Ergonomics in Automotive Design
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Module - 08
Lecture – 10
Driver Workload Measurement

Welcome to the course Ergonomics in Automotive Design.

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We are going to discuss our 8th module related to the driver's workload measurement. Under this module, we will go through two topics, the first one is about driver's task and workload assessment physiological and cognitive, and second one is the method to measure driver's workload.

Before starting to discuss about workload measurement techniques, we should know about driver's workload. The total amount of physical and mental resources and efforts required by the driver to perform various primary tasks are related to driving and/ or secondary task, is defined as the driver's workload. It is not directly related to driving under any given situation.

With the advancement of technology, numerous new devices or equipment which assists drivers in driver navigation were introduced. At the same time, there are so many other equipments and devices which are installed in vehicle for infotainment and for many other purposes.

Moreover, there are several factors in vehicle (internal and external) which leads to driver distraction. In this context, the estimation of driver's workload is of utmost necessity, to develop appropriate intervention strategies, to avoid error and accident while driving.

Driver's tasks and workload assessment

Most driver failures occur due to **information-processing failures**, that is, inability of the driver to make the right decisions at the right time and right place (Bhise, 2016).

The workload assessment is essential to understand
- How much occupied (both physically and mentally) is the driver during driving ?
- How many tasks can the driver handle safely?
- Would the driver be overloaded by this task under normal driving conditions?

Physical workload during driving

Driver's physical work includes **motor response** (neuro-muscular forces) by the driver to produce coordinated movements of different body parts (e.g., eye, head/neck, hand, arm, foot, leg, and torso) for reaching, grasping/ holding, operating the controls with needed speeds and accuracies.

If you look at the drivers failure and why it is happening; the majority of time it is related to failure of information processing, i.e. inability of the driver to make the right decision at right time and right place. The workload assessment is essential to understand. How much the driver is occupied in terms of physical and cognitive load? How many tasks can the driver handle safely? Moreover, we should also try to understand, would the driver be overloaded by the task under normal driving condition?.

The driver work load is the combination of both physical as well as mental aspect. So, first you should know, what are the various physical aspects of workload. So, driver's physical workload include motor responses, i.e. neuromuscular forces by the driver to produce coordinated movements of different body parts, it include eye, head, neck, hand arm, foot, leg, and torso; for reaching or grasping or operating the controls with needed speed and accuracies. So, these are the various aspects of physical workload.

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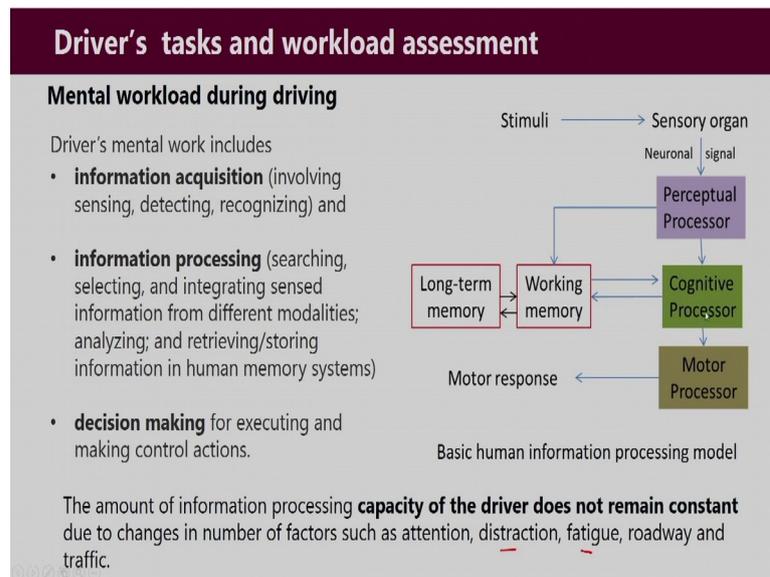
On the other hand, mental workload during driving includes information acquisition involving sensing, detecting, and recognizing. It also include information processing, i.e. searching, selecting, integrating sensed information from different sensory modalities, analyzing and retrieving or storing those information in our memory and at the end decision making for executing and making controlled actions.

The amount of information processing capacity of the driver does not remain constant; due to the changes of number of factors such as attention, destruction, fatigue, roadway condition, and traffic condition. Therefore, there are many factors which actually influences the driving situation and accordingly drivers workload changes. Now, if we look at this basic model of information processing, whenever some information is coming as stimuli, it reaches sense organs and goes to the perceptual processor.

From perceptual processor, it is moving to cognitive processor. In the cognitive processor, the long term and short term memory decision are made and these decisions ultimately leads to excute the motor response.

