A Crystal Ball For The Supply Chain
Bringing Current And Future Capacity Into The Delivery Equation

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The material war is over; the battle for capacity has just begun. Companies have invested in philosophies, software and systems to control materials yet the availability of capacity is a key factor in determining delivery. This can be even more complex when multiple plants / facilities are part of a supply chain. What companies need is visibility of the current status as well as where problems will occur in the future – a supply chain crystal ball. This paper describes one approach to the problem that has been implemented in the UK and provides an insight into the adoption process where important lessons were learnt.

In companies all over the world there is a trend that seems to be common. Competition is increasing from both the company's traditional competitors and from new entrants to the market place, often from overseas. Their customers are looking for a faster turn-round and on-time delivery and these, rather than price, are becoming the key differentiator.

This pressure to be more agile is often seen in make-to-order companies but even where it is in a make to stock environment, there is pressure to reduce stocks to a minimum whilst maintaining a full range of products. This inevitably leads to smaller lot sizes going through the plant and any issues that reduce the efficiency of the plant, lot changeovers, etc, become important.

Many companies concentrate on the engineering issues such as commonality of parts and assemblies, changeover issues using techniques like Single Minute Exchange of Dies (SMED), design issues such as design for ease of assembly and reducing 'floor to floor' processing time by using bigger, better and faster machines.

All of these may or may not be important to your company, but it may miss the point. What we are interested in is 'door to door' time rather than 'floor to floor' time. In effect we want to concentrate on issues that maximize throughput and minimize lead times and this may not be the same as maximizing resource usage, as traditional accounting methods such as using overhead recovery to cost production would tend to encourage.

Thus sequencing of lots to maximize throughput and minimize lead times is the key to increased service levels whilst reducing the cost of inventory.

So why do ERP systems not do this for us? Most ERP / MRP systems have a Capacity Requirements Planning (CRP) module that uses a coarse 'buckets of capacity' model in an attempt to indicate capacity overloads. This does not take account of the sequencing of the work within the capacity buckets and gives no facilities for carrying out what if scenarios on potential solutions to problems created by late updates on existing orders or new, high priority orders arriving. In addition the constraints are modelled at workcentre level and cannot include additional constraints such as operators, setters, tools, space etc. This is why many ERP suppliers have added some form of graphical and interactive tool, often referred to as Finite Capacity Schedulers, (FCS), to replace or augment CRP, either by integrating 'best of breed' tools that are proven in the market or developing their own.

Independent studies have shown that there are three critical success factors that contribute to successful computer based scheduling systems.

Firstly they should be fully integrated with other legacy software packages as in Figure 1,

Secondly they accurately represent the capacity constraints and process flows as in Figure 2,

Thirdly the schedules are generated at least once a day as in Figure 3.

