LARGE SCALE SYSTEMS INTEGRATION AND AUTOMATION OF A MULTI-SITE PRINTING OPERATION

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Keywords: prepress, imposition, CTP, systems integration, database

Abstract: It is well understood that the current wave of new production technologies have placed a strain upon classical prepress workflows. Furthermore, the advent of computer to plate (CTP) technology has essentially invalidated the existing hybrid workflow that grew up around the digital-to-film based production systems.

This report examines the system integration, software and database strategies required to automate a large (200 person), multi-site, specialty color prepress production process. Explicitly examined are the workflow "glue" technologies required to validate the production scheme for eventual implementation of a CTP process.

INTRODUCTION

This document is the result of work by the author and the management committee responsible for developing a plan for the future of the prepress operation at Valassis Communications Incorporated. The system resulting from this analysis is in the process of being built and implemented in the Valassis Printing Operations Division (POD).

Valassis is a multi-site heatset WEB based printing operation dealing with a specialty vertical printing product referred to as a free standing insert (FSI) which is delivered as a booklet included with nearly every Sunday newspaper in North America. Valassis prints approximately 53 million FSI booklets each week. Prepress is centralized in a large, new facility and the central prepress services three remote printing plants.

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The Page Level Automation project (PLA) has the goal of bringing Valassis into the area of computer to plate (CTP) workflow in the shortest possible time frame consistent with rational ongoing operations within the prepress. Further, it is intrinsic to the proposed process of moving to CTP that each step along the way should largely pay for itself by either reducing the cost of prepress or by providing greater flexibility to the marketing process that prepress supports and, ultimately, expresses as product. Some of the direct benefits of this automation are a very significant reduction in traditional prepress labor costs, greater control, lower error rate and a reduction in time per job cycle in prepress.

This paper will deal with two areas of the PLA project-- a summary description of the projects theoretical design, and a general description a new integration glue technology that was developed for this project. As a reference to this document a set of diagrams derived from a Computer Aided Software Engineering (CASE) (1) tool have been included. These express the design in a more rigorous fashion and are referenced as illustrations to the text.

SUMMARY PROJECT DESCRIPTION

PLA is based on a series of assumptions about prepress and prepress technology. One of these is that the electronic process, represented most commonly by the PostScript process, has demonstrated that it should completely supplant the traditional prepress process. This is well illustrated throughout the industry and is proven by example.

Another assumption that we have made is that the CTP process is the next most likely area to provide a quantum increase in productivity. This is not so well demonstrated in the commercial printing world. However, it is obvious in the technical, documentation and book arenas that CTP is a powerful and effective force. Further, certain constrained workflows in the color WEB market have been reasonably successfully integrated into CTP.

PLA is a classic systems integration that owes more to a Computer Integrated Manufacturing (CIM) system process than to the traditional workflow process followed by the printing industry. In this context we need to redefine the term "electronic workflow" from that commonly held by the CTP system vendor community -- e.g. a print que on steroids -- to the more comprehensive: "an end to end control system that deals with all areas of a specific production process". So, what PLA does is to deal with the tracking and control of prepress manufacturing material, process functions and data from receipt to the production of plate or film. Further, PLA operates upon a *sub*-page level -- i.e. it explicitly controls process at the page element level rather than simply the page level.

Of necessity, we have built PLA as a system rather than an application *per se*. So, PLA consists of existing application software surrounded by a new form of "glue" application that ties the application layer together. PLA is both data centric, as it exclusively uses a database reference model to control both atomic imaging data and the related controlling metadata, and process centric in the sense that processes -- both foreign to PLA and built for PLA -- are threaded together by a form of workflow shell that tracks both detail and global workflow without the need for dedicated user input.

By design, PLA is the application of well known information theory methods (2) to a previously uncentralized environment. Thus, PLA features a (logically) central database serving client front end processes that provide a semiautomation of the data manipulation processes. The server platform is Microsoft Windows NT Server running Microsoft SQLServer while the client platforms may be Windows, Windows NT or Macintosh based systems transparently. Specific application elements are written in C++. Included in the overall application are an image database with a versionalization feature and a data archive feature that employs a graphic arts specific hierarchical data management function.

In its current form, PLA is strictly a file oriented workflow to automated output and is designed to operate in a closed environment within which input variables are strictly limited. Please refer to the CASE diagrams for the following discussion of the basic process model.

The reader will note that the LEVEL 0 diagram presents four master processes (the rounded boxes), four data stores (the open ended boxes) and four external entities (the drop shadowed boxes). Processes one through three are of interest to us and will be briefly discussed.

PROCESS 1: ELECTRONIC PRODUCTION CONTROL

Level 1 DFD: Electronic Production Control illustrates the basic page production process. This diagram decomposes into four level 2 diagrams associated with processes five through eight.

Of note in this section of the analysis is the not stated element of the Intake Analysis diagram. The "PREFLIGHT RUN ANALYSIS" and the "POSTSCRIPT SANITY ANALYSIS" processes include the normal elements of preflight, e.g. the "are all of the elements there?" test and the "will it run?" test. We have developed, however, a third criteria that should be a part of any large format workflow: the "when will it be done" test. This tool relies upon a metric-to-RIP measure and provides (at this time) no better than an 85% Confidence Interval reliability. We believe that a new rule based tool will increase the C.I. to about the 90% level.

