



MTConnect-B2MML Companion Specification

DRAFT

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CONTENTS

1	Introduction	3
1.1	Background	3
2	References.....	5
2.1	MESA	5
2.2	MTConnect Institute	5
3	Capabilities and application of B2MML	6
4	Capabilities and Application of MTConnect.....	7
5	Integration of B2MML and MTConnect Capabilities	9
5.1	Mapping of Common Terms	9
5.2	Integrating B2MML Documents into MTConnect Assets	9
5.3	B2MML Product Definition Document as an MTConnect Asset.....	10
5.4	B2MML Production Schedule Document as an MTConnect Asset.....	14
5.5	Resources to support Implementers	19

1 Introduction

1.1 Background

In June 2017, MESA (Manufacturing Enterprise Solutions Association International) and the MTConnect Institute signed a memorandum of understanding to provide a mechanism for MESA and MTConnect to collaborate to extend the reach of their existing manufacturing information data modeling standards and implementation technologies in order to:

- Define the interaction between existing standards from each organization to provide a platform for improved manufacturing technology interoperability.
- Provide a forum for the exchange of information to support future continuous improvement of standards and specifications overseen by each body.
- Provide a mechanism for the exchange of insights, identification of overlaps, and harmonization of the works of both organizations; where appropriate.
- Provide a roadmap for implementers to leverage the capabilities of the standards and specifications of both bodies.

MESA is a not-for-profit global community of companies and academia encompassing a wide array of expertise focused on improving and extending the capabilities of the manufacturing environment through the application of advanced information technologies and world-class management practices. <http://www.mesa.org/>

One of the standards developed by MESA is the B2MML Standard. B2MML (Business To Manufacturing Markup Language) is based on the ANSI/ISA-95, Enterprise-Control System Integration, family of standards (ISA-95). These standards are also known internationally as IEC/ISO 62264. B2MML provides an XML representation of the ISA-95 standard. The B2MML Standard is the specific technology provided by MESA that is the focus of this document. <http://www.mesa.org/en/B2MML.asp>

The MTConnect Institute is a not-for-profit organization established to further the development of the MTConnect standard and publish related materials. Any company or organization can be a member and aid in furthering the development of the MTConnect standard by becoming a member of the institute's Technical Advisory Group. The MTConnect Institute is sponsored by AMT – The Association for Manufacturing Technology. www.mtconnect.org

The outcome of the agreement is this document called MTConnect-B2MML Companion Specification.

B2MML and the MTConnect Standard are open-source resources. The MTConnect-B2MML Companion Specification is also an open-source resource.

While much of the information covered by the B2MML specification is outside the scope of the MTConnect Standard, there is significant opportunity to improve the capabilities of manufacturing software systems through the integration of these two manufacturing standards.

The MTConnect-B2MML companion specification describes a methodology for:

- Providing a platform for managing and transporting B2MML documents between software applications within a manufacturing information system as an MTConnect Asset document.
- Define the mapping of data types that are common to both standards to support interoperability, harmonization, and consistency for the flow of information from the shop floor to higher level software systems and from those systems down to the shop floor.

The information presented in this Companion Specification is non-proprietary; meaning it is built on open standards, backed by both MESA and the MTConnect Institute whom together represent hundreds of companies, individuals, government organizations and nonprofits all working toward the goal of increased productivity in the manufacturing arena.

2 References

2.1 MESA

The following specifications from MESA regarding the B2MML standard are referenced by this specification.

[B2MML V0600] Standards and Tools, Ver. V0600

<https://services.mesa.org/ResourceLibrary/ShowResource/0f47758b-60f0-40c6-a71b-fa7b2363fb3a>

2.2 MTConnect Institute

The following specifications from the MTConnect Institute are referenced by this specification.

