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AUTO-ID CENTRE

WHITE PAPER

Methodologies for Integrating Auto-ID Data with existing Manufacturing Business Information Systems

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ABSTRACT

Auto-ID systems can provide frequent, and unique item level information at all points in the supply chain. In order to do so however, these systems must be tightly linked to existing Business Information Systems. The purpose of this study is to provide background information on manufacturing business information system (BIS), and to provide guidelines for the introduction of Auto-ID provided information into these systems. This study will also help users to prepare for new business processes, and to identify which systems may accompany Auto-ID provided information. This paper represents part of the activities of the Business Information and Industrial Control Action Group (BIICAG).

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WHITE PAPER

Methodologies for Integrating Auto-ID Data with existing Manufacturing Business Information Systems

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WHITE PAPER

Methodologies for Integrating Auto-ID Data with existing Manufacturing Business Information Systems

Contents

1. INTRODUCTION

1.1. Aims

Auto-ID systems can provide frequent, and unique item level information at all points in the supply chain. In order to do so however, these systems must be tightly linked to existing Business Information Systems. The purpose of this study is to provide background information on manufacturing business information system (BIS), and to provide guidelines for the introduction of Auto-ID provided information into these systems. This study will also help users to prepare for new business processes, and to identify which systems may accompany Auto-ID provided information. This paper represents part of the activities of the Business Information and Industrial Control Action Group (BIICAG).

1.2. Scope

In this paper we restrict the study of "Business Information System (BIS)" to manufacturing related business information systems which support supply chain processes in manufacturing enterprises. In particular, we consider specific examples of the typical Manufacturing BIS systems such as Manufacturing Execution System (MES); Supply Chain management (SCM) system; and Enterprise Resource Planning (ERP) system.

We finally emphasise that this study is not focused on the different systems associated with delivering Auto-ID data but rather on the Business Information Systems that are likely to receive it.

Auto-ID Data

Before beginning to examine the different BIS that might need to be integrated to Auto-ID data, we will define exactly what we mean by the term **Auto-ID Data**. By Auto-ID data we refer to any data originating or being stored within the Auto-ID information infrastructure and specifically to EPC™ and PML originated information. By way of example, Table 1, illustrates the types of Auto-ID data that might be required by a 3rd party information systems:

Table 1: Information Available from Auto-ID sources

INFORMATION TYPE	SOURCE WITHIN AUTO-ID ENVIRONMENT
Product Type	EPC™ (or Barcode)
Product ID	EPC™
Product Data – Parameter – History – Transaction Details	PML Core
Operation Data – Bill of Materials (BOM) – Recipes – Routing (e.g. distribution routes)	PML Extension
Product State – Location – Temperature	Other sensors (or stored in PML history)

In addition to considering which of these data types are required by different Business Information System it is important to also consider issues such as content, format and frequency.

1.3. Auto-ID Overview

Auto-ID Systems
An intelligent infrastructure which automatically and seamlessly links physical objects to each other, people and other information systems through the global internet has been introduced by the Auto-ID Center [1]. Four major components of this intelligent infrastructure are described below:

- **Electronic Tag:** refers to a family of technologies that transfer data wirelessly between tagged objects and electronic readers. When coupled to a reader network, it allows continuous tracking and identification of physical objects. (Examples of this technology are Radio frequency identification (RFID) and Electronic Identification (EMID) Technologies).

- **Electronic Product Code (EPC™):** is a numbering scheme which can provide unique identification for physical objects, assemblies and systems. The EPC™ code was intended to be universally and globally accepted as a means to link physical objects to the computer network [2].

- **ONS (Object Naming Server):** is the "glue" which links the EPC™ with its associated data stored in a Product Markup Language (PML) file. It is currently under development based on the standard domain naming service (DNS). The ONS is an automated networking service, which, when given an EPC™ number, returns a host address on which the corresponding PML file is located [1,2].

- **PML:** is intended to be a common language for describing physical objects, processes and environments. The primary objective of PML is to serve as a common base for software applications, data storage and analytical tools for industry and commerce [3, 4]. PML uses the same format and structures as the Extensible Markup Language (XML).

Joshi [5] introduced a generalized framework for examining supply chain processes using Auto-ID technologies. The EPCs™ on tags, coupled with tag readers and the controlling software application will form an automated tracking system for real time data acquisition. Along with ONS, PML and the internet, companies can convert acquired data into relevant information and store it securely at appropriate locations.

We finally emphasise that this study is not focused on the different systems associated with delivering Auto-ID data but rather on the Business Information Systems that are likely to receive it.

1.4. White Paper Overview

The paper begins with an introduction to key manufacturing BIS, identifying functions, input/output data flows and vendors. Specific data relevant to Auto-ID systems are identified. Approaches for Auto-ID data integration are then proposed and an illustrative example of Auto-ID data integration provided. As this is an interim report, we conclude with future development requirements.

