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EVALUATING A CHANGE PROCESS PRODUCT DATA MODEL FOR AN ANALYSIS DRIVEN SUPPLY CHAIN CASE STUDY

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ABSTRACT

This paper introduces a change management case study using Product Data-Driven Analysis scenarios from TIGER [TIGER, 97] – a supply chain case study - and an associated mapping to a STEP data model, a standard format product data model terminology. The case study describes supply chain scenarios that involve prime with contractors, subcontractors and consulting entities. The core activity within these scenarios is an engineering analysis of Printed Wiring Boards (PWB) with a focus on modeling product analysis data. Analysis of PWB can involve an iterative process that translates to changes to the product data. Application protocol 208 [STEP, Part 208/CD] is an underdeveloped part of the STEP standard and deals with product life cycle and change management. These changes are incorporated into the case study scenarios and the capability of AP 208 to capture them is evaluated.

INTRODUCTION

Product design and analysis processes most likely involve several groups of people from various professions using many software tools. For products such as aircrafts or automobiles, the design analysis process includes many components as well as many individual bodies, contractors and sub-contractors. One key point in the efficient design-analysis process is standardization of the data involved. By using standards, different organizations using various tools increase process automation thus speeding up the process and decreasing ambiguities. The iterative nature and the constant introduction of changes in the design analysis process underscore the importance and need for data representation standards.

The design analysis process can be viewed as an integral part of a product life cycle. The introduction of a change to an existing product or a new product development may invoke sequences of iterative steps in several aspects of product data. For example, a geometric dimension change to a product may require a new analysis procedure to be performed as well as approval by the product owner. Therefore, in this example, both technical and configuration management data types are invoked by this initiated change.

The International Standard Organization (ISO) is devising a standard ISO 10303, called STEP. This standard objective is to provide a neutral mechanism capable of describing product data throughout the lifecycle of a product independent of any particular system. This standard is compounded of several parts. Application Protocol (AP) 208 is a part that is under development, which deals with product data representation for life cycle management and change process. Application Protocol 208 is in the approval stage. AP208's scope includes identification of the reason for change, its cause, the approval and performance of the resulting change to the product, and the authorization of the corrective actions.

The case study being described in this paper is from the TIGER project - Team InteGrated-Electronic Response – and was a Defense Advanced Research Projects Agency project [Peak, 1997; Tamburini, 1997]. It dealt with early collaboration in the defense industry's multi-tiered supply chain. In the TIGER scenario, a large manufacturer delivers early printed wiring assembly designs to its supply chain. Along the supply chain there was a refining specification process. This process, which started with concept design, ended with specific advanced thermomechanical analyses. The TIGER Program demonstrated technologies that enable small to medium enterprises (SME) in the industry to embrace Electronic Commerce through Internet-based usage. TIGER Program participants included Boeing Defense and Space Group and Holaday Circuits representing the Prime and SME supplier, respectively; Boeing's Irving, Texas, PWB assembly plant (1st Tier supplier); Arthur D. Little; Atlanta Electronic Commerce Resource Center, Georgia Tech; International TechneGroup Inc.; and SCRA.

This paper takes a Product Data-Driven Analysis view of the TIGER project. The AP208 STEP data model is mapped to the Product Data-Driven Analysis change scenarios. Finally, the capability and capacity of AP 208 to capture those changes is evaluated.

CASE STUDY SCENARIOS

The prime contractor, (Figure. 1), issues the product's initial design specifications. The design layout is than transferred to first-tier support groups, and in turn these support groups issue Requests For Proposals (RFP) to SME's. The SME's, in turn, may access the internet-based Engineering Service Bureau (ESB) where they can utilize automated analysis in a self-serve manner [Scholand, 97].

