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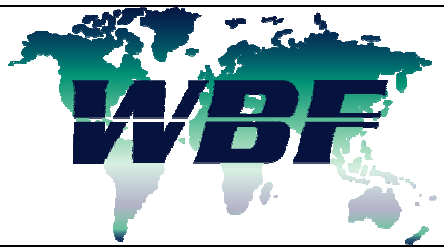

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ISA 95 Implementation Best Practices
Workflow Descriptions using B2MML

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ABSTRACT

This whitepaper focuses on the **best practices** to describe **Workflows** using **B2MML** applications based on the **ISA 95 Standards**.

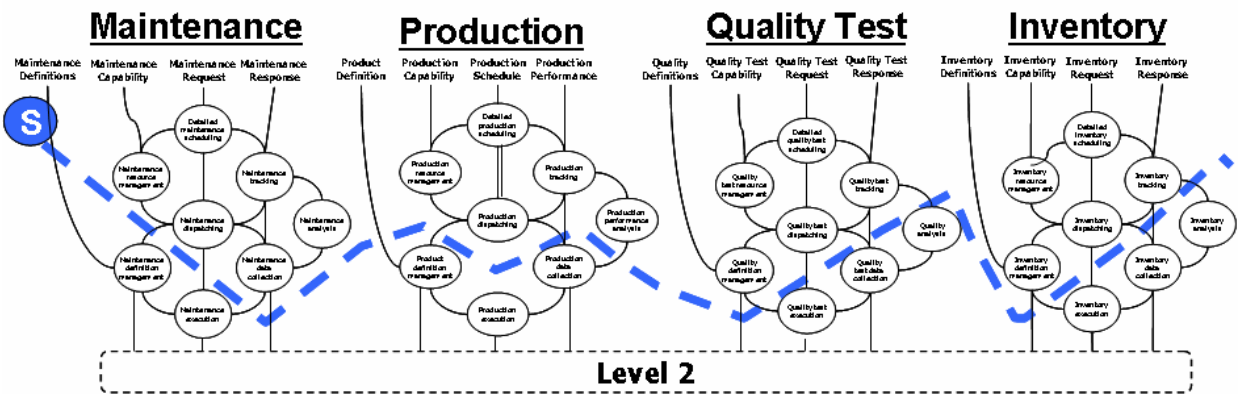
ISA 95 and B2MML, like any standard, are subject to interpretation. MES and ERP vendors could interpret these standards differently, which could result in variants of the implementations, thus leading to interoperability issues. This whitepaper outlines the best practices to describe Workflows using B2MML Applications, which would aid in more uniform implementations resulting in a **reduced project implementation time**.

B2MML Applications illustrate how ISA 95 Part 1 and 2 are applied to a usable XML based infrastructure; data mappings; description of the schema choices; how B2MML has been used; and how B2MML is evolving to support extensions and a broader range of transactions. Workflows illustrate how ISA 95 Part 3 and 5 are applied to describe workflows between B2MML applications and ERP Systems in typical manufacturing operations activities. These implementation best practices are summarized with examples that include Quality Management, Maintenance Notification and Production Scheduling/Production Performance Reporting scenarios.

INTRODUCTION

What does the standard provide? ISA 95 Parts 1 & 2 defines the content and context of the information required for the interfaces between enterprise activities and control activities. ISA 95 Part 3 shows activity models and data flows for manufacturing information that enables enterprise-control system integration. B2MML i.e. Business to Manufacturing Markup Language uses XML Schema Definitions to specify and constrain the content of the information flow between Enterprise and Control systems.

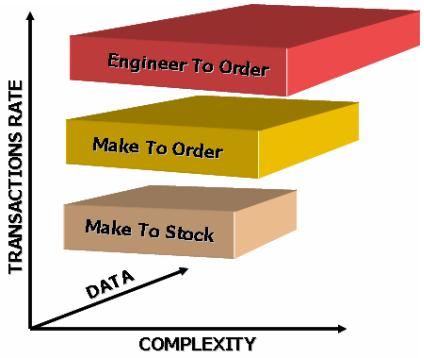
Why the need to define implementation best practices? The current definition of B2MML specifications is based on certain assumptions about enterprise activities and control activities. The blue line in the following figure of the activity models specified in Part 3, illustrates this:



The interactions between these activities (as described above) become more complex when considering the different production models:

- Make to Stock
- Make to Order
- Engineer to Order

Agile production models require more transactions and more complex data to be exchanged between Enterprise and Control Systems. The following figure illustrates this:



Given these complexities and the current specifications of B2MML, there is a need to define implementation best practices that would enable a more uniform interpretation and use of the standards.

