INDUSTRIAL DATA PROCESSING APPLICATIONS REPORT

Applications Production Scheduling and Control

Type of Industry Aerospace

Name of User McDonnell Douglas
St. Louis, Mo.

Equipment Used IBM System 360/40 & 360/65

IBM 1030 Data Collection Equipment

Synopsis

McDonnell Douglas makes extensive use of data processing in its St. Louis facility where the F4 Phantom aircraft are produced and several future manned spacecraft programs are under development. Just a brief synopsis of each system used would fill several volumes. This report centers on a few that are involved with the scheduling and control of parts production; in total, they form the Work Order Control System. From the time parts are scheduled for production until they are "flown away" a record is kept of their whereabouts and status, using a parts follow-up system involving data collection equipment. Data derived from this system provides input for numerous programs used to ascertain production status, to schedule production and to quickly inform product management of "trouble areas" where corrective action is required.

Background

McDonnell Douglas' Work Order Control System uses numerous data bases into which other areas of the company also feed data, and employs both manual and automated techniques to fulfill its function. While other functions in the manufacturing process employ data processing (for example, design engineers use computer graphics--cathode ray tube terminals linked to a computer--to produce programs for numerical control tools, and some of the numerical control tools are under direct control of a computer) work order control makes probably the most extensive use of data processing of any department involved in the manufacturing process.

The computers employed in Work Order Control's programs are an IBM System/360 Model 40 and a Model 65, part of the vast computer complex at the McDonnell Automation Co. which provides services for the component companies. The data banks used in work order control include:

(1) Bill of material file--listing part number, effectivity (the different models of an aircraft on which identical parts can be used), the quantity of each part required for the end item.

(2) Block requirements file--a listing by block (period of time, e.g. three months) of gross requirements.

(3) Work Order release file--containing part numbers and the date parts are to be started into production.

(4) Spares and miscellaneous requirements file--containing a listing of parts that are ordered separate from the aircraft.

(5) Accumulative master--an inventory file including every part number, its record since the previous release date taking into account over-inventory or under-inventory factors.

(6) Shortage file--containing a list of items particular areas are short; used for follow-up action by users and suppliers.

(7) Parts follow-up file--a list of open work orders, showing every work order that's in the shop with quantity of parts, schedule, serial numbers, current status and location, section number, etc. This is the key file used by numerous departments to ascertain status of orders and location of items in the production process.

(8) Standards file--containing "target" times for each step in the production process by shop area.

Systems Overview

One of the basic documents used in production planning and scheduling is called a tree chart. This chart is actually a graphic representation of the process by which the major components of an aircraft are put together. From this chart, section numbers are derived. Each part that goes into the aircraft carries, in addition to a part number, the section number that identifies its ultimate destination. At the same time, knowing at which stages the major components must be ready on the assembly line, it is possible to ascertain the dates on which work orders must be issued to the shop for parts and for subassemblies.

The input that starts the work order control cycle is an engineering drawing, released from design engineering. The drawing contains a part list which is routed to procurement as well as to production planning. Procurement enters the data from the parts list into the bill of material file, later used with input from production planning to produce purchase requisitions.

Production planning interprets the engineering drawing into a method of manufacture on a Planning Order. Work Order Control uses the Planning Order to issue work orders to the fabrication and assembly shops.

Work Order Control Functions

The basic functions of work order control are:

(1) Compute and maintain required quantities on both production and spare parts for all McDonnell-manufactured items.

(2) Compute and maintain scheduled start and completion dates for all effective releases.

(3) Provide means for adjusting shortage and overage quantities due to requirements changes.

(4) Provide open work order activity to the Parts Follow-Up System.

(5) Maintain historical records on each part number for machine analysis and posting to visual record cards.

(6) Provide functional reports, containing selected records, in the most efficient order for necessary action by the recipient operating departments.

Input to Work Order Control

From production planning, work order control receives a planning order which spells out in detail the material, tools, and operations necessary to produce each part. (In the case of assemblies, the planning order identifies component parts.)

Work order control checks data on the planning order against the engineering bill of material printout and also inserts the plus cycle number (number of working days between the completion of a part and its eventual installation into a tree chart item) and the section number (the section of the major assembly, shown on the tree chart, into which the component goes).