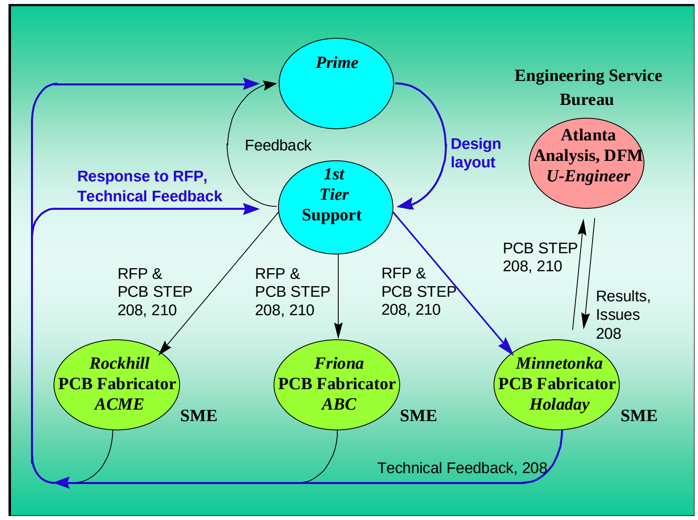

Figure 1 Tiger Project Actors

The Printed Wiring Board (PWB) is a core product in the TIGER project. For this case study, two change scenarios are explored. Part of the Georgia Tech EIS lab's contribution and expertise within the TIGER project is to enable the ESB technology. In this scenario, the analysis step of bare PWB product life cycle is the responsibility of the SME. The SME uploads product information in the STEP AP210 [STEP, Part 210] PWA format to an Internet-based ESB and plugs it into the ESB tools. The SME then performs the analyses themselves using the ESB's automated product data driven tools. The first change scenario is in fact a specification refinement iterative process, as illustrated in Figure 2

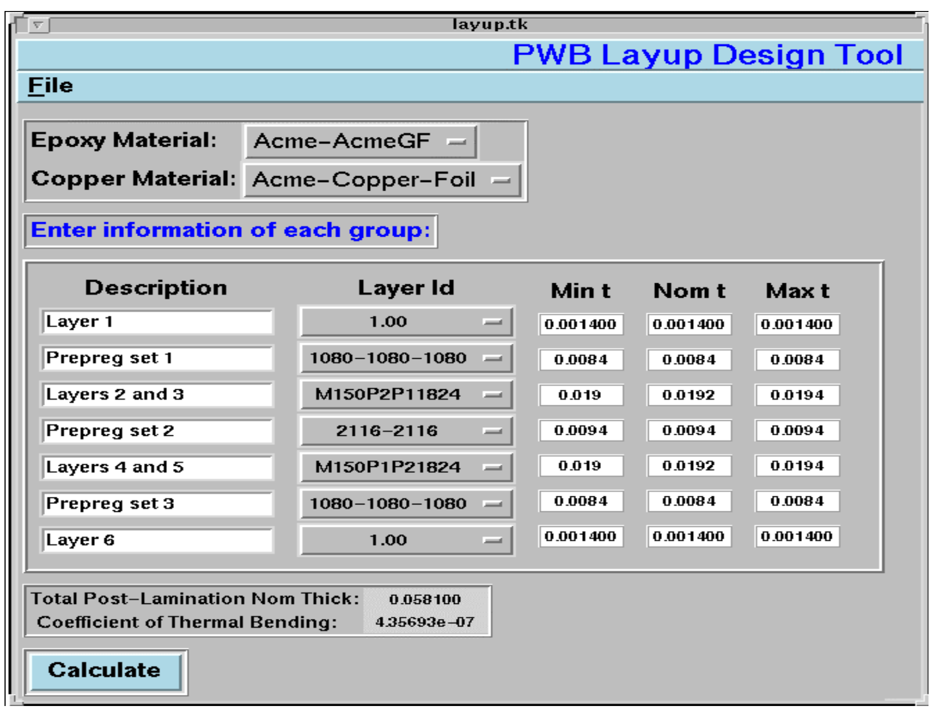

Figure 2 PWB Layup Design Tool Screen

The Description field is a design specification that was assigned by the prime, and the SME should be able to control the nominal board thickness as well as board warpage. For this change scenario, the layer ID's as well as the various thicknesses are subjected to change. All the elements that are subject to change in this scenario are the responsibility of the SME and deal with physically realizing the prime specs as specific PWB laminates, copper foils, and prepregs.

In the second change scenario, the object that is subject to change is the PWB material. However, the PWB material is part of the initial design specification and as such, it is owned by the prime. Figure 3.1 and Figure 3.2 are EXPRESS-G data models that explain the relationships among the various actors in these scenarios.

