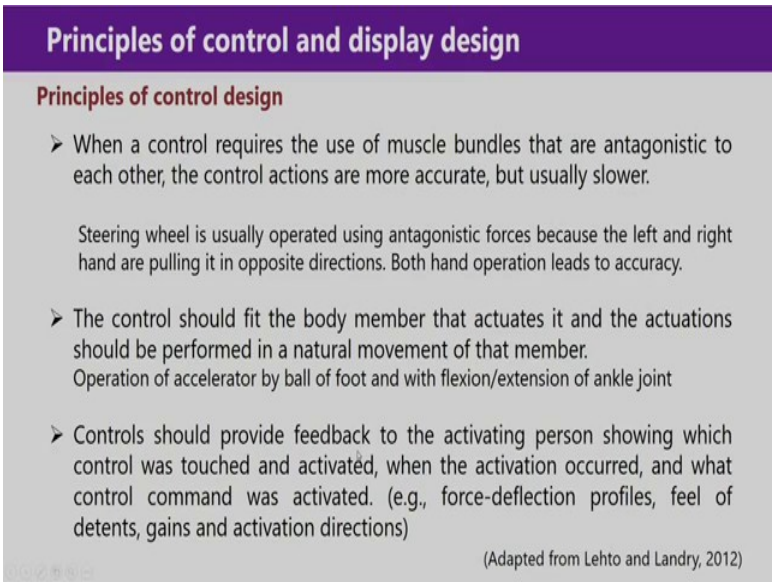

Now, after discussing about the principles of display design, now, we are going to discuss about the principles of control design; that, what are the various strategies or what are the various standards to be followed during the design of control. When a control requires the use of muscle bundles; that are antagonistic to each other, the control actions are more accurate but usually slower. So, for this purpose, while we are thinking of the steering wheel, it is usually operated using antagonistic forces because the left and right hand are pulling it in the opposite direction, and thus it is easy to precisely operate and precisely navigate the vehicle; both hand operations lead to the accuracy in this case.

The control should fit the body member that actuates it, and the actuation should be performed in the natural movement of the member. So, here it is mentioned that the body members, means, body parts, which are actuating that particular control and the actuation direction should be in the direction of movement of the body parts, or body joints. So, for this purpose, operation of accelerator by ball of foot and flexion/extension of ankle joint.

So, accelerator, brake or clutch; these different types of foot controls are designed in such a way, so that the driver can operate easily with the ball of foot and at the same time by the flexion/extension of the ankle joint. So, it is better to avoid any twisting movement for control operation. Control should provide feedback to the activating person showing which control was touched and activated, when the activation occurred and what control command was activated.

For example; force-deflection profiles, feel of detents, gain and activation directions; these are used as various feedback system. So, during operation of a control, there should be some feedback mechanism, so, that the driver or user can easily understand whether that particular control has been actuated or not.

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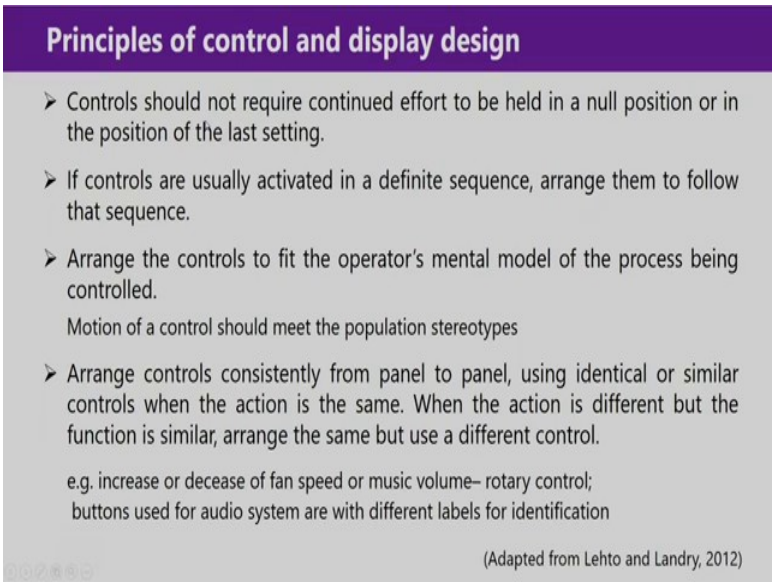

Control should not require continued effort to be held in a null position or in the position of the last setting. So, this is very important. So, while, we are going for different control operation, when it is set at a particular setting, then there should not be a requirement of holding that control. So, continuous effort need not be exerted for keeping control in a particular setting position. If controls are usually activated in a definite sequence, arrange them to follow that sequence.

So, according to this principle; so, various controls need to be positioned in a particular sequence. The controls should be positioned in such a way, that it should be operated in a sequence as per their requirement, to perform a particular task. Arrange the controls to fit the operator's mental model of the process being controlled. In this case motion stereotype of a particular population is needed to be taken care, so, that the control operation, its movement direction matches with the motion stereotype of that population. Next; arrange controls consistently from panel to panel using identical or similar controls when the action is the same. When the action is different, but the function is similar, arrange the same but use different controls.

So here, for example, increase or decrease in a fan's speed or music volume. Where there is this type of increase or decrease function, so, it is better to use rotary control. Although the functions are different, the rotary control is used for showing the increase and decrease directions. So, for that purpose, while it is rotating in clockwise direction, then it is going for higher level, and when it is going for anticlockwise direction, then it is reducing that particular function.

Similarly, buttons used for audio systems are with different labels, for easy identification. So, different buttons in an audio system performing different functions, but those buttons should be grouped together with proper labels for easy identification.

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Then, keep the control arrangement confined but not crowded. So, here it is mentioned that the control should be positioned in a confined space, systematically arranged but that should not be crowded. There should be sufficient space, so, that operator can operate that control easily and we also need to consider various situations, like where the operators are wearing gloves, so, in that case, the sufficient space should be there, so, that operator can operate with hands with the gloves.

