

Issues in Shop Floor Data Collection for Batch Operations

Dr Peter Green
BellHawk Systems Corporation

Introduction

The purpose of this paper is to examine issues in shop floor data collection. It primarily focuses on the relative advantages and disadvantages of using a barcode tracking module integrated with an ERP system or a separate data collection system that exchanges data with the ERP system. For the smaller organizations, it also addresses the issues of integrating a barcode collection system with a standard accounting system as an alternative to the expense of investing in an expensive ERP system.



The conclusions drawn are:

1. That it is simpler to use a data collection module directly integrated into an ERP system provided that your organization can live within the constraints imposed by the standardized approach of the ERP data collection model.
2. That it is necessary to use a separate, customized data-collection system if your organization has unique data collection requirements such as handling split batches, rework, and non-scheduled operations. This also applies if you need to interface the data collection system to weighing scales, counters, and other process monitoring and control equipment to simplify data collection.
3. That most smaller organizations, it is often less expensive to directly integrate a

comprehensive shop floor data collection system into a standard accounting system than it is to purchase an ERP system with an integrated data collection module.

4. That even if the primary purpose of the data collection system is for financial analysis, it is important that the system provide data that is beneficial for production supervisors and managers so as to ensure the accuracy of the data.

Note that almost all of the comments made relative to ERP systems also apply to legacy MRP systems.

Reasons for collecting data from the shop floor

There are many reasons for collecting data from the shop floor. It is important to understand which of these applies to a your particular situation in order to make a knowledgeable choice.

1. To know the current status of production. This is so that corrective action can be taken if the status does not meet requirement , for example if jobs are running late. It is also necessary to be able to accurately report job status to customers when they make inquiries of customer service.



2. To collect the incremental labor, machine, and material costs accrued as each job or other work packet progresses through the manufacturing facility. This is so that we can determine how much a job or other unit of production cost.
3. To measure productivity, such as the setup and run-rate of a machine or the number of units assembled per hour by a team of people. This is for comparison with productivity standards so that corrective action can be taken when there is a deviation.

4. To collect data about scrap and rework so that corrective action can be taken if these become excessive.



5. To monitor the status of raw and WIP material. This is to ensure that production will not be held up due to lack of materials. It is to enable corrective action to be taken if there are not adequate quantities of the right materials in the right place, at the right time.
6. To monitor finished goods material so as to ensure that we have adequate supplies on-hand to meet predicted customer demand.
7. To monitor the status of all material so as to be able to accurately account for the value of all material from an accounting viewpoint. It is also to be able to account for changes in material and to detect "shrinkage."
8. To track labor hours. This is to be able to determine efficiency of labor utilization and also as a feed into a payroll system. This may include the integration of

productivity measures for payment of performance based incentives.

9. To monitor the receipt of materials into material and the shipment of goods from finished goods material. It is also to trigger payments to vendors and invoices to customers from the accounting system.



10. To be able to analyze production measures. This can be so that we can measure continuous improvement over time. It can also be to measure the before and after performance related to a specific improvement initiative.

From this list it can be seen that there are multiple beneficiaries of the data collected. These fall into two major groups: First there are the people concerned with accounting and financial analysis. Second there are the people such as customer service, production managers, production supervisors, and production control who are concerned with getting product out to the customer. Unfortunately, all too often, the needs of the second group are largely ignored in the decision as to which type of data collection system to purchase.

