Feasibility of Integrating OAGIS and BPMN

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Abstract

Engineering and enterprise processes overlap in their concerns, for example, coordinating product design and customer relations. Integration of these processes provides more efficient communication and higher quality results than leaving them separated. Interoperation of standards for specifying engineering and enterprise processes is critical to integrating them. This paper contributes to this by examining the feasibility of integrating the Open Applications Group Integration Specification (OAGIS) with the Object Management Group's Business Process Model and Notation (OMG BPMN). These standards are complementary because OAGIS provides a wide range of enterprise interaction content, including engineering, manufacturing, enterprise resource planning, logistics, and eCommerce, while BPMN defines a commonly understood diagrammatic notation for enterprise processes and interactions in general. This paper focuses on the application of BPMN to enterprise interactions specified in OAGIS. It reviews BPMN interaction diagrams to determine the best to use with OAGIS, gives a procedure for applying these diagrams to OAGIS enterprise interactions, and validates the procedure on a particular example. It also gives additional results found during the study for use in future work.

1   Introduction

Engineering and enterprise processes are rapidly evolving and beginning to overlap in their concerns. Engineering processes must be coordinated with other processes in their enterprises, while enterprise processes directly affect and interact with engineering. For example, engineering change management links the engineering process of product design and the enterprise process of customer relationship management. Significant technological, economic, and strategic benefits can be attained through more effective capture, control, and management of engineering processes in conjunction with other enterprise processes.

Integrating engineering and enterprise processes as a chain of value-adding activities enables them to be improved, replicated, and monitored more effectively. They become a corporate asset that can be improved and increase in value over time. Separating engineering and enterprise activities reduces efficiency of new product development, inhibiting collaboration between engineering departments and external stakeholders. Furthermore, these collaborations are not well defined or understood as integral parts of overall enterprise processes, leading to sub-optimal engineering and enterprise management.

Interoperation of standards used in specifying engineering and enterprise processes is critical to integrating them. The work described in this paper focuses on the following standards:

- For engineering processes, the Open Applications Group (OAGi) Integration Specification (OAGIS) provides message content and architecture between disparate systems, companies, and supply chains that supports automation, as well as example enterprise interactions using messages defined in the specification [1]. OAGIS is a

widely used standard for engineering, manufacturing, enterprise resource planning, logistics, ecommerce, and other applications.

- For enterprise processes, the Object Management Group's (OMG) Business Process Model and Notation (BPMN) has a widely-used notation that is readily understandable by subject matter experts, including engineers, as well as supporting automation [2]. BPMN creates a standardized bridge between process design and automation.

OAGIS and BPMN are complementary because OAGIS provides enterprise interaction and message content for a wide range of engineering processes, as well as a message architecture that supports automation, while BPMN provides a diagrammatic notation for enterprise interactions that also supports automation.

This paper examines the feasibility of integrating OAGIS and BPMN. Section 2 develops specific candidate topics for the study. Section 3 analyzes these topics and selects some to include in the scope of work. Section 4 narrows the potential techniques used to achieve the selected topics by determining which parts of BPMN to apply. Section 5 presents a procedure to address the topics chosen in Section 3, using the parts of BPMN selected in Section 4, and uses the procedure on an example to determine the feasibility of integrating OAGIS and BPMN. Section 6 summarizes the paper. Annexes A through E give a number of additional results generated from this study for use in future work.

2   Concept

The concept portion of the study has two parts, first comparing OAGIS and BPMN in Section 2.1, and then based on that, identifying potential topics for the study in Section 2.2.

2.1   Comparing OAGIS and BPMN

To achieve interoperability between disparate systems, companies, and value chains, a messaging architecture is necessary to provide a common meaning and approach to engineering enterprise processes and communication. Messages built on such an architecture are used in system interactions ("scenarios"). These interactions provide a step-by-step guide to perform business and engineering tasks. Complex interactions, created by assembling basic scenarios with additional messaging steps can then be created to fulfill any needed business or engineering function.

OAGIS provides example interactions between enterprises (*business scenarios*) involving exchanges of messages or documents in standard forms (*business object documents*, BODs). BODs are defined using a verb-noun structure, which supports automation. Each scenario identifies BODs that will accomplish the desired business or engineering interaction. These scenarios are intended to be used as starting points to design interactions for specific needs of organizations and integration projects. Details for scenarios are captured with Unified Modeling

Language (UML) sequence diagrams [3], but these are only expressed as drawings, rather than forms supporting automation.

BPMN is a widely-used standard language for describing interactions between enterprises, such as those in OAGIS. It includes notations that are readily understandable by subject matter experts with backgrounds other than computation, which can be translated to an underlying formalism supporting automation. It is a simple means of communicating process information to other business and engineering users, process implementers, customers, and suppliers. Standardization relieves these users of needing to understand potentially different representations of the same process as it moves through its lifecycle of development, implementation, execution, monitoring, and analysis.

Table 1 summarizes the comparison between OAGIS and BPMN. OAGIS and BPMN complement each other, with OAGIS providing interaction and message content, as well as a message architecture that enables automation, while BPMN provides a diagrammatic notation for interactions and enables automation.

	OAGIS	**BPMN**
Interactions	Provides drawings that do not enable automation, similar to UML interactions diagrams (business scenarios).	Provides diagrammatic notation supporting automation (collaboration diagrams, including conversations, and choreography diagrams).
Messages	Provides verb-noun structure that enables automation (business object definitions, BODs).	Provides a way to reference message content, but not define it.

Table 1: Summary Comparison of OAGIS and BPMN

2.2 Overall Approach and Topics for Feasibility Study

Based on the comparison in Section 2.1, integration between BPMN and OAGIS can be achieved by using BPMN to define OAGIS business scenarios, because

- OAGIS provides enterprise interaction content for a wide range of engineering enterprise processes, while the BPMN defines a commonly understood diagrammatic notation for enterprise interactions.
- OAGIS provides message architecture for BPMN interactions enabling automation, and BPMN does the same for interactions drawings in OAGIS.

BPMN models for OAGIS business scenarios can be defined at three levels of detail:

1. Interactions only
   BPMN diagrams can be created corresponding to OAGIS business scenario drawings, showing message flows without internal message structure details. The resulting BPMN models would provide diagrams documenting OAGIS business scenarios in a widely-used notation, and an underlying file format supporting some automation.

2. Adding message structure
   BPMN message flows in the interactions above can refer to message structures from OAGIS BODs. The resulting BPMN models would link OAGIS business scenarios to message structures supporting them, and the underlying file format would support additional automation.

3. Performance
   Detail can be added enabling the BPMN models above to be carried out, either automatically (executed) or manually.

These levels represent a typical progression in using BPMN expressiveness capabilities. BPMN modelers usually start by visualizing processes in diagrams that are understandable by subject matter experts. Then these diagrams are progressively enriched to include additional information and structure, eventually producing an executable model.

3   Scoping

This section narrows the topics of Section 2.2 based on the strengths, weaknesses, opportunities, and threats involved in the project, as listed below.

- Strengths
    - BPMN diagrams are readily understandable by subject matter experts.
    - BPMN supports multiple levels of detail, enabling projects to develop models incrementally.
    - OAGIS and BPMN complement each other's strengths and weaknesses.
- Weaknesses
    - OAGIS documentation is lacking scenario details in some cases.
- Opportunities
    - OAGIS exception handling can be depicted in BPMN.
    - OAGIS parallel paths or alternative ends, depending on participant behaviors or event sources, can be depicted in BPMN.
- Threats
    - Approach might not be accepted by OAGIS users.

Sections 3.1 and 3.2 examine the weaknesses and threats involved in the study, respectively, while Section 3.3 gives a technical approach based on this analysis.

3.1   Details in OAGIS Business Scenario Documentation

OAGIS business scenarios are patterns for designing integration solutions based on the OAGIS message architecture.   The documentation for these scenarios is divided into six sections:

0. Overview
    Identifies the purpose of the scenario and where it fits within an organization's business processes.
1. Scenario Diagram
    Depicts the entities involved in the scenario, the information that flows between them, the order in which information flows occur as UML sequence diagrams, certain assumptions about the sequence of events, and about the technical approach, for example, publish and subscribe.
2. Assumptions
    Provides generic guidance on the intent and usage of the scenario.
3. Component Definition
    Lists roles and components identified in the Scenario Diagram.
4. Business Workflow (Sequence)
    Provides more information on events occurring in the workflow sequence.
5. Exception Handling
    A guide to the intent of the scenario and possible issues to consider. Does not cover all methods for handling exceptions in the scenario.

OAGIS Release 9.6 has sixty-four (64) business scenarios. Of these, twenty-nine (29) include all six sections above (0 to 5). The remaining scenarios contain the Overview (Section 0) and Scenario Diagram (Section 1) only. Table 5 in Annex A gives the level of detail for each scenario.

3.2   Acceptance by OAGIS Users

Any new modeling technique adopted for OAGIS business scenarios must be in line with the experience, expertise and capabilities of its users. An incremental approach is generally more suited to improvements in modeling languages, because users are directly affected by every change.   The BPMN diagram style chosen should be similar to the one currently used and provide a similar depth of the information.

3.3   Scope of Feasibility Study

The documentation of OAGIS business scenarios is adequate to create BPMN diagrams, because it includes drawings showing message exchange sequences (in section 1 of each scenario documentation, see Section 3.1). This reaches the first level of detail in BPMN models given in Section 2.2, which documents interactions by identifying messages, but does not specify internal message structure, or details needed to carry them out automatically.   Scoping the feasibility study to this level of detail also addresses the threat of not being accepted by OAGIS users by taking the most incremental approach, see Section 3.2. Higher levels of integration (adding message structure and performance) can be considered in future work.

4 Pre-feasibility

This section reviews BPMN diagramming capabilities in Section 4.1 to determine the most suitable BPMN interaction diagrams for modeling OAGIS business scenarios in Section 4.2.

4.1 BPMN Interaction Diagrams

BPMN interaction diagrams depict *message flows* between *participants*, including enterprises, departments, and software systems. Contrary to the name, BPMN *messages* can be informational or physical entities. BPMN interaction diagrams identify kinds of messages by name, but their internal content is assumed to be specified in some way outside of BPMN. Message flows occur at certain points during interactions, between two participants, though interactions can have more than two participants overall. BPMN has two kinds of interaction diagram for these concepts, as described in Sections 4.1.1 and 4.1.2, respectively.