2. MANUFACTURING BUSINESS INFORMATION SYSTEM

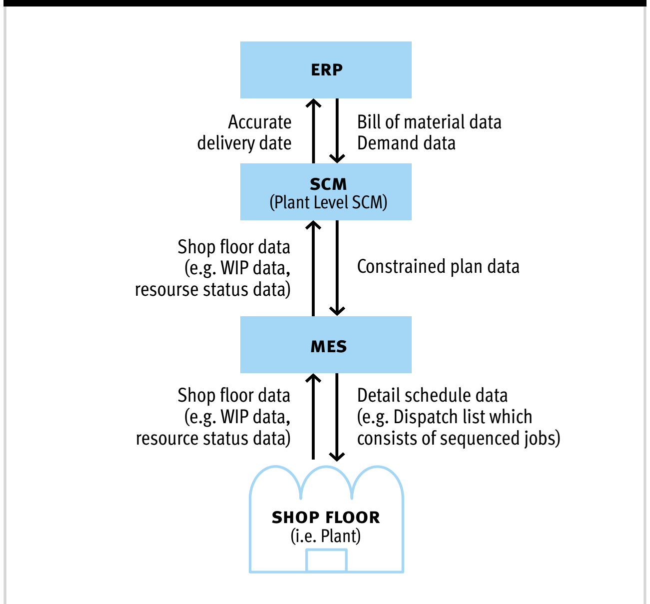
In this section we will briefly introduce the different classes for data Manufacturing Business information systems (BIS) under consideration and establish requirements for data Integration. To prevent misinterpretation, in this paper, we restrict the definition of Manufacturing BIS to mean only Manufacturing Execution Systems (MES), Supply Chain Management (SCM) systems and Enterprise Resource Planning (ERP) systems that are supporting the supply chain processes[1] of manufacturing enterprises.

[1] Here, supply chain does not define only supplier related management. In manufacturing enterprises, upstream manufacturing processes are suppliers to downstream manufacturing processes.

Figure 1 shows an example of how ERP, SCM and MES are connected together and typical data that is transferred between systems [2].

Figure 1

SCM, ERP, MES SYSTEMS INTEGRATION



[2] This is purely an illustrative example of ERP, SCM, MES interconnections. The Integration methodology and data transferred between systems can be changed according to the solution architecture. These days, there are many overlapping functions between ERP, SCM, MES systems.

2.1. MES

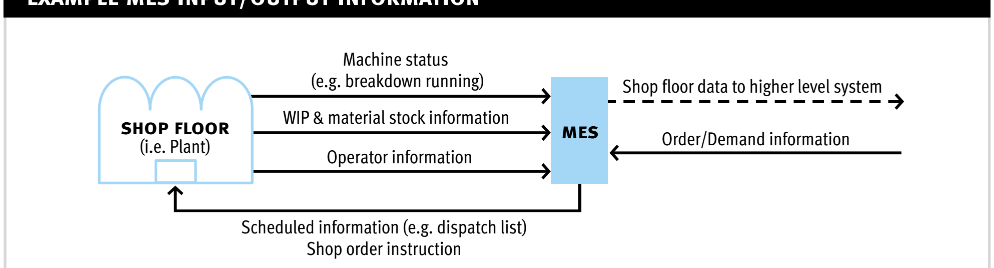
MES systems were first deployed in the 1980s and primarily focused on tracing lots of material in the production process. In the late 1980s, sophisticated MES users began to create additional customized functionality and to link it into their existing MES. We note the following MES description:

"MES Systems collect and deliver information enabling the optimization of production activities from order launch to finished goods. Using current and accurate data, MES guide, initiate, respond to, and report on plant activities as they occur. The resulting rapid response to changing conditions, coupled with a focus on reducing non-value-added activities, drives effective plant operations and processes. MES improve the return on operational assets as well as on-time delivery, inventory turns, gross margin, and cash flow performance. MES provide mission-critical information about production activities across the enterprise and supply chain via bi-directional communications" [6].

By way of illustration, Figure 2 indicates typical input and output information flows from a MES environment.

Figure 2

EXAMPLE MES INPUT/OUTPUT INFORMATION



Typically, MES systems include the following modules: Resource allocation and status, dispatching production units, data collection/acquisition, quality management, maintenance management, performance analysis, operations/detail scheduling, document control, labor management, process management and product tracking. We note however, that there is enormous variation between implementations.

For further reference, typical vendors and their www links are summarized in Table 2.

Table 2: Typical MES vendors

VENDOR	PRODUCT (S)	REFERENCE FOR FURTHER INFO
Brooks Automation	FACTORYworks, PROMIS, Encore	**http://www.brooks-pri.com**
Applied Materials	Workstream	**http://www.appliedmaterials.com**
Teradyne	SFDM	**http://www.teradyne.com**
Honeywell POMS	POMS MES	**http://www.poms.com**
Cimnetinc	Factelligence	**http://www.cimnetinc.com**
Wonderware (Invensys)	IndustrialSQL Server, InBatch	**http://www.wonderware.com**
IBM	Poseidon	**http://www.ibm.com**
Aspentech	InfoPlus.21	**http://www.aspentech.com**

2.2. ERP

Orlicky Reference developed the concepts of Material Requirements Planning (MRP) in the 1970s. He realized that the computer technology could be used to enable effective manufacturing inventory management. Using demand requirement information, together with information on the product structure from the bill of materials file, current inventory status from the inventory file, and component lead time data from the mater part file, MRP produces a time based schedule of planned order release on lower level items for purchasing and manufacturing.

A major limitation of MRP systems however, was the "assumption of an infinite capacity of resources." Manufacturing resource planning (MRP II) evolved from MRP by a gradual extension to MRP system features and in particular a consideration of finite capacity. MRP II is an extended MRP system with the functions of: Material requirements planning; master production schedule; capacity requirement; production activity control; purchasing and finance features.

In the early 1990's, MRP II was further extended to cover computer systems support for areas such as Engineering, Finance, Human Resources, Project Management etc. Hence, the term Enterprise Requirements Planning was coined. ERP can be defined, as a software solution that addresses the needs to meet the organizational goals (including manufacturing goals) of an enterprise by tightly integrating all functions of the organisation.

