**Introduction to Lean Construction**
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**Document Management, Workflow Process, Communication, Collab, Authen, Sensing**

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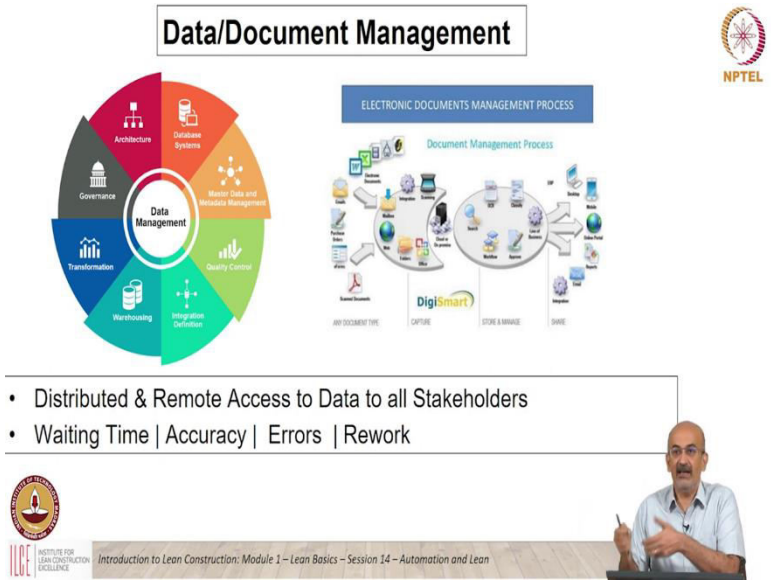


We go to data and document management. So, databases have been there for some time, we would have, I think many of us in the early years used databases on the PC and now we have all of our databases are web enabled, web access and then from databases we went to document management, where it is not just, I am looking at data in a particular way, I am looking at the documents relevant to the process.

And these documents are available to me not just on my machine but to anybody any person on the project. So, what did data and document management do? It gave us distributed remote access to data to all stakeholders.

Student: More transparency.

Professor: More transparency there is more transparency, it is easy to access. I know what is there, my waiting time for any document is reduced. The accuracy, the information accuracy is increased, errors are reduced, rework has reduced. These are just some critical elements; I think the list can go on you can see. But having data available at my fingertips has enabled, empowered me, has also, what does a transparency do?

Transparency makes me feel a part of the process? Exactly, so there is a lot of things which just availability of data does. And again, you are now not limited to your office hours, you

have to go to the cabinet, open the file get it, I can get it from anywhere, anytime. This has enabled so many things to be done, the processing time to really decrease.

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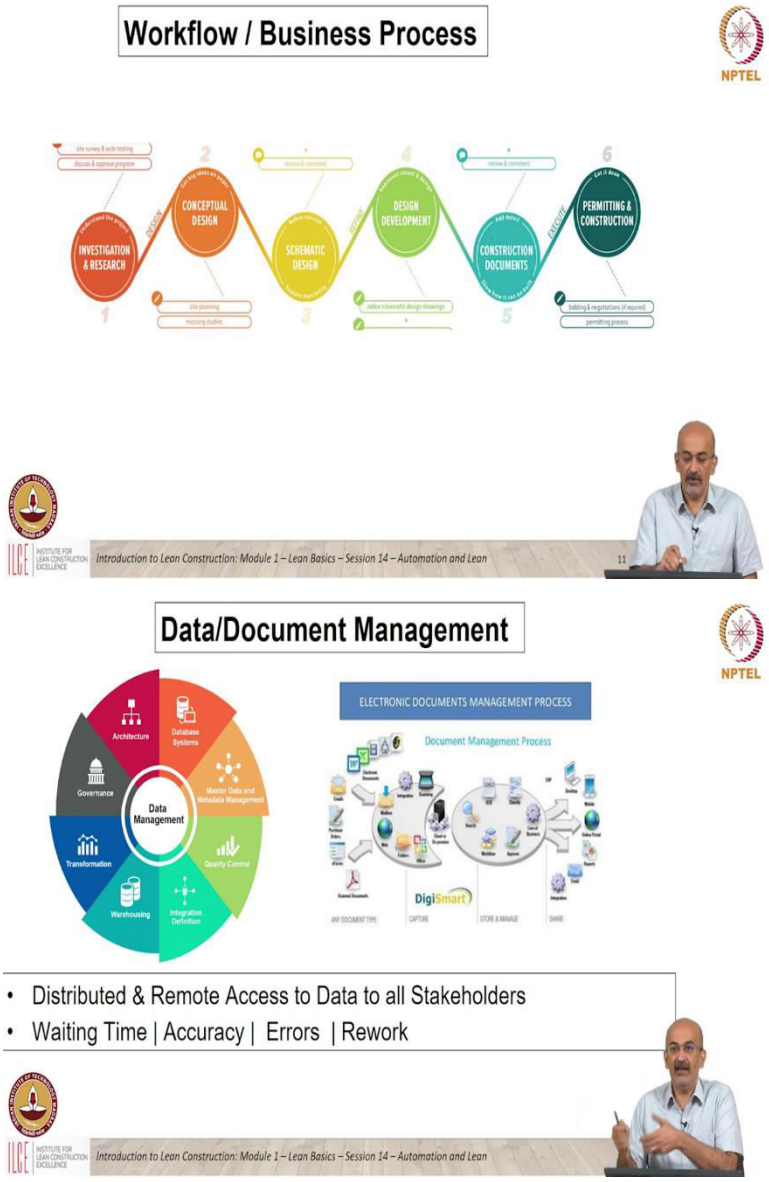


