Ergonomics Research Techniques

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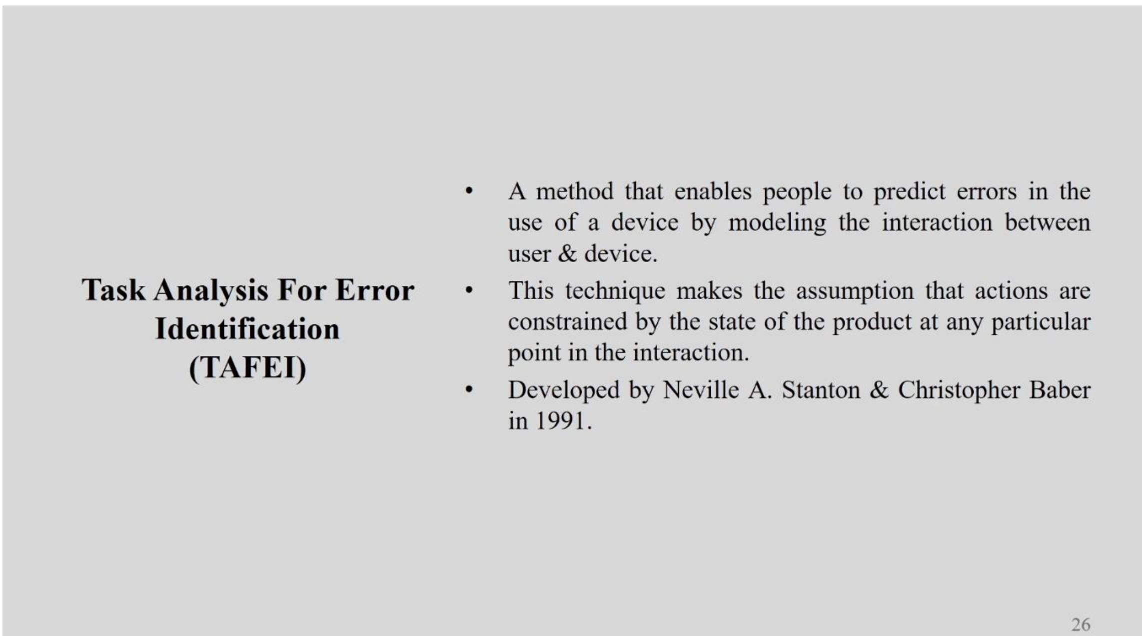
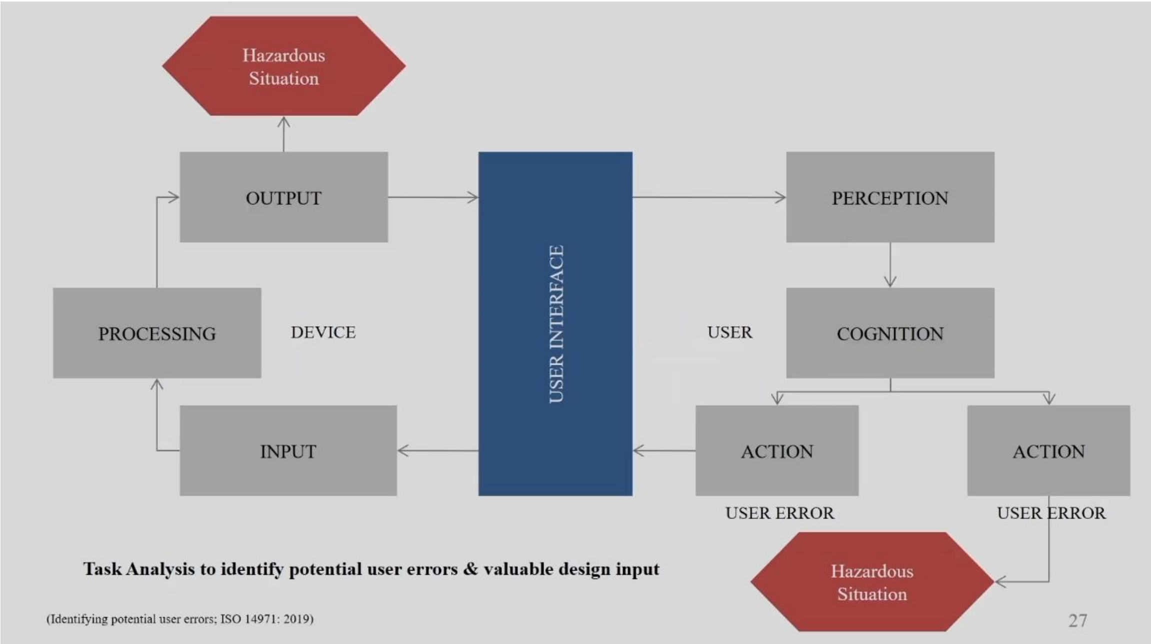
Week 9: Lec 31- Error analysis methods

Task Analysis for Error Identification (TAFEI)