Generally, ERP systems include the following modules:

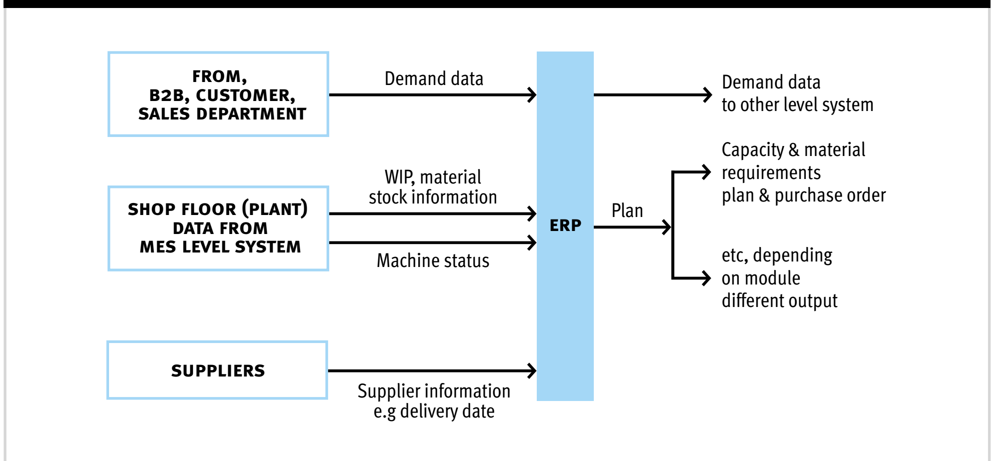
Inventory management, plant maintenance/service management, warehousing, production planning, human resources and finance, and recently, some of ERP companies are initiating marketing of a new product called "Logistics Execution System (LES)[3]", which begins to integrate execution level functionality within the ERP environment.

[3] Logistics Execution System (LES): LES differs from MES. LES focuses on the transactions/management of warehouse and transportation while MES focuses on the transactions/management of manufacturing plant (Some MES has capability to trace/manage transactions among distributed plants).

Figure 3 is a diagram, which indicates input and output information flows from an ERP environment. In this figure, we only focused on the manufacturing related transactional data (e.g. planning) and did not consider other data configured in the ERP system (e.g. Financing, product information).

Figure 3

EXAMPLE ERP INPUT/OUTPUT INFORMATION



Again, typical vendors and www links are summarized in Table 3.

Table 3: Typical ERP vendors

VENDOR	PRODUCT (S)	REFERENCE FOR FURTHER INFO
SAP	R3	**http://www.sap.com**
Oracle	Oracle ERP	**http://www.oracle.com**
JD Edwards	JD Edwards ERP	**http://www.jdedwards.com**
Baan	BaanERP	**http://www.baan.com**
Peoplesoft	Manufacturing, Supply Chain Planning, Supply Chain Analyst	**http://www.peoplesoft.com**
Mapics	Mapics ERP	**http://www.mapics.com**
IFS	IFS modules	**http://www.ifsab.com**

2.3. SCM

A large number of software packages emerged in the 90's that are collectively called SCM systems. The goal of the SCM system is to integrate the data between suppliers, manufacturers, warehouses, and retailers, so that goods are produced and delivered at the right quantities, and at the right time, while minimizing costs as well as satisfying customer requirements (e.g. due date).

The SCM system applies optimisation technologies to achieve improved plans by considering most of the factors and constraints that limit the ability to deliver on time. SCM system considers capacity and material requirements simultaneously to generate plans (ERP considers those sequentially[4]), and create a detailed production schedule that sequences the production optimally, to achieve the organization goals (e.g. minimizing inventory, maximizing throughput, etc.) as well as achieving customers' due dates.

[4] Recently many ERP vendors have introduced SCM concepts in order to improve the planning and scheduling capability of their ERP systems.

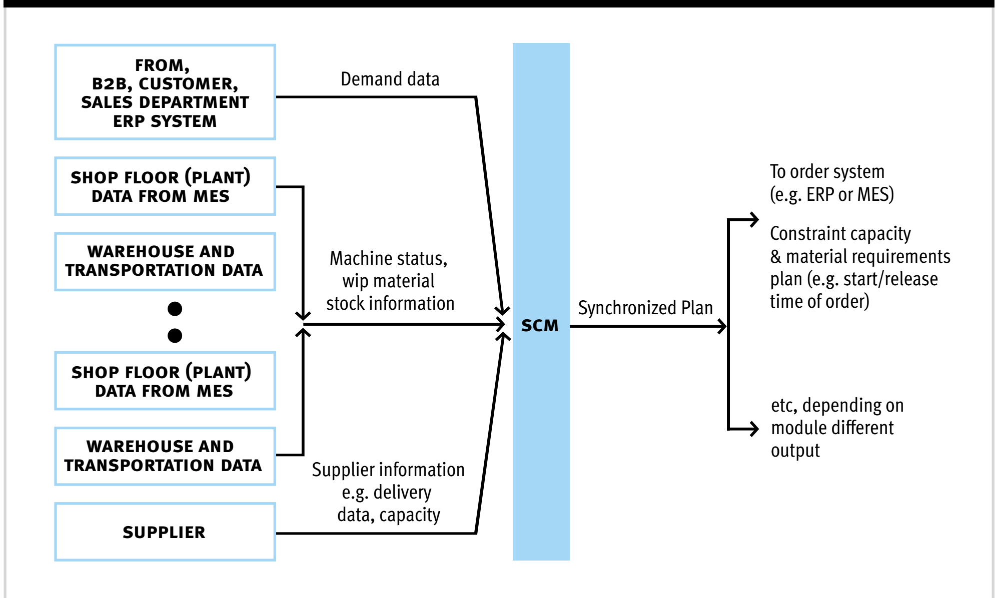
Generally, supply chain management systems consists of the followings:

- **Demand planning:** aims to reduce forecast error and to suggest buffers considering demand variability.
- **Master planning:** provide multi-site planning. Master planning based on the material, capacity, transportation and other constraints, simultaneously.
- **Manufacturing Planning:** generate plan considering material, capacity and other constraints which impact on manufacturing.
- **Transportation Planning:** consider dynamic transportation requirement and generate optimizing transportation plan.
- **Procurement Planning:** constraints such as supplier capacities, costs and lead times can be modeled as part of supply chain resulting in superior plans.