B2MML APPLICATIONS

What kind of information needs to be exchanged? B2MML describes XML schemas for four information categories:

- Capability & Capacity Definition
- Product Definition
- Production Schedule
- Production Performance

And four resource categories:

- Personnel
- Equipment
- Material (and Energy)
- Process Segments

A first approach is to determine what category of information needs to be exchanged in reference to the resources.

How to determine the context and content of the information that needs to be exchanged? It is important to understand the concept of the three distinct production models and the implications of these models to integration.

- **Make to Stock**

  This integration is probably the least complex in nature.

  - Product Definition and Capability are usually planned before execution.
  - Product customization is limited.
  - Master data needed to perform production can be pre-determined.
  - Master data needs to be synchronized less often.
    - Automatic realignment between planning and execution
    - Manual process
    - Communicated with the scheduling request

  Production Scheduling might happen on a large time window (weekly, bi-weekly, etc.) and can contain detailed scheduling information with multiple work orders to be dispatched to the shop floor.

  Performance can be reported at regular intervals, either at work order completion or at each execution step depending on the procurement and replenishment strategy.

- **Make to Order**

  Make to Order is often considered equivalent to a Make to Stock at zero inventories.

  - Product customization is important and hence Master Data assumes a more significant role. There is a more frequent flow of master data, which requires synchronization of the changes of product definition and capability.
  - Product definitions are often contained within the scheduling requests. These requests are more granular relatively to time and less regular in frequency.
  - Changes in the execution are usually notified after the completion of the operations – Production Performance results. In some cases these changes may be notified earlier to the planning system in order to re-sequence the plan and make the appropriate adjustments.

- **Engineer to Order**

  This is probably the most demanding integration.

  - Information Exchange is synchronous and more in near-time.
  - The aerospace industry offers one of the best examples. Products are designed and engineered to drive the planning, but these definitions could change during execution.
  - Change requests might be sent back to engineering/planning, which puts the execution on hold waiting for the changes to be reflected in planning. A new set of operations or a variation on the route (i.e. in case of added inspections) will then be communicated to the shop floor to complete the work orders.

  Messages are richer in content and require a significant amount of extensions to B2MML.

  Performance Reports contain as-designed and as-built data.

How is the context aggregated in such complex structures?

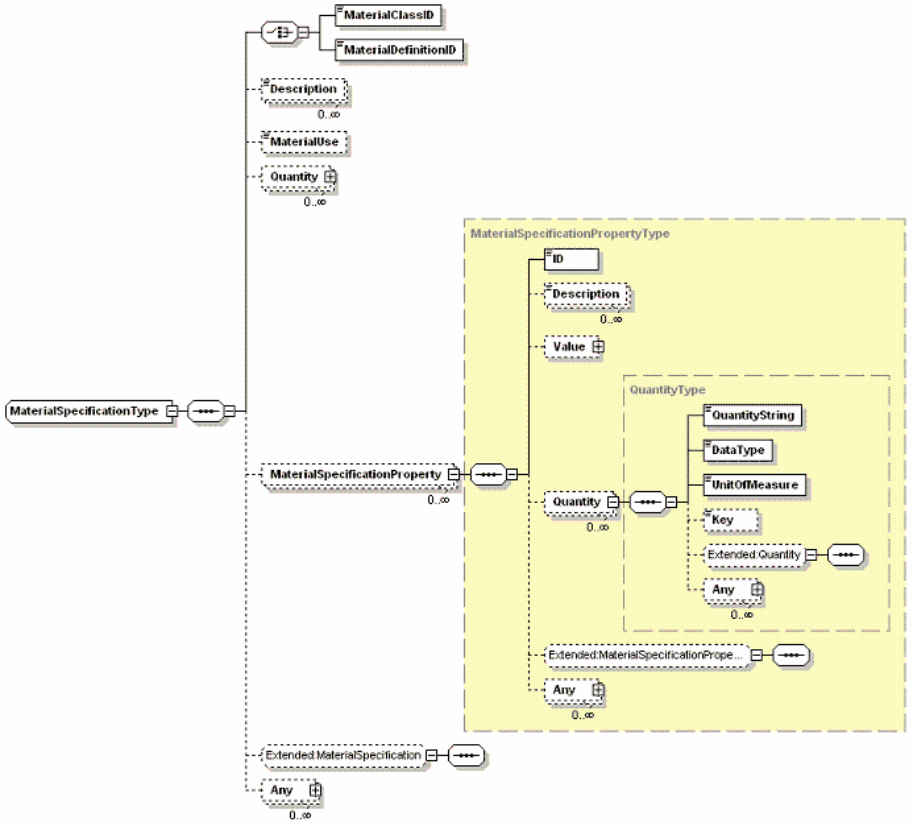
A key concept to understand is the use of Segments in the B2MML schemas. A segment is a functional unit of integration and defines the content model for information interchange.

