Product Engineering and Design Thinking
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Module - 02
High-Level Design and Fuzzy Front End of Innovation
Lecture - 06
FFE Interface with HLD and DT

Welcome back to today's session which is Module 2 and the name of the Module 2 here is High-Level Design and Fuzzy front-end of Innovation. And, the Number 1 lecture in Module 2 is Fuzzy front-end Interface with High-Level Design and Design Thinking. I have used the abbreviated forms. So, because by now you have you are quite accustomed with the abbreviation and so, we will use that in future slides.

The idea of discussing on high-level design is that because this terminology perhaps is new to many of you. When we talk about high-level design or low-level design we do not actually distinguish in terms of merit these two, but in terms of its task areas. Let us say when we take a helicopter view from the top, we see a greater area or if we may call it the system as a whole but as we climb down to the you know ground level or closer to the ground level we find that more details are visible.

And in fact, both are required that one is the system level view is required and two – the details are also required. So, when I am saying high-level it does not mean that academically something is high or academically something is low, it is that the terminology in the literature is used that way which says that high-level design means which will encompass or take a broader view and low-level design is more about the details.

As you see very commonly in your Google Map thing that when you know zoom out then you see one thing and when you zoom in you see the another thing. So, these are the differences.

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Now, with this short preamble I would go to the slides where I first would talk about the concepts covered here which is a high-level and low-level design that is I just talked about and then we will talk about the engineering of the front-end innovation and development. What is the front-end that also I will explain.

In that innovation design process the front-end is where the variables are not very clear and many of the variables or factors are unknown; unknown either in its entity or it is in magnitude. So, in the at the back end of course, that it is more streamlined everything is detailed out after the details are prepared, then it is a you know development phase. So, all the specifications are more or less known some tweaking etcetera of course, would be required, but then the you know broad level specifications are there.

So, the front-end is full of factors which are a bit unknown uncertain or the information about those are not adequately available and hence it is from the designer's point of view or the product engineers point of view or the innovators point of view is a bit hazy. Due to this haziness of this uncertainty it is called fuzzy. So, often we will call it fuzzy front end, but of course, when you are saying fuzzy front-end we would we should keep in mind that we would not ultimately leave it as fuzzy.

Ultimately we would like to explore what how the fuzziness can be listened or in other words which is called de-fuzzification. We will talk about that and subsequently comes the principles of innovation, we will talk about that and the as we were talking about the front-end we have to talk about their steps. We need to also therefore, thereafter need to align that design thinking and fuzzy front-end of innovation and development because through that is the vehicle through which we have to move.

And, we would see there are many similarities and then we would have a slide on conclusion and the reference is as useful.

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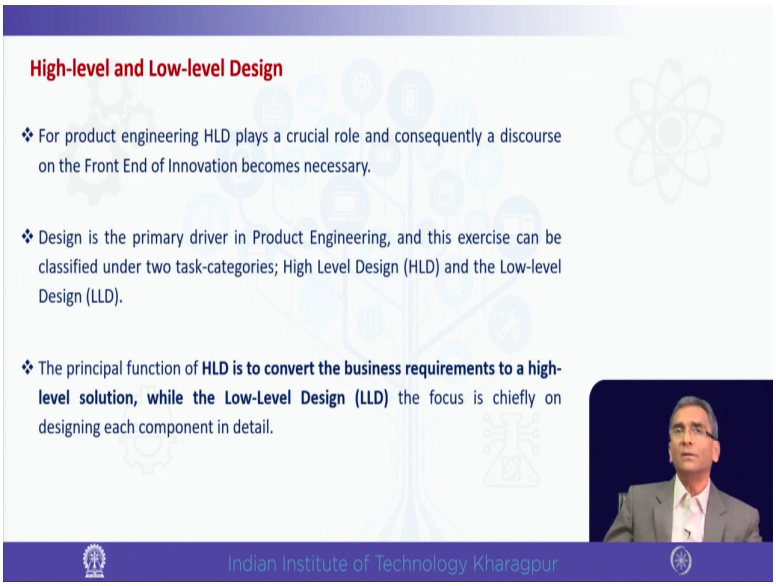

Now, we will move on to the topics one after another. As I have already mentioned high-level and low-level design I have already explained now, you have the material ready before you. Why I have kept the material ready in spite of my initial talks that in one place you would be able to get the information. So, you can read the slides later for your assignment and for your knowledge and for your use and also this will be helpful as a future reference if you read.

Hence we see that as I have said that the high-level design plays a crucial role in the front-end and design as such is a critical issue in product engineering. So, if we say that design is the primary driver of product engineering and this exercise can be classified under two categories, I have said so – HLD and LLD, high-level design and low-level design. The principal function of HLD is to convert the business requirement, the need.

As you remember we discussed when we discussed the empathy in design thinking, how to assess the need, either pains, the desired gains that is the business requirement to high-level solution. In other words, you can say we are trying to find out a solution for a problem or subsequently we will see we will call it a problem solution fit. We will talk about that.

And, we will talk about subsequent to problem solution fit other thing called product market fit, we will talk about that also. And, finally, at some point in time to execute from the innovation if the business is ventured in then business model fit and organizational fit etcetera we will also come in, alright.

