Entrepreneurship
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Ideation and Prototyping Part 5

Hi friends, welcome to the NPTEL course on Entrepreneurship. In the previous lecture, we have discussed the concept of ideation workshop and how we can bring an ideation workshop to fruition based on certain infrastructural facilities as well as the business process that we would adapt. In this session we would dwell a bit more on another aspect of the overall module of ideation prototyping. This is prototyping per se.

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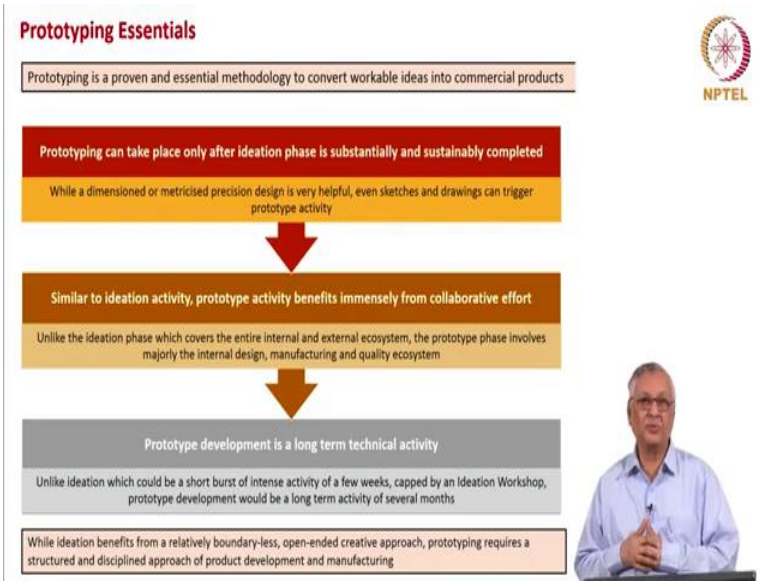

Although we have considered several aspects of prototyping in the earlier lectures. I would like to focus on the process of prototyping a bit more in this session. Prototyping is a very well proven and essential methodology to convert the workable idea into a commercial product. Without prototype it is impossible to get a product in a structured timely and also economically viable fashion.

There are companies which try to develop products. Without a pilot plan, without a prototype laboratories. But invariably such companies find that the costs of development, the costs of manufacturing and even the cost of product itself is unviable. So, prototyping is an essential methodology.

In respect of entrepreneurial companies, Prototype is even more fundamentally important because you are trying to create something which is not known to the market. It is a disruptive product or a disruptive service that you are trying to develop. And prototyping can take place only after the ideation phase is completed to the satisfaction of all the participants and the founder of the company.

While a dimension and precise model on the drawing board is very much advisable to develop a prototype. It is also possible that we start up the prototype phase with sketches or overall conceptual ideas of how the product should look like. It is similar to an ideation activity. However, prototyping activity benefits immensely from collaborative effort within the company.

The entire internal as well as external ecosystem is typically covered in the ideation phase. Whereas in the prototype phase we cover the internal ecosystem to a much greater degree, and what is covered in the external ecosystem tends to be the more of a vendor development and other logistics activity related to the manufacturing value chain.

Prototype development is a long-term technical activity, not necessarily a very creative activity which happens in the ideation phase. For the same reason it is also a very structured process driven activity and it could even take several months to get completed.

While ideation benefits from a boundary less thinking, very creative, open ended thinking, prototyping requires focus, moving on a particular path of development conforming to the logic of development, conforming to the mechanistic logics of manufacturing that is very important in prototyping. This is not to say that is no creativity that is required in prototyping. Creativity is required in prototyping phase as well. But certainly it is not that boundary less creativity that is expected in the ideation phase.

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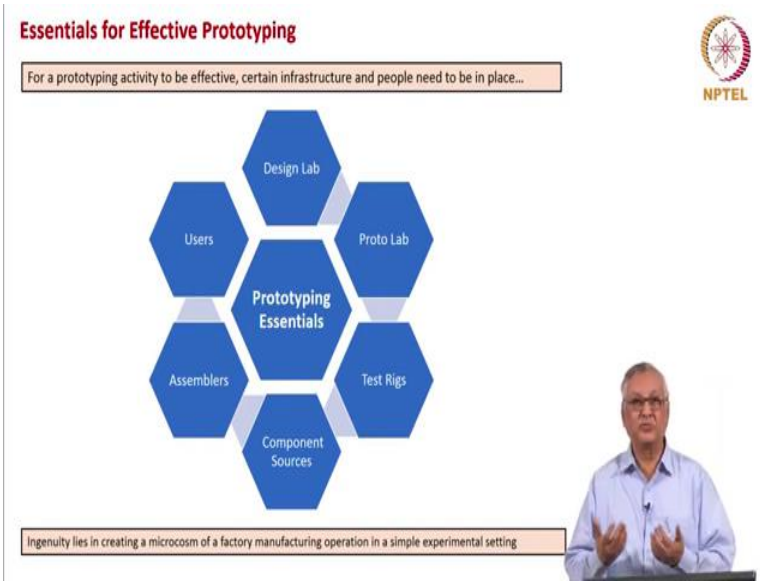

So, what are the essentials for effective prototyping? For prototyping activity to be effective, again infrastructure and people as well as process need to be in place. First is the design lab where you create the model. Second is the proto lab where you try to make or assemble components into the product, you require test rigs to make sure that the product is going to perform as you have thought about.

Then you require component sources, the assemblers, the users. This is the broad requirement of successful prototyping ecosystem but in matter of fact, the numbers which are involved in bringing a prototype together could be much larger than what I have presented here. The ingenuity of the company lies in making this prototype activity a microcosm of the full scale manufacturing activity. Without having as many facilities, without having as many equipment and without having as many people as a large scale manufacturing activity would do.

