

Production Scheduling in a Fast Moving Industry

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Executive Summary

According to the Oxford Dictionary, scheduling can be defined as a plan to carry out processes or procedures through providing lists of proposed events and times. Furthermore, it can also be viewed as a day-to-day plan and one can therefore argue that most people make use of scheduling, either consciously or unconsciously, in their everyday activities. It can also be defined as the planning of an event to take place at a particular time (Oxford Dictionaries Online).

On a larger scale scheduling plays an important part in the manufacturing industry. Adequate scheduling throughout all of the phases in a manufacturing environment will enable maximum output. The importance of sufficient scheduling in a fast moving industry such as a modern day printing factory is immeasurable. Insufficient production scheduling will ultimately decrease the factory's production capacity. Scheduling can be seen as the core activity in the printing industry.

This project focuses on understanding the manufacturing processes of BusinessPrint and analysing the shortcomings of their present scheduling methods. Adequate research on modern day methodologies gave guidance in order to propose a scheduling solution that should overcome the company's scheduling challenges. The indicated benefits that the company can reap by implementing the proposed solution will convince BusinessPrint to put the solution into practice.

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Chapter 1: Background

1.1. Introduction

BusinessPrint is a modern printing service that strives to accomplish great quality products with their customers at the core of their business. Together, the foundation and success of the company are the unique relationships that develop between BusinessPrint and their customers; it is this interdependence and trust that leads to mutual understanding and growth.

1.2. Facility and Operation Description

BusinessPrint consists of a spectrum of production processes needed to produce their wide range of products. These processes include designing the customer's products, printing, and cutting as well as binding and finishing the products. Some of the variety of products that BusinessPrint produce includes magazines, diaries, CD covers, posters and calendars to only name a few.

The facility of BusinessPrint, which is illustrated in Figure 1, consists of four major divisions. The production factory which covers the largest ground is in the middle, the warehouse on the right, the inbound and outbound division on the left and the offices at the bottom of the layout. There are approximately 25 resources in terms of machinery in the production factory. These 25 resources consist of:

- 6 Printers (which will be referred to as litho presses or presses)
- 3 Folding machines
- 2 Binding machines
- 2 Shrink rap machines
- 3 Guillotines
- 2 UV machines
- 2 Punching machines
- 2 Plating machines
- Laminating machine
- Cylinder machine
- Di-boss machine

BusinessPrint runs two production shifts per 24 hour working day. The first shift is from 6:00-14:00 and the second shift from 14:00-22:00, seven days of the week. The production flow of jobs in the factory can be best described by the flow of a pile of paper that's being transformed in the factory. Raw paper arrives at the inbound and travels to the warehouse to be stored. When that specific paper is needed for a job the production starts at the litho presses at the top of the factory layout. The paper then travels their unique path downwards through the factory and makes a stop at the desirable machines to be processed. After finishing and packaging it goes out via the outbound to the customer.

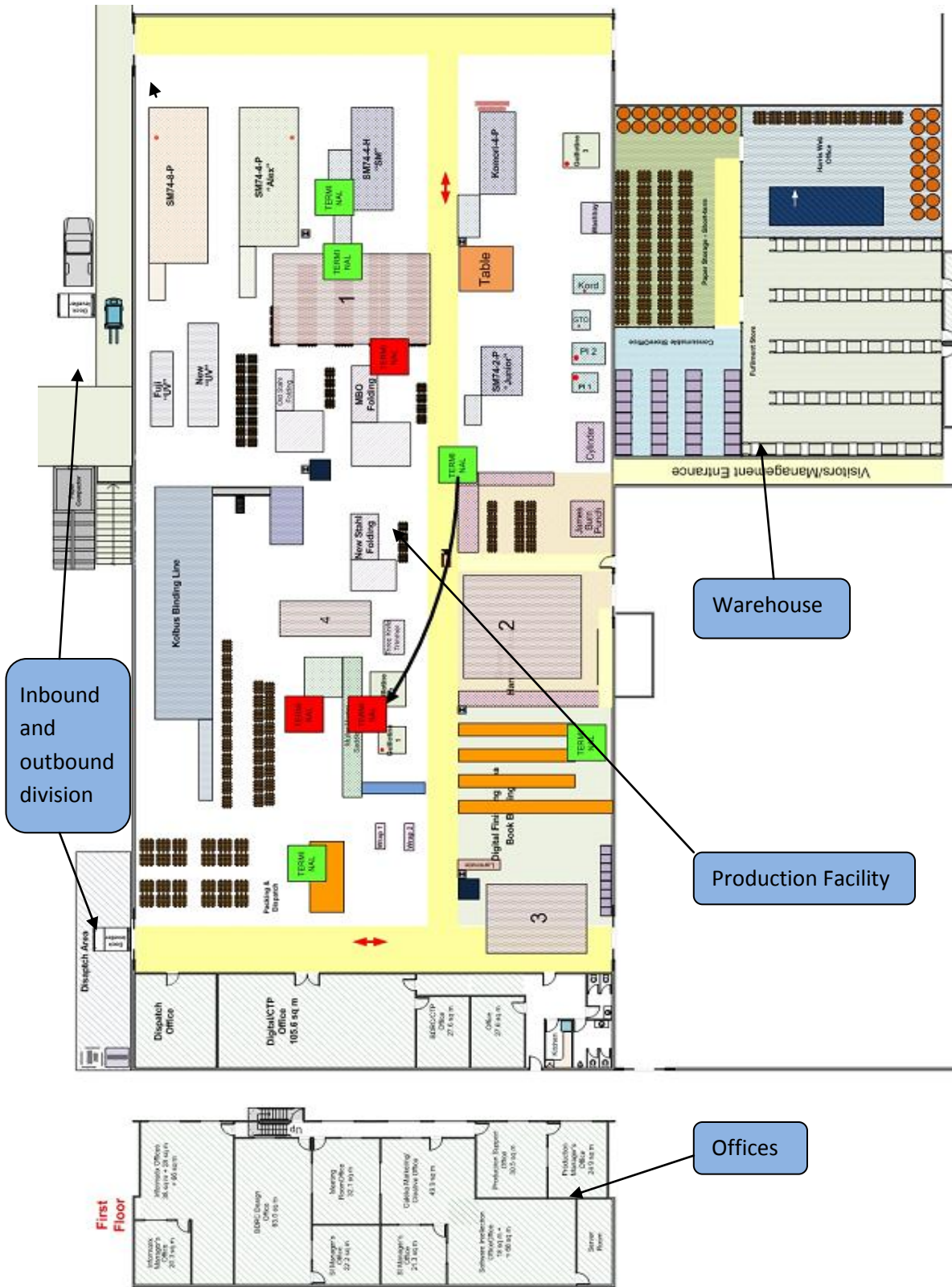


Figure 1: BusinessPrint facility layout

1.3. Problem Statement

“Scheduling, schmeduling. Is there anyone in this industry who has ever been able to keep to a schedule? It’s doubtful - there are simply too many emergencies to accommodate.” (Mishina, 2000).

BusinessPrint is working with a paper job ticket system and lacks an adequate scheduling system to schedule new jobs or jobs in progress for the production factory.

After customers’ quotes are finalised, new jobs to be printed and jobs in progress that have to be finished are scheduled manually in the production meetings that are held every day. New jobs to be printed are scheduled and prioritised by looking at customer delivery dates and making a presumption on the duration of completing the jobs. The company relies on the assumption since there are no standard measures on processing times to base a precise prediction on. BusinessPrint also try to prioritise and specify how jobs in progress flow through the rest of the factory after being printed in order to try to meet customer delivery dates. These meetings can waste up to two hours per day. Eight people, two schedulers and six line managers, are involved in these unnecessary meetings.

It is complicated to manually schedule these new jobs because there are six litho presses, each comprising individual capabilities and limitations. This is also the case for jobs already printed that need to go through numerous processes in the factory. It is impossible to manually specify and prioritise each job through its unique individual path in the factory up to the point of completion. Manual scheduling can not accommodate all the constraints that are present in the factory. Therefore there is a lot of manual emergency scheduling on the factory floor needed to try to finish jobs on time. Consequently, many unnecessary conversations between sales representatives, line clearance managers and machine operators occur. These manual steps also cause the printing jobs and people to frequently move backwards in the process to correct errors that were made or to update missing information.

After a printing schedule is derived in the production meetings, a list of jobs to be printed by each press operator is compiled. The press operator receives the list by hand and tries to complete his certain jobs given for the shift. It is most unlikely that all the jobs will be completed because they base the schedule by speculating how long the jobs will take. The crises of uncompleted jobs will only be noted 24 hours later in the production meeting the next day when the schedule is updated. Losing 24 hours in a fast moving industry is critical. Because of these uncompleted jobs the factory is running behind schedule and rush orders occur that need to start printing immediately, this disrupts the schedule of the current shift dramatically and causes a snowball effect.

The implication of not having a system that provides live feedback of work in progress is that an investigation has to be done in order to determine the status of work in progress that were done in the previous 24 hours. This is done every day before a production meeting can commence, by physically walking around in the factory and searching for pallets of finished printed, folded or bind jobs. This investigation takes about two to four hours per day.

On the company's factory floor, there is only one paper job ticket allocated and available for each specific job, which contains all the design details, that follows the job through the factory. This constraint however means that jobs can not be processed by more than one process or resource at a time. This means that if one part of a magazine is finished printing it cannot be folded until all the sections of the magazine have been printed. This delays the processing of a job severely.