Data from the planning order is then keypunched and entered into the computer for the work order control program. The planning order then goes to a document reproduction center to await output of a computer-printed overlay to be used in making duplicates.

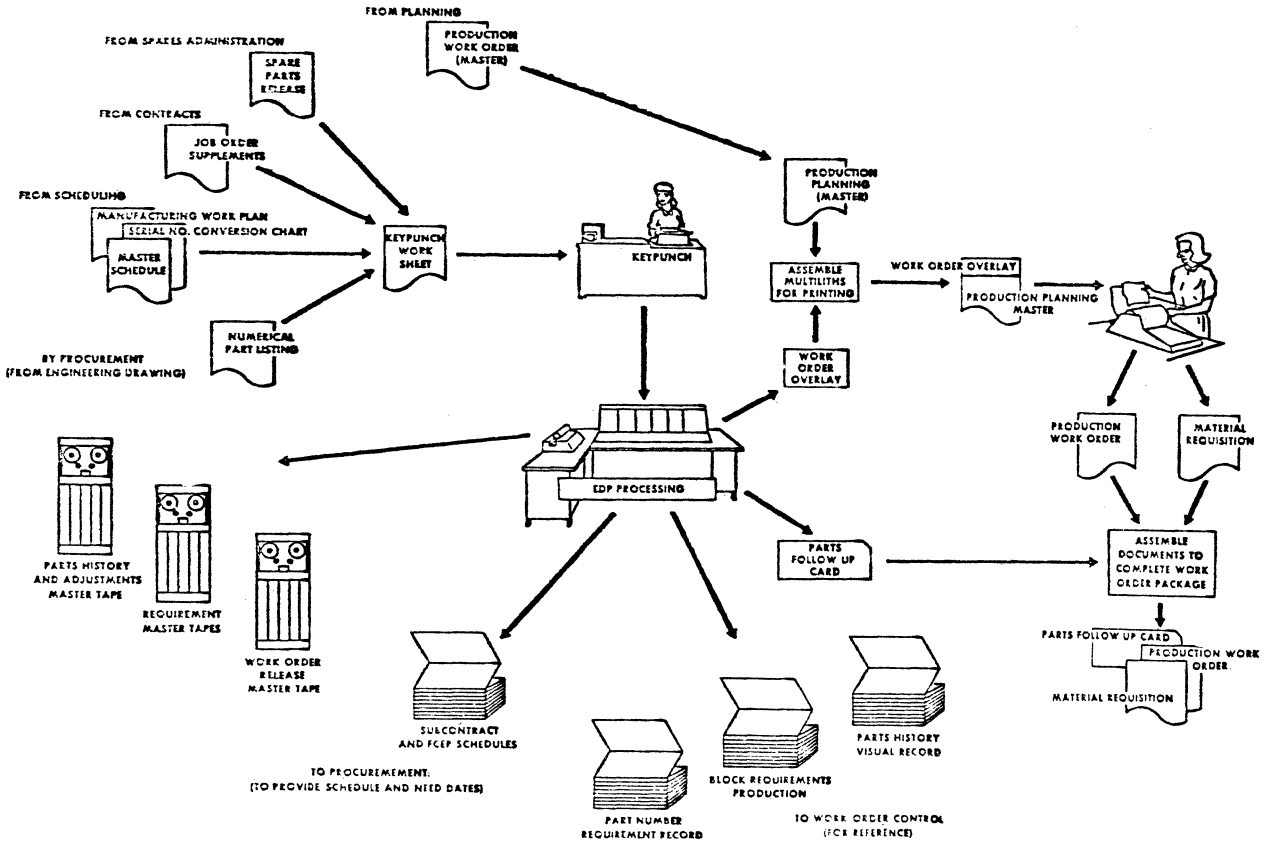
Work Order Control System

Four data banks are used in the work order control system. These are the Block Requirement Master (including bill of material data), Work Order Release Master, Spares and Miscellaneous Requirement Master and the Accumulative Master.

Data for these files comes from numerous sources including the parts follow-up system, contracts, manufacturing work plan, master schedule and from procurement.

