

[PSC], is a system that provides the necessary tools for management and operations personnel at the steel rolling mill to plan and schedule the production of the mill on a monthly, weekly and day to day basis, and to monitor the results. This module is totally integrated with the current [QMOS] modules available and in use at steel rolling mills.

## **A Model for Detail Production Scheduling & Control of a Steel Rolling Mill**

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### **Introduction**

Quad Infotech has collaborated with Birmingham Steel Corporation's Seattle Division to develop software for managing the production schedule in steel rolling mills. This software, named Production Scheduling and Control [PSC], provides the necessary tools for planning the production on a monthly, weekly, and day to day basis, and for monitoring the results. [PSC] also allows for complete billet inventory management, including the ordering of billets from the melt shop, billet yard operations, allocation of heats to a specific order, and tracking of billets through the rolling mill.

[PSC] is an enhancement of the Quad Mill Operating System [QMOS], a comprehensive package of programs used by management and operating personnel to monitor, collect, and analyze steel rolling mill production data. Program modules cover roll, guide, and setup shop operations, production and delay recording, bundle tagging, and shift reporting. [QMOS] has been operating in a number of steel plants throughout North America and Europe since 1992. Birmingham Steel implemented [QMOS] in Seattle in 1995. The Production Scheduling and Control module that is the subject of this paper was commissioned in Seattle beginning in July 1999.

### **Background**

Birmingham Steel produces rebar and merchant bar at its Seattle minimill for markets in the Western United States and Canada. Birmingham acquired the facility in 1991. At that time, the primary production assets consisted of two inefficient electric arc furnaces and an aging cross-country style bar mill capable of rolling rebar and merchants up to 4" X 4" angles.

Between 1992 and 1996, Birmingham invested more than 100 million dollars in a plant-wide modernization program. The first step was to replace the existing mill with a new Danieli 18 stand in-line mill with automatic straightening, stacking and bundling. The second phase of the facility upgrade was to replace the steelmaking furnaces with a single, highly efficient 100 ton/hour Fuchs furnace. The melt shop modernization included a ladle turret and stirring station, new bag houses, caster runout and cooling bed, and billet cranes. The investments raised the plant's capacity from less than 200,000 tons in 1991 to 650,000 tons by 1996 and extended its product offering to include flats and channels up to 6".

### **The need for a new scheduling system**

As the plant commissioned a wider range of sizes, the tasks of scheduling the production and managing the billet inventory became increasingly complex. Now there were more products and higher throughput. With the new mill, the delay required to switch from one product family to another was significantly reduced. At the same time, logistic issues and storage space considerations limited the amount of both billet and finished goods inventory that could be held. The combination of quick-change capability and inventory constraints led to shorter rolling cycles and therefore more items to schedule per week.

Production planning was further complicated by competitive pressures in the market. Orders for quantities of less than a heat, requests for custom sizes and cut lengths, and last minute bookings became commonplace. Entire product groups would be shifted around the calendar if it meant being able to capitalize on a sales opportunity. Often the rolling schedule was adjusted several times in a single day.

The continuous schedule revisions were becoming too time consuming to accurately manage by using the existing system, which consisted of spreadsheets and handwritten reports maintained by a team of employees from several departments. Rolling Mill personnel were in charge of the long range forecast covering the next several months. The cut list showing the amount of each combination of size, length, and grade to be rolled was prepared by the Sales Department. The cutting sequence was established by the Quality Control Department, who was also responsible for the assignment of individual heats to items on the cut list. Accounting tracked the billet production and consumption.

The various spreadsheets operated independently of each other, resulting in many inefficiencies due to the duplicate entry of certain data. For example, the same heat numbers and billet counts appeared in the Melt Shop production report, the billet yard map, the list of heats to be charged, and the billet accounting spreadsheets. In addition, time was wasted because some users of the schedule didn't have computer access, so reports had to be printed, copied, and delivered by hand. Sometimes a cut list or charge report became obsolete while still in the process of being distributed. And having several revisions of the same report in a single afternoon led to potentially expensive mistakes. It was unavoidable that occasionally the wrong billets were charged or the wrong product produced because a crane operator or mill operator was working from an outdated schedule.

By 1998, the Seattle Division moved to improve the scheduling system, and the [PSC] project was initiated. Designing the software as a new module in the existing system offered important advantages. Quad Infotech and the Seattle Division had a strong relationship, having worked together previously in the development of earlier modules. A schedule and billet inventory module would give the system the capability of monitoring the steel from the moment it was cast until it was rolled into finished product.