The lack of an appropriate scheduling system causes the following problems:

- BusinessPrint is never able to predict when jobs will be finished. Because of this the company struggle to meet customer delivery dates. This may eventually cause them to lose clients.
- The company has no track of workflow, and can't tell the progress of jobs in the factory. Consequently, BusinessPrint cannot control and estimate the productivity of the factory, machines and workers.
- Sales representatives are spending too much time on the factory floor instead of on the road marketing. This causes the company to lose possible business opportunities.
- Production capacity is constricted by a large extent. Because of this the company cannot accommodate as many jobs as they would like to.
- Time is lost due to manually scheduling during production meetings. Time is money and all the time lost eventually costs the company money.
- Workforce by numerous people from different departments is wasted because of the continuous struggle to schedule and organise jobs to try and meet customer delivery dates.

1.4. Project Aim

The aim of this project is to find a solution for the scheduling problem at BusinessPrint. Research on numerous different modern day scheduling methodologies is done in order to find a suitable solution to assist BusinessPrint to overcome all scheduling challenges. This research enables one to propose better methods for BusinessPrint and how the company should prioritise the jobs that need to be done. The new system is able to update the work in progress automatically. This is done by an integrated system that links the entire production by means of an electronic job ticket system. The system will also dismiss all the time consuming manual scheduling. Evaluation of the different tools and technologies is done, used to implement the desired scheduling methodology. Musselman (2001) states, that scheduling should provide a more structured and cost effective production process. This can be accomplished by:

- Providing visibility to the customer's orders,
- meeting manufacturing deadlines,
- allowing for 'what ifs', such as breakdowns of machinery, new orders and overtime,
- providing capacity planning for machines, workers and work centres,
- fewer set ups to reduce costs, less overtime and reduced work in progress,
- schedules should be generated more timely for example twice per day.

Reaching these objectives stated by Musselman (2001), is considered part of the project aim.

1.5. Project Scope

Considering all the processes involved before a client of BusinessPrint receives their finished product, numerous scheduling in different departments need to be completed. A few of these are; a schedule for raw material purchases, marketing schedule or plan, worker schedules and outbound transport schedules. The scope of this project will focus on job scheduling; from when customers' quotes are finalised to the production processes, as well as packaging. All the processes involved in the optimization of the production scheduling will be considered to be improved, since it will have a positive effect on the production scheduling improvements.

1.6. Conclusion

The modern printing service, BusinessPrint, that strives to accomplish great quality products, is working with a paper job ticket system and lacks an adequate scheduling system to schedule new jobs or jobs in progress for the company's production factory. The lack of ability to effectively schedule the company's production, ultimately causes the company to slender the production capacity of the factory. The aim of this project is thus to find a solution for the scheduling problem at BusinessPrint.

Chapter 2: Literature Study

2.1. Introduction

The task of production scheduling is to ensure that the client's order is delivered on time. Scheduling has to accommodate all the many printing jobs from all the different clients brought in by different salespersons, while achieving maximum efficiency with workers and equipment (Mishina, 2000).

Musselman (2001) states that there are two elements of scheduling: synchronisation and sequencing. Synchronisation is order-centric and globally ranks demand while assigning work centres according to their capacity. In addition, Musselman (2001) points out that it is most common in make-to-order and engineer-to-order situations where customised items are produced upon receiving of a customer's order. Sequencing on the other hand is work centre-centric and locally ranks demand on a time-phased basis according to project order completion (Musselman, 2001). It is used in make-to-stock situations because of a high product mix. Because of the extended lead times that are present significant finished goods inventories are maintained.

This chapter will highlight the scheduling challenges that are present in the printing industry. Different scheduling methodologies that may apply to a job shop environment will also be described as well as two supplementary techniques developed particularly for printing production.

2.2. Scheduling Challenges in the Printing Industry

Musselman (2001) argues that in most printing companies it is critical to understand the printing process before a realistic schedule can be developed. There are complexities when scheduling is done and some of the challenges that companies might face are listed below.

2.2.1. Combination Jobs

Similar jobs can be combined and printed together, for instance in a label printing company, where labels with similar colour and size are printed on the same paper (Musselman, 2001).

Musselman (2001) argues that combining jobs will improve press efficiency by ensuring fewer changeovers because of the longer press runs. From a scheduling perspective it is a challenge to keep these orders together through the press and to ensure that each order has dependent timing through the process. Therefore, when scheduling the combination job, all order requirements in the combination need to be kept in mind. This means that the job can only advance at a pace that suits all the orders in the combination job.

After the combination job is printed the challenges continue throughout the rest of the printing factory because the integrity of each job must be maintained. Eventually the different orders have to be split and they are sent across a completely different series of work centres. Each order has unique resource requirements and all of the orders have individual completion dates (Musselman, 2001).

Changing the load size at several points in the system for example forwarding quantity as the work order is processing is seen as accumulating or splitting of orders. Splitting and accumulating orders makes it possible for overlapping of orders which increases the productivity of the system (Musselman, 2001).

2.2.2. Press versus Converting

Musselman (2001) states that after the printers, the printed sheets continue through the rest of the factory. The next stage is when the printed sheets are converted to finished goods. As we learned that presses prefer long runs with the least amount of setups, short runs with more variety are preferred in the converting stage. A broader order mix will ensure improved work centre utilisation and will balance the workload better. For example, in a label printing production where the presses produced only one type of label for a long period of time, certain work centres would be over loaded and others would be starved. Thus, it is important to a company's overall production performance to have a healthy balance between long press runs and enough variety produced to utilise their converting work centres.

2.2.3. Resource Preferences

Physical assets like machines, operators and cylinders are used when orders proceed along their routes through the printing factory. These different resources can be divided into two categories namely single use capacity and multiple use capacity resources. Resources are used to exclusively identify individual machines of the process. A resource group is formed when a few resources is used in combination. These groups are used to limit what machines are qualified to run a certain job and on what preferred machine to run the job. These qualifications and preferences restrict jobs to a certain flow through the factory and decide where work is to be performed within these work centres (Musselman, 2001).

Musselman (2001) argues that it most often occurs that there are fewer operators than machines at some of the work centres. Because of this, some machines will not have an operator during certain shifts, thus not all the machines can be operated simultaneously. Operators rotate amongst machines to improve output. To schedule a work order at a specific machine, both operator and machine are necessary at a station. Work orders are routed to the applicable machine in the work centre, but are only serviced if an operator is available at that machine. Specific work order sequences are determined by the operator's work order selection rules in concern with machine availability.

2.2.4. Work Order Selection Rules

Musselman (2001) states that the number of cylinders, brand, availability, colour code, size, imprint, downstream processing time and due date are some of the factors in determining what work order should be scheduled next on the presses. In a manufacturing system the machines limit production flow because work orders must wait until a specific machine becomes available. When a machine becomes available and more than one work order is waiting for that specific machine, a decision must be made as to which work order to run first. This can be defined as the work order selection rules and these rules define the plant's manufacturing strategy.

At the presses, a number of order and item attributes define their respective work order selection rules. These attributes include customer number, priority, dynamic slack - due date minus remaining processing time compared to the current time - colour code, brand, size, imprint and press operation time. A preferred sequence in which to examine the orders for actual selection can be ranked according to the logic gathered from these attributes (Musselman, 2001).

Work order rules are limited by thresholds. Thresholds are used at the presses to determine which order is the most critical to print. An order is critical when the dynamic slack is smaller than the threshold value. This is done because the order is in danger of being late, thus it is moved higher on the selection list. This job is allowed to break the preferred work order sequence (Musselman, 2001).

2.2.5. Dual Processing constraints at Press

Scheduling presses are complicated by the press restrictions, cylinder limitations, setups and work order selection logic. Each press has its own constraints and capabilities. Thus when selecting a press to perform a certain job all of these capabilities and restrictions need to be kept in mind (Musselman, 2001).

When considering a setup that may be required before the next work order can be run. The duration of this setup is dependent on the order's attributes. For example setups for presses can be very complex because the setup depends on the changeover type and the work sequence. A full setup is needed when brand, colour code and size differ from the previous to the next work order but only partial setups are needed when similar jobs are following each other. Therefore, setup times at the press can range from short times to sometimes longer than an hour. This all depends on the number of cylinders and colours to be changed. By running similar jobs consecutively a large amount of setup time can be saved (Musselman, 2001).

2.2.6. Resource Allocation

Musselman (2001) states that to dynamically select which machine within a work centre is suitable to process a specific work order and to determine a work order's eligibility to start, resource allocation rules are used. Resource allocation rules can be used to restrict parallel processing, adjust work order routings and assists with machine selection.

A two-job press provides an example of restricted parallel processing. Due to the fact that it is prohibited and too expensive to put graphics on two sets of cylinders, the same work order can't be run simultaneously on both sides of this press (Musselman, 2001). Dependant machine selection can be described by means of a cutting example. A cutter or a group of cutters is selected, depending on the work order produced. For example when labels are cut, two cutting passes of sheets might be needed. The first cutter cuts the pile of sheets into strips, and the second cuts the strips into labels (Musselman, 2001).

For quality and efficiency, any cutter or group of cutters can be used for the first pass, while the second pass must be done by a cutter that ran the specific order earlier. The resource allocation rule must dynamically select this second cutting pass because these machine passes are identified separately on the work order route (Musselman, 2001).

Another challenge can be illustrated by means of a sheeter example. Sheeters are setup to do either white or metalized paper. Work orders are assigned to sheeters that are busy with particular type of work, either work on white paper or metalized paper. Dynamic reassignment of sheeters is then necessary if machine overloading occurs because of a one dimensional order mix. If the sheeter's present assignment is metalized paper it is switched to white paper if this machine is idle. This dynamic reassignment is done if the pre-set threshold at the other machine is exceeded with its backlog. This process helps that the current order mix gets processed by assigning the sheeters adequately (Musselman, 2001).