Control should have labels that can identify each switch action briefly but unambiguously; no abbreviation is required. So, controls should have labels. For different controls it is better to put labels, so, that the user can easily identify the function of the control. Select and orient controls to avoid accidental activations. So, control

should be designed to assure that their setting will not be inadvertently changed during normal or accident movements of body parts. So, while the driver is moving his hand or elbow or knee, then in that situation, say for example, when there is knee bumping against the gear. So, there should not be activation of the gear or switches on the door panel.

Similarly, due to elbow movement or hand movement, there should not be inadvertent activation of any of the controls, particularly which are related to the primary driving task or which are related to vehicle navigation.

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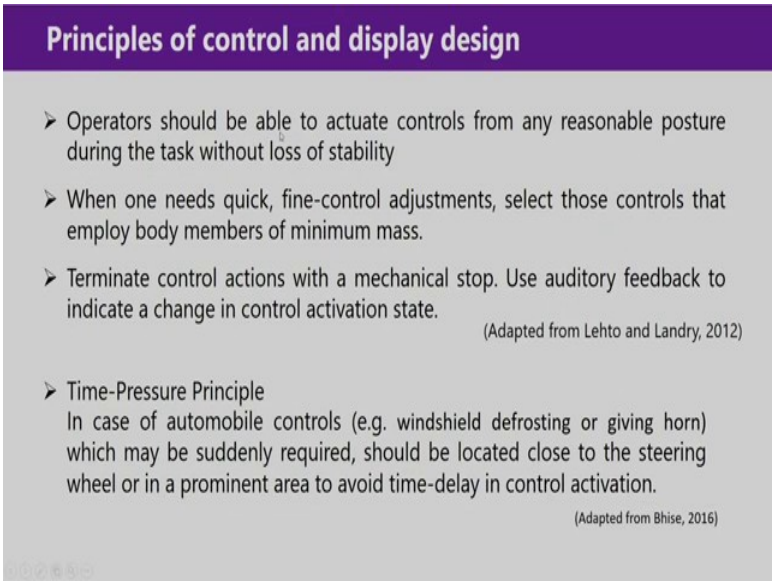

Operator should be able to actuate controls from any reasonable posture during the task without loss of stability. All the control should be positioned around the driver or the user in such a way, so, that they can easily operate those controls by normal reach or extended reach without significant body movements or without any change in the posture, which can disturb the stability. When one needs quick, fine-control adjustments, select those controls that employ body members of minimum mass.

So, for quick and fine-control adjustment, it is better to use the finger controls. So where, either that may be operated by touch or push. So, in that case, only with the fingers. We can operate that particular control with finger very fast and at the same time precisely. Moreover, we can also use voice-activated controls for this purpose. Terminate control action with mechanical stop; use auditory feedback to indicate a change in the control

activation state. So, terminate control action with the mechanical stop, so, while that control activation is happening, driver can easily understand and use auditory feedback to indicate a change in the control activation state.

So, when control is being activated, if there is any auditory feedback, then it is very good for the driver to understand, whether, that particular control has been activated or not. Next principle is related to the time. So, time-pressure principle. In case of automobile controls, for example, windshield defrosting or giving horn, so, these are very important, and we need to perform these controls very fast.

In that case, these types of control operations, which are needed to be performed; suddenly, these should be located close to the steering wheel or in a prominent area to avoid delay in control activation. So, if there is frosting of the windshield, then we have to activate the defrosting button, on the same time, if in front of the vehicle another vehicle changes the lane or is coming in front of the vehicle, then there is requirement of giving sudden horn. So, for that purpose, these types of control buttons should be nearby the steering wheel, so, that the driver can operate those controls very quickly.

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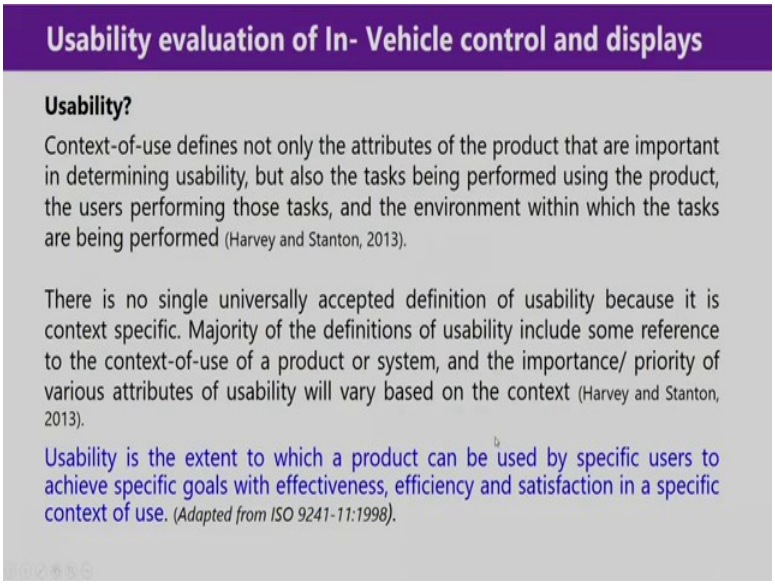

Now, after discussing various aspects of control and display design principles, we are going to discuss about the usability evaluation of in-vehicle control and display. So, apart from the normal functionality of the various controls and display, we also have to evaluate the usability aspect, means, how easy is to operate that particular control or

display? Now, what is usability and how we can define usability? The context of use defines not only the attributes of the product that are important in determining the usability, but also the task being performed using the product, the users performing the tasks, and the environment within which the tasks are being performed.

So, all these contexts are being taken care of during usability evaluation. So, usability evaluation is not only depending on the particular aspect. So, it depends on the context of use, and these various aspects, which I mentioned now. So, these aspects are influencing the usability of a particular control or display. There is not a single or universally accepted definition of usability because it is context specific. Majority of the definitions of usability include some reference to the context of use of the product or system, and the importance of priority of the various attributes of usability will be based on the context.

So, there is no one universal definition which is accepted to everybody because usability is very much context-specific and at the same time, in a particular context, which variables need to be given priority, that is also depending on that particular context. So, context to context, or use-case to use-case basis, the usability of the display or control is different, and accordingly we have to judge the usability. So, as per the definition; according to ISO 9241, in the chapter 11 which was published in 1998; usability can be defined as the extent to which a product can be used by specific-user to achieve specific goals with effectiveness, efficiency, and satisfaction in a specific context of use.

