

MANUFACTURING EFFICIENCY MEASUREMENT IN PLASTIC CARD PERSONALIZATION OPERATIONS

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SECTION 1. GENERAL OVERVIEW

This report provides a summary of theories used for the measurement and analysis of manufacturing efficiency in card personalization operations. The objective is to explain how information contained within an audit trail file with production time stamps can be used to measure and evaluate manufacturing operations, including speed measurement, job size calculation, and performance measurement using techniques to standardize measurement output for variations in average job size. To support these objectives, information is provided regarding the theory of speed and efficiency calculation and measurement for Datacard® card issuance systems.

The information is provided in three sections:

- Calculating Speed and Efficiency
- Evaluating Efficiency for Varying Average Job Sizes
- Using Audit Trail Files for Measuring Efficiency

While these theories were developed to support the measurement and evaluation of Datacard card issuance systems, the methods are suitable for measuring and understanding operational performance with any batch processing equipment which can provide time stamped audit information.

Please contact your Datacard account manager or the Datacard Technology & Operations Analysis Service organization for more information on this topic.

SECTION 2. CALCULATING SPEED AND EFFICIENCY

Estimating the production capacity of Datacard card issuance systems require an understanding of not only the maximum theoretical speed of the system, but of the factors which can limit the maximum practical output as well. This section of the report is designed to provide an overview of the factors regulating the production output of the Datacard® MX6000™ card issuance system and a framework for calculating speed for use in capacity calculations and production planning.

Output Constraints

The factors which tend to limit system output, providing actual output which is less than the theoretical maximum speed are referred to as “Output Constraints”. These Output Constraints include the system configuration, the job size and setup time, system service and the production process. The definition of each output constraint is defined later in this section. If the magnitude of each constraint can be accurately estimated or calculated, the actual output of the system can be accurately predicted.

The Impact of Job Size on System Output

Among the most significant factors in determining system output are average job size and setup time. Before each job begins, the operator must load production data and, in most cases, load raw materials for producing the cards. Once the job has been started the system moves the first card through each operation in the system before the first completed card is produced. These two intervals, referred to as “setup time” and “track load time” work to reduce the efficiency of the system, since nothing is “produced” until the first card appears, completely personalized, and the end of the system.

Calculating Theoretical Efficiency

The efficiency of this type of production system can be shown to be a function of Job Size, Maximum Rated Throughput, Track Fill Time and Job Select Time. This relationship can be expressed through the following set of calculations:

Theoretical Efficiency = $f\{\text{Job Size, Maximum Rated Throughput, Track Fill Time, Job Select Time}\}$

Job run time = (Job Size) / (Maximum rated throughput)

Total job time = (Track fill time) + (Job select time) + (Job run time)

Effective speed = (Job size) / (Total job time)

Theoretical Efficiency = (Effective speed) / Maximum rated throughput

So:

Theoretical Efficiency =

$(\text{Job Size} / (\text{Track Fill Time} + \text{Job Select Time} + (\text{Job size} / \text{Maximum Rated Speed}))) / \text{Maximum Rated Speed}$

This relationship of job size to efficiency can be seen in Figure 1.