### **[PSC] Design**

The design of the system was based on already proven [QMOS] concepts and technologies. The team of Quad analysts in close collaboration with Birmingham Steel technologists and operators designed a data model to match the existing [QMOS] model. The main functions of [PSC] then were designed and programmed with close teamwork between the two companies and continuous feedback from the users. The software has been under a continuous enhancement since the implementation of the basic functions in August 1999.

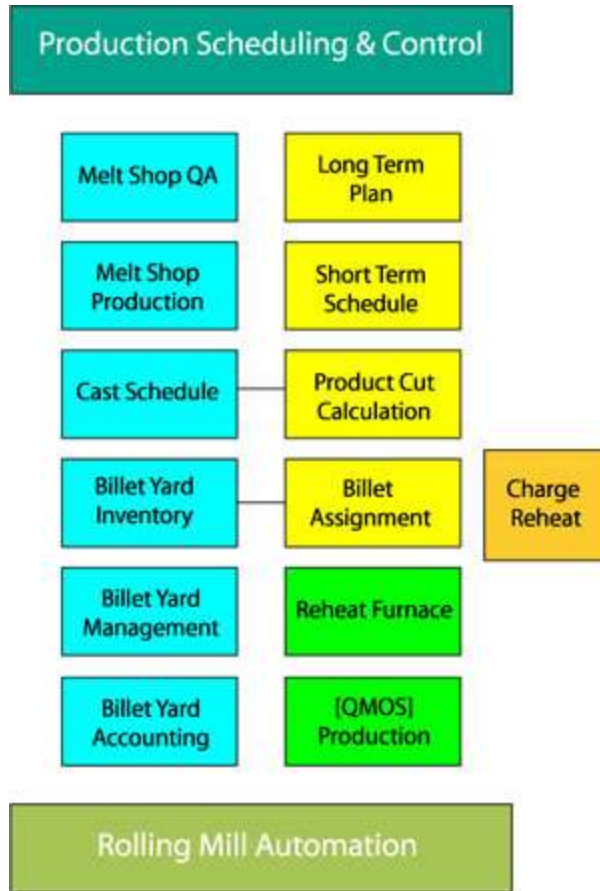


Fig. 1 – [PSC] Main Functions

[PSC] is a mature product that is helping the users in the daily operation of scheduling and production of the rolling mill. (Figure. 1) illustrates the main functions of [PSC] as part of the Quad Mill Operation System.

The long term planning and short term schedule are based on finite scheduling. The product cut sheet calculation and billet optimization can be a sophisticated algorithm depending on the complexity of the melt shop operation. The billet assignment allows the user to assign the best billet based on the quality and length to a product. This will minimize the amount of steel cropped from each billet based on the final product length and the cooling bed capabilities.

The billet yard management provides graphical and user friendly touch screens that manage and control the movement of the billets in the billet yard stacks and loading of the billets to the reheat furnace.

**[PSC] Main Features**

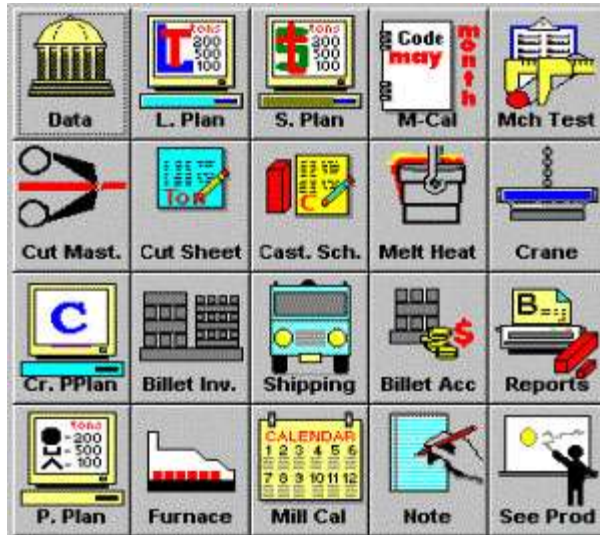


Fig. 2 – [PSC] Main Menu

The [PSC] module begins with a screen called Long Term Plan (Figure 3), which assists in managing the rolling mill production cycle.