Now, what are the various primary task and secondary task are been performed by the driver while driving? We have discussed in our earlier modules about the list of primary task as well as secondary task.
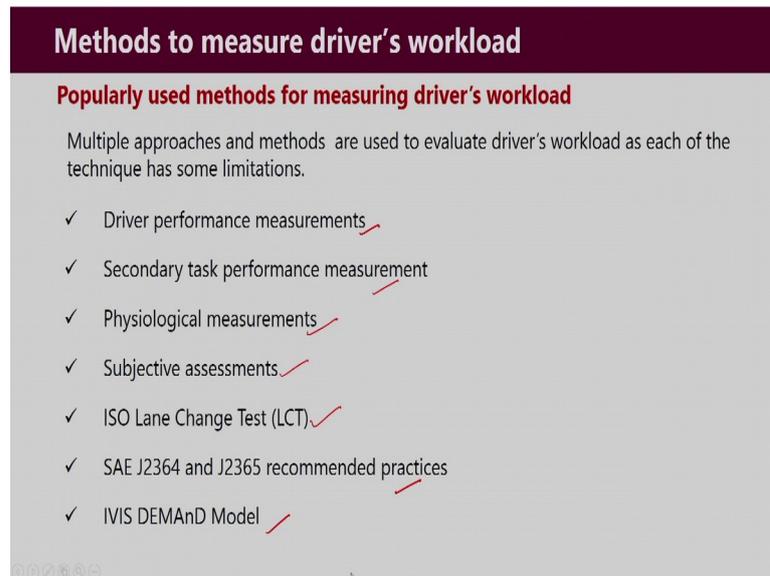
Generally, this primary tasks are involuntary in nature. Drivers has to perform those activities to navigate the vehicle safely without any accident or collision. So, for that purpose, generally which activities he or she has to perform? These activities include lateral control of the vehicle, longitudinal control of the vehicle, monitoring the roadway, i.e. the roadway condition, collecting information regarding the roadway condition and accordingly reacting. Then avoiding crash using in vehicle control and display for navigating the vehicle.

On the other hand, the secondary task are not directly related to driving task. These tasks includes activities related to driver distractions. Any sort of activities which are leading to driver destruction and not directly related to primary task of diving, are secondary tasks.

For the research purposes, we are going to measure workload of the drivers and different types of secondary task given to the driver along with the primary task. So, these types of task include peripheral detection task, arithmetic addition task, repetitive tapping task, the time estimation, choice reaction time task, critical tracking task, visual search task,

memory search task. So, these types of various tasks are given along with the primary task.

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There are various methods, popularly used for driver's workload measurement. But in general, in automotive industry, combination of these techniques are used because none of this technique are full proof or in other words, we can mention the each of these techniques has some limitations.

The popularly used method for measuring drivers workload includes driver performance measurement technique, secondary task performance measurement, physiological measurement, subjective measurement, ISO Lane Change Test, Society of Automotive Engineers J2364 and J2365 recommended practices and IVIS DEMAnD model. So, these are the various techniques popularly used for driver's workload measurement. We will discuss of all these techniques.

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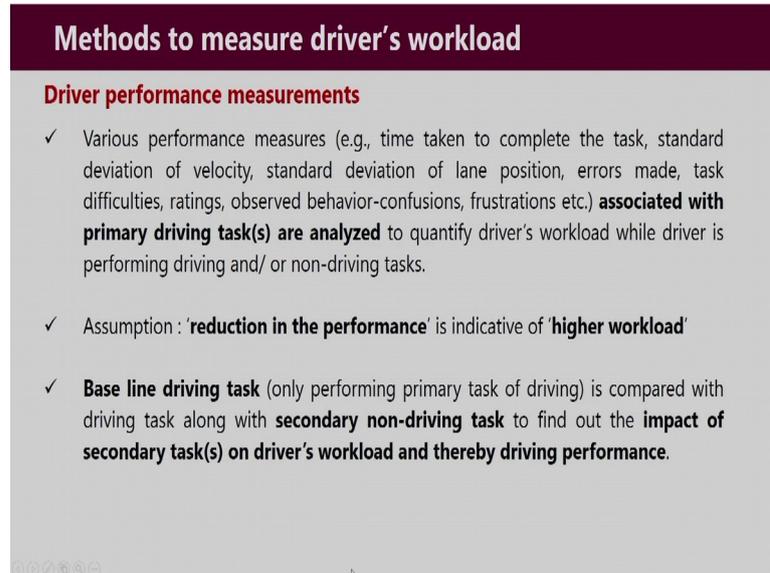
The first one is the driver performance measurement. Various performance measures, for example, time taken to complete the task, standard deviation of velocity, standard deviation of lane position, error made, task difficulties, ratings, observed behavior confusions, frustrations etc. associated with the primary task are analyzed to identify the drivers work load while driver is performing driving or non driving task.

In the driver performance measurement, usually, we need to concentrate on the drivers performance measures which are related to primary driving task. To quantify the drivers workload, some secondary tasks are given along with the primary task or only the primary task has been performed. Now, this is related to driver performance for the primary task.

The assumption for these techniques is taken as the reduction in the performance which is the indicative of higher workload either in primary task or in the secondary task. Therefore, the performance deterioration happens. The base line driving task (only performing the task of driving) is compared with driving task along with the secondary non-driving task. The purpose is to find out the impact of secondary task on drivers workload and thereby drivers performance.