Resource allocation rules can help to trigger work order eligibility and help with work order steering. Overlapping operations and processing at multiple work centres, can be used to reduce total processing time in printing. To do this, work orders are divided into split lots, and each load can be tracked individually through the system. There can however be constraints on these divided loads that have to be followed. For instance, all sub-loads have to be present at a processing point before processing can be done (Musselman, 2001).

2.2.7. Freezing

Scheduling can sometimes be influenced by external factors, for example a customer visiting the factory to see how work is progressing. The specific customer's work is then rushed to be printed on a press. The scheduling sequence has to be adjusted to accommodate the customer's visit. A freeze capability is implemented in the presses work order selection rule. Freezing allows the scheduler to print a near-term work order prior to what the work order on the standard selection sequence. Scheduling is then challenged to still meet deadlines with the frozen sequence. This is done by setting the boundaries of this frozen zone as small as possible but large enough to meet external factors demand (Musselman, 2001).

2.2.8. Initialization

Musselman (2001) states in a printing factory most production systems have numerous orders in process at any point in time. Work orders are probably distributed across several work centres simultaneously. For example, a part of the work order can be in packaging already when the rest is still at cutting or pre-cutting.

Because of this it is not straight forward to capture the initial state of the production system. In-process loads can be used together with shop floor reporting systems to establish where these loads are located in at the start of the scheduling horizon. In the case of an idle machine, the work order that was last processed by the machine is important to know. This will help to determine which order to run first and because of the long setups involved, it will save a lot of time. Production and order characteristics are taken into account to determine in-process loads, their locations and associated machine-order relationships (Musselman, 2001).

2.3. Various Job Shop Scheduling Methodologies

A manufacturing environment can be recognized as a job shop, whenever the factory uses shared resources to produce a high product mix however producing a low-volume of the variety of products. Job shops simultaneously processes more than one diverse, low-quantity jobs and processing this variety of jobs usually starts only after receiving the order from the customer. Jobs have different due dates, routings, quantities, priorities, and material and resource requirements (Velaga, 2007). The following approaches are a brief discussion of production scheduling methods that can be used for scheduling in a job shop.

2.3.1. Manual Scheduling

The role of a manual scheduler is confined to tracking job progress on the shop floor and reporting it to management. Manual scheduling can be adequate in smaller job shop environments but can lead to large work in progress, long lead times, poor on-time delivery and frequent fire fighting. The practice is to push schedules to meet due dates through extensive real time scheduling. This is known as fire fighting, which is done without knowing the ripple effect of their real-time on the production plan. Most of the time, manual scheduling results in chaos, poor planning and a lack of comprehensive knowledge of the dynamic nature of a job shop (Velaga, 2007).

In the printing industry, factories were usually separated into different areas such as printing, folding and binding departments to simplify the scheduling processes. This helped to break down all of the complexities present in each department. Different schedulers were assigned to the different departments of the factory. Scheduling for each department was adequately done by the personnel appointed, but it didn't integrate the different departments because of a lack of communication between them. (Musselman, 2001).

2.3.2. Scheduling on Whiteboards and Excel spreadsheets

Whiteboards are still used by some planners, this simple manual method could be sufficient for some small production facilities. Scheduling numerous operations of diverse jobs on resources of finite capacity can be very inconvenient and ineffective with these techniques. When the actual work flow significantly deviates from the whiteboard it is very time consuming to reschedule the workload (Velaga, 2007).

Excel is used in production scheduling for many reasons. Most people in the manufacturing world have computer access and can easily handle and process data in Excel. Scheduling data needed in Excel can easily be pulled into Excel spreadsheets from a majority of Enterprise Resource Planning (ERP) or Manufacturing Resource Planning (MRP) packages. Data can also be quickly edited in Excel and programming in Visual Basic for Applications (VBA) can be done for advanced operations (Velaga, 2007).

2.3.3. Scheduling by Project Management Software Tools

Various job shop schedulers use project management (PM) tools to schedule their production. Engineer to order (ETO) manufactures and Shipyard are popular PM tools to schedule diverse workloads. Scheduling with the critical path method, a method used by PM software, can however create meaningless production schedules because of jobs that queues up waiting for recourses (Velaga, 2007).

2.3.4. Enterprise Resource Planning Scheduling Models

Manufacturing companies is witnessing a rapid progress in the implementation of enterprise resource planning (ERP) systems. These systems enable companies to handle all their information very easily and improve the efficiency of business operations. ERP systems have integrated shop floor data collection systems with a central database; these systems enable customers to view their real-time job status (Velaga, 2007).

2.3.5. Scheduling by Theory of Constraints

The Drum-Buffer-Rope (DBR) method of the theory of constraints (TOC) is a simple method suggested for production scheduling in complex job shops. The DBR scheduling method assumes that a production system has a single resource constraint while the other resources have sufficient capacity to support any schedule that is scheduled according to the constrained resource capacity. The DBR system can be implemented by using Excel spreadsheets (Velaga, 2007). The idea with Scheduling with DBR is to keep the constraint resource busy and controlling work in progress in the system by releasing jobs at the right times (Velaga, 2007).

2.3.6. Scheduling by Lean Manufacturing Practices

Toyota production systems (TPS) is a world class production system with methods like Heijinka, One Piece Flow, Take Time and Kanban-these system however are not meaningful in job shops with simultaneous production of diverse , low quantity jobs. The Kanban real-time production scheduling system is quite powerful for controlling repetitive production when the demand is uniform and predictable (Velaga, 2007).

2.3.7. Scheduling Algorithms

Scheduling models and algorithms developed addresses issues like work in progress, production lean time and job lateness. These algorithms however fall short in solving scheduling problems of a job shop because the mathematical techniques are lacking to deal with practical scheduling problems. These algorithms are also insufficient because problems are reduced to a level where it can be solved by a non-trivial method. These scheduling algorithms developed by researchers are thus buried in mathematical treatment (Velaga, 2007).

2.3.8. Finite Capacity Scheduling

Finite capacity scheduling (FCS) hardware and software tools are used in job shop scheduling; a lot of flexibility, convenience and context help to users are offered by the windows-based tools. Job due dates can be met because of the availability of powerful information systems and sophisticated shop floor data collection systems that track job status and make seemingly rational decisions in real time. Benefits like fast workload rescheduling, prediction of future bottlenecks and job completion times, and efficient capacity planning are accomplished by implementing FCS tools (Velaga, 2007).

2.3.9. Slack-based techniques for Robust Scheduling

Robust scheduling is a scheduling technique that can be used to schedule jobs in a realistic, dynamic and uncertain job shop environment because it is able to absorb unexpected events. A realistic job shop environment can be described as an environment where machine break downs occur, changes in customer orders, changes in job due dates and priorities, delays in material supply, rework or rejection due to poor quality and because of operations that take longer to complete than expected. (Davenport, Gefflot, & Beck, 2001).

The central idea of slack-based techniques for robust scheduling is to absorb some level of uncertainty to make sure that rescheduling doesn't occur. This objective is accomplished by providing extra execution time to each activity. Three slack based techniques will be described and compared (Davenport, Gefflot, & Beck, 2001).

2.3.9.1. Temporal Protection

Temporal protection extends the production length of each activity based on the uncertainty statistics of the resource on which it is performed. The extra time allocated to each activity is known as slack time which can be used in the event of machine breakdown or for the use when other uncertainties occur. It can be illustrated by looking at two continuous processes following each other. If the machine breaks down while the first activity is performed the breakdown can be absorbed by the extra time within the protected duration. If the available protection time is adequate to accommodate the duration of the breakdown, its effect will not be felt in the rest of the schedule. If the duration of the breakdown last longer that the provided slack time, some reactive approach must be taken to restore consistency to the schedule. If no breakdowns occur the next process can start immediately. The slack provided by the temporal protection by the first activity is available for use for the following activity (Davenport, Gefflot, & Beck, 2001).

A healthy balance between too much protection and too little protection need to be maintained. Too much protection will provide a poor quality schedule with high robustness. Too little protection will defeat the purpose of robust schedules (Davenport, Gefflot, & Beck, 2001).

2.3.9.2. Time Window slack

Time window slack modifies the problem definition to, each activity will have at least a specified amount of slack rather than extending the duration of activities. This enables the amount of slack for each activity to be reasoned about during the problem solving. This is advantages because the slack time is not hidden within the activity (Davenport, Gefflot, & Beck, 2001).

2.3.9.3. Focused Time Window Slack

Activities are executed along a time horizon. The intuition is that the later in the schedule an activity takes place the more likely it is to have a disruptive event before its execution and therefore more slack time is needed for activities happening later in the process. Focussed time window slack considers the time horizon where time window slack and temporal protection only considers the amount of slack needed for individual activities (Davenport, Gefflot, & Beck, 2001).

2.4. Supplementary Scheduling Methods for the Printing Industry

2.4.1. Simulation-based Scheduling

In printing, the sequencing rules have to be diverse because the rules are influenced by a number of competing requirements. These requirements are, sequencing that varies from work centre to work centre, management that override strategies, a look-ahead criterion and a local prioritization scheme (Musselman, 2001).

To meet these requirements, a simulation-based, heuristic dispatch scheduling algorithm can be used. Reasons for the specific scheduling option are that the production flow process with its many subtle variations can be accurately represented. The first half of the system which is the press area is a characteristic of a compound flow shop and all orders in this area visits the same sequence of work centres. The second half of the processes consists of converting up to final packaging and this appears to have more recirculation job shop elements. This is evident because of the unique routings of jobs and the allowing of a job to visit a machine more than once. This hybrid system can be scheduled by the simulation based scheduling (Musselman, 2001).