Sequence	Product Group	Estimated Start Date	Schedule Start Date	Len. Ft	Schedule Tons	Change Hours	TML
001	001	01/01/00	01/01/00	100	1000	100	100
002	002	01/01/00	01/01/00	100	1000	100	100
003	003	01/01/00	01/01/00	100	1000	100	100
004	004	01/01/00	01/01/00	100	1000	100	100
005	005	01/01/00	01/01/00	100	1000	100	100
006	006	01/01/00	01/01/00	100	1000	100	100
007	007	01/01/00	01/01/00	100	1000	100	100
008	008	01/01/00	01/01/00	100	1000	100	100
009	009	01/01/00	01/01/00	100	1000	100	100
010	010	01/01/00	01/01/00	100	1000	100	100
011	011	01/01/00	01/01/00	100	1000	100	100
012	012	01/01/00	01/01/00	100	1000	100	100
013	013	01/01/00	01/01/00	100	1000	100	100
014	014	01/01/00	01/01/00	100	1000	100	100
015	015	01/01/00	01/01/00	100	1000	100	100
016	016	01/01/00	01/01/00	100	1000	100	100
017	017	01/01/00	01/01/00	100	1000	100	100
018	018	01/01/00	01/01/00	100	1000	100	100
019	019	01/01/00	01/01/00	100	1000	100	100
020	020	01/01/00	01/01/00	100	1000	100	100

Fig. 3 – [PSC] Long Term Plan

In Long Term Plan, the plant's product line is organized into groups based on product classification and commonality of mill setup. The Seattle Division has two product classes, rebar and merchant bar. At the present time there are 29 product groups, six for rebar and 23 for merchants (Figure 4).

To schedule a product group, the user generates a new line at the bottom of the screen by clicking the append button on the toolbar. The user then selects a product group from a pick list and enters the number of tons to be rolled. [PSC] automatically determines the estimated start date from the tons entered for the prior group, historical rolling rates, and the average length of the delay required for the mill to change groups.

Group ID	Class Description	Description	TPH	Tax	Straightener Overwidth	Tap	Bottom	Change Time (hrs)
45	Merchant Class	Carape Steels	39.00	.00				
46	Rebar Class	10 #30 Rebar	66.00	.00				
47	Rebar Class	15-18M Rebar	63.00	.00				
48	Rebar Class	16-19 Rebar	166.00	.00				
49	Rebar Class	22-34 Rebar	106.00	.00				
44	Rebar Class	45-57 Rebar	57.00	.00				
43	Merchant Class	5" Channel	60.00	.00				
50	Merchant Class	4" Channel	63.00	.00				
71	Merchant Class	5" Channel	70.00	.00				
72	Merchant Class	6" Channel	70.00	.00				
73	Merchant Class	1 X 1 Angle	22.00	.00				
74	Merchant Class	1 1/4 X 1 1/4 Angle	25.00	.00				
75	Merchant Class	1 1/2 X 1 1/2 Angle	36.00	.00				
76	Merchant Class	2 3/4 X 1 3/4 Angle	58.00	.00				

Fig. 4 – [PSC] Product Groups

A down-time calendar (Figure 5) allows scheduled maintenance time to be blacked out in thirty minute increments and ignored in the calculations.



Fig. 5 – [PSC] Down Time Calendar

The user has the option of scheduling a group for a period of time instead of a specific number of tons. This helps the mill to plan product changes so that they coincide with scheduled maintenance or else occur on day shifts when there are more employees available. For example, the Seattle mill normally performs routine maintenance every Thursday day shift. If a product group change is currently scheduled to occur late on Wednesday night shift, it may make sense to extend the rolling for a few hours. By doing so, the product change can be made to happen during a time when the mill was already down, thus eliminating a delay.

Long Term Plan is extremely flexible. If necessary, the sequence in which product groups are scheduled can be changed in just a few minutes. This is accomplished by simply clicking and dragging a line into a new position. Upon saving, the calendar is instantly recalculated. New lines can also be added directly into the schedule by clicking insert instead of append.

The schedule of product groups in Long Term Plan can be viewed in either calendar format or tabular report format. The calendar provides a convenient overview of the schedule for a particular month. The report format shows the total number of tons scheduled for each month, plus a summary of the actual results for previously rolled groups as well as the group that is currently in progress. This information is updated continuously in real time.

### Short Term Plan

Short Term Plan allows the user to schedule the individual products that belong to each group. A product is defined as a unique combination of section, grade, and cut length, and is designated by a numerical

product code. The Seattle Division's core product line consists of about 200 products distributed among the 29 product groups. In addition, Seattle produces another 200-300 special orders per year.

The short term schedule by product code for each group on the mill calendar is prepared a couple of weeks prior to the scheduled start date. The Sales Department analyzes order book and inventory data and projects how much of each product is needed from the mill to meet customer requirements until the next rolling cycle. The scheduler then consults with the Rolling Mill, Sales, and Shipping Departments to determine the optimum production sequence and uses Short Term Plan to generate the schedule.