So, here you can also see; the usability is completely depending on the specific context of use.

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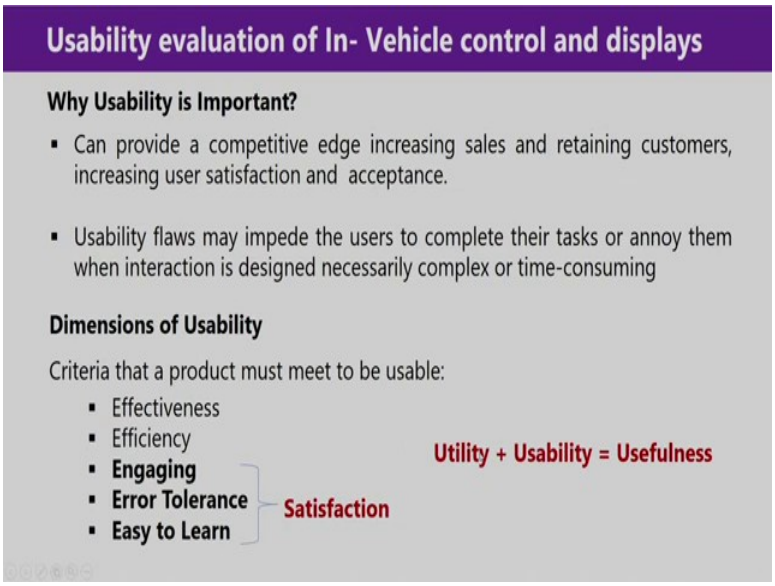

Now, why usability is important? Because usability can provide a competitive edge; increasing sales and retaining customers, increasing user satisfaction and acceptance of that particular product or particular device or particular automobile product in the market. Usability flaws may impede the users to complete their tasks and can annoy them when interaction is designed necessarily complex or time-consuming.

Now, there are various dimensions of usability. So, these are the basic five usability dimensions, that is, one is; effectiveness, another is efficiency, engaging, error tolerance, and easy to learn. Out of these, these last three – engaging, error tolerance, and easy to learn are responsible for satisfaction or dissatisfaction. So, ultimately, usefulness of control or a display depends on the functionality aspect as well as the usability aspect of that control or display.

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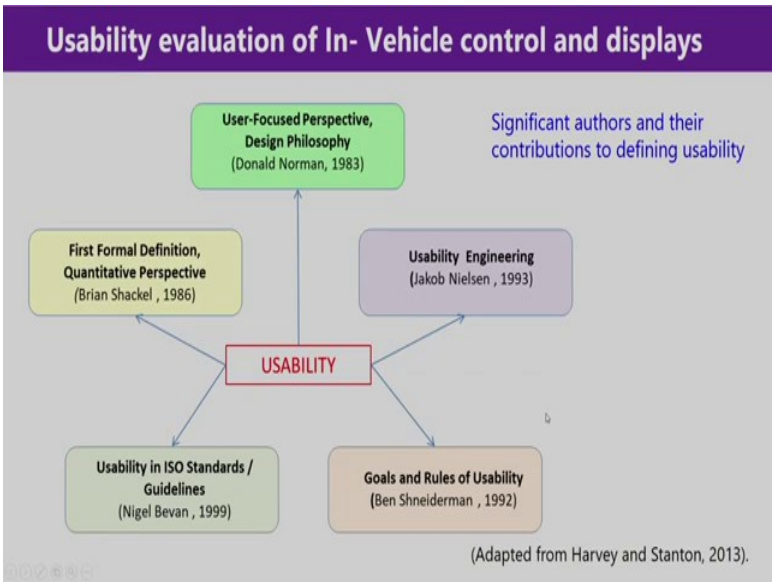

Now, there are various definitions or various aspect which has been considered by various authors during defining usability. So, here are a few examples; this is adapted from Harvey and Stanton (2013) from their book 'Usability evaluation of In-Vehicle information system.' So, here we can see, Jakob Nielsen (1993) he mainly mentioned about the usability engineering aspects; whereas, Donald Norman, he focused on user-focused perspective and design philosophy while defining the usability. Then, Brian Shackel (1986) has given the first formal definition, and that is based on the quantitative perspective.

Then, ISO, usability in ISO standards and guidelines are also available, and that we are getting from the reference by Nigel Bevan in 1999. Then goals and rules of usability was mentioned by Ben Shneiderman in 1992. So, in this way, if we look into the literature. So, we will find, there are different definition pertaining to different aspects of the usability, and those definitions differ from one to another.

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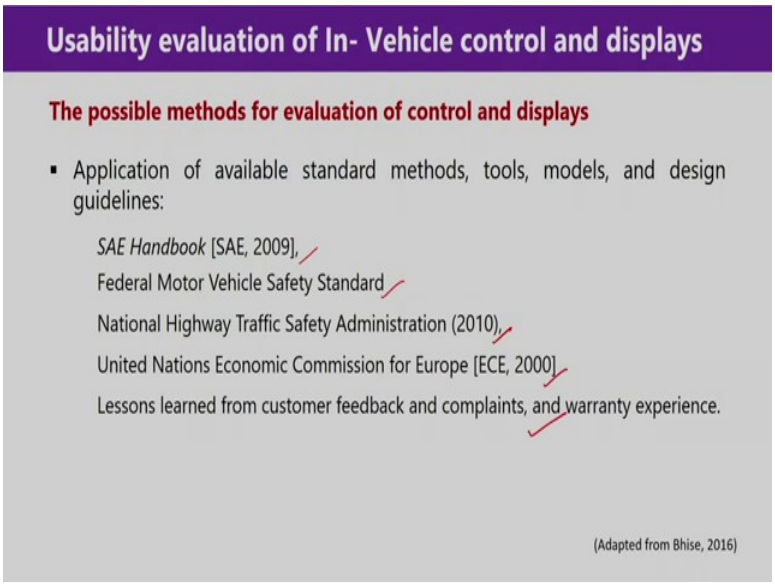

Now, the possible methods for evaluation of control and display. In-vehicle controls and display can be evaluated in various ways. So, one method is, applying the available standard methods, tools, models, and design guidelines. So, there are various standards and design guidelines which can be followed for evaluating different types of usability evaluation of a control or a display. So, these types of standards are available. So, one is; SAE Handbook, there are various SAE standards which are mentioned, similarly, Federal Motor vehicle standards, that is also available.