4.1.1 Collaborations

Collaboration diagrams show participants as rectangles (*pools*) with a label in its own compartment, as in Figure 1. Message flows between participants are shown as dashed arrows between pools or elements within pools. The kinds of messages exchanged are indicated by labelled envelope symbols overlaid on message flow arrows. Message flows appear in an order on collaboration diagrams, but BPMN does not interpret this as specifying the sequence in which they actually occur (see Figure 3 and Section 4.1.2 for sequencing message flows). Message flows can be grouped into *conversations*, notated as hexagons with solid double lines to participants. Conversations collapse multiple related messages into one symbol to visually simplify a diagram and to identify message flows that are related to the same engineering or business purpose.
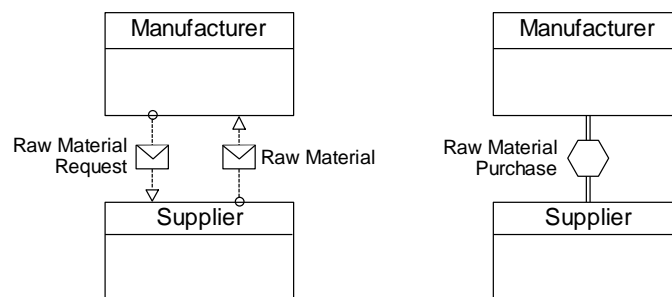

Figure 1: BPMN Collaboration Diagram

When all message flows in a collaboration diagram are collapsed under conversations, it is called a *conversation diagram*. These are useful for depicting complicated interactions, especially with more than two participants. For example, Figure 2 shows a simplified supply chain example in which the legal receiver of the goods, the Consignee, is different from the originator of the order, the Factory, and cost is reduced by including other goods in a single shipment, as arranged by a Consolidator (adapted from an example in [4]). An order is initiated in the conversation between the Factory and Supplier, while separate conversations with the Consignee are needed for legal transfer. Messages pass between the Consignee, Consolidator,

and Shipper as part of a single conversation to arrange shipment, while the Shipper agrees on a pickup location with the Supplier.
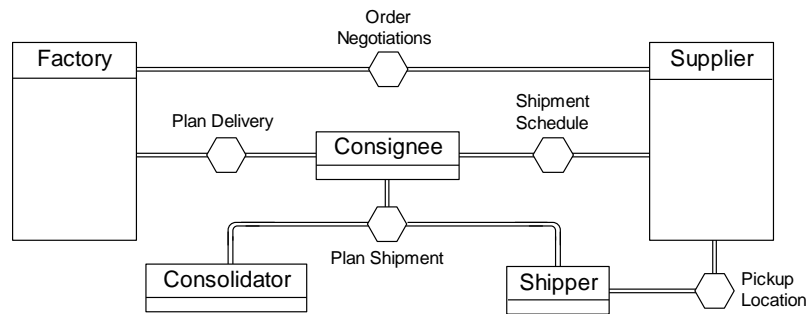

Figure 2: BPMN Collaboration with Conversations (Conversation Diagram)

To show the sequence in which message flows occur, collaboration diagrams must include *process diagrams*, to specify sequences of *activities* occurring within participants, as in Figure 3. BPMN provides send and receive activities for sending and receiving messages, which are the source and target of message flows, respectively. Arrows between activities (*sequence flows*) indicate the sequence in which activities occur. Activities shown can be limited to those that send and receive messages (*public* processes) or can include other activities only known to the participant performing them (*private* processes).
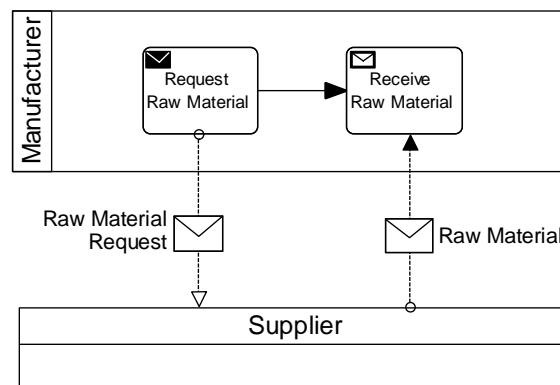

Figure 3: BPMN Collaboration Diagram with Process

4.1.2   Choreographies

Choreography diagrams depict various messages exchanges between two or more participants as rounded rectangles called *choreography activities*, as in Figure 4. This notation enables sequencing of message flows to be specified directly on their symbols, rather than through activities in process diagrams as in collaborations.
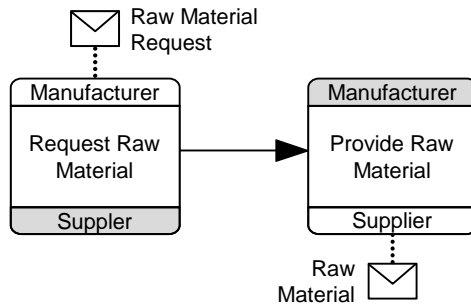
Figure 4: BPMN Choreography Diagram

4.2   BPMN interaction diagrams for OAGIS business scenarios

This section uses OAGIS Release 9.6 business scenario 47 (Full Cycle Purchasing), shown in Figure 5, as an example to determine the best kind of BPMN interaction diagram for modeling OAGIS business scenarios.   The OAGIS notation with the most detail is UML sequence diagrams, with participant names (OAGIS *components*) appearing in rectangles at the top of vertical dashed lines, and message flows (OAGIS *dialog flows*) shown as horizontal arrows in order from top to bottom, giving the order in which they occur. Message names (OAGIS BOD names, which follow a verb-noun convention) appear as labels on message flows. This paper uses BPMN terminology for interactions, sometimes with OAGIS terminology noted when referring to OAGIS business scenarios (UML interaction terminology is not used). Table 2 gives the translation between BPMN and OAGIS terminology.
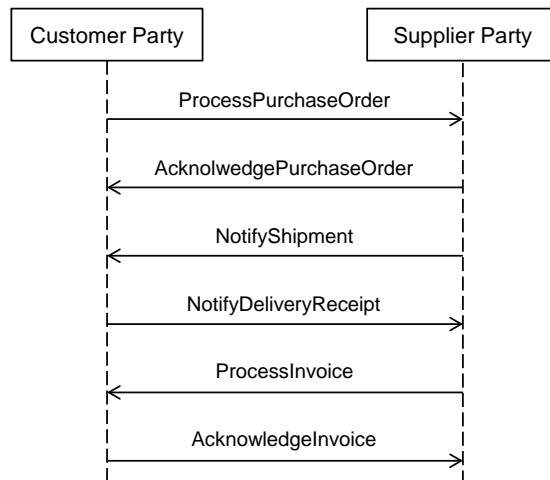

Figure 5: OAGIS Business Scenario Diagram (47, Full Cycle Purchasing)

BPMN	OAGIS
Interaction	Business scenario
Participant	Component
Message flow	Dialog flow
Message	Business Object Document (BOD)

Table 2: BPMN/OAGIS Terminology Mapping

Below are the various kinds of BPMN interaction diagrams applied to scenario 47 from Figure 5. Names of BPMN activities and messages are taken from OAGIS BOD names, which follow a verb-noun convention. Figure 6 shows a collaboration diagram, which appears to be similar to the OAGIS depiction, but the horizontal arrangement of messages is only an aspect of the drawing and in BPMN is not interpreted as the sequence in which message flows occur. Figure 7 groups message flows into request-reply conversations, but in BPMN this grouping is not interpreted as specifying sequencing of message flows.
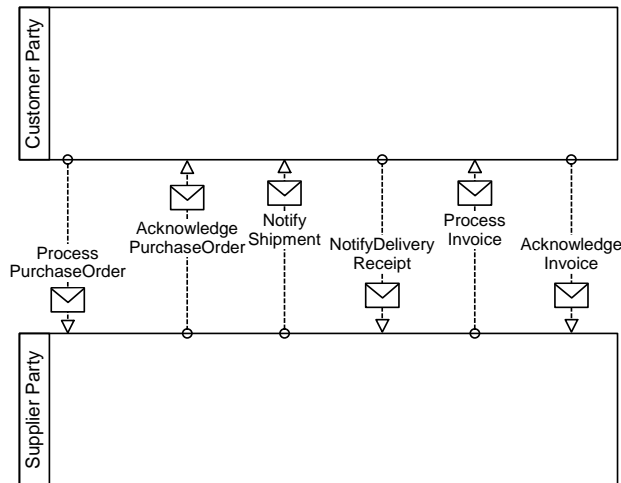
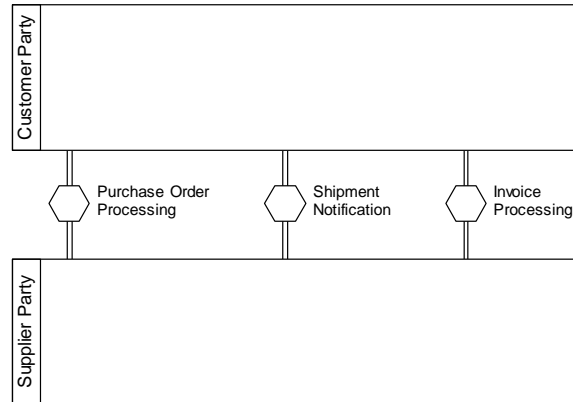**Figure 6: BPMN Collaboration Diagram for OAGIS Scenario 47**

Figure 7: BPMN Collaboration diagram with conversations (conversation diagram) for OAGIS Scenario 47

Figure 8 and Figure 9 show collaborations with participant public and private processes, respectively, with Figure 9 dividing activities into *lanes*. These figures specify sequencing of message flows through the sequencing of send and receive activities. Not all scenarios have this level of detail in their documentation, see Section 3.1.
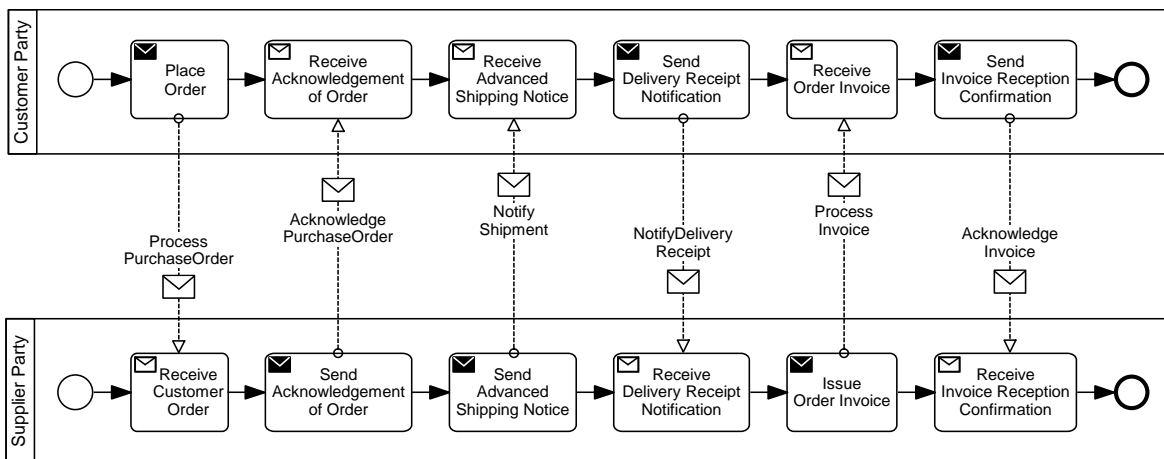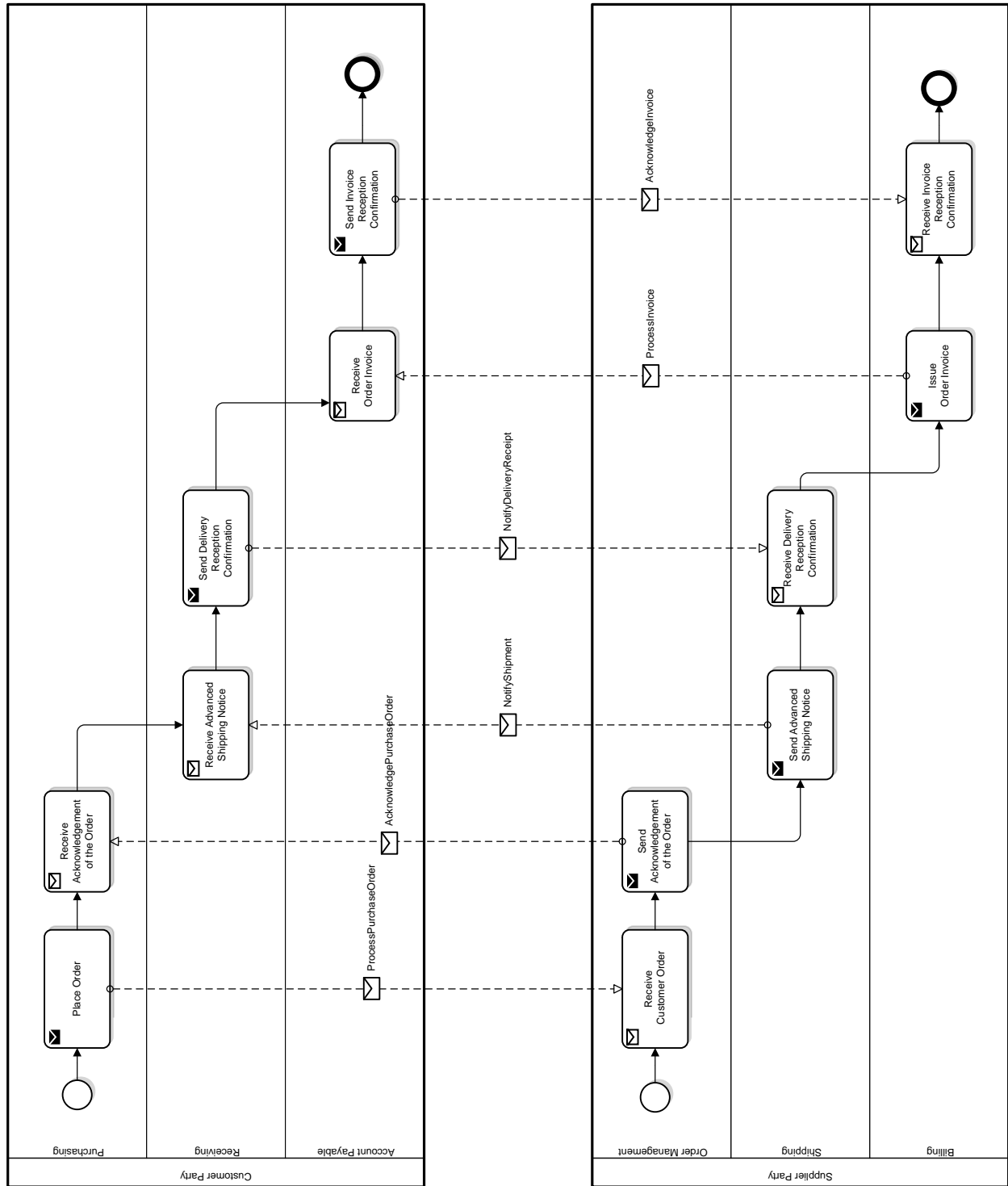