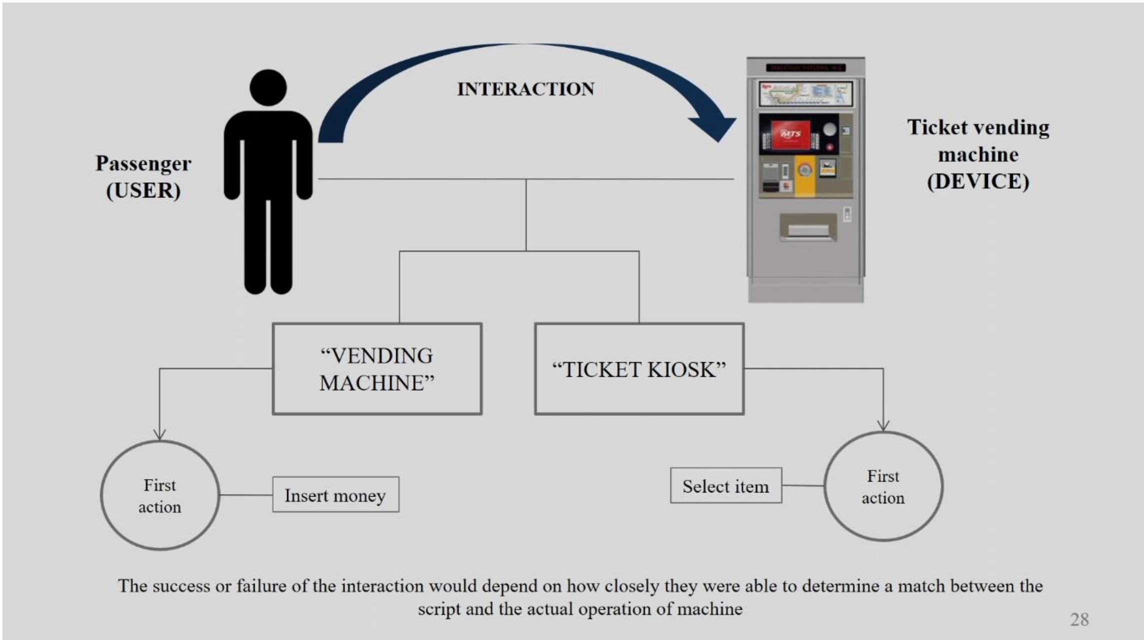
Last time we started understanding about the error analysis ok. So, we discussed that there are different methods in error analysis specifically human error analysis in a particular system right. So, I mentioned in this particular course we will be discussing two major technique through which we we go for the error analysis one is SHERPA which is which takes care about the systemic analysis of the human error ok. The next that we supposed to discuss today that is the task analysis for error identification or we call it as TAFEI ok. So,from the nomenclature you do understand what we will be doing we will be doing a task analysis from that particular task analysis we will try to understand or we will try to identify the error in a particular system. So, we will take as as we are going in this particular course that you know first we are understanding a particular topic and then we are going for the example. Here also we will go the in the same way. First we will understand the methodology or how do we take or how do we conduct the task analysis for error identification this particular method and then we will take up an a small example and then we will go for the advantage, disadvantage and different tools that is required for this particular analysis ok. So, let us understand small introduction or let us discuss about the small introduction of this particular tool. Here also same thing this particular tool or this particular method is not a very old method ok. Over the period of time when a system became more complex in nature specifically when there is a lot of development in the aeronautical science there are a lot of you know development in the aerospace engineering then you know complex system like nuclear power system. So, for all these cases we realized you know the scientist those days realized that there are a lot of you know due to lot of human error there are chances of accidents and there was a major demand that we should identify we should understand or we should pick them as an error or we should identify them on before the accident happens. If we can do this type of identification in the system you know prior to implement any kind of system in place what will happen there will be less chance of accident. We are not saying there will be no accident however chances of accidents will be less and the precautionary measures can be deployed beforehand ok. So, if there is a high chance of you know accident so there is a system where there is possibilities of you know error is very high in that case what will happen we can develop a precautionary measurement or we can design the system in such a way so that if by chance that error happens also there will be another system which can take care of the error and the system will not malfunction ok. So, from that perspective these error analysis are very very important and it helps to helps to you know function the bigger system in very you know error free manner or less with less error activities ok. And also here the decision making are very very important because if an error happen then if the decision is correct to counter measure that particular error, we will be able to handle the situation very nicely. Otherwise there will be a chance that the whole system will malfunction and the cost will be cost for this particular accident or particular that hazardous situation will be very high. So, identifying error is really an important step to control the whole environment ok. So, let us begin with the task analysis of error identification.



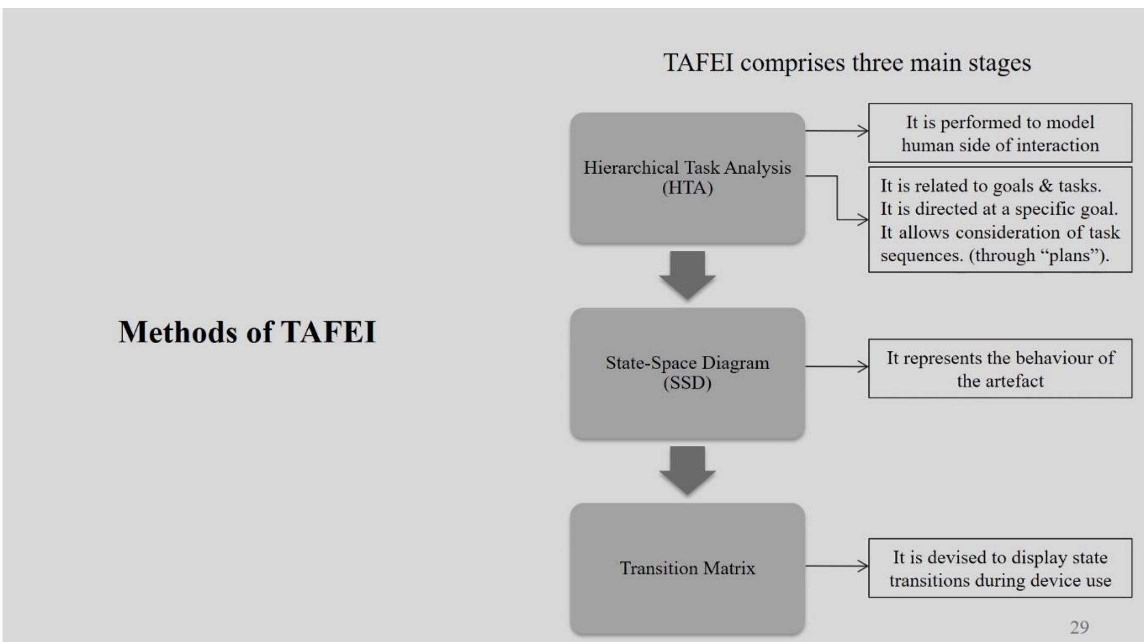
So, this particular method helps or enables people to predict again I am saying this is a predictive method ok. So, similarly as in other areas like ok in Sherpa also we try to predict it ok. So, to predict the errors in the use of a device by modeling the interaction between the user and device. So, here what we are trying to do is we are trying to understand the user and the device how they are interacting with each other. So, if we understand those interaction properly what will happen? So, that will give us an understanding what are the possible failure are there in those interaction and what are the sources of those error ok. So, this method actually what we will do we will model the interaction between the user and the device. So, this technique is not very old as I mentioned earlier also. It is a in 1991 Stanton and Baber you know they actually came out with this particular method. So, this technique makes the assumption that actions are constrained by the state of the particular product that we are currently going to discuss at any particular point in the interaction. So, suppose we are I am taking this lecture through a device right ok. So, there is a monitor through where these presentation is being displayed and I am looking at it and I am talking to the camera right. Now, if this is a particular system. So, I am going to I am actually interacting with camera and also with the this particular monitor. Now, each interaction with this monitor and the camera can be you know detailed it out and there are possible error, erroneous action can be identified to understand what are the possible way to malfunction this particular process ok. So, here is a display if by mistake my no it is a no touch screen system right. So, if by mistake I touch the screen the slide will move. So, if it is not required still I am by mistake I am you know taking a chance to put my finger on the screen the slide will move. So, again it is an error right. So, how I am interacting with my device you know we need to understand those detail and we need to understand what are the possible errors may come. So, we will take those examples in the next phase of the presentation. So, let us know more about this particular system.