Engineering drawings, production planning masters, support part releases and other production authorizations provide part number requirements, effectivities, quantity per aircraft, installation points, make departments, cycle time, next assembly and stock time. This information, used with the Master Schedule and Manufacturing Work Plan, determine total aircraft per block, model mix per block, major section installation, and scheduled "need" days of subassemblies and details relevant to their major section installation point.

WORK ORDER RELEASE SYSTEM



Schedule start and completion dates are computed and maintained by release date. These dates reflect consideration of installation point "need" day, next assembly flow time, part cycle time and advance time required to adjust for shop work load fluctuations.

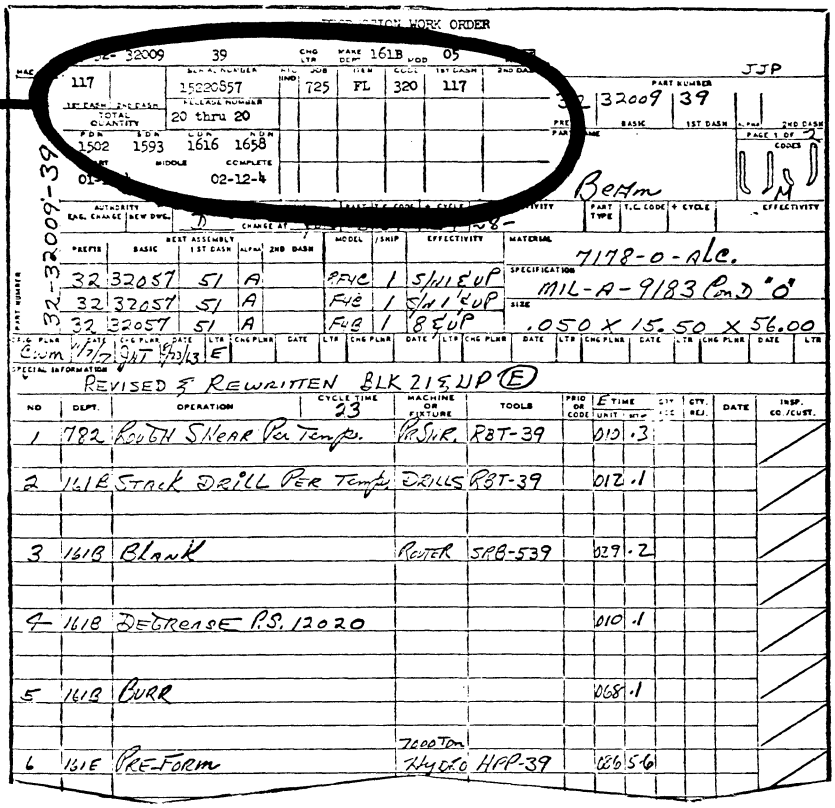
When a block of production parts is to be released, it is ascertained whether additional quantities--beyond what will go into the aircraft--are needed for each part number.

Validated shortages and overages are automatically replaced at the time of the next production release along with automatic work order date adjustments to coincide with using next assembly requirement schedules.

Output from Work Order Control

From the work order control program, numerous outputs are derived, including a multilith overlay that is used with the planning order master to produce actual work orders. The overlay provides information such as start and completion dates, quantity, and cost segregation. The overlay is placed on the planning order master and duplicate copies are made, using Xerox 2400 and Multilith 2650 copy reproduction units. The top half of the work order, with overlay, becomes the material requisition form for raw material.

Multilith Overlay



For assembly work orders, the work order release program triggers a material requisition (for purchased parts and equipment) from the bill of material file. A listing of the material requisitions prepared for each assembly order is sent to work order control and goes into the work order packet. The requisition, in punched card form, is automatically forwarded to stores and parts are delivered to the assembly area based on the assembly schedule. No stock, partial fills, receipts by Production Control etc. are reported using the punched card requisition in the IBM data collection equipment. Procurement matches work order control's identification of purchased part requirements against the engineering bill of material. Only after this check is the actual requisition released. Punched cards for each work order also are output. These identify the part and work order serial number and are used to report status and location in the parts follow-up system.