Figure 8: BPMN Collaboration Diagram with PUBLIC Processes for OAGIS Scenario 47
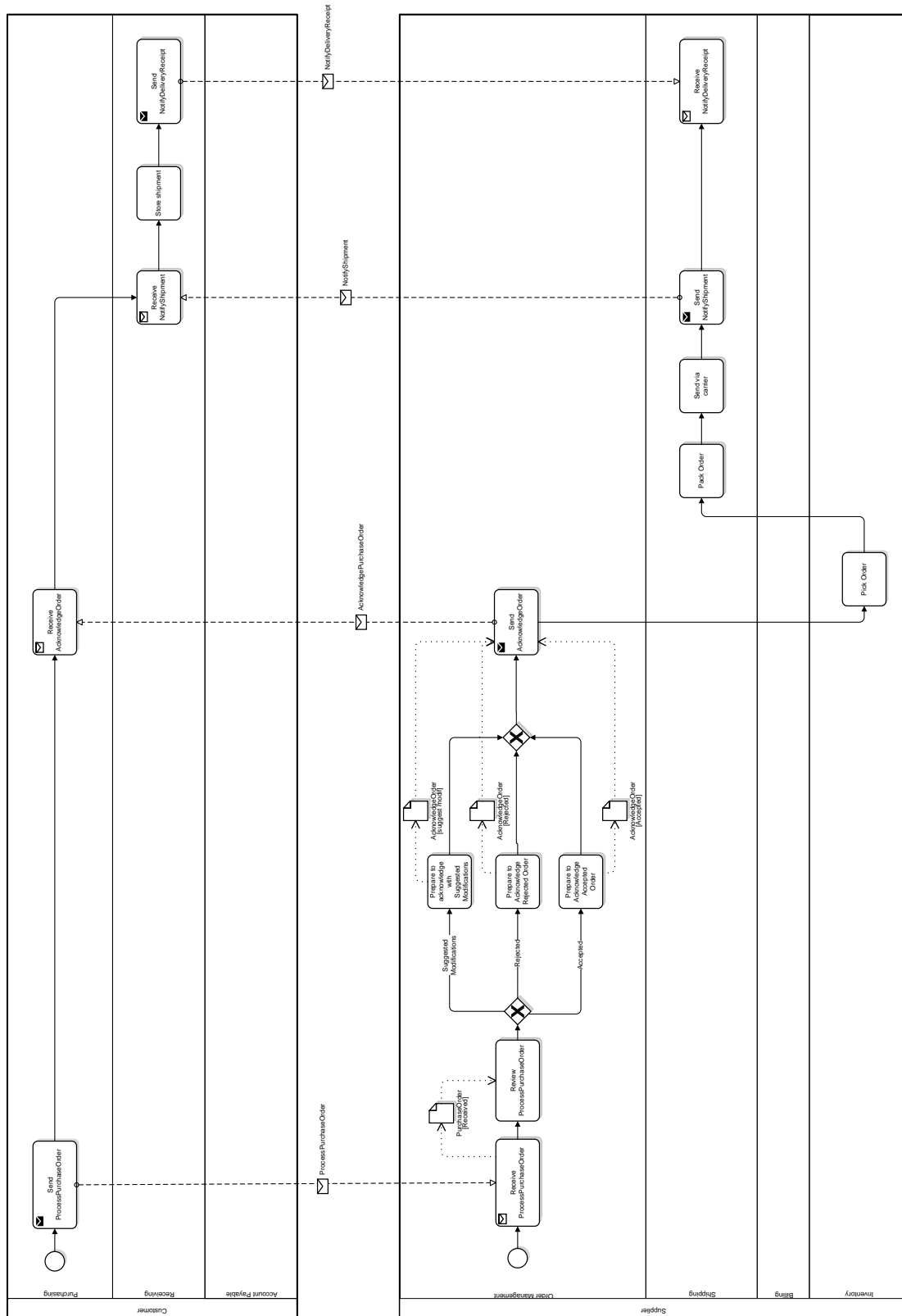
Figure 9: BPMN Collaboration Diagrams with Private Activity Processes for OAGIS Scenario 47

Figure 10 shows a choreography diagram, which provides explicit sequencing of message flows, separated from participant processes, making it more difficult for subject matter experts to understand. Choreography diagrams are usually more difficult for subject matter experts to grasp, because they omit activities of the participants, which are ultimately needed to perform choreographies. Figure 11 combines collaboration and choreography, providing a precise but complex depiction of the scenario. Many information elements are duplicated, making the diagram difficult to read for subject matter experts.
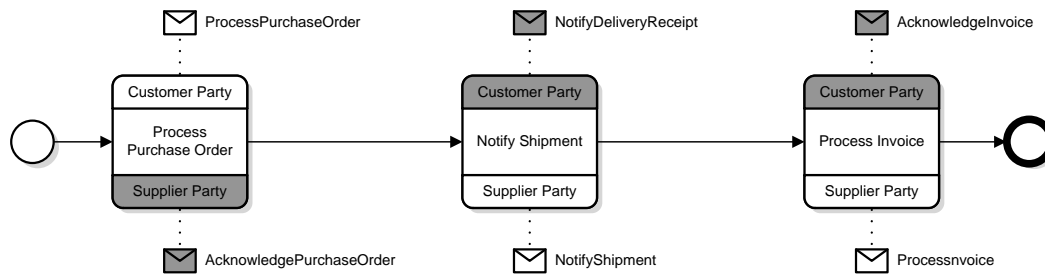
Figure 10: BPMN Choreography Diagram for OAGIS Scenario 47
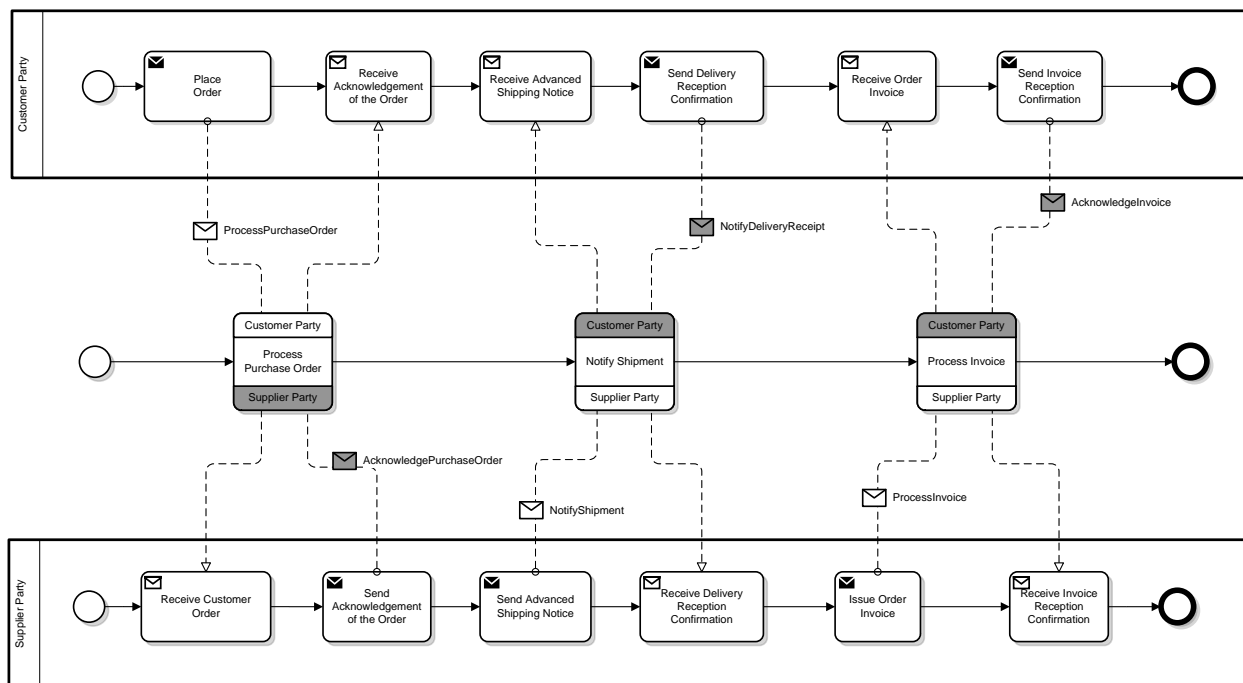
Figure 11: Combined BPMN Choreography and Collaboration Diagram for OAGIS Scenario 47

Table 3 summarizes the analysis above. When processes are included in collaborations, their capabilities are equivalent to choreographies, and they are more easily understood by subject matter experts, because processes can be shown in participant pools to make the interaction more concrete. Based on this analysis, the rest of the paper will use BPMN collaboration diagrams with public processes.

	Collaboration	Choreography
Participants, Messages, Message Flow	✓	✓ (message flow shown as activities)
Sequencing Message Flow	(through processes in participants, if shown)	✓
Grouping Message Flow	✓ (conversations)	✓
Processes in Participants	✓ (unless only showing conversations)	
Concrete enough for subject matter experts	✓	

Table 3: Summary Comparison of BPMN Collaboration and Choreography Capabilities

5   Feasibility

This section provides a procedure to create BPMN collaboration diagrams with public processes for OAGIS business scenarios, and uses it on an example to determine the feasibility of integrating OAGIS and BPMN (see Section 4 about BPMN interaction diagrams for OAGIS scenarios).   Each step is applied to OAGIS business scenario 47 (Full Cycle Purchasing), see Figure 5 in Section 4.2). The information used in each step is from the OAGIS business scenario description and diagram (sections 0 and 1 of the OAGIS scenario documentation, respectively, see Section 3.1), unless otherwise noted.