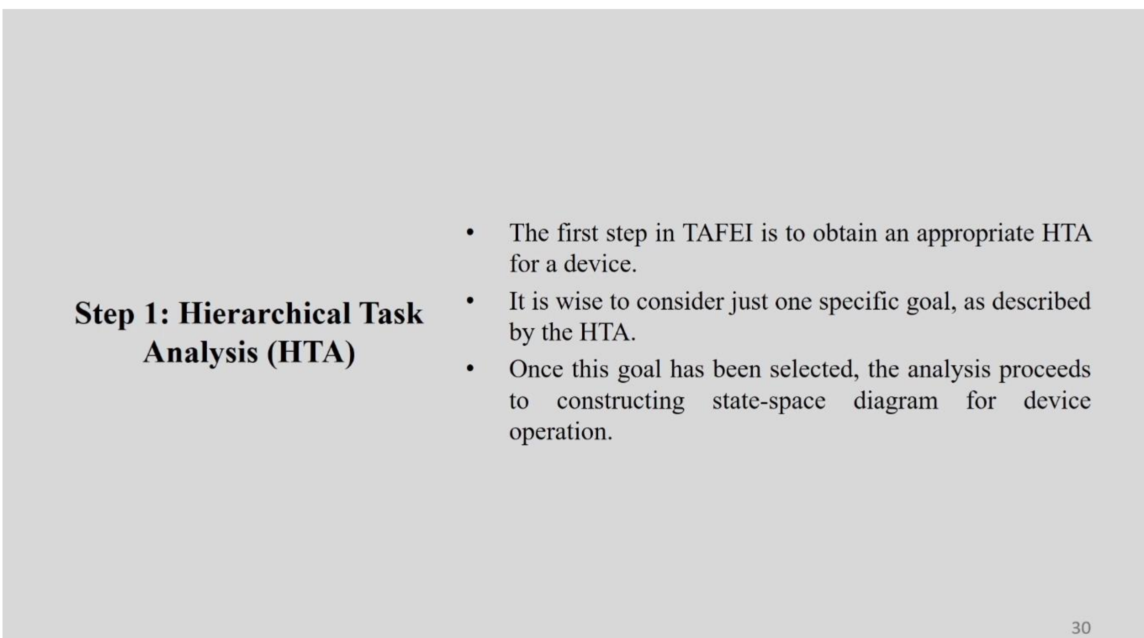
So, this particular diagram shows that how the there is a device and there is a human means the operator and it is an interface how they are interacting with each other to run this particular system. So, here you can see this is the user interface. This is very important because from this particular point what will happen the user will get the information back user will get the information back from the device right. So, first let us understand there is an information there is an information which is going as an input to the processing unit of the system. Now, once there is an input in the device and it perceived by the processing unit what will happen there will be a process and there will be a generation of an output right. So, input then processing and then output then this can be with a particular material, particular information, particular action many things can be possible. Now, when there is an output possibilities are there it can create some hazardous situation. Now, once there is an output, output will where it will go? Output will be going to the user as a feedback system for the through the user interface right. So, once there is of there is an output what will happen the user this particular user will perceive this output through their perception ok. So, once they perceive they will recognize that particular information and there will be action, there will be action ok. That action again will go back as an input to the system. Now, here in this particular action there are possibilities that there will be you know error and it can create an a hazardous situation right. So, both cases where the in output is there and the action performed by the human is there possibilities are there to have an hazardous situation. And if we identify these users error beforehand, then we will be able to control these hazardous situation through some control measures. Of course, we cannot say there will be no error. If human is working in a particular situation for different reasons, different causal factors are there which may cause the you know generation of error human error ok. However, we can definitely control it if we can predict it beforehand and we can have some control measure. Now, here point is the decision making. If there is some error, if we can identify it properly or we have an identification method to identify that error then definitely the human can take a better decision to control that hazard. So, if error happens also the system will not malfunction drastically ok. There are some control measures which will control it and the system will continue to perform with proper activities ok. So, that is why the this particular analysis, this particular method is very important when there is a task to be performed and there is an interaction between the device and the user ok. So, when there is a there is an interaction in the system the user and the device of course, we can use this particular method to predict the possible errors and to based on the possible errors what we can do we can have our control measures ready ok. So, we can design the training, we can design the you know facilities to to to control that particular accidents and many other things depending on the context. So, let us move further.



