AUTO-ID ENABLED REAL-TIME MANUFACTURING SHOP-FLOOR MANAGEMENT: A CASE STUDY IN A FASTENER MANUFACTURER

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ABSTRACT
This research is motivated by a practical fastener company which is a supplier for most major automobile factories in China. Each month it receives more than 150 new orders, including 4000+ kinds of fasteners, and the production volume usually keeps in billion-level. As the managers suffer from the bottleneck of collecting the real-time shop-floor information, it is difficult to evaluate the available machine capacity, estimate the latest start time, and release appropriate amount of production orders. This paper presents a real-life case study to describe how to implement Auto-ID technology on a manufacturing shop-floor and use the collected real-time information to support decision-making processes. Meanwhile, the lessons like how to institutionalize a project team, how to defuse the resistance from the personnel will be discussed. We hope the experiences and insights learned from this project can be shared with other fastener manufacturers which are contemplating to adopt Auto-ID technology in their shop-floor management.

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1 INTRODUCTION

In the face of financial crisis, global automobile industry falls into doldrums, while China's automobile industry achieves rapid growth. By October 2009, China's automobile production and sales volume has broken 10 million, having enormous impact on related industries in both upstream and downstream (http://www.ccidconsulting.com). Because of the frequent customer order change and long production cycle time, it brings big challenge in inventory management and the production planning and scheduling. In order to reduce the production cost and increasing the competition, the upstream automobile component industries are interested in adopting advanced technology to solve the above problem.

Aim to deal with different planning and scheduling problems at different manufacturing environments, some customized APS (Advanced Planning and Scheduling) system are developed [1, 2]. A number of researchers have pursued more distributed solutions in which decisions about routing, planning, and scheduling are more closely linked to the execution of production and control of the flow of material [3]. When implement these computer integrated manufacturing (CIM) system, people recognized the need for automatic object identification (Auto-ID) and “tracing and tracking” on manufacturing shop-floors [4]. A number of Auto-ID technologies exist to aid in dealing with information capture and dissemination in an automated manufacturing environment, and thus facilitate implementation of the CIM architecture, to address the time value of information in decision-making [5]. Perhaps the most widely recognized Auto-ID system is the barcode system developed in the 1970s, which also accounts for the biggest share of the worldwide Auto-ID market. More recently, Radio Frequency Identification (RFID) technologies have begun to find greater use in automatic identification [6]. Auto-ID does this by increasing the certainty of the current and historical information about a product as it moves through the manufacturing process, as well as improves the control, quality and efficiency of the manufacturing process itself and yields results that impact customer satisfaction, the income statement and shareholder value [7]. Such as Wal-Mart and Target in the United States, Tesco, BMW, Volvo in Europe, and the U.S. Department of Defense, have announced RFID initiatives in response to technology improvements [8-12]. Such RFID-enabled real-time visibility and traceability substantially improve shop-floor management in general and Work-In-Progress (WIP) materials management in particular [13].

According to the experience of the Auto-ID center, we follow their procedures to implement the RFID application [7] (1)Begin with an investment-grade business case to identify the highest potential value-creating opportunities. (2) Determine deployment models. (3) Conduct pilots to test and refine deployment models. (4) Scale deployment to obtain maximum benefits.

This paper presents a real-life case study by combined application of Auto-ID technology i.e. RFID, Bar code to support an intelligent decision support system within the manufacturing shop-floor in a fastener manufacture which is a supplier for most major automobile factories in China. The operation mode in this fastener manufacturing shop-floor is a typical HFS (Hybrid flow shop) system, and it has several characteristics. 1) high volume/ high variety, long production cycle time, long mold changeover time, long technical process 2) frequent customer order change and a large number of rush order 3) short of real time information and 4) difficult to carry out production planning and scheduling

The rest of the paper is organized as follows: Section 2 introduces the case company, and discusses the current decision-making processes of its shop-floor and the cause and effect analysis will be conducted. Section 3 explains the details of how to institutionalize the implementation project. Section 4 discusses how to deploy the Auto-ID devices in the shop-floor and combine with a developed intelligent decision support system to realize an intelligent manufacturing control system. Section 5 describes a scenario to exemplify that the Auto-ID solution can help to facilitate the shop-floor decision-making. Section 6
evaluates the project by listing some implementation challenges and improvements. Section 7 is the generalization of this case study.