Alternatives for Shop Floor Data Collection

1. Manual data collection. In this method, shop floor personnel record

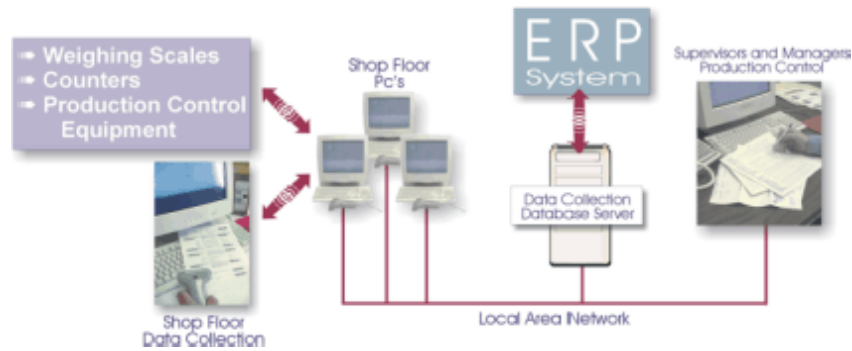


production data on paper forms using a pencil. This data is entered into the computer by a data-entry person sometime later. The major problem here is the delay between when the data is recorded and when it is available for analysis. This is also labor intensive and error prone.

2. Direct keyboard entry into a data collection system. The problem here is data entry errors. It is our experience that people on the factory floor make at least one keystroke error in forty when entering data. This implies that, if you have a 10 digit part number, every fourth part number will be entered incorrectly. Keying in data is slow and also requires significant training.
3. Using barcodes to scan data directly into a data collection system. Here the data is recorded immediately and the keystroke errors are virtually eliminated. It is much quicker and easier to scan a barcode. It also reduces training, especially when English is a second language.

It is apparent that using barcode scanning has many advantages, which is why almost all organizations are transitioning to the use of barcode scanning for their shop floor data collection.

Separate Data Collection System



Alternatives for Barcode Data Collection Systems

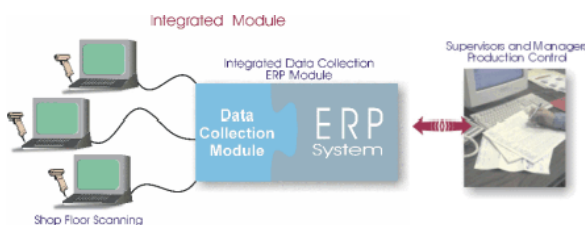
1. A data collection module that is integrated with an ERP system. In this case data from the barcode scanners is directly input to the ERP system.
2. A separate data collection system. In this case, the data is collected in a separate database, which is used to provide the real-time data needed by production managers, supervisors, and production control people. The data collection server exchanges data with an accounting or ERP system on a periodic or real-time basis.

The benefits of a shop floor module integrated with the ERP system are:

1. There is usually a single source vendor who can handle all the issues that may arise.
2. There is one database that needs to be maintained.
3. System integration issues are minimized.

There are a number of disadvantages, however. These include:

1. ERP systems are very expensive and difficult to customize. In fact most companies try to avoid customizing these systems because any customizations usually have to be



redone when the ERP vendor issues a new version of their software. Because the data collection module is an integral part of the ERP system, it too has the same issues.

This can cause major difficulties, as data collection systems often need to be customized to minimize manual data entry time and mistakes. This may include integration with weighing scales, counters, and process control equipment. It also includes adapting the barcode data collection to reflect cellular versus batch operations and labor intensive versus machine centric operations that all coexist in many plants.

2. Most ERP data collection systems are unable to handle the complexities of truly tracking what happens on the shop floor. For example most ERP systems are unable to handle unscheduled operations, split batches, and rework cycles. As a result they are unable to produce reports that are truly useful to shop floor supervisors and managers.
3. ERP based data collection systems are typically very unforgiving of missed barcode scans or other data entry errors. This is because every data entry activity results in a transaction that is directly reflected in the General Ledger, which is at the heart of every ERP or Accounting System.
4. ERP systems typically do a poor job of collecting data needed for manufacturing engineering analysis. This includes monitoring setup, run, down, and tear-down times for machines as well as reasons for down time, scrap, and rework (for subsequent Pareto analysis of failure modes).
5. The ERP system is typically under the control of the Information Technology group. As a result, any needed changes

typically take 3 to 6 months to implement due to work backlogs in the IT group.