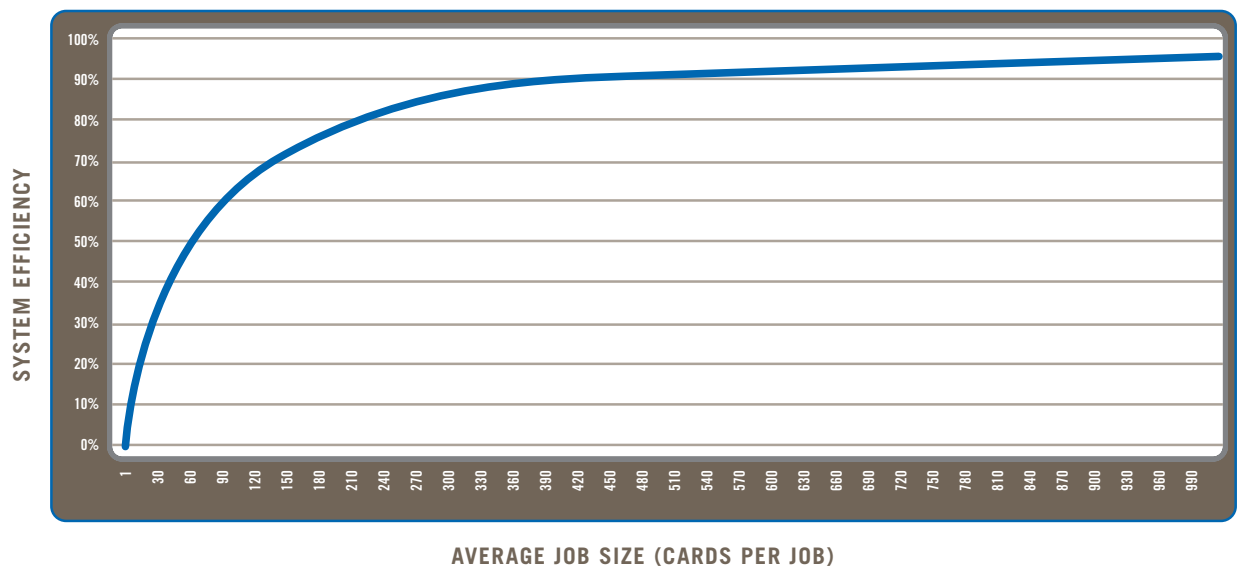


Figure 1 — Job Size vs. Efficiency

Estimating Actual Output

Evaluating operational performance requires development of an estimate of actual production output of the MX6000 system, which in turn requires the determination of a specific system's Maximum Rates Configuration Speed, an estimate of the average job size and setup time, an estimate of system service requirements and an estimate of the time required for non-system related production process steps. This process can be visualized as a funnel through which successive output constraints serve to limit the speed of the system as indicated in Figure 2.