Note that, in the analysis of the "cell assembly" processes, we use the term "cell" as opposed to page. This is an abstraction for any atomic PostScript element. Most often this is the page but practice leads us to a more universal term.

The cell assembly processes represent the three basic workflow types seen in the prepress; 1) file supplied (prepress has NO responsibility for the file other than imposition), 2) film supplied ("pickup film") and, 3) art supplied (the traditional electronic page assembly processes). Inspection of these diagrams reveals the obvious -- the art supplied workflow is simultaneously the most complex and the most prone to error. *A lesson should be derived from this, to wit: automate to CTP those workflows that are file and film supplied now. Art supplied workflows should be approached with caution* (3),(4).

PROCESS 2: IN COMMON AND MECHANICAL PRODUCTION CONTROL

One of the more interesting elements of this analysis is the ease that one can automate certain production tasks given that a standardized input and a limited output set are used. The Level 1 DFD: In Common and Mechanical Production Control diagram illustrates all elements of the production process after the production and geometric placement of all data to the cell atom. It should be noted that the term "mechanical" in this area of the analysis refers only to the physical production at the imagesetter or platesetter. No manual steps are required and, for those process marked "<AUTOSCRIPT>", no labor component is involved at all.

The significant part of this section of the system is illustrated by the Level 2 DFD: Standardized Electronic Procedures diagram. The PAGE ASSEMBLY process does not refer to an atomic page but, rather, to a standardized imposition page. We have built a rule based system (with some mild neural network elements) that drives non standard cell assemblies to a standardized imposition page which can then be imposed via standard, albeit script driven, imposition systems such as the new version of Preps. This workflow was, originally, to be dependent upon the Luminous OPEN product, however, we have replaced OPEN with a new communication software device known as a Job Board Manager (JBM) which will be discussed later in this paper.

PROCESS 3: MASTER SCHEDULING

This is where the predictive PostScript metric tool of the intake analysis is important. By having some kind of handle on total system times we can begin to rationally schedule resources.

Level 1 DFD: Master Scheduling should be fairly self evident. Keep in mind that a significant analysis of machine work volume needs to be done and employee skill and effectiveness levels can be subjective (there is an easy nominal type of nonparametric statistic that can be used here, however, this requires some value judgments upon the part of line management and it is quite interesting how difficult this often is).

Our collected work estimates are matched to resource availability and a set of JBM triggers are generated that drive the queuing order at workstations -- both manned and unmanned.

Behind the process model is a SQL data model consisting of some 27 tables containing over 200 data types at this time. Table structures are linked by either JOINS or interface software to the existing legacy Valassis MIS. Table design falls into two rough categories -- data and metadata. Data elements comprise the image database portion and the file geometry store. Metadata (data about data) elements represent both the key tuples and certain job tracking tuples.

A NEW GLUE TECHNOLOGY -- THE JOB BOARD MANAGER

It was not the purpose of this project to replace existing commercial production products such as Quark Express. However, we need to control these tools more effectively in large scale production operations if we are to have any hope of reducing error.

We desired, by the judicious use of off the shelf software and certain *de novo* code, to glue together standard applications, time workstation operations without the need for operator input and drive the entire scheduling and priority process centrally and automatically. To do this we built the JBM -- the current state of which is illustrated in Figure 1. The theory of this tool is to allow a distributed "view" of any job (or jobs) by hierarchical explosion. All data are entered into the system via the JBM and all applications are launched from and stored through the JBM. Thus the JBM not only tracks elements but also tracks time and type of work (as well as user). Work can be distributed to numerous workstations across a workstation cloud without the resource confusion so commonly associated with such job parallelization today.

Thus, work shows up as a queuing list (within JBM) on an operators workstation. The operator will perform the work and the system will measure the time required per quanta of work. We can, then, easily determine how best to load level the work across the available operators and determine how to best staff for successive shifts.

Contrast the JBM approach to an OPEN or Brisque (an OPEN metaphor) approach. OPEN workflows are linear and job by client oriented. Internal parallelization of work (e.g. more than one workflow thread per job) is difficult. Further, with OPEN particularly, while process steps are strong and ergonomically assembled, there really is no data model intrinsic to the application. JBM, on the other hand, is both broad and long in the sense that JBM is intrinsically data centric and easily parallelized both between jobs and within jobs. Further, not well demonstrated by the one color line art of Figure 1, note the status marbles. These act as process "signal lights". A process is not allowed to continue until triggered at which point the signal light in question turns from red to green. Thus, a page or flat cannot be sent to, say, the print que unless all elements are available and set to a "go" trigger state.

Further, by controlling input to and output from applications such as Express and Photoshop from the JBM we are able to move the workflow back toward the originating applications. By requiring all material to be databased we control (at least to a great extent) the high level of entropy in a prepress production operation. We thus achieve what we believe to be much greater systems throughput reliability.

