Industrial Management & Data Systems

POM: a highly visual production and operations management environment

Godfrey C. Onwubolu, Samson Mhlanga,

Article information:

To cite this document:

Godfrey C. Onwubolu, Samson Mhlanga, (1997) "POM: a highly visual production and operations management environment", Industrial Management & Data Systems, Vol. 97 Issue: 3, pp.99-113, <https://doi.org/10.1108/02635579710173167>

Permanent link to this document:

<https://doi.org/10.1108/02635579710173167>

Downloaded on: 08 January 2019, At: 05:29 (PT)

References: this document contains references to 8 other documents.

To copy this document: permissions@emeraldinsight.com

The fulltext of this document has been downloaded 1200 times since 2006*

Users who downloaded this article also downloaded:

(1997), "Classics in production and operations management", International Journal of Operations & Production Management, Vol. 17 Iss 1 pp. 15-28 https://doi.org/10.1108/01443579710157961

(2016), "Visual management in production management: a literature synthesis", Journal of Manufacturing Technology Management, Vol. 27 Iss 6 pp. 766-799 https://doi.org/10.1108/JMTM-08-2015-0071

Access to this document was granted through an Emerald subscription provided by emerald-srm:322938 []

For Authors

If you would like to write for this, or any other Emerald publication, then please use our Emerald for Authors service information about how to choose which publication to write for and submission guidelines are available for all. Please visit www.emeraldinsight.com/authors for more information.

About Emerald www.emeraldinsight.com

Emerald is a global publisher linking research and practice to the benefit of society. The company manages a portfolio of more than 290 journals and over 2,350 books and book series volumes, as well as providing an extensive range of online products and additional customer resources and services.

Emerald is both COUNTER 4 and TRANSFER compliant. The organization is a partner of the Committee on Publication Ethics (COPE) and also works with Portico and the LOCKSS initiative for digital archive preservation.

*Related content and download information correct at time of download.

POM: a highly visual production and operations management environment

Godfrey C. Onwubolu and Samson Mhlanga

Department of Industrial Engineering, National University of Science & Technology, Bulawayo, Zimbabwe

Reports the development and successful implementation of a computer-integrated production and operations management system (POM), encompassing schedule activities such as aggregate production plan, master production schedule and material requirements plan, and capacity activities such as financial plan, resource requirements plan, rough-cut capacity plan and capacity requirements plan, at the planning level. POM's icon-menu-driven system, which associates icons with decision model spreadsheets, makes it very user-friendly, and facilitates the integration of decisions encountered by industrial/manufacturing engineers and operations managers.

Introduction

Organizing and managing schedule (or priority) and capacity activities involved in production management is considered the most basic and most difficult management task in a manufacturing environment. Both schedule (or priority) and capacity must be balanced and performed at planning and execution levels. At the planning level, the schedule activities include corporate strategic plan, business plan, aggregate production plan, master production schedule and material requirements plan. The accompanying capacity activities at the planning level include financial planning, resource requirement plan, rough-cut capacity plan and capacity requirement plan. At the execution level, the schedule elements include final assembly schedule, stock picking schedules, order priorities and operations sequence. The capacity elements at this level include labour control, inventory control, factory order control, machine (or work centre) control, tool control and preventive maintenance. The major problem encountered by manufacturing/industrial engineers and production/operations managers is to bring these elements together, to integrate them, in order to establish a weekly production schedule which satisfies each assembly and product requirement at each work centre for a given time-phased planning horizon. An important aspect of integrating the various elements of production management is decision making.

Decisions have to be made as to whether or not to accept outputs which may depend on previous decisions made. Decisions also have to be made as to whether or not to utilize inputs which may affect later decisions to be made.

The two decision approaches commonly in use are the successive approach and the interactive approach. The successive approach is one in which all the decisions are assigned to the computer to treat them simultaneously with an optimizing strategy. This approach does not simulate the way in which decisions are made in practice especially when the problem domain is complex. The interactive approach allows the human to define and

perform individual decisions at one time. In this case it is possible to influence successive decisions by the outcomes of previous decisions. This is the way decisions are made in practice although it may require several iterations to alter previous decisions made. This technique is easier to comprehend and the decision maker needs to have a knowledge of the environment.

Research work in the area of interactive computer-assisted production planning systems includes that by Southern[1,2], Lindeque and Kruger[3] and Morgan[4]. More recently Starr and Mahmoodi[5] presented a successfully implemented production planning system that utilizes a cross-breed of analytical methods, linear programming and spreadsheet analyser. The use of linear programming for resource allocation requires that there be one objective and that all functions be linear. In practice, however, costs involved are usually non-linear such as in aggregate planning. This paper describes the development and successful implementation of a computer-integrated production and operation management system (POM) based on a spreadsheet analyser for all schedule and capacity elements at the planning level. The use of a spreadsheet analyser for the implementation for all the decision elements makes POM a highly visual and transparent environment to the user.

POM overview

POM is a menu-driven system developed to run in an MS-DOS Windows environment. The main menu in the form of icons is created in the Microsoft Works for Windows environment[6], the data integration program was written in Turbo C[7] and the remainder of the system was developed using Lotus 1-2-3 Release 2.4[8].

The goals of POM are:

- 1 to present user-driven production planning opportunities;
- 2 to perform the production planning with flexibility for decision making; and
- 3 to present the production planning results in highly visual form.