Parts Follow-Up System

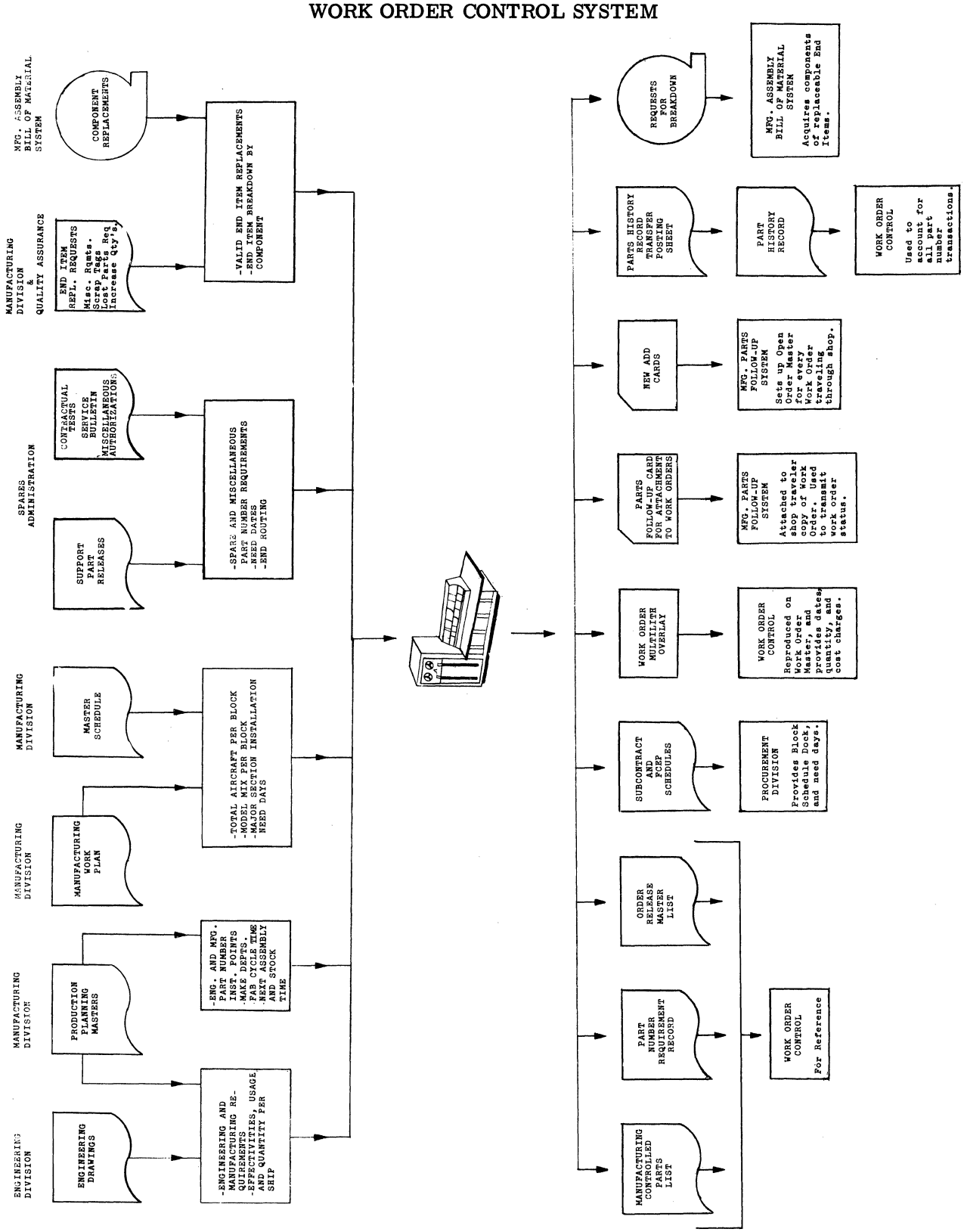
The parts follow-up system utilizes an IBM data collection system and the punched cards produced for the fabrication and assembly work order packets. There are 530 IBM Model 1031 card-badge readers located throughout the fabrication and assembly areas. Data input via these readers is recorded on-line and edited through an IBM 360/40 with a Model 2314 disc system, with eight disc drives, for later processing on a Model 65 computer.