CONCLUSION

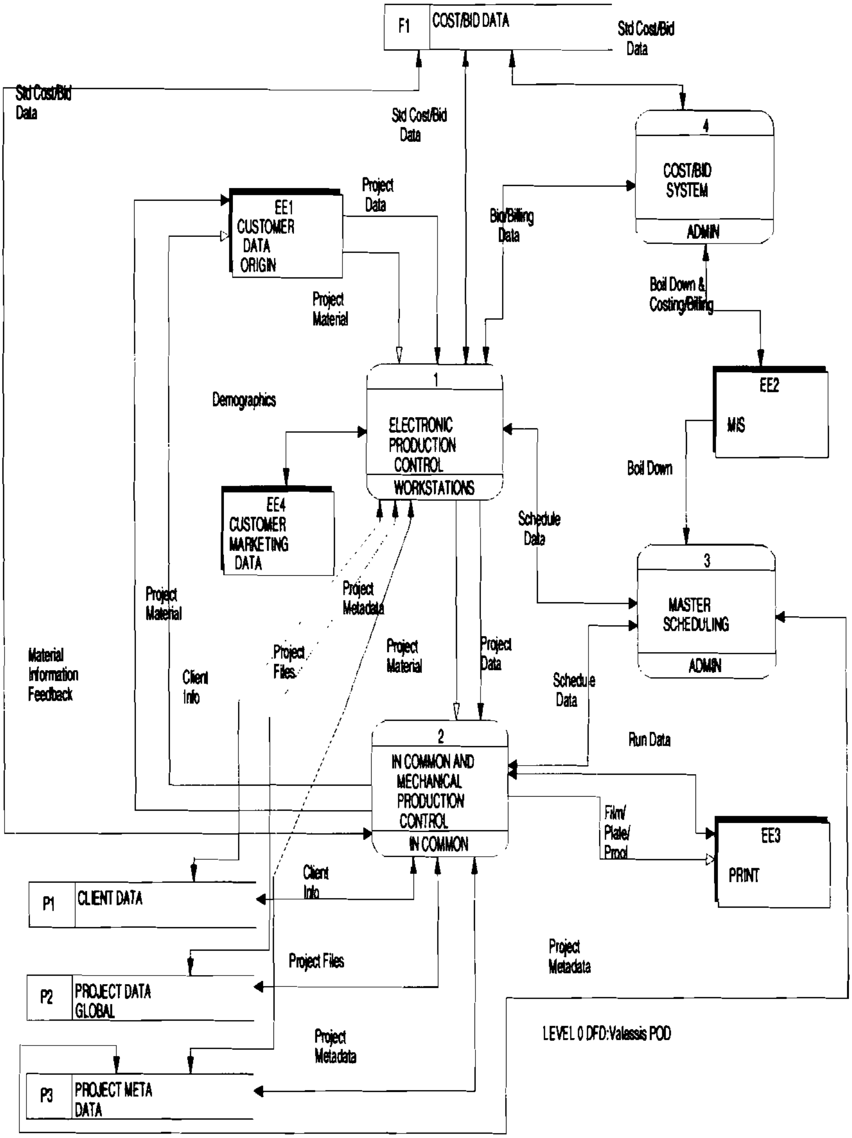
PLA is the first of a new class of application systems needed within the print production process, e.g. a CIM like system designed for flexible, demand production. Further, it is hoped that the dialog about "workflow" within plant operations will begin to be shifted from the narrow, loosely coupled output based tools now available to more comprehensive systems of which PLA is an exemplar

(1) ___, POSE, Computer Systems Advisers, Inc. Woodcliffe Lake, New Jersey.

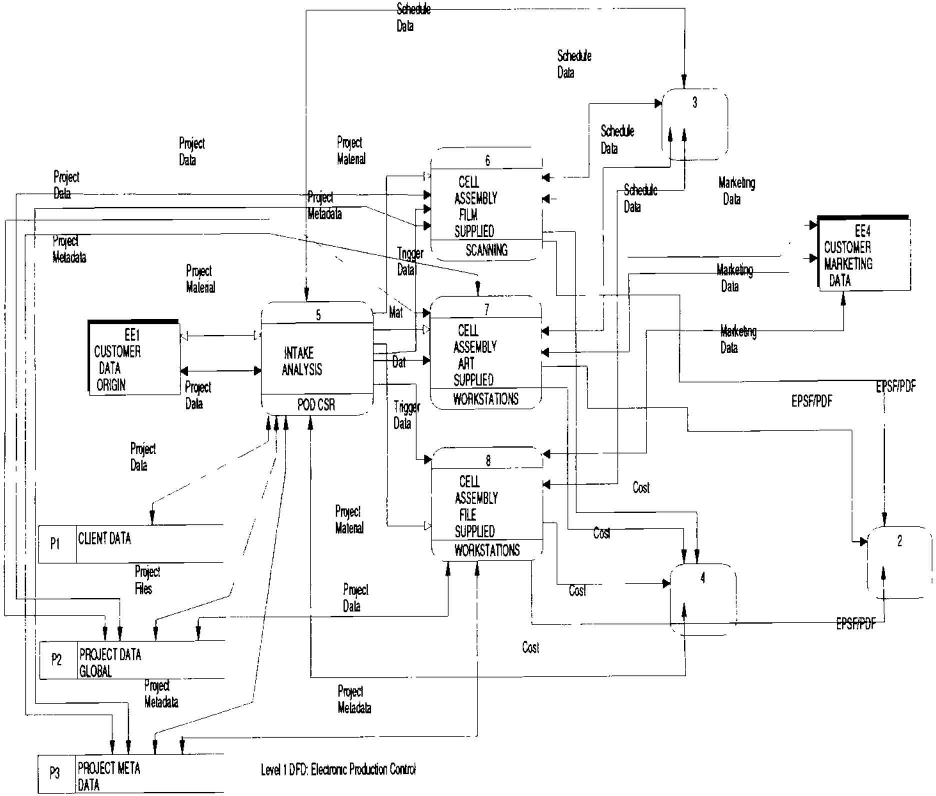
(2) Yourdon, E., Modern Structured Analysis, Yourdon Press, 1989.