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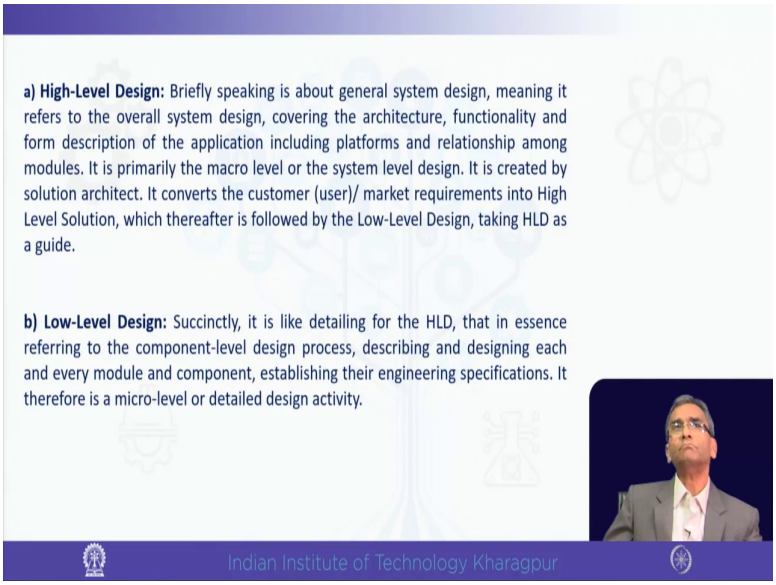

Now, we will talk about the problem solution fit or the high-level solution where it is the translation of business requirement to the solution, while the low-level design focus is chiefly on designing each component each module in detail. Like, if we are developing a car what

will be its broad configuration, its mileage, whether it would have hybrid part train of ice-engine and electric that is the high-level.

And, at the low-level one would consider the type of battery or say for example, the type of propeller shaft or those details. All are required in successful delivery of the product, but these are the two things which are in different tiers of their need as well as importance.

These are whatever I have discussed, but I have kept it is in this slide for your consumption and study later and so that you can answer your assignments nicely reading this and, but here I would like to point out it is created by solution architect it converts the customer user of market requirements into high-level solution as I have already mentioned. So, practically this point is already covered and as I said it actually looks at in the overall system in the high-level design.

Similarly, low-level design it is a basically the details of the modules and the components. In fact, in other words you may call it the nuts and bolts. What is the specification of a particular component in this? What will be the pin diameter? What will be the pulley size, pulley diameter? What will be the bearing number and all that will be the detail design.

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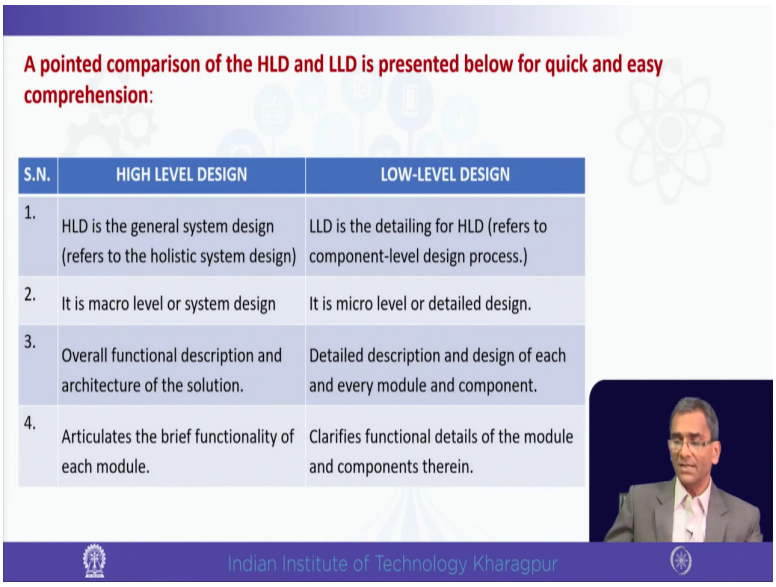

Now, a quick comparison. These are already discussed though, but maybe it would be in one chart will be very helpful for you to decipher quickly the difference. So, one is the system level, the high-level one and the low-level one is the component level. The high-level one is the macro level and the low-level design is the micro level. So, and the HLD is the overall functional description and architecture of the solution and as we as I said that it is the module and component level.

The HLD articulates the brief functionality of each module and LLD clarifies the functional details of each module and the component.