Short Term Plan is made up of two screens plus a report. The first screen in Short Term Plan is the same as in Long Term Plan. The user picks a row and then moves to the second screen (Figure 6) by clicking on the Select Product tab.

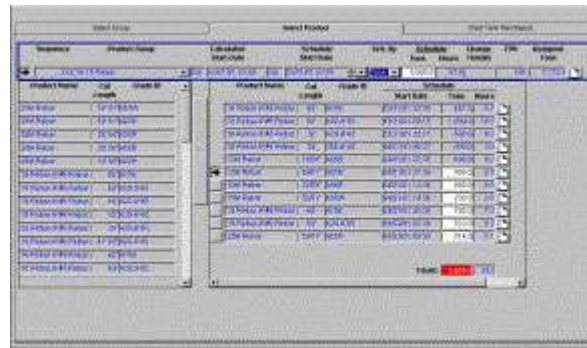


Fig. 6 – [PSC] Short Term Plan

Select Product is divided into three main windows. The top window displays the row selected on the previous screen. The left window contains a list of all the products belonging to the selected group. The user simply highlights all the products requested by Sales, clicks the arrow in the center of the screen, and the products are copied into the schedule window on the right. After the scheduled tons are entered, [PSC] shows the estimated start time for each product. Planned down time from Mill Calendar is factored into the calculations. The following group can be scheduled by using the scroll bar in the upper window to advance to the next row of Long Term Plan. This eliminates the need to move back and forth between screens when scheduling multiple groups.

The design of Short Term Plan includes many powerful features. When creating new product codes, the user can choose the order in which products appear in the pick list on the Select Product screen. Standard products can be put near the top for ease of access, while special products that a customer may buy only once are located at the bottom. Products can be selected multiple times, allowing the tons for a single product code to be split between different parts of the production run. The rolling sequence of the scheduled products in the window on the right can be rearranged by clicking and dragging. A delete button permits a product to be cancelled with a single click. Thus, even significant schedule changes can be made quickly.

The total tons for all product codes are displayed at the bottom of the schedule window. Color is used to indicate whether the total of the individual products is the same as the group tons in Long Term Plan. If the numbers do not match, the group tons in the upper window can be set equal to the sum of the tons for the individual products.







Fig. 11 – [PSC] Assign Heats

The design of Assign Heats is analogous to the design of Select Product. A narrow window in the upper part of the screen contains the row highlighted in Cut Sheet. The window to the left shows the entire billet inventory as it is stacked in the billet yard. Billets having the same heat number, grade, and billet length are assumed to occupy the same layer in the stack. If a heat was cast into two billet lengths, it will appear as two rows in the inventory, even though physically the billets may lie side by side in the same layer. The billets can be sorted by heat number, intended product, grade, or billet size by clicking on the appropriate column heading.



Fig. 12 – [PSC] Furnace Production Data

The billet inventory data is entered by the Melt Shop Lab Technician. A screen called Furnace Production Data (Figure 12) is used for entering data originating from the electric furnace, such as the intended grade, energy consumption, and alloys added during tapping. Caster Production Data (Figure 13) is used for entering alloy additions made at the stirring station and for recording the final chemical analysis. The number of billets of each combination of length, grade, and intended product are entered in the lower window. An unlimited number of products from a single heat are permitted.

Upon opening the Assign Heats screen, [PSC] searches the billet inventory for heats having the grade and billet length required by the product in the upper window. These heats are given a green background, while heats matching in billet length only have a yellow background. The color code merely serves as a guideline. There are no restrictions preventing billets of a different grade or length from being allocated to the selected product. This allows the user the flexibility to assign billets that were originally designated for a different product.

Heats are assigned by highlighting the row and then clicking the arrow button in the center of the screen. By default, all billets from the same layer will be assigned unless a lesser number is entered in the box below the arrow prior to clicking on it. When only a portion of the billets in a layer are assigned, the row in the window on the left is split into two parts. A shortcut allows the user to highlight several heats and assign them simultaneously as long as they are stacked consecutively in one stack. As heats are assigned, the button used to highlight the row is disabled so that the user can see that it is no longer available.



assigned, but exceptions can occur due to miscounts or billet quality problems spotted by the crane operator.

There are major benefits to having [PSC] installed in the billet crane. Eliminating the need to distribute printed charge reports saves time and greatly reduces the risk that the wrong heat will be charged my mistake. And since the crane operator's billet count is used to track the billets through the reheat furnace and rolling mill, the count must be correct.