[MT Part 1] MTConnect® Standard: Part 1 – Overview, Version 1.3.0

https://static1.squarespace.com/static/54011775e4b0bc1fe0fb8494/t/557f2897e4b04b2acd80b5/1434396823825/mtc_part_1_overview_v1.3.pdf

[MT Part 2] MTConnect® Standard: Part 2 – Components and DataItems, Version 1.3.1

https://static1.squarespace.com/static/54011775e4b0bc1fe0fb8494/t/557af7d6e4b07045fec768d/1434122198226/MTC_Part_2_Components++1.3.1+Final.pdf

[MT Part 3] MTConnect® Standard: Part 3 – Streams, Version 1.3.1

https://static1.squarespace.com/static/54011775e4b0bc1fe0fb8494/t/557acdbae4b0d4d1d367b696/1434111418321/MTC_Part_3_Streams_1+3+1_FINAL.pdf

[MT Part 3.1] MTConnect® Standard: Part 3.1 – Interfaces Version 1.3.0

https://static1.squarespace.com/static/54011775e4b0bc1fe0fb8494/t/557f28fde4b09b7d71fc6bcf/1434396925113/mtc_part_3.1_interfaces_v1.3.pdf

[MT Part 4] MTConnect® Standard: Part 4 – Assets, Version 1.3.0

https://static1.squarespace.com/static/54011775e4b0bc1fe0fb8494/t/557f290fe4b09b7d71fc6c52/1434396943780/mtc_part_4_assets_v1.3.pdf

[MT Part 4.1] MTConnect® Standard: Part 4.1 – Cutting Tools, Version 1.3.0

https://static1.squarespace.com/static/54011775e4b0bc1fe0fb8494/t/557f2920e4b025137e0dd1eb/1434396960393/mtc_part_4.1_cutting_tools_v1.3.pdf

3 Capabilities and Application of B2MML

B2MML provides standard data models for creating XML documents that represent information from manufacturing management systems (MES, ERP, etc.) to shop floor execution systems. It also provides a standard structure for creating XML documents that encapsulate information collected during the production process and presents that information in a standard document format to higher level software systems.

B2MML and MTConnect complement each other. B2MML provides a mechanism for structuring manufacturing information in a standardize document format. MTConnect provides a mechanism for managing those documents and/or moving them between software systems where the information is required.

B2MML provides a wide variety of data models to support different types of information. For the purpose of this cooperative effort between MESA and MTConnect, the following information models are of specific interest:

- Product Definition
- Production Schedule

Additionally, there are numerous discrete pieces of information that are used in both the B2MML and MTConnect Standards that share a common meaning and context across the standards. The names applied to each of these pieces of information typically differ, but a basic substitution table can be created to map these pieces of information between the information models used in each standard.

4 Capabilities and Application of MTConnect

MTConnect provides specific functionalities that support the inter-operability with other standards like B2MML. These are:

- Semantic data models for representing data collected from the manufacturing shop floor.
- Semantic data models for representing information relating to the shop floor that is expressed in document form.
- Definition and Reference Implementation software for an MTConnect Agent which stores and organizes information collected from a manufacturing operation. This Agent also produces structured documents containing the information collected for consumption by client software applications.
- Extensibility that allows an implementer to expand the functionality of an MTConnect implementation to include additional content.

One of the basic functions of the MTConnect Standard is the definition of a structured schema for representing contextualized data to client software applications. The standard also provides a dictionary that provides a standardized definition for data collected from manufacturing operations. This means that all data is provided with full context – name, definition, scaling, etc. Data collected from shop operations is stored in the MTConnect Agent.

MTConnect Assets provides a mechanism for representing complex information associated with manufacturing operations in electronic document form. Examples of types of MTConnect Assets include:

- Description of Cutting Tools
- Electronic Documents such as Maintenance Manuals, Test Results, Operator Instructions, etc.
- Description of Manufacturing Processes
- Routings to define the movement of parts through the manufacturing process
- Part Genealogy
- Quality Inspection Data

The electronic documents representing MTConnect Assets can be encoded using XML. As such, this provides a straightforward mechanism for integrating with B2MML documents that are also encoded using XML. The means for representing a B2MML document as an MTConnect Asset will be addressed later in this document.

The MTConnect Agent is a software application that collects both streaming data and Asset documents from various data sources present in a manufacturing operation. The agent stores this information in two separate buffers – one for each type of data. From the perspective of a client software application, the Agent functions as a REST server. Software applications make requests for information from the Agent using HTTP commands. The Agent responds to those requests with a Response Document that contains the requested information. Those Request Documents are encoded in XML. Once a B2MML document is represented as an MTConnect Asset, the MTConnect Agent will collect those documents, store and organize them, and publish them to client software applications when requested.

MTConnect is, by definition, an Extensible Standard; meaning that information not presently defined within the MTConnect Standard may be integrated into the MTConnect framework by an implementer. That additional information can then inherit all of the capabilities and functionality of the MTConnect Standard.