Figure 4 is a diagram, which indicates input and output information flows from a SCM environment.

Figure 4

EXAMPLE SCM INPUT/OUTPUT INFORMATION



Typical vendors are summarized in table 4.

Table 4: Typical SCM vendors

VENDOR	PRODUCT (S)	REFERENCE FOR FURTHER INFO
i2	Factory Planner, Supply chain planner, Demand planner, Transportation planner (Rhythm)	**http://www.i2.com**
Manugistics	Networks family products	**http://www.manugistics.com**
Adexa	Material and Capacity Planner, Supply Chain Planner, Demand Planner, etc	**http://www.adexa.com**

2.4. Manufacturing BIS data for Integration with Auto-ID systems

Real time, item-level Auto-ID data needs to be integrated with existing Manufacturing BIS in order to improve companies' business processes. In order to prepare for the integration, one should understand what kinds of data are available to manufacturing BIS in current practice. Data needed by Manufacturing BIS varies in character, source and the frequency at which it is updated. From a data processing point of view, it could be divided into dynamic and static data[5].

Table 5 shows sample manufacturing related data. (Note that due to enhancements of each BIS, BIS products have many overlapping features and data requirements). It is considered that Auto-ID data will be integrated with existing data defined in Table 5[6] to improve planning and scheduling and product tracking performance. Some of the existing solutions in Table 5 have a certain level of capability to source and use real time or **pseudo real time** data (e.g. WIP, Inventory data). However, in current practice, real time data collection is not well achieved in most industries and Item level information is not used or supported; Even if existing systems could currently handle item level, real time data, there would still be a scalability issue.

[5] Static data updates only when needed (e.g. product data is updated when a company develops a new product. Routing data is updated when a new routing is added to the existing processes).

[6] In this Table, Data Defined means "the data source where the data comes from".

Table 5: Manufacturing Related data files for BIS

DATA FILE	DESCRIPTION	DYNAMIC/STATIC	DATA DEFINED
Product Data	Product structure and BOM data	Static	ERP, SCM, MES
Routing/Operation Data	Describes the operations which must be performed in order to manufacture items	Static	ERP, SCM, MES
Resource Data	Information about each resource (i.e. operator, work center, cell machine, group of machines, etc) identified for capacity planning and product scheduling purposes	Static	ERP, SCM, MES
Stock/Inventory Data	Details of the stores, bin locations & quantity	Dynamic	ERP, SCM, MES (Currently not many companies are collecting inventory status data in real time fashion except those who use MES).
Work-in-progress Data	Details of all outstanding operations scheduled to go through work data	Dynamic	ERP, SCM, MES In many high tech companies, MES is widely used in collecting real time data.
Order/Demand Data	Work orders, purchase orders.	Dynamic	ERP, SCM, MES
Transportation Data	Information on transportation time, availability and cost, etc.	Dynamic	ERP, SCM

3. AUTO-ID BASED INFORMATION SYSTEM PROVISION

In this section, we introduce integrated workflows between Auto-ID technologies and Manufacturing BIS; explain key data for integration between Auto-ID data and Manufacturing BIS; and use a query example to illustrate how to get only useful data from the huge amount of data available in distributed locations.

3.1. Overview

The EPCs™ on tags, coupled with tag readers and the controlling software application will form an automated tracking system for real time data acquisition. Along with ONS, PML and the internet, we can convert acquired data into relevant information and store it securely at appropriate locations. The following scenario for warehouse application was presented by Joshi [5]:

Data acquisition begins from the point at which goods arrive at the inventory stocking points. Tag readers at the entry point, which read the EPCs™ on the tags, then proceed to inventory shelves, which are also equipped with tag readers. When orders from customers are processed, and packages are ready to be shipped, they are passed out on to the loading dock through another set of tag readers again which note the EPCs™ of the goods being shipped. A software application managing data acquisition for the distributor warehouse communicates with the tag readers installed at various locations in the warehouse. It receives large amounts of data from many inputs. This data has the potential to be converted into real time information. The software application gathers the EPCs™ of products being tracked by the tag readers, queries the ONS for the web address where information about the product is stored, updates that information if necessary, and maintains localized data records relevant to operations of the warehouse. The updated product information can be stored either in a centralized database or distributed databases.

In order to describe configuration, location, time and measurement of physical objects, PML provides a number of constructs and data types. These include **a data element, node element, trace element.**

It is also important to describe business transaction data. The EAN.UCC's Business Modeling Group (BMG) has developed detailed business process models covering all aspects of a business transaction. They identified four basic business activities such as Data alignment (i.e. The exchange of information between the buyer and seller), Order, Shipment and Invoice. These business processes include the transmission and receipt of messages between the prospective buyer and seller as well as relevant third parties (e.g. shippers) [8]. Based on these processes, they also identified five core data elements: **Core Party; core Item; Core Order; Dispatch Advice; Core Invoice.**

Common business processes are modeled for business transaction [9]. Among them, are **query price and availability, query availability, request promise of availability, create sales/order forecast, create shipping schedule for JIT delivery, manage purchase order, create order, query order status, distribute order status etc.**

However, these business processes are focusing only on simple transactions and do not fully cover manufacturing related transactions. In the next section we will provide an example workflow of manufacturing business information systems when integrated with Auto-ID technologies (i.e. Auto-ID provided data) and briefly address some use case examples and address integration issues.