2 ABOUT THE COLLABORATING COMPANY

2.1 Company Introduction

In the past few years, by the rapid growth of automobile industry, our collaborating fastener company has developed into one of the largest automobile component supplier in China. Different with other fastener company, it focuses on the high tensile fastener for automobile industry i.e. Volkswagen, GM, Honda, Ford, etc. Every year they will produce more than 4000+ kinds of fasteners and the production volume usually keeps in billion-level. Compare with other fastener manufacturer, the case company pays more attention to achieve the on time delivery. Therefore, more finished products and WIP inventories are prepared in the warehouse and shop-floor to balance the fluctuation caused by the frequent changes from customer orders.

2.2 Cause And Effect Analysis For The Current Decision-Making Process

Through an extensive investigation in the collaborating industry, we find that there are two levels of decision maker. The upper level is the production plan department which is responsible for making the short term or middle term plans. The lower level is the shop-floor and the warehouse. The warehouse concerns about the reduction of WIP and finished product inventory, the improvement of picking and delivery efficiency. The shop-floor concerns about the high equipment utilization. The decision-making processes include several stages which are detailed demonstrated as follows.

● Stage 1: Production Plan Making And Releasing, And Order Progress Monitoring

Generally, the production plan department will receive the notification of the estimated demand for the next 3 months from their customers, and the final accurate order will be confirmed from time to time. Their major responsibilities are 1) Making and releasing paper based production orders to shop-floor and raw material requirement plan to warehouse. 2) Monitoring the progress of released production order.

Before making the production plan, the customer order list will be printed out. A conventional manual procedure will be carried out for collecting the related data e.g. equipment loading, production average cycle time, technical document, WIP/finished product inventory. Then, the latest start time will be calculated according to the estimated production cycle time and due date of an order. The production orders will be sequenced by priority to generate a new version of final production plan. However, the arrival of rush orders and frequent customer order changes are also very common in this company. For example when rush order arrivals, they should call the shop-floor for querying if there are enough capacity for the rush order. If the answer is negative, they should negotiate with the customer to postpone the delivery date or implement split shipment plan. When the customer wants to change a specific order, they should call the shop-floor to trace the progress of the order, and decide how to adjust the production plan immediately.

During the monitoring process, all staffs in production plan department will be assigned to shop-floor for collecting the WIP information and monitoring the order progress. Normally, the shop-floor adopts “material flow card” to collect the shop-floor information throughout the production process. In this card, some corresponding information e.g. WIP inventory, progress of production order will be recorded by manual, and then imported to ‘excel’ with predefined format.

● Stage 2: Scheduling And Order Releasing

In fastener manufacturing, each product should pass 5 to 10 production stages according to their predefined process route, for example, cold drawing, cold forging, thread rolling, heat
treatment, and packing. When an order arrives a specific stage, which equipment in the group will finally take the job operation is randomly selected. Therefore, after the production orders are released to the shop-floor, the control right to the orders will be transferred to the shop-floor manager. According to the experience of the shop-floor manager, he has extremely freedom to arrange the operation sequence of the released orders. Commonly, the production order will be sequenced according to the type of product and the capacity and capability of the equipment (Emergent production order has priority). For example, in the stage like forging, before processing the order, pre-install a set of mould to the machine is necessary. But it may cost a half hour to 3 hours. If the product orders in the same family can be scheduled consecutively, the total setup time can be reduced. Moreover, in the heat treatment stage and electroplating stage, the jobs should be grouped together into batch for simultaneously process. Thus scheduling the product orders into a same family to share the setup operation for reducing the total setup time and grouping the jobs together into bath to minimize the make-span are the primary concerns of shop-floor manager.