(3) Ray, W., The Implications of Large Format Imagesetters on the Postscript Electronic Workflow, TAGA Proceedings, 1993.

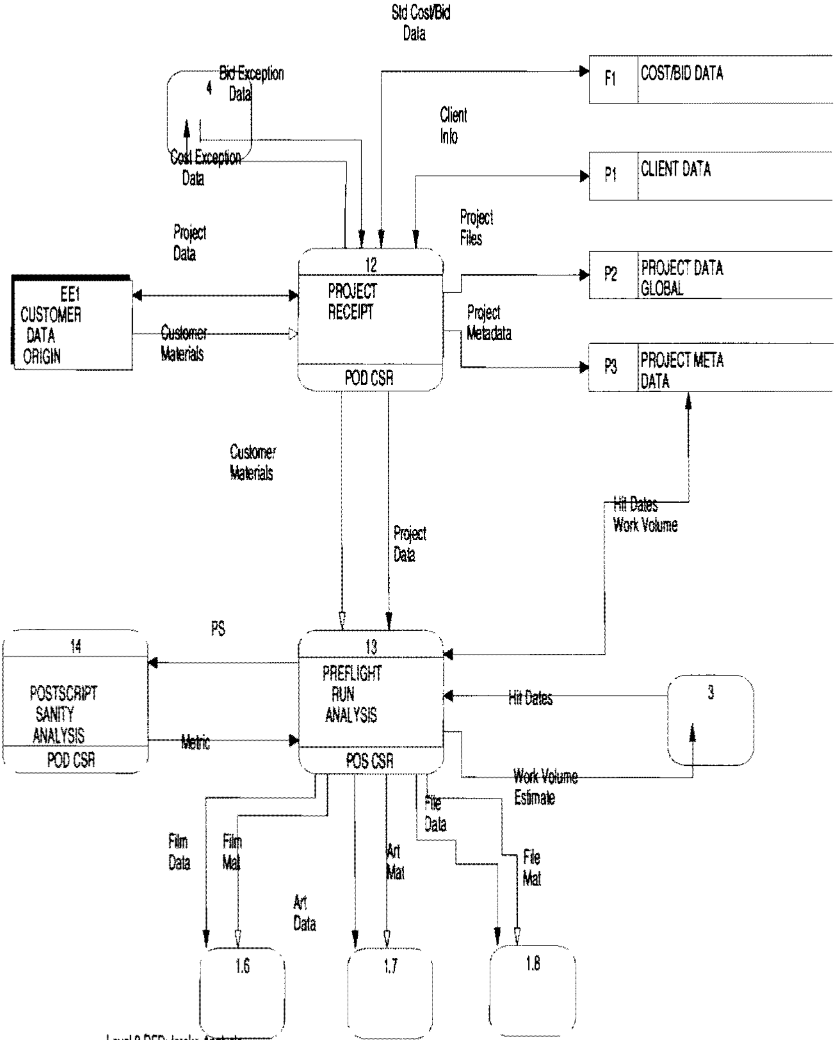
(4) Ray, W., CTP: It's the Software More than Hardware, PIA Technology Trends Advisory, 1996.