3.2. Integrated Workflow

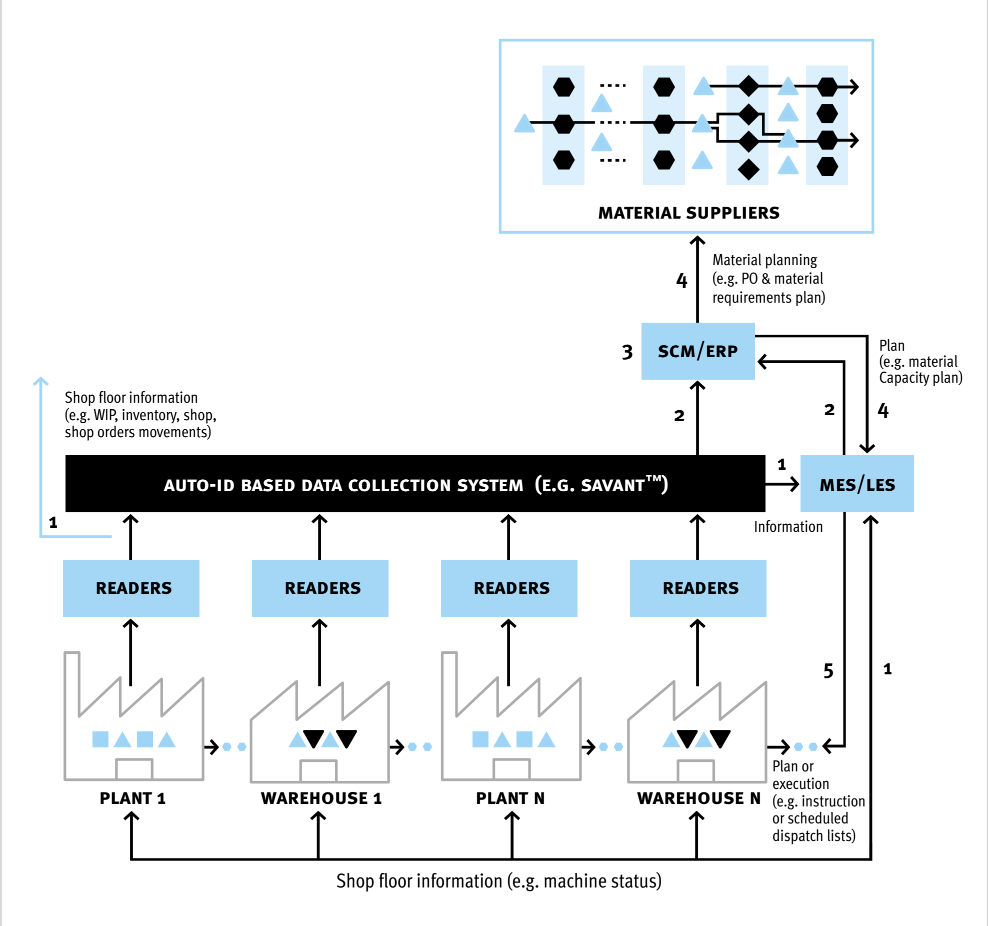
The solution for the integration of Auto-ID data with an existing manufacturing BIS is potentially different in each individual case. However, in order to give an idea of the development of the integrated business processes for Auto-ID and manufacturing BIS, we present two example workflows: one a general integrated workflow, the other one a specific workflow associated with factory scheduling.

Figure 5:

General Workflow Example
We first provide a brief desciption of general workflow[7]

1. A Manufacturer which has distributed plants around world collects item level, real time information (e.g. WIP, Inventory and shop order transaction) with the aid of Auto-ID technology. Data read by Readers transferred to the Auto-ID based data collection system (e.g. Savant™ [8]). Real time resource information (e.g. machine in the plant or automated guided vehicle in the warehouse) is also collected either using MES or LES[9].
2. Those data collected in (1) are transferred to ERP or SCM.
3. A SCM planning engine generates a production plan using real time information.
4. The manufacture sends the plan to the MES level for detailed scheduling or to send material requirements to suppliers.
5. The MES generates a dispatch list for each work center or shop floor.

WORKFLOW OF INTEGRATED MANUFACTURING BIS WITH AUTO-ID TECHNOLOGIES



7 In this workflow we ignore transactions in the supplier-side.

8 Savant™: Savant™ is has been developed by Auto-ID Center and OATSystems. It is a data router for Auto-ID that performs operations such as data capturing, data monitoring, and data transmission.

9 LES is previously described in footnote 5.

The above workflows do not include the control aspect of Auto-ID. A brief example of control (by MES) based on Auto-ID data can be as follows:

Whenever, there are disruptions (e.g. material problems, machine breakdown) which violate the company's goal (e.g. due date) in the shop floor or warehouse, users will be able to detect those disruptions with the aid of Auto-ID system (i.e. whenever late orders happens or inventory inaccuracy problem occurs, Auto-ID based data collection system will detect those information) and MES system (i.e. Whenever machine breakdown or operator breakdown occurs it will detect those either by direct or indirect interface).