Musselman (2001) states, the scheduling problem are so huge and intricate that it is mathematically intractable. The process is complicated by various actions like expediting, batching, overlapping, operation splitting, sequence-dependent setups, re-entrant flaws, unequal machine availability, machine preferences, multiple resource constraints on an operation and dynamic job selection based on current system conditions. Scheduling computational speed is important; it will allow time to review the results

so that necessary adjustments can be made before sending it to the shop floor for implementation (Musselman, 2001).

The simulation based scheduling solution can be used jointly with an Enterprise Resource Planning (ERP) system which has most of the requisite data to ensure an adequate input requirement system (Musselman, 2001).

2.4.2. Dynamic Scheduling

Electronic scheduling is a reality in today's printing shops. Programmed Solutions Incorporated (PSI) (Norwalk CT) print management solution, is one of the many scheduling software that orchestrate all the processes from estimating through to accounting. This software limits access to the scheduling board to only authorized employees such as production or scheduling managers, but enables all the employees to view the schedule. Employees on the factory floor can access data collection, electronic job tickets, and the schedule, and are able to e-mail problems to the production manager (Mishina, 2000).

Electronic scheduling systems fall into three categories. The first is a loading system, where it will distribute or allow the user to type in the amount of time the job will take in each department when jobs are entered into the system. These systems sometimes fails to show scheduling conflicts when they occur (Mishina, 2000).

Logic Associates, Hagen, Programmed Solutions Incorporated (PSI) and Micro Ink are some of the print management software that falls into the second category scheduling systems. These systems have merged with the Internet print management provider, printCafe. The modules within this scheduling system are able to accept information, complete loading dynamically, electrically update the schedule and jobs can be rescheduled or unscheduled by users by means of forward and backward scheduling (Mishina, 2000).

The third category consists of manufacturers like AHP Systems (Chicago), which also forms part of printCafe. The third category offers true dynamic scheduling, whenever key points in the schedule is missed, the system will automatically schedule the job based on a variety of criteria. For example if work is low in the bindery the system will search for jobs available to be moved forward to the binding area (Mishina, 2000).

Printers usually schedule the jobs of a job shop by looking at job delivery dates, whereas the third category dynamic scheduling focuses on scheduling jobs with the goal of balancing work throughout the plant. This technique used by dynamic scheduling will enhance plant and resource utilization and production output (Mishina, 2000).

The different scheduling systems as mentioned above can also differ at screen level; this is the way in which the scheduling systems present the jobs. Some show the electronic scheduling cards which

signify each job. Other systems show each piece of equipment alongside the list of jobs on the screen. A third kind shows bars to represent each piece of equipment. Systems presenting their jobs as described by the last variation are most preferable because most printing professionals are visually oriented (Mishina, 2000).

2.5. Conclusion

Looking at the challenges faced in the printing industry there are numerous job shop methodologies available to overcome these challenges. Some of these methodologies described above will however fall short in scheduling the production of BusinessPrint. Supplementary methods for the printing industry were therefore developed to accommodate the unique production manner and challenges of the printing industry.

Chapter 3: Analysing the proposed Scheduling Methodologies

3.1. Introduction

BusinessPrint has a medium sized job shop factory and produce a wide variety of products using an ample amount of resources. The company thus complies with the aforementioned description of a typical job shop. Analysing the different scheduling methodologies, the problems of BusinessPrint as stated in the first chapter will be considered together with the project aim in order to choose a methodology that will satisfy both of these controls.

3.2. Manual Scheduling

Looking at the abovementioned description and techniques of manual scheduling, it will not be sufficient to overcome the production scheduling problems of BusinessPrint. The reason for this statement is that manual scheduling will definitely lead to large work in progress, long lead times and poor on time delivery at BusinessPrint. Manual scheduling won't be able to accommodate all the variations in the production factory and will eventually lead to chaos, poor planning and a lack of comprehensive knowledge of production on the factory floor (Velaga, 2007).

Poor communication as a result of manual scheduling in a printing factory will lead to decrease in profit due to lost opportunities. Consequences of actions taken in the different departments will not be well understood in advance. Regular interruptions by priority requests will disrupt the scheduling in the various areas because they will be quickly elevated, irrespective of their impact. The effect of these interruptions will not be measured because of the lack of an adequate system at BusinessPrint. Tracking order progress will also be time-consuming and inconsistent, thus manual scheduling can only be used more as a rough guide at the company. Time will be lost walking around the factory to determine the precise status of the work in progress (Musselman, 2001).

Manual scheduling is thus inefficient for production scheduling in complex job shops such as a printing factory that simultaneously handle numerous, diverse orders with different due dates (Velaga, 2007).

3.3. Scheduling on Whiteboards and Excel spreadsheets

Bearing in mind the fast moving, numerous operations of diverse jobs and ever changing production schedule of BusinessPrint, one would know that scheduling on a whiteboard would not be contributing to the quest for a scheduling solution at the company. Whiteboard scheduling would be too time-consuming to adjust schedules accurately or to reschedule certain jobs (Velaga, 2007).

BusinessPrint would not be able to use only Excel as a scheduling tool, for this tool is only appropriate for small and simple job shop production systems. Scheduling in Excel has some major limitations for scheduling the production of a complex job shop factory such as BusinessPrint. Excel together with Visual Basic for Applications (VBA) can not sufficiently address the scheduling complexities of the majority of high mix, low volume jobs at the company. Individual weekly calendars and calendar exceptions of resources, multiple resource requirements, changes in job priorities, fast and extensive what-if analysis are a few of the scheduling challenges that can not be accommodated by Excel (Velaga, 2007).

These shortcomings of Excel however can be overcome when it is used in combination with appropriate scheduling software. Excel can be used to share data with the scheduling software through its spreadsheets, while the scheduling is done by the scheduling software (Velaga, 2007). The combination of Excel together with scheduling software can be sufficient and will be considered to schedule the production at BusinessPrint.

3.4. Scheduling by Project Management Software Tools

Project Management (PM) software tools will not sufficiently contribute to a scheduling solution for BusinessPrint, because PM packages do not offer powerful, dependable and fast what-if analysis and are not capable to automatically resolve resource conflicts. PM tools are thus not sufficient to schedule the complex resource-constrained production processes of the company but it does provide a very effective display of project or production schedules. Displaying and presenting the projects and schedules, PM tools will help the management of the company to view project progression and compile status reports (Velaga, 2007).

3.5. Enterprise Resource Planning Scheduling Modules

Using the Enterprise Resource Planning (ERP) systems, BusinessPrint will be enabled to handle all their information very easily and improve the efficiency of business operations. ERP systems can help the company to integrate the shop floor by using data collection systems with a central database; these systems can enable the company to view their real-time job status. (Velaga, 2007). Implementing an ERP system, the company will receive live feedback of work in progress. The ERP system will wipe out the physically walking around in the factory and searching for pallets of finished printed, folded or bind jobs in order to determine the work in progress.

ERP systems perform better against the ones listed before it, but the system lacks strong resource planning and intelligent decision support modules. ERP scheduling systems are used because it replaces the laborious manual scheduling and rescheduling that is done in Excel and on the Whiteboards. ERP systems automatically provide job information for planning and scheduling purposes. The poor level of scheduling knowledge on the shop floor is also improved by using ERP systems. The modules are based on a Manufacturing Resource Planning (MRP) scheduling logic but it is inappropriate for job shop

scheduling because many of them fail to give a feasible schedule automatically that satisfies all relevant constraints (Velaga, 2007). BusinessPrint can selectively use some of the advantages offered by an ERP system and implement it alongside an adequate automatic scheduling system.

3.6. Scheduling by Theory of Constraints

Theory of Constraints (TOC) scheduling will not comply with BusinessPrint because the rule of having one constraint resource will not be hold. The company has alternating constrained resources depending on the product mix, which is processed at a given time. The Drum-Buffer-Rope (DBR) method, used by TOC, becomes insufficient because jobs will queue because of finite capacity resources. Scheduling with the DBR scheduling method would mean that the company should change the complex job shop, this may be expensive and it needs strategic thinking because such changes may result in excessive resource capacities (Velaga, 2007).

3.7. Scheduling by Lean Manufacturing Practices

BusinessPrint can not make use of the well known Kanban system of Toyota because it can not provide the predictability of workflow, work in progress, lead times, resource utilization patterns and job completion times in a job shop environment. The reason for these complexities is that the company has unpredictable demand and diverse jobs that move through different sequences of work centres (Velaga, 2007).

The Paired-cell Overlapping Loops of Cards (POLCA) method of quick response manufacturing (QRM) is a shop floor control approach that can be used for job shop scheduling. POLCA can address the complexity arising from multiple job routings but it can not provide what-if analysis and predictability that is needed for job shops (Velaga, 2007). Although POLCA will overpower Kanban in a job shop environment it won't be satisfactory to schedule the production at BusinessPrint.

3.8. Scheduling Algorithms

Scheduling algorithms will fall short in solving scheduling problems of BusinessPrint because the mathematical techniques are lacking to deal with practical scheduling problems. Scheduling with these algorithms will be time consuming in such a fast moving industry. These algorithms will also be insufficient because problems are reduced to a level where it can be solved by a non-trivial method. The company will struggle to solve any production scheduling issues with these mathematical models (Velaga, 2007).