5 Integration of B2MML and MTConnect Capabilities

The integration between B2MML and MTConnect involves two technical areas:

- Integration of B2MML documents as extensions to MTConnect Assets
- Mapping of terms between B2MML and MTConnect

Since B2MML addresses a wide variety of data models to support different types of information within the manufacturing environment and MTConnect represents a wide variety of data types collected from the manufacturing environment, the integration between these two standards can be an ever-growing effort with a variety of solutions.

As such, it is the intent of this Companion Specification to lay the groundwork for this ongoing integration. The results will be a set of initial sample implementations that will be provided to the open source community with the expectation that that community will continue to grow and expand the implementation examples and contribute their work back to the community.

The initial sample implementations were developed as part of the DMDII sponsored SPEC-OPS project. The sample content is being made available at www.mtcup.org - an open resource provided by the MTConnect community.

5.1 Mapping of Common Terms

The first step in defining the interoperation between B2MML and MTConnect is to identify those terms that have common meaning and usage between the two standards. The actual name applied to any term is likely not to be the same in both standards. However, as long as we can define terms with common meaning and functionality in both standards, a straightforward mapping process can be used to transfer the information associated with these terms between the data models supported by each standard.

An initial set of terms and definitions has been developed in support of the SPEC-OPS project. That initial list of terms is available at www.mtcup.org . This list of terms primarily focuses on data types associated with Shop Orders, Product Definitions, and Product Scheduling.

Implementers wishing to develop information systems using both B2MML and MTConnect are urged to utilize this initial list of terms and to contribute additional content to extend the set of terms common to both standards.

5.2 Integrating B2MML Documents into MTConnect Assets

The other area defined for interoperation between B2MML and MTConnect is the integration of B2MML documents with MTConnect Assets. The main reason for integrating B2MML documents with MTConnect Assets is to provide a common mechanism for identifying,

managing, storing, and transporting both B2MML documents and other MTConnect Assets (Parts, Processes, Cutting Tools, Files, etc.) in a common format and utilizing a common set of software tools and technologies.

MTConnect is an extensible standard; meaning an integrator can add additional content to an MTConnect implementation by extending the schema associated with any of the MTConnect Information Models. In this case, the MTConnect Assets Information Model would be extended to support additional Asset types – one for each of the B2MML document types that the integrator wishes to support in a system.

The integration of B2MML documents as a type of MTConnect Asset is a relatively straightforward process. B2MML and MTConnect encode documents using XML. XML documents are validated based upon a schema that is designed for each document type. XML has a useful feature that allows different parts of a document to be defined using different schemas. This feature allows an implementer to extend the MTConnect Assets schema for a new type of MTConnect Asset (B2MML) by defining a relatively small extension to the MTConnect Assets schema. This additional content provides identity and some basic information about the B2MML document. It is then possible to embed the entire B2MML document into the MTConnect Asset by merely identifying it and associating the B2MML schema and namespace for that document. By doing this, a software application can request and interpret MTConnect Assets representing B2MML information and then further interpret the B2MML content since the reference to the schema for that content is embedded into the MTConnect Asset document.

In the SPEC-OPS project, two B2MML MTConnect Asset types have been implemented to demonstrate how this procedure works - B2MML Product Definition Asset type and a B2MML Production Schedule Asset type.

5.3 B2MML Product Definition Document as an MTConnect Asset

The following figure demonstrates how a B2MML Product Definition document can be embedded into an MTConnect Asset to create a B2MML Product Definition Asset type.

A new MTConnect Asset type called B2MMLProductDefinition is created. MTConnect provides a basic structure (“wrapper”) which defines critical information for identifying and managing documents based upon this new Asset type.

The XML element called `b2mml:ProductDefinition` represents the content of the original B2MML file. This content is defined by a specific B2MML schema. An example of that schema would be <http://www.mesa.org/xml/B2MML-V0600> .