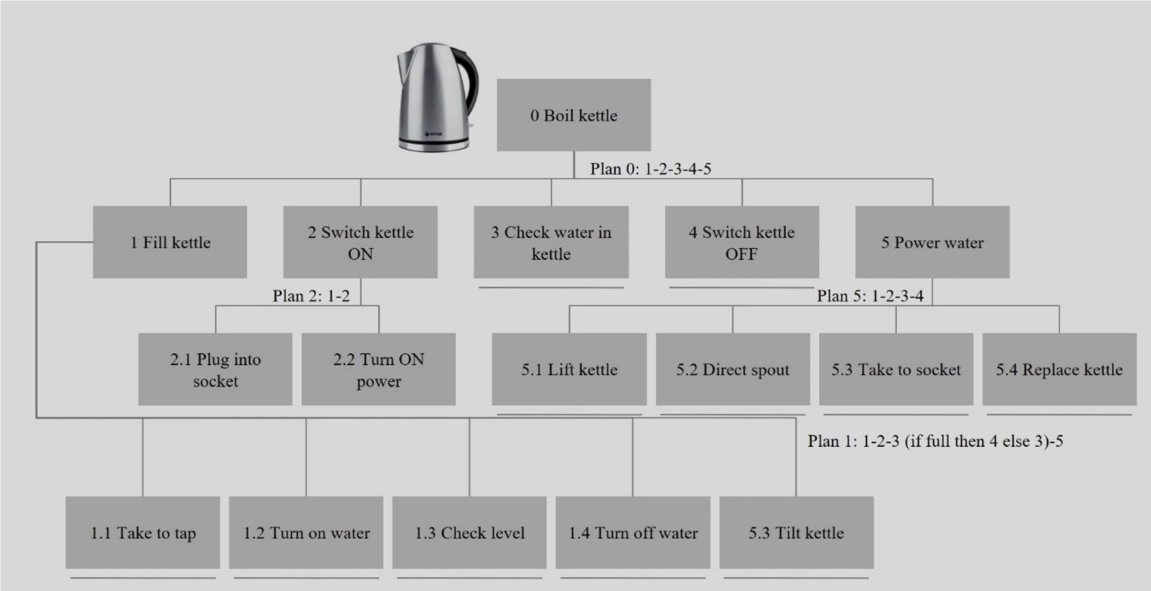
So, this is an example where there is a ticket vending machine and the human is coming and putting the you know coins or the money to the ticket vending machine and the he or she is receiving the ticket back. So, there is definite interaction point that interaction points are two two types one is ticket vending machine is asking for money and ticket vending machine is giving the ticket to the human ok. So, error can happen both the cases when when there is an user they are giving a command they are giving a command to the ticket vending machine and ticket vending machine the first you know first activity towards the vending machine by the human is inserting money. So, here while inserting money there can be an error. If the position of the you know money collection is not correct or not recognized by the human there is a possibility to do an error. If the person is not in a position to reach that particular place or reach that particular point of the machine is is not possible to you know reach by the person there can be error ok. If the person is not in a position to read the information you know displayed in the system what is the next step to be performed there can be an error ok. So, there can be human error for different places for different reason ok. So, there we can what are the possible you know error points we can predict. The another portion will be when the machine is actually giving you the ticket how to collect it. First is identify the position from where the person need to collect the ticket collect the ticket how long the vending machine hold the ticket in the same position. It may happen the system is designed in such a way after maybe 30 seconds or maybe 15 second the ticket will go back as it happens in the ATM in in case of ATM right. So, if you do not understand the whole process the there will be an error performed by the human. So, in this particular ticket vending machine what we can do if we do this TAFEI we can understand what are the possible place or what are the possible interactions there where the you know human error can come in and cause the malfunction of the whole system. So, based on the how successfully we predict these errors we will be able to design the machine nicely or we will be able to design the machine in such a way so that human are bound to not to do any error ok. They will be prohibited. So, so designers can help to design that in the whole machine. So, system will be designed in that way. So, this the success or failure of this particular interaction definitely will depend on how closely they were able to determine the match between the script and the actual operation of the machine ok. So, how like when they are saying insert money and how long this particular action will be active the if human do not understand or human cannot you know reciprocate that particular timing the machine will malfunction. So, the kind of understanding you know perception and after perceiving the information how they are acting upon it ok. So, do they need change or do they need exact money? What is the kind of information they are displaying ok? So, all these things are very important if we design this, if we before we design this we understand these possible errors what will happen we will be able to design the system perfectly ok. Perfectly I am I cannot say it will be complete error fee, but as much as possible we can reduce the error ok.



Now, when we talk about TAFEI of course, there are steps that to be followed as we did in SHERPA in or any other previous method that you know step by step we should go ahead. Again hierarchical task analysis is an inevitable method where you know every wherever we are going for the cognitive task analysis this hierarchical task analysis is the initial stage because these actually gives you the basic platform to analyze the whole system. So, here also in case of TAFEI we will start with hierarchical task analysis. So, data can be retrieved from your previous study if you have already done the hierarchical task analysis for the system you can use the same data. Once you have your hierarchical task analysis data what you will do you will go for the state space diagram, state space diagram SSD and then the transition matrix. Transition matrix means from one state how do you transit from one to another that is the transition matrix you can draw. Now, in hierarchical task analysis it is performed to model the human side of the interaction. So, here the objective major objective is to understand the human actions ok. In the hierarchical for this TAFEI when we will be doing hierarchical task analysis we will be majorly concentrate on the human action because in the whole system we are actually identifying or predicting the human error ok. So, it is related to the goals and task of course, whenever we do HTA we look for the goal and to achieve those goals what are the tasks to be followed ok. So, it is directed at a specific particular goal and it allows the consideration of task sequence, that is the major you know or I can say basic rule of HTA. In SSD like space state diagram what exactly we try to do, it represents the behavior of the artifact. So, if there is an action by the human what is the behavior of that particular artifact when the human is doing you know interacting with that. So, that state of artifact we are trying to understand through the state space diagram. And in the transition matrix, it is devised to display the state transition during device use ok. So, if I am using a particular device what are the transition is happening from one to another. So, that matrix need to be derived in this particular. So, basically we have three major know steps to be followed in a TAFEI first is HTA from human perspective, human activity perspective, then state space diagram and the transition matrix. Let us do it in detail.