- **Stage 3: Raw Material And Finished Product Preparing And Delivery**

  The warehouse manager is responsible for making material preparation scheme after receiving new orders. Firstly, he opens an Excel file which records the inventory information, and then checks the related items one by one as well as marks the printed order sheet with information like quantity and probable storage location. Secondly, he assigns the picking up order to the tally clerk who is responsible for finding out the required material or product from the shelf and loading into pallets, and assigns a logistic operator to deliver the pallet to the appointed location. After receiving the pick-up task, the material operator will look for the appoint material in the informed probable storage location one by one, and loading them to the pallet. If some required material cannot be found in the warehouse, they will write a remake on the pick-up task sheet.

- **Existing Problems:**

  Among the above process stages, there are several problems which negatively influence the operation efficiency and effectiveness.

  - **The Current Paper Based Approach To Collect And Manage Shop-Floor Information Is Ineffective And Inefficient**

    Current shop-floor information collection approach relies substantially on manual approach. Typical practice is writing a lot of number on a form and keying into the computer later. However, paper-based manual system is time-consuming, prone to errors, tedious, and frequently damaged, lost or misplaced. As a result, the information does not accurately and promptly reflect the real-life situations and changes of the situations due to disturbances [4]. In addition, because the information can’t be imported to the computer timely, and can’t avoid the problems such as documents missing or illegible, the acquisition, sharing, and feedback of shop-floor information are asynchronous and not sufficient enough to support their decision-making. The following situation will be caused: “Isolated production planning and production execution.”

  - **Isolated Production Planning, Scheduling And Execution**

    Our collaborating industry is short of efficient technology and method to integrate the isolated implementation of production planning, scheduling and execution. However the production manager suffers from the bottleneck of collecting the real-time information without the accurate, complete, consistent and timely WIP information, production progress tempo, and production status, equipment load. The frequently change of customer order and the complexity of production processes leads that evaluate the available equipment capacity, estimate the latest start time, and release appropriate amount of production
orders to shop-floor are mission impossible. The isolated planning result is not always reasonable to the reality of the shop-floor.

Excessive pursuit of reduction of the total setup time and minimize the make-span cause the delay of urgent orders and the increase of WIP inventory. Therefore, the most difficult issue is how to optimize the shop-floor scheduling in multi stage to handle the fire-fighting between the on time product delivery and the maximize productivity. As a result, the schedule scheme has to be changed frequently, and obviously will also cause enormous impact on the WIP management.

- The WIP Management Is Inefficient

For the multi-workshop and multi-process circumstance, the coordination among production stages becomes very difficult. WIP shortage or overstock causes some production chaos such as generate some scrap, stop for waiting material, and overtime operation. A mass of redundant materials are accumulated in the production line, but the information such as quantity, variety and position of these redundant materials are not clear to manager and it always not easy for the relevant personal to find out when they are needed. Moreover, lots of management issues existing in the shop-floor are caused by the low efficient WIP management and high level WIP inventory, for instance: 1) the chance of defects and rework will increase because problems can be existed a long time and will not be detected until the WIP is tested by the quality control department, 2) a false sense of security will be provided to the manager, making the existing issues become unobvious.

3 PROJECT INSTITUTIONALIZATION

3.1 Project Teaming-Up

This project is sponsored by the government and collaborated by the university and the case company. The project team involves two parts, one is AUTOM group (from University) and the other is the company group. Fig. 1 shows the organization of the project team. The AUTOM Group is responsible for the related technical tasks i.e. business process analysis, system development, onsite implementation. Company group is mainly responsible for provide information for business analysis, helping AUTOM group to implement the solution in the shop-floor, providing the feedback information, and providing IT support. These two groups first carry out a meeting to select some critical person to build-up a project coordinating committee from own group respectively. They are responsible for 1) establish a feasible project plan and make sure the specific milestone 2) Monitor the progress of the project.