(Refer Slide Time: 09:01)

Methods to measure driver's workload

Impact of secondary tasks (in addition to primary driving task) on driving performance

	Task Description			Ratio of Dual Task to Single Task (%)	
No.	Primary Task	Secondary Task	Measure	(D/S)%	Reference
1	Car following on a freeway	Exchanging text messages	Standard deviation of following distance	1.5	Drews et al. (2009)
			Lane crossings per kilometer	1.88	
2	Driving on a simulated two-lane roadway at about 50 mph	Reading cross streets on a map	Standard deviation of lateral position	1.5	Lambert et al. (2005)
		Read a short message from a text pager	Standard deviation of lateral position	1.41	
3	Driving on a simulated roadway at 60 kph	Sending text message using cell phone	Mean time headway	1.49	Hosking et al. (2009)
			Standard deviation of lateral position	1.45	
4	Following a lead vehicle while braking from 65 mph to 30-45 mph in a fixed-base driving simulator	Naturalistic conversing on a hands-free cell phone with a research confederate after 4 days of practice	Collision frequency (vehicle contacted objects in the environment)	1.71	Cooper and Strayer (2008)
			Brake reaction time	1.2	
			Following distance	1.12	

(Adapted from Bhise, 2016)

Bhise (2016) compared four research works reported by various researchers. So, from this four reported literature; he found that the secondary task have impact on the driving performance. So, in these studies, the primary task and the secondary tasks are listed.

While either the primary task only given or primary task and secondary task given in combination, various performance driving performance related measures were analyzed. It was observed that due to introduction of the secondary task, there is deterioration of the performance as it is indicated in this list.

For example, while the person is performing the only primary task, i.e. car following on a free away; along with that if we introduce the secondary task, i.e. the exchanging text messages. The result will be the performance deterioration due to the introduction of the secondary task.

In terms of standard deviation of the following distance; when we have compared, ratio of dual task to single task came 1.5. Similarly, when lane crossing per kilometer was compared; then again ratio for dual task or say single task came 1.88. So, based on these four research findings; it can be assumed that the introduction of the secondary task affect the driving performance in comparison to the primary task.

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Now, we will discuss about the next measure of drivers workload, i.e. secondary task performance measurement. The performance in the second task is used to measure the driver's workload while driver is performing driving task.

Here, the assumption is that the secondary task on the top of primary driving task will increase the drivers total workload. Thus the level of performance in the secondary task will indicate the spare capacity of the drivers available after maintaining the primary task performance. In this workload measurement technique, driver is instructed to maintain the performance in the primary task, i.e. maintain the lane, speed, heading distance etc.

While the performance is measured in a given secondary task, the driver is instructed to maintain the performance in the primary task. Here, we are measuring the performance given in the secondary task to understand how the pair capacity of the drivers available after maintaining the primary task. So, various secondary task are given for this purpose which include peripheral detection task, arithmetic addition task, repetitive tapping task, then time estimation, random number generation, choice reaction time task, critical tracking task, visual search task, and memory search task.

Methods to measure driver's workload

The use of the secondary task as a method to measure driver workload has a number of shortcomings (Bhise, 2016).

✓ Introduction of the secondary task may modify or interfere with the driver's primary task and thereby there might be a change in the workload imposed by primary task.

✓ It is difficult for some drivers to maintain the same level of attention and priority in performing the primary task when the secondary task is introduced.

✓ The interference in the primary task is greater when the tasks share the same response resources than where the responses occupy different resources.

The use of the secondary task as a method to measure diver's workload has a number of shortcomings as reported by Bhise, 2016. Firstly, the introduction of the secondary task may modify or interference with the drivers primary task and thereby there might be a change in the workload imposed by the primary task.

Secondly, it is difficult for some drivers to maintain the same level of attention and priority, in performing the primary task when the secondary task is introduced. Thirdly, the interference of the primary task is greater when the task in both primary and secondary are sharing the same response resources.

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Methods to measure driver's workload

Physiological measurements

✓ The **performance in the secondary task** is used to measure the driver's workload while driver is performing driving tasks.

✓ Assumption : **Higher physical and mental demands** (workloads) **would affect various physiological variables**. Thus, measuring these variable would indicate the level of driver's workload while the driver is performing primary and/or secondary tasks.

✓ Workload changes the level of arousal, excitement, stress/tenseness, thought processes, muscle tone etc. during performing a task and thereby affect physiological variables, e.g.
  - heart rate, blood pressure,
  - respiration rate, oxygen uptake, energy exenditure
  - electrical activity of muscles (through electromyogram, EMG),
  - electrical activity of brain (electroencephalogram, EEG),
  - electrical activity of heart (electrocardiogram, ECG),

The next measurement technique is the physiological measurement for driver's workload assessment. The performance in the secondary task is used to measure the driver's workload while driver is performing driving task. Here, the assumption is higher physical and mental demands, i.e. the workloads would affect various physiological variables. Thus, measuring these variables would indicate the level of driver's workload while driver is performing primary and/ or secondary task.

Workload changes the level of arousal, excitement, stress or tenseness, third processes, muscle tone, etc while performing a task and thereby affect the various physiological variables. These physiological variables used for these measurement include heart rate, blood pressure, respiratory rate, oxygen uptake, energy expenditure, electrical activity of muscles through electromyogram (EMG), electrical activity of the brain through electroencephalography (EEG), electrical activity of the heart, electrocardiogram (ECG).

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Methods to measure driver's workload

- electrical activities of the eye muscles (electro-occulograms, EOG),
- galvanic skin response,
- body and skin temperatures, sweat rate,
- eye movement variables (pupil diameter, blink rate, eye fixation, etc.)