Godfrey C. Onwubolu and
Samson Mhlanga
*POM: a highly visual
production and operations
management environment*
Industrial Management &
Data Systems
97/3 [1997] 99–113

In order to meet these goals, careful consid-
eration was given to the selection of soft-
ware for implementation. Since production
schedule and capacity at the planning level
lends itself to a tabular format, a spread-
sheet was needed. Lotus 1-2-3 spreadsheet
was chosen because it has the capabilities
for mathematical calculations, and it has a
mechanism for linking two spreadsheets
through a formula link. It has the capability
of taking up formulae for referencing
between cells and has numerical formulae,
string formulae and logical formulae as
tools for mathematical calculations. The

main advantage of Lotus 1-2-3 is its macro
facility. A macro is a set of instructions
which can be created by a user for perform-
ing repetitive tasks in Lotus 1-2-3 worksheet
without having to retype the instructions
each time. The Microsoft Works for
Windows icon menu system has the
capability of associating each icon with an
application program so that when the pro-
gram is completed, automatic transfer is
made to the main menu. The Microsoft
Works for Windows has the capability for
embedding objects such as files, pictures
and art. The embedded objects are placed as
icons which are linked to the file. Before
icons of the files were created there was
need to associate the spreadsheet models to
Lotus 1-2-3 Release 2.4 and the data integra-
tion program running on C-language were
associated to Turbo C.

Planning production using POM enables
the user to work with a cascade of interactive
screens. The main menu screen enables the
user to select an icon describing the planning
function to be activated (Figure 1). This is
done by clicking the mouse on the icon of
interest. The Lotus 1-2-3 screens (Figure 2)
for the various planning elements are used to
edit, define range, copy, move, file, print,
graph, query and quit. The data integration
panel (Figure 3) is a menu developed for inte-
gration when specialized packages such as
STORM or LINDO are used. There may be a
need to have an independent link from that
generated using Lotus 1-2-3. To facilitate this

Figure 1
Production planning elements in POM's main menu

Figure 2
Lotus 1-2-3 main menu for various production planning elements

	A	B	C	D	E	F	G	H	
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

Godfrey C. Onwubolu and
Samson Mhlanga
*POM: a highly visual
production and operations
management environment*
Industrial Management &
Data Systems
97/3 [1997] 99–113

Figure 3
POM's data integration panel in Turbo C

MAIN MENU		
FORECAST		1
BUSINESS PLANNING		2
AGGREGATE PLANNING		3
MASTER PRODUCTION SCHEDULING		4
MATERIAL REQUIREMENT PLANNING		5
CAPACITY REQUIREMENT PLANNING		6
↑	↑	↑

a C-language program was written which transfers text files from one name (as per specification of the user) and stores it in another name that can be accessed by a subsequent function as a text file. The functions of each main menu option of the data integration panel are presented in Table I. A summary of POM's hardware installation requirements are presented in Table II.

Table I
Main menu functions of POM data integration panel

Main option	Function	
Forecasting	Retrieve results of forecasting by Lotus	1
	Save results for next stage, business planning	2
	Quit to main menu	3
	Please make your selection	
Business planning	Retrieve forecast results	1
	Save results of rough-cut capacity planning	2
	Quit to main menu	3
	Please make your selection	
Aggregate planning	Retrieve the forecast results	1
	Retrieve costs from aggregate database	2
	Send forecast result to MPS	3
	Quit to main menu	4
	Please make your selection	
Master production scheduling	Retrieve the forecast results	1
	Retrieve input to MPS from MPS database	2
	Prepare results of MPS for MRP	3
	Quit to main menu	4
	Please make your selection	
Material requirement planning	Retrieve MPS results	1
	Prepare data from DB-MRP for MRP	2
	Prepare MRP results – CRP/purchasing	3
	Quit to main menu	4
	Please make your selection	
Capacity requirement planning	Retrieve MRP results	1
	Save results of CRP	2
	Quit to main menu	3
	Please make your selection	

Table II
Hardware installation requirements for POM

Operating system	MS-DOS 3.1 or later Microsoft Works for Windows 3.1 or later
Hardware system	IBM PC or compatible with an 80486 processor or higher and at least 2MB of RAM and 14 MB of free space on hard disk
Monitor	Video graphics array (VGA) or better
Auxiliary storage (Microsoft Works)	11.5 MB
Auxiliary storage (Lotus 1-2-3)	7MB
Auxiliary storage (POM)	74KB

POM production planning example

A detailed description of how to use POM to plan and manage production is given in this section. The icons in Figure 1 have been so arranged that the user can go from one integration element to the other in a sequential manner, although this is not necessary.

Sales historical records

SALES.WK1 is the Lotus 1-2-3 worksheet for this option. Since there is need to keep a record of 36 months of a product but use only the last 12 months' records to calculate the forecast, a database SALES.WK1 was designed (Figure 4). The database holds sales historical data for several products. Two macros were written: SALCPY to send data to OUTPUT range and QUIT to quit. To choose which products are to be considered for forecasting, a macro is run using <ALT-F3> function keys. This pulls out a new menu (Figure 5) but maintains all the sales historical records of Figure 4.

From the macro menu, the user is requested to select the macro to run. Selecting the macro SALCPY results in the control panel displaying: copy what? The user can respond by specifying the range name (for example PRODUCT 1) or the range B30..B41. The range name PRODUCT 1 tallies with B30..B41, PRODUCT 2 tallies with C30..C41, PRODUCT 3 tallies with D30..D41 etc. Specifying the range name or range sends the last 12 sales historical records to the OUTPUT range A48..A59. It is important at this stage to save the worksheet and then select QUIT macro to exit.