After collecting information on those disruptions either from Auto-ID data collection system or MES, the MES system could re-generate the schedule and then broadcast corrective actions to the shop floor or warehouse (e.g. reprioritized dispatch lists, change of due date, swapping of an item pegged to the important customer order with an item pegged to less important customer order based on the due date or cost)

Specific Workflow Example – Scheduling

Figure 6 shows a 3 staged scheduling example demonstrating BIS and Auto-ID integration with a particular focus on operations at the MES level:

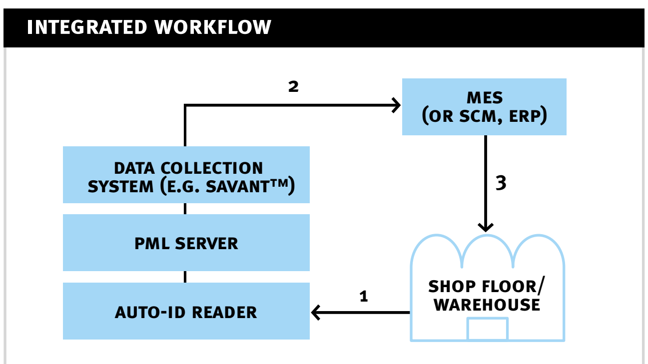
1. From the shop floor, transaction data are collected by Auto-ID readers, either in real time or batch. In Figure 6, shop orders "sf001" and "sf002" are in location id "100" and their job completion times are 10:10:23:59:58 and 10:10:23:59:59, respectively (Their quantities are 100 and 200, respectively). Here we assume that the customer for sf002 has higher priority than the customer for sf001, and that this data is stored in the MES server.

2. The transaction data are then transferred to MES or other Manufacturing BIS system[10] for scheduling. (Note that integration between Auto-ID data collection system and MES can be done in many ways – for simple solutions, it can be done via a relational database or so called flat files). Once data are transferred, MES schedules are generated based on predefined scheduling rules (here we assume it is quantity, based priority rule and customer priority). So in this example, even if shop order "sf001" arrived earlier than "sf002", because of the predefined rules, the BIS system gives higher priority to "sf002" when scheduling.

3. Once it is scheduled, the order (dispatch lists) is sent to the operators for execution (either in paper format or in the BIS system).

[10] Recently, many functions in ERP, SCM and MES are overlapping therefore it is not reasonable to say only "MES" can do this. Some ERP and SCM vendors claim that they do have this kind of capability.

Figure 6: Integrated workflow and transaction details



DATA FROM AUTO-ID TO MES (OR SCM, ERP)

Shop Order	Location	Part No	Completion Time	Quantity
sf001	100	IC001	20021010:23:59:58	100
sf002	100	IC001	20021010:23:59:59	200

DATA FROM MES (OR SCM, ERP) TO WAREHOUSE

No	Resource	Shop Order	Part No	Quantity	Location	Operation	Customer	Start Time
1	Assemble 1	sf002	IC002	200	200	10	2	20021011:00:10:00
1	Assemble 1	sf001	IC002	100	200	10	1	20021011:00:20:00

When designing a solution for integration between different levels of systems, one should understand the timescales of each system (e.g. Control system is usually working on seconds basis; MES usually works from seconds to one day; ERP usually works from days to years).

In this section, we presented two brief workflows for Auto-ID applications in the Manufacturing BIS area. Each company has different Manufacturing BIS and each needs to develop appropriate workflow in order to prepare integration with Auto-ID technology (especially data). The purpose of this section was to show example workflow cases as a guideline.

3.3. Key Data for the Integration

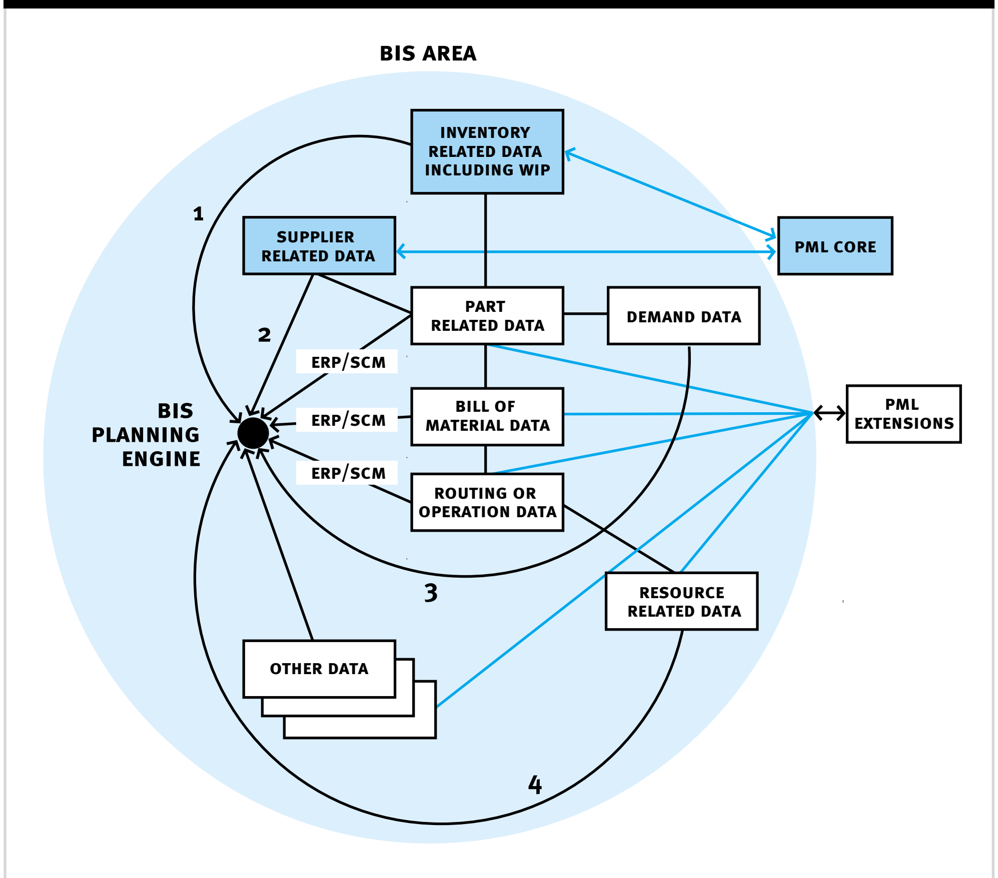
For any kind of integration work, understanding the data structures of the parties (or systems) involved is a critical preliminary. In this section, we will review key data structures of Manufacturing BIS for integration with Auto-ID data (mainly with PML).