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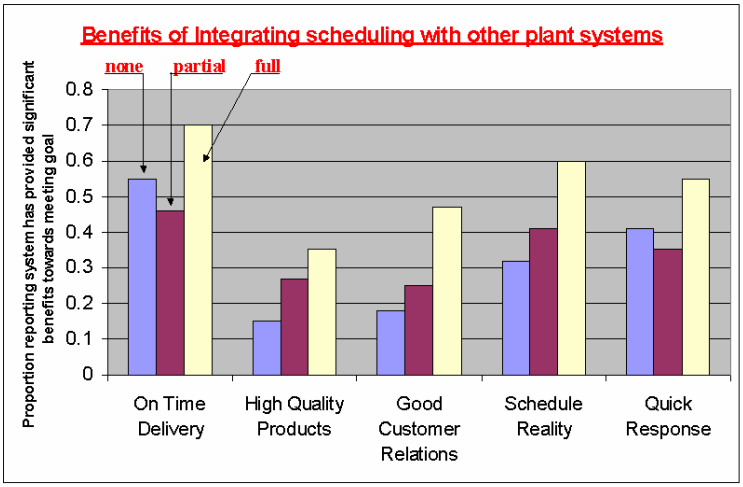
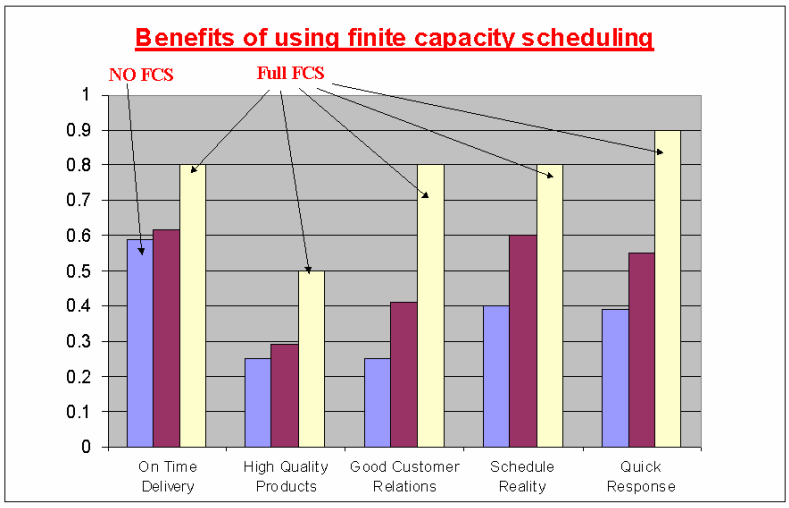
Critical Success Factors - Computer Based Scheduling



Source: LaForge & Craighead, P & IM Journal Volume 41 Number 1

Figure 1

Critical Success Factors - Computer Based Scheduling



Source: LaForge & Craighead, P & IM Journal Volume 41 Number 1

Figure 2

Critical Success Factors - Computer Based Scheduling

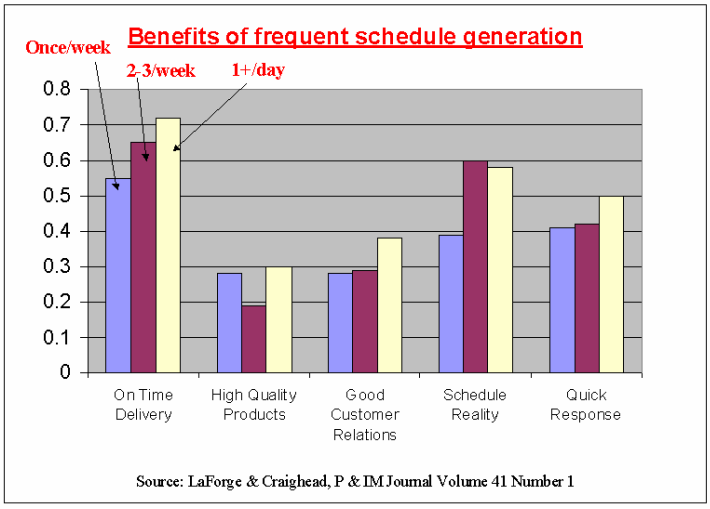


Figure 3

There are also many documented case studies that show the benefits of using FCS systems. The wide range of applications and size of company using FCS software these days is a good indicator of these products' ease-of-use and flexibility to adapt to almost any manufacturing environment.

So now FCS is doing a good job producing better sequencing and achievable schedules that allow companies to be more agile and responsive whilst maintaining customer service levels. How can we add material constraints? MRP works in a particular way that can prevent many FCS packages providing an Advanced Planning and Scheduling (APS) solution, where the system must take into account both the availability of materials and resources whilst generating the schedule. This is because most MRP systems take customer orders and break them down into requirements for individual parts using a Bill of Materials (BOM), then aggregate the requirements for the parts into works and purchase orders at each level of the BOM. The relationship between a works or purchase order for a part and the customer orders is often lost in this process. Sometimes all the relationships at each level of the BOM, not just the customer orders, are lost.