5.1   Step 1: Identify Participants

Identify interaction participants:

- An OAGIS business scenario description typically specifies participants (OAGIS components, see Section 4.2) using terms like company, partner, and organization. Scenario descriptions usually specify unique names for participants that are the only ones of their kind in a scenario. Scenarios that have multiple participants of the same kind might introduce unique role names for each participant indicating an engineering or business function it provides.
- Participants are notated in OAGIS business scenario diagrams as yellow rectangles at the top of the scenario diagram with labels inside them. They are also listed in section 3 (Component Definition) of OAGIS scenario documentation, and their names are used in sections 0 (Overview) and 4 (Business Workflow, see Section 3.1).

Participant names in BPMN diagrams will be the same as component names in OAGIS scenario diagrams. The resulting BPMN collaboration diagram for scenario 47 is shown in Figure 12. Participant rectangles (pools) can be oriented horizontally or vertically. Pools will be horizontal in this paper.
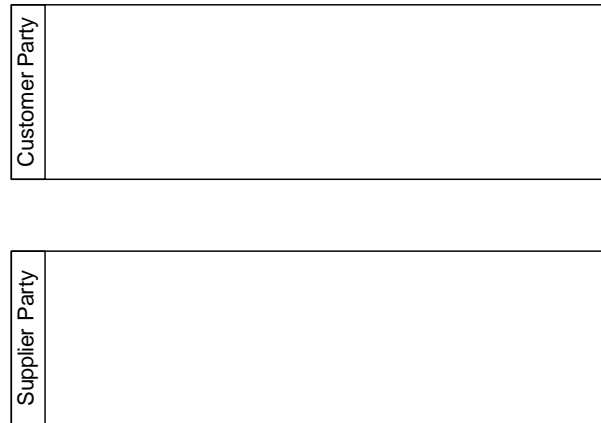

Figure 12: BPMN Participants for OAGIS Scenario 47

5.2 Step 2: Identify Message Flows and Messages

Identify message flows and messages:

- Message flows (OAGIS dialog flows, see Section 4.2) are notated in scenario diagrams as arrows between source and the target participants.
- Message names (OAGIS BODs, see Section 4.2) appear as labels on dialog flow arrows in scenario diagrams, and follow a verb-noun convention. They are also listed in section 4 (Business WorkFlow) of OAGIS scenario documentation, see Section 3.1. Many scenarios describe the context, purpose, and usage of their BODs.
- Multiple scenario diagrams sometimes use the same message (OAGIS BOD), which means the same kind of information flows between participants in multiple scenarios, though the exact content is usually different in each one. See Annex B for an index of message reuse in OAGIS interactions.
- The sequence in which message flows (OAGIS dialog flows) occur is specified in OAGIS scenario diagrams by the order of horizontal arrows from top to bottom. Sequencing is also specified in more detail in section 4 (Business Workflow) of OAGIS scenario documentation and summarized in section 0 (Overview), see Section 3.1. Scenario diagrams as they are currently defined have no alternative or failure sequences, even if these are described in other parts of OAGIS documentation.

Source and targets of message flows in BPMN diagrams at this stage will be participants corresponding to those of OAGIS message flows (dialog flows).[1,2] Messages in BPMN diagrams

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[1] A tool for checking the use of OAGIS BODs within BPMN diagrams is described in Annex C.

will have the same name as the corresponding messages (BODs) in OAGIS scenarios. BPMN message flows should reuse messages in the same way as (dialog flows) in OAGIS scenarios. Message flows in BPMN diagrams will be in the same order (left to right) as those (dialog flows) in OAGIS scenarios diagrams (top to bottom), even though BPMN does not interpret the visual order as sequencing in BPMN collaborations (see Section 5.4 for sequencing). The resulting BPMN collaboration diagram for scenario 47 is shown in Figure 13.
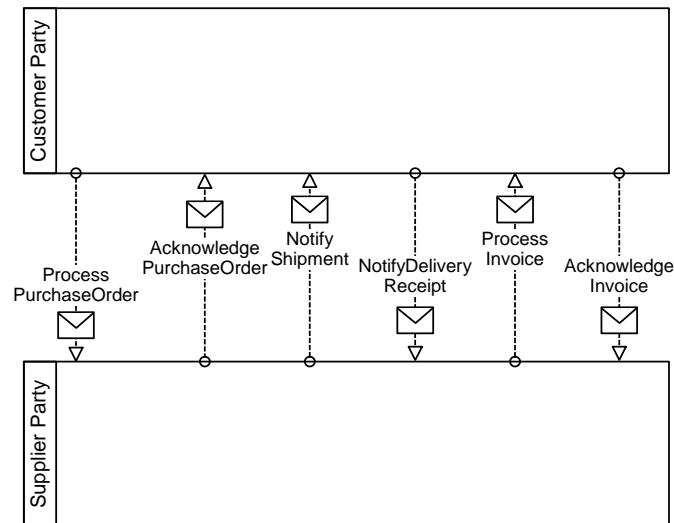

Figure 13: BPMN Messages and Message Flows for OAGIS Scenario 47

5.3   Step 3: Choose Activity Names

BPMN activities with sequence flows between them will be added in the BPMN diagrams of Section 5.4 to specify the sequence in which messages flow. These activities will be sources and targets of message flows and be performed by source and target participants, building on message flows and participants from Section 5.2. These activities are not present in OAGIS scenario diagrams. To prepare for Section 5.4, activity names must be chosen that align with OAGIS scenario terminology. This paper uses verb-noun names, which section 4 (Business Workflow) of OAGIS scenario documentation (see Section 3.1) sometimes implicitly suggest, otherwise, the generic verbs "send" and "receive" can be used with the name of the message (BOD) being sent or received.

When activity names are different from message names, it is useful to build a table of which activities are associated with which messages, as in the activities for scenario 47 in Table 4, which uses names suggested by OAGIS scenario documentation. For example, section 4 of scenario 47 documentation says "Once the order is packed, an Advanced Shipping Notice is sent to the Buyer via the NotifyShipment BOD." This suggests activity names for sending and receiving these notices ("Send Advanced Shipping Notice" and "Receive Advanced Shipping Notice" respectively). Activity names should be the same for each message (BOD) in all BPMN

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[2] Additional message flows are needed to exchange some OAGIS BODs, see Annex D, but these are not addressed in the rest of this paper.

diagrams where the message is used, see Section 5.2. For example the NotifyShipment message sent and received by Advanced Shipping Notice activities is also used in OAGIS scenarios 44, 46, 53, 54, 55, 58, 59, 60, 61, 62, 63, see Annex B. BPMN diagrams for these scenarios should also use the send and receive Advanced Shipping Notice activities to send and receive NotifyShipment messages.

Activity names	Message name
Place Order / Receive Customer Order	ProcessPurchaseOrder
Send / Receive Acknowledgement of Order	AcknowledgePurchaseOrder
Send / Receive Advanced Shipping Notice	NotifyShipment
Send / Receive Delivery Receipt Notification	NotifyDeliveryReceipt
Issue / Receive Order Invoice	ProcessInvoice
Send / Receive Invoice Reception Confirmation	AcknowledgeInvoice

Table 4: Linking BPMN Activity Names to OAGIS Message (BOD) Names for OAGIS Scenario 47

5.4   Step 4: Assemble the BPMN Diagram with Processes

The results of Sections 5.2 and 5.3 are combined to produce a BPMN diagram with public processes in participants. The activities of Section 5.3 are placed in the participants of the BPMN diagram from Section 5.2 above or below message flows for messages (OAGIS BODs) corresponding to the activities. Send activities are placed at the source of message flows and receive activities at the targets.   BPMN start and end events are added at the left and right of the diagram, respectively. Finally, BPMN sequence flows are added between adjacent events and activities from left to right, to ensure message flows occur in the same order as in the OAGIS scenario. The resulting BPMN diagram is shown in Figure 14.
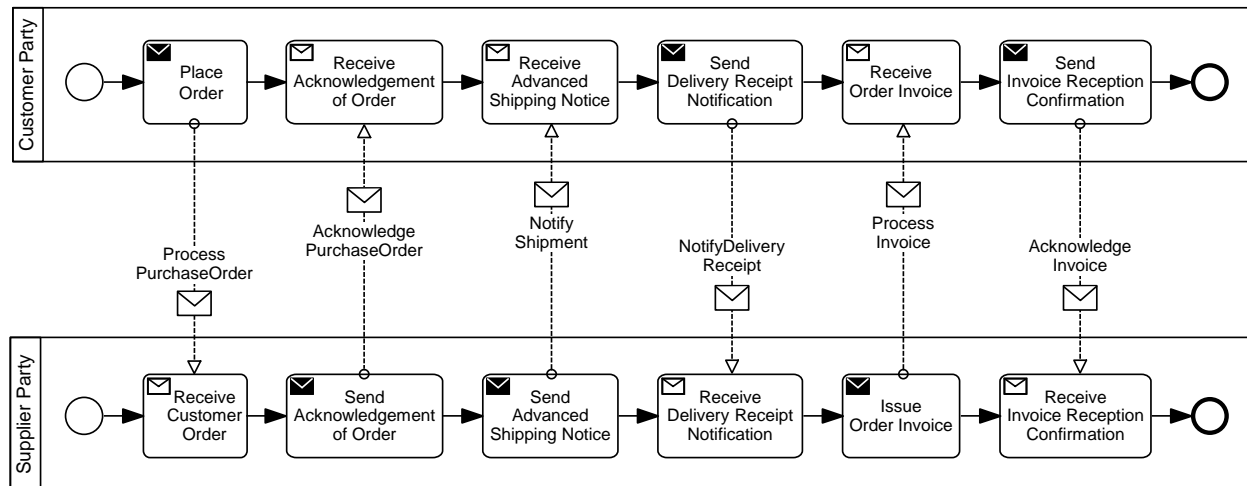
Figure 14: BPMN Collaboration Diagram with Messages, Message Flows, and Process Activities for OAGIS Scenario 47

6   Summary

This paper describes a study into the feasibility of integrating OAGIS and BPMN, as a contribution to integrating engineering and enterprise processes in general. These standards are complementary because OAGIS provides enterprise interaction content for a wide range of engineering processes, while the BPMN defines a commonly understood diagrammatic notation for enterprise interactions (see Section 2).   OAGIS and BPMN interactions are compared and three levels of integration are identified: interactions only, adding message structure, and performance (see Section 3). The paper addresses the first level of integration (interactions only), based on the amount of information available in OAGIS documentation and acceptance by users. The kinds of BPMN interaction diagrams are reviewed and evaluated for application to OAGIS using a representative example. A particular kind of BPMN diagram that shows enterprise interactions via portions of processes inside the enterprises is selected as best suited for the purpose (see Section 4). The chosen kind of BPMN diagram is used in a suggested procedure for application to OAGIS, which is validated against a representative example (see Section 5) to show its feasibility. Additional results of this study are provided for future work, including levels of documentation detail in OAGIS interactions in Annex A, an index of OAGIS messages (BODs) used in OAGIS interactions in Annex B, description of a conformance testing tool for OAGIS interactions specified in BPMN in Annex C, example OAGIS message flows needed for performance in Annex D, and suggested changes to OAGIS 9.6 in Annex E.

Acknowledgements

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Commercial equipment and materials might be identified to adequately specify certain procedures. In no case does such identification imply recommendation or endorsement by the U.S. National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

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A. OAGIS Business Scenario Content

Table 5 gives the level of detail in OAGIS business scenario documentation, see Section 3.1.