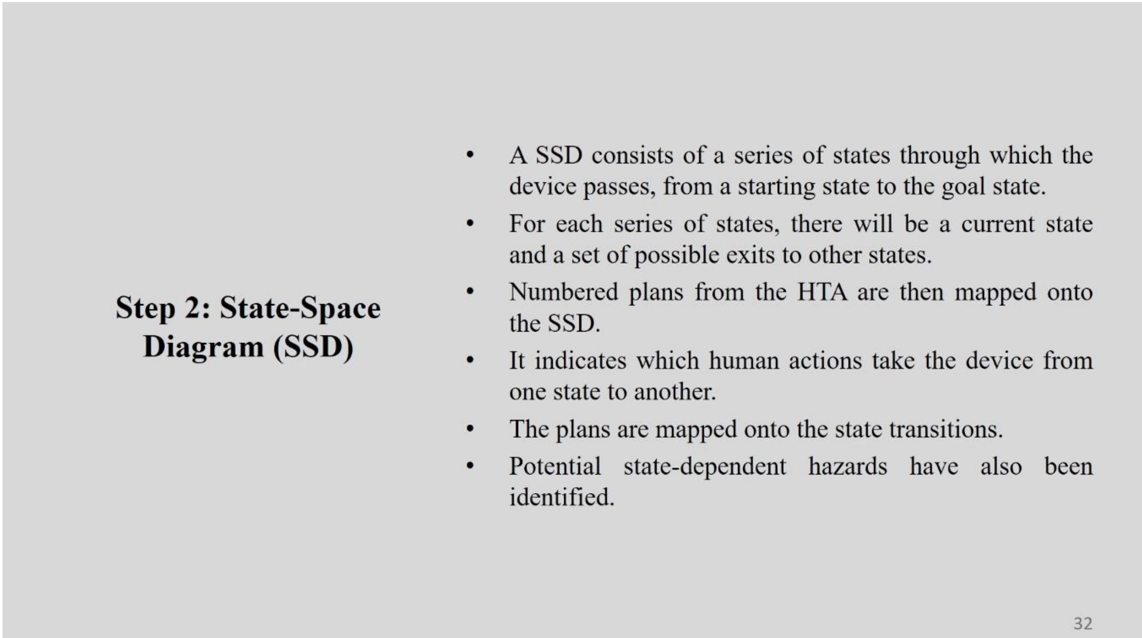


So, as I mentioned HTA. Without HTA we cannot go ahead. So,once this goal of this particular task is being selected the analysis proceed to the constructing the state space diagram for the device operation ok. And for TAFEI always what we try to do we select one goal, one basic goal and then we analyze. Maybe if in the whole system there are two three goals we will take those goals separately and once the HTA is being established we will connect them. So, then it becomes very easy for us to create that blueprint ok. So, it is not that in a we will take a very big goal. No. We will take small goals and small two three goals if it is required then we will connect them.