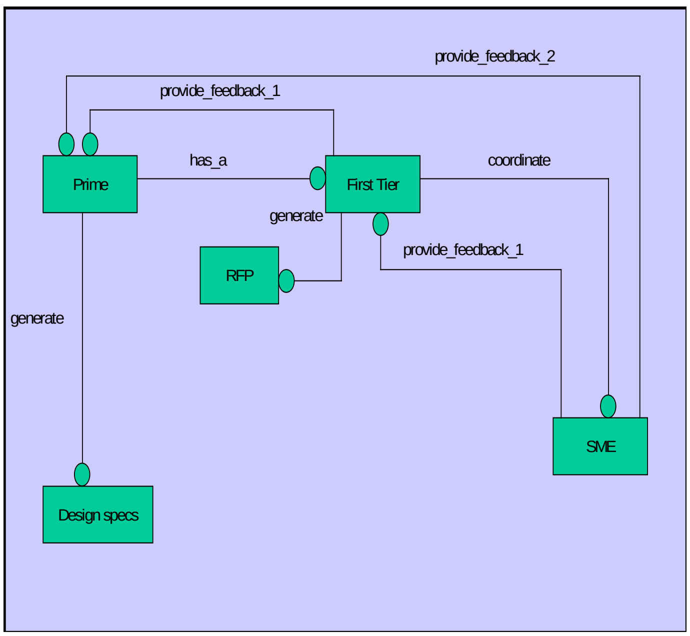

Figure 3.1 Abstract Tiger Actor Data Model 1

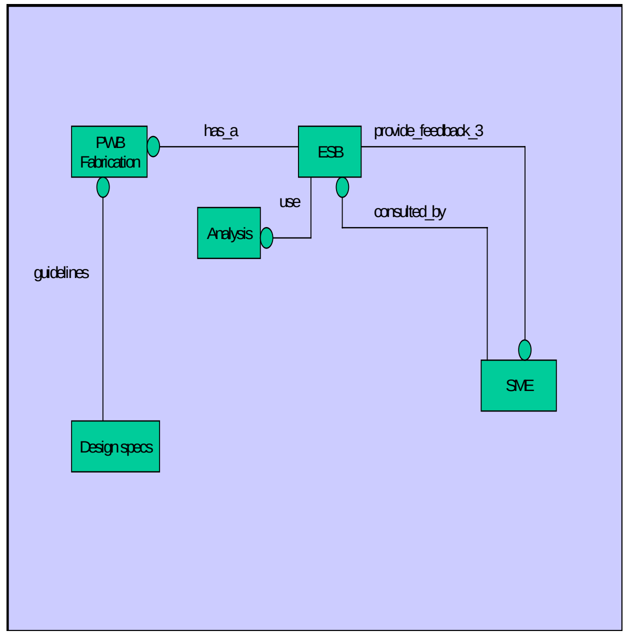

Figure 3.2 Abstract Tiger Actor Data Model 2

Figures 3.1 and 3.2 are complementary data schemas that illustrate the level of connectivity among actors in the supply chain TIGER scenarios. It is useful to point out that the prime actor is in contact with the other actors as a provider of requirements and specifications and as an entity that deals with feedback issues. For example, Figure 3.2 indicates the analysis role of the ESB within the TIGER project.

The core PWB data model without the attributes is shown in Figure 4. This model describes PWBs and their relations to PWB thermal models. Some of the main components in this schema are the PWB, PWB thermal model, and the Printed Wiring Assembly, which are associated with the Printed Wiring Board. Three types of possible layers are described in the schema: PWB Copper Layer, Prepreg Set, and PWB Copper-Cladded Laminate. The PWA entity describes the component attachment to the PWB. The PWB is the bare board and its thermal bending behavior (warpage) is described by the entity "PWB thermal bending model." Each electrical component has an electrical package and a "component occurrence" entity that is described by its surface and location. Figure 4 aids in explaining the change scenarios in the following manner: First, the designer is able to choose various layers for a given set of PWB design requirements. The layers construct the PWB and therefore create the PWB thermal behavior. Figure 4 also shows the PWB relation to various electrical components on the one hand and the part physical characteristics on the other hand.