So, people would think of in established organizations also prototype activity as being a small cross-section of the manufacturing activity. So, a scale up of 10 to 1 or 100 to 1 take place and that is very typical in a process driven industries such as pharmaceuticals specialty chemicals.

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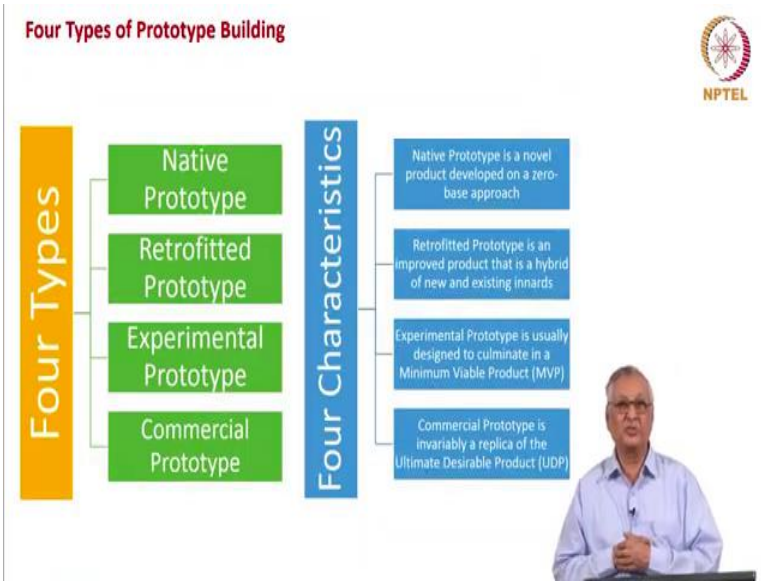

What are the different types of prototypes? I would think of four types of prototypes. One is the native prototype - an idea which, which we considered in the last session an ideation whether the electric vehicle has to be a native electric vehicle or retrofitted electric vehicle. Therefore, we have a prototype which could be a native prototype or a retrofitted prototype.

So, the native prototype is a novel product developed from ground zero. That is, we have put white sheet to work with your ideas and created everything new. On the other hand, retrofitted prototype is a hybrid of novel ideas, novel components as well as established and proven components which could be tailored to meet the new need. Then we also have an experimental prototype which is basically an contraption to prove whether the concept would work. It is a proof of concept prototype.

Then you would have a commercial prototype which is as close to the final ultimate desirable product. That is the commercial prototype. So, you can say that the experimental prototype is a minimum viable product that is which demonstrates that the concept would work. And the commercial prototype would be one which is the ultimate desirable product which is offered to the customer.

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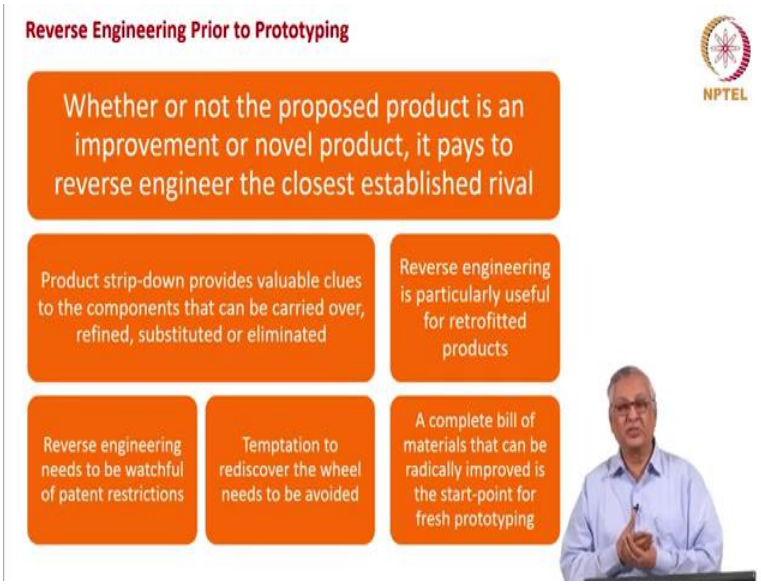

Before we start, before we start prototyping, we really need to do some reverse engineering, reverse engineering is not, not aimed at copying a product at this stage. Reverse engineering is to understand the inert of the product, how they work. Because when you look at an automobile, what you see is only the external form factor, how have people arrange the componentry insight, what kind of materials have been used and what kind of technologies being used in getting the accessories into the automobile. These are all largely unseen.

Same applies to a watch, what how does the componentry the PCB and others circuitry work in the watch. Therefore, reverse engineering is a very useful way to start understanding how the existing products and how the proposed product would work and whether or not the new product is a retro fitted product or whether it is a novel product. We need to do reverse engineering to ensure our engineering understanding of the product is brought to a higher level.

And products stripped down provides lot of valuable clues about the components and the kind of thinning down that could be achieved in the form factor. Typically, what happens is that industries are loathe to change their designs unless it is incumbent on them to change and be competitive.

Therefore, a watch which looks large could have a lot of empty space even as the new components could have become miniaturised in the developmental stages. Therefore, when you

open a watch and see what is actually inside, you understand that you would be in a as if be able to reduce the form factor of the watch significantly if only you looked at the design, internal design in different fashion and it should be watchful of patent restrictions.

When you look at reverse engineering the temptation would always be at a kind of bipolar temptation. One would be to use keep using those, those components and then start off with new product development. That needs to be avoided as much as trying to rediscover the wheel and the start-up development of each product component a new. So, both temptations need to be avoided.