To provide APS functionality the scheduling system must understand these relationships in order to know how to sequence the works / purchase orders to make, say, an assembly. For example, you need to make the frame and wheels and buy the saddle before you can assemble a bike. In addition you need the operational sequence for making the frame and wheels, the process route and the purchase lead-time for the saddle.

APS systems have traditionally been very expensive because they often duplicate MRP functionality, re-blowing the BOM to understand the links between the works / purchase orders. They can also duplicate ERP functionality including forecasting systems, distribution software and other features which introduces unnecessary functionality that users already have and are satisfied with.

Other solutions take a different approach and use the information provided by ERP to peg or allocate materials between producing and consuming orders and use these links as constraints on the sequencing of work. Schedules produced in this way are more realistic and, importantly, achievable, so that purchased materials are not brought in too early and take up unnecessary space and cash.

The next stage is to spread the use of capacity as a constraint across a supply chain. In today's environment of lean manufacturing and supply chains, you can no longer treat your company as an island when it come to making delivery promises to your clients. You have to take into account your suppliers, sub-contractors, logistics contractors, etc, when you answer an Available to Promise (ATP) enquiry.

The more advanced applications of APS solutions allow you to take the actual current stocks and workloads of a supply chain into account when making delivery promises. Hence the solution can take into account the current and future finite capacity into the delivery calculation.

In the past other supply chain management solutions have used a single high level model of the entire supply chain that is maintained by you. This model can never be accurate enough to take into account the current and future workloads of your entire supply chain, since much of the work of your suppliers and sub-contractors is not related to you and therefore cannot be included in your supply chain model.

Modern and secure messaging systems and the latest applications of APS solutions have provided a way forward.

Let us imagine that our factory makes Widgets as in Figure 4 and our best sales person is currently sitting in front of one of our regular clients discussing delivery dates for a possible new order for 5000 Widgets. Our competitor has already offered a good delivery date, so to secure the order our sales person must beat the competitor's delivery, but be certain that the date quoted is achievable. Unfortunately we do not carry stocks of the materials that Widgets are made from and to compound the problem we have to sub-contract the Widget plating operation. To give accurate delivery promises we must take into account the stocks and resource availability of both our supplier and sub-contractor as well as the capacity of our own manufacturing plant.