We go to workflow and business process. So, when we looked at data document management, we were managing the documents. Now we come a little more into the core of a lean kind of thinking. So, we know that lean and looking at lean is about process.

So, when we look at work flow, so we have two words there, work is a part of the process and flow is also remembered part of lean. So, what does the workflow try to enable?

Student: To know or schedule after which what we have to do?

Professor: Right. So, basically in addition to my document management, the process through which the documents have to flow are now defined in my system and the flow is now not manually done but automated. So, if you look at here is, I mean here we have seen the whole construction or the project process so if I take just construction documents, there will be a workflow in construction. There will be a workflow in design, there will be workflow in this. At the same time there is also a project workflow.

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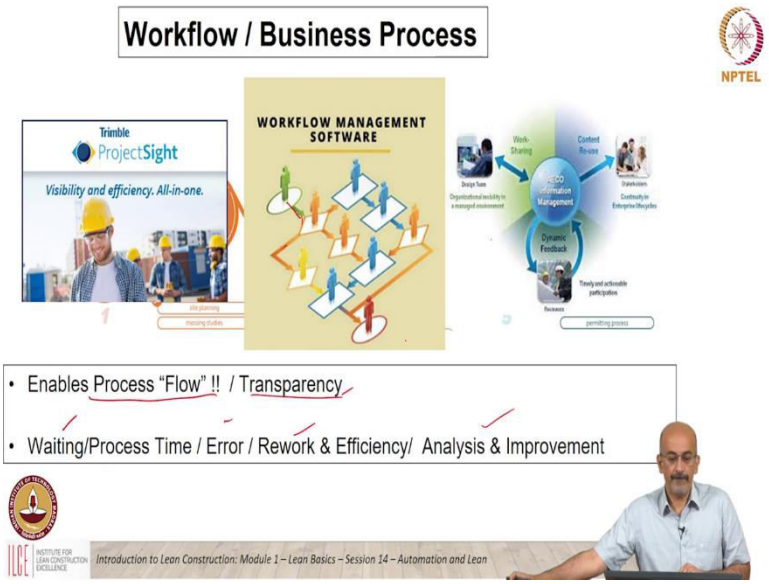


So, there are tools, some commercial tools, what we call workflow management software. As you can see there are different stakeholders, different customers or internal customers what workflow does is it enables your documents or whatever is required the document and the information to flow through the system as it is defined by the process.

It is not that I have to pull the document process it and then send it to the next person. That flow takes place. So, here it enables process flow. My waiting time just because I finished a file and sitting at my table is not there. Once I finish a file and approve it, it automatically goes to the next person and the person gets a reminder that the file is waiting for you and you have so many files to clear.

When I open the file, where I need to sign, what data this and that can also be computationally checked, if then conditions are checked and once I approve the file, it goes to the next or if it is a drawing or whatever it gives me a history, versions, lot of information are at our fingertips. So, the flow gets improved. Transparency gets improved.

Student: push system there is flow, also in pull system there is a flow?

Professor: So, in the pull systema also there is a flow. So, we have not gone into the detail of pull and push but if you take a Kanban system, what it does is make a pull. So, I can have a IT based Kanban system which can enable pull. So, the principle of pull is independent of technology. But the information required for pull or processing required for pull can be enabled through technology. So, I am glad you brought up this question.

So, many of these technologies we can enable a more transparent pull system in the process. So, for example in the workflow process, I can set a rule which says my file will not be forwarded to the next person, if the person has so many files waiting. So, if I get backed up, I know that, that person is not cleared first. So, rather than just keep pushing the files to him or her, I am, I also then understand.