Fig. 15 – [PSC] Crane Operator's Touch Screen

Before [PSC], the billet count had to be called over the radio to the pulpit operator, who then entered the billet schedule into the [QMOS] tracking system. Because of the noisy environment, miscommunication caused frequent errors. Finally, the crane operator can be responsible for updating the billet yard map as heats are moved from one stack to another, keeping the inventory accurate.

Crane operator can move the billets from stack to stack by the means of a touch screen as illustrated in (Fig. 16)



Fig. 16 - Crane operator Touch screen for billet movements from stack to stack

## Billet Accounting

The last significant feature of [PSC] is the billet accounting reports. Until now, Accounting Department personnel had to spend hours per week entering melt shop and rolling mill production data into spreadsheets to prepare needed reports. [PSC] makes it possible to generate reports automatically because as each billet passes through the mill, sensors record whether it is converted into prime material or scrap. Billets that are ejected from the roll line before entering the first mill stand are returned to the

inventory to be rescheduled. Special screens allow billets that are scrapped in the billet yard or shipped to a customer to be subtracted from the inventory.

Several reports are available. Daily billet production and consumption reports list the heats cast by the melt shop and used by the rolling mill. A monthly billet activity report summarizes all events related to heats that were in inventory on the first day of the month and heats that were cast during the month. A reconciliation report shows the beginning, produced, scrapped, shipped, consumed, and ending tons for each date in a range specified by the user. Customized reports can also be designed and printed.

## **Summary**

[PSC] has proven to be highly valuable to Birmingham Steel's Seattle Division. The system addresses many facets of production scheduling and billet inventory control that are beyond the scope of enterprise resource planning software currently on the market. [PSC] enables the user to produce more detailed and accurate forecasts than is possible with spreadsheet methods, and in less time.

## **Key benefits to the Seattle Division include**

- Ability to quickly reconfigure the rolling schedule in order to accommodate last minute orders.
- Significant reduction in scheduling related errors, particularly in billet charging.
- Provides database to capture detailed process information useful in improving efficiency and yield.
- Reduction in workload of several employees allowing them to focus on other tasks.
- Faster, more accurate production reporting.

July 2001, prepared for AISE September 2001, Cleveland

## **References**

1. [QMOS] design documents
2. [QMOS] User Manual

About Quad Infotech:

Quad Infotech Inc. is a Software Engineering and Design company specializes in the development of computer software for the steel industry. Quad's unique combination of steel rolling mill and melt shop process knowledge combined with computer software design expertise makes Quad's Software Products leader in the World Wide Steel Industry.

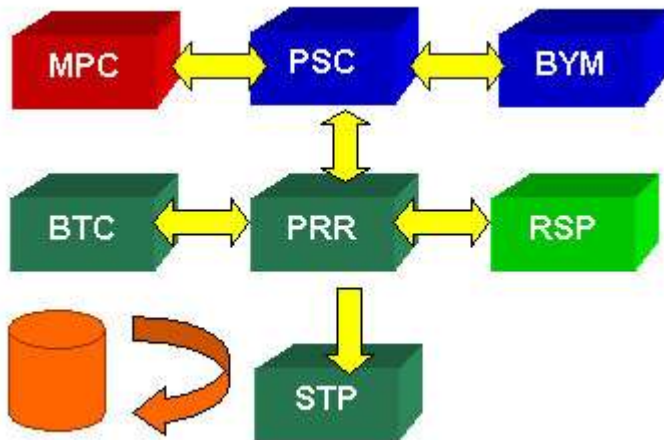
The family of software modules Quad Infotech has developed for steel plant operations is called the "Quad Mill Operation System" [QMOS].

[QMOS] is implemented as a full service product including site assessment, information analysis, data conversion, site training, This product is currently operating in a number of steel plants throughout Canada and the United States.

## **The list of [QMOS] modules are as following**

[RSP]: Roll Shop Planner  
[PSP]: Mill Scheduling & Product Set Up  
[GSP]: Guide Shop Planner  
[BCI]: Bearing and Chock and Stand Building  
[SBI]: Saw/Shear Blade Inventory

[PRR]: Production Control & Reporting  
[STP]: Shift Planner and Production Analysis  
[BTC]: Bundle Tag Control  
[PSC]: Production Scheduling and Control  
[BYM]: Billet Yard Management  
[MPC]: Melt Shop Production Scheduling & Control



## Oracle DB

[QMOS] Modules

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