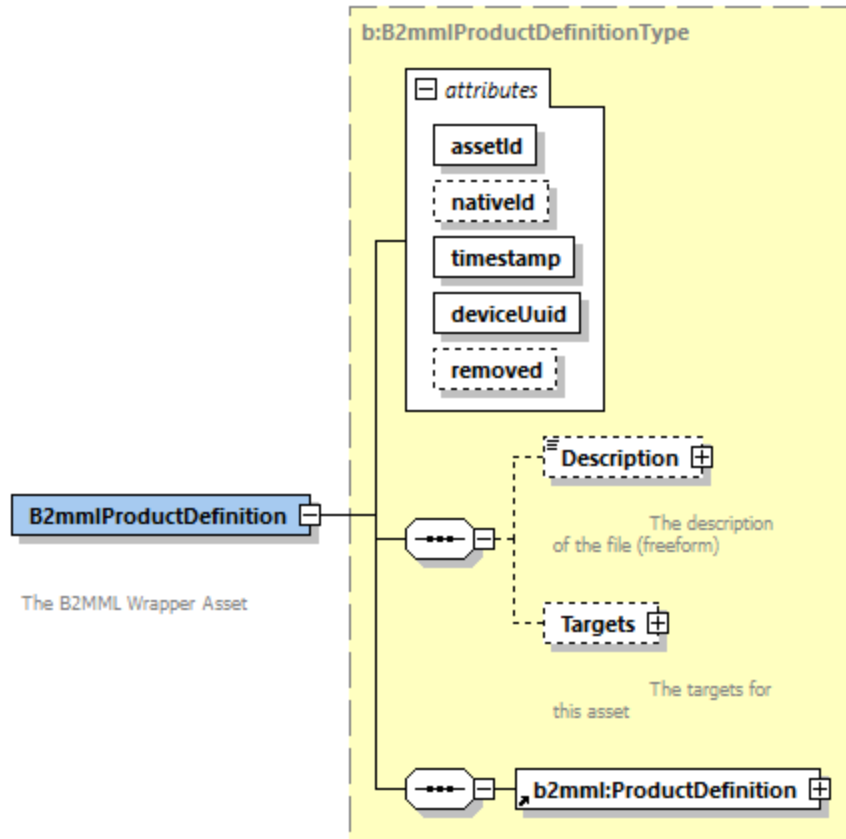


Figure 1: Structure for a B2MMLProductDefinition Type Asset

Within the B2MML document portion of this MTConnect Asset document, there is specific information that would be useful for planning how that part might be produced in a specific manufacturing environment. The following is an example of the information included within the B2MML content portion of this MTConnect Asset that can be extracted by a software application and utilized to define how a specific part might be produced.