So, the whole system I mean, one of the principles of the whole system is if there is one person who is bottlenecking, it affects the whole line. So, then it comes to the attention of the manager who can then kind of take some action. So, the pull can be implemented more effectively with an IT based system. But independent of IT, if you have a good pull system in your place, the concept is independent. But IT can implement it.

Again, if you have come back, so you have definitely waiting process reduction, error reduction, rework reduction, analysis and improvement and as I said, we can enable pull processes or whichever way we want all this can be done with a lot more transparency and standardization. So, I should also include the term standardization because this makes things standard, your forms are standard, there is less variability in my approach to kind of deciding on things because the process has been standardized.

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We are familiar with this, if you look at communication, we use all kinds of communication tools today and compared to 20, 30 years back the amount of communication platforms that is available to us is phenomenal and it is not just text communication, it is visual, it is video, it is all forms. So, kind of you can see there are several communication options that are available and communication definitely enables collaboration.

So, just communication does not mean you will collaborate but the fact that real time communication is available to you and you will definitely need other factors to enable collaboration but the communication platform is there. And then here we come into this part of authentication. That is also become important today.

I am not going to do a bank transaction, unless the bank knows that it is me who is doing it and they try to authenticate. Construction also, in contract document signing, many transactions that are happening will need authentication things like blockchain are enabling, easier and more powerful authentication systems. So, all this becomes very important and again we are using, when we take the term collaboration, it is a core concept in lean, it is a core requirement that we try to enable collaboration.

So, we had enabled collaboration through big room meetings for example, independent of technology. You bring people into one room; you ask them to discuss collaboration increases. Now we can do big room meetings through IT platforms which does not need physical co-location. So, that definitely has its pluses and minuses but if people are remotely located, like they are today.

When you have a design office somewhere else, you have the procurement requirement somewhere else then this facilitates collaboration, enables it. And in many ways the record keeping, the fact that we can record the meetings etcetera makes it the documentation also better. So, if you look at it, we have rapid information exchange. Faster decision making, faster understanding of others constraints and problems, rapid authentication, transparency remote participation.

Again, it impacts the standard metrics, waiting time, processing time, reduces communication error. It reduces it very importantly people feel empowered. When you collaborate and people are a part of the decision-making process, there is certainly empowerment.

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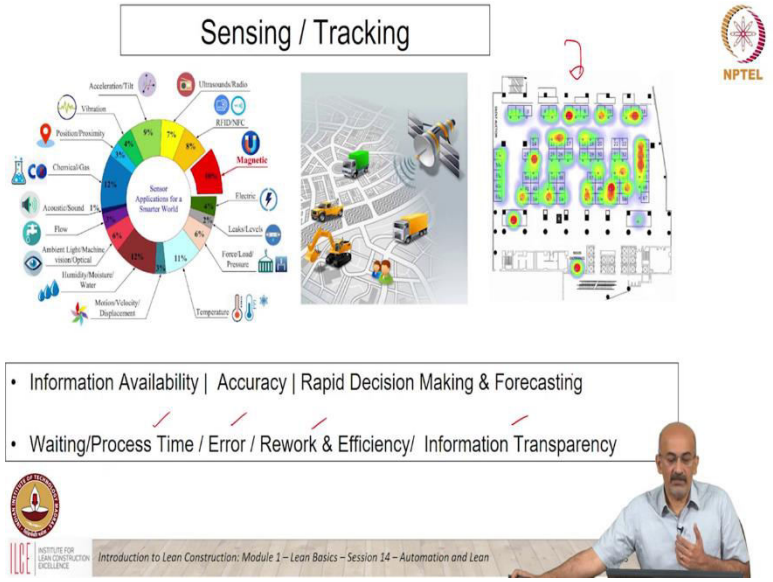


Now we come to technologies which are kind of in the frontier. We look at sensing and tracking. So, on the slide here, I have a variety of sensors that are available today and all of these sensors have become small enough. They can be deployed on anything, we have lot of sensing technologies. We have GPS technologies which has been for positioning.

We have, there has been a lot of challenge of positioning people indoors but we are starting to have technology where you can locate people and see their movement patterns indoors or on a construction site where a GPS might not be able to penetrate. So, sensing is a huge area. It is becoming more and more important and with technologies like 5G.

This will become the, communications required for sensors to give us data becomes easier, the communication pathways become much faster and information availability becomes a major kind of, before even if I am sensing on a site, I do not have the pathways to be able to,

whether the technology to transmit it is less. Today, not only is my sensing much better but my information technology pathways are also much better.