So, we can consult these types of standards, while we are evaluating various in-vehicle controls and displays. Then, there are also guidelines from National Highway Traffic Safety Administration, United Nations Economic Commission for Europe, then apart from these types of standards, there are also various lessons learned from customer feedback, and complaints and warranty experiences which are collected by the different companies.

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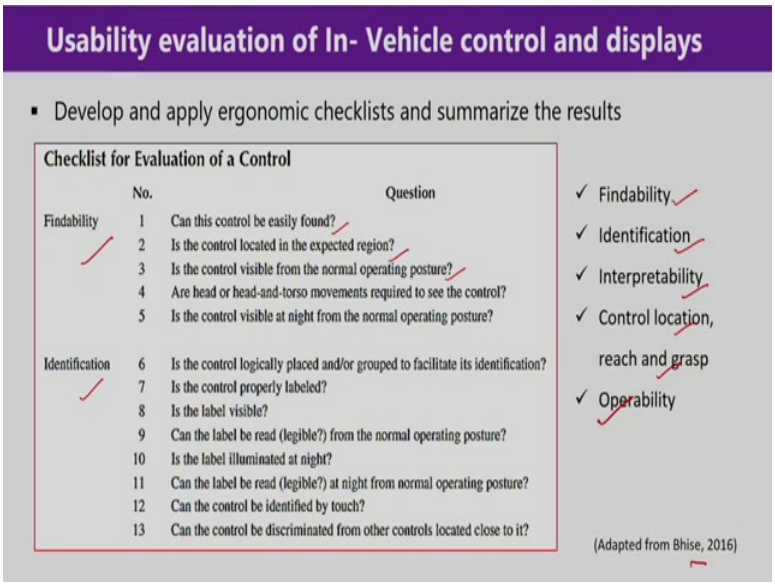

Now, various display or control can be evaluated based on the checklist. So, for that purpose, we need to develop and apply ergonomic checklist and summarize the result to interpret whether the display or that control is effective or very much useful. So that, usability can be evaluated based on various checklist which has been prepared for a control or display.

So, these types of checklist generally consider these aspects; like findability, identification, interpretability and control location, reach and grasp and as well as the operability. So, out of these aspects, right now, we are just taking example of findability and the identification. So, for findability; so, this is taken from Vivek D. Bhise's book published in 2016. So, in that book he mentioned that findability could be evaluated like, this type of five questions, for a particular control. So, can this control be easily found, is the control located in the expected region, is the control visible from the normal operating posture?

So, in this way, five questions are there for evaluating the findability. Similarly, while we are evaluating the identification, whether that particular control can be identified easily, so for that purpose, he also provided a set of questions. So, this type of question-based checklist we can use for evaluating the usability of a control.

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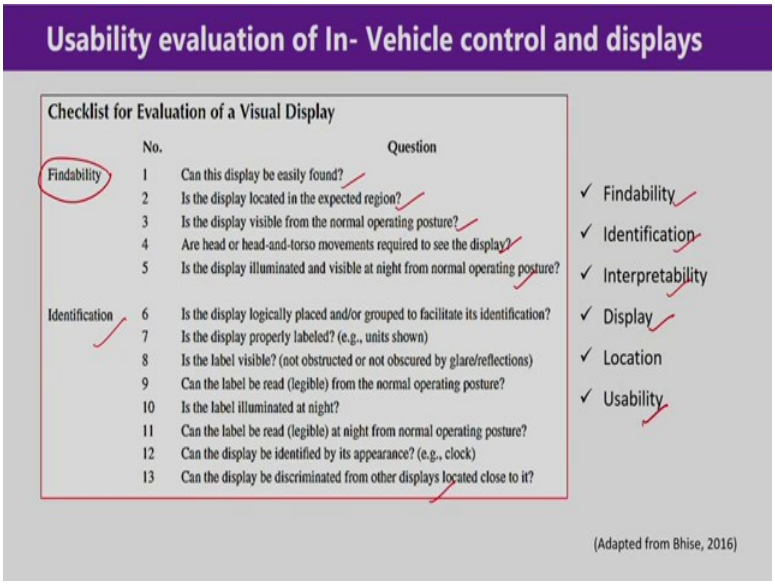

Similarly, for display, there are also various aspects for evaluation; one is; findability, identification, interpretability, then display location and usability. So, here also, Vivek D Bhise in his book 'Automotive Ergonomics.' So, he mentioned that; findability could be evaluated with these type of five questions; can this display be easily found, is the display located in the expected region, is the display visible from the normal operating posture, is head and torso movements required to see the display, then; is the display illuminated and visible at night from normal operating posture?

So, these are the various questions which are used for understanding the findability of that particular display. Similarly, he also provided a set of questions for identifying that particular display. So, these are the various questions for that purpose. So, we can follow these types of checklist-based evaluation criteria for judging the superiority of a particular control or a particular display.

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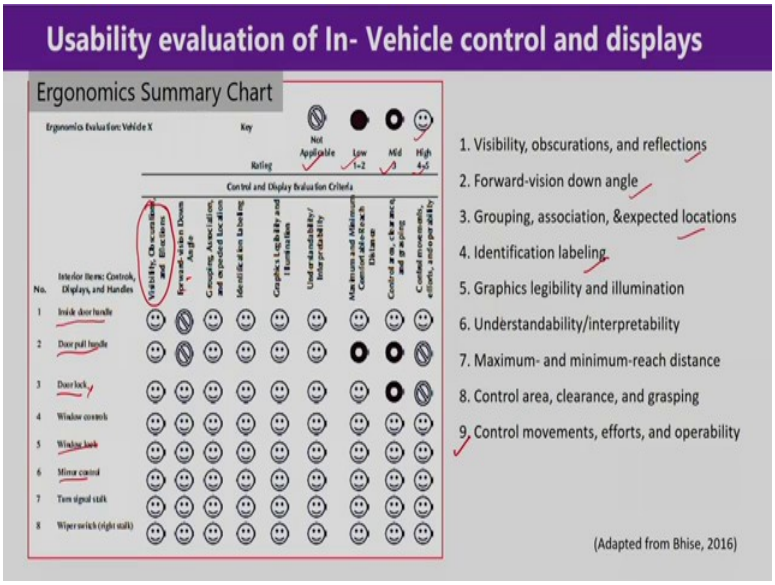

Now, the ergonomics summary chart; so, in this chart, what is used? Various usability dimensions, like visibility, obscuration, reflection, forward-vision, forward-vision down angle, grouping, association, expected location identification, labeling. So, in this way, there is total of nine aspects. These nine aspects of evaluation are positioned at the top of a table; these are the vertical column. So, all these nine variables are positioned one after another in that vertical columns, and in the left-side panel, it is for the different types of control or display evaluation.