Scenarios with content in Sections 0 to 5	Scenarios with content in Sections 0 and 1 exclusively
1 General Ledger to Sub Ledger	2 General Ledger to Budget
34 Engineering Change Scenario	3 Order Management to Accounts Receivable
35 ERP to Finite Scheduling and MES	4 Order Management to Credit Management to Accounts Receivable
37 Catalog and Price List Exchange	5 Order Management to Accounts Receivable and General Ledger
38 Unit of Measure Exchange	6 Order Management with Billing to Accounts Receivable
39 Request for Quote and Quote Exchange	7 Purchasing to Accounts Payable to General Ledger
40 Request for Quote and Quote Exchange - Through an Intermediary	8 Purchasing to Accounts Payable to General Ledger Posting from Purchasing
41 Forecast Exchange - Update	9 Project Accounting Synchronization
42 Production to Manufacturing Execution System	10 Feeder Applications to Project Accounting
43 Production to standalone MES	11 Human Resources to Manufacturing
44 Supply Chain Execution	12 Basic Purchase Order Process
45 Sub Ledgers to General Ledger - GL Actuals	13 Plant Data Collection / Warehouse Management/Cycle Counts
46 Vendor Managed Inventory	14 Plant Data Collection / Warehouse Management / Issues
47 Full Cycle Purchasing	15 Plant Data Collection / Warehouse Management / Transfers
48 Sales Lead	16 Plant Data Collection / Warehouse Management / Receipts
49 Sales Opportunity	17 Plant Data Collection / Warehouse Management / Production Orders
50 Product Data Management Collaboration	18 Plant Data Collection Work In Process
51 Location Services	19 Plant Data Collection / Warehouse Management / Shipping
53 Inventory Visibility	20 Plant Data Collection / Warehouse Management / Time and Attendance
54 Mid-Market Order to Cash Procure to Pay	21 Manufacturing to Purchasing
55 High Tech Procure to Pay	22 Manufacturing with Available to Promise to Order Management
56 High Tech Invoicing	23 Manufacturing to Order Management Financials with Manufacturing for Engineer to Order and Configure to Order
57 High Tech Forecasting	24 Invoice Matching, Matching in Purchasing, Invoices entered in Purchasing
58 Metals Industry Order to Cash Procure to Pay	25 Invoice Matching, Matching in Accounts Payable
59 High Tech Logistics - Direct Ship Model	26 Synchronize Sales Orders for Shipping
60 High Tech Logistics - Standard VMI With Outsourced - Customer Agent	27 Sales Force Automation to Order Management, Updating Orders
61 High Tech Logistics - Customer Operated Hub	28 Sales Force Automation to Order Management, Inquiry of Orders
62 High Tech Logistics - Dynamic VMI - Supplier Operated	29 Sales Force Automation to Order Management and Shipping
63 High Tech Logistics - Dynamic VMI With Outsourced Supplier Agent	30 Supply Chain Integration
	31 Customer Service Integration, Field Service, No Returns

Scenarios with content in Sections 0 to 5	Scenarios with content in Sections 0 and 1 exclusively
	32 Human Resources Integration to Manufacturing
	33 Human Resources to Time Data Collection
	36 Maintenance to Field Devices
	52 Sarbanes Oxley Data Exchange
	64 Item Non conformance[3]

Table 5: OAGIS Business Scenario Content Summary

B. Bod Reuse Matrix

Table 6 gives OAGIS business scenarios (by number) that use each OAGIS BOD, see Section 5.2.

BOD	Scenarios	BOD	Scenarios
AcknowledgeAllocateResource	42,43	ProcessOpportunity	49
AcknowledgeEngineeringWork Document	50	ProcessPlanningSchedule	57,60,61, 62,63
AcknowledgeInvoice	47,54,56, 58,59,60,61,62,63	ProcessProductionOrder	17,23,43
AcknowledgeIssueInventory	42,43	ProcessPurchaseOrder	12,30,47, 54,55,58, 59,60,62, 63
AcknowledgeJournalEntry	1	ProcessQuote	39,40
AcknowledgeMaintenanceOrder	36	ProcessReceiveDelivery	16,44
AcknowledgeMatchDocument	25	ProcessRecoverWIP	43
AcknowledgeMergeWIP	43	ProcessRequisition	21
AcknowledgeMoveInventory	15,31	ProcessRFQ	39,40
AcknowledgeMoveWIP	43	ProcessRiskControlLibrary	52
AcknowledgeOpportunity	49	ProcessSalesLead	48
AcknowledgePickList	31	ProcessSalesOrder	27,29,31, 42,43
AcknowledgePlanningSchedule	57,60,61, 62,63	ProcessShipment	59,61,62, 63
AcknowledgeProductionOrder	17,23,43	ProcessSplitWIP	43
AcknowledgePurchaseOrder	12,30,47, 54,55,58, 59,60,62, 63	RespondConfirmWIP	18
AcknowledgeQuote	39,40	RespondConfirmWIP	43
AcknowledgeReceiveDelivery	16,44,46	RespondCredit	3,4
AcknowledgeRecoverWIP	43	RespondCreditStatus	3,4
AcknowledgeRequisition	21	RespondEmployeeWorkTime	11,20,33
AcknowledgeRFQ	39,40	RespondInspectDelivery	21

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[3] Scenario 64 also includes Section 2 (Assumptions).

AcknowledgeRiskControlLibrary	52		RespondInventoryCount	13
AcknowledgeSalesLead	48		RespondIssueInventory	35
AcknowledgeSalesOrder	27,29,42, 43		RespondMaintenanceOrder	36
AcknowledgeShipment	59,61,62, 63		RespondPickList	19,30
AcknowledgeSplitWIP	43		RespondProductAvailability	22
CancelMaintenanceOrder	36		RespondPurchaseOrder	55,58
CancelPurchaseOrder	55,58		RespondQuote	39,40
CancelQuote	39		RespondReceiveDelivery	21
CancelRFQ	39		RespondRequisition	21
CancelSalesOrder	27,29		RespondRFQ	39,40
ChangeCreditStatus	3,4		RespondSalesLead	48
ChangeOpportunity	49		RespondSalesOrder	27,29
ChangePurchaseOrder	55,58		RespondWipConfirm	35
ChangeQuote	39,40		ShowActualLedger	45
ChangeRequisition	21		ShowConfirmWIP	18
ChangeRFQ	39,40		ShowCredit	3
ChangeSalesLead	48		ShowEngineeringChangeOrder	34
ChangeSalesOrder	27,29		ShowEngineeringWork Document	50
ConfirmBOD	1,2,5,6,7, 8,11,22,23,24 ,25,26,27,29, 31, 32,34,36, 37,38,39, 41,42,43, 44,45,46, 49,50,53, 55,58		ShowInventoryConsumption	46
GetActualLedger	45		ShowInventoryCount	13
GetConfirmWIP	18		ShowIssueInventory	14
GetCredit	3		ShowItemNonconformance	6
GetEngineeringChangeOrder	34		ShowLocationService	51
GetEngineeringWorkDocument	50		ShowMaintenanceOrder	36
GetInventoryConsumption	46		ShowOpportunity	49
GetInventoryCount	13		ShowPersonnel	11,20,33
GetIssueInventory	14		ShowPickList	19
GetLocationService	51		ShowProductAvailability	22
GetMaintenanceOrder	36		ShowProductionOrder	17
GetOpportunity	49		ShowPurchaseOrder	16,21
GetPersonnel	11,20,33		ShowQuote	39,40
GetPickList	19		ShowRFQ	39,40
GetProductAvailability	22		ShowRiskControlLibrary	52

GetProductionOrder	17	ShowSalesLead	48
GetPurchaseOrder	16,21	ShowSalesOrder	28
GetQuote	39,40	ShowUnitOfMeasureGroup	38
GetRFQ	39,40	ShowWipStatus	42,43
GetRiskControlLibrary	52	SyncBOM	23,34,35, 42,43
GetSalesLead	48	SyncCatalog	37
GetSalesOrder	28	SyncChartOfAccounts	1,2
GetUnitOfMeasureGroup	38	SyncCustomerPartyMaster	31
GetWipStatus	42	SyncDispatchList	35
LoadBudgetLedger	2	SyncEmployeeWorkSchedule	11,31,32
LoadInvoiceLedgerEntry	24	SyncEngineeringChangeOrder	34
LoadMatchDocument	25	SyncEngineeringWorkDocument	50
LoadPayable	7,8,24	SyncField	11,32
LoadProjectAccounting	10	SyncField Unit ofMeasure Codes	38
LoadReceivable	5,6,23,30,31	SyncInventoryBalance	22,23
NotifyCommercialInvoice	59,61,62, 63	SyncInventoryBalance	46,53
NotifyDeliveryReceipt	47	SyncItemMaster	22,23,31, 35,37,38, 43
NotifyExportDeclaration	59,61,62, 63	SyncPartyMaster	24,25
NotifyHazardousMaterial ShipmentDocument	59,61,62, 63	SyncPersonnel	11,31,32
NotifyInspectDelivery	21	SyncPlanningSchedule	44
NotifyInventoryBalance	60,62,63	SyncPlanningSchedule (Schedule type=Demand)	41
NotifyInvoiceRemittance	56	SyncPlanningSchedule (Schedule type=Supply)	41
NotifyIssueInventory	14	SyncPriceList	37
NotifyPlanningSchedule	57	SyncProductionOrder	42,43
NotifyPurchaseOrder	21,61	SyncProjectMaster	9
NotifyReceiveDelivery	21,31,53, 54,55,59, 60,61,62, 63	SyncPurchaseOrder	30,35
NotifyRemittanceAdvice	59,60,61, 62,63	SyncRouting	34,35,42, 43
NotifyShipment	44,46,47, 53,54,55, 58,59,60, 61,62,63	SyncSalesOrder	26,29,30, 31
NotifyShipmentUnit	59,60,61, 62,63	SyncSequenceSchedule	44
NotifyShipperLettersOff Instruction	59,61,62, 63	SyncSequenceSchedule (Schedule type=Demand)	41
PostJournal	23,30,31	SyncSequenceSchedule (Schedule type=Supply)	41
PostJournalEntry	1,5,6,7,8, 11,24,25,45	SyncShipmentSchedule	44

Process Picklist	31		SyncShipmentSchedule (Schedule type=Demand)	41
ProcessAllocateResource	42,43		SyncShipmentSchedule (Schedule type=Supply)	41
ProcessEngineeringChangeOrder	34,6		SyncUnitOfMeasureGroup	38
ProcessEngineeringWork Document	50		UpdateConfirmWIP	18
ProcessInvoice	25		UpdateConfirmWIP	43
ProcessInvoice	47,54,56, 58,59,60, 61,62,63		UpdateCredit	3,4
ProcessIssueInventory	42,43		UpdateEmployeeWorkTime	11,20,33
ProcessItemNonconformance (Engineering Action requested)	6		UpdateInspectDelivery	21
ProcessItemNonconformance (Notification)	6		UpdateInventoryCount	13
ProcessItemNonconformance (Supplier Defect detected)	6		UpdateIssueInventory	35
ProcessMaintenanceOrder	36		UpdateMaintenanceOrder	36
ProcessMatchDocument	25		UpdatePickList	19,30
ProcessMergeWIP	43		UpdateProductAvailability	22
ProcessMoveInventory	15,31		UpdateReceiveDelivery	21
ProcessMoveWIP	43		UpdateWipConfirm	35

Table 6: OAGIS BOD Reuse in Business Scenarios

C. Conformance Testing for OAGIS Business Scenarios in BPMN

A key success factor for integrating engineering information and enterprise processes is customer-driven conformance assurance for standards individually, and for their integration. This will enable tool vendors and customers to verify compliance of tools without the overhead of official designations from standards bodies or other organizations, though these organizations can use the services to establish designations if desired. Customer-driven conformance assurance leverages the movement towards service-oriented architectures and cloud computing, where the services are available on the web through widely supported protocols.