But what a reverse engineering activity should produce is a complete built of materials where you would not leave out any simple component or the complex component out of your design periscope. That is very important. That is one of the important outcomes of reverse engineering.

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So, let us look at how do you do prototyping of a smart wearable. And what is a smart wearable. Smart wearable is a one of the product, which we use, which we touch or which we wear. Smart watch is something which we know as being one of the elegant and flagship products of smarter wearable's group.

Then we have smart glasses, which Google has pioneered. Then you can have smart meters like glucose meter which could be smart in terms of understanding our glucose levels and it need not

necessarily be through the invasive methodology it could look at different aspects. Then you can have smart diagnostics a digital blood pressure meter. You can have smart clothing, smart trackers, more than activity trackers. Smart viewers. How do you improve your vision? You can have smart communicators improve listening. Then you can have smart pens. So, let us say smart wearable's is a class of products which is available for prototyping.

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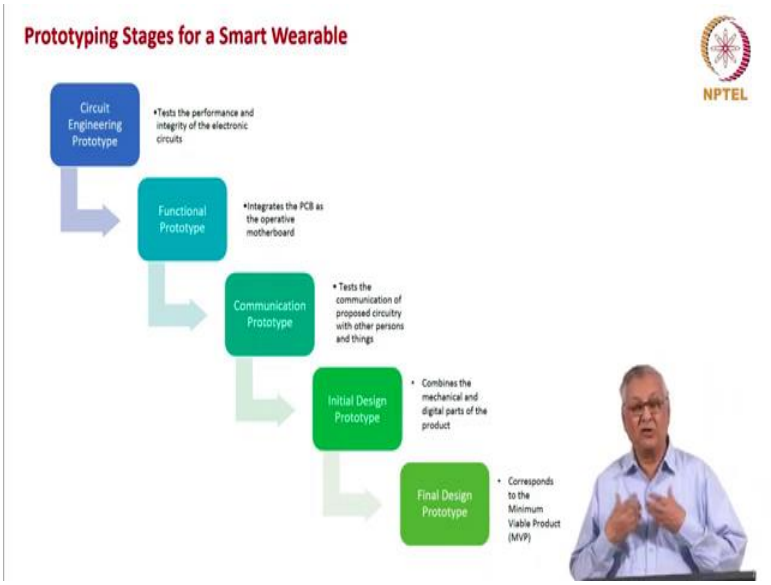

So, if you have to take up any of these smart wearable's and develop it. At first you have to understand what is this product. It is a digital mechanical product or an electromechanical product. So, how do you develop the prototype? Entrepreneurial firms which try to develop these kinds of products typically do not look at the product as it is envisaged to be the product as it is prototype.

The first ever prototype is in terms of this circuitry because you are thinking of developing a circuit which is going to perform certain actions which are quite novel, quite disruptive to the way the products are made. So, you think of let us say the stethoscope being replaced by a digital handheld diagnostic device. So, it is going to have a circuitry which measures the heart rate and it transmits in a different way than the conventional stethoscope would transfer.

Then it will make some analysis. It will also compare with certain data that has been already put in maybe some artificial intelligence would be there depending on the person characteristics and

come out, comes out with not only the blood pressure measurement, but also certain other diagnostics to be able to do that, you have implanted certain electric circuitry or electronic circulatory in this device and you would like to know whether this electronics circuitry would function the way you have done.

So, the first prototype is a circuit engineering prototype which test the performance and integrity of the electronic circuits. Once you do, understand that the circuitry is working well then you try to make a PCB out of this electronics circuit. That is the motherboard which is going to hold your entire intellectual property and execution of this new device. That is the functional prototype.

Still, it is not the smart watch or the smart diagnostic which you are having in mind. Then it comes to the next phase of communication prototype. The communication prototype is the one which is actually going to communicate with either the body or the external environment or with other devices, because the circuit itself may be working in a particularly good manner.

But when you put a case over it or when you make it operate through a particular piece of clothing, it may not behave in the same way the Bluetooth efficacy may be quite different. This sensor efficacy may be quite different. Therefore, how do I convert this functional prototype into a real IOT device which is effective in various classes of functionality.

And that therefore is the communication prototype, which test the communication of the proposed circuitry with other persons as well as with other things. That is the communication prototype. Once it is established that is circuitry functions as an integrated mechanism.

And in relation to the environment, you come to the actual design whether you would like to have round watch or whether you would like to have a square watch, whether the thickness has to be 5mm or 10mm. And similarly, in respect of the handheld medical diagnostic, should it be going within the pump or we should have a slider mechanism.

Those are the kinds of things which come under the initial design prototype wherein you combine the mechanical and digital parts of the product in an elegant way. And later on, once it is proved that this concept is working you come to the final design prototype which is in a sense the minimal viable product.

And again, as with every other process in this ideation and prototyping phase, this process can be iterative. They do not go in in simple steps. People would need to go back to the earlier processes, earlier phases, and come back with improved prototypes. So, this is one way of prototyping a smart wearable.