3.9. Finite Capacity Scheduling

The drawback of Finite Capacity Scheduling (FCS) is because it works with a specific scheduling model, it can only solve scheduling problems that fit into the underlying paradigm. Two major shortcomings of FCS solutions are it does not accommodate variation and detailed schedule outputs (Velaga, 2007). Bearing in mind the two shortcomings of FCS, accommodation of variation are probably the reason why scheduling in a printing factory is so unique and complex. BusinessPrint would thus not be able to use FCS for production scheduling.

3.10. Slack-based Techniques for Robust Scheduling

Robust scheduling can help BusinessPrint to create a schedule that can be used to schedule jobs in the realistic, dynamic and uncertain job shop environment of the company. Providing extra execution time for each process in the factory will enable BusinessPrint to absorb some level of uncertainty. This will prevent the company from the numerous rescheduling or rush scheduling of jobs that is currently disrupting their production flow (Davenport, Gefflot, & Beck, 2001).

3.11. Conclusion

The numerous scheduling methodologies analysed in this chapter can all be used to schedule the production within a job shop factory. Analysing these methods illustrated that only a few will be suitable to use for the complex production scheduling at BusinessPrint. Taking into account the company's stated problem and the project aim, there are only three methods that will be considered for the solution at the company.

These methods are; the combination of Excel together with scheduling software, the implementation of an ERP system to ensure the company will receive live feedback of work in progress, and BusinessPrint can make use of the Slack-based techniques to determine the duration of the processes in the schedule. The two supplementary scheduling methods for the printing industry as described in the literature review in chapter two can both be considered as adequate techniques for production scheduling.

Chapter 4: Problem Solving and Results

4.1. Introduction

BusinessPrint represents a typical complex job shop environment where all of the uncertainties present in a job shop as discussed in the literature review are present in the company. Collectively as described by Musselman (2001) there are numerous other challenges that are also present when one considers developing a production schedule in the printing industry. The ideal solution proposed to BusinessPrint in this chapter will be a form of dynamic scheduling. This electronic based scheduling solution will be in line with the tested systems implemented at printing companies Modern Litho (2011) and at Grand River Printing & Imaging Incorporated (2000). The results arising from this improved system will also be estimated from two case studies in relation to these printing companies.

Through analysing the problems at BusinessPrint one would realise that scheduling is the heart of a job shop production environment. Optimizing or solving the scheduling problems at BusinessPrint will ultimately effect numerous processes that are related to the production schedule. To ensure thorough improvement of the production scheduling problems, one would have to improve all of the processes that influences the scheduling dilemma.

The procedure used to solve the scheduling problem at BusinessPrint, is described as follows: The first step was to understand the current workflow (as is state), at the company together with all of its limitations. The second step was then to describe how the company would transform from the current workflow to the ideal workflow. The third step was to document the ideal workflow (to be state), by which BusinessPrint would be able to function after the improved system was implemented, with all of its benefits.

4.2. Current Workflow at BusinessPrint (As is state)

A basic illustration shown in Figure 2 is the current workflow at BusinessPrint. A brief description of the processes are given together with the shortcomings of the company's current manual scheduling system.

- Job Requirement from Customer

This manual process begins with BusinessPrint receiving a verbal, written or e-mailed proposed job from the customer. The majority of the time, this information is incomplete and incorrect.

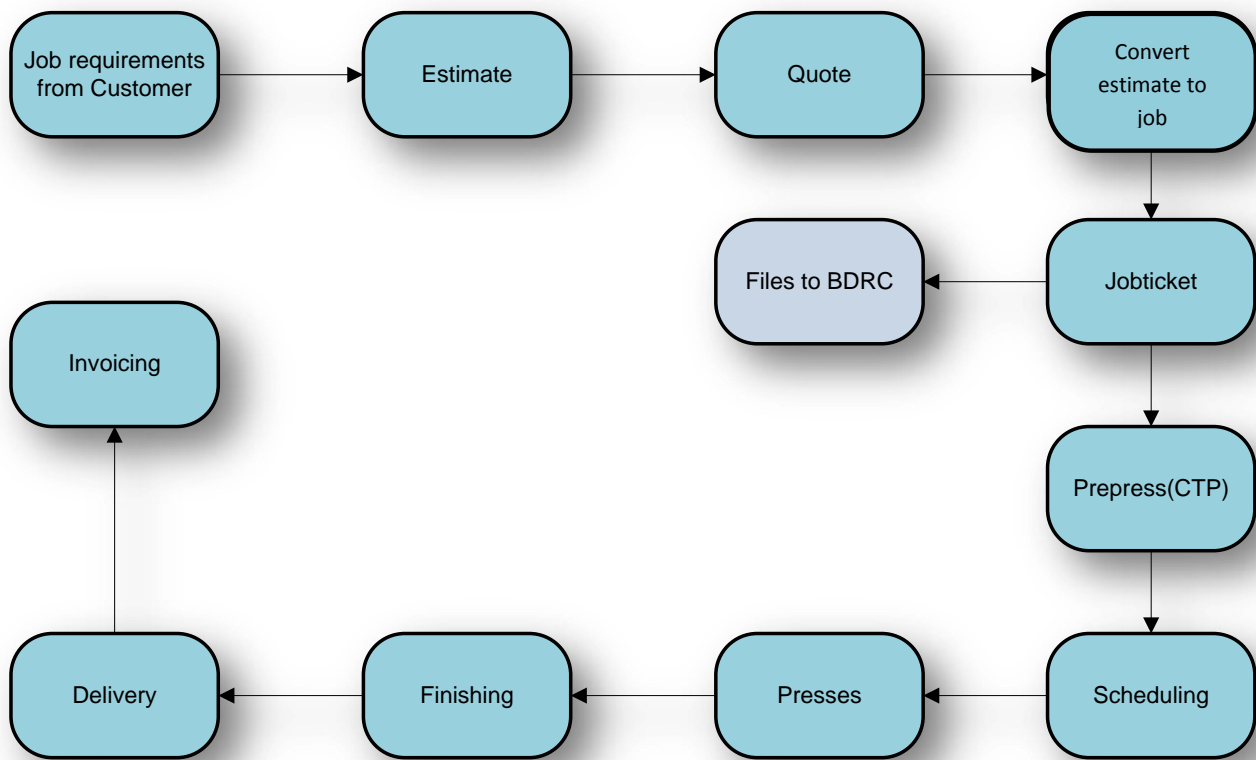


Figure 2: Current workflow at BusinessPrint

- Estimate

Sales representatives manually prepares an estimate by handwriting a pre-order sheet based on what they learned from the customer about the proposed job. Delays are caused by incomplete and incorrect information; because once the estimator begins working on the estimate he calls the customer or the sales representative in order to obtain the correct required information. The handwritten pre-order sheet in addition can be difficult to read and can cause job specifications to be overlooked. Because of this inadequate manual process, the company takes two to three days to produce an estimate. Unsatisfied customers and many lost jobs are the result of these unnecessary long processes.

- Quote

Once the estimator has finalised the estimate, the quote is send to the customer. If the customer has any queries it will be discussed with the sales representative. These quotes are based on the estimates, the estimates however are produced from guessing the production duration of the different processes on the factory floor. The quotes are therefore inaccurate and has to be revised throughout the process and sometimes quotes must be re-issued to the customer as more data becomes available. This is done to ensure that the quotes reflect the actual job specifications, but prolongs the process even more.

- Convert Estimate to Job

After the customer has accepted the quote the job can be created. To create a job in the system, the customer's files are electronically added into Tharstens, an Enterprise Resource Planning (ERP) and Management Information Systems (MIS) software currently used by BusinessPrint, which converts the estimate to a job in the system.

- Jobticket

Tharstens create a paper job ticket, see Appendix A, which are printed and it can be corrected by the planner as he updates it by hand. Job tickets are incomplete and this result in incorrect information about consumables and specifications. Hand written corrections makes the backtracking of order specifications impossible. These mistakes cause the company to for instance have either too much or little ink for a job. The customer files and job files are then send to the Business Design and Reprography Centre (BDRC) where ripping, impositions and colour matching are done for the printing jobs.

- Prepress

The incomplete paper job ticket and the customer files are taken to the Prepress where the customer proofs are printed. The hard copy proofs are then transported to the customer. The transport to and from the customer takes two days, one day each. The proofs are then reviewed by the customer, sometimes with multiple iterations. This proofing process can take up to four to five days. This delays production to almost a week and there are also transport costs involved.

The required paper for each job is calculated manually, and the paper buying is only triggered when job tickets are already on the floor. When there are not sufficient paper for a specific job, the additional ordering and buying of paper delays the process with two more days.

After the customer has approved the hard copy proof, the Computer to Plate (CTP) takes place. This is where the computer designs of the customers job are imbedded into plate designs which are used on the presses for the actual printing, plates are manually loaded. The prepress does all inpositioning on the printing plates and adjust the information on the customer files as necessary. BusinessPrint use Prinergy Connect to do impositions on the plates. It is a Portable Document Format (PDF) based prepress workflow and content management tool that organizes prepress and plate production. After plates are produced, the plates goes into a rack. The job ticket then goes to the line clearance manager that manages the presses on the factory floor.

- Scheduling

It takes approximately two to four hours per day to derive the schedule for one days printing, as the detailed procedure for generating schedules were described in the problem statement in the first chapter. The line clearance manager collects the job tickets and follows the jobs to be printed as listed in the schedule created in the production meeting every day. On weekends, when there are no daily production meetings to supply the daily schedule, the press operators find it difficult to know what jobs are ready to be printed.

- Presses

The job tickets as well as the plates for each job are placed in a bin at the presses. The machine minder operating the press follows his specified jobs on the schedule provided to him. He collects the plates and loads the press with the plates, he initially sets ink keys by hand and eye, and continues to waste paper until colour quality is met. BusinessPrint does not have any system in place to track these makeready waste, so manual predictions are made about the counts of the waste involved because of makereadies.