Figure 7 briefly shows a feasible BIS and PML integration example. The figure also shows what kinds of data (either dynamic or static data) the BIS system generally uses for its own decision-making.

Figure 7:

1. Dynamic data (MES)
2. Dynamic data (e.g. supply capacity or stock information
3. Dynamic data provided by BIS (e.g. ERP or B2B input)
4. Dynamic data provided by BIS (MES)

BIS AND PML INTEGRATION



As discussed in [4], PML Core addresses the location and telemetry related information and those information are related to the inventory related data of BIS system (e.g. In most SCM and ERP, inventory file contains location information, quantity and date information).

Example BIS data (SCM or ERP) related to the inventory and WIP are as follows:

– **Inventory related data (either finished goods or raw materials)**
  `inventory_location_id; part_id; part_quantity; part_arrival_time; purchase_order_number.`

– **WIP related data**
  `Shop_order_id; operation; resource; current_location; unfinished_part_id; unfinished_quantity; finished_part_id; finished_quantity; finish_location; completion_time; completion_flag`

PML Extensions address product-related information and process-related information [4]. These kinds of information are related to the bill of material, routing/operation related data, resource data, part/product data, etc. Example BIS product-related data (SCM or ERP) are as follows:

– **Bill of material related data**
  `produced_part_id; produced_quantity; routing; operation; consumed_part_id; consumed_quantity.`

– **Routing related data**
  `Routing_id; operation; run_time; runtime_unit_of_measure`

– **Product/Part related data**
  `part_id; description; unit_price; price_unit_of_measure.`

Even if those data presented above provide real time information of material movement (or order transactions), to provide truly real time synchronized decision-making (i.e. material and capacity synchronized decision making), real time resource status data is essential[11]:

[11] These data are mainly defined in the MES

– **Resource tracking data**
  `Resource_id; resource_type; status; location; description; total_down_time; In_production_time.`

In current practice, even if ERP and SCM has data for WIP (or inventory status data) and resource status data, those data are mostly collected by MES because of its dynamic nature (Many MES systems have capability to directly interface with machines to monitor/collect real time status of machine) and the purpose of each system (For example, when companies introduce ERP system, they want to standardize their business process while when companies introduce MES, they wants to trace shop floor activities more accurately).

The data files in Figure 7 only show basic files required to represent manufacturing BIS needs (more data may be required for complex modeling). Here, basic files means the minimum data required to run the planning engine (In the figure the dotted lines show possible relationships between PML and BIS). Straight lines show the relation among different data within BIS. Arrow lines show data used for planning decisions).

[12] The data in this table are examples. The purpose of this table is to give the reader an example of a structured approach.

Once the existing data structures for the company specific IT are understood, the data mapping between data sources (e.g. PML and Manufacturing BIS data) and workflow (as in the previous section) should be developed. Table 6 shows the example data mapping between PML and manufacturing BIS[12]. For mapping, one should know the data type (e.g. string, character) and its source table name (if it is relational database).

Table 6: Example data mapping (between Manufacturing BiS and PML)

TABLE (BIS)	FIELD (BIS)	FORMAT (BIS)	PML FIELD
Part	Part type	Char (10)	Part

[13] In current practice, ERP systems are less frequently used for planning purposes than SCM and MES. Some ERP vendors claim that they have capability to deal with dynamic change of shop floor data.

The performance of BIS (SCM, MES)[13] planning function is heavily dependent on the "cleanness" of data, proper frequency of data collection and other factors.

3.4. Example: Query and Enhancing Existing Manufacturing BIS Functionality

Since Auto-ID technology has he potential to provide huge amount of data on products in distributed locations it is very important to know how to only query useful information from those data. To query a meaningful set of data, one should know the structures of the data to be queried. By understanding the query methods and data files needed for querying Auto-ID data, Manufacturing BIS solution providers and users can enhance the performance of existing Manufacturing BIS functionality (mainly by using real time, item level data). In this section, we present a brief example of data query and show how Auto-ID data and manufacturing BIS integration could enhance the quality of existing BIS planning functionality.

[14] RosettaNet: is a consortium of major information technology, electronic components and semiconductor manufacturing companies working to create and implement industry wide, open e-business process standards. More information can be found at http://www.rosettaNet.org.

[15] Partner Interface Processes (PIP): define business processes between trading partners. Currently PIP fit into seven clusters that represent the backbone of the trading network (seven clusters are: partner product and service review; production information; order management; inventory management; marketing information management; manufacturing) . More information on PIP can be found at http://www.rosettaNet.org

Consider an electronics industry example using the RosettaNet[14] transaction Standard. Currently RosettaNet provides so called Partner Interface Processes (PIP)[15] for distributed work in processes in the assembly, fabricate and test area of micro-electronics manufacturing plant [10, 11]. Those PIPs support the process used (1) by a solution requester (e. g. customer) to query the status of a product being assembled or manufactured, and (2) by a solution provider (e.g., manufacturer or assembler) to return the requested information.

"The solution requester initiates the process by sending a work in process query to the product solution provider. To facilitate communications, the query document includes both query constraint lines and incomplete results lines. After processing the query, the product solution provider completes the results lines and returns the information to the requesting party".