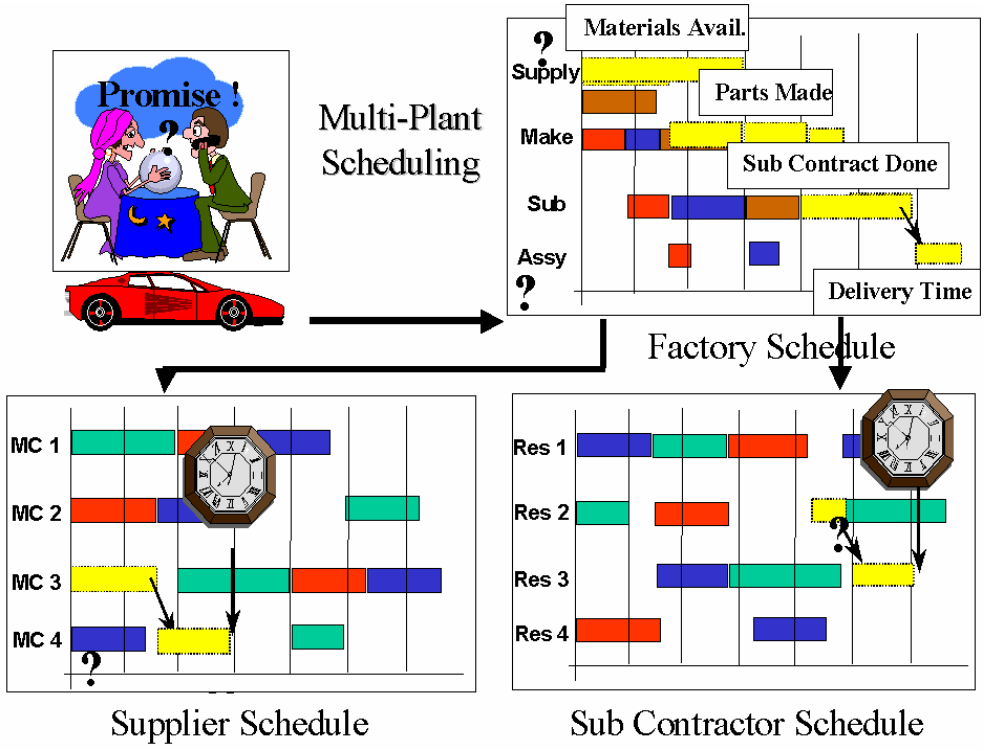


Figure 4

To obtain the delivery promise our sales person emails an enquiry to our Widget Maker's APS. This processes the enquiry and determines that to make the Widgets we must first buy the materials, so it automatically sends its own enquiry to the supplier's live schedule.

The supplier may be a manufacturer or a logistics / warehousing company. In either case the supplier's APS system there determines if the materials are available from stock and if not it schedules the operations necessary to manufacture the materials and then responds to the Widget Maker's APS system with a delivery date.

The Widget Maker's APS now knows when the materials will be available and is able to schedule the manufacturing operations up to the point of the plating sub-contract process. When it reaches this point it sends an enquiry to the plating sub-contractor's live schedule. This schedules the necessary operations and again returns the plating completion time to the Widget Maker's APS. This is then able to complete the scheduling of the last assembly operation on the Widgets and then respond to the sales person with the required promise date. Although we have not seen the schedules and workloads of our suppliers and sub-contractors during this process, we do know that they have been taken into account in generating our promise date.

A basic requirement of this Supply Chain Scheduling process is a simple and robust messaging system which can pass the enquiries and responses between the users. This can be either standard email messages or Microsoft® NT Message Queues to handle the communications. Both systems will store the messages when an APS is not available, so no communications should be lost.

NT Message Queues are faster and more robust, but email offers the option of allowing your user to send requests to those suppliers, etc, who do not have a computer based scheduling system. In this case the supplier could respond by manually typing the relevant data into the pro-forma email request, or another system could generate the response automatically.

Some valuable lessons can be learnt from an implementation case study of such a system at Pfizer in the UK.

Pfizer Inc, the largest pharmaceutical company in the world, discovers, develops, manufactures and markets leading prescription medicines for humans and animals and many of the world's best-known consumer brands. Its principal UK subsidiary, Pfizer Limited is the European Research and Development Headquarters and is based at Sandwich in Kent. It is responsible for the direct employment of

approximately 3600 people. A global Pfizer aim is to provide innovative, value-added products to improve the quality of life of people around the world and help them enjoy longer, healthier and more productive lives.

A large part of the work of Pfizer in Sandwich is the research and development of new products. These products have to be put through stringent clinical trials to ensure they are safe and effective. Ensuring effective and timely delivery of supplies to the clinic throughout all phases of clinical trial represents a major challenge to Pharmaceutical Sciences – a division of the Pfizer Research and Development organisation. In the context of increased global pharmaceutical competition and consolidation, such pioneering and ambitious aims require equally pioneering and ambitious solutions. Pfizer found a partner with which to create what originally began as a Finite Capacity Scheduling (FCS) application which then subsequently evolved into what is rapidly becoming a pioneering supply chain solution for Pharmaceutical Sciences.

In order to appreciate the problem, it is essential to understand how its solution originated and subsequently developed, which in turn requires an appreciation of the sheer scale and complexities of Pfizer's operations. In the UK alone, every day in 2002, over 2.7 million people took a Pfizer medicine, many of which originated from Pfizer, Sandwich. It was here back in 1998, within one element of the Pharmaceutical Research and Development division, where the origins of the solution to provide timely clinical supplies are to be found.