![Figure 1: Organization of Project Team](image-url)
3.2 Periodical System Testing

The objective is to ensure the developed system is applicable and effective to the shop-floor management. The functionality test is taken place by the following mechanism. The testing plan is divided into 4 periods. The first period is testing the functional models which are developed for managing the static basic information. The second period is testing the functions which are used for collecting and managing the real-time information from the shop-floor and warehouse. The third period is testing the functions which are developed for production planning and scheduling purpose. The fourth period is used for combining the real-time information to the decision-making models.

Each periodical system testing will firstly be tested in the lab with simulation data to grantee the functionality. Then it will be delivered to the company to test and refine by real field data. The pilot application is vital because it can provide a chance for us to assess the potential benefits by a realistic circumstance. It allows the user to explore how the Auto-ID technology and the provided models can be used to improve current business process. That can give the users insights into the hidden issues.

In each period, the company will first choose some pilot for testing and the testing will repeat for 5-10 rounds (each round will cost 2-3 weeks). At the end of each round, some suggestions will be given for AUTOMs group. These suggestions are significant for the system modification and updating. While the test in the pilot shows promise, the company will increase the number of pilot until the whole shop-floor.

3.3 Targeted Staff Training

The objective is to make sure the operator in the shop-floor can easy accept the new business process and active to use the new system. The training is taken place in two levels. First the AUTOM team will invite the operator in the pilot to promote new managerial concepts and explain the different between the previous method and the new method. When these operators are familiar with the developed system, they will be promoted as team leader to teach the new operator how to use this system. It is obvious easier for them to communicate with other operator than AUTOM team member.

3.4 Standardized Operation Specification

It is obvious that a successful IT project not only relies on the good system design. Therefore, a standardized operation specification is drafted by AUTOMs group and Company group together to guide the operation.

4 DESIGN OF AUTO-ID ENABLED INTELLIGENT DECISION SUPPORT SYSTEM

Before provide an Auto-ID solution for a specific industry, the following questions should be carefully considered:

1) What’s the business process? What’s the most challenge in the business process?
2) Is the existing Auto-ID device scheme can be used in this environment?
3) If the Auto-ID technology can deal with their problem?
4) What’s the benefit of implement Auto-ID technology?
5) Can the new system ease be integrated with the existing system?
6) How to process large amount of primitive data into useful information?

In order to improve shop-floor productivity and quality, reduce the wastes of manufacturing resources, cut the costs in manufacturing logistics, improve the responsiveness to market and engineering changes and achieve real-time and seamless dual-way connectivity and interoperability between the application system enterprise, shop-floor, work cell and Auto-ID device levels, the AUTOM team provides a general solution which can fulfil most of the environment of manufacturing shop-floor according to the manufacturing hierarchy [14]. As shown in Fig 2. It consists of 4 main parts. The top level is the decision support system (DSS)
which is responsible for helping the manager to make production plan, schedule scheme, and logistics plan. The part in the lower level are shop-floor gateway, smart gateway and smart object [14].

- Smart Objects (SOs) are physical manufacturing resources that are made ‘smart’ by equipping with a certain degree of intelligence: memory, services, communicating ability and specific logics.
- Smart Gateway acts as a server to host and connect all SOs of the concerned production line or work-cell or work station, and also provides a suite of software applications for managing their operations and activities.
- Shop-floor Gateway is at the centre of the overall infrastructure. Its purpose is to provide a two-way information channel between shop-floor and enterprise application. From operations to enterprise decisions, it collects real-time information from the Smart Gateways and converts the information into standard formats to be directly used by enterprise application systems (EASs). From decisions to operations, it receives enterprise’s decisions from EASs and translates them into production orders or tasks.

![AUTOM Infrastructure](image)

**Figure 2: AUTOM Infrastructure**

### 4.1 Deployment Of Auto-ID Devices

Before establishing the Auto-ID enabled environment, the most typical questions the user will ask: 1) which frequency should be used: LF, HF, or UHF? 2) Should the existing Barcode be replace by RFID tag? 3) Which resource should be tagged? 4) Where the RFID readers should be deployed?