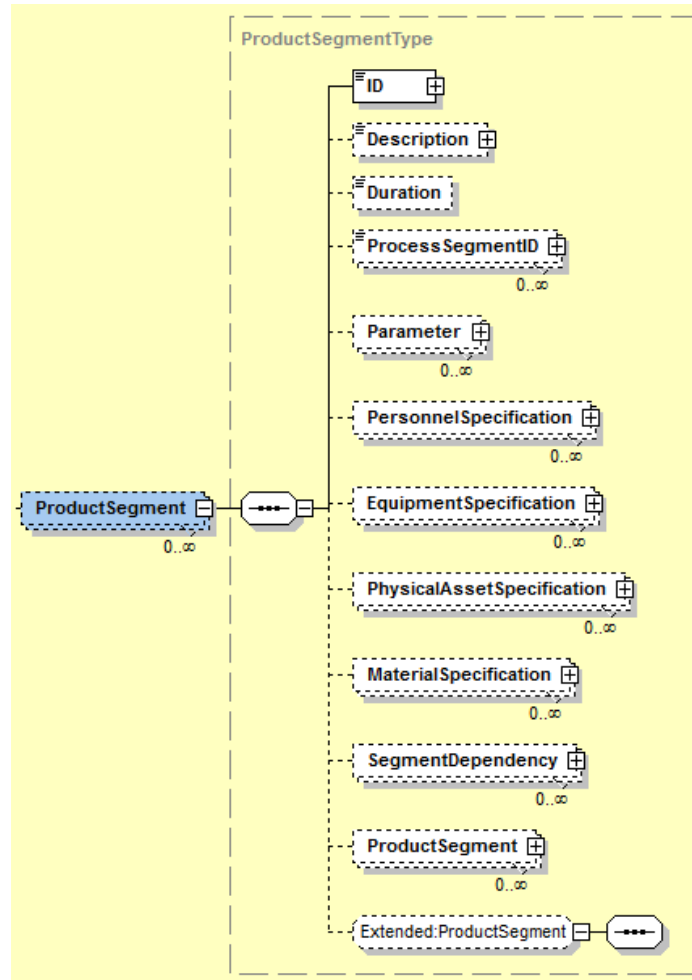


Figure 2: Structure for a B2MML Product Segment

This example demonstrates how a B2MML document can be integrated into an MTConnect Asset model; leveraging the capabilities and functionality of both the MTConnect Standard to define and manage the document and B2MML to carry information to software applications that is beyond the scope of information defined within MTConnect. In this example, two B2MML documents are represented as MTConnect Assets.

```
<?xml version="1.0" encoding="UTF-8"?>
<MTConnectAssets xsi:schemaLocation="urn:mtconnect.org:B2MML:1.3
  /schemas/B2MML_1.3.xsd" xmlns:b="urn:mtconnect.org:B2MML:1.3"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns="urn:mtconnect.org:MTConnectAssets:1.3"
  xmlns:m="urn:mtconnect.org:MTConnectAssets:1.3">
  <Header assetCount="132" assetBufferSize="10240" version="1.4.0.3"
    instanceId="1505504796" sender="ubuntu" creationTime="2017-10-
    12T13:50:35Z"/>
  <Assets>
    <B2mmlProductDefinition assetId="9ede2e6c-f2f2-55fb-ab60-f7ae2a21ad17"
      deviceUuid="itamco Haas 1c2bc0" timestamp="2017-09-
      15T19:46:49.679251Z">
      <ProductDefinition xmlns="http://www.mesa.org/xml/B2MML-V0600">
        <ID>TEST-00003 </ID>
        <Description>Base, Part 1a, Rev. - Base, Part 1a</Description>
        <ProductSegment>
          <ID>TEST-00003 </ID>
        </ProductSegment>
      </ProductDefinition>
    </B2mmlProductDefinition>
    <B2mmlProductDefinition assetId="42078e08-169a-5183-ad38-78f2daa0593c"
      deviceUuid="itamco Haas 1c2bc0" timestamp="2017-09-
      15T19:46:49.242110Z">
      <ProductDefinition xmlns="http://www.mesa.org/xml/B2MML-V0600">
        <ID>TEST-00004 </ID>
        <Description>Rear Mount, HV, Left, Rev. - Rear, HV, Mount, Left</Description>
        <ProductSegment>
          <ID>TEST-00004</ID>
        </ProductSegment>
      </ProductDefinition>
    </B2mmlProductDefinition>
  </Assets>
</MTConnectAssets>
```

In this example, the content defined in Blue is the MTConnect portion of this document. The content in Red is the B2MML content of this document.

5.4 B2MML Production Schedule Document as an MTConnect Asset

Likewise, the following figure demonstrates how a B2MML Production Schedule document can be embedded into an MTConnect Asset to create a B2MML Production Schedule Asset type.

A new MTConnect Asset type called `B2MMLProductionSchedule` is created. The same “wrapper” that was used for the `B2MMLProductDefinition` asset type is used here.

The XML element called `b2mml:ProductionSchedule` represents the content of the original B2MML file. Again, this content is defined by a specific B2MML schema.