Within what was to become the Pharmaceutical Sciences Supply Chain, a further eight distinct but related areas are grouped into three general stages: the manufacture and testing of the Drug Substance (the active pharmaceutical ingredient); the manufacture of this into the appropriate dosage forms (together with the associated testing activities); and the ultimate packaging and dispatch of the finished product. Each stage is controlled by rigorous Quality Assurance (QA) regimes.

Jayne, a Business Integrator at Pfizer, Sandwich has been involved with the project since its inception. She explains the situation at this time. "Back in 1998 we had no concept of a supply chain; indeed with the exception of the Solid Manufacturing area, we had no electronic scheduling at all; each of the eight areas operated in an autonomous fashion. Because the end product 'miraculously' appeared at the last stage – the Pharmacy - no one really even saw the need to have more than minimal interaction between groups." The results were as might be expected, with significant time being invested in fire fighting activities, no visibility of the big picture from a management perspective and no visibility on a local level of how each area impacted any of the others.

At this time, a consultant was engaged to evaluate the scheduling operation in Solid Manufacturing, a heavily tailored version of MS Project, with a view to its possible use in other areas. His conclusion played a seminal role in the birth of what would begin as a united supply chain solution for Pharmaceutical Sciences in Sandwich, with potential to ultimately evolve into a global supply chain solution. While confirming the benefits Pfizer could liberate with FCS tools, he most crucially advised Pfizer to see these from an overall business perspective and to focus on implementing these at a supply chain level.

Jayne was charged with investigating the roadmap by which this might be accomplished, both in terms of identifying the conceptual challenges and then the means to make it a reality. The way that this task was carried out is now widely recognised as being a core element to the success of the project and offers important lessons from which others can learn. First, she looked to involve leadership representatives

from all areas involved in the business. All Senior Directors were involved in a brainstorming exercise looking at Pharmaceutical Sciences. This resulted in a common realisation at the highest levels that their business model essentially represented a siloed approach. Secondly, she involved the IT department from the outset to research and select the optimum technology solution. "This resulted in a Holistic Business Improvement Programme, those with responsibility for both IT and business processes were working hand in hand in an informed manner on a common problem."

However, at this stage there was no formal mandate in place from Senior Management to develop a united supply chain, neither were there any radical implementation plans. Jayne with two Senior Managers formed a working group which then linked with other key stakeholders, this time at a hands on and operational level. She explains the reasons for this and the particular challenges within an environment like Pharmaceutical Sciences, Sandwich. "In most situations where a tool like APS is used, the prevailing culture is one of manufacturing or production. At Pfizer, the culture is predominantly creative and scientific, where the appreciation of manufacturing and production realities is not as deeply ingrained. Consequently, there is a great deal more education to be done, not just about *what* can be done with such a tool, but *why* it is beneficial to do so. This is even more acute when approaching a supply chain methodology where the critical factor is the interaction between each link of the chain."

While this process of education was undertaken, an in-depth search for the correct tool was in progress, led by the original consultant working closely with Pfizer's IT department. After investigating and discounting the merits of a Manufacturing Execution System (MES), the consultant's appreciation of both Pfizer's business processes and IT requirements led to a shortlist of two candidates, Both were subjected to further rigorous scrutiny and both were found to be suitable for Pfizer's needs. However, one had several superior benefits. While being more flexible and offering greater functionality, most important for Pfizer was its ease of use.

Jayne elaborates, "In a scientific, non-manufacturing culture, the user interface of the system we chose made a lot more sense, being by far the most intuitive to use. Users at all levels could understand the visual imagery of a Gantt chart and the drag and drop functionality meant that it just felt right to use in a way people could associate with their actual business needs."