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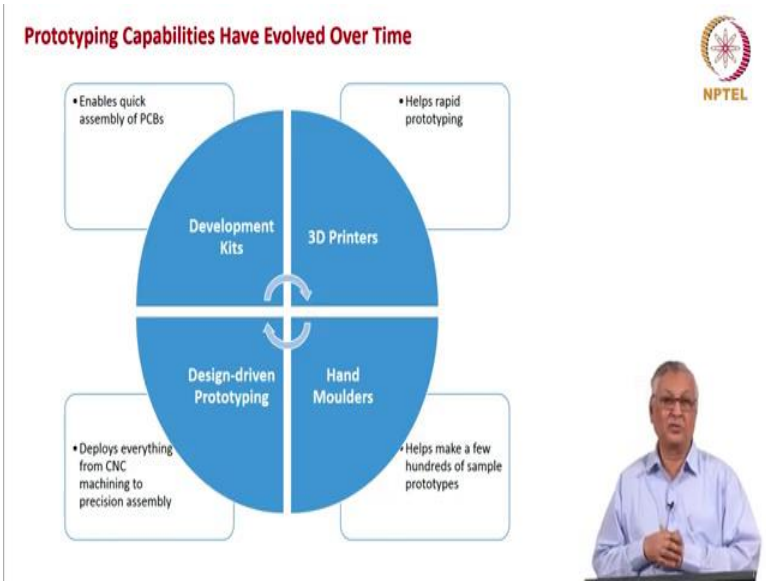

But unknown to us or not known to laypeople. The prototyping capabilities have also evolved over time. Their development kits which are available, which make people undertake prototype development rather fast. And they these kits enable quick development of the PCBs. We also have 3D printers which help in rapid prototyping the component which are required can be very quickly made and latched on to the electronic components.

Then we also have hand moulders who can make for you a few hundred samples of the prototype which you have in mind at the functional stage or at the communication stage or even at the initial digital mechanical stage these are the hand moulders. Then finally you have the design driven prototype makers who are having sophisticated CNC machines and who can make these cases or the covers at the exorbitant features and also the way you required with the finishes.

So, we have prototyping capabilities just as we have designed studios which are specializing in industrial design. We also have prototype companies which are specialized in providing development kits and enabling rapid prototype development.

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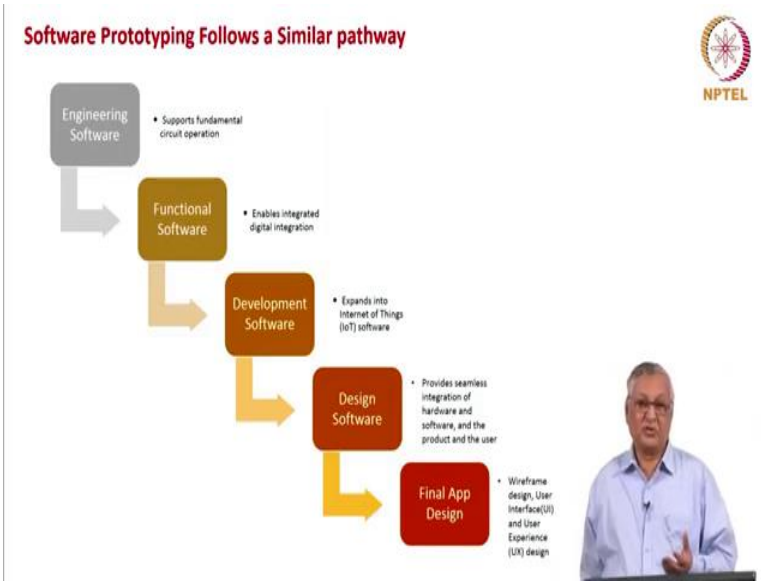

Even in respect of software as an independent product or software as supplement to the smart wearable category of products. A similar pathway can be observed. You start with engineering software where you support the fundamental circuit operation. Then you get into the functional software which looks at the integration of the digital aspects.

Then you have a development software which corresponds to the communication product with how you convert that product into an IOT device. Then the device design software which seamlessly integrates the hardware and software and makes the functionality between the product and user very helpful and seamless.

Then finally you have the final app design which involves the wireframe design user interface, then user experience. They all brought in to one kind of elegant app that helps the entire product software. So, this kind of software development happens when software itself is the product of the entrepreneur or when this software is part of the overall product profile which the entrepreneur has taken up in terms of a smart wearable or any other product.

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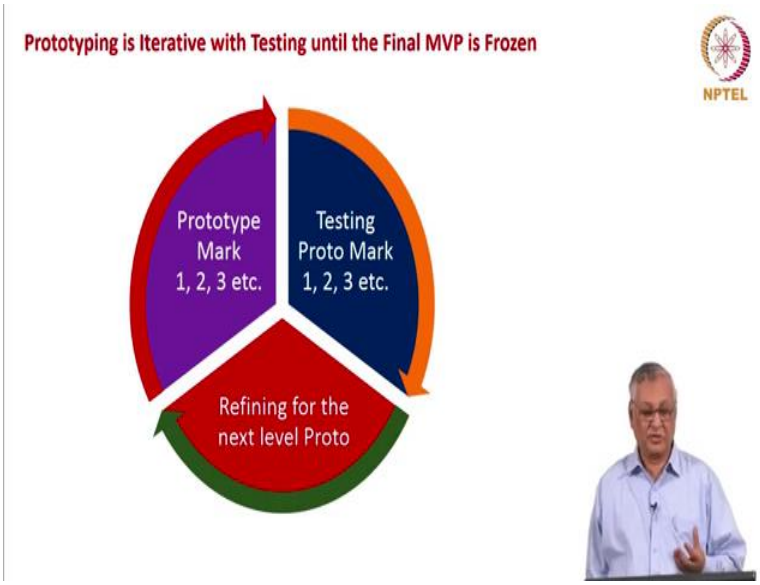

And prototyping for sure is an iterative process. And typically, companies have mark 1, mark 2, mark 3 kind of prototypes. So, the idea is to start with a mark 1 prototype. Test the mark 1 prototype refine it for the next level. And this iteration goes on until you think you have achieved a prototype functionality and perfection that the market would accept.