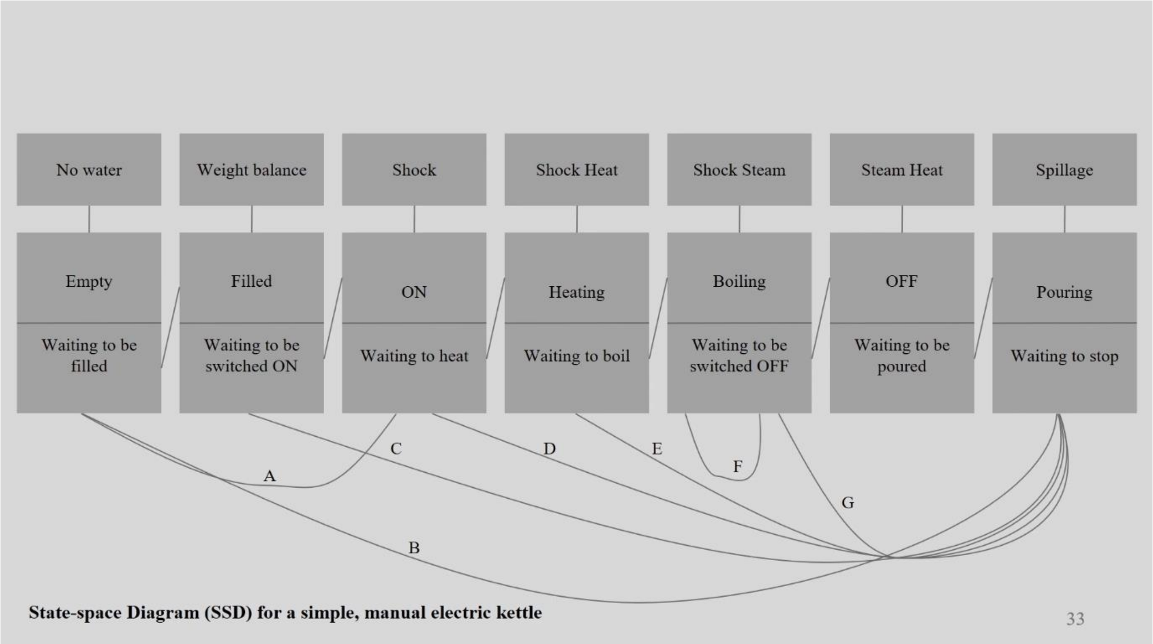


Hierarchical Task Analysis for a simple, manual electric kettle

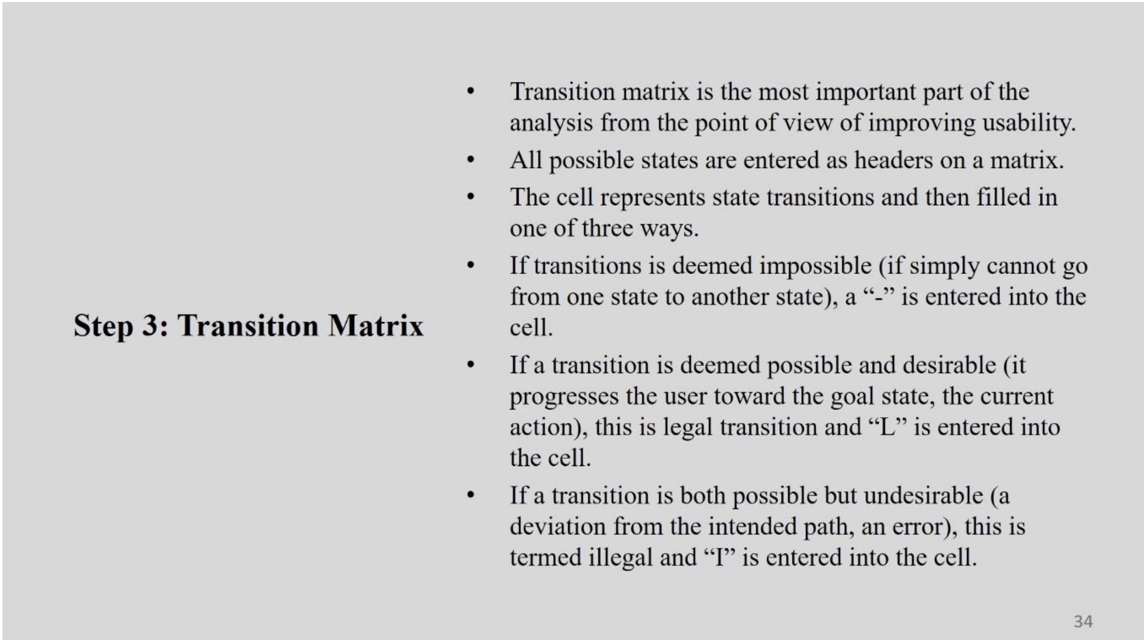
So, here for an example we try to understand if we want to boil a glass of water or a cup of water in a electrical kettle. So, first the major objective or major goal is boiling the kettle. So, if that is so first step is you know fill the kettle because you have to understand if there is water or not. So, fill the kettle switch the kettle that you know you have to switch it on and the check the water in the kettle water level then if it is boiling then you switch it off and pour the water ok. So, if that so in switch on plug in switch on to do a switch on switching on that particular for that particular bottle what you need to do you have to either first plug on plug in that socket and then turn on the power. If it is already plugged in then you may need to skip that particular step. Whereas, pouring the water it is lift the kettle direct that particular spout take to this socket and you know replace it with the kettle. So, that way you can do it whereas, we are we are talking about the filling the kettle there are few more steps. So, take it to the tap that particular kettle you need to take it to the tap, turn on the water, check the level, turn off the water and tilt that kettle ok. You can just check the water level and you make it. So, that way you can create your HTA.



Now, once you have that HTA ready with you you can take it further for your SSD or we can call it a state space diagram. So, a state space diagram consists of series of states series ok. It is not a single ok. Once you have HTA you can have series of states through which the device passes from a starting state to the goal state one position. So, here water is cold and it is passing through steps different steps and it is a boiled water ok. So, one state to another state. For each series of states there will be a current state and a set of possible exit to each state. So, here if we take this statement so, boiling water. It may happen I need just warm water. I can switch it off at any point of time when I feel it is warm right. So, any exit point. So, those exit points we need to identify. Numbered that plants from the HTA are then mapped onto the SSD. It indicates which human action take the device from one state to another state. So, for boiling kettle maybe human action is switching off the that particular switch right. We are going and switching it off ok. So, that may be an human action. It may happen the switch is on you are not bothered. So, what you do electrical kettle you just take it out from the base plate. So, these are the human action. So, if you do not want that water to go at the boiling state you are you want only warm water you can take it out ok. So, which human action is actually deciding that this is the exit point. So, it indicates which human action take the device from one state to another state. So, that is the state space diagram you have to design, you have to understand, you have to predict it or analyze it ok. So, the plants are mapped onto the state transition. So, from one state to another which transition it is and the potential state dependent hazards. So, here I said if you switch it off without boiling maybe there is a less chance of error or there is a less chance of accident. Whereas, you if you just take that particular kettle out from the base platform there is always a chance of any kind of electrical accidents right. So, what action can cause an hazard? What action can cause a hazard hazardous situation in that particular system you need to identify that. So, potential state dependent hazard have also been identified in this particular state.



So, this is the you know state space diagram possible state state space diagram for this electrical kettle. So, you have first initially no water you are owing the balance you are trying to understand can be shock, shock heat, shock system, steam, steam heat and then spillage ok you are draining it. Now, from here you can see in there can be different exit point. So, you know when you are actually there is no water if it is it is empty waiting to be filled from, here you can directly go for the you know shock empty you are actually switching on there is a possibility of an accident ok. Whereas, it is empty and you are trying to pour the water ok. So, there is an accident. So, that way you need to really understand these interaction these interactions understanding these interactions are very very important. For each step see you can see from 1, 2, 3, 4, 5 for each state you can go directly to the by mistake you can pour the water and there is a hazardous situation, there is a hazardous situation right. It is a error. It is a error performed by human being. So, if we design the kettle in such a way or if we design the whole system in such a way that if we try to perform any one of these action system will create an alert that you are doing mistake, automatically the person who is actually operating he or she will stop performing doing that and the system will be safe right. So, this way we can use the state space diagram to understand or to predict or identify the human error in the whole system.



Now, of course, transition matrix is very important to understand. Because if we do not understand the transition matrix, we will not be able to identify what are exact interaction point interaction point between the human and machine and where we should start our intervention, where we are going to start our intervention, design intervention, safety intervention, training intervention whatever interventions we need to do where to start ok, if we do not understand this transition matrix. So, transition matrix is the most important part of the analysis from the point of view of you improving the usability as I mentioned if we do not understand these interaction we really do not know how do we redesign the whole system, how do we start the training program ok. What is the kind of manual I should write before we introduce a particular product in the market ok. So, this transition matrix is very, very important for any kind of you know such analysis. So, all possible states are entered as you know headers on the matrix and the cell represent the state transition and then filled in the in one of three ways ok. First one here I do just little correction this A should be capital and it should come here as like this ok. So, if the transition is deemed as just impossible, so you term it as A ok entered into that particular cell. If the transition is deemed possible and desirable and this is legal transition then we term this as L and if it is possible, but undesirable ok. One is just impossible this particular transition is not really possible then it is A where whereas, if it is possible and legal it is desirable then it is L. In third case it is possible, but it is not desirable that means, illegal. So, it is I. So, A, L and I ok. So, that way we will be writing these transitions. So, these denominations like these representations are very important to know.