Physiological measures to estimate the driver's mental workload is relatively less reliable as there may be large individual variations as well as influenced by many factors (e.g., anxiety, stress) (Bhise, 2016).

The physiological measures are rarely used during the vehicle development process due to following reasons (Bhise, 2016)
- Correlation between the physiological measures and real world performance are not well established
- Physiological measures are difficult to obtain during the driving environment, and
- Data acquisition, analysis and interpretation incur higher value for infrastructure/ equipment, cost, and trained manpower.

Furthermore, electrical activities of the eye muscles which is called electroocculograms, then galvanic skin response, body and skin temperature, sweat rate and eye movement variables that relate to eye tracking (includes pupil diameter, blink rate, eye fixation, fixation duration, fixation frequency, etc.).

Physiological measures to estimate the driver's mental workload is relatively less reliable, as there may be a large individual variation as well as it may be influenced by factors like anxiety stress. So, these physiological measures which has been discussed are not the good estimate for the mental workload, however, they are very good estimate for the physical workload. It is not good for the mental workload because metal workload is influenced by so many other factors and there are also subject to subject variations. The physiological measures are rarely used during vehicle development process due to following reasons:

Firstly, correlation between the physiological measures and the real hour performance is not well established. Secondly, physiological measures are difficult to obtain during actual driving condition. Thirdly, data acquisition, analysis, interpretation incur higher value for infrastructure or equipment cost and for trained manpower.

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Methods to measure driver's workload

Subjective assessments

✓ Subjective response of the driver regarding the level of difficulty, stress, discomfort, mental workload, physical workload, etc., during performance of different primary and/ or secondary tasks are generally collected using rating scales (Tsang and Velazquez, 1996).

✓ Assumption: Drivers can directly express their perception regarding the various dimensions of the workload

✓ Popularly used subjective workload measurement techniques used in automotive industries are
  • NASA-Task Load Index (TLX) (Hart and Staveland, 1988)
  • Driving Activity Load Index (DALI) (Pauzié, 2008).
  • Subjective Workload Assessment Technique (SWAT) (Reid et al., 1982), and
  • Workload Profile (WP) (Rubia et al., 2004).

Now, moving to the next topic, i.e. the subjective assessment for driver's workload. In subjective response of the drivers regarding the level of difficulty, stress, discomfort, mental workload, physical workload etcetera during performance of the different primary and/ or secondary task are generally collected using rating scales.

So, for subjective assessment, generally, we ask the subjects to rate on a rating scale about his/ her perception of the difficulty, stress, discomfort, mental workload, physical workload and other aspects. Here, the assumption is that the driver can directly express their perception regarding the various dimensions of the workload. Therefore, it is easy to collect the reliable information.

Popularly used subjective workload measurement techniques include NASA, TLX, Driving Activity Load Index, DALI, SWAT and workload profile.

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These subjective methods are commonly used in vehicle development because they are easy to obtain the measurements required; instrumentation and have high face validity as the voice of the consumer or customer.

Also, there are various disadvantages of the subjective methods which includes: rater may find it difficult to understand the definition or description of the individual scales used for the subjective measurement purposes. Moreover, the rater may find it difficult to understand many issues associated with comparing different products and situations. Third, the agreement between different raters may not be well agreed.

Methods to measure driver's workload

NASA-Task Load Index (TLX)

NASA-TLX is a multidimensional rating scaled based procedure to estimate overall workload score based on a weighted average of ratings on six subscales (Hart and Staveland, 1988).

These six sub-scales include (1) Mental Demand, (2) Physical Demand, (3) Temporal Demand, (4) Own Performance, (5) Effort, and (6) Frustration

The subjective response is collected from the drivers on each of the subscales (specified by 5-point/ 20 point/100-point interval scales). The standardized descriptors used for each subscale category and adjectives used to define their end points are presented in the next slide.

After getting the rating on these six sub-scales, **pairwise comparisons** are performed between these six factors, in order to determine the **higher source of workload factor** for each pair.

Among the various subjective measurement techniques of driver's workload measurement, we will be going to discuss about the NASA TLX method. NASA TLX is a multidimensional rating scale based on procedure to estimate overall workload score; this is based on weighted average of rating of six subscales.

So, in NASA TLX, there are six subscales and the operator or the driver after driving has to rate on six different subscales. These subscales include mental demand, physical demand, temporal demand, own performance, effort and frustration. The subject response is collected from the drivers on each of the subscales that subscales may be specified on 5 point, 20 point, even 100 point interval scale. The standardize descriptions used for each of the subscale and adjectives used for defining their limits are painted in the next slide.

So, after getting the ratings on each of the sub-scales; pairwise comparison of these subscales are performed in order to determine higher source of work load factor; out of the six subscales which have more influence on the workload measurement. So, that is estimated by pairwise comparison of this factors or sub-scales.

Methods to measure driver's workload

The ratings on individual subscales can be used as evaluation scores, or an overall workload score can be obtained from a weighted sum of the ratings on the six scales.

Descriptors used for each subscale of NASA-TLX

Title	End points	Description
Mental demand	low/ high	~~Low, high~~ How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching)? Was the task easy or demanding, simple or complex, exacting or forgiving?
Physical demand	low/ high	How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
Temporal demand	low/ high	How much time pressure did you feel due to the rate or pace at which the tasks of task elements occurred? Was the pace slow and leisurely or rapid and frantic?