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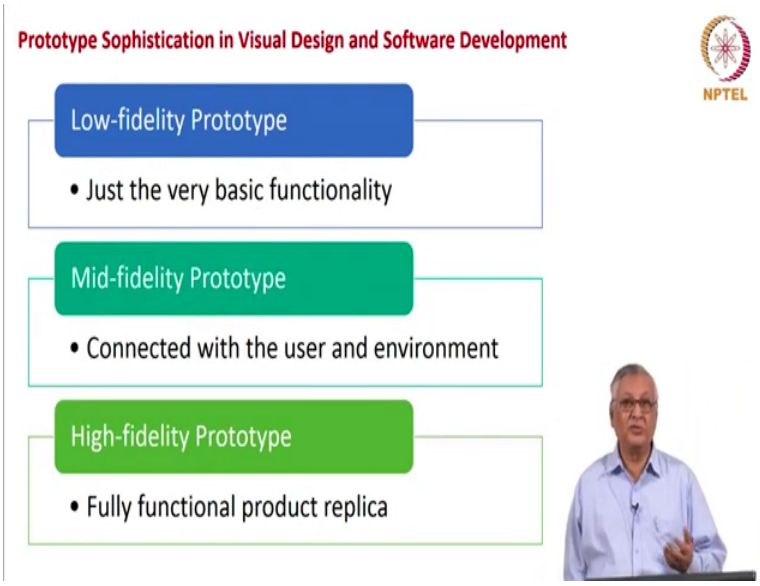

And similarly, when you look at the software and visual design products you have got three types of products which is a low-fidelity prototype just the very basic functionality. Then you

also have a mid-fidelity prototype which is connected with the user and the environment. And the third one is the high-fidelity prototype where you have the fully functional product replica which simulates the kind of product which the market would require.

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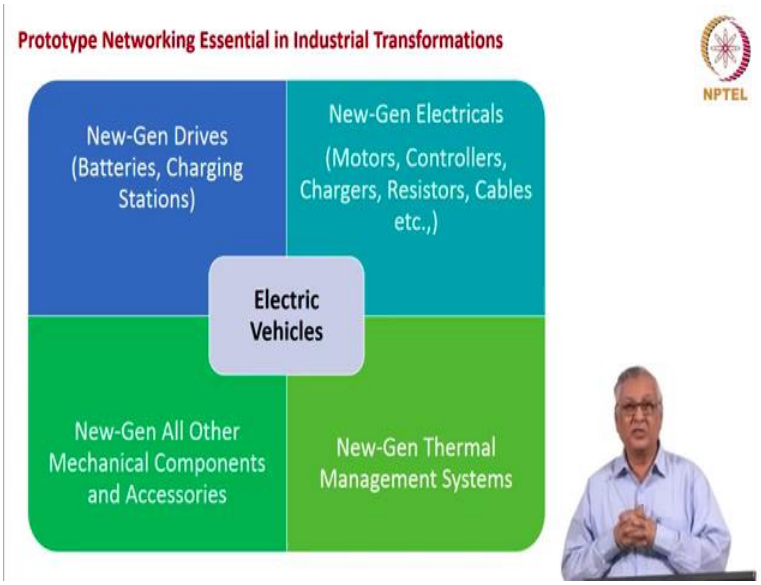

When we talk about prototyping for industrial transformations that is the entire ecosystem is getting changed. We need to network not only within ourselves, but we need to network the entire ecosystem. So, if you are trying to look at an electric vehicle prototype, it is not sufficient to have the ideation workshop. It is not sufficient just to have the departmental workshop.

You would really need to have an ecosystem workshop wherein you are trying to discuss with the other developers of components and other systems as to how they are developing their own prototypes. So, for a change the entire ecosystem is going to be on the same boat. Everybody is into the game of developing prototypes for their respective products.

So, you look at electric vehicles. You have the requirement for new generation drives which means batteries charging stations so a truck maker or car maker cannot think of an electric battery which is available as an off the shelf development and say that yes this is the space I have reserved for this kind of battery. It is not possible.

You have to identify the electric battery makers, work with them, understand how their prototypes are evolving and accordingly develop your own prototype. So, that is one aspect.

Then you have a whole set of new generation electricals, which are different kinds of motors, controllers, chargers, resistors, cables which need to be redesigned.

And again, you need to work with the prototype makers of that particular class of products. Then entirely new generation of thermal management systems is coming in as part of the electric vehicle system so that the heat dissipation is excellent and also safety of the product is ensured. Again, you need to work with them.

And the rest of the mechanical components have to be substantially redesigned and make them lighter, make them more feasible for electric vehicle configuration because the power and range are the once which are at a premium in an electric vehicle. Unlike an IC engine vehicle. You cannot simply say that I will double my horsepower and then I will carry the bulk weight along.

You need to be much more frugal in the way you design the electric vehicle. Therefore, you have to perforce even if you are starting with a retro fitted electric vehicle, perforce you have to move into a native electric vehicle sooner or later. Therefore, you need to work with all the other mechanical component accessory makers and their prototypes to make sure that you got a perfect electric vehicle prototype.

So, prototype networking is a whole new subject itself in understanding how prototype development has to take place under circumstances of industrial transformation. And we know that almost every industry is undergoing a transformation whether it is an energy industry or oil industry or specialty chemical industry, there are transformations occurring all over. So, how do we work with every participant?