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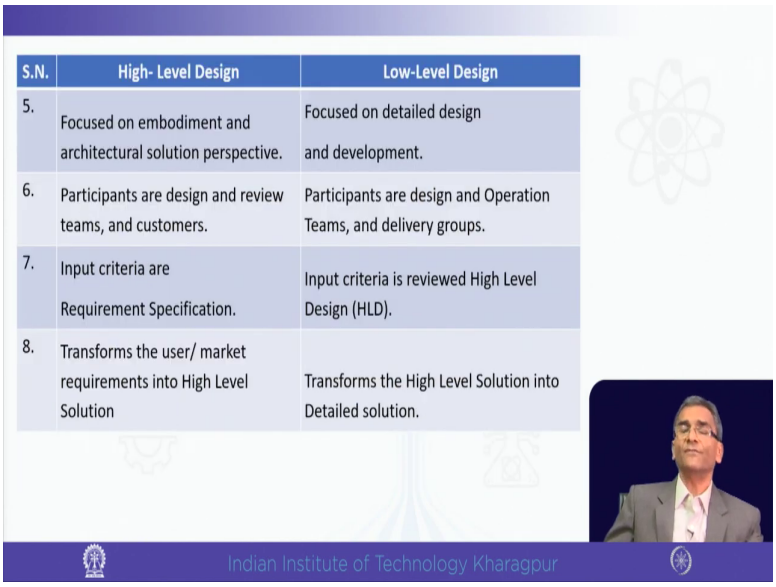

HLD focuses on embodiment, architectural solutions perspective and the low-level design focuses on details. Here one thing is to be noted when we work in a project engineering team and as you would be working and you are already working perhaps, you know that it is a team that works and the high-level design team interacts with a you know design and review teams together along with the customer or client or the user.

Whereas, they for the low-level, the team comprises of design operation and the delivery groups. All the persons involved in this even the sometimes it may be the quality, sometimes the or the procurement, the supplies, the logistics, packaging, all these would come in there. As the input criteria for HLD is the requirement specification whereas, here it is basically derived from the high-level design criteria and their requirement.

And, lastly that HLD transforms the user or market requirements into high-level solution and the LLD transforms the high-level solutions into detailed solutions. This is a tabular form of the textual description I have made because this is important to understand. So, I am a bit over emphasizing it because to tell you that there are two categories both are design engineers, both are product engineers, both are equally important for an organization.

Only thing it depends on what role one will adopt and what I would say inspire some. Some people are very interested I have seen from my experience to work in greater detail; some people are more interested in looking at the system level thing, alright.

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So, now engineering of the front-end innovation and development coming back to the topic as I started with – the front-end or the earlier part of the innovation and development activities is

where enterprise often lack critical information regarding rather several concerning aspects of variables.

Depending on what will be the market, what do the persona, what will be the scenario, what will be the purchasing capability of that market or community, how will this a segment behave over a time, temporal, what are the technology available and what the future technology going to be in shorter span or longer ones. So, all these are so kind of a fluid and therefore, they are practically not very crisp, not very well defined.

So, there this in spite of this uncertainty one has to act and therefore, there must be a method or understanding each one of them thoroughly would actually bring a the clarity or rather remove the fuzziness or would be bringing or would create de-fuzzification. So, here let me tell you here the. So, what is the front end, how far is the front end? Front-end basically is to that point where we are not practically committing ourselves to very high expenditures or expenses.

What is that as long as we are planning designing, tweaking with ideas, even doing some prototyping, financial outlays or cash burning is not much, but then the moment we actually proceed for the manufacturing, full scale development and manufacturing, then the real investment begins. And, it has been seen that when the investment begins for development and manufacturing after so much of investments etcetera, then any corrections or changes if warranted would be extremely expensive or difficult.

Because always one has to would keep in mind the resources are limited. It is not abandoned. So, the challenge is within the given resources how we accomplish the task. So, it is very important that the first part is correct. If the first part is correct and the second part takes from the first part as we have seen from HLD and LLD, then there is a chance, there is a great chance that it will go, it will not go wrong.

So, to correct it is in the beginning like a child. If a child is well groomed and then further refining, polishing and adding certain characteristics to it would be relatively easier. So, is here or is the foundation of a building, whatever you whatever you look at it. So, that the

haziness is called fuzziness as commonly called fuzzy front-end and that lacks of clarity and the that lacking should go.

The understanding of high-level design and the front-end innovation and development are based on a common perspective. It will help in our future discussion or methodology that is why we are discussing both together.

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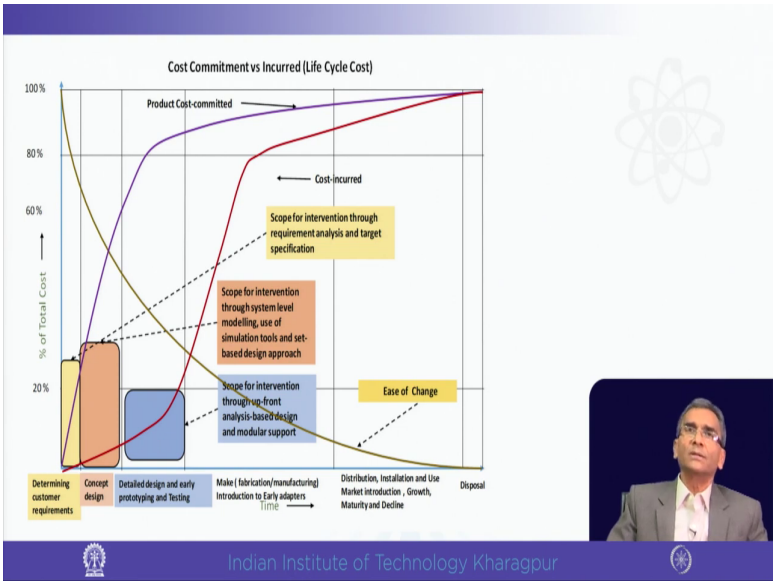

This is the, this is one of the main reasons why we are discussing this. Here you see a graph, apparently a little complex there are so many lines, these and that etcetera. But, very soon it will become very lucid to you. If I say they on the left you see a purple graph which means that as we progress with different or various stages of innovation and development like say determining customer requirements, as we have already discussed customer requirements and concept design, then detailed design and so forth.