By this stage, following the positive endorsement of the consultant, each of the eight business areas had been rolled onto MS Project. Some of these were now highly tailored but not linked to each another in any way. Discussions on how best to implement the APS were happening at the very time that further issues arising from the use of siloed, individual schedules were becoming all too clear. Jayne again, "We were planning for Y2K using our existing technology with the aim of establishing levels that each area needed to produce to cope with any potential Y2K issues. Immediately it became obvious that everyone had their own ideas about what they might need to produce but with no awareness of how this interacted with other areas in the company and whether such targets were even possible. At a strategic level it confirmed the lack of visibility across the business as a whole. It took literally weeks to put the pieces of the puzzle together. It was at this stage when we were looking at all the possibilities that we thought, 'wouldn't it be great if we join it all up?'" This thought provided the basis for the next evolutionary jump, with the formation of the embryonic role of Supply Chain Co-ordinator. It also gave birth to the idea of bringing together each individual plan under the control of a single Master Plan.

The actual implementation began in 2000 in response to a specific business need which saw the APS rolled out to Solid Manufacturing, Analysis and Drug Substance. Being distinct operational business areas, this ruled out a one configuration fits all approach. Instead, each unit used an off-the-shelf system, locally configured to their own particular requirements. Within Pfizer this is referred to as the end of Phase 1 in its development of a global supply chain solution. In principle, a local supply chain had been recognised as very desirable and significant steps had been taken to automate the planning and scheduling

capabilities of individual business areas. There was also a growing awareness of the importance to understand and manage the interaction between different areas. The role of Supply Chain Co-ordinator was still in embryonic, unofficial committee form and was still non-mandated.

Phase 2 began in July 2001 with an off-site brainstorming session involving senior representatives from both management and operational levels. The key purpose was to begin to increase the buy-in at all levels for seeing the need for a united supply chain strategy. Participants from each area were actively encouraged to outline their particular business requirements and to identify the factors which impacted on their planning and scheduling capabilities. This played a significant role in each business area becoming more aware of its place in the series of processes required for Pfizer, Sandwich to operate as a whole. It also enabled specific problems to be identified. From Jayne's perspective, this event had a further, possibly even greater significance. "In many ways this was the official birth within Pfizer of a supply chain solution identity in that it led to the creation of the concept of the 'Pharm Sci Supply Chain' with its slogan, 'Right Product, Right Place, Right Time'. This logo has now been adopted globally throughout Pfizer."

The first steps for implementing the outcome of the brainstorming session began with the recognition that the APS solution selected needed to be used in a much more significant way than previously had been the case. They brought in an independent consultant with in-depth knowledge of the capabilities of the APS solution they had selected. Over a three month period from September 2001, the consultant worked closely with the embryonic supply chain team and helped them begin to understand what would be required at a business process and APS level to develop such a supply chain. They helped roll out the APS solution to the remaining business units and established links between six of the eight areas. This linking strengthened the conviction that ultimately, each area would need to be linked to an overall master plan. Jayne comments on the growing symbiotic relationship between what the APS could do and what Pfizer needed to do. "The use of the tool evolved in step with our own understanding of what we could and what we needed to do. In many ways, the sheer configurability of the tool acted as a spur to our thought processes – it was only as we appreciated the scope of what the tool could do that we began to see the possibilities for own business processes."

Phase 2 received a further considerable boost in the appointment of two supply chain strategists from outside the Pfizer environment. The combination of proven commercial supply chain experience and the ability to rapidly understand the unique situation within Pfizer added sizeable momentum to the drive to implement a united supply chain methodology. At the same time, an operational working group was set up with representatives of each of the eight business areas. Building on the work already completed, the group met weekly to continue to identify what the APS tool could and could not do and how this impacted the business processes of the groups as a whole.

Towards the end of 2002, the Pfizer / APS system had become substantially configured, but the operational working group had identified key issues that needed to be addressed at a comprehensive system level. Specifically these were in the areas of reliability and stability of the communication links. Business Implementation Manager Hugh explains, "In any supply chain situation, the chain is only as strong as the weakest link. Given the degrees of separation, both technologically and physically, between various business areas within Pharmaceutical Sciences, Sandwich, establishing robust communication links was critical. In terms of technology, the APS tool had made significant increases in its own communication functionality that complemented our own ongoing IT system developments. Pfizer and the originator of the APS tool now started to work closer together to access their expertise directly. As much of our strategy increasingly rested on them, this was imperative."