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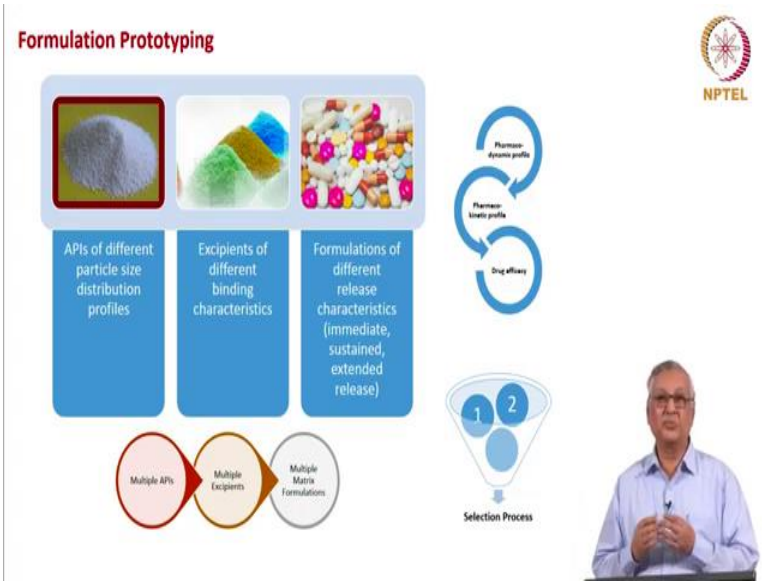

And this prototyping works not merely on mechanical parts because that is the concept we have and it is also working in software as we saw earlier. But it works in abstract products or continuous manufactured products. We think of a formulation. Formulation is the final medicine. You can how active pharmaceutical ingredients APIs of different particle sizes. So, when you have the particle size distribution in a particular manner the dissolution of that particle becomes different in the human body.

So, each particle size distribution the courser the particle is the harder for it to dissolve. Therefore, the penetration the body in the cellular mechanism is that much harder. But at the same time if you have extremely fine particle distribution, it is impossible to bind it together because that bulk drug has to be bound together to remain as a stable medicine. Stable drug or stable capsule. So, you cannot choose the extremely fine formulation. Therefore, you had different PSD mixes which are available from different API manufacturers. So, that is the one set.

Then you have excipients, excipients are those things which are added to increase the bulk of the product typically for a 10mg product, the active pharmaceutical ingredient maybe even make just 1mg and 1mg is so small that you cannot even find it to put into your mouth. So, the drug could be lost.

So, for you to feel and use the drug, you need excipients which are in a way neutral products. That is they do not have any therapeutic effect but they are required either to bind the particles of effect together or to increase the overall size shape of the product or even the colour of the product.

Therefore, these are the excipients with certain binding characteristics. So, when you mix this APIs and then these excipients you develop the drug so you can think of a matrix of different APIs, of different PSDs and different excipients and see which of these metrics formulations works better.

And each of these will have different pharmacodynamic properties, different pharmacokinetic properties. When you talk about pharmacodynamic and pharmacokinetic the way the drug is acting on the organism and the way the organism is acting on the drug you need to measure those things.

So, for the formulation A B C D E F G H, you have the appropriate pharmacodynamic and pharmacokinetic profile and then you filter these things through a particular filtering matrix which you have and then arrive at the final prototype. So, this is all the prototype and for this. You do not require a manufacturing plant. But do, you do require mini plant within the R and D lab where you can do this. You can dissolve the things in a particular dissolution mechanism. Stir them and find out how the prototype is working.

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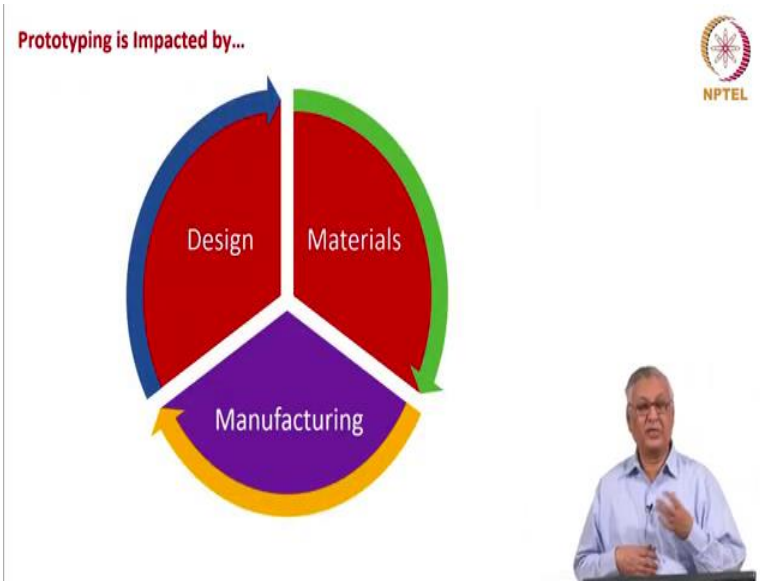

Again, as I said prototyping is impacted by design, materials and manufacturing. They go through in a particular loop. If you find that it is difficult to handle these materials, then you got to reformulate. Therefore, you get back to the design stage.

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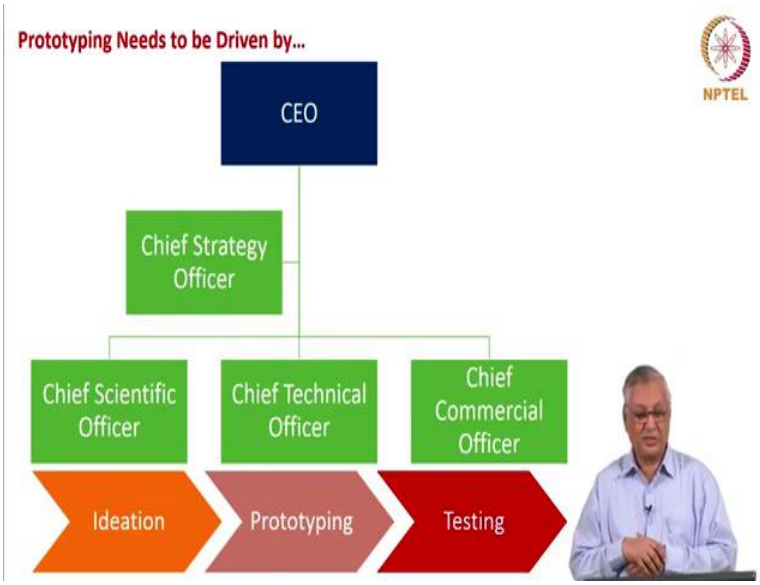

Prototyping typically needs to be driven by the chief executive officer of the company, not in terms of participation in the prototyping work but in terms of understanding how this ideation

prototype and testing together are working because there are three different verticals involved in this and therefore three different groups of people involved in this.