As we move forward, we estimate assess and do the budget and that is the costing we do. That ok, if we do this product this will be the costing from these steps we come to realize that is the cost it would incur. But, while doing so, we are not spending the money then for example, if we are designing our drawing room or our table with certain drawers etcetera, we are doing the sketch, ok.

Here will be the layout will be like this, this will be the length and width and this the where the drawers will be, this will be the color, this will be the rendering. While doing that we are doing this sketching planning, maybe we are discussing with the carpenter or the builder actually we are not spending money.

Money will spend when we will buy the material, we will be buying the necessary tools and actually engage people manpower to do the work, hire the place etcetera. So, that is very expensive. So, their actual outlay financial outlay would happen, but before that when I am designing the table, then a table or any product say it may be a refrigerator, it may be a television set, it may be a mixer grinder, it may be a spacecraft.

In fact, we will talk about the spacecraft later the Mangalyaan which has been developed very frugally, very affordably, but now currently if we come to our context is that here we are making a commitment that if we do this, this is the cost we have not actually spent.

Now, the commitment, now you see on top of it now product cost committed, that is the purple line on the left hand side which is going upward from the bottom, bottom corner, low bottom corner to up the right top corner. From the low left bottom corner to top right corner the purple color line which is the product cost commitment.

But, the actual cost that is incurred that is not happening then, but later as we said that we are bringing in material and procuring, some part of it was yes spent in the beginning, but that is very small compared to the actual cost incurred subsequently and which is in red line that I can see that you can see.

And, another line which is coming so, these are the two main lines here the which actually is the crux of this diagram, if we understood we have understood these two our major drill is done. Now, there is one curve just with that I will move on to the boxes, but the other curve is that where it starts from the top left corner goes to the bottom right corner which is the changes and this is the ease of change.

Now, ease of change is shown with a line which is a kind of a gray or brown color. So, we see that the ease would be good high in the beginning, but low to towards the end. So, it is better to change if possible or make the corrections, make the amendments, make the revisions after review and rearrangements whatever.

So, that is to be done at the early stage that is the emphasis. The cost is the main driver why it should be done there. About you can see 80 percent of the cost is committed, but really not spent very minimal say 10 – 15 percent cost is spent only at before the development phase. But, as soon as development begins the huge expenses happen. So, that is the consideration which would bring us to this.

And, so, these three different areas determining customer requirements and that with a dotted line you see the scope of intervention through requirement analysis and target specification, how this can be addressed. Similarly, for the concept design scope for intervention through system level modeling, the different modeling, different digital modeling, different analysis, using several tools and approaches it can actually save lot of incorrect or erroneous design concepts or features.

So, if those are tackled in the beginning itself, the rest would become easier. So, similarly is the detailed design part, scope for intervention through our from analysis based design and this modular support. So, here we understand from this graph that why what is the motivator actually in any endeavor the money is the one of the important motivator because if we are losing out then there is no fun.

So, we need to understand where the outlay and how is the inlay. So, that is one important thing I wanted to impress upon you. That is very very important task. So, as we move from this from the detail design, then make and fabrication, then manufacturing and then distribution, installation etcetera, the actual cost goes up and where much cannot be done, but here in the beginning much can be done in terms of planning.

So, planning is important and finally, when it comes to disposal, practically very small difference is there.

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I shall not dwell much on this slides because it is already discussed. I will tell you only the crux. As I said that I have prepared the slides for your consumption letter so that you can read

it. The use of term fuzzy front-end of innovation development by default implies that the front-end is complex and difficult to understand.

So, the difficulty that in understanding that if we can remove with adequate information brought in or enough study done on that, then that will be very very helpful. Then the one similarity essentially is noticeable that the front-end is typically characteristic by the ideas. These ideas are about how an entrepreneur enterprise or industry might solve or satisfy customer or user needs.

So, we may say that is a problem solving idea that is being talked of and an idea is an infusion of technology, design features, functionalities and processes focused at one or more customer needs. When the enterprise is evaluating several ideas, it has to evaluate consequently many times more in respect of the inherent customer needs.