It should be noted that the circumstance and the business process in each company are unique. Therefore the scheme for the deployment of RFID tag and RFID reader should be designed according to different production requirements and working environment. Despite giant strides in RFID technology, tags remain too expensive for item-level deployment that is, placing tags on every product in an inventory. The price of a typical low-cost tag is $0.5
Meanwhile, there is no denying that Barcode is cheap, reliable, relatively easy to produce, and barcode technology is more mature than RFID, which gives significant comfort value to some users. But barcodes identify only classes of products, not individual items. It has to be deliberately scanned at specific orientations (establishing line of sight), and it does not work if the symbol becomes damaged [6]. Therefore, we decide to adopt both RFID tags and barcode for attaching the resource which should be tracked. The smart objects including operator, equipment, container are attached with HF (High Frequency) tags, and the packages of the finished product, locations and the pallets in the warehouse are attached with barcode. Therefore, for example a group of WIP items in a container can be traced and tracked in the workshop, the cost is very low and the tagged containers are reusable.

As mentioned previously, the Smart Gateway is an innovative platform that centrally connects and manages the multiple types of SOs necessary for capturing real-time manufacturing data. Smart Gateway could be categorized into stationary and mobile Smart Gateways. In our collaborating company, the stationary Smart Gateway is placed at a designated location (e.g. the entrance of the buffer in the shop-floor, nearby a workstation or assembly line). The mobile Smart Gateway is installed in a moveable manufacturing resource (e.g. trolleys) as shown in Figure 3.

![Figure 3: Smart Gateway](image)

### 4.2 Development of Auto-ID Enabled Decision Support System

As mentioned in AUTOM infrastructure, the purpose of shop-floor Gateway is to provide a two-way information channel between shop-floor and enterprise application. In this case, from operations to decisions and control, it collects real-time information from the Smart Gateways and converts the information into standard formats by XML to be directly used by decision support system. From decisions to operations, it receives enterprise’s decisions from DSS and translates them into production orders or logistics tasks.

Different with other management system, the decision support system should be customized based on the specific business process. Thus, we customized an intelligent decision support system (IDSS) on the basis of our AUTOM group proposed infrastructure for the collaborating company. The implementation of the IDSS follows the service-oriented architecture (SOA) model. The data exchange among the different models adopts standard XML schema. A set of services are developed for the so-called ‘Smart Gateway’ and ‘Shop-floor Gateway’ to realize the real-time monitoring, visibility and traceability. And different sets of services are provided for corresponding managers to support better planning, scheduling and operation control. They are 1)‘Customer Order management Service’, ‘Capacity Evaluation Service’, ‘Order Sequencing and Re-priority Service’, 2) ‘Job-level Capacity Balancing Service’, ‘Job Release Service’, 3)‘Pallet Loading Scheme management Service’, ‘Pallet delivery scheme management Service’. The first set of services is provided for the production manager to support better planning, the second set of services is provided for shop-floor manager to
carry out reasonable schedule scheme, and the third set of services is provided for warehouse manager to better manage pallet loading and delivery scheme. Details of the services will be described in the next section with a description of scenario, as shown in Figure 4.

5 SHOP-FLOOR DECISION-MAKING WITH IDSS

- **Step 1**: Production Manager: Customer Order Management
  With the “Customer Order Management Service”, the production manager will combine the waiting production order list with the new imported production order list in a unified view of explorer. In this explorer, by using the real-time information service provided by the shop-floor gateway, the manager can review the current WIP and finished production inventory information of corresponding product. Such information helps to conduct a final production quantity decision.

- **Step 2**: Production Manager: Capacity Evaluation
  When the new production order list is generated, the production manager can open the “Capacity Evaluation Service” to carry out a so-called equipment capacity evaluation (ECE). The ECE result indicates whether the capacity of equipment can meet the requirement. If negative, the service would offer a capacity evaluate report which
shows the bottleneck stage information and a predicted complete date for each order. By using this explorer, the production manager can view not only the capacity evaluation result for each order, but also can realize the overall production capacity information of each equipment in the setting period to support him make better decision.