A web-based, open source tool is available to test conformance of BPMN models containing messages, data objects, and data stores referencing OAGIS BODs [5]. It checks whether BPMN messages, data objects and data stores used in BPMN 2.0 interchange files are referencing elements in the OAGIS 9.6 namespace. BPMN messages are checked against OAGIS BODs, see Section 5.2, while data objects and data stores are checked against OAGIS nouns. A message defined using a noun, or a data store/object defined using a BOD will generate a validation error. Validation warnings are given for messages, data stores/objects that are undefined (not pointing to BPMN item definitions) or that are not defined in the OAGIS namespace. Example test files are available in the source of this tool.

D. Example Message Flows for Performing Interactions

To carry out interactions, participants typically perform more steps (BPMN activities) than defined by the procedure in Section 5.3. That procedure does not consider the exact content of messages. When message content (BOD attributes) is taken into account, participants sometimes require additional activities to carry out interactions, which might send or receive messages. These additional activities and message flows are presented in the subannexes below, using OAGIS scenario 58 (Metals Industry Order to Cash Procure) as an example of patterns found in multiple scenarios. The BPMN collaboration diagram for scenario 58 resulting from the procedure in Section 5 is presented, followed by a more detailed BPMN diagram capturing additional aspects of the scenario and BODs in OAGIS documentation. These patterns could be a topic for future investigation into adding message structure and performance, see Section 2.2.

D.1. Acknowledge or Respond

A common interaction pattern in OAGIS business scenarios is for a participant to send a request to another, who responds by acknowledging receipt with an indication of whether the request will be fulfilled or not (accepted or rejected). An example of this pattern (Acknowledge or Respond) is shown in Figure 15, with the message flows involved circled in an OAGIS business scenario on the left and a partial BPMN translation on the right. The request is made with a ProcessPurchaseOrder BOD and the response with an AcknowledgePurchaseOrder BOD, documented in OAGIS as "communicate the acceptance or rejection of the PurchaseOrder from the SupplierParty." Both diagrams hide steps internal to the participants, for example, determining whether to accept or reject the request and what to do when a request is accepted or rejected.
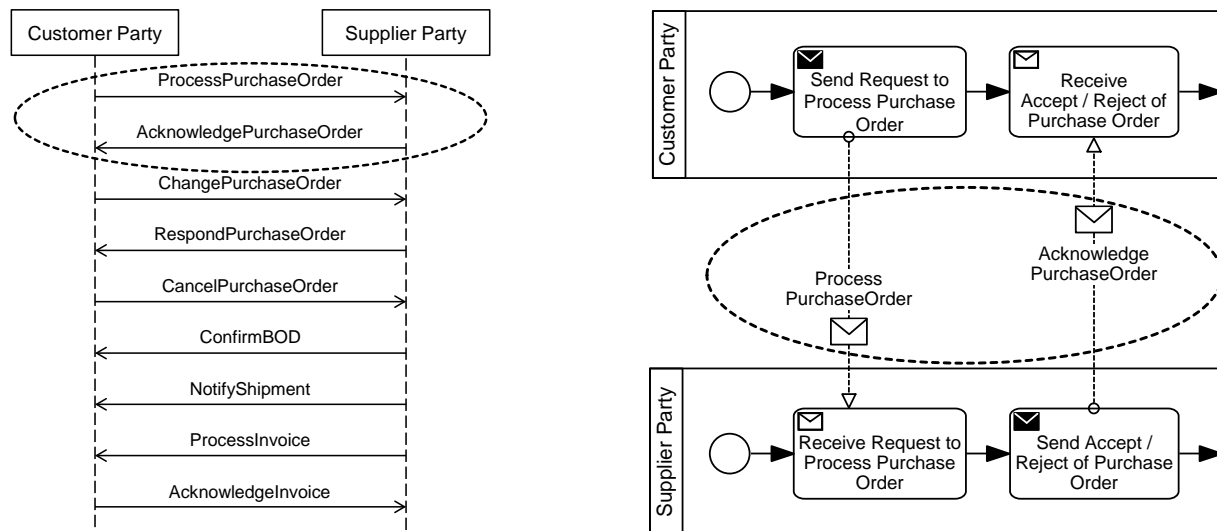

Figure 15: Acknowledge Interaction Example

Figure 16 shows a general Acknowledge or Respond pattern in BPMN, including additional aspects of participant processes that are not visible to other participants. In particular, the activities for sending and receiving acknowledgement are broken up according to whether the message (BOD) indicates acceptance or rejection of the request. This introduces another message flow that is not in Figure 15, reflecting more accurately the notion of acceptance or rejection described in OAGIS documentation.
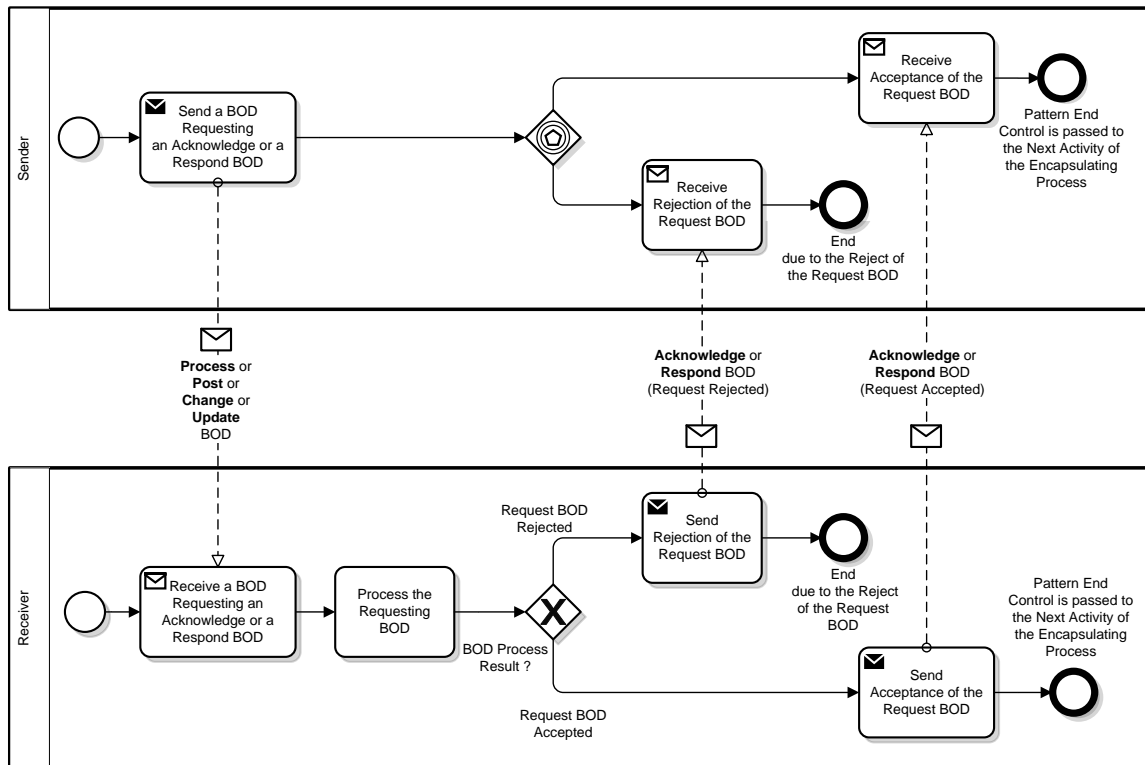
Figure 16: Acknowledge or Respond Interaction Pattern

D.2. Confirm

Another pattern for replying to requests gives the results of processing using ConfirmBOD, a general OAGIS message indicating success, warning, or error. More specific versions of ConfirmBOD can be used in some cases, depending on the verb of the request. Table 7 gives ConfirmBODs for responding to request with various verbs. Some of these are specialized with names constructed from the noun portion of the request message, while some are just the general ConfirmBOD. Requests can require that a general ConfirmBOD should be sent in reply instead of a specialized one, even for requests that have specialized ConfirmBODs. Requests must give a ConfirmationCode that specifies when a ConfirmBOD is to be returned, with possible values "Always", "OnError", or "Never", indicating a confirmation should always be sent, sent only on error, or never sent, respectively.

Request	Confirmation
Post[noun] (synonym for Process in financial scenarios)	Acknowledge[noun]
Process[noun]	Acknowledge[noun]
Cancel[noun]	ConfirmBOD
Load[noun] (synonym for Sync in financial scenarios)	ConfirmBOD
Notifiy[noun]	ConfirmBOD
Sync[noun]	ConfirmBOD
Change[noun]	Respond[noun]
Update[noun]	Respond[noun]
Get[noun]	Show[noun]
Acknowledge[noun]	ConfirmBOD
Respond[noun]	ConfirmBOD
Show[noun]	ConfirmBOD