Forecasting

FORECAST.WK1 is the Lotus 1-2-3 worksheet for this option. A single exponential forecasting formulation was fitted in the FORECAST.WK1 worksheet (Figure 6). The smoothing

Godfrey C. Onwubolu and
Samson Mhlana
*POM: a highly visual
production and operations
management environment*
Industrial Management &
Data Systems
97/3 [1997] 99–113

Figure 4

Lotus 1-2-3 worksheet for sales historical data

	A	B	C	D	E	F	G	H
1	SALES HISTORICAL RECORDS							
2	(1)TO SEND DATA TO OUTPUT RUN MACRO				(2)TO QUIT MODEL RUN MACRO			
3	SALCPY				QUIT			
4								
5	MONTH	PRODUCT1	PRODUCT2	PRODUCT3	PRODUCT4	PRODUCT5	PRODUCT6	
6	1	32	65	56				
7	2	32	56	76				
8	3	34	53	87				
9	4	54	56	96				
10	5	45	67	87				
11	6	46	66	65				
12	7	53	63	54				
13	8	42	51	43				
14	9	35	46	46				
15	10	46	47	73				
16	11	57	42	62				
17	12	67	49	61				
18	13	78	58	83				
19	14	58	63	72				
20	15	65	64	83				
21	16	45	67	84				
22	17	34	66	94				
23	18	34	61	67				
24	19	23	59	64				
25	20	23	52	63				
26	21	35	52	62				
27	22	34	35	69				
28	23	47	66	93				
29	24	51	79	47				
30	25	33	75	49				
31	26	26	45	42				
32	27	34	46	41				
33	28	35	57	40				
34	29	40	66	41				
35	30	45	65	96				
36	31	42	56	84				
37	32	43	75	86				
38	33	41	66	88				
39	34	48	64	77				
40	35	46	60	56				
41	36	47	56	64				
42								
43								
44								
45								
46								
47	OUTPUT							
48	33							
49	28							
50	34							
51	35							
52	40							
53	45							
54	42							
55	43							
56	41							
57	48							
58	46							
59	47							
60								

constant is stored in cell A3 and one (1) minus the smoothing constant is stored in cell B3. The user can change the smoothing constant in cell A3 which automatically adjusts the value in cell B3. The OUTPUT range of the sales historical records holding the 12 last

data for any of the products being considered is directly linked to the DEMAND range of the forecast worksheet using a formula that links the spreadsheet of the sales historical data to the forecast spreadsheet. The formula is written for each demand cell B5..B16. For

Godfrey C. Onwubolu and
Samson Mhlanga
*POM: a highly visual
production and operations
management environment*
Industrial Management &
Data Systems
97/3 [1997] 99-113

example, for product 1, the last 12 sales historical records data exported to the forecast worksheet is {33, 28, 34, 35, 40, 45, 42, 43, 41, 48, 46, 47}, for product 2 is {49, 42, 41, 40, 41, 96, 84, 86, 88, 77, 56, 64} and for product 3 is {49, 42, 41, 40, 41, 96, 84, 86, 88, 77, 56, 64}. The single exponential forecast formulation is given in cells C5..C16 based on the demands in cells B5..B16. Two macros were written in the forecast worksheet: SAVE to save the forecast results and TO-QUIT to exit the worksheet. When the user presses ALT-F3 the macro menu for forecast (Figure 7) appears. Choosing the SAVE macro asks a further question whether the user wants to save the forecast result. Responding Y <ENTER> requests the user to enter the name of the file to hold the forecast result. The forecast results are then saved in the specified file. Part of the SAVE macro has been written in such a way that the cell pointer moves down each forecast result as it saves the contents of the B49..B60 cell range

Figure 5

POM's macro menu for sales historical records

List ◀ ▶ ▲ ▼ ?
Select the macro to run:
MONTH OUTPUT PRODUCT1 PRODUCT2 PRODUCT3 PRODUCT4 QUIT SALCPY
Copy what? B30..B41

Figure 6

Lotus 1-2-3 worksheet for forecast

	A	B	C	D	E	F	G	H
1	EXPONENTIAL SMOOTHING CONSTANT WEIGHTED FORECASTING TECHNIQUE							
2	smoothing constant A3				(1)TO OUTPUT RUN MACRO			
3	0.2		0.8		SAVE			
4	MONTH	DEMAND	FORECAST					
5	1	33	33.0					
6	2	26	29.0					
7	3	34	33.0		(2)TO QUIT WORKSHEET RUN MACRO			
8	4	35	34.0		TO_QUIT			
9	5	40	38.9					
10	6	45	43.8					
11	7	42	42.4					
12	8	43	42.9					
13	9	41	41.4					
14	10	48	46.7					
15	11	46	46.1					
16	12	47	46.8					
17								
18								
19	OUTPUT							
20		33						
21		26						
22		34						
23		35						
24		40						
25		45						
26		42						
27		43						
28		41						
29		45						
30		46						
31		47						
32								
33								
34								
35								

Figure 7

POM's macro menu for forecast

List ◀ ▶ ▲ ▼ ?
Select the macro to run:
COUNTER FILE GATE KEYPRESS \$AVE TO FILE TO_QUIT WD WRITE-REC
Do you want to save forecast result Y(es)N(o):
Enter name of file: (filename)

into the file. The TO-QUIT option (see Figure 7) may then be chosen to exit the forecast worksheet.

Financial plan

FINANCE.WK1 is the Lotus 1-2-3 worksheet (Figure 8) for this option. For each product and operation, the processing times, labour rates and material costs per unit are held in the worksheet. A range, INPUT was defined as cells H20..H31 to import forecasts for each product using the READPRO macro that was written. To run the macro, <ALT-F3> function keys are pressed to give the macro menu shown in Figure 9. When the user selects READPRO macro, the name of the file to be imported is requested. This file must hold the forecast information saved earlier. The forecast for a product is then imported and stored on the current financial plan worksheet within the INPUT range defined as H20..H31. A cell, SUM was created at location H35 to store the summation of the forecast for the planning time horizon which then becomes the planned production for a product being considered by the user. The user then runs the macro COPYPRO which then copies the planned production from cell SUM to the location for planned production for a product. The macro READPRO imports the forecasts (Figure 6) of the sales historic records (Figure 4) for each product to cells H20..H31 named INPUT in the financial plan worksheet. The sum of the forecasts for product 1 becomes the planned production of 479, for product 2 a planned production of 739 and for product 3 a planned production of 760.