The implementation of new communication links formed the basis for the beginning of Phase 2b, which commenced in early 2003. A primary goal was to link the individual scheduling areas not just to a master planner, but also to one another. In doing so, Pfizer would have visibility over every area of the process and awareness of how each stage interacted with the others. Adrian, one of the external supply chain strategists brought in during Phase 2, explains why this was a watershed in the development of the united supply chain solution. "In order to achieve this level of communication, our weekly schedule meetings had to move from using Excel spreadsheets to a Gantt chart on the master plan in order to plan workflow. It became a prerequisite for any request for work to be done. This raised the fundamental trust issue – it meant everyone, from Senior Directors to Operational Manager, would have to trust the APS tool for every element within the chain." Jayne elaborates on the scale of the task. "We only had five people on the project, three from Pfizer

and two from the APS tool vendor. It represented a significant time investment and if it wasn't for the willingness of all concerned to go the extra mile or ten, we wouldn't have been able to do this."

This phase commenced in February 2003 and coincided with a growing trend towards globalisation within the Pharmaceutical industry as a whole and also within Pfizer. This combined with the system at Sandwich beginning to deliver benefits, fuelled the recognition of the potential benefits of extending the supply chain to a global level. A further driver was the move within Pfizer to see each of its individual operations as global assets. Sandwich could therefore be called upon by other Pfizer sites and vice versa.

Hence in summer 2003, the united supply chain project at Sandwich entered its current stage, 9.2 GTI (Global Transition Initiative). Aware of its significance in the wider Pfizer context, 9.2 GTI focussed on three primary questions.

1. What do we need to do to make using the system as a whole easier?
2. What technical resources do we need, that is, global keys?
3. What refinement or customising of the scheduling rules will be required to meet a global Pfizer context?

It was also becoming clear to the newly formed Global Working Group that the role of the Master Planner was central, which would necessitate a Master Planner at each of the four global sites.

"This truly marked the beginning of the process of rolling out our APS tool globally," remarks Jayne. The Sandwich model in terms of connected solution and organic adoption of the whole concept of a united supply chain contrasted markedly with the legion of disparate point solutions in place elsewhere and an imposed drive to adopt a supply chain model in a very short time frame. She continues, "This created all sorts of challenges, particularly in the area of dealing with a range of legacy systems in place globally, assessment of other potential tools within the global Pfizer toolset and the actual site readiness of each location." However, the weight of benefits delivered by Sandwich kept up the momentum with the Master Plan being rolled out to each area. This currently only provides a very specific level of Rough Cut Capacity planning, but crucially gives the benefit of global visibility which is accessible from each local Master Planner. A schematic is shown in Figure 5.