So, this is, for example, here, inside the door, inside door handle, door pull-handle, door lock, window lock; so these are the various vehicle components, means, control and displays which are needed to be evaluated, and based on these criteria we have to evaluate. Then, for each of the criteria, say, visibility, obscuration and reflection, for this particular one, there are four options. So, if the user or the subject is going to rate for the first criteria, say for example, for door lock, then there are four options; one is; whether it is applicable for this particular criteria or that particular usability dimension is applicable in this; in the evaluation of door lock. Then, if not applicable, this type of sign is required; then if it is low; 1 to 2 rating, then, that black dot if it is mid, then this type of symbol and if it is high, then this type of smiling faces.

So, based on that, each of the control or display, based on these different types of evaluation criteria, we can go for rating each of the evaluation criteria in these four

categories and our target will be, that for each of the control or display, all these aspects of usability dimension should be satisfied, and we should try to get the high user rating; high user rating means, in majority of the cases, it should be the smiling faces. Then, if we are getting the smiling faces for majority of the usability dimensions, for a particular control or display, we can understand, that this is a good design of that control or that display. So, this type of ergonomics summary chart is very much useful for evaluating control and display.

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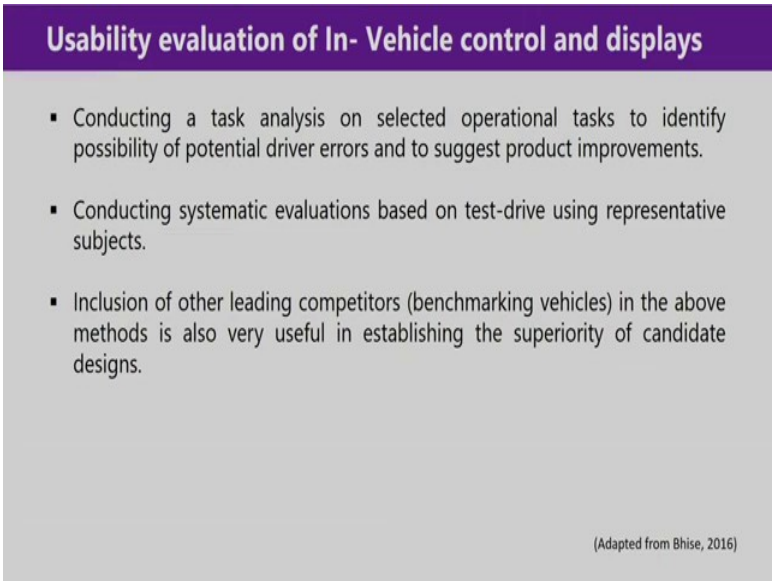

Then, conducting a task analysis on selected operational task to identify the possibility of potential driver errors and to suggest product improvements. So, other options for evaluating the control or display is to conduct a task analysis; for selected task; operational task. So, users have to ask, to perform various in-vehicle tasks, which will require majority of the control and display operations and after the task is completed, then various feedback is collected from the users, in terms of their difficulty to use or ease of use, at the same time whether they are satisfied in using it or not. So, this type of various aspects are investigated from that user.

Then, conducting a systematic evaluation based on test drive, using representative subject. So, after developing a new vehicle or inserting or installing new controls and display, then, we can also go for test drive with selective representative subjects, and we can also collect the feedback from them. So, that will also be helpful for modifying or

making the correction in those displays or controls. Then, inclusion of other leading competitors, means, benchmarking vehicles. So, while we are evaluating any control and display, then, at the same time, we will also have to think about the other competitors; what type of controls and display they are using and how these newly developed vehicle or newly developed controls and displays installed in that vehicle, how it is different or how it is superior to the existing other competitive vehicles in the market.

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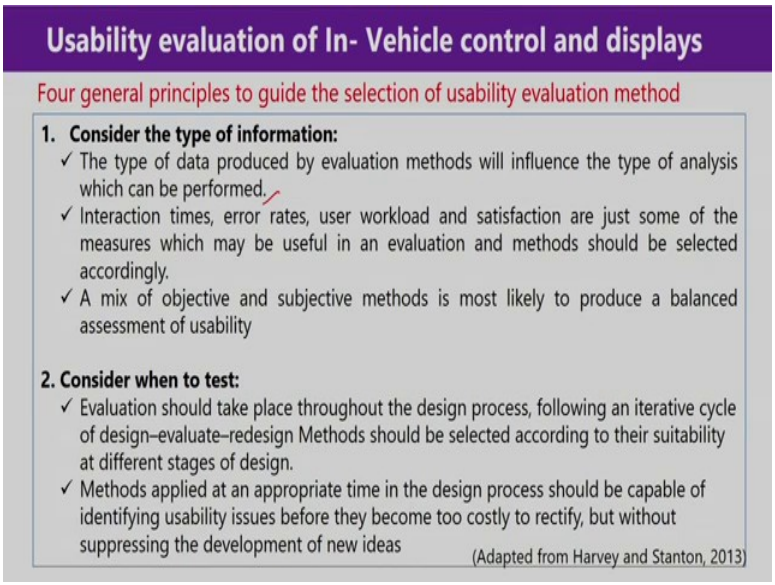

Now, four general principles to guide the selection of usability evaluation method; so, the first one is the; consider the type of information. While we are evaluating any control and display, then we have to think about which type of information is being presented. The type of data produced by evaluation methods will influence the type of analysis which can be performed. Second; interaction times, error rates, user workload and satisfaction are just some of the measures which may be useful in evaluation and method should be selected accordingly.