The two processes of running macros READPRO and COPYPRO are repeated by the user to generate planned productions for all products. Cells B17..F19 have been so formulated to compute production costs and material costs for each product and the total production cost is stored in cell location F19. Four cells were assigned names such as BUDGETSALE with which the user supplies the budgeted sale to the Lotus 1-2-3 worksheet, OVERHEAD for overhead expressed as percentage of the total production cost,

Godfrey C. Onwubolu and
Samson Mhlanga
*POM: a highly visual
production and operations
management environment*
Industrial Management &
Data Systems
97/3 [1997] 99–113

Figure 8

Lotus 1-2-3 worksheet for financial plan

	A	B	C	D	E	F	G	H	I
1	FINANCIAL PLAN WORKSHEET								
2		PROD1	PROD2	PROD3	PROD4	LABOUR COSTS			
3	OPERATION								
4									
5	OP1	0.6	0.7	0.6		20			
6	OP2	0.2	0.1	0.2		10			
7	OP3	0.15	0.1	0.15		5			BUDGET SALES
8									60000000
9									
10								OVERHEAD	
11								25	
12									
13								SELLEXP	
14								35	
15	[PLANPRO:	479	739	780					
16	MAT/UNIT	5	4	6				ADMEXP	
17		8961.25	11454.5	11210		31645.75		40	
18		2395	2956	4560		9911			
19	TOTAL PROD COSTX1,000					41556.75		INPUT	
20	BUDGET INCOME							33	
21	BUDGET SALES?					60000000		29	
22	COST OF GOODS SOLD					41556750		33	
23	OVERHEAD (% OF PRODUCTION)?					10369187		35	
24	GROSS MARGIN					8054062		39	
25	SELING EXPENSES					2618921.		44	
26	ADMIN EXPENSES					3221625		42	
27	OPERATING INCOME					2013515.		43	
28								41	
29								47	
30								46	
31								47	
32									
33									
34									
35								479	
36									
37									
38									

Figure 9

POM's macro menu for financial plan

SELLEXP for the selling expenses expressed as a percentage of the gross and ADMEXP for the administration expenses.

The financial plan worksheet then uses these inputs to compute the cost of goods sold, overheads, gross margin, selling expenses, administrative expenses and operating income. From the output of the operating income stored in cell location F27, an indication is given as to whether or not the financial plan is feasible. A positive value shows a feasible plan and a negative value shows a non-feasible plan. The operating income of \$68,984.34 in the current worksheet for product 1, product 2 and product 3

in Figure 8 shows a feasible financial plan because it is a positive value.

A non-feasible financial plan cautions the user that the forecast may have to be adjusted. Moreover, adjusting any of the processing times, material costs, sales budget, overheads, selling expenses and administration expenses, automatically changes the operating income. This attribute of flexibility in adjustment of the operating income is possible through the inter-cells formula-link capability of Lotus 1-2-3 and is a key to integration.

Aggregate planning

The database for POM's aggregate planning is DB-AGG.WK1 holding the costs for material, inventory holding, stock out, subcontracting, hiring and training, lay-off, straight line, overtime, as well as beginning inventory, size of workforce, labour hours and safety stock coefficient as shown in Figure 10. Three macros which were written for this worksheet include QUERY, SAVE and QUIT. The user presses <ALT-F3> to activate the macro menu (Figure 11) and chooses the QUERY macro which was written using query logic

Figure 10
Lotus 1-2-3 worksheet for aggregate plan database

A B C D E F G H I J K L M												
COSTS AND INFORMATION FOR AGGREGATE PLANNING												
(1) TO QUERY DATA RUN MACRO /QUERY	(2) TO SEND DATA TO TEXT FILE RUN MACRO SAVE			(3) TO QUIT RUN MACRO QUIT								
MONTH	MATERIAL COST	INVENTORY COST	MARGINAL HOLD-COST	CONTR-COST	HIRING & TRIGG	LAYOFF	LABOUR HRS REQ	STRAIGHT LINE-COST	OVERTIME COST	BEGINING INVENTORY	CONSTANT WORKFORCE	SAFETY STOCK COEFFICIENT
1	1	4	34	12	12	4	6	5	8	12	10	40
2	2	5	23	11	23	5	7	6	8	12	30	40
3	3	7	12	23	32	6	8	4	8	12	20	40
4	4	6	56	94	49	7	6	5	8	12	20	40
5	5	9	67	17	54	5	7	7	8	12	30	40
6	6	3	87	45	56	9	5	8	8	12	40	40
7	7	5	98	56	67	5	6	3	8	12	40	40
8	8	2	97	54	78	7	8	6	8	12	60	40
9	9	3	65	65	86	6	7	5	8	12	10	40
10	10	4	54	333	86	9	6	9	8	12	30	40
11	11	5	94	44	54	4	7	5	8	12	60	40
12	12	5	45	44	34	4	8	7	8	12	50	40
13	13	6	56	56	35	5	7	6	8	12	40	40
CRITERIA RANGE												
OUTPUT												
PRODUCT	1	MATERIAL	INVENTORY	MARGINAL	CONTR-CST	HIRING	LABOUR	STRAIGHT	OVERTIME	BEGINING	CONSTANT	SAFETY STOCK
1	1	4	94	12	12	4	6	5	8	12	10	40
SEND												
4												
31												
32												
33												
34												
35												
36												
37												
38												
39												
40												
41												
42												
43												
44												
45												
46												
47												

Figure 11
POM's macro menu for aggregate plan data-
base query

for extraction of data from a database. The user is then requested to input the product number resulting in all information relating to the product number being copied to the SEND range A31..A42. To save the current worksheet after querying, the user runs the SAVE macro and quits the session by running the QUIT macro. The information within the SEND range becomes the input to the aggregate plan worksheet. The information in the SEND range in Figure 10 relates to product 1. Any of the products can be queried in similar manner.

