How to Compute Your Plant's DAM Capacity

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Do you know your plant's capacity? If your answer is, "Yes, because we have a scheduling department and an extensive scheduling system module built into our ERP," I would say "No, you don't." What is my reasoning? First, an answer like this doesn't really answer the question I asked; it doesn't tell me what the plant capacity is. Second, this answer doesn't tell me the process used to determine the plant's capacity. Third, this answer doesn't tell me how plant capacity estimates are verified and validated. Fourth, this answer doesn't tell me if their capacity is static (the same across all product types and product mix) or dynamic (different by product type and product mix).

We have all been obsessed with global labor costs in this industry, but what is hidden in terms of the cost of not understanding our plant's true capacity could make our plants so DAM profitable that we would not have to worry about global labor costs ever again. Yes, the opportunity could very well be that great.

Few of us are willing to admit we don't know our plant's capacity. It would be like a dentist not knowing how to brush teeth. Yet with our need to build advanced technology HDI boards with sequential lamination, figuring out our plant capacity is a very difficult thing. Let me give you some examples that will more than pound this important point home. How much quick-turn work can you handle in your factory if it is a one-day, two-day, three-day, or four-day quick-turn? Is it 0%, 5%, 10%, and 20% by volume? What if you have a mixture of different quick-turn levels? How could you load your shop or set your promise dates to ensure perfect on-time delivery? Let's compound the problem with HDI work with products that have two–eight lamination cycles. Based on the quick-turn commitments, how much plant capacity would you have left for regular 15-day orders? These are not questions that work well on spreadsheets. If you don't believe me, try using a spreadsheet to work out the different cycle times for each job in each scenario. The only way you can answer questions like these is with a model.

Model Behavior

Why is the model important? Because it allows you to see what will likely happen given an existing scenario, and allow you to play around or use a mathematical algorithm to optimize to a better alternative scenario.

What is a model? One definition is an advanced calculator meant to compute a very specific set of things based on some logic structure. We use a model to predict the controlled impedance of our boards. Models range from simple to advanced. A more advanced model is able to simulate visual results so that we can play around with it in "what if" games, come up with decisions, and observe how they play out, without actually experimenting in the real world, which could be impossible or very expensive. An example of an advanced model that allows users to simulate results is the PCB registration software system sold by Xact PCB. I wrote about my early work in registration and how I modeled it using JMP data analysis software in DAM Registration (February 2013).

It's also important to describe what a model is not. For example, a database isn't a model. An equation that you derive from the data in the database is a model. An Oracle system or SAP system isn't a model, even if it has modules that claim modeling or simulation is happening behind the scenes. Anything that creates a dependency in which you have to accept on faith that it works and you don't understand how it works isn't a model. It would unfortunately be like HAL, which I discussed in What is the DAM Problem with Scheduling? (July 2013). When HAL is running the show, things tend to go from bad to terrible.

Note: Models aren't perfect and this often is why people often don't trust them. They are an abstraction of reality, not reality itself. For example, Newton's second law, F = ma, is an imperfect model that doesn't work well close to or at the speed of light. But we still use it. However, if a model is flawed in some way and doesn't represent reality perfectly, then why would we use it? Let me avoid answering this question for a moment and make another point. A model exposes our understanding of what we think is important and how we think things work. The problem with this is that it could prove what we thought was true is actually false: It could prove we are wrong. Who wants anything to do with that? Not me! I am perfect! I am right! We don't need models here! OK, let me calm down and take a few deep, meditative breaths. By the way, if you boil it down, my little fit was the rhetoric of the dark ages, when they preferred mysticism over reason.

And now we have come full circle, back to our capacity problem. Can we use our best reasoning powers to determine the true capacity of our plant? Until now, there wasn't much available. Operations has always been confused about the problem: Is it people, who won't obediently do exactly as they are told (the dark ages when people existed as non-thinking slaves) or is it the management system being less than perfect (again, to admit to this as managers, we could be executed if it were the dark ages)? It is time to step into the light, and into the Age of Reason, using a model and the scientific method.

I have created a generic, imperfect model on which others can build better models, either working with me, or with others, or by themselves. You can see an example of how it functions by clicking here.