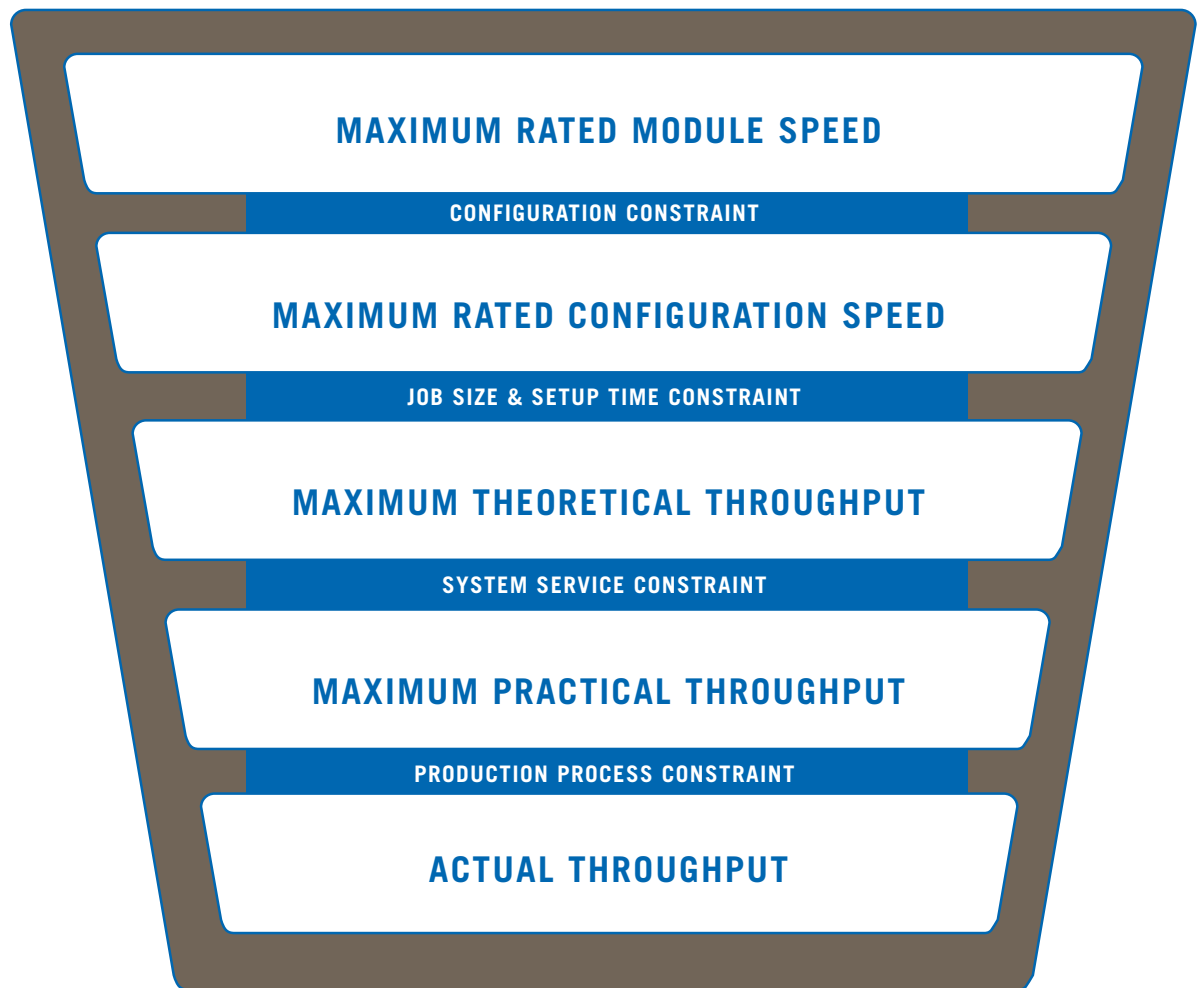


Figure 2 — Output Constraint Funnel

This example illustrates how this method is used to estimate an actual throughput. Assume the following information and calculate the impact of job size and setup time using the equations provided above:

- MX6000 system: 1 magnetic stripe encoding module, 1 graphics printing module, 3 embossing modules, 1 topping module
- Average job size of 100 cards, setup time of 90 seconds per job, track fill time of 100 seconds
- 5% estimated downtime for preventive maintenance, equipment service and maintenance
- Average estimated non-system related process efficiency of 90%

The terms used in Figure 2 have precise meanings when used in the context of speed and efficiency calculation and operational analysis. The definitions of these terms, as used in this report, are provided below:

	SPEED (CPH)	EFFICIENCY
MAXIMUM RATED MODULE SPEED	1500	
MAXIMUM RATED CONFIGURATION SPEED	1500	100%
MAXIMUM THEORETICAL THROUGHPUT	960	64%
MAXIMUM PRACTICAL THROUGHPUT	912	61%
ACTUAL THROUGHPUT	821	55%

Maximum Rated Module Speed

Each module available for the MX6000 system is tested in the laboratory using a MX6000 system configured with only an input module and the module under test. The system runs representative data at its maximum speed for one hour without error and the number of documents produced is recorded as the *Maximum Rated Module Speed*.

Configuration Constraint

The particular modules in a MX6000 system configuration, in conjunction with the specific application in use, determine the maximum possible system speed. This is referred to as the *Configuration Constraint*.

Maximum Rated Configuration Speed

The maximum possible speed of any MX6000 system is less than or equal to the Maximum Rated Module Speed of the slowest module in the system. In some cases, certain combinations of modules will run slower than the Maximum Rated Module Speed of either module due primarily to module timing characteristics and delays in preparing a module for processing a document. Individual modules can also run at less than the rated module speed when certain applications (such as smart card encoding applications) require more than the rated cycle time to complete. The maximum possible speed of a specific system configuration is labeled the *Maximum Rated Configuration Speed*.

Job Size & Setup Time Constraint

Each time a production job is finished the MX6000 system must clear the document track before the next job can be started. A system operator must setup the system for the next job, which can include selecting and loading the data, loading documents and changing supplies. The smaller the size of the job, the more times the track must be cleared and the next job set up. Since the MX6000 system is not producing documents during this period, system efficiency goes down as the size of the job is reduced. For any MX6000 system configuration there is a fixed time required to clear the track and a given Maximum Rated Configuration Speed. Assuming a standard time setup time allows the calculation of a maximum theoretical efficiency.

Maximum Theoretical Throughput

Multiplying the Maximum Rated Configuration Speed by the maximum theoretical efficiency, which is determined by the Job Size & Setup Time Constraint, yields the *Maximum Theoretical Throughput*. This figure represents the maximum number of documents which can possibly be produced by the system given a specific job size and setup time. Job size can have a dramatic impact on the *Maximum Theoretical Throughput*, and for average job sizes below 50 cards can be the most significant factor in determining system output.

System Service Constraint

All MX6000 system configurations require regular, planned preventative maintenance to operate properly. In addition, unexpected errors and component failures are also possible, which reduce the availability of the system for document production.