The aggregate plan worksheet is AGGPLAN.WK1 (Figure 12). Two main macros written for the aggregate planning are READCOST to extract the information previously queried in the DB-AGG.WK1 and READFOR; which extracts the forecast already obtained in the forecast worksheet FORECAST.WK1 and held in a file. To perform the aggregate plan, the user presses <ALT-F3> to pull out the current macro menu (Figure 13). Selecting the READCOST macro option moves the cell pointer to location E8 and extracts the previous query data from the aggregate plan database DB-AGG.WK1 and places these information in range E8..E19 in the current AGGPLAN.WK1 worksheet. This information includes inventory holding cost, marginal stock for stock out, marginal cost of subcontracting, hiring and training cost, lay-off cost, labour hours required, straight line cost, overtime cost, beginning inventory, size of workforce and safety stock coefficient. The values of these parameters which appear on column E8..E19 in Figure 12 correspond to data in SEND range A31..A42 of the aggregate plan database DB-AGG.WK1 for product 1. By running the READFOR macro using <ALT-F3> ENTER, the cell pointer moves to cell location C25 and prompts the user to supply the name of the file holding the forecast for the product under consideration. When this is supplied, the forecast is extracted from the file and pasted in the current aggregate plan worksheet within range C25..C36. The forecast data become the demand forecast. Using this information and the working days per month in cell range D25..D36, the aggregate

plan worksheet for cell ranges B25..B36 has been mathematically formulated to compute and store the beginning inventory, cell ranges E25..E36 to compute and store the safety stock, F25..F36 to compute and store the production requirement and G25..G36 to compute and store the ending inventory.

Although linear programming can be used for aggregate planning, the “cut and try” method of aggregate planning for checking that forecast demands are within the company was adopted for POM system. There are four strategies in the cut and try method which were implemented in the aggregate plan worksheet AGGPLAN.WK1:

- *Production plan 1* (chase strategy) which utilizes exact production but a varying workforce, was implemented in cell range A38..K54. This strategy matches the production rate to the order rate by hiring and laying off employees as orders vary.
- *Production plan 2* (stable workforce strategy) which utilizes a constant workforce but varying inventory and stockout was implemented in cell range A56..M72. This strategy involves varying the output by varying the number of hours worked through flexible work schedules or overtime.
- *Production plan 3* (level strategy) which utilizes a constant low workforce; subcontracting was implemented in cell range A76..H90. This strategy maintains a stable workforce working at a constant output rate with shortages and surpluses absorbed by fluctuating inventory levels, order backlogs and lost sales.
- *Production plan 4* (mixed strategy) which utilizes a constant workforce and schedules overtime implemented in cell range A92..M108. This strategy seeks an optimal solution which integrates two or more strategies in order to optimize cost.

Comparison of the four plans was implemented in cell range A111..F127 so that the user can compare the total cost for each of the plans. For product 1 under consideration, the total cost using plan 1 is \$19,230, for plan 2 is \$2,578,723, for plan 3 is \$25,845, and for plan 4 is \$1,603,807. Since plan 1 is minimum, the POM aggregate plan advises the user to adopt plan 1 which uses exact production but varies workforce. Varying the costs in cell range E8..E19 or the forecast in cell range C25..C36 results in different total costs for plan 1, plan 2, plan 3 and plan 4.

Master production schedule

POM's database for the master production schedule is MPS.WK1 and it holds the

Figure 12
Lotus 1-2-3 worksheet for aggregate plan

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	AGGREGATE PLANNING												
2	(1)TO IMPORT COSTS RUN MACRO												
3	READCOST												
4	(2)TO IMPORT FORECAST DEMAND RUN MACRO												
5	READFOR												
6	INPUT AREA												
7	COSTS												
8	MATERIAL												
9	INVENTORY HOLDING COST (IN-H-COST)												
10	MARGINAL COST OF STOCK OUT (M-C-ST-OUT)												
11	MARGINAL COST OF SUBCONTRACTING (M-C-S)												
12	HIRING AND TRAINING COST (HRG-TRG)												
13	LAYOFF COST												
14	LABOURHOURS REQUIRED (HRS-RQD)												
15	STRAIGHT LINE COST (HRS/DAY) (ST-LN-COST)												
16	OVERTIME COST(TIME AND A HALF) (OVERTIME)												
17	BEGINNING INVENTORY (BEG-INV)												
18	SIZE OF WORKFORCE												
19	SAFETY STOCK COEFFICIENTS												
20	PRODUCTION PLANNING REQUIREMENT												
21													
22													
23	MONTH	BEGINNING INVENTORY	DEMAND FORECAST	WORKG DAYS PER MONTH	SAFETY STOCK	PRODUCTION REQUIREMENT	ENDING INVENTORY						
24	JAN	10	36	22	31	6	31	6					
25	FEB	6	29	19	7	7	29	7					
26	MAR	7	39	21	8	8	34	8					
27	APR	8	35	21	9	9	96	9					
28	MAY	9	39	22	10	10	40	10					
29	JUN	10	44	20	11	11	45	11					
30	JUL	11	42	22	11	11	42	11					
31	AUG	11	49	19	11	11	43	11					
32	SEP	11	41	21	10	10	41	10					
33	OCT	10	47	21	12	12	49	12					
34	NOV	12	46	22	12	12	46	12					
35	DEC	12	47	20	12	12	47	12					
36											491		
37													