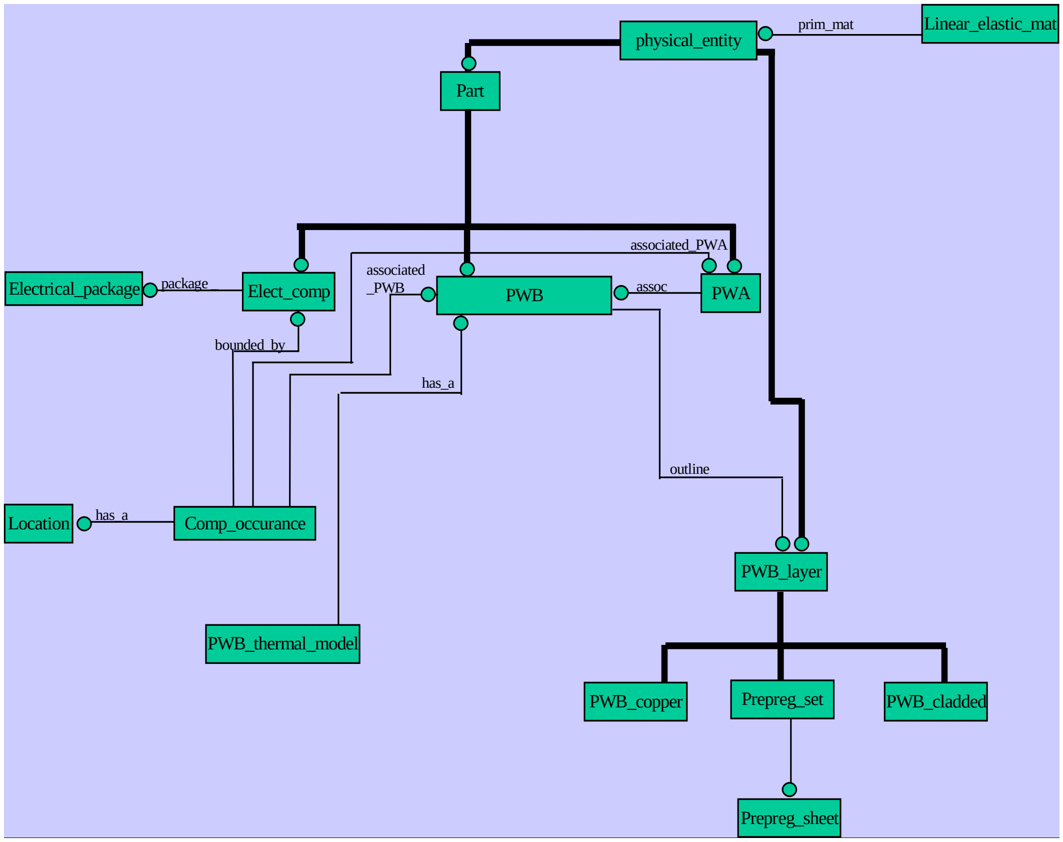

Figure 4 Core PWB Data Model

TIGER DESIGN ANALYSIS SCENARIO MAPPING TO STEP AP 208 CORE DATA MODEL

The following five points are within the scope of AP 208:

1. The product change identification
2. The change classification as either a deviation from original specifications or as a planned enhancement
3. The anomaly identification, which triggers the change or changes
4. The task specifications required to implement and inspect the change(s)
5. The required corrective action to prevent re-occurrence of the change, if it is a non-enhancement change.

The relevant TIGER data model is a derivative of the change scenarios mentioned in previous sections. The mapping action is actually an identifying and attaching procedure. An element in the case study data model is identified and matched against an AP 208 data item. Figure 5 illustrate this concept.

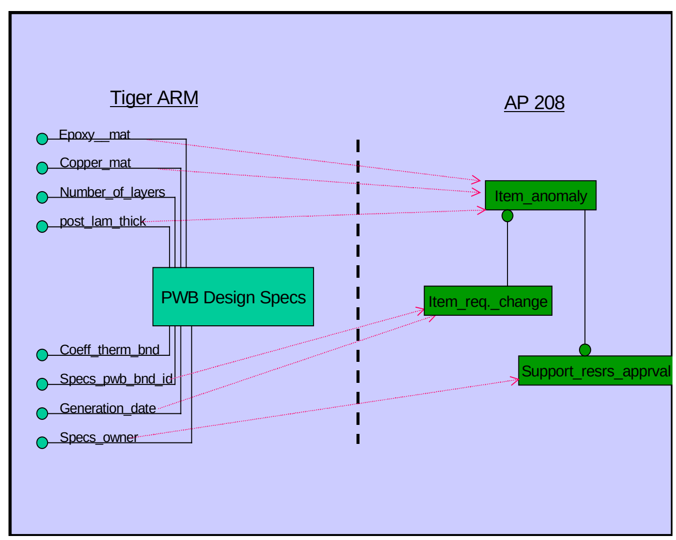

Figure 5 Abstract Tiger Model to AP 208 Application Reference Model Mapping

This simplified combination illustrates the mapping principle. The “post lamination thickness” may trigger this change, and therefore can be described as “item anomaly.”