Maximum Practical Throughput

Since the system will not be available for production 100% of the time due to System Service Restraints, the *Maximum Practical Throughput* will be less than the Maximum Theoretical Throughput. This value is determined by multiplying the Maximum Theoretical Throughput by the percentage of time.

Production Process Constraint

Any action taken by an operator while the MX6000 system is not producing documents reduces the efficiency of the process. Some action of this type may be related to document production, such as balancing document counts or checking document quality at the end of a production run. Other actions may be unrelated to document production, such as operator breaks.

Actual Throughput

The Maximum Practical Throughput multiplied by the process efficiency, which is due to Production Process Constraints, yields the *Actual Throughput*. Any time the system is available but not in use reduces output from the Maximum Practical Throughput to the *Actual Throughput*.

SECTION 3. EVALUATING EFFICIENCY FOR VARYING AVERAGE JOB SIZES

Given the degree to which average job size impacts maximum theoretical throughput, developing a methodology for measuring and rating operator efficiency in a production operation with widely varying job sizes and system performance characteristics offers a significant challenge. Skilled operators are often asked to perform the most difficult work, which includes work with the smallest average job size. Since these jobs always run less efficiently due to the setup and track fill requirements, and consume more time to perform quality checks and balancing, the best operators quite frequently produce the fewest card when compared to those individuals running larger, less complicated work. The solution to this measurement problem lies in the development of a measurement which has been “corrected” or normalized for the impact of average job size variation.

The graph and equations used for estimating MX6000 system efficiency based on job size can be used for a variety of purposes, including capacity planning and scheduling, but just as importantly they can be used to refine the efficiency measurement methodology used in card personalization. A summary of the methodology can be seen in Figure 3.

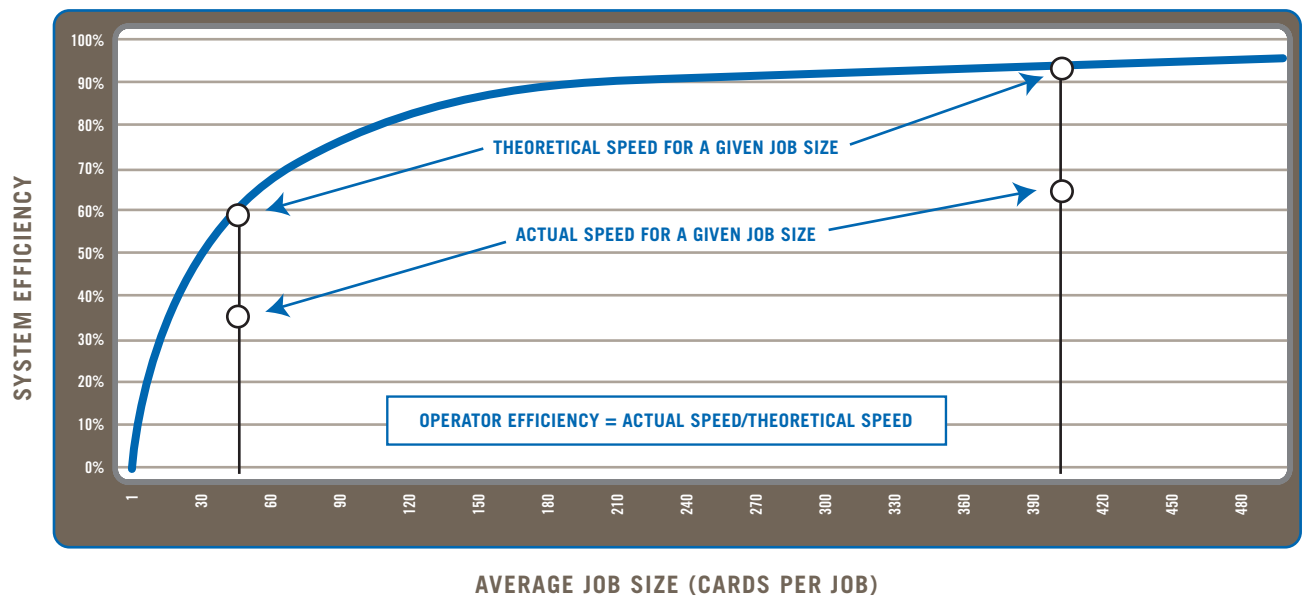


Figure 3 - Normalizing Efficiency for Job Size Variation

By measuring the average job size for any operator during a given time, and using a reasonable assumption for average track fill time and average setup time, the production manager is able to use the MX6000 system efficiency vs. job size calculation to establish the maximum theoretical throughput for that system under a given job size constraint. Dividing the actual throughput for the time period in question by the theoretical maximum throughput based on the efficiency vs. job size equation provides a measurement of operator efficiency which has been normalized for fluctuations in job size. This technique allows production management to accurately compare performance without concern for the structure of the jobs.