- **Step 3**: Production Manager: Order Sequencing And Re-Prioritization
  It is certainly inappropriate to sequence the production order only based on the due date of customer order. The involved factors include order priority, customer priority, required product quantity, processing difficulty, required operation time, and process complexity should also be carefully considered. Therefore, a predesigned algorithm which sets the defined weightiness of the previous mentioned factors as parameter will be invoked for evaluation. According to the evaluation result, the production manager can release the sequenced orders to shop-floor manager.

- **Step 4**: Shop-Floor Manager: Job-Level Capacity Balancing
  With the “Job-level capacity balancing Service”, the shop-floor manager can balance the capacity of stage in job-level for the received production order and generate the production job with split lot number. In this model, some corresponding services provided by the shop-floor gateway will be adopted, including ‘real-time job progress visibility service’, ‘real-time equipment status service’. On the ‘capacity balancing result explorer’, the shop-floor manager can review the details of the stage in a setting period, including total capacity, required capacity, spare capacity, equipment quantity, real-time capacity gap, and the required daily average working hours. By the supporting information, the shop-floor manager will make an adjustment for the production order. Once the balancing result is confirmed, the production job will be transferred to the corresponding stage job pool.

- **Step 5**: Shop-Floor Manager: Job Release
  By invoking the ‘real-time stage job pool monitoring service’, the job operation status in job pool can easily be checked from time to time. The shop-floor manager can assign production job to specific equipment or adjust the sequence of production jobs when necessary.

- **Step 6**: Warehouse Manager: Make Material Purchase Plan, Pallet Loading Scheme And Pallet Delivery Scheme
  When the production manager issues the production order to shop-floor, the warehouse manager will receive the material preparation plan either. On ‘material preparation management explorer’, by invoking the real-time material inventory information visibility service, the warehouse manager can easily generate a material purchase plan. In the other hand, once the production job is received, the warehouse manager will be notified to make pallet loading scheme and delivery scheme.

- **Step 7**: Warehouse Operator: Pick Material And Deliver Pallet
  With the help of the mobile smart gateway, the execution of material preparation scheme and the pallet delivery scheme become easier. Task the former as an example, the assigned material preparation tasks are sequenced by their priority. The specific warehouse operator selects the most urgent task to prepare. Material can be easily found from the specified storage location by following the real-time instructions of the ‘material preparation explorer’ on mobile gateway. The inclusion relationship among the Barcode of material, RFID tag of container, Barcode of Pallet or the barcode of Location can be rebounded to the latest status through the whole process.

- **Step 8**: Shop-Floor Operator: Job Execution
  On the shop-floor, the operator and the equipment follow the one-to-one binding relationship, so the operator can view the assigned production job list by patting staff card or equipment card on the stationary gateway. The operator should take the jobs from the system according to the priority, unless exception occurs i.e. mould damage, mould shortage, material shortage, and equipment breakdown. When these exception occurs, by adopting the ‘exception report service’ provided by the stationary gateway,
these corresponding exception information of a production job will be transferred to the shop-floor gateway and displays on the ‘exception report statistics explorer’. If it is the shortage of material exception, the warehouse manager will immediately notify the appropriate warehouse operator to carry out the corresponding material preparation and delivery task with highest priority. If it is the equipment breakdown exception, the shop-floor manager will inform the maintenance staff to repair the equipment as soon as possible. Meanwhile, according to the seriousness of the equipment exception, two kinds of decision will be carried out. The shop-floor manager will decide whether to make the adjustment for the production jobs. The production manager will make an estimation to judge if the order can be complete before the required due date. If not, he needs to communicate with the customer to postpone the delivery or make split shipment plan. In addition, the stationary gateway provides a service for the operator to report when a production job is completed. By patting the RFID card which attached to the container, the real-time information of the production job including current WIP information, the operation equipment, and current stage will be recorded immediately. The shop-floor gateway will gather the information for generating corresponding real-time information viewer e.g. real-time WIP information explorer, real-time production order progress explorer to support the decision-making.