Next important aspect is; a mix of objective and subjective method is most likely to produce a balanced assessment of usability. Then, another aspect is considering; when to test? That usability evaluation is also depending on the time and the context of the test. So, evaluation should take place throughout the design process, following an interactive cycle of design-evaluate and redesign. So, every time we need to design, then evaluate and if there is some problem or if any loop-holes are identified, then we have to go for

re-design. So, this method should be selected according to their suitability, at different stages of design. Methods applied at an appropriate time in the design process should be capable of identifying usability issues before they become too costly to rectify, but without suppressing the development of new ideas.

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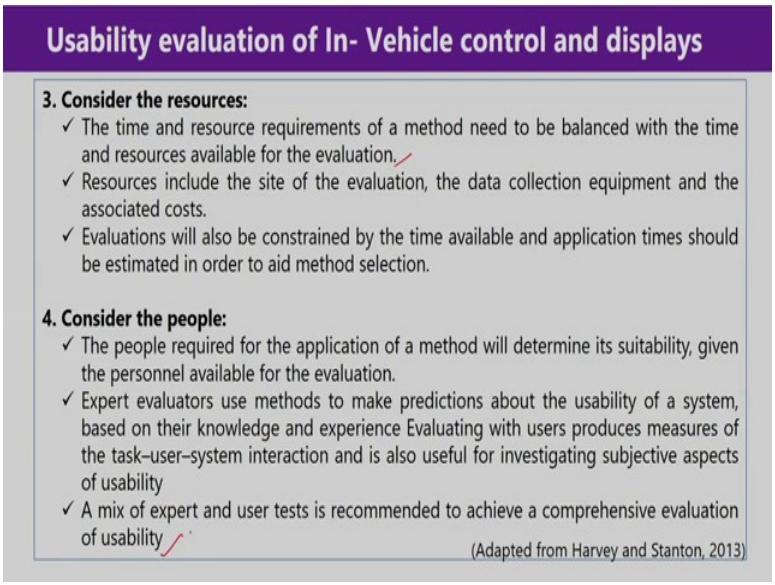

Third; consider the resources; the time and resource requirement of a method needs to be balanced with the time and resources available for the evaluation. So, while we are going to evaluate control and display. So, this is important that how much time is available for the evaluation and accordingly we have to plan. Now, which evaluation method to be followed. Then, resources include the site of evaluation, the data collection equipment, and the associated cost; based on that; the usability evaluation method needs to be selected. Evaluation will also be constrained by the time available and application times should be estimated in order to aid the particular method selection.

Consider the people, means, who are going to evaluate the display or control. The people required for the application of a method will determine its suitability, given the personnel available for the evaluation. Expert evaluation use methods to make predictions about the usability of a system based on their knowledge and experience. Evaluating with users produces measures of the task-user-system interaction and is also useful for investigating subjective aspects of usability. So, various subjective aspects of usability can also be

investigated and particularly for expert evaluation using a heuristic, that is also very much used for evaluating the various displays.

A mix of expert and user test is recommended to achieve a comprehensive evaluation of usability. So, not only expert evaluation, at the same time, user evaluation is also needed to be carried out.

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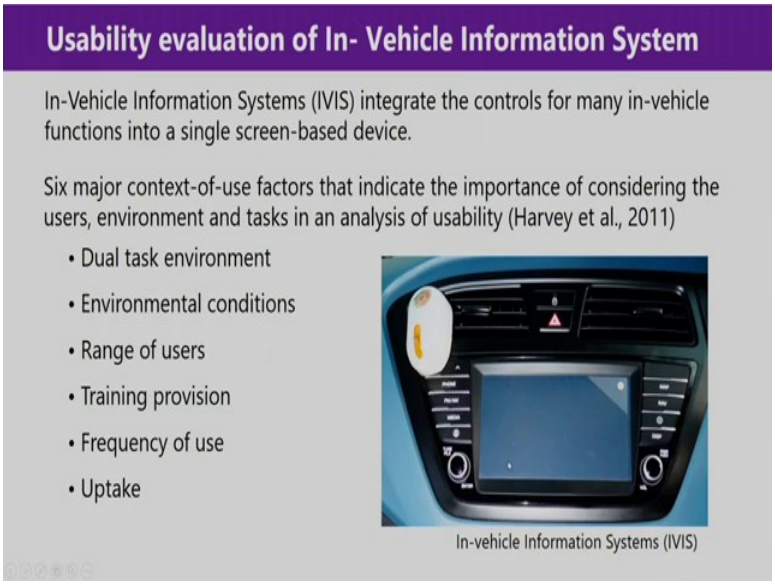

Now, we are going to discuss about the in-vehicle information systems and its usability. So, nowadays, there are in-vehicle information systems, and these are installed in majority of the vehicles. So, in-vehicle information systems are actually touch-screen based devices which are used for controlling various in-vehicle functions. So, six major context-of-use factors that indicate the importance of considering the user's environment and the task in analysis of usability, as mentioned by Harvey et al. in 2011.

So, these key or major usability dimensions are; dual-task environment, environmental conditions, range of user, then training provision, frequency of use and uptake. So, first is a dual-task environment. So, while operators or driver is using this information system, in-vehicle information system. So, that is not his primary task; the primary task is the driving the vehicle or navigating the vehicle, and without affecting the primary task, he has to perform this secondary task of using this important information system; in-vehicle information system. So, primary task should not be affected or should not be disturbed.

Second; environmental condition; so, during evaluation of the usability of this type of information system, then, we also need to consider various environmental condition, like illumination level as well as the glare or luminous contrast, then different types of, there may be other environmental condition, which is affecting this type of functionality and usability of this type of information system. Then range of users; while we are evaluating the information system, then, we also have to think about the user; who is the user, their age group, their level of experience, their physical capabilities, eyesight. So, based on this, we also decide who is going to evaluate that information system.

Then, training provision; whether for using that particular system; training is required, or it is very easy to learn. So, training is related to learnability, memorability. So, if the information system is designed in such a way, that it is very easy to learn and once the operator is using or the driver is using that particular information system, he is very much satisfied, then automatically he will go for using it again and again. Then, the frequency of use.