The purposes of the follow-up system are:

(1) To facilitate the on-schedule movement of work orders through the detail fabrication and assembly shops by advance recognition and notification of trouble items and trouble areas to production and production control supervision.

(2) To provide supervision with work order counts and conditions active in each work center.

WORK ORDER CONTROL SYSTEM



(3) To furnish a current location of all open work orders, to be used for shortage coordination and schedule revisions.

(4) To provide a daily listing of completed detail fabrication and assembly work orders.

(5) To establish a record base for labor accounting, performance reporting systems, and shop load forecasting.

Each of the data collection units throughout the shop has programed into it an identification feature, so that in addition to recording data input by individuals in the shop, it also identifies itself. As work progresses through the shop, the follow-up cards are entered into the data collection devices. The cards identify model number, part number and serial number. Variable information including location, quantity, operations and status are also entered.

Input from the data collection system updates a Master Open Order Record that includes the whereabouts and status of every order in the shop. Each day, a master list of this file is printed out. Outputs from the system include:

(1) A material shortage tape, used for the procured parts shortage system.

(2) Expended labor activity updated with work order charges.

(3) Exception status expedite report, used by production and production control supervision to expedite potential or actual shortage items through work centers; also used by production control planners to establish priorities.

(4) Summary of open order status report, which presents counts of work orders at work centers by follow-up categories, to scheduled operational start dates.

(5) Work order location index, used by production control planners for shortage coordination and for schedule adjustments; also used by production control expediting to pinpoint specific trouble item work orders.

(6) Completion reports, used by production control planners in shortage coordination, also used to update work order completion records.

Procured Parts Shortage System

The purpose of the procured parts shortage system is to establish controls over current procured parts and raw material needs to assure that procurement action is compatible with schedule requirements. Also, the system minimizes procurement division reaction time to shortage conditions.

Raw material shortages are reported from the fabrication areas through the parts follow-up system. Work order serial number, order quantity, material type, start date and priority information are supplied, along with order location.

Purchased parts shortages are reported from assembly areas. In these areas, parts are kept in minimum bundles. When a bundle is opened the item is entered into the shortage system indicating the need date and ship short. Once each week, a physical check is made to ensure that the recorded status is accurate.

Outputs from this system include:

(1) Material no-stock reports--containing information about every work order which is or will be held up for material. Used by Fabrication Control.

(2) Assembly shortages--a listing of current information by assembly departments for every procured part detail below a 6-week supply.

(3) Vendor shortages--a separate report for each vendor, showing the status and priority of each delinquent part. Distributed by the Procurement Follow-Up Group to field expediters for action.

(4) Unplaced purchase requisitions lists--a listing of items requiring expedited placement of purchase orders.

(5) Complete shortage lists--containing all shortage records, combining data from specialized listings. This list is screened daily for the shortage coordination groups who spot and handle trouble items.

(6) New adds and unanswered records--a separate list for primary investigation, identifying items which have not been verified by material planners as having valid open purchase orders or purchase requisitions.

Part History Records

At the time a part is scheduled to go into production, a part history card is prepared with the part number printed at the top of the record. Each day a printout of part status is sent to the work order control section and the data for each part is heat transferred from the printout to the part history records. Input for the printout comes from the work order release and production control centers in manufacturing areas, and from data on other magnetic tape files. As soon as a work order is released to the production area, work order control records that fact by inserting the parts follow-up card into a data collection unit. All significant activity on that part is identified through the data collection system and then printed out for transferral to the part history record.

The part history includes:

(1) Cost charges--work order serial number and quantity of parts on work order.

(2) Changes to work orders--such as cost charge or quantity changes.

(3) Inventory adjustments.

(4) Department receiving and stocking parts--including date received and quantity received, on completion of work orders.

(5) Quantity of parts open on fabrication orders and quantity of parts open on rework order.

Major Assembly

After parts have been either manufactured by McDonnell Douglas or purchased, the components are then moved into the major assembly area, where other systems are used in scheduling and control of the Major Assembly operation.