Table 7: Mapping between OAGIS Request and Reply messages

An example of this pattern (Confirm) is shown in Figure 17, with the message flows involved circled in an OAGIS business scenario on the left and a partial BPMN translation on the right. The request is made with a CancelPurchaseOrder BOD and the response with a ConfirmBOD. Figure 18 shows a general Confirmation pattern in BPMN, including additional aspects of participant processes that are not visible to other participants. For example, the activities for sending and receiving confirmation are broken up according to whether the message (BOD) indicates an error in processing the request. This introduces another message flow that is not in Figure 17, reflecting more accurately the notion of confirmation described in OAGIS documentation.
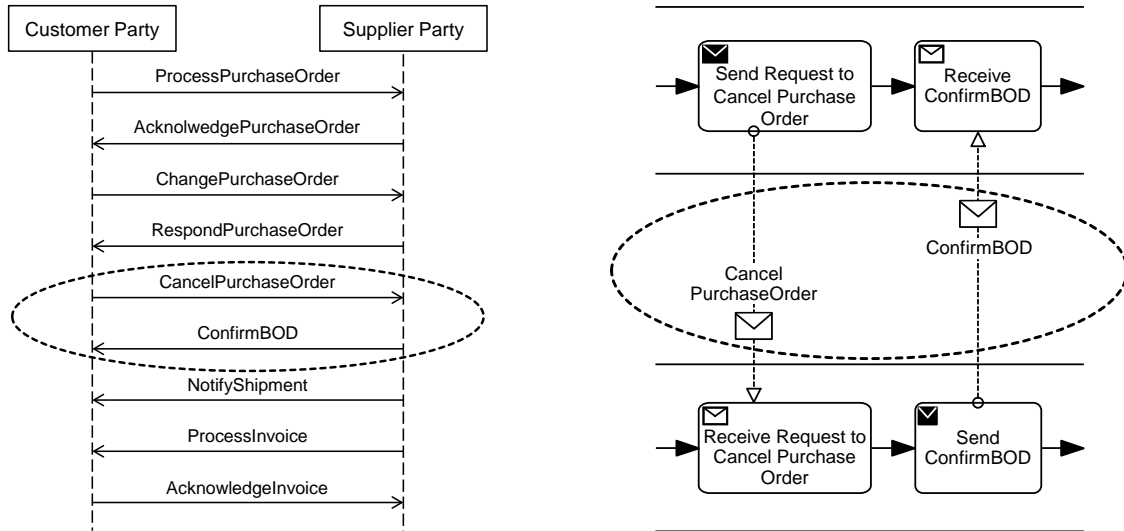
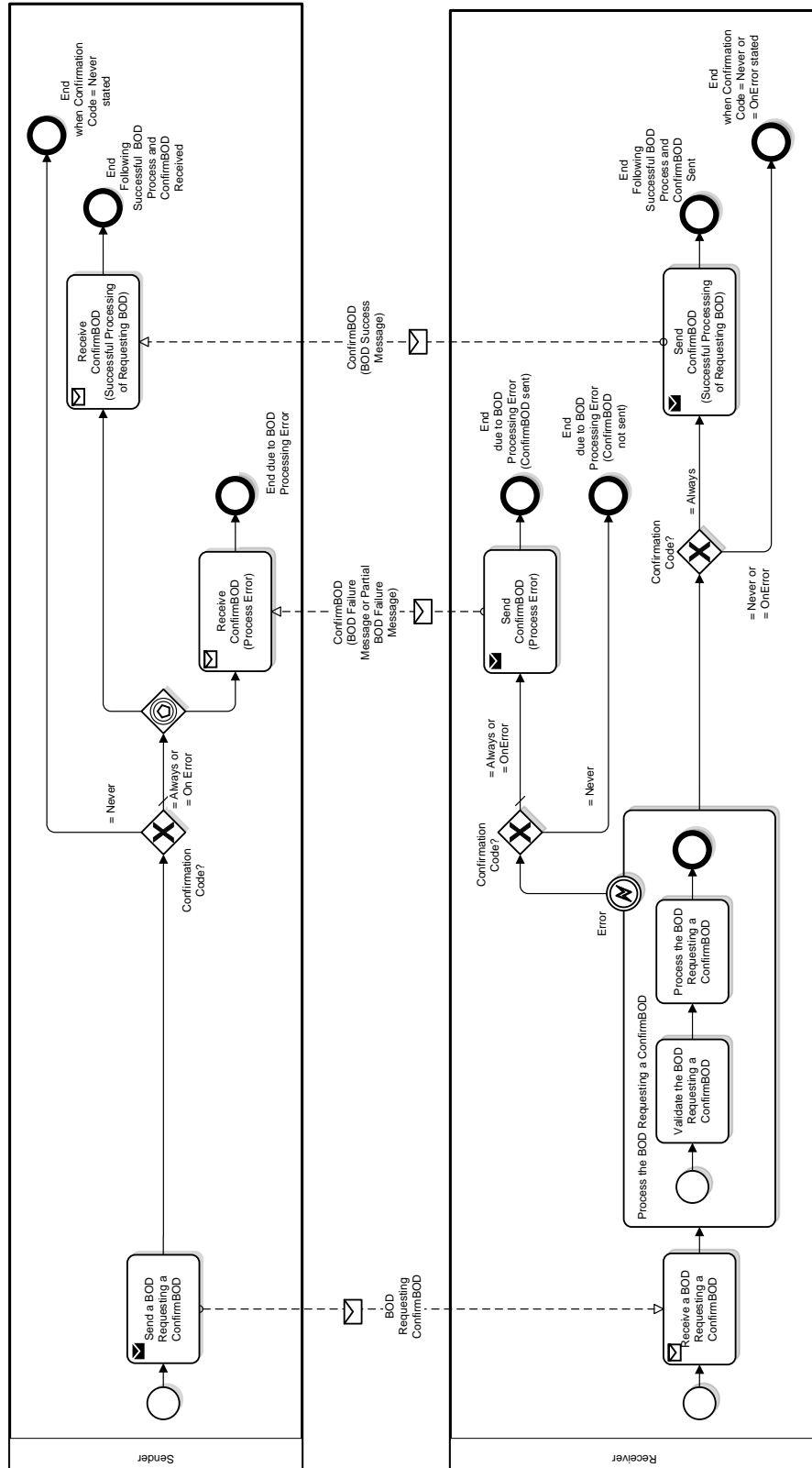**Figure 17: Confirm Interaction Example**

Figure 18: Confirm Interaction Pattern

D.3. Request-Change-Cancel

A larger pattern in OAGIS interactions is when an initial request is followed by changes to the request and finally by cancellation. Figure 15 in Section D.1 shows an example of this pattern (Request-Change-Cancel) with the first three request-reply pairs on the left. The first is started by an initial request, the second by a change request, and the third by cancellation.   The first and last of these pairs are translated to BPMN on the right of Figure 15 and Figure 16, respectively, and the second pair can be translated similarly. Figure 19 shows a general Request-Change-Cancel pattern in BPMN, including additional aspects of participant processes that are not visible to other participants. In particular, the activities for sending and receiving change requests and cancellations are contained within a BPMN grouping construct that does not restrict the order in which activities occur (ad hoc sub-processes, indicated with a tilde symbol). The activities can occur in any order and be repeated, as determined by the performer, though in this particular case, the cancellation activities must occur after the change request activities and only occur once in each occurrence of the subprocess. The BPMN diagram does not introduce more message flows, as in Annexes D.1 and D.2, but it reflects more accurately the notion of change and cancellation described in OAGIS documentation, in particular, the possibility of multiple change requests. It can be combined with the patterns of Annexes D.1 and D.2 to completely capture the scenario.
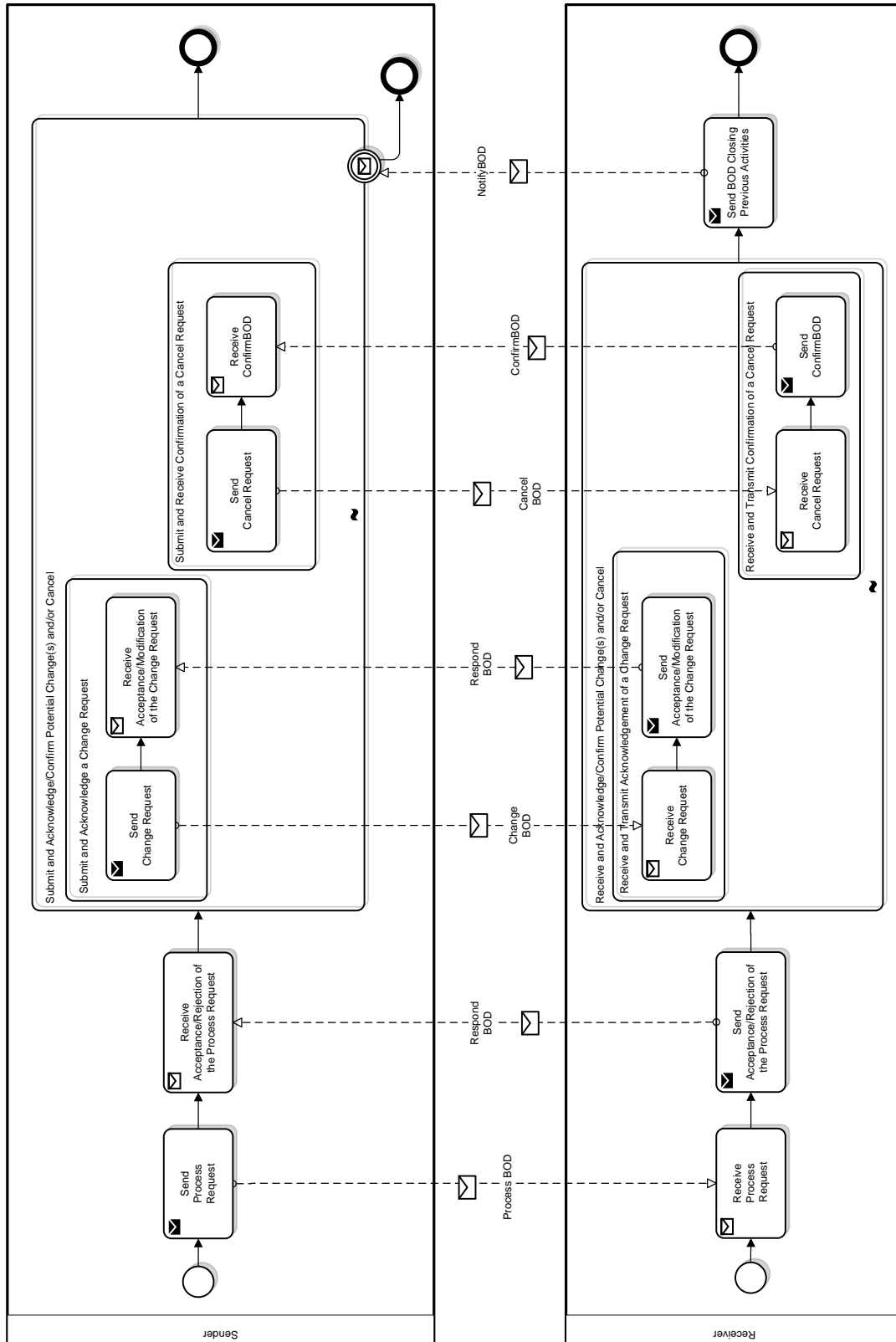
Figure 19: Request-Change-Cancel Interaction Pattern

D.4. Alternate Send Patterns

In scenario 56 (High Tech Invoicing), the ProcessInvoice BOD can be sent either by the Customer Party or by the Supplier Party, but this is not apparent in the scenario diagram shown in Figure 20, or the translation to BPMN in Figure 21. It can be depicted with additional activities (following an Alternate Start pattern) shown in Figure 22, reflecting the potential alternate start of such process. The process can be started when the Customer Party or Supplier Party sends a Request for an Invoice. This clarifies that different activities are performed depending of which participant sends the request. The alternatives are modeled in one collaboration for brevity, but could be modeled in two collaborations for clarity.
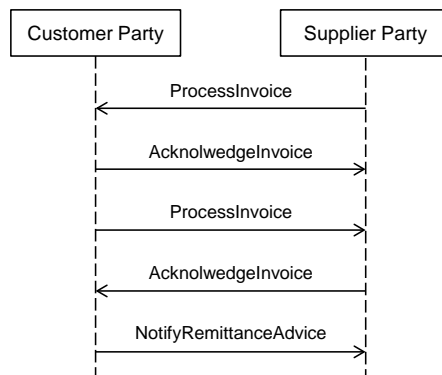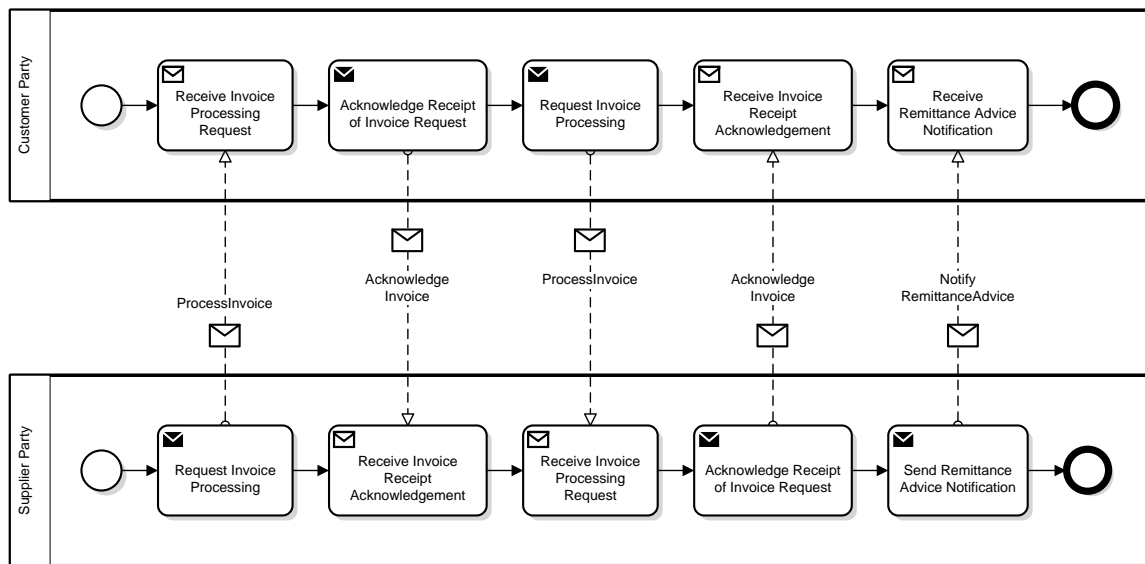
Figure 20: Alternate Start Example