Figure 12

	A	B	C	D	E	F	G	H	I	J	K	L	M
111	COMPARISON OF FOUR PLANS												
112													
113		PLAN 1:	PLAN 2:	PLAN 3:	PLAN 4:								
114		EXACT	CONSTANT	CONSTANT	CONSTANT								
115		PRODUCTION	WORK FORCE	LOW WORK	WORK FORCE								
116		VARY WORK	VARY	FORCE	SUBCONTRACT								
117		FORCE	INVENTORY										
118			AND										
119			STOCK OUT										
120	COST												
121	HIRING		0										
122	LAYOFF		0										
123	EXCESS INVENTORY			2559-499		963907							
124	SHORTAGE			0									
125	SUBCONTRACT				0								
126	OVERTIME					0							
127	STRAIGHT TIME		19290	19280	20845	640000							
128			19280	2578723	20845	1603907							
129													
130													
131													
132													
133													
134													
135													

Figure 13

POM's macro menu for aggregate plan

manual forecast (Figure 14) and customer order (Figure 15). The input data for each product for the different time buckets within the planning horizon is stored in the cell range INPUT within locations A11..026. To run the database macro the user presses <ALT-F3> function keys to pull out the macro menu for manual forecast (Figure 16). By selecting the QUERY option, the product number is requested from the user. When supplied, all the information relating to the product is extracted within the INPUT range A11..026 into the SEND range locations A44..A58. For example, the current SEND range A44..A58 contains the manual forecast for time buckets 1, 2, ... 12 as well as safety stock and projected available balance at time $t = 0$. Similarly when the customer order is required, the user presses <ALT-F3> function keys to pull up the macro menu for customer order (Figure 17). By selecting the SAVE option the manual forecast or customer order may be saved. To quit the database QUIT option is chosen.

Once the user is working with the master production schedule worksheet MPS.WK1 (Figure 18), pressing <ALT-F3> keys pulls up the macro menu for MPS (Figure 19). When the user chooses the SYS-FOR option the cell pointer moves to cell range SYS-FOR C14..C25 and the file name holding the forecast information of the FORECAST.WK1 worksheet is

opened. The file contents are then extracted and pasted in the SYS-FOR cell range. These data constitute the systems forecast. For product 1, the forecast results for 12 weeks extracted from FORECAST.WK1 and pasted in cell range C14..C25 are {33, 29, 33, 35, 39, 44, 42, 43, 41, 47, 46, 47}. The user then chooses the MAN-FOR option from the macro menu which results in the cell pointer moving to the cell range MAN A37..A51 and the manual forecast for 12 weeks of {23, 56, 23, 0, 0, 0, 0, 0, 0, 0, 0, 0} from the MPS database is extracted into cell location, B14..B25 of the MPS worksheet.

Similarly, by choosing the CUST option the cell pointer moves to the cell range CUS B37..B50 and the customer order for 12 weeks of {45, 64, 46, 44, 65, 66, 78, 78, 87, 0, 0, 0} from the MPS database is extracted into these cell locations D14..D25 of the MPS worksheet.

The range F14..F25 has been formulated to compute the master production schedule for each week and the results for the total planned horizon are copied to the OUTPUT range C37..C48. The total demands for each week are computed and stored in range E14..E25; the projected available balances for each week are computed and stored in range G14..G25, available to promise in range H14..H25, and cumulative available to promise in I14..I25. For example, the master production schedule of product 1 for weeks 1, 2, ...12 in Figure 18 is given by {0, 49, 46, 35, 39, 44, 42, 43, 41, 47, 46, 47}.

Material requirement planning

POM's material requirement planning database is DB-MRP.WK1 (Figure 20). The data area contains the levels of each finished product, assembly or subassembly in the bill of material (BOM), the lot size, lead times, make/buy options, current inventory,

Godfrey C. Onwubolu and
Samson Mhlanga
*POM: a highly visual
production and operations
management environment*
Industrial Management &
Data Systems
97/3 [1997] 99–113

Figure 14
Lotus 1-2-3 Worksheet for MPS database: (a) manual forecast

scheduled receipt and due dates. When the user presses the <ALT-F3> function keys the database menu screen (Figure 21) is pulled out. Selecting option QUERY prompts the user to input the part number selection. For example, supplying the part number as BP-215 results in all information describing the

part number being extracted and pasted in the range ODB-MRP in locations A46..A53. Choosing the DBSEND-MRP prompts the user to save the extracted information. The QUIT option enables the user to quit the database. MRP.WK1 is the material requirement planning worksheet for POM (Figure 22). The user