The video shows the data entry tables such as the production specifications for product A, which is a 66-step sequential lamination HDI job, the production specifications for product B, which is a straightforward 29-step multilayer job, the specific plant capacities for each department, and so on. This example is very much simplified and in no way close to the limits of the model and the modeling software used to create it, which allows for hundreds of different jobs specified. However, the point in modeling is not to cover every single detail of the territory perfectly, but to make sure that the required territory is spanned to an adequate level of detail. So, as Lean theory tries to tell us, if we break our products up into logical families that cover the span in processing variations, this allows us to simplify what we need to know in order to know what our true plant capacity is, and it makes our modeling efforts easier and more productive.

In the training I received from Robin Clark of QMT Group to construct operational models over the last couple of years, I have repeatedly found people in my class from organizations as varied as the Mayo Clinic and Boeing. These companies have found that having a modeling capability within their organization is of strategic importance. Anyway, we were learning to develop what is called discrete event models, or simulations. The model in the video link is a discrete event simulation.

Discrete Event Simulation

What's a discrete event simulation? If you think of your factory as a series of events that happen at specific times, such as, 10 panels go into the press, get laminated for 60 minutes, come out of the press, get broken down in 10 minutes, get stacked in two minutes, and then get moved to the next operation in five minutes, a discrete event simulation considers all of this detail, creates a huge multidimensional table, and updates it precisely to each event based on the parameters and inputs that you specify. It does this very quickly, typically many thousands of times, where it appears everything is happening simultaneously in one continuous flow. It is sort of like a movie, which really is a bunch of still pictures that change very quickly. So with the timing for the processes and the capacities specified for each department, which is all stuff we know about our factories (because of the sophisticated ways we handle our data), along with the logic that determines the priority of what is going to be worked on first, and so on, you can get a good dynamic simulated representation of your entire plant. A model (and the software behind it) can keep track of every single item (panel or job or subassembly or even worker and piece of equipment down to a drill bit if you desire) during a run (running the model to see the simulated result) and report back the statistics at any level of detail you desire.

So let's try a few things with this model and see what happens. In a month (five-week month with 560 hours of production time across two eight-hour shifts running seven days a week), can we build 2,000 panels of product A and 2,000 panels of product B that have the same specifications for the products and the plant shown in the model in the video? Also, we want the average cycle time for the factory to be less than eight days; in order to achieve this we think we have to keep the total WIP of the factory down below 2,000 panels as best we can.

The first thing we have to determine is how we are going to start our jobs. Let's say we are going to start 40 panels of A and 40 panels of B at the beginning of each shift.

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Figure 1 shows the result. We failed! Our average cycle time was 11.24 days. We were 1,000 panels short for our product A commitment and we were 400 panels short for our product B commitment. We could just end our analysis right here and say that we don't have the capacity. Our true capacity for product A (assuming no scrap) is 1,000 panels and our true capacity for product B is 1,600 panels. But we would be dead wrong. Why? It is because there is no such thing as a true static capacity for the type of plants we run in our industry. This fact will be the subject of future articles.

For now, let me make a provocative statement. I don't know of a single board shop that I have been in that is Lean. Yes, many that I have seen have done multiple Kaizen events, but that doesn't make them Lean. Let me explain. The most important concept about being Lean is takt time: the timing of work from start, through each department, all the way to packaging and shipping. If you don't have a clock on your wall in your plant keeping track of this, then you aren't Lean. What you are is unpredictable. In fact, you can see it in Figure 1, where so many processes appear to be the bottleneck—almost half the plant! If this describes your plant you aren't Lean. The good news is that you can be so much better.