Change Scenario I

The first change scenario is a specification refinement iterative process. As illustrated in Figure 2, the Description field is a design specification where the analysis expert should be able to control the nominal board thickness as well as board warpage. For this change scenario, the layer ID's as well as the various thicknesses are subjected to change. All the elements that are subject to change in this scenario are the responsibility of the SME -- which is to say that a change authorization should be issued by the SME. Figure 6 illustrates in detail the entity level mapping between the Tiger data model and the AP208 data model. For example, the entity "PWB_thermal_model" is partially described by the attributes "post lamination thickness" and "PWB warpage." Both of these attributes correspond to the definition of anomalies according to the AP 208 terminology and within the context of the first scenario. Therefore, the "PWB_thermal_model" entity and the "item_anomaly" are connected with the dashed arrow in Figure 6 "Layer ID" and the thicknesses associated with the layers can be described as attributes of "PWB_layer" and its children. However, those attributes are the changed elements within TIGER's first scenario framework. Therefore, the entity "PWB_layer" is connected to the item "req. change" with the dashed arrow. In the same manner, the mapping between the Small Medium Enterprise (SME) to the enterprise entity of the AP208 data model is illustrated.

Change Scenario II

In the second change scenario, the object that is subjected to change is the PWB material. However, the PWB material is part of the initial design specification and as such, is owned by the Prime. Figure 3 is a data model that illustrates the