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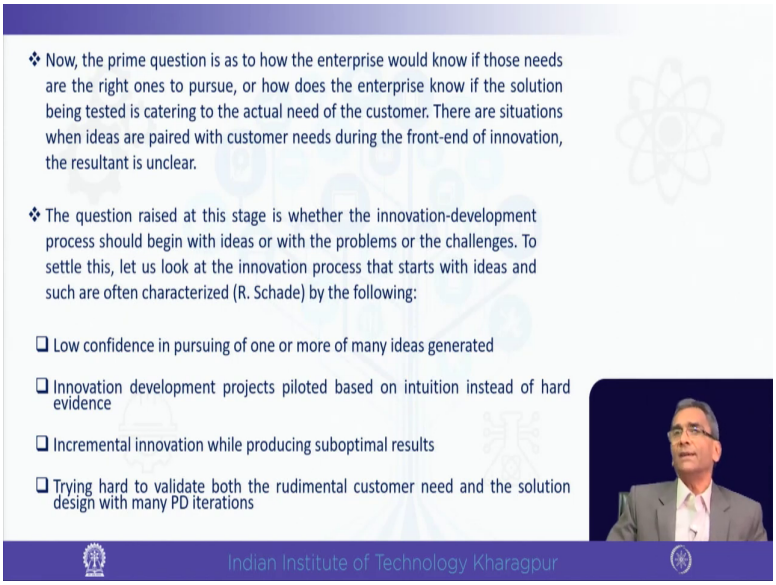

Now, the prime question is as to how the enterprise would know if those needs are the right ones to pursue? That is a big question. There are situations when ideas are paired with customer needs so, they are not in sync. The question raised at this stage is whether the innovative innovation development process should bring should begin with the ideas or with the problems.

What should come first? Ideas, should we start with the ideas or we should start with the problem? It is better to start with a problem because problem is more definite. If it is idea, there is a chance that idea will match some of the need and requirement or solve some problem, but it is not fully guaranteed. So, it is always better if we go with the problem first.

Trying hard to validate both the rudimental customer need and the solution design with many product development iterations will happen otherwise if the matching is not from the very beginning. And, obviously, there would be such a lack of confidence in pursuing one or more of the ideas generated unless we know whether it is meeting ultimately the customer need and requirement and it is creating their satisfaction.

So, innovation development projects piloted based on intuition instead of hard evidence is a very important concern and therefore, those should be addressed and it is preferable that we should start with the problem a good challenge which is existing and which is tangible and based on the discovery it is been it is found.

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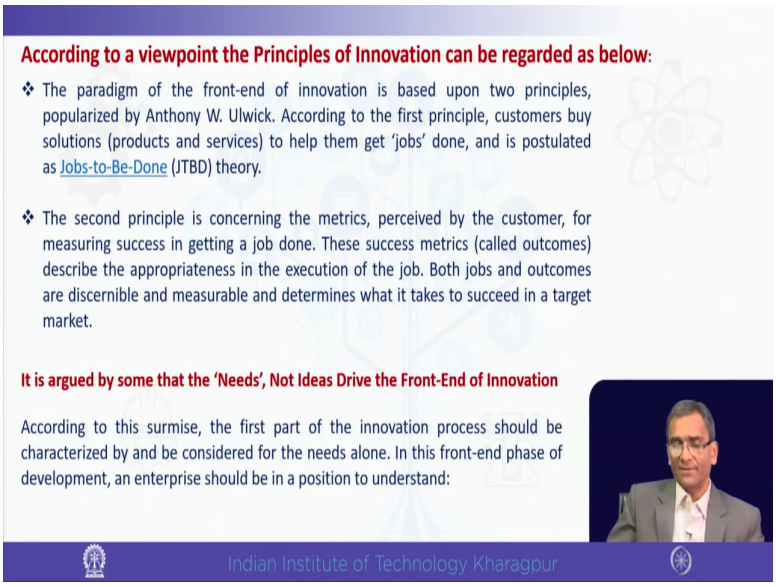

According to a viewpoint of principles of innovation, can be regarded as below – what is that? It is that anything we do a solution, it is purposed that it will do it will execute some job for the user or the customer or this innovation principle is called job to be done, theory.

The second principle of this is that ok if we know that it has to do some job to be done, job to be done either to eliminate some pain or reduce that pain or improve the gain or how something is solved or how the productivity is increasing, how the work is being made easier or how the you know resources are saved whatever the problems are. But, then another thing is that how are we you know measuring the outcomes, the metric. So, it is improving how much it is improving. So, that is the another principle.

So, it is argued by some that needs not ideas drive the front-end innovation and which is in some sense has some wisdom in it.

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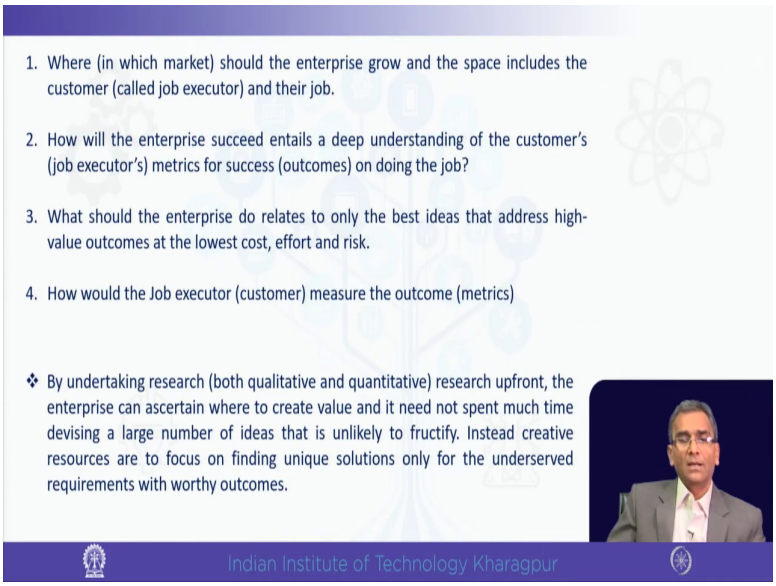

The question to be answered is where in which market should the enterprise grow, the what is the market, where it should be done by the that is the that grow and the space includes the customer called job executor as I just mentioned. 2 – How will the enterprise succeed? That means, one has to have a deep understanding of the customer's needs and metrics for success.