The Segment Requirement element encompasses the aggregation of all the production and process related information within one schema to be transacted through activities such as Production Schedule and Production Performance.

Typically, a Segments maps to functionalities like operations, unit procedures, phases of execution and it reports information like equipment/resources allocation and materials input and outputs.

Examples that show the correlations among the different schemas and how they represent different contents of the same information:

In the ProductDefinition schema the user can enter specific structural information. The following figure, for example, shows how the Material Specification information is organized within the Product Definition.

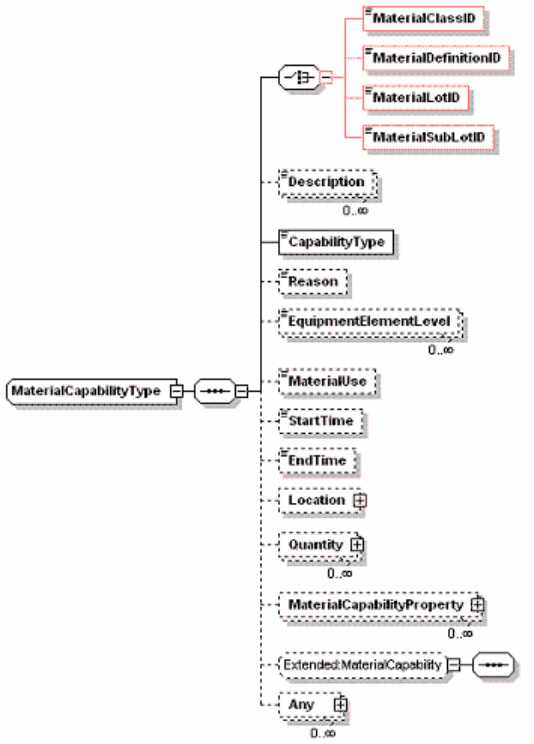


A possible interpretation of the structure may be the following XML snippet, where a class of materials, a specific inventory lot of that material and a WIP sub lot of the item are described:

```
<MaterialClass>
        <ID>Sug001</ID>
        <Description>Pure Cane Sugar Type 1</Description>
        <MaterialClassProperty>
            [...]
        </MaterialClassProperty>
        <MaterialDefinitionID>String</MaterialDefinitionID>
        <Any/>
    </MaterialClass>
    <MaterialDefinition>
        [...]
        <MaterialClassID>Sug001</MaterialClassID>
```

```
            <MaterialLotID>Lot_Sug_123</MaterialLotID>
            <Any/>
</MaterialDefinition>
<MaterialLot>
            <ID>Lot_Sug_123</ID>
            <Description>Domino Cane Sugar</Description>
            <MaterialDefinitionID>…</MaterialDefinitionID>
            <Status>Ready</Status>
            <MaterialLotProperty>
                        <ID>PlannedQty</ID>
                        <Description>Expected Quantity at hand</Description>
                        <Value>
                                    <ValueString>200</ValueString>
                                    <DataType OtherValue="String" EnumerationID="String">dec</DataType>
                                    <UnitOfMeasure>KG</UnitOfMeasure>
                                    <Key/>
                                    <Any/>
                        </Value>
                        […]
            </MaterialLotProperty>
            <MaterialSubLot>
                        <ID>WIP_Sug_001</ID>
                        <Description/>
                        <Status>Ready</Status>
                        <StorageLocation>Silo1</StorageLocation>
                        <Quantity>
                                    <QuantityString>20</QuantityString>
                                    <DataType OtherValue="String" EnumerationID="String">string</DataType>
                                    <UnitOfMeasure>KG</UnitOfMeasure>
                                    <Key/>
                                    <Any/>
                        </Quantity>
                        <MaterialLotID>Lot_Sug_123</MaterialLotID>
                        <Any/>
            </MaterialSubLot>
            […]
```