6 EVALUATION AND REFLECTION

6.1 Implementation Challenges

When implement the project in the company, the first challenge we meet is the standardization problem. After an extensive investigation, we find the company is short of management documents for the equipment, container, and product ID. Take product ID for instance. There are more than 4000 kinds of product, but the product ID management is extremely confused. It is very common that several different kinds of product for different customer share a same product ID. Therefore, if try to implement Auto-ID enable decision support system, the standardization is the big challenge should be deal with first.

Another challenge is the change of working habit, though everyone knows that there are problems exist in the current business process. But people always like to follow their own habit. To the manager, they have interest to use new technology to help them improve their management efficiency. But to the operator in the shop-floor, most of them do not want to try. Since their salary is only related to their working hours and the more chaos in shop-floor the more autonomy they have. Therefore at the beginning, they resist to use the new system. The most common excuse is ‘if the new system does not work, it is possible to impact the production efficiency, the on time delivery can’t be guaranteed’. Therefore, after a deep discussion with the enterprise manager, we adopt the pilot strategy in limited equipment and give the participants some award to encourage the use of system.

6.2 Improvements

The provided solution replaces the inaccurate, incomplete, and inconsistent paper based manual data collection method by Auto-ID technology on the manufacturing shop-floor, as well as makes the manufacturing information become real-time visible, traceable and transparent.

1) On the shop-floor, the availability of the container is critical to production efficiency. The application of the RFID tags in container enables the track and trace ability. With the real-time visibility to the container, fewer containers are required and less human resource are assigned tracking the container, the availability of the container become more appropriately.

2) Based on the real-time information, the monitoring service provides a visibility for the corresponding warehouse operator to avoid the delay of material delivery as far as possible. Previously, the shop-floor operator sometimes will unaware of a potential out
of stock. Now the real-time information will automatically trigger an alarm to notice the 
warehouse operator to execute the assigned delivery task or resort the order in the job 
pool to avoid the situation.

3) With the real time information, the manager has the possibility to make a better 
decision, improving the responsiveness to market and engineering change as well as the shop-floor productivity and quality

4) By scanning and labelling, the errors of information recording are eliminated. The picking activity in the warehouse can be eased because the mobile gateway can indicate the operator go to the right source location to get right quantity of material to the right 
destination. Therefore the operators do not have to spend time to looking for the material.

6.3 Future Work
There are some possible extensions and improvements for future development of the 
presented system:

1) Due to the great success on the pilot shop-floor, the project team decide to extend the 
scope of the project to the whole enterprise.

2) In the current system, the decision-making are provided by the manager himself. The ‘Auto Decision-making’ model will be provided to achieve real time rescheduling and generate the delivery task automatically.

3) In this system, though a large variety of statistics reports are provided, but still not enough. In the future more types of analysis reports will be provided as well.

4) Some technology like data mining for production prediction based on the real-time job 
pool monitoring should be investigate and researched for reducing the production 
exception.

7 CONCLUSION
This paper has presented a case study of applying a feasible Auto-ID technology for the 
manufacturing shop-floor management in a fastener manufacturer. Specific decision making 
process of the shop-floor have been discussed and analysed. An innovative smart gateway is 
adopted for the project team to collect the real-time information from the shop-floor, and a shop-floor gateway and a decision support system are customized to address the problems 
existing in the shop-floor.

This project is significant in three aspects. First, the case study has demonstrated how the 
proposed infrastructure can be realized in a real-life manufacturing environment in a similar fastener company which enables the real-time adaptive decision-making. Second, the 
detailed illustration of the implement procedure can be used as a roadmap for guiding the 
development and deployment of Auto-ID enabled shop-floor management. Third, we hope 
the experience and insight learned from this project can be shared with other fastener 
manufacturers who have a similar shop-floor and decision making process.

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