Sometimes the job tickets are still incomplete and incorrect in terms of the colour specifications for a customers job, then the machine minder has to wait until the sales representative has clarified the issue, which waste a few more hours.

As jobs are finishing on the presses, printed hand written tags are placed on the pallets containing predicted quantities of the different sections of a job. These quantities are predicted because the autocount systems already in use at the presses can not be trusted. When all the sections are finished the job ticket gets passed on to the line clearance manager, managing the finishing processes.

- Finishing

There are no scheduling system in place at the finishing department. As job tickets arrive at finishing, priority are given to jobs with earliest delivery dates. Because pallets of jobs were tagged manually and placed somewhere on the factory floor, the finishing line clearance manager needs to search and identify all the pallets of different sections belonging to the same job before various finishing processes can start.

As jobs are printed, the current system in place to check or verify the paper quantities of jobs printed can not be trusted. This can cause a serious problem in the finishing processes when a shortage occur. This shortage will only be recognised when the presses is already set up for another printing job. To reprint jobs because of shortages is very time consuming as some of the processes mentioned above need to be repeated.

- Delivery

Because of the unscheduled production of the production factory of BusinessPrint, the company can not determine delivery times of jobs. After the finishing processes the customer products get packed and transported to the customers. Job tickets are send to the accounting department to commence with invoicing. The job status are updated in Tharstens to one of the following; finished production, invoiced, invoice completed or job completed. Tharstens sends jobs to Pastel Evolution where invoicing are completed.

- Invoicing

The accountant's job is to check all the steps to ensure that everything is invoiced, but because jobs gets rushed to customers after packaging there are no sufficient time to complete this necessary action before jobs are send out. This cause them to sometimes under invoice. Fifty percent of the jobs skip the invoicing step, because the sales representatives does not follow it up due to the lack of a suitable process.

There are no addequete systems in place to track the actual versus estimated figures at the company. Customer or job profitability and other financial metrics required to run BusinessPrint can also not be properly measured.

4.3. Systems, Software and Hardware to be implemented at BusinessPrint

The scheduling problem at BusinessPrint can be overcome by implementing scheduling software that orchestrates all the processes from estimating through to accounting, in order to fully automate the company's printing factory. This objective can be accomplished by implementing a software system that integrate and connect the software and hardware already in use by BusinessPrint by means of Job Messaging Format (JMF) or Job Definition Format (JDF) software. The company should also implement other software and hardware as proposed together with the JMF or JDF system. Such systems have been implemented at the printing companies Modern Litho (2010) and Grand River Printing & Imaging Incorporated (2000).

Two examples of software systems that BusinessPrint could implement:

- The third category dynamic scheduling as described by Mishina (2000): Programmed Solutions Incorporated (PSI), a print management solution using an Analytic Hierarchy Process (AHP) system (Mishina, 2000).
- The Electronics for Imaging (EFI) Monarch Foundation or Planner system is a Management Information Systems (MIS) suite, wich include the scheduling software Printflow, together with Kodak's Prinergy/InSite (Modern Litho-Print Automation Case Study, 2010).

Tharstens is the same software as Monarch Foundation and possesses the same capabilities thus it can also be used to solve the scheduling problem at BusinessPrint. The software is already in use by the company however it is limited because of the non integrated production systems of BusinessPrint. Tharstens includes a scheduling module which will be enabled to use if the company execute the changes as proposed, this will enable the company to use Tharstens to its full potential. BusinessPrint should execute the improvements to enable Tharstens to plan and support all the processes from quoting the customer, scheduling the production up to when jobs are delivered to the customer. The company should also spend adequate time to do time studies for all the production processes in the factory in order to establish accurate production times to be entered as benchmarks in the scheduling software.

The Auto-Count systems that the company is currently using have to be examined and repaired at every press and binding machine in order to produce printed labels showing precise production quantities. In order to integrate workflow communication an adequate networking cable like Cat6 will be necessary. Each press and binding machine will become a workstation with its own Auto-Count system running connected to the workflow to be monitored. If the current servers of BusinessPrint does not have the capacity to accommodate all these systems, investing in an improved server will be compulsory.

Only two of the six presses currently used by BusinessPrint is computerized and have the ability to be electronically integrated. To fully benefit from these proposed systems, BusinessPrint will need to have at least four computerized presses. Two of the non computerized presses together with one of the old computerized presses must be replaced with three presses that can be integrated into the system.

Implementing such a configuration will enable BusinessPrint to increase the company's production capacity up to 25% without the need to employ more workers. (Modern Litho-Print Automation Case Study, 2010).

4.4. The Ideal Workflow at BusinessPrint (To-be state)

If BusinessPrint would implement the changes as proposed the company will experience the same automated system that Modern Litho did in 2010, the workflow at BusinessPrint will change dramatically. In figure 3 below, the new workflow after the new system will be implemented is displayed. A short description of the processes as well as the benefits will be given.

- Estimates and Quotes

Implementing the improvements will ensure that BusinessPrint will produce estimates and quotes much faster. This system will require all sales personnel to fill in the templates as configured by the e4print software. The templates are based on bindery types that are associated with specific types of projects and the projects related fields. These templates can be filled in from anywhere with internet access, for instance on the customer site. Before these requests can be submitted all the relevant information should be completed. The complete request is sent to the estimator. The request falls into the estimators queue, but can be prioritized (Modern Litho-Print Automation Case Study, 2010).

The quotes are completed by the estimator in order of priority. Quotes are then automatically pushed to Preps, InSite and Tharstens. Tharstens triggers an e-mail to be sent to the customer or the sales representative. Quotes are then represented to the customer by the sales representative (Modern Litho-Print Automation Case Study, 2010).

This will enable BusinessPrint to finalise quotes in no more than two days and the system integration will eliminate the need to manually re-enter customer data (Modern Litho-Print Automation Case Study, 2010).

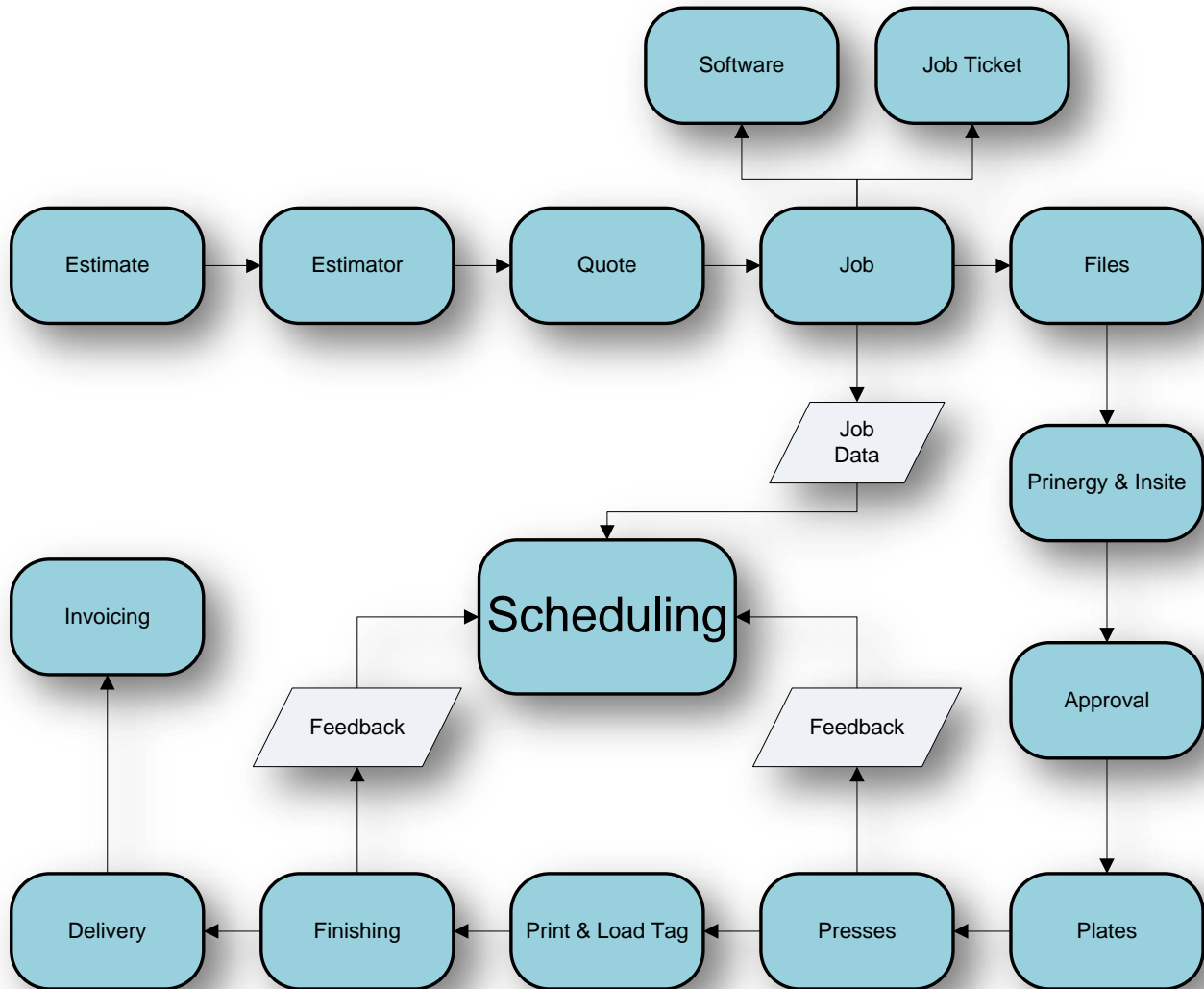


Figure 3: Ideal workflow at BusinessPrint

- Creating job in the system, File handling and Proofing

As the customer approves the quote, the job is submitted through Insite, which automatically sends an e-mail to the customer service representative (CSR) with the quote number. Tharstens is also integrated because it is a web-based operation it can be done from anywhere. The job gets started in Tharstens, querying a job number from e4print to create a job. Tharstens can plan the majority of the jobs automatically according to quotes and Prinergy does impositions automatically. The scheduling module included in Tharstens is then used to do automatic scheduling. The Gantt chart display of the scheduling module provides an illustration of every machine in the production factory together with the scheduled jobs. Tharstens includes a paper table which can trigger the ordering of paper automatically together with Xpedx. Because of the electronic job ticket, jobs can be viewed by any workstation within the factory (Modern Litho-Print Automation Case Study, 2010).