PARTS HISTORY RECORD TRANSFER POSTING

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T05  32- 32061-  34   1286                          0000  00261 00000        P/T  M   DEPT 161   EX PC 00051
T05  32- 32061-  65   1286                            2-  00031 00000        P/T  M   DEPT 161   EX PC 00003
05   32- 32063-   5   1286                                                  1- S19102142821 SER 1228038 3
T05  32- 32063-   5   1286                            16- 00071 00000        P/T  M   DEPT 161   EX PC 00004
05   32- 32063-   7   1286 713  40N 320 12851936 006
05   32- 32063-   7   1286 725  CL  320 12851936 053
C
T05  32- 32063-   7   1286                          0000  00059 00000        P/T  M   DEPT 161   EX PC 00004
05   32- 32065-  59   1286 720  33                                           1- S102CA230
T05  32- 32065-  59   1286                            11- 00120 00000        P/T CM   DEPT 161   EX PC 00056
05   32- 32065-  67   1286 725  BE  320 12851937 139
C
T05  32- 32065-  67   1286                          0000  00139 00000        P/T  M   DEPT 161   EX PC 00020
T05  32- 32065-  515  1286                            16  00015 00000        P/T SA   DEPT 171   EX PC 00000
T05  32- 32065-  516  1286                            16  00015 00000        P/T SA   DEPT 171   EX PC 00000
T05  32- 32067-  51FA 1286                          0000  00000 00000        P/T LD   DEPT       EX PC 00000
05   32- 32067-  239  1286 720  33                                           1- S92ND214
T05  32- 32067-  239  1286                          0000  00000 00000        P/T  M   DEPT 161   EX PC 00004
05   32- 32067-  429  1286 720  33                                           1- S102CA119
T05  32- 32067-  429  1286                            19  00000 00000        P/T SF   DEPT 161B  EX PC 00009
05   32- 32067-  431  1286 720  33                                           1- S102CA120
T05  32- 32067-  431  1286                            17  00000 00000        P/T SF   DEPT 161   EX PC 00009
T05  32- 32067-  735  1286                             7  00018 00000        P/T SF   DEPT 161   EX PC 00004
T05  32- 32067-  736  1286                             4  00033 00000        P/T SF   DEPT 161   EX PC 00004
     32067-  771                                                             1- S102ND199
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THE STATUS OF EACH PART IS PRINTED OUT BY COMPUTER EACH DAY FOR HEAT TRANSFER TO THE PART HISTORY RECORDS (BELOW). THERE IS A RECORD FOR EVERY PART.

MOD 05 PART NUMBER 32- 32171- 115

McDONNELL AIRCRAFT CORP.