The benefits of a separate data collection system are:

1. Separate data collection systems can be customized much more easily than plug-in data collection modules to ERP systems. ERP systems have many complex interactions to accurately account for transactions. As a result, they are difficult to customize. Also the business model of the ERP vendors is "one-size fits all" which is the antithesis of customization. This is reflected in their plug-in data collection modules, which have the same issues.
2. Changes can be made to the data collection system without making any changes to the ERP system. Also changes can be made to the ERP or accounting system without requiring that the data collection system be changed.
3. Separate data collection systems can be customized to track the complexities of any production operation. As a result they are able to produce real-time information that is truly useful for production managers, supervisors, and production control people. Plug-in ERP data collection modules often only produce data that is useful to accounting and financial analysis people.
4. Separate data collection systems are typically designed for custom integration. As a result, they can be adapted to efficiently collect data in many different situations, including integration with weighing scales, counters, and process control equipment.
5. Separate data collection systems are typically placed under the control of manufacturing engineering. As a result

changes can be quickly made both in the data captured and the reports produced.

The disadvantages of a separate data collection system are:

1. The data collection system is supplied by a separate vendor. There is not a single vendor handling the ERP and data collection issues. In reality there are many vendors in a system: computer vendors, network equipment vendors, operating system vendors, barcode equipment vendors, and EDI service vendors to name but a few. There is no question, however, that a separate customized data collection system does present more potential problems, especially for the Information Technology group.
2. There needs to be a systems integration activity to integrate the data collection system with the ERP or accounting package. Typically the data collection system needs to import orders for manufacturing and open purchase orders. It needs to export changes to material, including shipping and receiving, as well as reporting resources such as machine time and labor hours consumed to the ERP system.
3. There are two databases, one for production (in the data collection system) and one for accounting (in the ERP or accounting system). Typically production control maintains one and the information technology group maintains the other. There is a danger that the two may become inconsistent due to changes in one database not being reflected in the other.

The really big advantage of separate data collection systems is that they produce data that is immediately useful to first line supervisors. They also allow data to be edited and corrected before it is fed to the ERP/Accounting system. When missed scans

or other data entry errors occur they are quickly spotted and corrected by first line supervisors because they are using the data produced by the data collection system in real-time to run their production operations.

Data input into an ERP system through a data collection module typically does not produce any real-time information that is useful to production supervisors. Any reports they get are typically produced at least a day later and, as a result, are largely ignored by first line supervisors. As a result, data entry errors are caught by accounting who are the primary beneficiaries of this type of system. This typically happens at month end by which time it is impossible to reconstruct what happened. As a result, many ERP systems using an integral data collection module suffer from chronically bad data that significantly reduces their usefulness.

Not infrequently we hear a dialog like this: "Hi this is Joe in accounting, I see that Charlie Smith took 3.5 hours to machine the bracket on Job 34791 when the standard time is 18 minutes. I think you guys in production made a data entry mistake." "When was this?" "About three weeks ago, on the 25th." "Charlie quit last week. Three weeks ago you say? Beats the heck out of me."



Direct data entry into an ERP system is often regarded by production as "Something we have to do for accounting." They see no

benefit for themselves and, as a result, data entry errors are not caught. In contrast, most production organizations perceive separate data collection systems as their systems, to be well maintained just like any other production resource. From their viewpoint the fact that the resultant system exports accurate accounting data to the ERP system is simply a byproduct.

Reconciling Different Views

One of the major issues underlying many of the difficulties in shop floor data collection is reconciling the accounting/ERP view of the production floor with what happens on the production floor.

Sometimes these views are very different. An ERP system may regard a job to produce a set of parts as a route through a set of production operations plus a bill-of-materials. In reality, on the shop floor, the job may be split into a number of batches rather than just being one batch. Some of these batches may be rework batches and others may include unscheduled operations. Also the materials and machinery used may deviate from that specified in the ERP system.