You have the chief scientific officer who is very much involved in this ideation, a chief technical officer who is involved in the prototyping, which is an operational issue. There is a chief commercial officer who is involved in the testing. This is for a typically large organization. As we discussed in the earlier phases in entrepreneur organization, which has multitasking, you may not find the same kind of differentiation, but there could be people who need to be brought together and who need to be kind of made collaborative in this process. And that becomes the task of the entrepreneur to handle.

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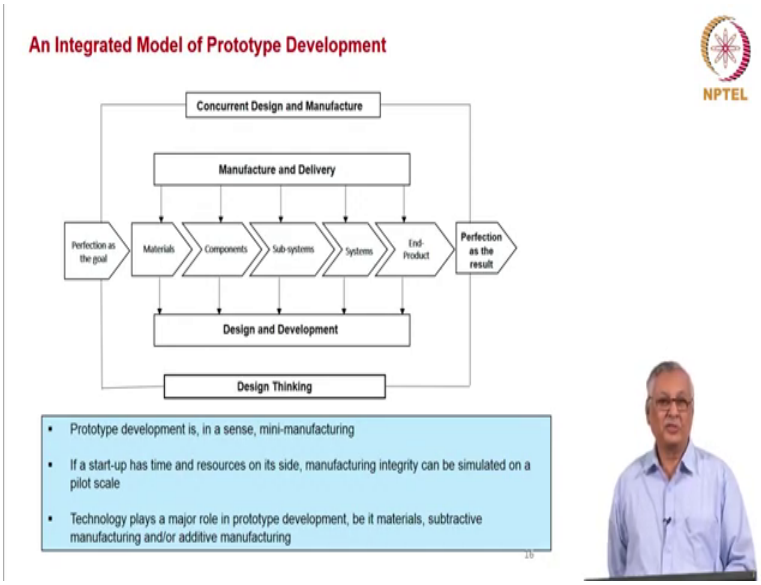

I must also add one more point here. Although the start-ups by themselves may not have the time and resources. Today's start up ecosystem is such that they could utilize certain anchor facilities or common facilities that are offered by incubators and accelerators to further this objective. When you look at IIT Madras research park or similar industrial research parks provided by the other major institutions. You can see that they have the necessary infrastructure that could enable a firm develop some of these prototypes on appropriate lines and utilize the common facilities and infrastructure inputs that are available.

And also being an adjunct of a larger engineering or scientific institution helps in providing appropriate inputs that could be used to tweak the prototyping process if it is required. So, these are the advantages of the well-developed incubator and accelerator system that has taken roots in our Indian start up ecosystem.

I have mentioned earlier that prototyping is a microcosm of overall manufacturing. So, if you look at a typical large manufacturing system. We have perfection as the goal and our result will also be measured by how perfect we are. And as you have seen in the development phase, we are moving from certain unseen circuitry which lies somewhere in the product to finally elegant minimum viable product or ultimate desirable product. So, that is the flow we had in the prototype development.

So, when we bring materials, components, subsystem, systems and product in an established manufacturing scenario. You will notice this similarity, which we had in the prototype development and in a big manufacturing setup, we have had several developments in management theory in practice.

How do we do the basic design and development? How do we do the manufacturing and delivery? What is the design thinking involved in making perfection as a goal? And how we can bring together different constituents of the company through concurrent design and manufacture all of these things are there. But by having a good prototyping capability an entrepreneur firm even without understand the ultimate goal. I would say is laying an integrated model of prototype development as the foundation of its likely future manufacturing development.

So, if an entrepreneur firm is able to develop its products on healthy lines in this interconnected manner. It is likely that the prototype development actually lays the foundation not only for the minimum viable product and the ultimate desirable product, but it also lay foundation for an elegant operational framework within the company.

And in this whole process of prototype development technology plays a significant role. Computer scientist, the electronics engineers, the mechanical engineers and in the formulation aspect the chemical engineers and the pharmaceutical scientists. They all need to play a significant role to bring together this.

And why is that the large companies are able to do certain prototypes faster and more precisely is because they are able to set up pilot plants, kilo labs or prototype laboratories at significant cost. If only a start-up has got that luxury of time and resources, it is very well possible for start-ups also not to experiment with somewhat erroneous products to start with, but come up with very good prototypes even from day 1.

So, it is again a tossup, in one of the lecture sessions which I would take. I talked about the start-ups being classified into an R and D start up and then a commercial and manufacturing start up. Many, many of the start-ups I see are doing R and D in the field. They are coming up with their products even before they are fully proven as prototypes and they are getting funded as equity funding.

And that is in my opinion, destroying the value of the company because you are using long term equity for short term working capital usage and why you are not taking short term working capital because your production cycle is not established.

And why is the production cycle not established? Because you are not perfected your prototype development. You have not perfected your manufacturing process. So, you are not able to say that my cost of production is this much. If I produce this much amount of componentry, I am going to get this much amount of finished product. I am not able to say.