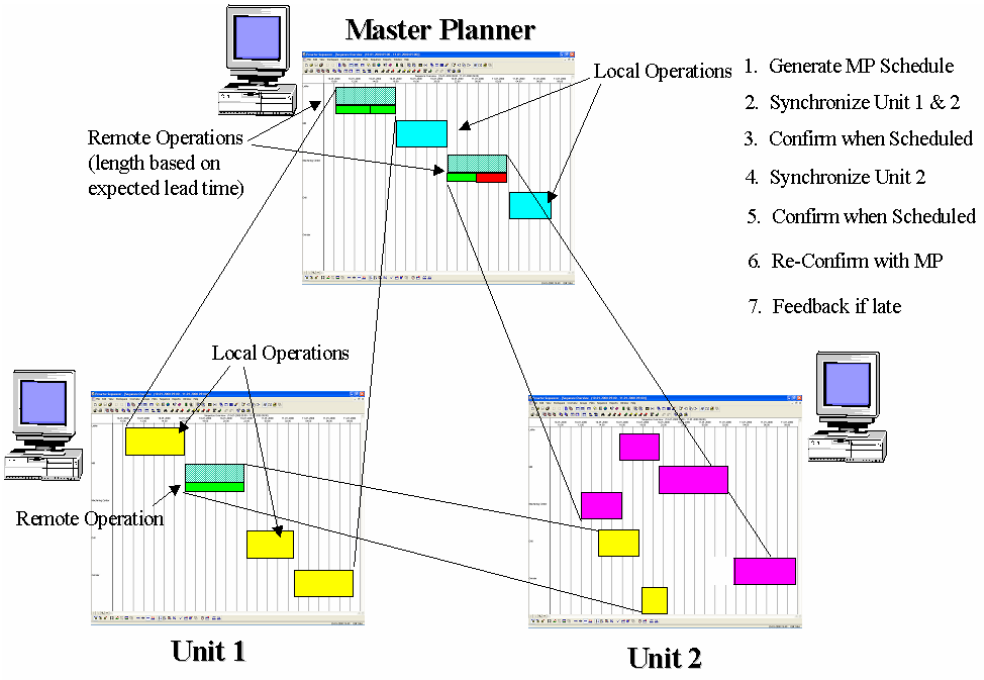


Figure 5

In this case a Master Planning System working with lead times as the method to estimate how long each process took in each operating unit first generated an enquiry to each operating unit in the supply chain asking for confirmation of the lead time based on the finite capacity and current load. Each operating unit has an APS with a model of their unit including resources, process routes and scheduling rules that match their specific needs. The local unit planner can then expand the enquiry into each of the process steps and

then load them onto their schedule to obtain a real lead time or makespan for that batch. Where an operation is not carried out at the current unit, then this is referred to as a remote operation and again messages must be sent to obtain the makespan for that operation.

A colour coding system or traffic light is used to highlight the current status of an operation step. The main colour of the bar refers to the product type. The bottom half of the bar is split into two. The left half changes colour according to whether all operations at lower levels have been scheduled. The right half indicates whether the makespan is within the expected lead time that a higher system has used to estimate when a batch will be ready.

This information is then passed back to the higher level system as well as other units that are affected using a messaging system. If the makespan extends beyond the expected lead time then this is indicated back to higher level system and the right hand lower bar colour turn red. Action can then be taken to synchronise processes along the supply chain.

Hugh outlines some of the other key benefits of the APS enabled supply chain. "Each of the individual areas using our APS solution benefits from the usual advantages of FCS: optimised workflow with minimum bottlenecks; massively increased flexibility to quickly re-schedule if order requirements change at short notice, or even mid production run; the ability to run various what-if scenarios. When these are pulled together in a united supply chain context, the total benefits are greater than the sum of the individual parts. On a Sandwich scale, we can now monitor all areas of a supply chain but even more importantly, we now have visibility regarding the status of each link. Everyone involved knows what they are doing, but more importantly, they know why."

In summary this live application that provides visibility at each stage of the supply chain and an overview at the Master Planning level supported by a peer to peer communication system on a PC network shows what can be achieved with modern APS systems.

The author would like to thank Pfizer UK for permission to publish details from an approved case study and for the illustrations supplied.

ABOUT THE AUTHOR

Mike Novels is Chairman and Managing Director of Preactor International, a company based in the UK that provides software, support, training and consultancy in scheduling applications throughout the world in a wide range of industrial and commercial sectors. Mike's career started as a metallurgist in the aerospace industry having obtained an Honours degree at Bath University. He then moved to general engineering companies until in 1975 he co-founded a design consultancy company that culminated in the launch of a range of robotic manipulators that he marketed all over the world. Mike then joined the Hawker Siddeley Group to create a consulting team to advise the 120 companies in the Group on automation and IT systems. This team developed into a self-supporting enterprise with particular expertise in simulation of manufacturing systems and later, scheduling technology. In 1992 the company was purchased by a management team led by Mike from BTR (now Invensys) and launched the Preactor range of scheduling software, a system that has since been installed in more than 1,000 companies in 41 countries. Mike is married with three children, one grandchild, likes all sports and will try to convince the unwary that he is unbeatable at most of them.

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