The rating on individual subscales can be used as evaluation scores or an overall workload can be obtained from the weighted sum of the rating on six scales. And that is used for comparing the overall workload between two task while drivers are using two different instruments or two different in vehicle information system. So, we can use this type of subjective assessment techniques; where the overall weighted sum is indicating the workload of the driver.

Descriptors used for each of these subscales are presented in this table. So, first one is the mental demand or the both end of the scale is high and low. As we already discussed that 5 point, 10 point or 100 points and drivers has to rate on that scale. So, the mental demand deals with how much mental and perceptual activity was required? Is he thinking, deciding, calculating, remembering, looking, searching?

Was the task easy or demanding, simple or complex, exacting or forgiving? So, these are questions related to mental demand. While getting information regarding to physical demand, the questions which are asked are how much physical activity was required was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?

For understanding the temporal demand, the types of questions are asked are how much time pressure the driver feel due to the rate or pace at which the tasks or task elements occurred. Was the space slow and leisurely or rapid or frantic?

Methods to measure driver's workload

Continuation of the table

Title	End points	Description
Performance	Good/ :poor	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
Effort	low/ high	How hard did you have to work (mentally and physically) to accomplish your level of performance?
Frustration	low/ high	How insecure, discouraged, irritated, stressed, and annoyed versus secure, gratified, content, relaxed, and complacent did you feel during the task?

Similarly, for assessing the performance the questions are asked how successful do you think you were in accomplishing the goals of the task said by the experimenter? How satisfied were you with the performance in a accomplishing these goals? For effort, the question is how hard did you have to work to accomplish your level of performance and to understand the frustration level of the driver the question is how insecure, discouraged, irritated, stressed and annoyed versus secured, gratified, content, relaxed and complacent did you feel during the task.

(Refer Slide Time: 22:37)

Methods to measure driver's workload

Driving Activity Load Index (DALI)

DALI is used to measure driver's perceptions of their workload whilst performing driving and/or non-driving secondary tasks.

This is **a modified NASA-TLX** workload measurement technique and is designed specifically for the driving context. The basic principle of the DALI is similar to the NASA-TLX, with a scale rating procedure for six pre-defined factors, followed by a weighing procedure in order to combine the six individual scales into a global score (Pauzié, 2008).

The main difference lies in the choice of the main factors composing the workload score.
DALI includes following 6 scales for subjective rating (Pauzié, 2008) by drivers:

(a) **Effort of attention, (b) Visual demand,**

(c) **Auditory demand, (d) Temporal demand,**

(f) **Interference and (g) Situational stress**

Now, the next subjective assessment technique is the Driving Activity Load Index (DALI). So, DALI is used to measure driver's perception of their work load while performing driving and/ or non-driving secondary task.

This is actually modified NASA TLX workload measurement techniques and is designed specifically for driving context. The basic principle of DALI is similar to NASA TLX with scale rating procedure for six predefined factors followed by a weighted procedure in order to combine the six individual scales into global score. The main difference lies in the choice of main factors composing the workload score.

Although here also for six scores, the same procedure of calculating the global score, the difference is in terms of the factors or subscales. So, DALI includes 6 subscales like NASA TLX and these subscales are effort of attention, visual demand, auditory demand, temporal demand, interference due to the secondary task and situational stress.

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Methods to measure driver's workload

Workload dimensions for the DALI (Pauzié, 2008)

Title	End points	Description
Effort of attention	low/ high	to evaluate the attention required by the activity – to think about, to decide, to choose, to look for and so on.
Visual demand	low/ high	evaluate the visual demand necessary for the activity
Auditory demand	low/ high	to evaluate the auditory demand necessary for the activity
Temporal demand	low/ high	To evaluate the specific constraint owing to timing demand when running the activity
Interference	low/ high	to evaluate the possible disturbance when running the driving activity simultaneously with any other supplementary task such as phoning, using systems or radio and so on.
Situational stress	low/ high	to evaluate the level of constraints/stress while conducting the activity such as fatigue, insecure feeling, irritation, discouragement and so on.

Now, if you look at this table; the workload dimensions and the descriptions are mentioned. The first column is showing the previous workload dimension, six workload dimensions and the second column is the end points. The one end of the scale is low and another end is high. The last column is giving the description of each of this workload measurement dimensions.

Methods to measure driver's workload

In a study reported by Harvey and Stanton (2013), out of the 6 scales used in DALI; only 4 scales namely global attention demand/ effort of attention, visual demand, stress interference were used. They compared workloads for the use of touch screen and rotary controller against primary driving task (as control).

They observed a trend that control condition producing lowest levels of subjective workload (where applicable), followed by the touch screen and finally the rotary controller.

	Control		Touch Screen		Rotary Controller		
	Mean	SD	Mean	SD	Mean	SD	N
Global attention demand	2.20	1.01	3.50	0.83	4.05	1.10	20
Visual demand	2.70	1.17	4.05	8.26	4.35	0.81	20
Stress	1.45	1.15	3.15	1.81	3.95	1.10	20
Interference	—	—	3.70	0.73	4.10	1.25	20

Mean (SD) subjective rating for different scales under various test conditions
(Adapted from: Harvey and Stanton , 2013)

Now, for the method to measure the drivers work load, we use the DALI technique. So, here in a study reported by Harvey and Stanton (2013), out of the 6 scales which are used in DALI; they only used 4 scales; these 4 scales were global attentional demand or effort of attention, visual demand, stress, and interference.