	To state							
		Empty	Filled	ON	Heating	Boiling	OFF	Pouring
From state	**Empty**	-	L (1)	I (A)	-	-	-	I (B)
	Filled		-	L (2)	-	-	-	I (C)
	ON			-	L (M)	-	-	I (D)
	Heating					L (M)	-	I (E)
	Boiling					I (F)	L (4)	I (G)
	OFF							L (5)
	Pouring							

Character "L" denotes all of the error free transitions
Character "I" denotes all of the errors.
Each error has an associate character (A to G)

Transition Matrix for a simple, manual electric kettle

So, let us see this ok for the same example boiling that kettle. So, let us understand. So, initially this these are the you know from different state and to the state. So, from this these states it can go to these state. So, we just created this matrix and so here I mentioned L means legal possibilities, I means possible however it is illegal and the each type of error we marked as A, B, C, D, E, F, G like this ok like A, B, C, D, E, F, G and then L, phi this is I these are all I ok not legal ok. So, this way the transition matrix can be created and for this manual electrical heat you know kettle and from there you can understand where the design intervention can be possible to introduce or while writing the manual of this particular heater the user's guideline you can inform the user how to use it, what are the possible point where the accidents can happen ok. So, if you have this matrix ready with you will be able to create the guideline very nicely otherwise you will not be able to understand where the possible interaction and how the if there is a chance to have some hazardous situation in that particular interaction how do you miss it ok. So, this interactions understanding is very very important and here the process of TAFEI actually ends ok. So, first we do the hierarchical task analysis, then we go for the SSD, state space diagram we are trying to understanding the positions of those state when the interactions are happening and the exit points that we understand in the state space diagram and then we start with doing the interaction matrix and transition matrix from one state to another state how do we transit ok and there what are the possible errors are errors are there or predicted errors ok and then we complete this matrix. Once we complete this matrix we get the data and we start our intervention program.

Error	Transition	Error description	Design solution
A	1 to 3	Switch empty kettle ON	Transparent kettle walls and/ or link to water supply
B	1 to 7	Pour empty kettle	Transparent kettle walls and/ or link to water supply
C	2 to 7	Pour cold water	Constant hot water or auto heat when kettle placed on base after filling
D	3 to 7	Pour kettle before boiled	Kettle status indicator showing water temperature
E	4 to 7	Pour kettle before boiled	Kettle status indicator showing water temperature
F	5 to 5	Fail to turn OFF boiling kettle	Auto cutoff switch when kettle boiling
G	5 to 7	Pour boiling water before turning kettle OFF	Auto cutoff switch when kettle boiling

Error description and design solution for a simple, manual electric kettle 36

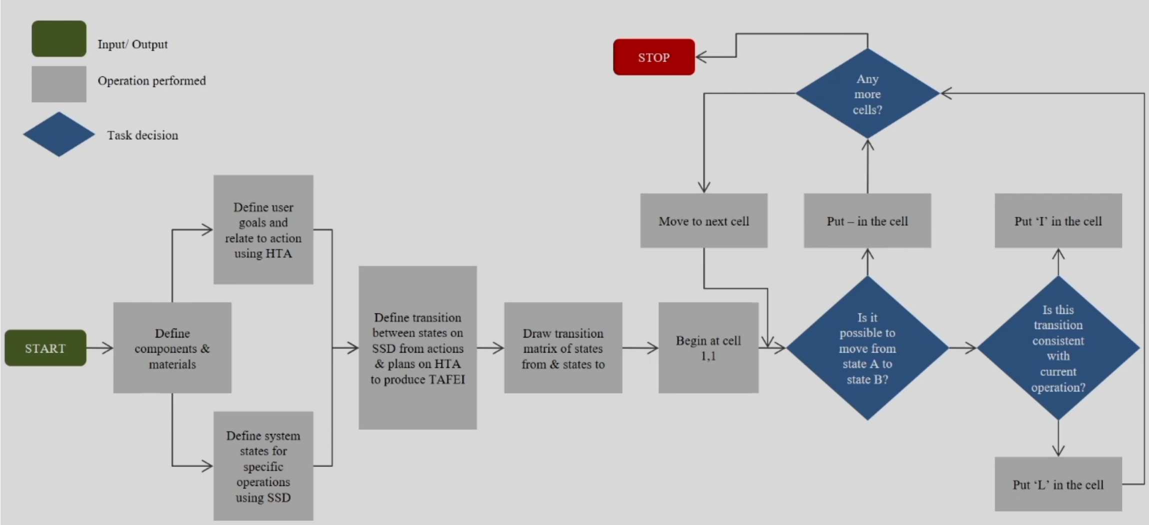
This is the error description and design such solution for a simple manual electrical kettle. So, you can see from these transition we have written if it happens 1, 2, 3 like first 1 from empty to directly if we go for these 3 ok this particular position then what will you switch the empty kettle on. So, what is the design solution the no transparent kettle valve. So, if you have a transparent kettle valve you can easily understand yes this kettle is not filled right. So, if it has a metal valve then you cannot see ok. So, you make it transparent it is a design intervention and you can definitely avoid this error if 1 to 7. So, pour the empty kettle. So, what will happen again you know if it is a transparent valve you can you know avoid this or link to the water supply directly you are linking to the water supply. Now 2 to 7. So, pour the cold water you have not switch it on. So, you have a filled water water is filled in the kettle however, you missed these, these, these and these and you are directly going for the pouring. So, what will happen that you know constant hot water or auto heat when the kettle is placed on the bottle. So, that way you all can avoid. So, these all are the varieties of design solution for these possible errors ok. 5 to 7 if you are skipping from 5 to 7. So, pouring the boiling water before turning off the switch. So, auto cut off. As soon as you take that kettle out the power will be auto cut ok. So, there will be less chance of accident. So, you understand that you know boiling a glass of water in a particular electrical kettle it looks very, very simple. However, the whole job or whole system has so much of possibilities that errors may happen and you face some kind of accident and to avoid these accidents, these possible intervention or these possible redesigning elements can be taken care ok. So, if you keep on increasing these factors in your product what will happen the cost or also will go high, also the safety factor of that product will increase the less chance of error will be and the whole system will function properly ok. So, this way this TAFEI will help you to function the system perfectly ok.