The following shows an example hypothetical query to determine work in process status:

Description
Company A wants to know the quantity of product AA's finished goods quantity and WIP quantity in the distributed plants at time "2:10pm, April 6th, year 2002".

Hypothetical query

```
Work In Process Query
Search all databases, and Return results where, the product type AA,
Completion time "2:10 pm, April 6th, 2002 year",
```

The query result may display the following information depending on the further condition:

```
Result "final product type AA", "location", "quantity", "operation id
or routing id", "start time" etc.
```

The query will find the data throughout the "given database", and display data with the following conditions:

- "completion time equals 2:10pm, April 6th, 2002"
- "final product type equals AA" ,
- "quantity",
- "location" (Globally agreed location id to define specific location distributed plants)
- "operation id or routing id" etc

Hence in order to use Auto-ID data for such a WIP transaction, the following data need to be considered:

- EPC™ Code of palette/Case/Item
- Lot id or shop order id (i.e. EPC™)
- Material id (or product type)
- Procedure id (This is related to shop order if used in manufacturing)
- Stage or operation (Current stage in the routing. This is related to routing information)
- State (i.e. shop order or lot state)
- Equipment id or transportation id or carrier id (e.g. Palette id)
- Time (start time for the generation of alarming and calculation of elapsed time)
- Priority
- Customer id
- PO number
- Start time
- End time
- Quantity
- Operator id
- Location id (i.e. site)
- Instruction

We have reviewed an example query and data structure for the transaction data, to get a meaningful set of data from the huge amount of data provided by Auto-ID assuming existing BIS functionality.
In the next part of this section, we will explain how a data query and Auto-ID data could be conceptually integrated by manufacturing BIS to enhance its existing functionality. We shall examine a so called "Available to Promise" example in an SCM system.

Available to promise (ATP) case [16]

After receiving a customer's request for quote (RFQ), the SCM first checks for available to promise (ATP) quantities to immediately satisfy a customer order. This check takes place across the total number of finished goods stocks (mainly warehouse) in the supply chain networks with the aid of real time data provided by Auto-ID technologies (using the logic in the [11] and data read by readers, we could get the information on the finished goods).

[16] Available to Promise: When a company receives a request for quotation, this function checks for uncommitted inventory then WIP to fulfill the order and propose a delivery date to the customer.

Work In Process Query

```
Find all database, and Return result where, the product type xx,
location="warehouse X, or XXX", "quantity"
```

(To simplify, we assume that when product XX are in the warehouses, they are finished goods)

- Based on the provided information, the SCM determines the optimal set of stocking locations that can satisfy the order in the most cost effective manner.

- Once the queried data is transferred to the SCM level, the SCM uses predefined logic to physically assign orders to finished goods. As a simple example, SCM can compare the estimated delivery date considering the current location of the finished goods, and then assign finished goods to orders. With the aid of Auto-ID technology (item level information provision), we could assign physical goods/products to orders (Currently in practice, it is almost impossible to assign finished goods physically for certain orders).

  In current practice, when there are many orders for the same product, shop floor operators (or warehouse operators) just takes out products by First-in-First-out rule and it is impossible to trace the history. But using item level Auto-ID based tracking capability, manufacturers are able to assign goods/products to order, trace product and could reassign "goods/products" to the other order (e.g. to urgent order) whenever needed.

  To enable this kind of capability, the existing manufacturing BIS (MES/SCM/ERP) needs to have "an EPC™ field" (which will contain EPC™ number of a pallet/case/item) in its order/inventory/WIP related data tables.

- If there are not enough stocks, the SCM system considers a scheduled receipt and WIP. To enable this process, the operators should trace real time information on the scheduled receipt, suppliers and WIP transactions (Using this query, the user can sort products by receiving time data for given locations). Example data field required for a scheduled receipt are: part number; PO number; part receiving time; quantity; stock location; supplier name etc.

  In order to consider WIP quantity in the processes (other than stock holding position in the warehouse), other data collection locations should be defined (e.g. In many plants, at the end of a process or at the front of process, there are small stock keeping location or queue station).

The benefits of this extended example are to enable the SCM system to have a more dynamic and interactive interface with shop floor behaviour.

4. CONCLUSION

In this paper, we have reviewed the basics of Auto-ID technologies, introduced manufacturing related BIS; described integrated workflow for BIS and Auto-ID technologies and data needed for the integration and provided examples of query and manufacturing BIS functionality that could be enhanced by integration with Auto-ID.

Some general steps to be considered in Auto-ID Integration are as follows:

- Understanding existing BIS systems, PML (Core and Extension) and their interfaces. First of all, before the integration project begins, one should fully understand companies' strategic IT plan. If one ignores the future expansion of company's IT systems, there will be extra work every time there are such expansions.

– Once current/future IT architecture is studied, define the scope (or levels of detail) of the project. For example, is it critical to be tracking all the movements? The scope should be defined depending on the benefits expected.

– After defining the scope, one should decide which system should be a key integration area based on the given IT architecture. For example, if there is an MES system, this could be a key integration area with Auto-ID data. But if there is no MES, and the company has SCM or ERP, one should check whether existing SCM functions could handle real time data or not (the user should consider what is the proper data collection interval is for the given architecture and business). If it is not necessary to collect shop floor data in real time, the user could use pseudo real time data collection.

– Establish data mapping among systems and developing detail workflows

New information provided by Auto-ID technologies (e.g. EPC™ and PML) will improve the data quality in existing BIS and enhance the planning and execution quality of manufacturing BIS. To best achieve gains, existing Manufacturing BIS systems need to be modified, and enhanced in order to include new Auto-ID provided information in their functionality.

This study provided examples, rather than solutions, to help to prepare for Auto-ID integration and to understand how new data could help to enhance the existing manufacturing BIS.

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