They compared workload for the use of touch screen and rotary control against the primary task as the control. So, now if you look at this table; there are the four dimensions which they in the study global attention, visual demand, stress and interference. The control condition is the only performing the driving task; that time these are the mean and standard deviation value for this various subscales. And this is for the during operation of the touch screen along with the primary driving task and this is the rotary controller.

It was observed that the control condition was producing the lowest level of subjective workload; whereas the subjective workload is more in case of touch screen and it is relatively more in case of rotary control. They conduct this experiment on 20 people and they found that use of touch screen is relatively better than the rotary controls because the global demand visual demand and stress interference is relatively less in case of touch screen.

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Next is the Subjective Workload Assessment Technique (SWAT). In SWAT, the workload is a function of three dimensions, i.e. time load, mental effort load and psychological load.

So, unlike other assessment techniques discussed earlier with 6 scales, here are 3 scales. For each of these three sub-scale there are three possible levels, low, medium and high. All possible combinations of the three levels of each dimension yield a 27 scales; three dimensional matrix to present the workload. The method uses conjoint measurement and scaling techniques to develop a single interval rating scale as reported by Reid et al. (1988).

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Methods to measure driver's workload

Scales used in SWAT technique (adapted from Bhise, 2016)

No.	Scale	Level	Descriptors
1	Time load	Low	Often have spare time. Interruptions or overlap among activities occur infrequently or not at all.
		Medium	Occasionally have spare time. Interruptions or overlap among activities occur infrequently.
		High	Almost never have spare time. Interruptions or overlap among activities are very frequent or occur all the time.
2	Mental effort load	Low	Very little conscious mental effort or concentration required. Activity is almost automatic, requiring little or no attention.
		Medium	Moderate conscious mental effort or concentration required. Complexity of activity is moderately high due to uncertainty, unpredictability, or unfamiliarity. Considerable attention required.
		High	Extensive mental effort and concentration are necessary. Very complex activity requiring total attention.
3	Psychological stress load	Low	Little confusion, risk, frustration, or anxiety exists and can be easily accommodated.
		Medium	Moderate stress due to confusion, frustration, or anxiety noticeably adds to workload. Significant compensation is required to maintain adequate performance.
		High	High to very intense stress due to confusion, frustration, or anxiety. High extreme determination and self-control required.

Now, in this table, we are showing the various scales, i.e. time load, mental effort load and psychological stress load under each of these scale there are three levels low, medium and high. So, for low, there often have spare time, interruptions or overload among activities occur infrequently or not at all. For medium, occasionally have the spare time and in case of high, almost never. So, in this way all the levels low, medium and high are described in the description section.

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Methods to measure driver's workload

Workload Profile (WP)

The WP method is based on the multiple resource model (Wickens, 1987).

It considers **eight (08)** workload dimensions:
(1) Perceptual/central processing, (2) Response selection and execution,
(3) Spatial processing, (4) Verbal processing, (5) Visual processing,
(6) Auditory processing, (7) Manual output, and (8) Speech output

After completion of the assigned tasks, subjects are asked to provide rating (on a scale staring at 0 and ending at 1) for each of the task (in a random order) for eight workload dimensions. Thus, a rating of 0 means that the task does not require the dimension and 1 means that the task required maximum attentional resource.

The ratings on these eight dimensions of each task are later summed to obtain an overall workload rating for the task.

The next method is Workload Profile (WP). The work profile method is based on multiple resource model as reported by Wickens (1987) consists of eight work load dimensions. So, unlike the SWAT technique, here are 8 workload dimensions, viz. perceptual or central processing, response selection and execution, spatial processing, verbal processing, visual processing, auditory processing, manual output and speech output. So, these are the 8 various workload dimensions which are used in workload profile technique.

After completion of the assigned task subject are asked to provide ratings on a scale of starting at 0 and ending at 1; for each of the task in a random order for 8 workload dimensions. Thus a rating of 0 means that the task does not require the dimension and 1 mean; means that the task require maximum attentional resource. The ratings on these 8 dimensions of each task are later summed to obtain the overall workload rating for that particular task.

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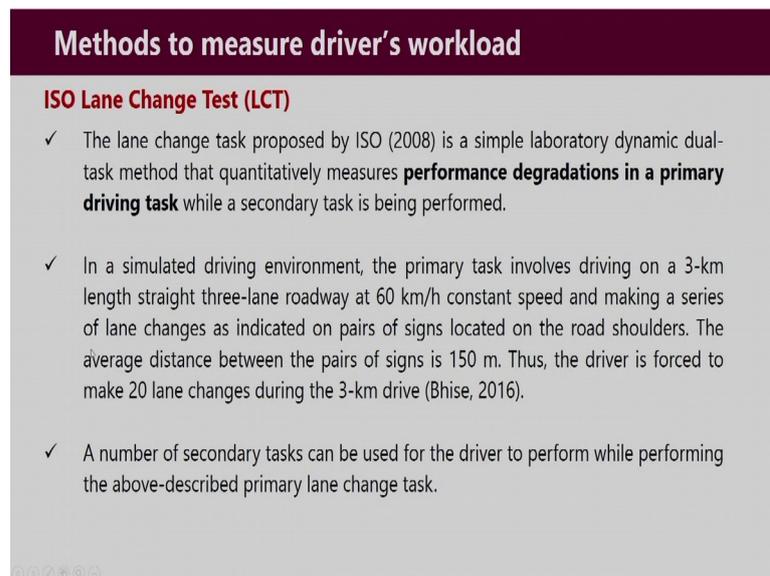