Figure 15
Lotus 1-2-3 Worksheet for MPS database: (b) customer order

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	MASTER PRODUCTION SCHEDULING DATABASE												
2	(1) TO QUERY DATA	(2) TO SAVE	(3) TO QUIT SPREADSHEET										
3	RUN MACRO	RUN MACRO	RUN MACRO										
4	QUERY	SAVE	QUIT										
5													
6													
7													
8													
9													
10	CUSTOMER ORDER CURRENT												
11	PRODUCT	ONE	TWO	THREE	TIME BUCKET	FIVE	SIX	SEVEN	EIGHT	NINE	TEN	ELEVEN	TWELVE
12	1	45	56	64	FOUR	44	65	66	79	78	87	0	0
13	2	56	76	76	46	98	75	54	69	45	84	56	65
14	3				89								
15	4												
16	5												
17	6												
18	7												
19	8												
20	9												
21	10												
22	11												
23	12												
24	13												
25	14												
26	15												
27													
28													
29	PRODUCT	ONE	TWO	THREE	FOUR	FIVE	SIX	SEVEN	EIGHT	NINE	TEN	ELEVEN	TWELVE
30	1												
31													
32													
33													
34													
35													
36													
37	PRODUCT	ONE	OUTPUT RANGE	THREE	FOUR	FIVE	SIX	SEVEN	EIGHT	NINE	TEN	ELEVEN	TWELVE
38	1	45	TWO	54	46	44	65	66	79	78	87	0	0
39													
40													
41													
42													
43	SEND												
44	1												
45	45												
46	64												
47	46												
48	44												
49	65												
50	68												
51	78												
52	79												
53	87												
54	0												
55	0												
56	0												
57													
58													
59													

Godfrey C. Onwubolu and
Samson Mhlanga
*POM: a highly visual
production and operations
management environment*
Industrial Management &
Data Systems
97/3 [1997] 99-113

Figure 16

POM's macro menu for master production
schedule database query manual forecast

List ◀ ▶ ▲ ▼ ?
Select the macro to run:
COUNTER FILE INPUT LAB OUTPUT PRODUCT QUERY QUIT SAVE SEND W/D WRITE_REC 'IQ

Figure 17

POM's macro menu for master production
schedule database query customer order

List ◀ ▶ ▲ ▼ ?
Select the macro to run:
COUNTER FILE INPUT LAB OUTPUT PRODUCT QUERY QUIT SAVE SEND W/D WRITE_REC 'LAB 'IQ

accesses the MRP macro (Figure 23) by pressing function keys <ALT-F3>. When the macro option GROSS is selected the gross requirement is extracted from the database and pasted in the range GRQT within cell locations B13..B24. For product 1, the gross requirement corresponds to the master production schedule of {0, 49, 46, 35, 39, 44, 42, 43, 41, 47, 46, 47} previously obtained in MPS.WK1 worksheet. When the READATA macro option is selected the cell pointer moves to the INPUT range A31..A36 and extracts the previous query from the MRP database (Figure 20). The cell pointer moves to cell location C12 and pastes the schedule receipts at the exact time bucket.

Figure 18

Lotus 1-2-3 worksheet for master production schedule

	A	B	C	D	E	F	G	H	I
1	MASTER PRODUCTION SCHEDULE								
2									
3	(1)TO IMPORT	(2)TO IMPORT			(3)TO IMPORT		(4)TO SAVE	(5)TO QUIT	
4	SYSTEM FORECAST	MANUAL FORECAST			CUSTOMER ORDER		MPS RESULTS	RUN MACRO	
5	RUN MACRO	RUN MACRO			RUN MACRO		RUN MACRO		
6	SYS-FOR	MAN-FOR			CUST		SAVE	QUIT	
7									
8									
9									
10	WEEK	MANUAL	SYSTEM	CUSTOMER	TOTAL	MASTER	PROJECTED	AVAILABLE	CUMULATIVE
11	NUMBER	FORECAST	FORECAST	ORDER	DEMAND	PRODUCTION	AVAILABLE	TO	ATP
12						SCHEDULE	BALANCE	PROMISE	
13									
14	1	23	33	45	45	0	15	15	15
15	2	56	29	64	64	49	0	-15	0
16	3	23	33	46	46	46	0	0	0
17	4	0	35	44	35	35	0	0	0
18	5	0	39	65	39	39	0	0	0
19	6	0	44	66	44	44	0	0	0
20	7	0	42	78	42	42	0	0	0
21	8	0	43	78	43	43	0	0	0
22	9	0	41	87	41	41	0	0	0
23	10	0	47	0	47	47	0	47	47
24	11	0	46	0	46	46	0	46	93
25	12	0	47	0	47	47	0	47	140
26									
27									
28									
29									
30									
31									
32									
33									
34									
35	MANUAL	CUSTOMER	MP8						
36	RECEIVE	RECEIVE	OUTPUT						
37	1		1 0						
38	23		45 49						
39	56		64 46						
40	0		46 35						
41	0		44 49						
42	0		65 44						
43	0		66 42						
44	0		78 43						
45	0		78 41						
46	0		87 47						
47	0		0 46						
48	0		0 47						
49	0		0						
50	0								
51	60								
52									
53									
54									

Godfrey C. Onwubolu and
Samson Mhlanga
*POM: a highly visual
production and operations
management environment*
Industrial Management &
Data Systems
97/3 [1997] 99–113

In the current MRP worksheet the scheduled receipts are zero for all the 12 weeks except the third week when the value is 10. Initial inventory in week 1 is 10. The net requirements for the planning horizon are computed in cell range N-RQT within cell locations E13..E24 and using the lead time the net requirement is offset to obtain the planned order release. The planned order release is then saved using the SAVE option. The current planned order release for product 1 (Figure 22) given as {22, 46, 35, 39, 44, 42, 43, 41, 47, 46, 47} shows that for a net requirement of 24 in week 2 the order has to be placed in week 1 to give the suppliers sufficient time of 1 week lead time to deliver the part. The part number

Figure 19

POM's macro menu for master production schedule

List ◀ ▶ ▲ ▼ ?
Select the macro to run:
COUNTER CUS FILE FOR SYS MAN-FOR OUTPUT QUIT SAVE SYS-FOR WD WRITE_REC