Then, the evaluation of this type of display is also depending on the frequency of use. If it is frequently being used or regularly used, then there is no requirement of memorability. So, as it is regularly used. So, driver can easily recall various functions, various buttons, tools, menus. So, it will be very easy for him or her. Then, uptake. So, uptake means, whether that particular system is being accepted by the user or not.

So, based on the usability evaluation as well as from the various functional point of view, that system may be very much effective, very much efficient, but the question is that whether the user is going to use that or whether the user likes that one and they want to have that type of system in their own vehicle. So, this perceived usability and its corresponding user eagerness to use that information system is also very important.

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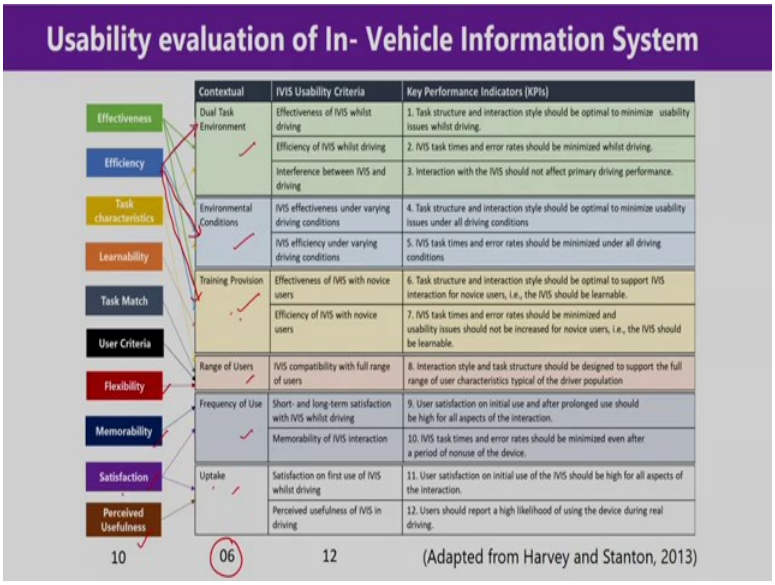

Now, this particular chart we are using for evaluating the in-vehicle information system. So, this has been adapted from Harvey and Stanton (2013), from their book 'Usability evaluation of in-vehicle information system.' So, here, we can see, on the left-side column, there are ten key usability dimensions, those are effectiveness, efficiency, task characteristics, learnability, task match, user criteria, flexibility, memorability, satisfaction, and perceived usefulness.

So, as we mentioned that perceived usefulness is very much important for uptake of that system. So, these ten key dimensions; key usability dimensions are depending on the contextual use of that in-vehicle information system. So, there are six contextual use of that contextual scenario where that in-vehicle information system is being evaluated. So, one is; dual-task environment, then environmental condition, training provision, range of user, frequency of use and uptake; as we mentioned earlier. Then, in each of this contextual environment. So, we are further categorizing, or we can think about the IVIS; in-vehicle information system usability criteria, under each of this context.

So, in a dual-task environmental context, IVIS usability criteria, would be three. So, effectiveness of IVIS while driving, efficiency of IVIS while driving, and interference between IVIS and driving. So, these three usability criteria are coming under the context of dual-task. On the other hand, we can see if we look at efficiency. So, efficiency is again related to the context of the dual-task environment, and it is again related to

environmental condition; at the same time, it is related to training provision. So, efficiency is related in these three contexts. So, efficiency of the in-vehicle information system can be just based on these three contexts; one is, dual-task environment, environmental condition as well as training provision. So, while we are evaluating in the context of dual-task environment, then there are some key performance indicators, which are mentioned as KPIs.

So, how we can evaluate the efficiency or how we can evaluate in the context of a dual-task environment? So, first one; task structure and interpretation style could be optimal to minimize the usability issues while driving. IVIS task time and error rates should be minimized while driving. Next one; interaction with the IVIS should not affect the primary driving performance. Similarly, while we are thinking about the training provision context; in that context, again there are, this type of two IVIS usability criteria, and those usability criteria, again can be judged, based on these two key performance indicators.

So, based on that key performance indicators, then, for that particular context, we can evaluate that particular or specific usability dimension. So, usability dimensions; each of the dimensions are actually being evaluated in different context, as it is shown by different arrows. So, satisfaction is evaluated in the context of frequency of use, at the same time, uptake. Then, user criteria or flexibility, it is related to, range of users. So, in this way, based on these different use contexts, we can evaluate various key usability dimensions using various key performance indicators.

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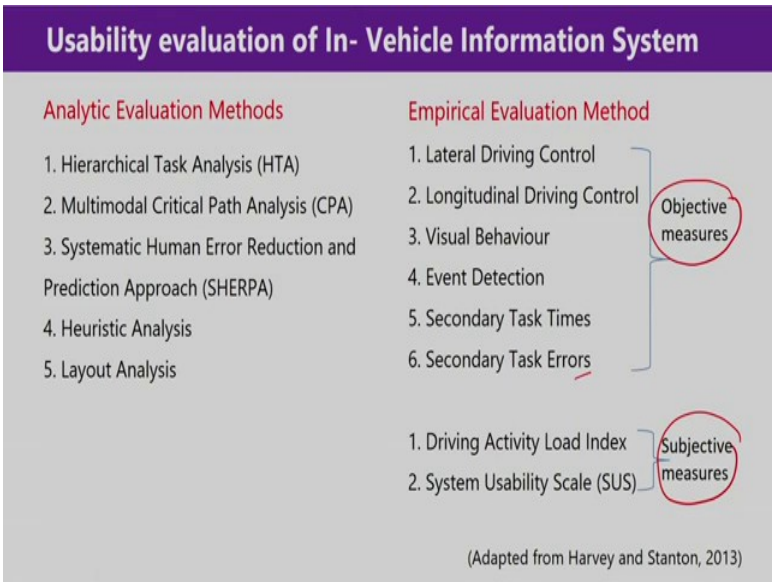

Now, usability evaluation of in-vehicle information system. One is; analytical evaluation method as well as there is an empirical evaluation method. So, for evaluating in-vehicle information system, we can go for either one or both of these methods. So, in analytical methods there are also various types of analytical methods. So, one is; hierarchical task analysis, second one; multimodal critical path analysis, third; systematic human error reduction and prediction approach, heuristic analysis, and layout analysis. On the other hand, for empirical evaluation methods, there is a lateral driving control, longitudinal driving control, visual behavior, event detection, secondary task times and secondary task errors. So, all these are coming under objective measures.