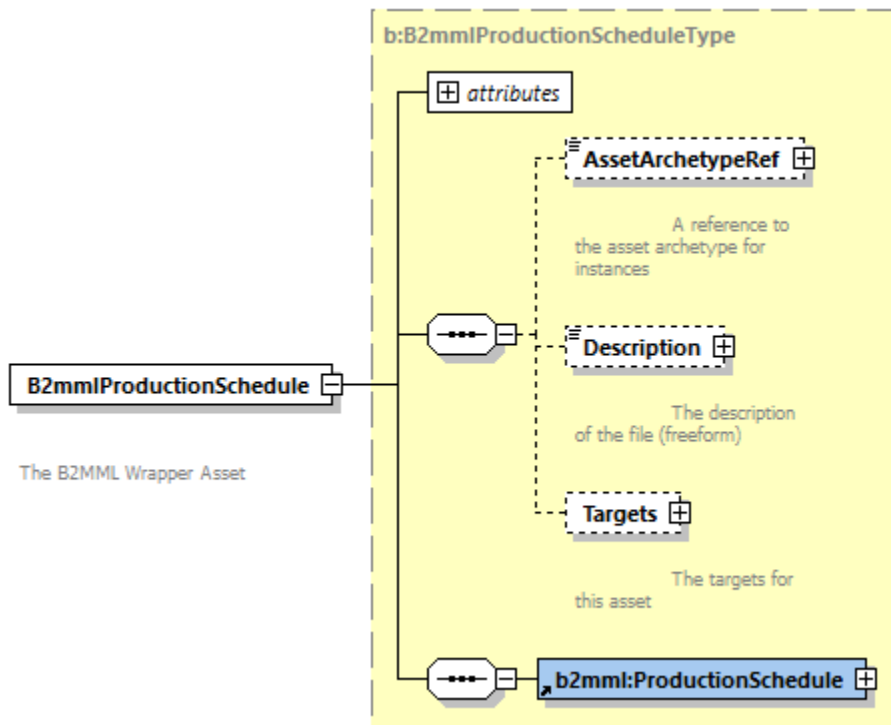


Figure 3: Structure for a B2MMLProductionSchedule Type Asset

Within the B2MML document portion of this MTConnect Asset document, there is specific information that would be useful for scheduling parts through a specific manufacturing environment. The following is an example of the information included within the B2MML portion of this MTConnect Asset that can be extracted by a software application and then interpreted as requirements for producing a specific part.

The production request portion of the B2MML document is used to convey information relating to a production order; often referred to as a shop order or SO. This information may be used to initiate a set of actions required to produce a part and is a key input to a Production Scheduling software system.

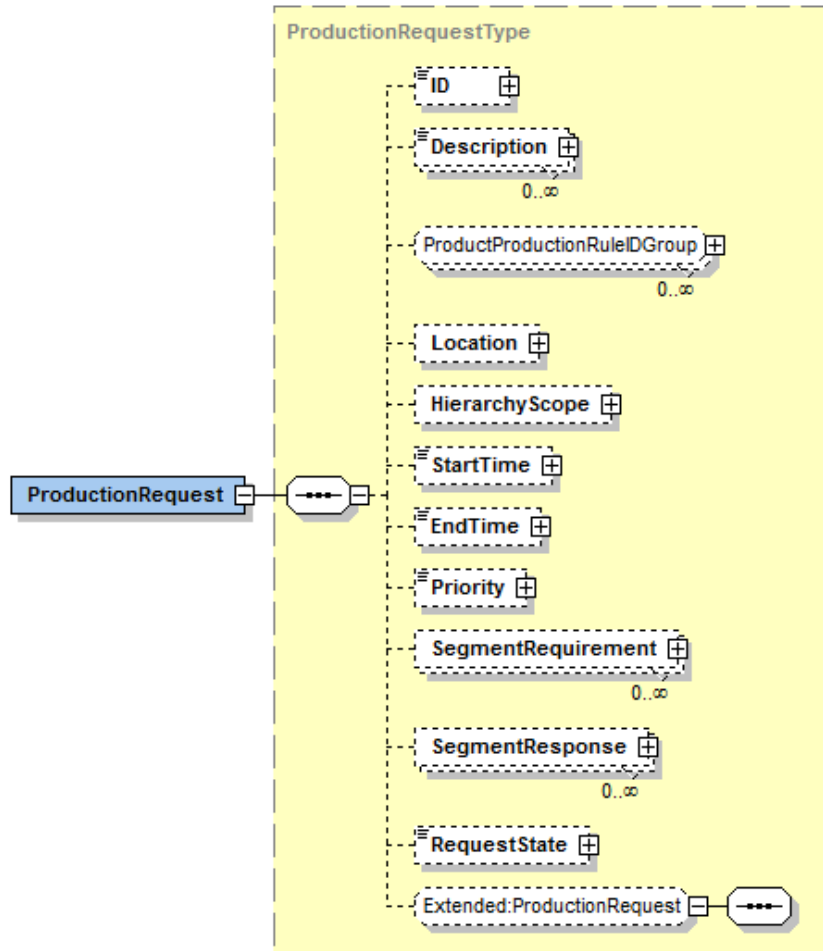


Figure 4: Structure for a B2MML Production Request

The Production Request portion of the B2MML document contains specific information regarding the production of a part – requirements relating to start and completion dates for the SO, material usage, planned production times, equipment usage, and target costs. This information is contained in the Segment Requirement portion of the Production Request. This is key information required by a Scheduling Software system to generate production plans and part routing information.