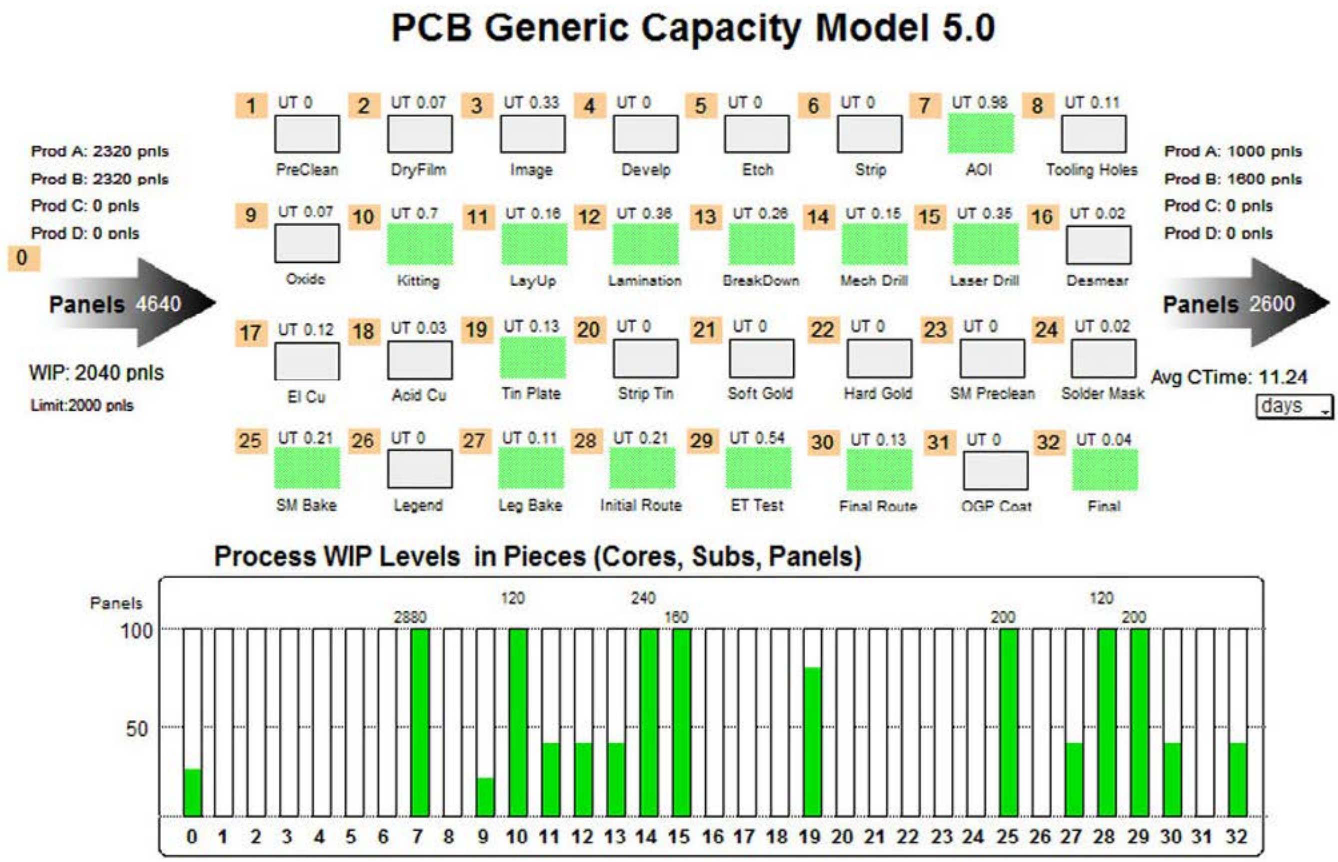


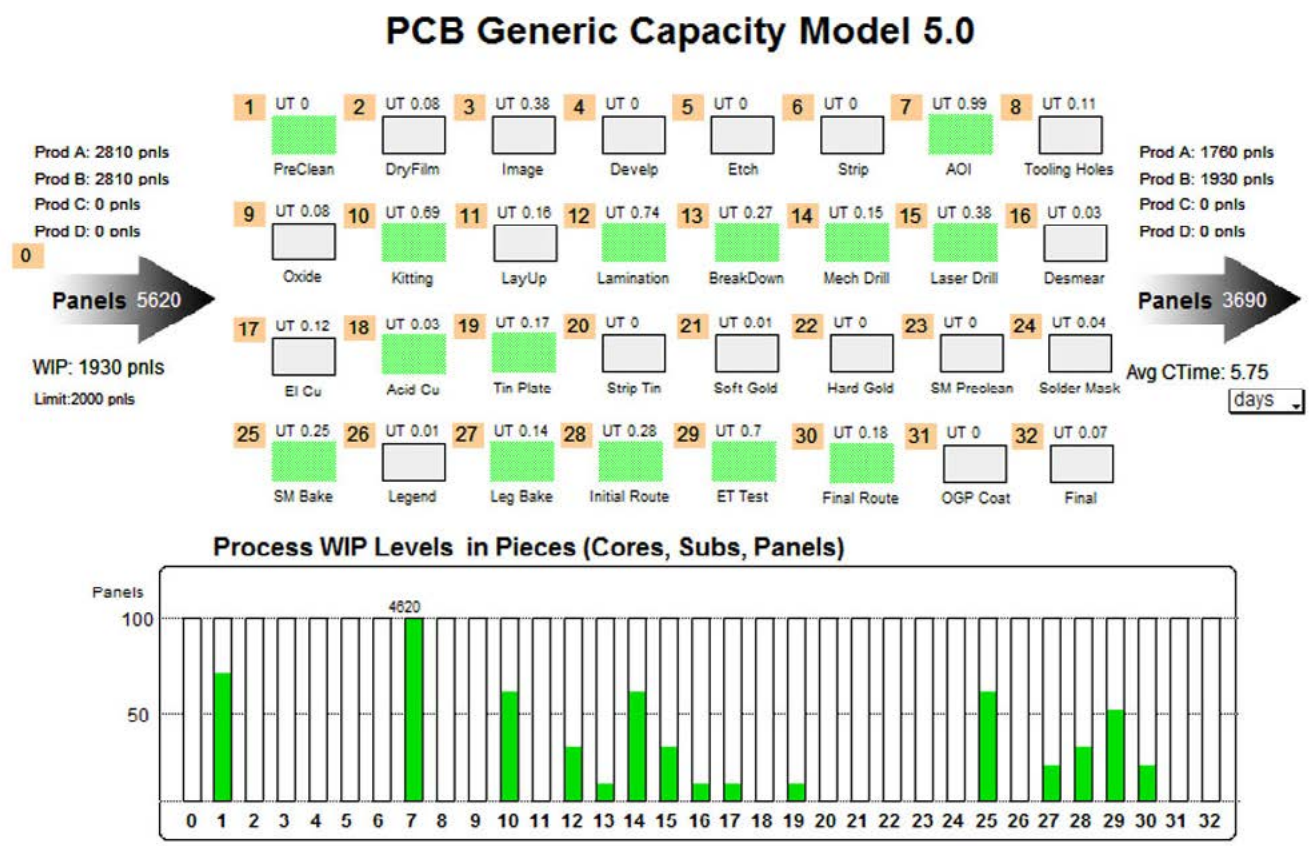
Figure 1: Capacity result with infrequent large lots. Each department is labeled and numbered. The numbers correspond to the number on the Process WIP levels graph. The green squares show which departments were processing panels at the end of the simulation and the green bars show the WIP levels, which can help to identify bottlenecks.

Let me give you an example. Many shops have been forced, for a number of reasons, to process small lot sizes and as a result, their cycle times and throughput have improved. But when they get that large volume, somewhat rare order (which is always exciting) they clump the lots as if they are one super lot and release them almost all at once on the floor. Before too long they have a WIP problem, delivery problem, and often higher scrap, too. Also, this chews up a lot of capacity. I talked about this in Remove DAM Variation and Your Company Will Win! (July 2012), where I explained the freeway analogy: If more cars are paced at the same speed and if more cars are sequenced to enter the freeway at precise intervals, the more cars you can have on the freeway. This means that how you pace and time your starts will remove or create plant capacity! Is this in fact true?

Let's try out the model in this way and see. Let's start product precisely at two-hour intervals of 10 panels each of product A and product B. Figure 2 shows the result.

We have nearly doubled our throughput (plant capacity) and reduced the cycle time by 48%! If you got these results with your model, should you challenge them and test them to see if they are in fact true? Absolutely. The model doesn't think, we do. And only through challenge, observation, and inquiry can our thinking about how we run operations be improved. And if the model isn't making you smarter about how to run your business then you have an IT solution like HAL, and that isn't good.

Also notice in Figure 2 that there is one definitive bottleneck and that is AOI. This is re-



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ally amazing, because we have done nothing to change the structure of the plant and the equipment that is in it. We just changed how we start jobs. Now keep in mind this bottleneck is also a function of how we start and time jobs through the factory as well as the lot size we use, the size and scale of the equipment, and the product mix. So if you are thinking about arbitrarily increasing the frequency of your starts and decreasing the size of your lots just because of this article, this could be very hazardous to keeping your job if you do it without a good model and use a scientific approach.

The bottom line is that there is no such thing as a true static plant capacity in our industry. The plant capacity that we have on any particular day is a function of the decisions we make and how we manage our plant! Very little of this will be revealed in a spreadsheet analysis, but very much of it will be revealed in a simulation model. Modeling will begin to infiltrate our industry and when it does it will happen quickly, just like Lean did. The question is, do you want to be the first to use this tool and get the gains now and pull away from your competitors, or do you want to wait until you must do something about it because you are so far behind? **PCB**

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