If you are using an ERP data collection module there are a number of approaches to this problem:

1. Ignore it. Simply collect data for the main batch and ignore split batches, rework cycles, and unscheduled operations. Your data will not be very good and you will

have created a tough problem for the shop floor as they have to remember when to collect data and when not to.

2. Change your production operation to fit the available data collection module. Disallow split batches, rework operations, and unscheduled operations. Your productivity, quality, and yields will all drop but you can collect all the data using a standard plug-in module.
3. Find a standard ERP data collection module that is designed for your production operation. Unfortunately all production operations are different, even for companies making similar products. Companies specialize in certain market segments to avoid competing on price in a commodity market. This makes the one-size fits all approach of ERP data collection systems not work very well for most production operations.
4. Customize the data collection module to allow split batches, rework, and unscheduled operation. This is expensive and your customizations will probably need to be redone at the next ERP version upgrade.
5. Manually aggregate all the resources consumed on unscheduled operations and key these into the ERP system. Here we are going back to the problems of manual data entry but we have made it worse by using barcode scanning in some cases and pencil and paper in others.

If you elect to use a separate data collection system, the data integration problem takes the form of matching abstractions. The ERP system regards a job as a sequence of steps that consume resources and produce material. The data collection system will correctly collect data on the split lots, rework and unscheduled operations. The problem comes when data about a job has to be exported to

the ERP system so that the ERP system can compare planned versus actual resources used at each step in its manufacture.

Fortunately the ERP system has a higher level of abstraction than the Data Collection System. So we can add up the total of resources consumed on each of the operations, as measured by the Data Collection System and then report this as the amount of resources consumed on a specific job step to the ERP system.

The only possible issue is reporting resource usage on unscheduled operations. Most ERP systems can account correctly for unscheduled operations on jobs when performing an estimated versus actual cost comparison. Their integrated data collection modules, however, usually cannot handle the complexities of the shop floor. With a separate data collection system the resources used on unscheduled operations can be aggregated and reported to the ERP system automatically.

Note that if your ERP system cannot correctly handle accounting for the cost of unscheduled job operations then you have a major problem with your ERP system in either case.

Handling Material

On the shop floor, we track material by placing a barcode label on every box, bag, barrel,



reel, or other container of bulk materials. We then record the part/item number and other data, such as quantity, weight, and lot number (for traceability) in a database. We may also

record item specific data such as hardness, color, or melting point that makes the contents of this container different from that of another container of the same part or item. In addition we may track electronic or mechanical assemblies as individual items with their own barcodes.

An ERP system tracks material from three viewpoints:

- Accounting for the value of material.
- Accounting for the value of material consumed and produced as a result of jobs.
- Performing material requirement planning and issuing requisitions to purchase materials or requests to start jobs to produce WIP material.

If the ERP system is capable of tracking all the material data required at the shop floor level then material transactions are simply passed through from either type of data collection system to the ERP system.

The benefits of a separate data collection system in this case are:

1. If a separate customized data collection system is needed to collect job-tracking data then this same system can be used to relay material transactions to the ERP system.
2. Typically a separate data collection system will warn if the wrong materials are about to be used as the materials are scanned onto the job step.
3. The material transactions can be integrated with weighing scales, counters, and other process monitoring equipment to eliminate manual entry of data and the resultant data entry errors.

Some ERP systems cannot handle the detailed tracking of individual containers or items. They are simply concerned with the aggregate

quantities. On the shop floor, however, it is essential to keep track of individual containers or items when:

- Material, while having the same part number, is not interchangeable. If a customer orders a 2000 foot length of cable, this order cannot be filled with two 1000 foot lengths. If a customer orders 100 eight foot lengths of lumber, this cannot be filled with 200 four foot lengths. Also chemicals with slightly different characteristics must often be carefully matched in mixing operations,
- Materials with the same part number are stored in different locations. Not knowing where the material is can cause a lot of wasted time finding the material.
- Material in containers is partially consumed. It is essential to track individual containers so as to use-up partial containers first to minimize material space.
- Material ages. Here it is essential to use the oldest material first and often to discard materials beyond a certain age.