That is how will the enterprise succeed because enterprise only succeeds when it solves the problem. A doctor's – doctor succeeds only when he cures patients or she cures patients. A lawyer become successful when he wins cases for the clients. So, I mean an example. So, by undertaking research both in qualitative and quantitative turn upfront, the enterprise can have

certain way to create value and did not spend much time devising a large number of ideas that is unlikely to fructify.

So, that synchronization that matching is the most important thing that on one hand we have problems. Of course, we need to have ideas, but the synchronization is important.

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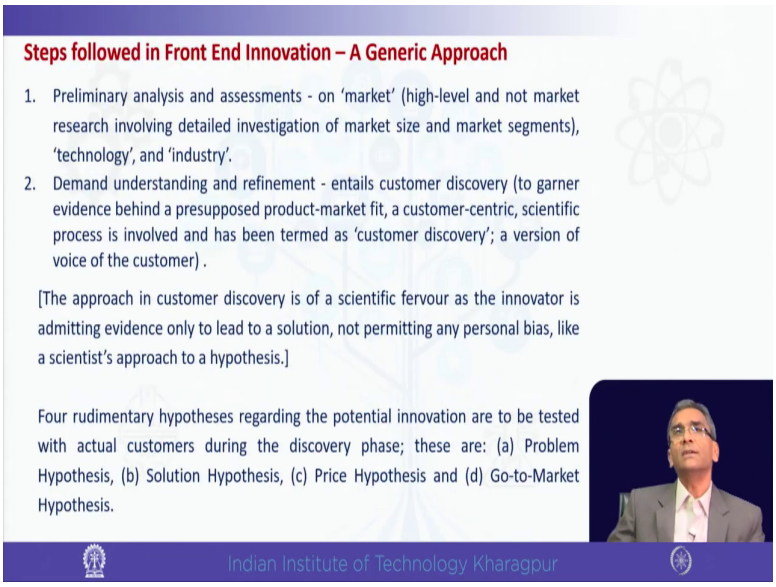

These are the steps followed in front-end innovation, a very generic approach here which is the preliminary analysis and assessment of a market. Market means it need not be a very you know in-depth analysis of market research, but general perception about the market, how much is the growth, what will be the intake, what will be the broad size, roughly who would be the customers – like that.

To demand understanding and refinement entails customer discovery. Customer discovery is what? Not to go and find who the customer is rather the need of the customer that is whether to that the whether the whether it is a customer centric thing, that is whether the product market fit is likely to happen and whether it fulfills the hypothesis that the problem is correct.

The perceived solution is correct, the price is right and then the go-to market approach is also I mean through which channel etcetera that would be marketed and gone. So, that is also important. So, these four hypothesis are important to consider and to be kept in mind.

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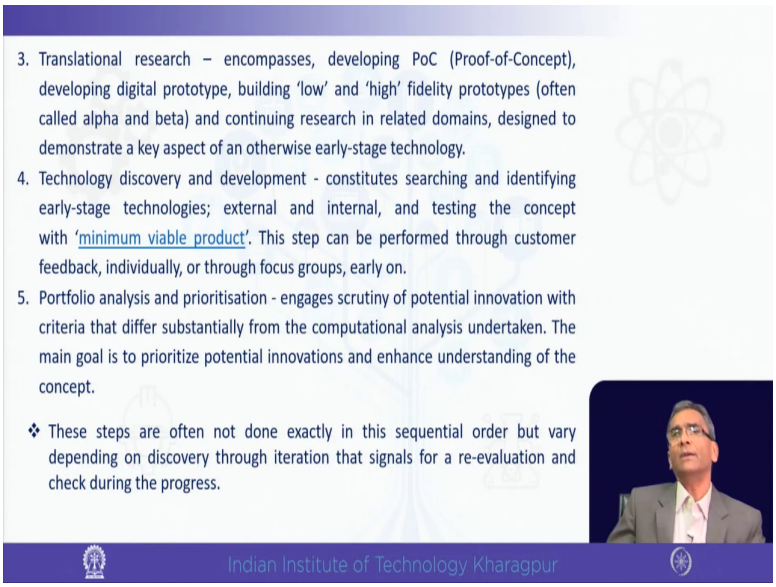

Next is the translational research that is the that is the technology part of it, proof of concept, product development of low and high fidelity. That prototyping of low and high fidelity the, low fidelity prototypings are those which are so to say that not just the beginning or to tests a

feature or two, not the entire product or it is not closer rather to the final product, it is just test one or two feature.