PART HISTORY RECORD

MOD 05 PART NUMBER 32- 32171- 115

CONTROL	MOD	PART NUMBER	TRAN DAY NO.	JOB NO.	ITEM NO.	COST CODE	WORK ORDER SERIAL NO.	QTY REL.	QTY COMP.	PARTS OVER/ SHORT	PARTS OPEN ON FAB	PARTS OPEN ON RWK	PARTS AVAIL	TRAN QTY	REMARKS
T	05	32- 32171- 115	0912							0000	00000	00000			P/T SA DEPT EX PC 00001
	05	32- 32171- 115	0916	713	37	320	09150456	025							
	05	32- 32171- 115	0916	713	38	320	09150456	024							
	05	32- 32171- 115	0978	CD0977	D174B		09150456		049						
	05	32- 32171- 115	0916							0000	00049	00000			P/T M DEPT 161B EX PC 00001
T	05	32- 32171- 115	0927							0000	00049	00000			P/T M DEPT 161B EX PC 00002
T	05	32- 32171- 115	0954							0000	00049	00000			P/T M DEPT 161B EX PC 00001
T	05	32- 32171- 115	0978							0000	00000	00000			P/T M DEPT 161B EX PC 00001
	05	32- 32171- 115	0981	720	31	320	09807482	034							
	05	32- 32171- 115	0981	720	32	320	09807482	044							
C	05	32- 32171- 115	1072	CD1071	D174B		09807482		076					2-	UNREC COMP
T	05	32- 32171- 115	0981							0000	00078	00000			P/T M DEPT 161B EX PC 00005
	05	32- 32171- 115	1033	713	37									1-	S101NA141
T	05	32- 32171- 115	1033							1-	00078	00000			P/T M DEPT 161B EX PC 00005
	05	32- 32171- 115	1045	713	37									1-	S101NA218 32- 32171- 503
T	05	32- 32171- 115	1045							2-	00078	00000			P/T M DEPT 161B EX PC 00005
T	05	32- 32171- 115	1072							2-	00000	00000			P/T M DEPT 161B EX PC 00005
	05	32- 32171- 115	1073											2-	WLOST-PARTS SER 09807482
T	05	32- 32171- 115	1073							4-	00000	00000			P/T M DEPT 161B EX PC 00005
	05	32- 32171- 115	1111	720	33	320	11101622	048							
C	05	32- 32171- 115	1165	CD1164	D174Z		11101622		035					1-	UNREC COMP
T	05	32- 32171- 115	1111							0000	00048	00000			P/T M DEPT 161B EX PC 00005
	05	32- 32171- 115	1160											12-	S230422215 38 SER 11101622
T	05	32- 32171- 115	1160							12-	00036	00000			P/T M DEPT 161B EX PC 00005
	05	32- 32171- 115	1161	720	33	320	11601153	012							
C	05	32- 32171- 115	1244	CD1243	D174Z		11601153		013					1	SHOP OVER
T	05	32- 32171- 115	1161							0000	00048	00000			P/T M DEPT 161B EX PC 00005
T	05	32- 32171- 115	1165							0000	00012	00000			P/T M DEPT 161B EX PC 00005
	05	32- 32171- 115	1166											1-	WLOST-PART SER 11101622
T	05	32- 32171- 115	1166							1-	00012	00000			P/T M DEPT 161B EX PC 00005
	05	32- 32171- 115	1189	725	AE	320			001001					1-	REL FR OVER
	05	32- 32171- 115	1189	725	AE	320	11877590	047							
C	05	32- 32171- 115	1272	CD1271	D174Z		11877590		000						
T	05	32- 32171- 115	1189							0000	00059	00000			P/T M DEPT 161B EX PC 00003
T	05	32- 32171- 115	1244							1	00047	00000			P/T M DEPT 161B EX PC 00003
	05	32- 32171- 115	1251				1250F029	047							SPLIT FR 11877590
C	05	32- 32171- 115	1297	CD1296	D176V		1250F029		048					1	SHOP OVER
T	05	32- 32171- 115	1251							1	00047	00000			P/T M DEPT 161B EX PC 00003
	05	32- 32171- 115	1252	725	BL	320			001001					1-	REL FR OVER
	05	32- 32171- 115	1252	725	BL	320	12511319	049							
C	05	32- 32171- 115	1307	CD1306	D176V		12511319		050					1	SHOP OVER
T	05	32- 32171- 115	1252							0000	00096	00000			P/T M DEPT 161B EX PC 00003
T	05	32- 32171- 115	1272							0000	00096	00000			P/T M DEPT 161B EX PC 00003
	05	32- 32171- 115	1288	725	CL	320	12871756	050							
C															
T	05	32- 32171- 115	1288							0000	00146	00000			P/T M DEPT 161B EX PC 00003
T	05	32- 32171- 115	1297							1	00099	00000			P/T M DEPT 161B EX PC 00003
T	05	32- 32171- 115	1307							2	00050	00000			P/T M DEPT 161B EX PC 00003

Results and Future Plans

The systems used in production scheduling and control are continually undergoing refinements and improvements. Some of them have been in existence for five years or more, others have been added from time to time. The major result from the use of data processing is the capability it provides for assuring that contract schedules are met and that all functions are performed with a maximum of efficiency. The parts follow-up system is perhaps the key system since it enables manufacturing management to quickly spot areas where corrective action is required. In addition it is the key to labor reporting, performance reporting, shop load forecasting and critical machine utilization.

There are several possible enhancements of the systems under consideration. One improvement being developed is the use of on-line inquiry-response terminals instead of printouts of some of the reports so that production control can inquire at any time about the status of a work order instead of using the daily printout. Expansion of the Data Collection system (IBM 1030 units attached to IBM 360/40) to include IBM 2740 Communication Terminals and 2260 Display units for inquiring against the various work order control data bases has been approved by A. D. Loddeke, production manager, McDonnell Aircraft Co. and is scheduled for implementation.