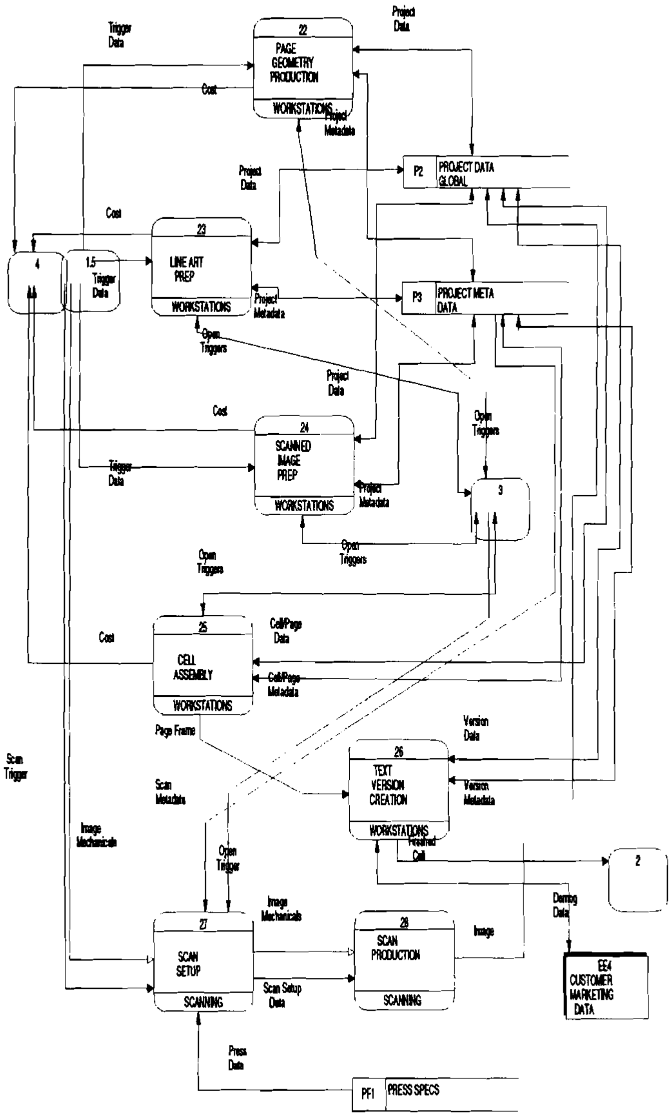
LEVEL 0 DFD:Valassis POD



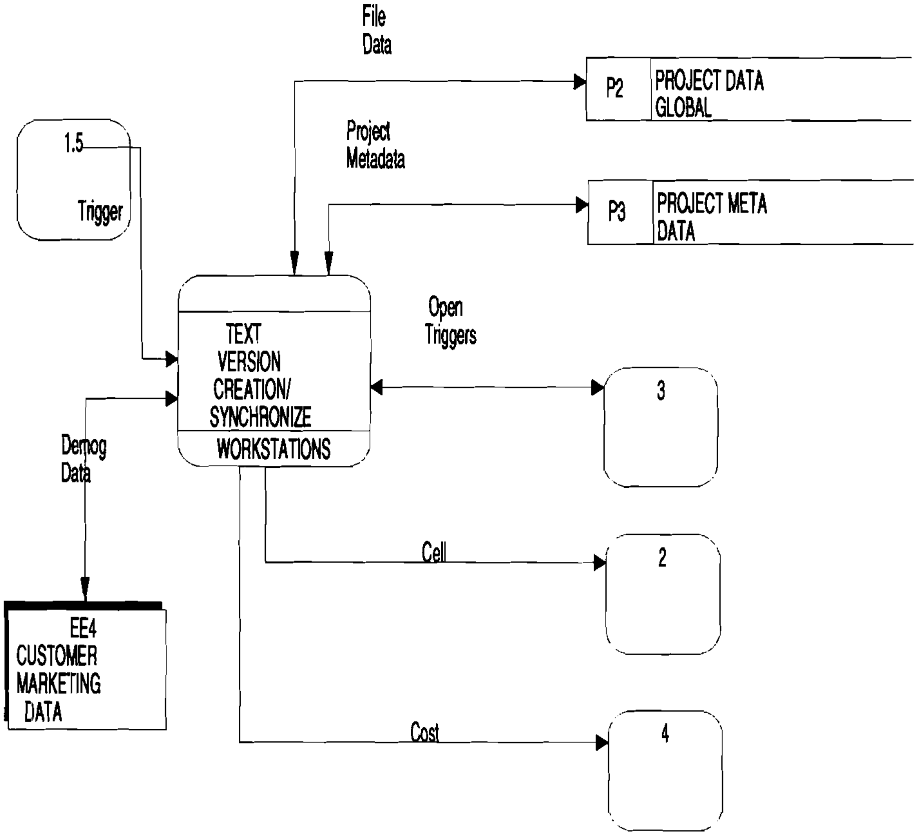
Level 1 DFD: Electronic Production Control