Once the customer files are loaded into InSite, jobs automatically go into the production stream. The customer files are automatically processed and an electronic proof is send back to the customer within minutes, waiting for their approval. The customer gets notified of this through e-mail. If the customer makes changes to the proof, Tharstens will update these changes. After the changes have been updated Tharstens does impositions and sends them to Prinergy. This integration between Tharstens and Prinergy will eliminate the manual preparation steps of BusinessPrint (Modern Litho-Print Automation Case Study, 2010).

Implementing such a system BusinessPrint can effectively consolidate these tree steps into one automated process with the new workflow. According to the quotes, Tharstens automatically plans jobs and receives job identification form e4print and InSite. Impositions are also automatically done by Tharstens leaving little manual processes. The electronic proofs eliminate the transportation costs involved in sending the customer's hard copy proofs (Modern Litho-Print Automation Case Study, 2010).

- Plating

If the customer approves the electronic proof, Pinergy sends the plates to the Prinergy Connect, where plate making is completed. Prinergy Connect puts the job number, customer name and form number on the plate outside of the image area. Prinergy Connect which is currently used by BusinessPrint can be integrated here because the automatic plate setter, Magnus used by Modern Litho is too expensive. When the plates are ready for pickup, the scheduling module will reflect this in the schedule (Modern Litho-Print Automation Case Study, 2010).

BusinessPrint can benefit from this plate making because plates will be generated as soon as proofs are approved and ready to use on the presses. This solves confusion in the press room and eliminates a significant amount of waiting time. Less error in the press room will occur because of the integrated plate making system (Modern Litho-Print Automation Case Study, 2010).

- Production

This integrated Tharstens system will enable BusinessPrint to automatically calculate waste at every step in the process. As the press operator loads the job, the integration between Prinergy and the Heidelberg Prinect Prepress Interface will allow the operator to load the ink density key settings at the press. This integration can decrease the make ready time and waste by up to 50%. The Auto-Count system will eliminate shortages because of counting errors and will print load tags automatically with the exact counts (Modern Litho-Print Automation Case Study, 2010).

- Bindery or Finishing

The company will be able to see when a job is ready for finishing on the job ticket or on the scheduling module's schedule. This will notify the personnel at bindery to pick up the job if it is not there already. The company will benefit from these systems together with the Auto-Count metric which makes load tags, counts, job tickets and schedules electronic or computer printed. There is no need for manual scheduling and there is little room for error in interpreting the contents (Modern Litho-Print Automation Case Study, 2010).

- Distribution and Invoicing

The finished products are transferred to the outbound. Tharstens enables the automatic creation of shipping documentation. It also includes the tracking number onto the electronic job ticket in order to simplify tracking and billing. This will ensure that all the information needed to accurately invoice a job is available. Pastel Evolution currently used by BusinessPrint can also be linked with Tharstens to eliminate the manual calculation of sales tax (Modern Litho-Print Automation Case Study, 2010).

- Financial Performance

These systems will make all information on how to run a business available to BusinessPrint. Excel can be used alongside these programs for further analysis if the company need to do so (Modern Litho-Print Automation Case Study, 2010).

In figure 4 below is a basic illustration of how the software is integrated:

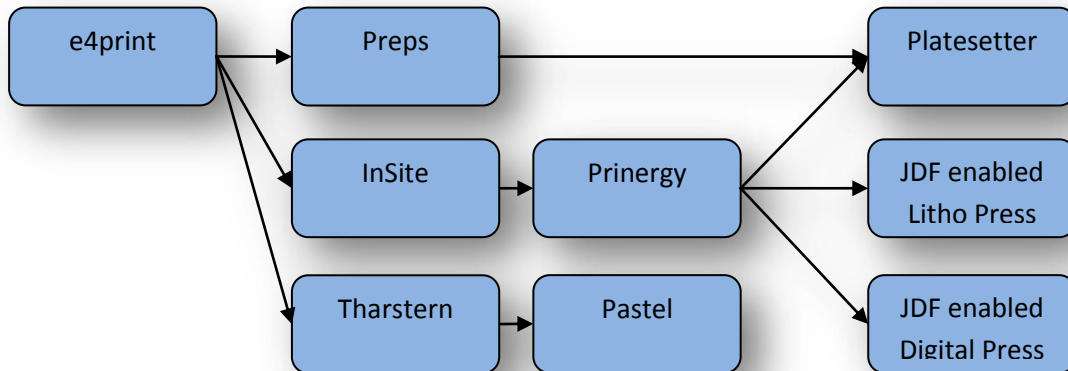


Figure 4: Integration of Software

4.5. Conclusion

BusinessPrint represents a typical complex job shop environment where all of the uncertainties and challenges present in the printing industry as discussed in the literature review are present. The scheduling problem at BusinessPrint can however be overcome by implementing scheduling software that orchestrates all the processes from estimating through to accounting, in order to fully automate the company's printing factory. Such a system will dramatically change the workflow and processes of the company. These changes will be beneficial to BusinessPrint and will ultimately increase the company's production capabilities and capacity.

Chapter 5: Findings and Recommendations

5.1. Introduction

The results BusinessPrint will achieve from implementing such a system will best be recognized by the dramatic increase in the company's production output. The company will have all business and production information available in real time; this will help BusinessPrint to improve business management. The company will experience at least a two day reduction in turnaround time and will enjoy the automatic flow of some jobs through the plant without a problem (Modern Litho-Print Automation Case Study, 2010).

5.2. Improvements in Process Flow and Results

- Estimates and Quotes

If BusinessPrint implement the new automated process, it will result in a much more streamlined workflow. Because of the paper job ticket system that the company is currently using, it takes days to finalise and complete one quote; this lingering process can be improved by implementing InSite. InSite will ensure that all the necessary information is present before allowing sales to submit a request for estimates. This is accomplished by using the custom order forms provided by e4print. This system will enhance the completion of estimates dramatically, reducing the present drawn out time of three to five days to a swift time of one or two days (Modern Litho-Print Automation Case Study, 2010).

- Creating job in the system, file handling and proofing

When the customer accepts the quote and completes the uploading of files to be processed, numerous processes are all compressed to be processed simultaneously, some of these processes even happen automatically. These processes include; processing the files, proofing, creating of the electronic job ticket, imposition, and planning and scheduling are all done in parallel. BusinessPrint is currently delivering hard copy proofs to their customers that take four to five days to produce; this automated process can enable them to deliver proofs within hours after the file has been uploaded. This is the result of the fast colour calibrated remote monitor proofing that the automated process is able deliver. (Modern Litho-Print Automation Case Study, 2010).

Making use of the electronic proofing system, BusinessPrint will be enabled to retain and acquire customers and ensure customer satisfaction. Such a system will eliminate many manual steps because of the mark-up being done online; this streamlines the workflow and reduces the opportunity for errors at this critical stage (Modern Litho-Print Automation Case Study, 2010).

Results: These proofs add up to a total of R 90 per proof, which includes production costs of R 50 and travelling costs of R 40. Producing 750 jobs per month will result in an annual proofing saving of **R 810 000**.

- Scheduling

Using the scheduling module provided by Tharstens to schedule the production of the factory together with accurate production times of all the processes in the factory, manual scheduling can be eliminated. This combination will reduce the manual scheduling time of approximately four hours per day to less than an hour. Correct production times arising from the time studies and the Gantt display of the scheduling module, will simplify prioritization of jobs to a large extent because completion dates of jobs will be accurately displayed by the module. These dates will be measured by the scheduling module and will indicate if deadlines will be reached. If the scheduled finishing date is later than the delivery date, the specific job must be scheduled to start earlier. Because the production processes on the factory floor are integrated and connected by means of a networking cable, monitoring work in progress and updating the production schedule will be an automated process.

Results: The production meetings that waste two hours per day involving eight people, two schedulers and six line managers, which work at R 170 per hour, will be eliminated. There are approximately twenty of these meeting per month. Resulting in a monthly saving of R 54 400. Eliminating the average of three hours per day of manual updating the schedule, which happens every day of the month, by two line managers that walk around in the factory floor, searching for pallets before production meetings can commence, will result in a monthly saving of R 30 600. The scheduling solution on the presses which the scheduling module will offer to BusinessPrint will result in an annual saving of **R 1 020 000**. This automated scheduling solution will possibly replace some of the work previously done by employees and will cause them to be redundant. Management will have to reassign these employees or retrench them, which will lead to more revenue or savings.