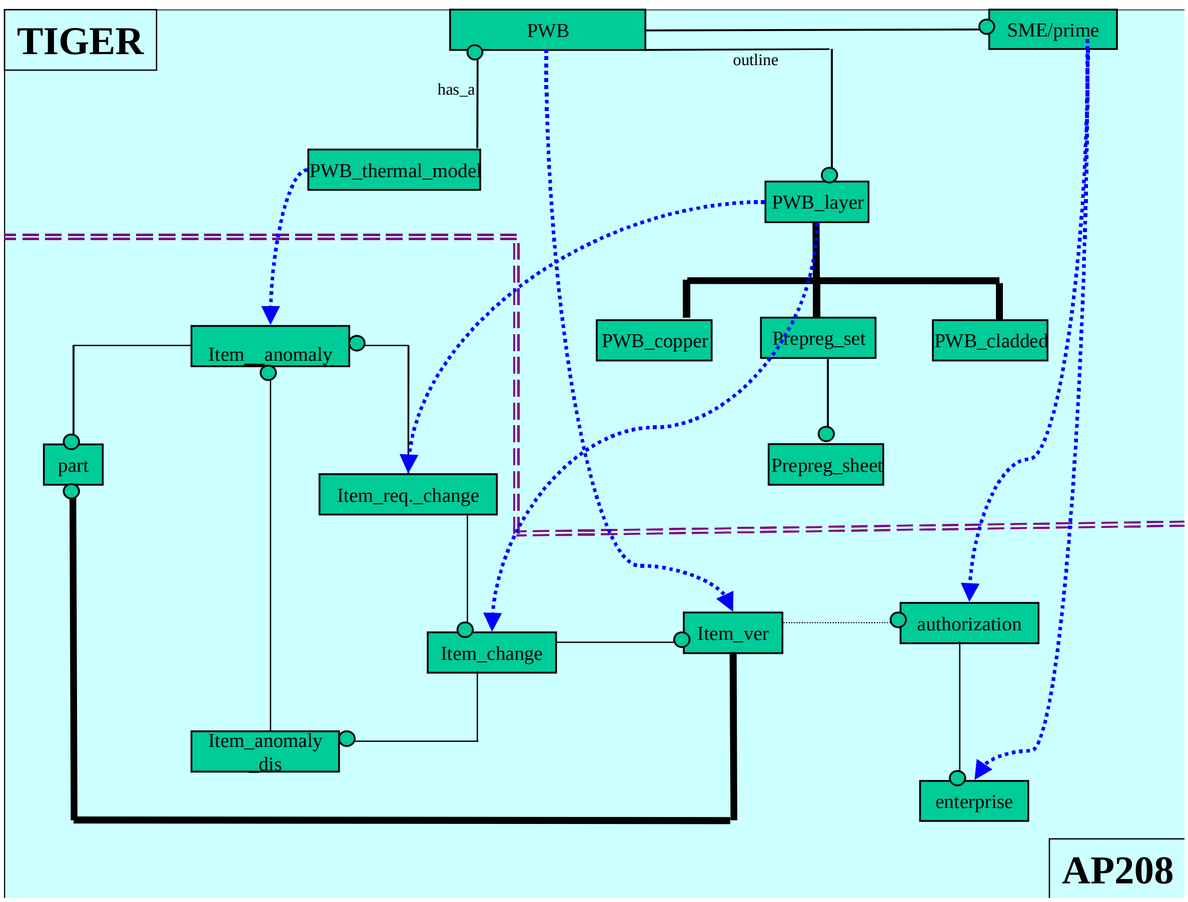

Figure 6 Abstract change scenarios (1 and 2) Model to AP 208 Application Reference Model Mapping

relationships among the various actors in these scenarios. For example, in this second scenario, the anomalies are the same as in the first scenario, namely, the "PWB_thermal_model_total_thickness" and the "PWB_thermal_model_warpage" (both items are represented as PWB_thermal_model in Figure 6). The difference in this second scenario is the change, namely the material change. Therefore, the enterprise responsible for the authorization is the Prime in this case. In Figure 6 some of the entities can be mapped to more than one item with in the AP208 schema. For example, the entity "PWB_layer" may be mapped to an "item that require a change" and a "changed item".

CONCLUDING REARKS

This section includes two parts: a discussion about AP208 capability issues that the authors encountered during the mapping process; and an examination of how AP208 terminology can be used to describe the changes in the two given change scenarios. The final part of this conclusion envisions an extended usage of AP208 in similar analysis based scenarios.

The TIGER case study illustrates a supply chain, multi-player design analysis process. The two change scenarios chosen in this framework illustrate the iterative nature of the analysis process. In the two scenarios, the main elements described by AP208 are the change itself and the consequences of that change. The concept of item anomaly is defined in AP208 as:

"An Item_anomaly is the identification of a nonconformance or a deviation from design nominal conditions for a product. The identification of a nonconformance or a deviation is reported by a Support_resource. Each Item_anomaly may be an Item_flaw or an Item_issue_or_concern.

The data associated with Item_anomaly are the following:

anomaly_cause;
anomaly_type;
detection_method;
item;
item_anomaly_description;
item_anomaly_identifier.

In the two TIGER scenarios, the PWB warpage and the total lamination thickness were mapped to the Item Anomaly definition. In both cases, these two attributes were the consequences of the iterative process. The designer in both of these scenarios had "ballpark" data for the expected total lamination thickness as well as the feasible warpage. Therefore, the anomaly concept can be used efficiently. However, within the "Item_Anomaly" attribute coverage there is no specific description that is able to cover the iterative nature of the analysis process. There is an attribute description named "detection method", but there is no explicit field that conveys the creation nature of these anomalies. In analysis processes, the mechanisms for tracking, understanding, and facilitating evolution are important. Therefore, AP208 is able to map change and change consequences, but additional attributes that would channel the nature of "Item_anomaly" would be useful. These additional attributes would be able to describe the iterative nature of such processes.

Another important concept underlined in the TIGER case study is the characteristic nature of the supply chain process. AP208, armed with the notion of "enterprise" and "authorization," was able to describe the parts ownership and authorization mechanisms. Authorization is defined in AP208 in the following manner:

"authorization: the decision making mechanism through which the appropriate level of permission is granted to proceed with the execution of planned actions or resource allocations. This includes a commitment or acknowledgment to perform a particular task or series of tasks".

This definition facilitates the relevant mapping for the change scenarios. However, the chain description of the data transition from one owner to another -- which is characteristic of the supply chain process -- is not covered by this AP208 definition.

In General, AP208 proved to be a capable mechanism to describe the TIGER scenario change data models. However, it is clear that AP208 does not explicitly support the richness of data needed in a multi-actor iterative analysis process.

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