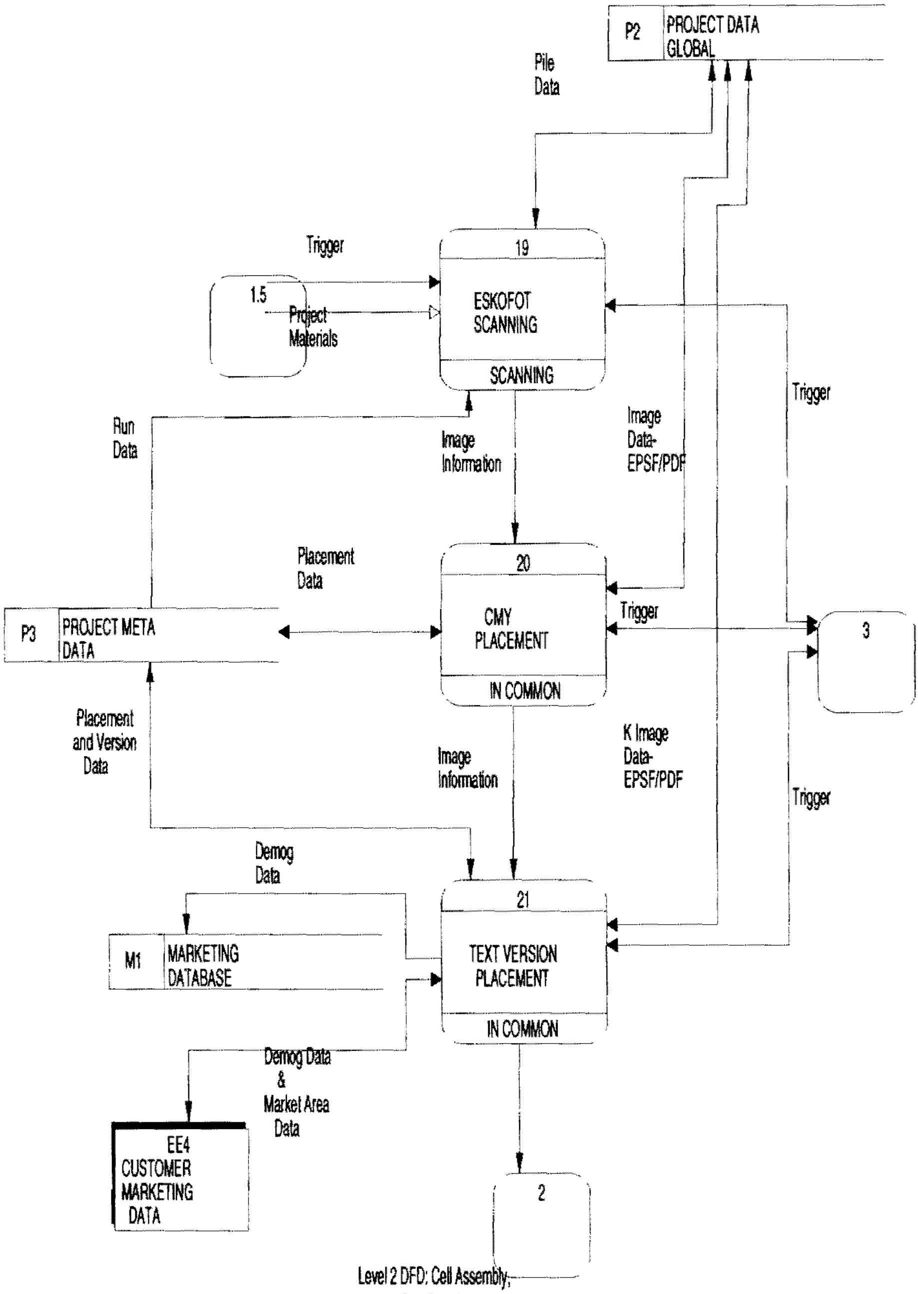
Level 2 DFD: Intake Analysis



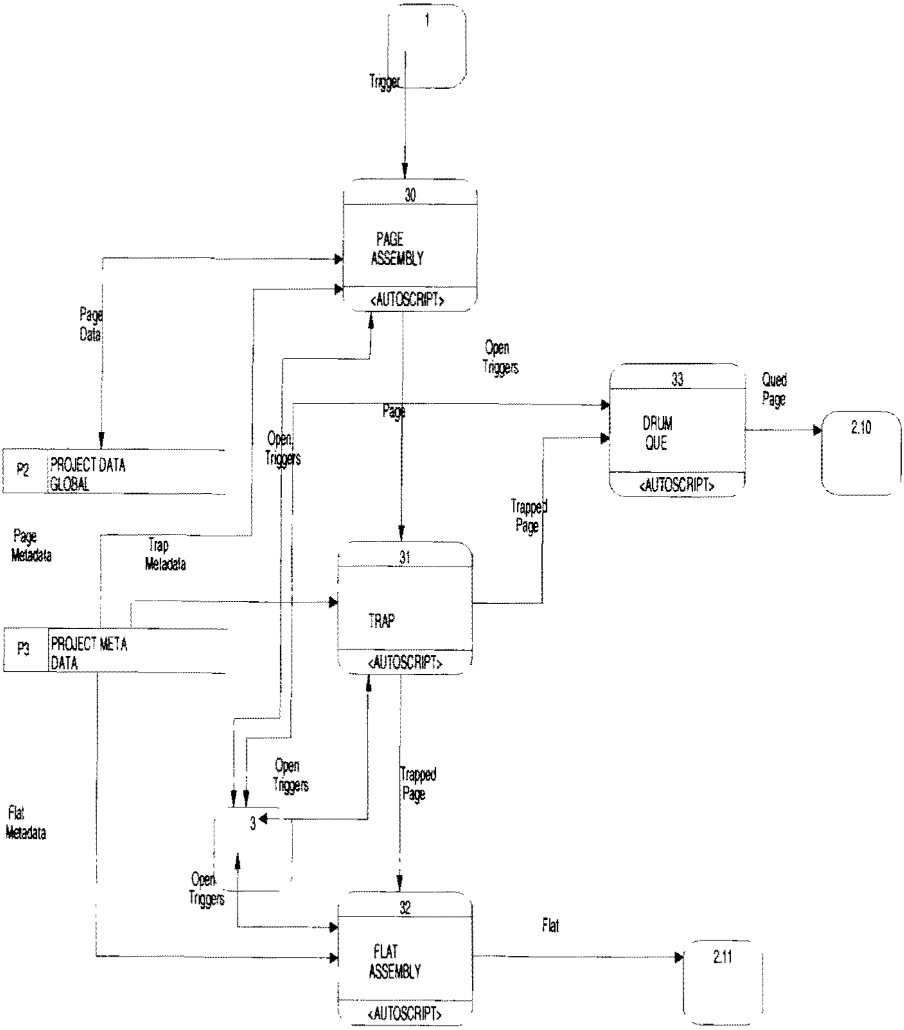
Level 2 DFD: Cell Assembly, Art Supplied