4. USING AUDIT TRAIL FILES FOR EVALUATING EFFICIENCY

The information required to calculate MX6000 system speed average job size and system efficiency can be obtained from the MX6000 system audit trail files. Audit trail files can be configured to provide a time stamp for each card produced, as well as a start and end time for each job. An example of a MX6000 system audit trail file is seen in Figure 4.

D_JobName	D_MachID	D_OperID	D_Date	D_Time	D_StrtDate	D_StrtTime
Job1	SN1234	Bob	9/14/2005	10:05:09	9/14/2005	10:05:02
Job1	SN1234	Bob	9/14/2005	10:05:14	9/14/2005	10:05:02
Job1	SN1234	Bob	9/14/2005	10:05:19	9/14/2005	10:05:02
Job1	SN1234	Bob	9/14/2005	10:05:26	9/14/2005	10:05:02
Job1	SN1234	Bob	9/14/2005	10:05:31	9/14/2005	10:05:02
Job1	SN1234	Bob	9/14/2005	10:05:37	9/14/2005	10:05:02
Job1	SN1234	Bob	9/14/2005	10:05:42	9/14/2005	10:05:02
Job1	SN1234	Bob	9/14/2005	10:05:47	9/14/2005	10:05:02
Job1	SN1234	Bob	9/14/2005	10:05:55	9/14/2005	10:05:02
Job1	SN1234	Bob	9/14/2005	10:06:01	9/14/2005	10:05:02
Job1	SN1234	Bob	9/14/2005	10:06:06	9/14/2005	10:05:02
Job2	SN1234	Bob	9/14/2005	10:07:10	9/14/2005	10:07:03
Job2	SN1234	Bob	9/14/2005	10:07:15	9/14/2005	10:07:03
Job2	SN1234	Bob	9/14/2005	10:07:21	9/14/2005	10:07:03
Job2	SN1234	Bob	9/14/2005	10:07:27	9/14/2005	10:07:03
Job2	SN1234	Bob	9/14/2005	10:07:32	9/14/2005	10:07:03
Job2	SN1234	Bob	9/14/2005	10:07:36	9/14/2005	10:07:03
Job2	SN1234	Bob	9/14/2005	10:07:43	9/14/2005	10:07:03
Job2	SN1234	Bob	9/14/2005	10:07:48	9/14/2005	10:07:03
Job2	SN1234	Bob	9/14/2005	10:07:57	9/14/2005	10:07:03
Job2	SN1234	Bob	9/14/2005	10:08:04	9/14/2005	10:07:03
Job2	SN1234	Bob	9/14/2005	10:08:08	9/14/2005	10:07:03

Figure 4 - Audit Trial Example

Applying some elementary mathematics will result in nearly all of the information necessary to solve the efficiency equation provided in section two of this report. A track fill time must be estimated since no reliable track fill figure can be determined from the audit trail file.

$$\text{Average Job Size} = \text{Total Number of Cards} / \text{Total Number of Jobs}$$

$$\text{Maximum Rated Throughput} = \text{Average "Normal" interval between cards}$$

$$\text{Setup Time} = \text{Track Fill Time} + \text{Job Select Time} = \text{Job2 Start Time} - \text{Job1 End Time (Last Card Processed Time)}$$

Setup Time can be averaged from "Normal" intervals between jobs in the audit file or based on shop standards

$$\text{Theoretical Efficiency} = (\text{Job Size} / (\text{Setup Time} + (\text{Job size} / \text{Maximum Rated Speed}))) / \text{Maximum Rated Speed}$$

The systematic collection and analysis of this audit trail information can provide an effective tool for measuring and comparing performance between systems, job types, operators and production shifts by normalizing the efficiency data with respect to varying job size. This data also provides an effective method for measuring the impact of changes to the production process by factoring out the impact of varying job sizes in day to day results.

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