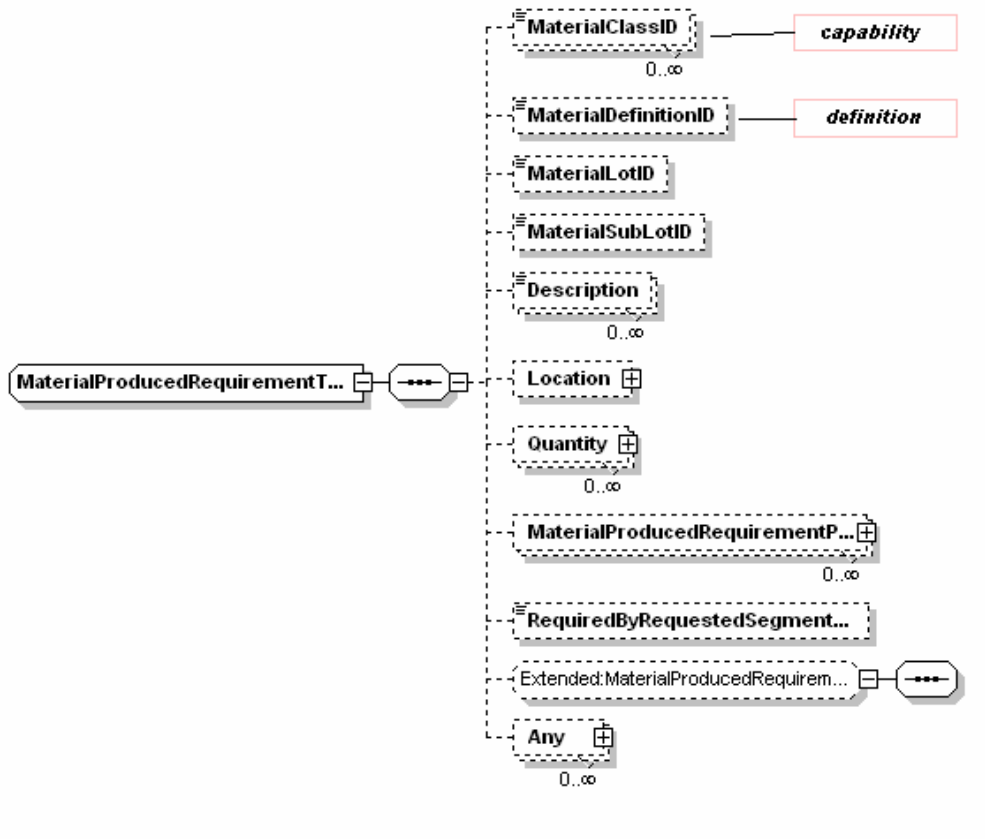
The system will also have to know specific capability information about that material, i.e. its availability and its use. The following figure shows where this information can apply and the red area within the figure shows the reference to the material definition:



A possible XML instance might be as follows:

```
<MaterialCapability>
        <MaterialClassID>Sug001</MaterialClassID>
        <Description>Pure Cane Sugar</Description>
        <CapabilityType>Committed</CapabilityType>
        <Reason>String</Reason>
        <EquipmentElementLevel>Area</EquipmentElementLevel>
        <MaterialUse>Consumable</MaterialUse>
        <StartTime>2001-12-17T09:30:47-05:00</StartTime>
         <EndTime>2001-12-21T09:30:47-05:00</EndTime>
         <Location>
                <EquipmentID>Blenders</EquipmentID>
                <EquipmentElementLevel>Area</EquipmentElementLevel>
        </Location>
        <Quantity>
                <QuantityString>200</QuantityString>
                <DataType>dec</DataType>
                <UnitOfMeasure>KG</UnitOfMeasure>
                <Key> </Key>
        </Quantity>
 [..]
</MaterialCapability>
```

As previously mentioned, it all comes together in the Production Schedule, where the master data is referenced in a Production Request. The figure below captures an excerpt of the Segment Requirements where a material has been planned and released to production.