Task Analysis For Error Identification (TAFEI)

- TAFEI enables the analyst to model the interaction between human action and system states.
- This can be used to identify potential errors and consider the task flow in a goal-oriented scenario.
- TAFEI can also be used to evaluate existing systems.

37

So, TAFEI actually enables the analyst to model the interaction between human action and the system states. This can be used to identify the potential errors and consider the task flow in a goal oriented scenario here. The goal was if you have a glass of water cold water you are actually going to boil it that was the goal and to do so, what are the steps to be followed. So, TAFEI can also be used to evaluate the existing system. It is not that you always do it beforehand if you have an existing system you can use TAFEI, you use the result and you design the training method, you design the control measure in the for the whole system.



A series of decision stages involved in the TAFEI technique

38

So, these are the you know series of decision stages involved in the TAFEI technique. So, you know it starts here. So, define and define the components and the material where it goes for the HTA using HTA you define the goal and define the you know system state for specific operation that is through SSD. Once you have HTA and SSD so, you define the you know transition between state on SSD from action and plans, actions and plans on HTA to produce that particular TAFEI and you draw these transition matrix. So, drawing this transition matrix is very very important and how you are this you know drawing this transition matrix correctly will actually the you know will tell you how correct, you know how beneficial your TAFEI is for the whole system. So, being at cell 101 what you can do if it is possible from move from A to B or not you need to check, if it is possible then go this direction otherwise do go this direction. So, that way you keep on doing. So, if it is you know L means possible legal movement then definitely you can go from any other cell and then you can go for the stopping the activity. So, this is a series of decisions where you can take manual decisions and you can perform the activity nicely. So, these are the steps to be followed. So, here I mentioned input and output in square of this ash color that these are the operation these all are the operation and in the task decision like these are the decisions, decision to be made. So, these are the important decisions where you can have some kind of intervention.

Advantages of TAFEI

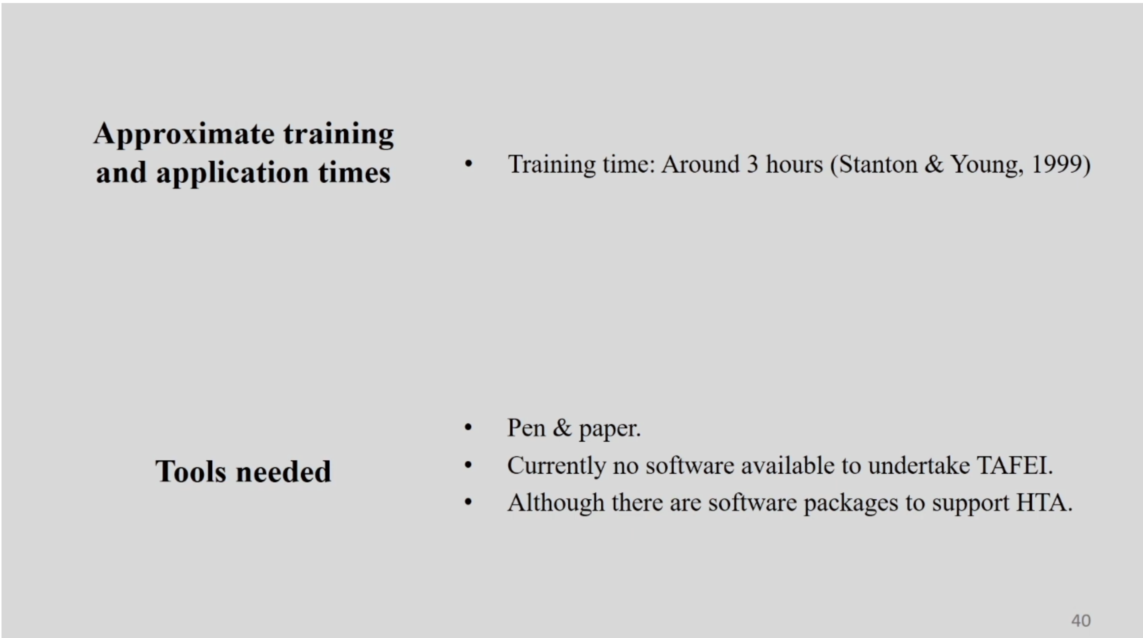
- Structured & thorough procedure.
- Sound theoretical underpinning.
- Flexible, generic methodology.

Disadvantages of TAFEI

- Not a rapid technique, as HTA and state-space diagram (SSDs) are prerequisites.
- Requires some skill to perform effectively.
- Limited to goal-directed behaviour.

39

So, advantages it is very much structured and thorough procedure and it sounds very much theoretical and underpinning like it is not that many other underlying things are there it is very clear flexible and very generic method it is not that you know specific case only you can do or other case you cannot do it is a very generic method. So, that is why researchers prefer to get results from TAFEI and improve the situation whereas there are again some disadvantages. So, it is not a rapid technique because you have to depend on the HTA and HTA takes always lot of time along with SSD. It is not only HTA, it needs SSD. So, of course, it is a time consuming requires some skill of course, I already mentioned in all other previous lectures that HTA needs skill of course, SSD also needs skill. So, it is a skilled based task and limited to goal directed behavior. If there is no specific goal has been identified in the whole system you will not be able to perform this.



So, let us understand the what are the tools required. It needs only pen and paper. Currently I have no idea that if there is any software or any kind of you know web version is available. However, there is a possibility to develop some kind of algorithm to translate the HTA and SSD data into the transition matrix creation. However, still now as per my knowledge there is no such thing available. Although there are software supports which actually helps the HTA that we mentioned in earlier lectures also. Here Stanton mentioned that it takes around 3 hours kind of time to train a person how to perform TAFEI. However, it is absolutely based on the previous knowledge and the acceptance capacity of that particular researcher. So, it is not fixed it can take more hours or it can take less hours. So, however, this is quite easy process as per I understand and it is a very generic process so that you can implement it at any system and you can identify or predict the human error for your system. So, that is all for today. I hope you all understood the error identification method. So, first one was SHERPA and second one was TAFEI. It is not only SHERPA and TAFEI. There are many other method. However, these are the two major method that we actually practice to identify the human error in system in broader cases. Thank you for today. We will start the next session in the next class. Thank you. Thank you.