I can see the accuracy, the rapid decision making. Again, you can see a lot of these will be, a lot of the standard metrics will be benefited through sensing technology.

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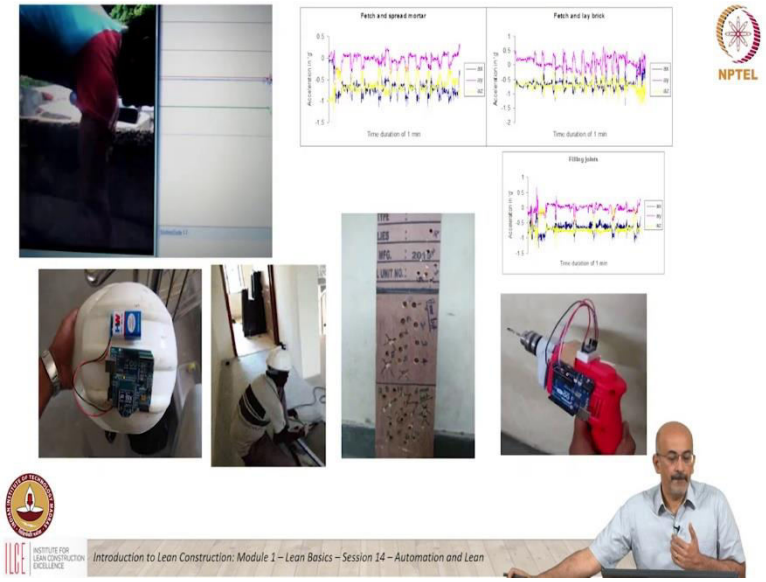


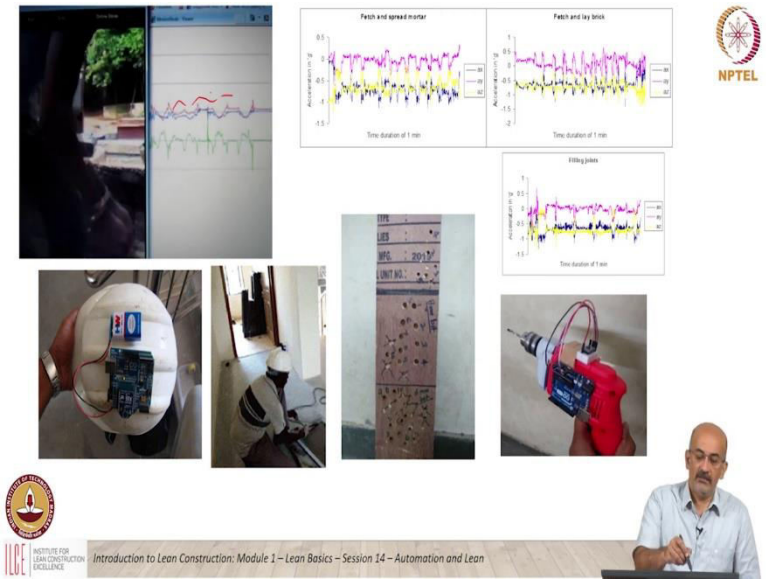


Let me give a few examples here. So, this is an example where one of the projects we did, you can see what is happening, you have a worker and the worker has been instrumented with an accelerometer and the patterns you see here are the accelerometers readings which is and the waste of the worker. So, what do you think would be the outcome of sensing application like this?

You can identify what the worker is doing? How much time is put on bricklaying? How much time is may put on shifting? How much time is the person not working? All of this can be now got from sensing information. Earlier to do work sampling, I had to actually go in and kind of do it manually. But this comes up as a part of the process, it need not be work sampling.

This can be just a part of your overall value-added time into the whole process, to understand what constraints the worker has faced if they were not able to actually perform appropriate amount of active time. Similar example here, you can see here a drill which this was another project which we did, a drill has been instrumented with a sensor. What this sensor does is, it can predict when if the drill is working properly and when the maintenance requirement for the drill will come.

So, rather than do routine maintenance on some pattern which the drill might not require you can actually base on this sensing, understand when, do preventive maintenance at the right time. Not just do annual maintenance or periodic maintenance becomes what do you say knowledge based preventive maintenance.

Student: Based on number of number of hours.

Professor: You know it is based on the pattern, the drilling pattern. Seeing how the drill is behaving, is it rattling, is it this, that is the sensing that is there. So, one side it prevents the drill from breaking down. If the drill breaks down what happens? Affects your work? On the other side, if I am doing periodic maintenance which is not required, I am wasting money. So, this gives you, this is the sensing enables you to do it.