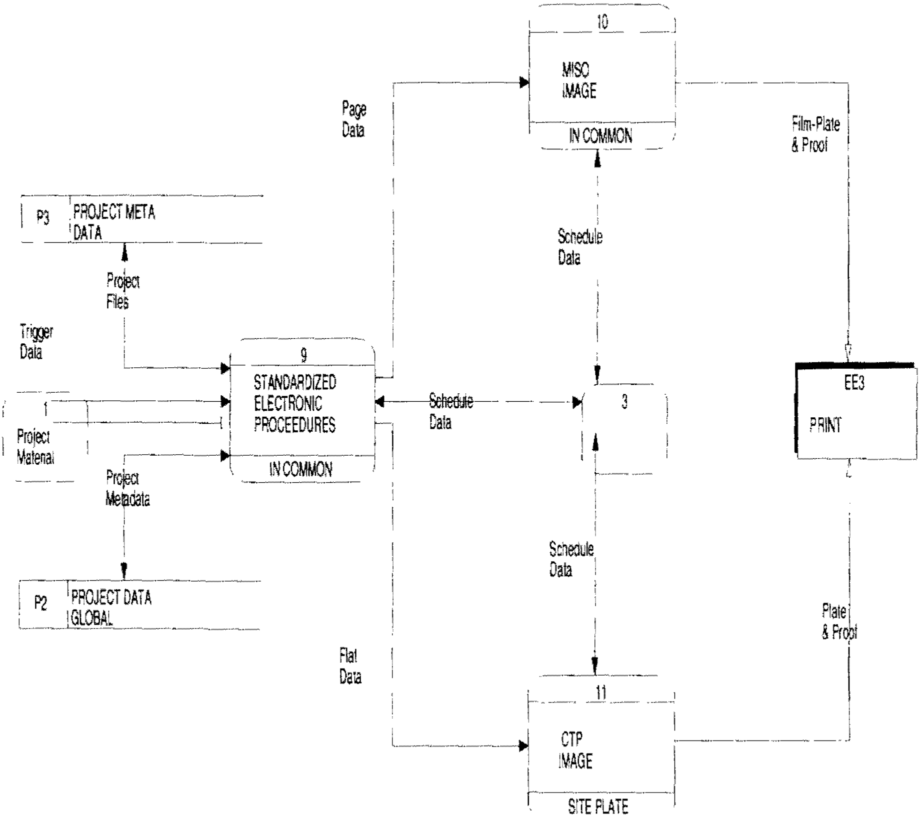
Level 2 DFD: Cell Assembly,
File Supplied



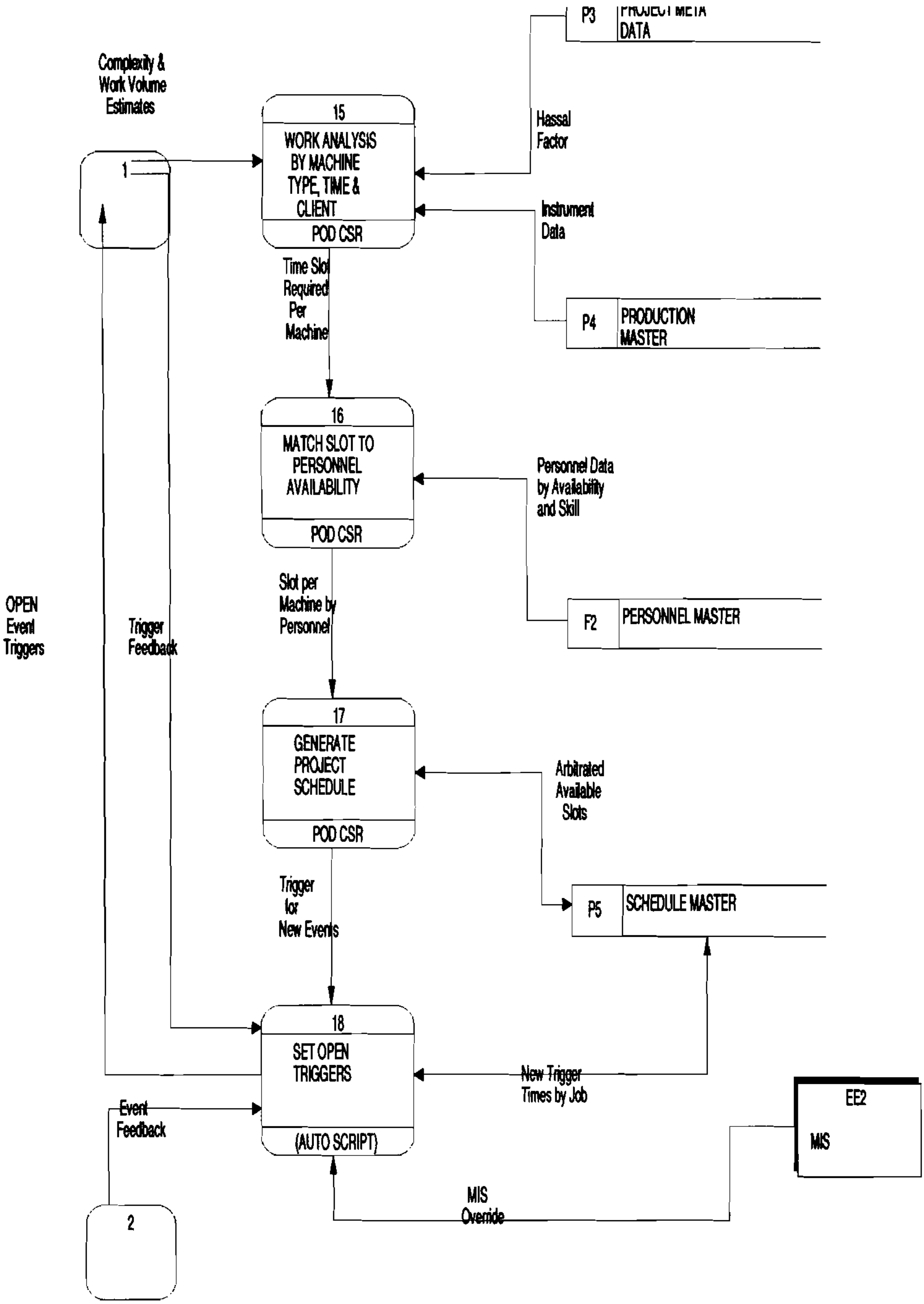
Level 2 DFD: Cell Assembly, Film Supplied