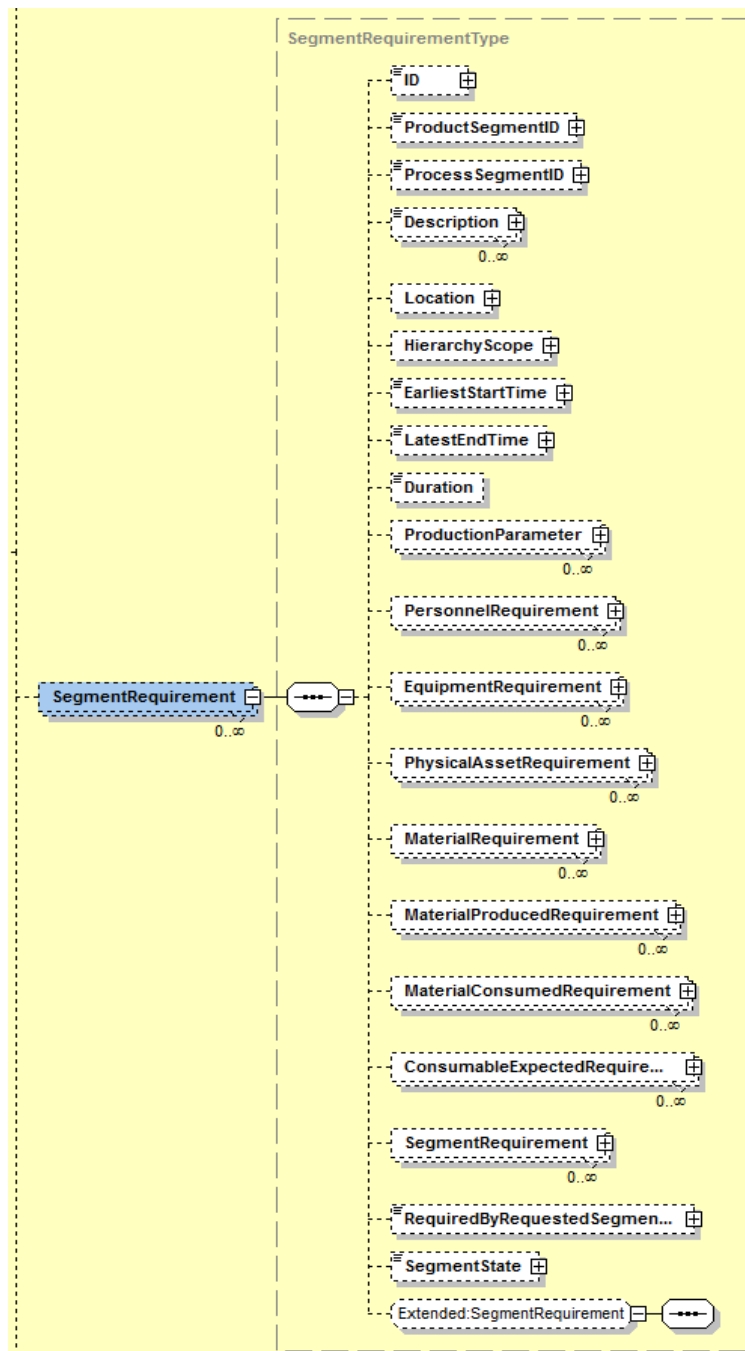


Figure 5: Structure for a B2MML Segment Requirement

This example demonstrates how a B2MML Production Schedule document can be integrated into an MTConnect Asset model. In this example, one B2MML Production Schedule document is represented as an MTConnect Asset.

```

<?xml version="1.0" encoding="UTF-8"?>
<MTConnectAssets xsi:schemaLocation="urn:mtconnect.org:B2MML:1.3
  /schemas/B2MML 1.3.xsd" xmlns:b="urn:mtconnect.org:B2MML:1.3"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns="urn:mtconnect.org:MTConnectAssets:1.3"
  xmlns:m="urn:mtconnect.org:MTConnectAssets:1.3">
  <Header assetCount="132" assetBufferSize="10240" version="1.4.0.3"
    instancelId="1505504796" sender="ubuntu" creationTime="2017-10-
    12T15:00:06Z"/>
  <Assets>
    <B2mmlProductionSchedule assetId="49d681d4-a790-5a71-91ec-6fe760e8a297"
      deviceUuid="6ee5c9" timestamp="2017-09-15T19:46:49.746808Z">
      <AssetArchetypeRef assetId="9ede2e6c-f2f2-55fb-ab60-f7ae2a21ad17"
        assetType="b:B2mmlProductDefinition"/>
      <Targets>
        <Target type="DEVICE" targetId="WC81-SS">
          <TargetDevice>WC81-SS</TargetDevice>
        </Target>
        <Target type="DEVICE" targetId="WC41-HTC">
          <TargetDevice>WC41-HTC</TargetDevice>
        </Target>
        <Target type="DEVICE" targetId="WC89-QC">
          <TargetDevice>WC89-QC</TargetDevice>
        </Target>
      </Targets>
      <ProductionSchedule xmlns="http://www.mesa.org/xml/B2MML-V0600">
        <ID>M17-10450</ID>
        <ProductionRequest>
          <ID>M17-10450</ID>
          <Description>Base, Part 1a, Rev. - Base, Part 1a</Description>
          <StartTime>2017-09-11T00:00:00-04:00</StartTime>
          <EndTime>2017-09-15T17:00:00-04:00</EndTime>
          <SegmentRequirement>
            <ProductSegmentID>TEST-00003 </ProductSegmentID>
            <LatestEndTime>2017-09-15T17:00:00-04:00</LatestEndTime>
            <Duration>PT15H30M</Duration>
            <MaterialProducedRequirement>
              <Quantity>
                <QuantityString>0.1E2</QuantityString>
                <DataType>Amount</DataType>
              </Quantity>
            </MaterialProducedRequirement>
          </SegmentRequirement>
        </ProductionRequest>
      </ProductionSchedule>
    </B2mmlProductionSchedule>
  </Assets>
</MTConnectAssets>

```

```

    </Quantity>
  </MaterialProducedRequirement>
  <MaterialConsumedRequirement>
    <MaterialConsumedRequirementProperty>