Figure 20

Lotus 1-2-3 worksheet for material requirement planning

	A	B	C	D	E	F	G	H
1	DATABASE OF MATERIAL REQUIREMENT PLANNING							
2								
3								
4	(1)TO QUERY DATA		(2)TO SEND RESULTS			(3)TO QUIT		
5	RUN MACRO		RUN MACRO			RUN MACRO		
6	\QUERY		\DBSEND_MRP			QUIT		
7								
8								
9								
10	LEVEL	PART_NUM	LOT_SIZE	LEADTIME	MAKE_BUY	CUR_INVENT	SCHED-RECEIPTS	DUE_DATE
11		0 FP-100	L		1 M	5	20	2
12		1 MP-105	L		2 M	10	30	2
13		1 BP-200	L		2 B	5	10	3
14		1 BP-205	L		2 B	20	5	1
15		1 BP-210	L		2 B	20	8	2
16		1 BP-215	L		2 B	10	10	3
17								
18								
19								
20								
21								
22								
23								
24	LEVEL	CRITERIA RANGE						
25		PART_NUM	LOT_SIZE	LEADTIME	MAKE_BUY	CUR_INVENT	SCHED-RECEIPTS	DUE_DATE
26		FP-100						
27								
28								
29	LEVEL	OUTPUT RANGE						
30		PART_NUM	LOT_SIZE	LEADTIME	MAKE_BUY	CUR_INVENT	SCHED-RECEIPTS	DUE_DATE
31		0 FP-100	L		1 M	5	20	2
32								
33								
34	OD8_MRP							
35	0							
36	FP-100							
37	L							
38	1							
39	M							
40								
41	5							
42	20							
43	2							
44								
45								
46								

Figure 21

POM's macro menu for material requirement planning database

List ◀ ▶ ▲ ▼ ?
Select the macro to run:
COUNTER DBASE_MRP FILE LAB ODB_MRP PART_NUM QUIT WD WRITE_REC QUERY

BP-215 is a bought-part from the information held in the INPUT range of location A35. A similar procedure is adopted by the user to generate the planned order releases for all parts in the bill of material (BOM).

Summary and conclusions

One of the greatest recent contributions of information technology towards management science advancement is the electronic spreadsheet. Since a production schedule lends itself to a tabular format, the electronic spreadsheet has now become a powerful tool for manufacturing decision support. This article has demonstrated the

Godfrey C. Onwubolu and
Samson Mhlanga
*POM: a highly visual
production and operations
management environment*
Industrial Management &
Data Systems
97/3 [1997] 99-113

Figure 22

Lotus 1-2-3 worksheet for material requirement planning

	A	B	C	D	E	F	H
1	MATERIAL REQUIREMENT PLANNING						
2							
3	(1)TO IMPORT GROSS RQT	(2)TO IMPORT DATA FROM DB-MRP	(3)TO QUIT				
4	RUN MACRO	RUN MACRO	RUN MACRO				
5	GROSS	READDATA	Q				
6							
7	LEADTIME =	1					
8							
9							
10	WEEK	GROSS	SCHEDULED	PROJECTED	NET	PLANNED	
11	NUMBER	REQUIREMENT	RECEIPTS	INVENTORY	REQUIREMENT	ORDER	
12						RELEASE	
13	1	0	0	5	0	24	0
14	2	48	20	-24	24	46	24
15	3	46	0	-70	46	35	46
16	4	35	0	-105	35	39	35
17	5	39	0	-144	39	44	39
18	6	44	0	-188	44	42	44
19	7	42	0	-230	42	43	42
20	8	43	0	-273	43	41	43
21	9	41	0	-314	41	47	41
22	10	47	0	-361	47	46	47
23	11	46	0	-407	46	47	46
24	12	47	0	-454	47		47
25							
26							
27							
28							
29							
30	INPUT						
31	0	level					
32	FP-100	Part Number					
33	L	Lot size					
34	1	leadtime					
35	M	make/buy					
36	5	current inventory					
37	20	scheduled receipts					
38	2	due date					
39							
40							
41							
42							

Figure 23

Lotus 1-2-3 worksheet for material requirement planning

successful development of an integrated production management decision support environment, which brings together the schedule and capacity functions at the manufacturing planning level in a closed-loop manner. The system, which is entirely menu-driven, relies on the user to make decisions which determine whether or not to proceed downstream with the planning functions. POM is considered to be highly visible and transparent because all the data used for decision making are visible to the user. Operations engineers and managers using electronic spreadsheet-based decision support systems must be conversant with the problems they are solving because they must make practical decisions that affect operations planning.

References

- 1 Southern, G., "Teaching factory management: a practical approach", *European Journal of Engineering Education*, Vol. 7, 1982, pp. 189-200.
- 2 Southern, G., "Teaching the techniques of computer aided production management and simulation modelling", *International Journal of Operations & Production Management*, Vol. 6, 1986, pp. 15-24.
- 3 Lindeque, P. and Kruger, P.S., "The design of a microcomputer-based simulator for production management training", *Computers and Industrial Engineering*, Vol. 14, 1988, pp. 53-62.
- 4 Morgan, C.L., "Achieving academic and practitioner objectives in the basic POM survey course", *Production and Inventory Management Journal*, 1989, Vol. 31, pp. 48-51.
- 5 Starr, P.J. and Mahmoodi, F., "Development and teaching a computer-assisted course in production planning", *Production Planning and Control*, Vol. 5 No. 2, 1994, pp. 199-205.
- 6 Microsoft Corporation, *Microsoft Works for Windows User's Guide*, Redmond, WA, 1992.
- 7 Borland International, *Turbo C++ User's Manual*, Version 3.0, 1992.
- 8 Lotus Development Corporation, *Lotus 1-2-3 User's Manual*, Release 2.4, Cambridge, MA, 1985.