Next technique is the ISO Lane Change Test (LCT). The lane change task proposed by ISO in 2008 is a simple laboratory dynamic dual task method that quantitatively measures performance degradation in primary driving task. So, although what primary and secondary task are given, but performance degradation is measured for the primary task, while a secondary task is performed.

In a simulated driving environment, the primary task involves driving on 3 kilometer length straight three lane roadway at 60 km per hour constant speed and making a series of lane change as indicated by the pairs of signs located on the road shoulders. The average distance between the pair signs is 150 meter. Thus, the driver is focused to make 20 lane changes during the 3 kilometer ride.

A number of secondary task can be used for the diver to perform while performing the above described primary lane changed task. So, while the driver is performing the lane changed as specified in ISO; these type of 3 kilometer lane changing task driver is performing the different types of secondary task are given to assess the influence of the secondary task on the driving performance.

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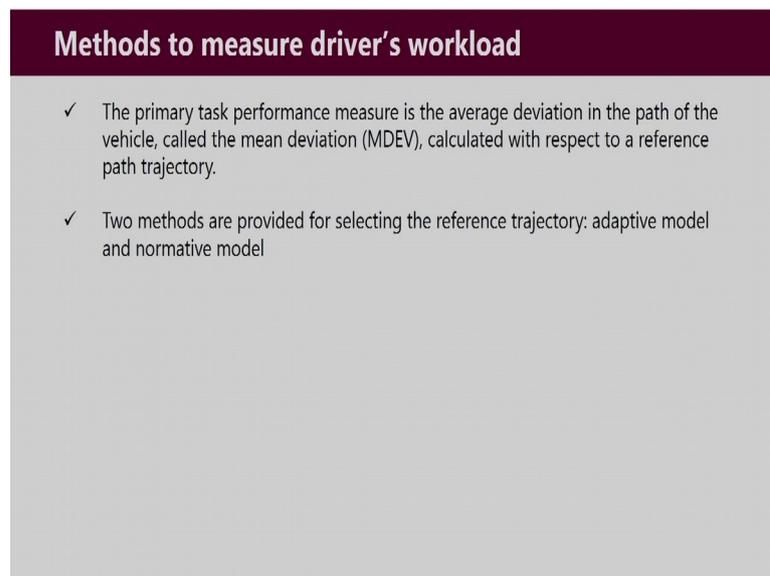
Methods to measure driver's workload

✓ The primary task performance measure is the average deviation in the path of the vehicle, called the mean deviation (MDEV), calculated with respect to a reference path trajectory.

✓ Two methods are provided for selecting the reference trajectory: adaptive model and normative model

The primary task performance measures is average deviation in the path of the vehicle called mean deviation (MDEV) calculated with respect to the reference path trajectory. Two methods are provided for selecting the reference trajectory adaptive model and normative model.

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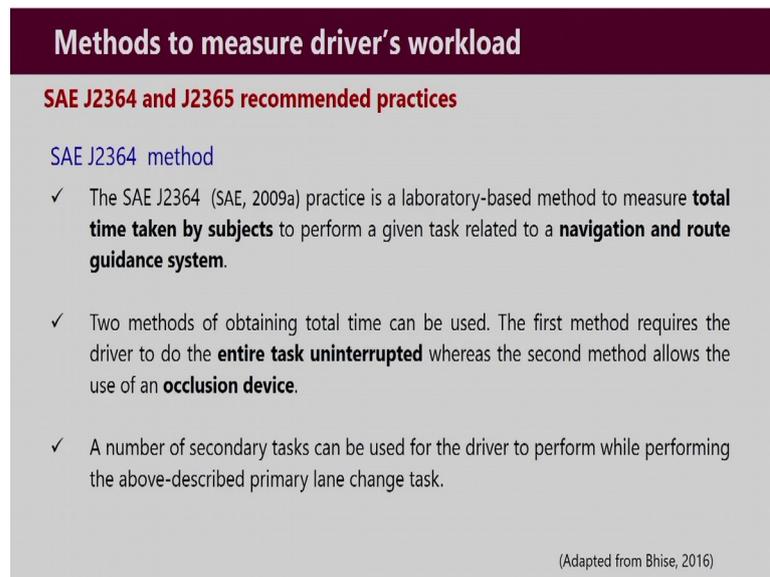
Next technique is the SAE; J2364 and J2365 recommended practices. So, first we are going to discuss about the J2364 method. The SAE J recommended practice are actually laboratory based methods. And in this method total time taken by the subject to perform a given task related to navigation and route guidance system.