      <ID>Availability</ID>
      <Value>
        <ValueString>Available</ValueString>
        <DataType>string</DataType>
      </Value>
    </MaterialConsumedRequirementProperty>
  </MaterialConsumedRequirement>
</SegmentRequirement>
<ID>005 </ID>
<Duration>PT10M</Duration>
<ProductionParameter>
  <Parameter>
    <ID>SetupTime</ID>
    <Value>
      <ValueString>PT0S</ValueString>
      <DataType>duration</DataType>
    </Value>
  </Parameter>
</ProductionParameter>
<EquipmentRequirement>
  <EquipmentID>WC81-SS </EquipmentID>
  <Description>Shipping Support </Description>
  <EquipmentRequirementProperty>
    <ID>Cost</ID>
    <Value>
      <ValueString>6.918049999999999</ValueString>
      <DataType>Amount</DataType>
      <UnitOfMeasure>US Dollar</UnitOfMeasure>
    </Value>
  </EquipmentRequirementProperty>
</EquipmentRequirement>
</SegmentRequirement>
  <RequestState>Released</RequestState>
</ProductionRequest>
  <ScheduleState>Released</ScheduleState>
</ProductionSchedule>
</B2mmlProductionSchedule>
</Assets>
</MTConnectAssets>

```

The content defined on the previous pages in Blue is the MTConnect portion of this document. The content in Red is the B2MML content of this document.

5.5 Resources to support Implementers

There are three (3) different types of resources available to implementers to aid in the development of information systems utilizing both the B2MML and MTConnect Standards.

- B2MML Standards listed in Section 2 of this document.
- MTConnect Standards listed in Section 2 of this document.
- Examples provided at www.mtcup.org

The materials provided at www.mtcup.org include the following:

- Sample XML diagrams demonstrating the integration of B2MML documents into MTConnect Assets
- Sample MTConnect Assets schema demonstrating the extensions to the MTConnect schema to incorporate the B2MML documents.
- Sample MTConnect Asset Response Documents demonstrating how B2MML documents can be presented to software applications as MTConnect Assets.
- A Table of Terms demonstrating the mapping of information between the B2MML and MTConnect Standards.

All the materials on www.mtcup.org are provided as open-source content. These materials are available to implementers to utilize free of charge. Implementers are encouraged to contribute additional content to the www.mtcup.org site by providing either more examples of integrations between MTConnect and B2MML documents or extensions to the Table of Terms to support the mapping of new data types between the two standards.