But, then the high fidelity one is more closer to the prototype product and resembles more with that. Say for example, if someone is trying to check a gear whether it is the mechanism, gear order mechanism whether it is functioning one can use a 3D printed material of plastic or maybe wooden ones to check whether mechanism works. But, in actual practice to withstand the real load maybe then full-scale alloy steel material is to be used which is the beta prototyping.

But, be that as it may, it is always advisable before picking up a physical prototype, it is better to create digital prototype these days. The digital prototype means which is done using the computer systems digitally, virtually and therefore, it is a time and cost saving thing and once it is proven that digital prototyping is working fine, then one can go for the physical prototype to check the final form and shape and functions.

Portfolio analysis that the main goal is to prioritize potential innovations and enhance understanding of the concept. These steps are often not done exactly in the same sequential order, but they can change their orders, but it can be done in that different ways, iterative way and non-linearly also.

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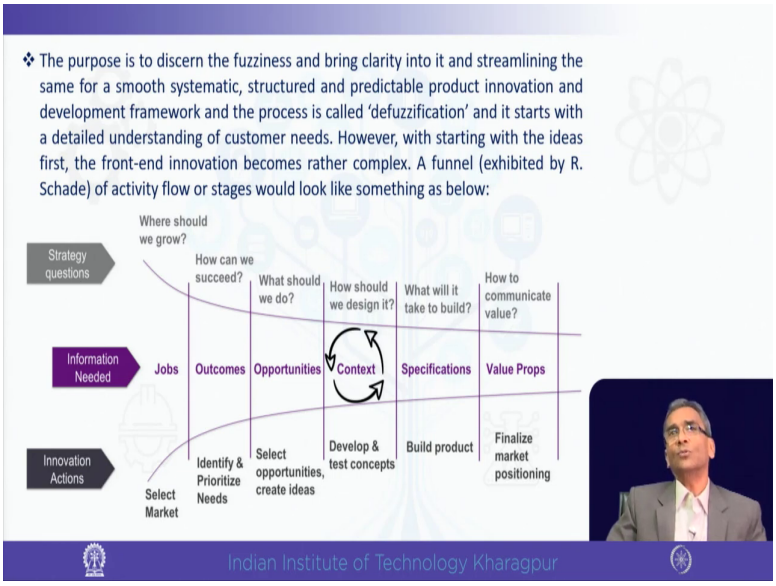

Here as we said that instead of idea, the problem should come first and already we have discussed that where should we grow, how can we succeed, what should we do, the jobs, outcomes, opportunities etcetera would be the flowing and that is the funnel – that is rather more effective.

So, this is the funnel we are talking of and the fuzzy front-end based approaches would best suit and this will help in great de-fuzzification if at the individual levels the questions are thoroughly answered.

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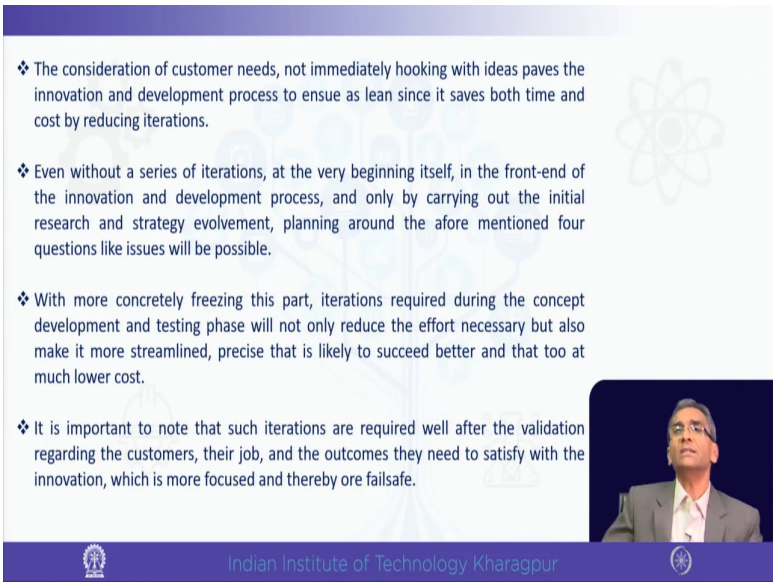

I have already mentioned this, the consideration of customer needs even without a series of iterations if it is matching, this mismatch will go. So, it can be done with more concretely freezing this part, the initial part rest will be more streamlined, I have discussed.

It is important to note that such iterations are required while after the validation regarding the customers, their job and the outcomes they need to satisfy with innovation, which is focused on the fail safe operation that it should not fail. The idea is it should not fail.