WORKFLOW DESCRIPTIONS

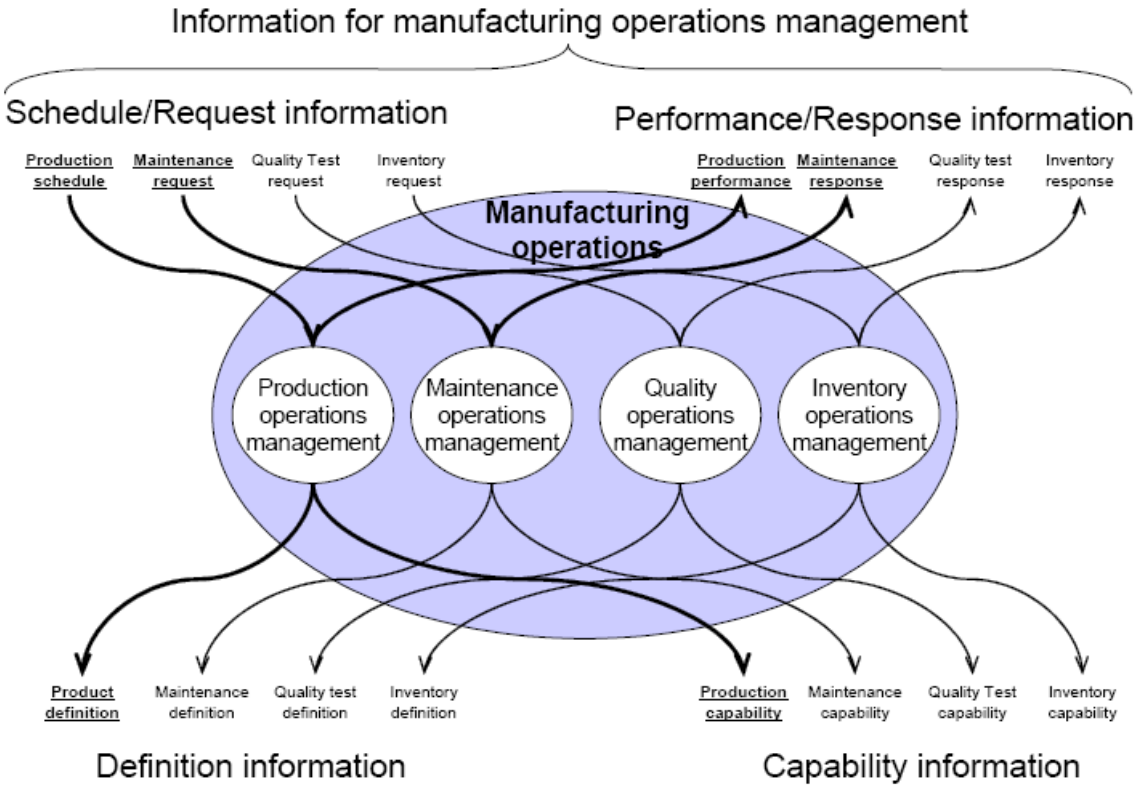
Why are workflows complex? As per the ISA 95 Part 1 functional data flow model there are nineteen different data flows of interest between the enterprise and control system:

- Schedule
- Production from plan
- Production capability
- Incoming order confirmation
- Long term and short term material and energy requirements
- Material and energy inventory
- Production cost objectives
- Production performance and costs
- Quality assurance results
- Standards and customer requirements
- In-process waiver request
- Finished goods inventory
- Process data
- Pack out schedule
- Product and process know how
- Maintenance requests
- Maintenance responses
- Maintenance standards and methods
- Maintenance technical feedback

There are three different production types – Discrete Manufacturing, Batch Processing and Continuous Processing and three different production models – Engineer to Order, Make to Order and Make to Stock. This leads to nine combinations (or hybrids) of the production types and models with each having a specific set of business processes within the enterprise and control domains.

When the data flows of interest are considered within each of the hybrid production types and models, it leads to complex workflow descriptions.