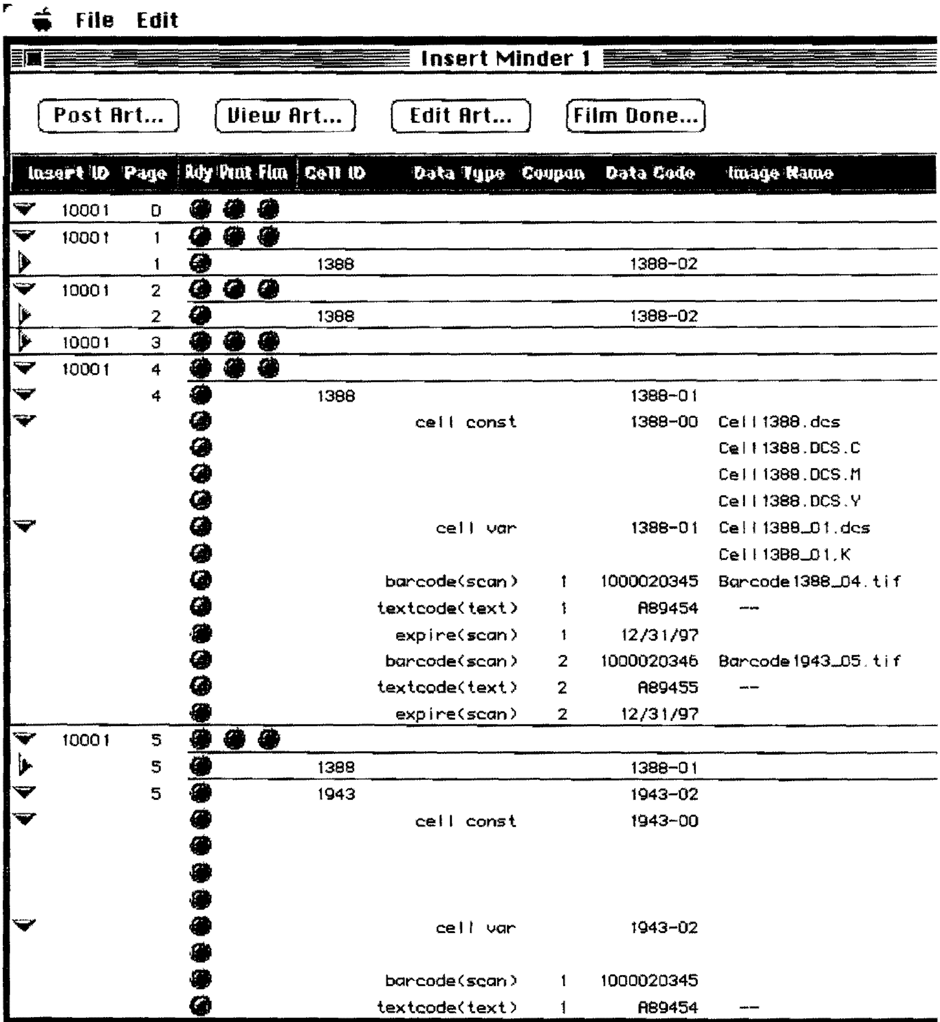
Levle 2 DFD:Standardized
Electronic
Proceedures



Levie 1 DFD: in Common and Mechanical
Production Control



Level 1 DFD:Master Scheduling



File Edit

Insert Minder 1

Post Art... | View Art... | Edit Art... | Film Done...

Insert ID	Page	Rdy	Prnt	Flm	Cell ID	Data Type	Coupon	Data Code	Image Name
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10001	1	●	●	●					
	1	●			1388			1388-02	
10001	2	●	●	●					
	2	●			1388			1388-02	
10001	3	●	●	●					
10001	4	●	●	●					
	4	●			1388			1388-01	
		●				cell const		1388-00	Cell1388.dcs
		●							Cell1388.DCS.C
		●							Cell1388.DCS.M
		●							Cell1388.DCS.Y
		●				cell var		1388-01	Cell1388_01.dcs
		●							Cell1388_01.K
		●				barcode(scan)	1	1000020345	Barcode1388_04.tif
		●				textcode(text)	1	A89454	--
		●				expire(scan)	1	12/31/97	
		●				barcode(scan)	2	1000020346	Barcode1943_05.tif
		●				textcode(text)	2	A89455	--
		●				expire(scan)	2	12/31/97	
10001	5	●	●	●					
	5	●			1388			1388-01	
	5	●			1943			1943-02	
		●				cell const		1943-00	
		●							
		●							
		●							
		●				cell var		1943-02	
		●							
		●				barcode(scan)	1	1000020345	
		●				textcode(text)	1	A89454	--

FIGURE 1: The Insert Minder view of the Job Board Manager.