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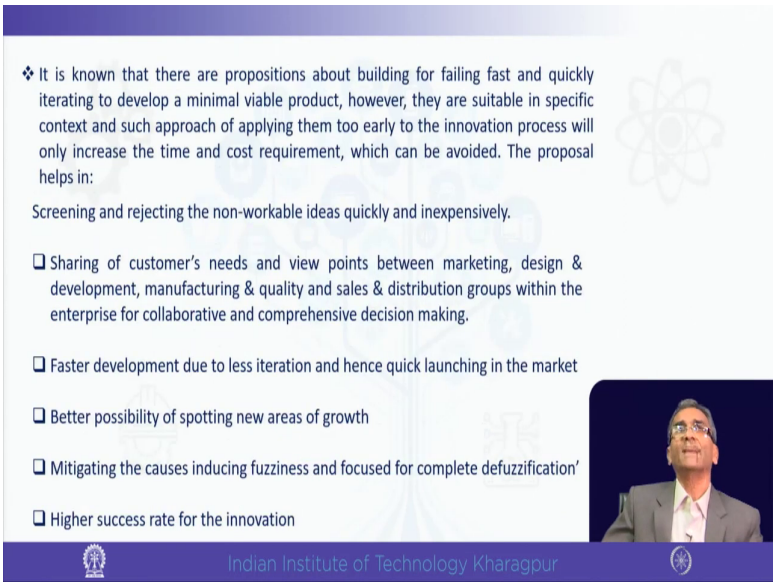

It is known that there are propositions about building and failing fast. There is a top fail fast fail quickly, so that you know where you are going wrong and correct make take corrections act, corrective actions quickly, so that you can pivot and come out. Screening and rejecting the non workable ideas quickly and inexpensively is a great key.

So, sharing the customer needs and viewpoints between marketing, design and all these stakeholders, manufacturing quality will help that. Faster development due to less iterations and hence quick launching in the market because if we can reduce the you know number of iterations by adopting the practice it would help.

Better possibility of spotting new areas of growth, and mitigating the cause inducing fuzziness and focused for complete defuzzification. Higher success rate for innovation.

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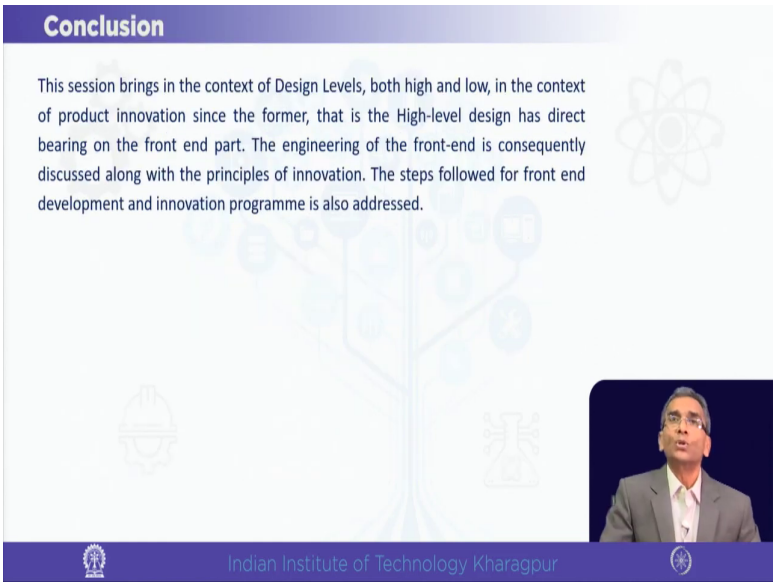

So, in conclusion we say this session brings the context of design levels both high and low in the context of product innovation since the former that is the high-level design has direct bearing on the front-end part and of course, in the entire product development therefore, in the entire product engineering cycle therefore.

The engineering of the front-end is consequently discussed along with the principles of innovation. The steps followed for front-end development and innovation programme is also addressed and I would go to the reference slide.

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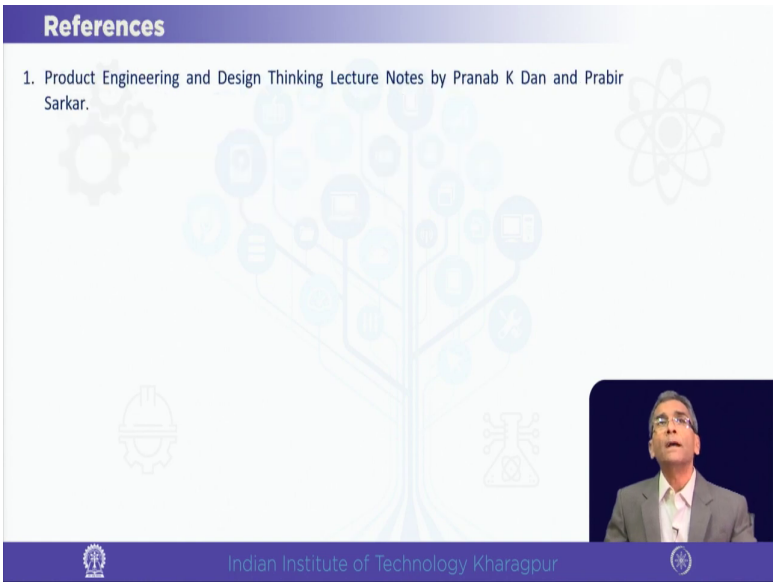

And, here the lecture notes that we are discussing would be a key and with that I come to the end of today's session. And, thank you very much for your attention and being present in this lecture.

Thank you once again.