Therefore, I am not able to approach any institution for working capital, because my working capital cycle is unknown therefore it is important to focus on prototyping and ensure that the prototyping development gives us a firm production cycle a very well managed product profile that is very important. So, the importance of prototype development cannot be underemphasized in entrepreneur development.

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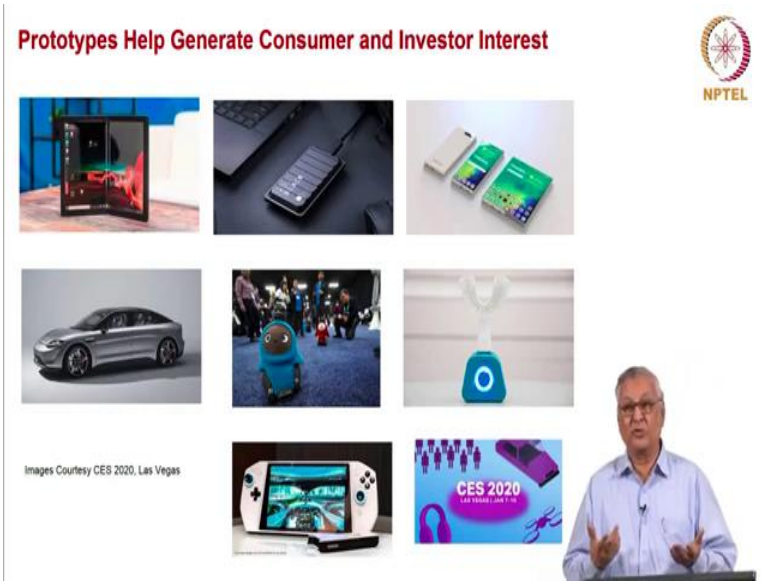

Now, what do prototypes do? Prototypes obviously prove the product concept, but more importantly they also enhance the confidence of the entire organizational team. In the goal the company has, but in addition to these two important things, prototypes help to generate consumer and investor interests.

When laptop computers come with foldable laptops or with the 8 TB kind of drives foldable or slidable smart phones and vision concept car of Sony or a Robo or the 32-tooth brushing toothbrush, which I mentioned earlier or aliens software. All of these are showcased in this year CES 2020 that was held in Las Vegas in January 2020.

Now, they generate lot of consumer interest. And when people try out willingly, there is alpha testing or the beta testing. If a geek is the one who is testing your product in his hands or her hands then alpha testing is automatically taking place. And if lay consumer is finding out how this AR module is working or how the Robo is interacting, then you have beta testing also happens.

So, the prototypes help not only in the normal path way of development of the product, a normal path way of developing an entrepreneur firm. It is also generating greater consumer interest investor interest, which is providing significant input into the entrepreneurial development process.

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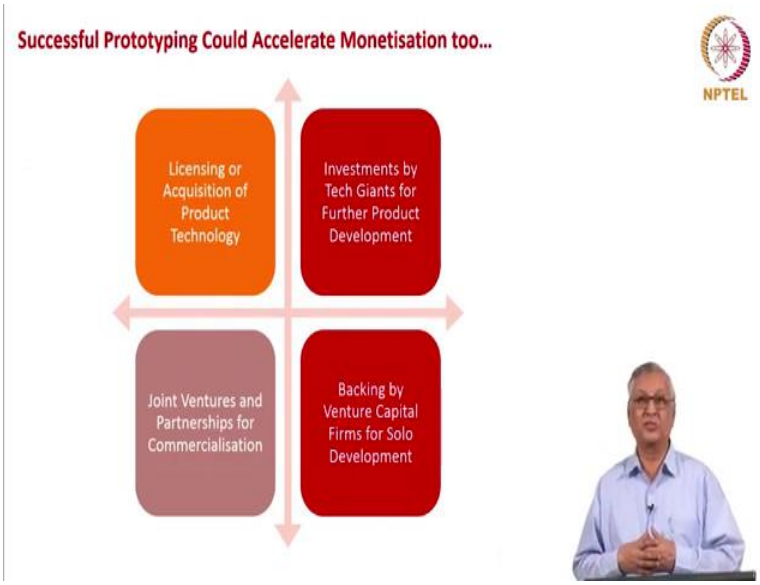

And successful prototyping has got much more than just one building block of the entrepreneurial development. If the prototype is very successful and we are able to demonstrate it could accelerate the monetisation of the company. You could license the prototype or somebody else could acquire the entire product technology assuming that you have developed a medical diagnostic device, which is replacing the medical stethoscope. Somebody may be interested J&J could be interested. Or an Abbott could be interested in acquiring the technology.

So, you have through demonstration of the prototype successfully, you have created monetization opportunities. On the other hand, if the prototype could be taken to the next level. Tech majors could make major investments into your company for further product development. There could be joint ventures and partnerships for commercialization when the product is developed into the commercial product stage or venture capital funds would be so interested in the value that could be ultimately built into this product. They could back you up and you may decide to remain solo and try to develop this product to the hilt till the final valuation goal is achieved.

So, successful prototype essential as it is for building confidence into our own venture and how it could take the form of the commercial product has several other supplemental monetary benefits as the prototyping process takes place. So, as much as ideation. Prototyping also is very important.

And in this lecture series, obviously we could go only sequential that is the ideation phase first followed by the prototyping phase, followed by the testing and validation phase. But to be realistic, prototype stage and the testing and validation phase are very closely interactive. We talked about the circuit working out as we have design then the functionality as a Bluetooth device we have looked at. Therefore, testing and validation is an integral part of prototype development.

It is just not go, no go kind of system as so it is an input to the successful development of the prototype, but we can only consider them as sequential parts. But we have to keep in mind that these are integral processes and they are also iterative process. So, prototype development that way is extremely important aid to put the entrepreneur firm in the right path. Thank you.