The total time taken by the subjects is actually measured or the given task and the task is related to navigation and route guidance systems. So, two methods of obtaining total time can be used; the first method require the drivers to do the entire task uninterruptedly where as the second methods allow to use a occlusion device. A number of secondary task can be used for the driver to perform while performing the above described primary lane changed task.

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Methods to measure driver's workload

✓ The subjects for the test should be licensed older drivers (aged 45–65 years) who are initially not familiar with the device. The total time taken to complete the task is measured **after five practice trials**.

✓ The SAE practice recommends using **10 subjects** and measuring total time three times (**three trials** after the first five practice trials) for each subject. The task is performed under **a static or non-driving situation** in a laboratory bench test type situation.

✓ For the occlusion method, the total time is measured by summing all the glances to use the device/ to complete the task being evaluated.

✓ The task is considered to be acceptable if it can be completed in less than **15 s** under uninterrupted method and **20 s under the occlusion method**.

(Adapted from Bhise, 2016)

The subjects for the test should be licensed older driver age between 45 to 65 years; who are initially not familiar with the device. Because this technique is mainly used for evaluating the device newly introduced in vehicle information system device or any other device which are newly introduced. It is used to evaluate how that is affecting the driver's workload.

The total time taken to complete the task is measured after five practice trials. The SAE practice recommends using 10 subjects and three times for each of the subjects. While the subjects are performing a static non driving situation in a laboratory bench test type situation. For the occlusion method total time is measured by summing all the glances performing through the occlusion device to complete the task or use of the device being evaluated. The task is considered to be acceptable, if it can be completed within 15 second under uninterrupted method or within 20 second under occlusion method.

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In SAE J2365 method practice presents and analytical method to calculate the time; to complete a given in vehicle navigation and route guidance task. So, it also the like earlier one and only used for the vehicle navigation and route guidance task. The advantage of this method is that it does not require the working version of the device which is going to be evaluated; it can be implemented at the early design phase. The method is usually useful in the early design phase in which a number of alternate design concepts and their operational features can be evaluated by comparing the total time estimates to perform each of the given task. The major limitation of this method include non consideration of voice activated controls, voice output and communication between driver and others or passenger operation.

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Methods to measure driver's workload

The calculation method is based on the Goals, Operators, Methods and Selection Rules Model

The method involves

(a) breaking down the task into a series of simple steps;

(b) applying predetermined times by considering appropriate mental operations, key strokes, age multipliers, and other operators in each step;

(c) summing the assigned times for each sub-goal (e.g., move hand to the device, select a city) and goal (e.g., enter a destination using the street address method) in each step; and

(d) summing the completion times over all steps to obtain an estimate of the total time required.

(Adapted from Bhise, 2016)

The calculation method is based on goals, operators, methods and selection rule model. The method involves as described by Bhise (2016); firstly, this method involves breaking down the task into series of simple steps. Secondly, applying the predetermined times by considering appropriate mental operations, key strokes, age multipliers and other operators in each step.

Summing the assigned times for each sub goals, i.e. move hand to the device, select a city and goal, i.e. enter the destination using the street address method in each steps. And last step is summing the competition times over all steps to obtain the estimate of total time required. So, following this steps ultimately total time is calculated to perform the task.

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Methods to measure driver's workload

IVIS DEMAnD Model

✓ The level **of driver distraction associated with an in-vehicle device** can be evaluated using **In-Vehicle Information System Design Evaluation and Model of Attention Demand** (called the IVIS DEMAnD Model) which is a computer based model system.

✓ Hankey et al. (2001) developed this model to allow automotive designers and safety engineers to predict driver workload levels on either an existing or a proposed vehicle information system

✓ This model is useful to enter dimensional data for a given vehicle, along with the locations of controls and displays for the system being analyzed. The model uses empirical data from a database of human factors to predict the driver workload associated with the system or a task completed on that system (Bhise , 2016).

The last technique is In-Vehicle Information System Design Evaluation and Model of Attention Demand (IVIS DEMAnD). The level of driver distraction associated with in vehicle device can be evaluated using this technique; this technique is actually a computer based model system. Hankey et al. (2001) developed this model to allow automotive designers and safety engineers to predict drivers workload levels on their existing or a proposed vehicle information system.

So, the engineers, safety engineer or the automotive designers introducing new device use this work workload measurement techniques. This model is useful to enter dimensional data for a given vehicle along with the location of controls and displays for the system being analyzed. The model uses empirical data from a database of human factors to predict the drivers workload associated with the system or task completed on that system.

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Key learning from Module 8

✓ Definition of driver's workload

✓ Various primary (driving related) and secondary (non-driving) tasks performed by drivers during driving

✓ Activities related to physical and mental workload

✓ Approaches and methods are used to evaluate driver's workload

Now, we are going to discuss about the key learning's in module 8. So, in this module we learnt about the definitions of drivers workload, then we discussed about the various primary task performed by the drivers which is related to driving and various secondary task which is not directly related to driving. And then activities related to physical and mental workload were discussed. And finally, various approaches and methods used for evaluation of drivers workload discussed and their advantages-disadvantages were also mentioned.

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Now, these are the various references which has been used for preparation of different slides. So, you can go through these references for detailed understanding or more understanding of the subject related to driver's workload measurement, procedures and their limitation or their advantages.

Thank you.