And you will find today lot of advanced drills comes with these kinds of sensors inbuilt but when you have several drills on site, this technology can, we need to make it smaller, this is a prototype and be able to use it for monitoring tools. Here is another technology we develop sometime back; this is to do with worker tracking. So, I have a tracking device, you can embed it in a helmet and you know where the worker is on site.

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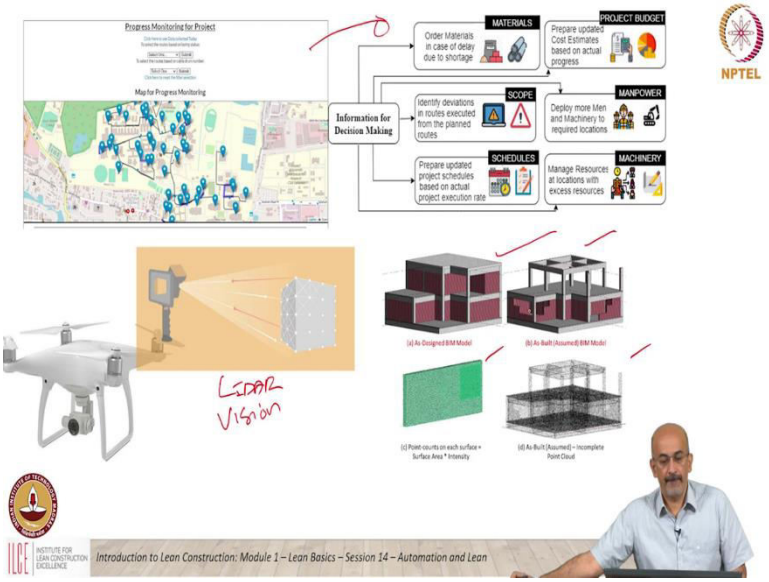


Here are some more examples, so here is now we are looking at it from a GIS point of view, Geographic Information Systems and actually tracking progress of work based on GPS data. So, the references to all of these works will be given in the supplementary reading and using this, a project manager can make good decisions on material scope of work, schedules, budget, manpower based on real time information that is coming out not based on information that is 2-3 weeks old and a lot of this is available because of positioning and sensing data.

We are familiar with drones and we can see in more and more drones and technology such as LIDAR or you do not even need LIDAR. It is just vision, vision-based sensing. I can take a camera to a site take photographs of it and then develop 3D models and then start doing quantity estimates of work finished, construction progress monitoring or what we are calling computer vision-based construction progress monitoring.

So, all of these are sensing technologies that are enabling us to be able to do processes more effectively, accurately and thereby reduce waste.

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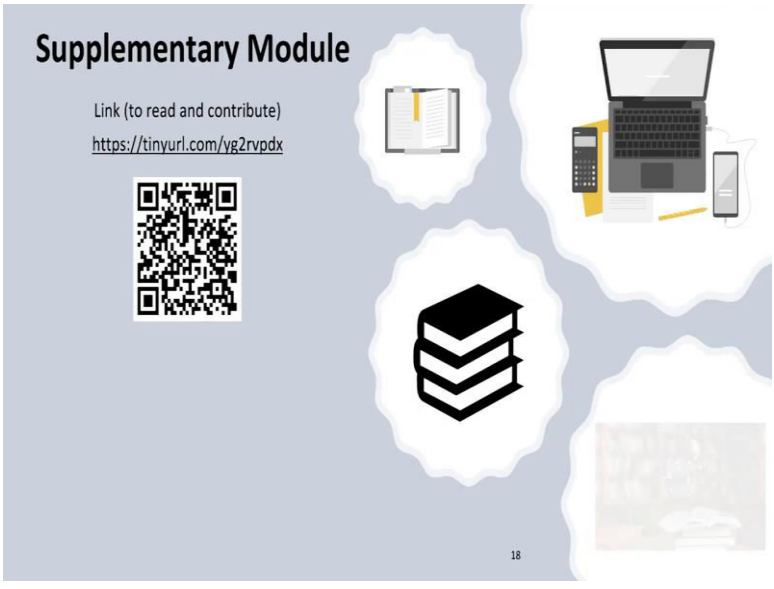

Here is another technology. So, in this case it is computer vision that is being used to track workers. How will this impact? So, you can see, we can not only do tracking and what the person is doing? We can detect work practices, we can detect hazards, productivity overall workflow improvement, try to make sure that things are done just in time. There is workplace availability, reduce the idle time and waste basically.

But again, this is only sensing information, the sensing information has to be processed and decisions have to be taken out of it to be able to, the management decisions have to be taken, how work phase decisions have to be taken. How does those decisions enabled we will come know.