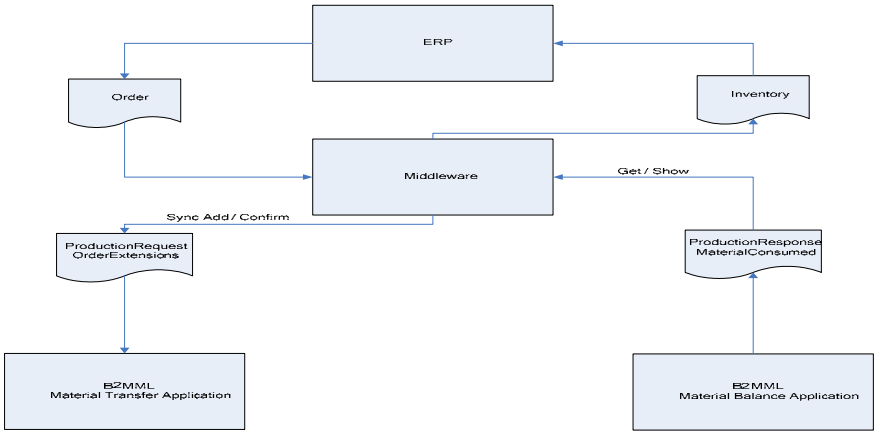
How to describe required Workflows? ISA 95 Part 3 defines the activity models of manufacturing operations management that enable enterprise and control system integration.



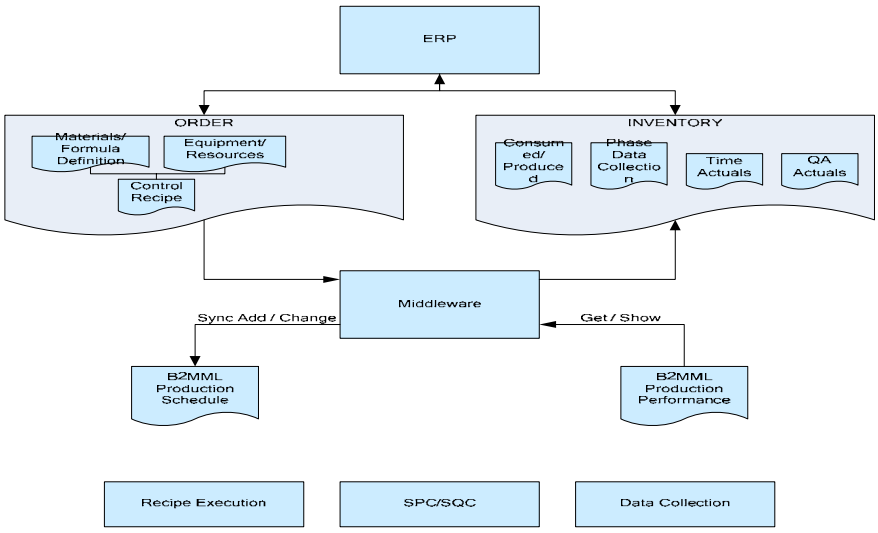
The key to defining the information aspects of manufacturing operations is capturing the context and content of data that needs to be exchanged – this is what gets defined as B2MML Applications. B2MML Applications in conjunction with the transaction models defined in ISA 95 Part 5, provide a basis for describing the workflows.

Examples of workflows for the different production types:

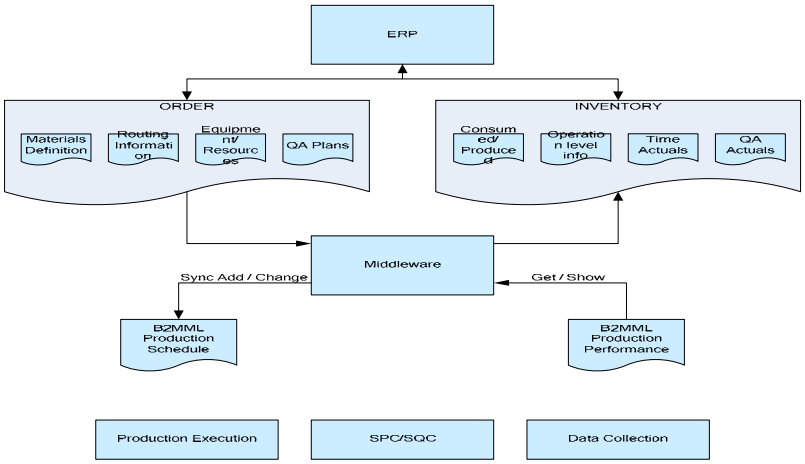
- **Continuous Process Example**



- **Batch Processing Example**



- **Discrete Manufacturing Example**



CONCLUSION

The key to defining B2MML applications is identifying the context and content of the information that needs to be exchanged. Workflow descriptions using B2MML varies in complexity depending on the production model and these workflows require identifying the B2MML elements that would be used to correlate data that flows between Enterprise and Control systems. B2MML Applications in conjunction with the transaction models provide a starting point for describing the workflows in enterprise-control system integration.