Results: Tharstens scheduling module will also schedule the processes after the presses such as the bindery processes. The Auto-Count systems which precisely label the pallets will eliminate the searching of pallets happening prior to the bindery processes. This scheduling module will eliminate the manual scheduling on the bindery machines. The current searching of pallets is normally done by a single line clearance manager that works at R 170 per hour. If 750 jobs per month are produced and half an hour of searching is necessary for each job the searching cost eliminated per year is R 765 000. The manual scheduling needed for bindery includes a scheduler and a line clearance manager, both working at R 170 per hour. They waste another half and hour per job to schedule and organise it to be bind, this result in an annual saving of R 1 530 000. The adequate scheduling system provides a total annual saving of **R 2 295 000**.

- Production

BusinessPrint will benefit from the domino effect that the integration and automation will cause in the company. Because of the electronic job ticket all the information of jobs are immediately available from any computer in the organization. Tracking down hard copy job tickets will be a thing of the past.

BusinessPrint can use the ability of Tharstens to automatically calculate waste in every step of the process to ensure that exact amount of paper are ordered for each job. The integration between Tharstens and Xpedx will eliminate the manual calculating, ordering and buying of paper (Modern Litho-Print Automation Case Study, 2010).

Results: The savings BusinessPrint will earn from a production point of view will also be enormous. The company produces about 750 jobs per month and each job enquire an average of three make readies, thus it is 2250 forms per month and 27000 forms annually. Approximately 200 sheets of waste paper per form will be saved; this equals 5, 4 million sheets per year. At an average price of R 1, 40 per sheet it results in an annual paper saving of **R 7 560 000**. The company will also save about 15% of the current ink costs because of shorten make readies, which are R 250 000 per month. This results in **R 450 000** ink savings per year. BusinessPrint will also save about 15 min per each make ready, with 27000 make readies a year it results in 6750 hours of make ready time saved. There are two employees working at each press, a machine minder and an assistant, at rates of R 170 and R 30 respectively. This will result in annual salary savings of **R 1 350 000**.

5.3. Summary of Savings in the different Processes

In the table below, follows a summary of the savings as predicted from which BusinessPrint will benefit. The savings in rand value could not be estimated throughout all the processes due to the fact that some of the processes alter in such an enormous manner that the influence of the change will only be fully predictable once the system is implemented.

Process	Status after Improved System	Saving	Savings in Rand	Comment
Estimates and Quotes	Fast electronic accurate quoting.	Decreases from 3-5 days average, to about 2 days.		No more lost jobs due to slow response time on quotes.
Creating job in the system as well as proofing	Automated processes and electronic job ticket. Proofs available and approved in less than an hour plus automated impositions.	Reduced the entire process from between 3-5 days to 2 days.	Result in an annual proofing saving of R 810 000 .	Quick turnaround of proofs. Jobs are created accurately with all sufficient data available.
Plating	More automated.	Plating can start earlier because job specifications are ready on time and accurate.		Plating also reflected schedule in Printflow.

Scheduling	Automated scheduling reduced time and improved accuracy.	Four wasted hours because of production meetings and three hours to update the schedule.	Annual saving of R 1 020 000 on the presses.	Automated scheduling eliminated manual scheduling.
Production	Automated production with Auto-Count systems running, live feedback reporting work in progress.	Savings on make ready paper per form, as well as ink costs and about 15 min per each make ready.	Annual paper saving of R 7 560 000 , ink savings of R 450 000 per year and annual salary saving of R 1 350 000 .	Enormous amount of savings and production improvements throughout the factory.
Bindery or Finishing	Rarely any shortages, no more need for manual scheduling, Printflow includes finishing processes into scheduling.	No more searching for pallets, because of sufficient labelling system thus fewer errors. One hour of manual scheduling saved.	Annual binding saving of R 2 295 000 .	Controlled pallets by sufficient numbering and automated scheduling.
Distribution and Invoicing	Files are electronically distributed thus all information are available for invoicing and sales tax are automatically calculated.	Waiting for files and paperwork in eliminated.		Invoices are generated faster and more accurate.
Financial Performance	All the information needed is available for analysis in real time.	Every job's turnaround time is reduced by two days. Efficiency is increased in all departments.		Increased production capacity by 25% without adding additional people. Sales will most probably increase because sales representatives are freed up to do intensive marketing.

Table 1: Summary of Savings in different Processes

5.4. Summary of Predicted Costs and Savings for the Project

5.4.1. Project Savings

Predicted savings per year:

Proofing savings of:	R 810 000.
Press scheduling savings of:	R 1 020 000
Paper savings of:	R 7 560 000
Ink saving of:	R 450 000
Production salary savings of:	R 1 350 000.
Binding scheduling savings of:	R 2 295 000
Total annual savings of:	R 13 485 000

The three presses that need to be replaced can be sold by the company for:

SM 74-4-H with a present market value of:	R 1 700 000
SM 74-4-P+LX with a present market value of:	R 3 200 000
SM 74-2-P with a present market value of:	R 550 000
Total replacement value of:	R 5 450 000

5.4.2. Predicted Costs for the Project

The three presses that needs to be purchased by BusinessPrint:

SM 74-4-P+LX with a new replacement value of:	R 8 528 000
Total replacement value of:	R 25 584 000

The software and hardware needed to optimise the system:

Full Tharstens package:	R 280 000
Full Prinergy package:	R 500 000
Six network points, R 300 each:	R 1 800
Cat6 network cable, R 5 per meter, 200 meter:	R 1 000
Software Integration:	R 200 000
Total software and hardware cost:	R 982 800

Total cost for project **R 26 566 800**

5.5. Conclusion

These automated and improved systems will enhance the production ability of BusinessPrint throughout the entire plant. As in the case of Modern Litho, BusinessPrint will experience a major improvement in turnaround time. BusinessPrint will be able to produce jobs automatically from start to finish in 20 percent of the typical time used presently. BusinessPrint will be enabled to predict when jobs will be finished and because of this the company will meet customer delivery dates. The company will be able to keep track of workflow, and predict with accuracy the progress of jobs in the factory. Consequently, BusinessPrint will be in command of the productivity of the factory, machines and workers. Sales representatives would not be necessary on the factory floor in order to track their jobs but instead they can channel their energy into marketing. This can ultimately cause the company to acquire possible business opportunities. Workforce by numerous people from different departments will become available to increase productivity and work rate, which will result in improved output in various areas of the organisation.

Implementing these systems BusinessPrint will not only benefit from the solid footing in terms of the company's internal production factory, but the company will also increase customer service capabilities. BusinessPrint will be able to acquire new customers and will possess the ability to retain existing customers. The impact of such an improved system will deliver a competitive advantage, increase customer satisfaction and optimise internal production processes which together will lead to more revenue.

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Appendix A

Basic illustration of a Job Ticket used at BusinessPrint:

Customer		Customer No	Quantity	Job No					
Business Print MARKETING		BPC103	1,500	16704					
Rep: Massimo Mancini	Contact: Massimo Mancini	Delivery Address: MARKETING Pretoria Gauteng	Delivery Date: 23/08/2011 Job Opened: 17/08/2011 12:35:51PM						
Order No:	Tel No:								
Estimate No: 50838 - 16704	Fax No:								
Selling Price: R 8,320.20 0.00	Cell No:								
Estimator: John Smart	E-mail:								
Product Description: 005 MAGAZINES			Material Needed						
Title: Booklet			Paper						
Size: 148 X 210mm.			Power single coated gloss White 250gsm						
Pages: Cover: 4 Pages, Centre spread: 4 Pages, Text: 16 Pages.			Power single coated gloss White 150gsm						
Material: Cover: Power single coated gloss White 250gsm, Centre spread: Power single coated gloss White 150gsm, Text: Power single coated gloss White 150gsm.			Power single coated gloss White 150gsm						
Printing: Cover: 4 colour process both sides. Centre spread: 4 colour process both sides. Text: 1 Black both sides.									
Finishing: Saddle stitch two wires.									
Origination: Client to supply print-ready PDF files.									
Proofs: We supply one set of position proofs..									
Packing Instructions: Shrinkwrap 25 items per parcel.									
Delivery: Deliver to one address in Pretoria / Johannesburg area.									
Origination	Sections	Operation	Quantity	Min/Section	Total Minutes				
Cover	1	RIPP proof	1		8				
		SM74 platemaking	4		20				
Centre spread	1	RIPP proof	1		8				
		SM74 platemaking	4		20				
Text 1	1	RIPP proof	2		16				
		SM74 platemaking	2		10				
Printing	Sections	Operation	Passes	Runs	TotalRuns	Total Minutes	Color: F / R	TotalSheets	SetupSpd
Cover	1	SM74 4 w&t make ready	4	1	4	40			
		SM74 4 run	2	387	774	7	4 4	787	400
Centre spread	1	SM74 4 w&t make ready	4	1	4	40			
		SM74 4 run	2	387	774	7	4 4	787	400
Text 1	1	SM74 2 sheetwork make ready	2	1	2	20			
		SM74 2 run	1	1,530	1,530	12	1 1	1,730	200
Finishing	Sections	Operation	Passes	TotalRuns	Total Minutes				
Cover	1	Cylinder score m/r	1	1	10				
		Cylinder score run	1	386	8				
		Guillotine m/r	1	1	10				
		Guillotine run	1	1	2				
Centre spread	1	CUT: Guillotine m/r	1	1	10				
		CUT: Guillotine run	1	1	2				
		FLD: fold x1 m/r	1	1	15				
		FLD: fold x1 run 4-page section	1	1,548	13				
Text 1	1	FLD: fold x3 m/r	1	1	25				
		FLD: fold x3 run full section	1	1,530	13				
Binding	1	STS: Muller Martini m/r	1	1	45				
		STS: Muller Martini s/s run	1	1,500	12				
Packing		PCK: shrinkwrap magazines	1	1,500	52				
Despatch		Delivery	1	1	1				
Method of Working									