In these cases, it will probably be necessary to use a separate data collection system that keeps track of individual items for production control. The data collection system then exports aggregate changes to material levels to the ERP system for accounting purposes.

Handling Labor

An issue that ERP systems often have problems with is correctly accounting for labor on jobs. The



ERP view is that that of labor consumed on a job step. Employees scan in, using a barcode on their badges, when they start a job step and scan out when they finish a job step.

Unfortunately in reality people often work on different jobs concurrently, especially in a machine intensive environment. They may also be working as part of multiple cellular teams at the same time. The complexities of the labor tracking and allocation often require significant customization, which make standard ERP tracking modules unsuitable for this task. With a separate data collection system, the data can be allocated and aggregated before it is exported to the ERP system.

There is also the issue of time-clock elimination. With placing the ability to scan employee barcodes on the shop floor, there is no need for separate time clocks. Employees can clock-in and clock-out at their work station. This eliminates waiting lines at time-clocks and also eliminates discrepancies between labor hours recorded on jobs and time-clock hours. ERP systems cannot typically perform time-clock replacement whereas separate shop floor data collection systems can. These systems can collect the time clock data as part of normal data collection activities and export the data directly to a payroll system. This saves the cost of time clocks and the labor in entering time clock data into the payroll service.

Smaller Systems

One of the questions we often get asked is "Do I need to purchase an ERP system." For many of the smaller batch-oriented plants, the answer is no. You can do just fine with an accounting system integrated with a separate shop floor data collection system.



The separation of functions in a system such as this is typically as follows:

Accounting system:

- General ledger and financial reporting
- Issuing purchase orders, tracking accounts payable, and issuing payment checks
- Issuing invoices and tracking payments.
- Valuing material.

Shop floor data collection system:

- Order entry
- Tracking jobs, rework, and scrap
- Tracking material
- Tracking labor, including export to payroll.
- Shipping and receiving transactions

Some more sophisticated shop-floor data collection systems (such as BellHawk Systems' BellHawk™) also have modules such as:

- Automated generation of purchase requisitions and jobs in response to predicted material shortages (MRP functionality)
- Production scheduling
- Job completion date prediction
- Q/C test data collection.

These extend the capabilities of the combination accounting/shop-floor data collection system into the MRP/ERP domain. The combination system gives all the customization benefits of a separate shop-floor data collection system without the expense of investing in an ERP system.

Another major benefit is that accounting can choose an accounting system that really works

for them, rather than being stuck with the limitations of the one that comes with the ERP system.

Conclusions

If you have an ERP system and are looking to add shop floor data collection then you should carefully examine the capabilities of add-in data collection modules. If these meet all your data collection requirements then this standard approach is definitely the way to go.

If you need customization to the ERP shop floor data collection module to efficiently accommodate your shop floor data collection needs, then you should seriously consider a separate shop-floor data collection system. These are typically designed for ease of customization whereas the add-in ERP data collection modules are not typically intended to be customized. Most important is that data collection systems are typically supported by a local systems integrator who is experienced in customization and can work closely with your team to ensure an exact fit to your needs.

If you are a smaller plant and do not need all the sophisticated capabilities of an ERP system then you should seriously consider simply implementing an accounting system combined with a customized shop floor data collection system. It will probably be a lot quicker and less costly to implement.

Finally, make sure that your integrated system provides benefits for the people who collect the data, especially the first-line production supervisors who ensure data correctness. Otherwise you may find your ERP system becoming totally worthless due to lack of good data.

Author

Dr. Peter Green received his BS. and Ph.D in Electronics and Computer Science from Leeds University in England. He is a



systems architect with over 30 years experience designing and implementing systems for industrial, commercial, and government clients. Dr Green was also a Professor at WPI and a member of the research staff at MIT. His specialties include the design of real-time tracking systems and the implementation of real-time systems with embedded intelligence.