Apart from these objective measures, there are subjective measures; for example, Driving Activity Load Index, in short, it is called DALI and System Usability Scale (SUS). So, these types of different usability evaluation methods are available for the in-vehicle information system. And, we can use these methods based on the suitability; in which context, which method should be; any particular method or combinations of various methods can also be used for evaluating the in-vehicle information system. So, that we have to judge based on the various criteria, as been mentioned earlier, that these consider the various types of information; i.e., consider when to test, then the resources, then the type of people. So, based on that, we have to decide which evaluation technique we should follow.

Now, at this end of module 4; so, what we ultimately learnt from this module?

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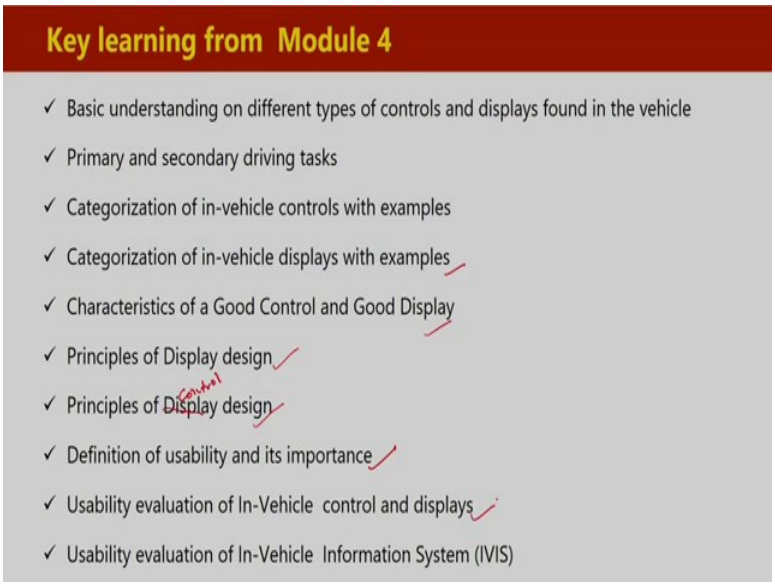

So, we discussed; basic understanding of different types of controls and display found inside the vehicle, then primary and secondary driving task, how it is different and why those tasks are related to different types of control and display design. Then categorization of in-vehicle controls with examples; then categorization of in-vehicle displays with examples, then we discussed about the characteristics of good control as well as good displays.

Then, principles of display design, then we discussed about the principle of control design; then the definition of usability and its importance, then usability evaluation of in-vehicle controls and display and then we discussed about the usability of in-vehicle information system. So, these are the various topics; we covered under module 4.

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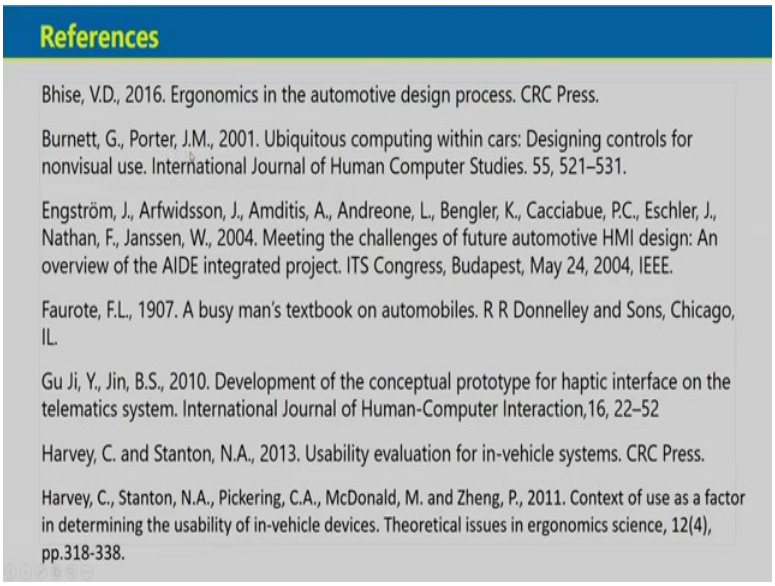

So, these are the various references which have been consulted for preparing these slides.

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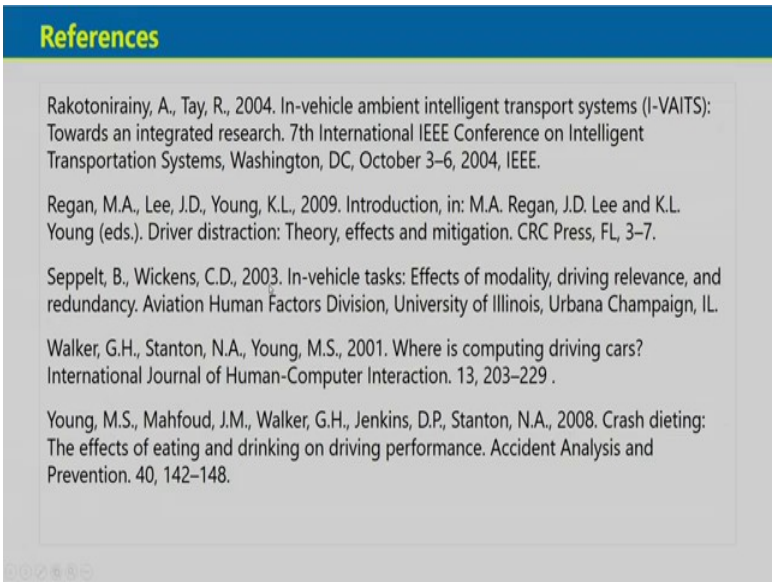

So, you can go through these references for a detailed understanding of various control and display design and usability evaluation.

Thank you.