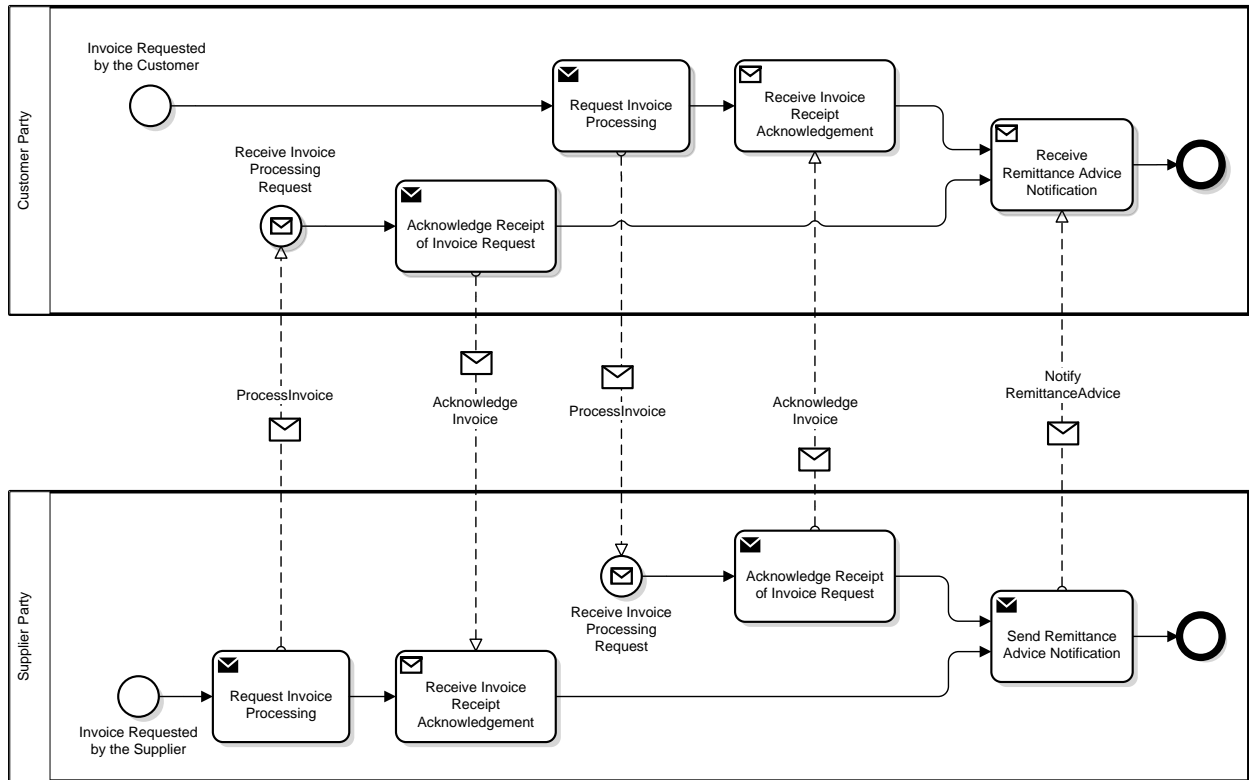**Figure 21: Alternate Start Example in BPMN**

Figure 22: Alternate Start Example with Additional Activities

In scenario 57 (High Tech Forecasting), the NotifyPlanningScheduleBOD can be sent by the Supplier Party or the Customer Party, but this is not apparent in the scenario diagram shown in Figure 23, or the translation to BPMN in Figure 24. It can be depicted with additional activities (following an Alternate Send pattern) shown in Figure 25, reflecting the potential alternate message flows of such process. The message updating the initial request can from Customer, the Supplier or both, because they are in a BPMN grouping construct that does not restrict the order in which activities occur (ad hoc sub-processes, indicated with a tilde symbol).
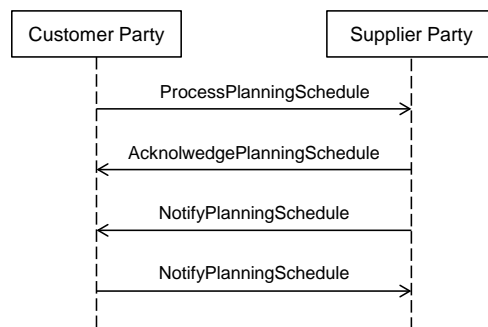

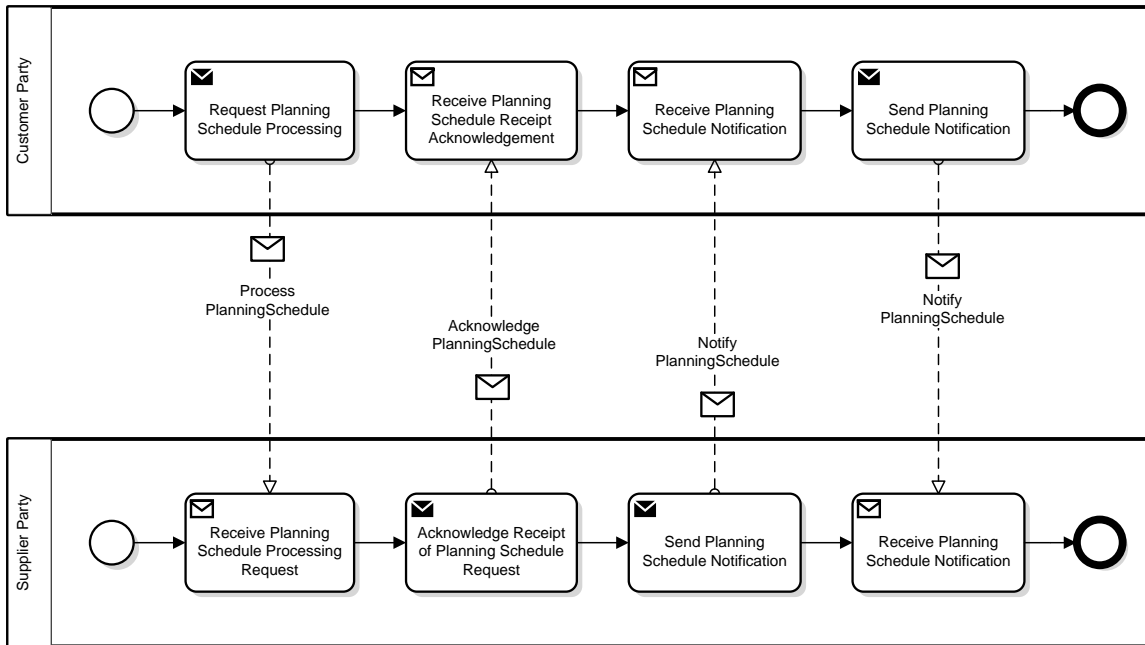**Figure 23: Alternate Send Example**

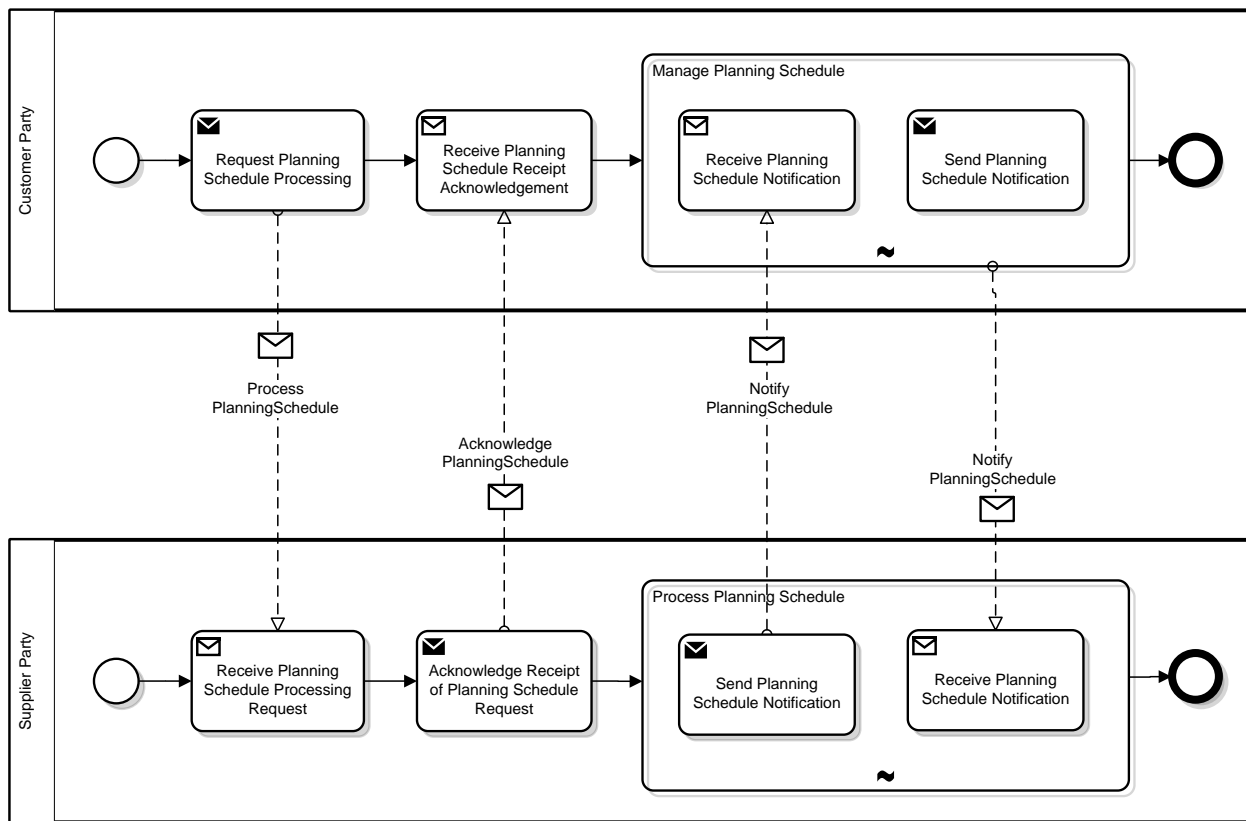**Figure 24: Alternate Send Example in BPMN**

Figure 25: Alternate Send Example with Additional Activities

E. Suggested Changes to OAGIS

Table 8 gives suggested changes, questions and clarifications for OAGIS 9.6 resulting from the feasibility study.

Scenario	Comments
01	Multi-Instances Marker used in the Sub-Ledgers Participant (Pool) to indicate that the synchronization of multiple Sub-Ledgers is done in parallel with the General Ledge. Is it the case or one Sub-Ledger must be identified?
03	Comment "Sending Open Item Balances" is included in a Notation and is attached to the "Credit Management" Participant. Is it appropriate or should it be connected to another Participant, an Activity or an Exchange between Participants?
09	Participant's Pools not aligned to make diagram easier to read.
10	Participant's Pools not aligned to make diagram easier to read.
22	Description is a Copy/Paste of Scenario 21. However, the JPEG image provides a Scenario Diagram for Scenario 22.
23	Repetitive Name of Messages between" Inventory (Finished Goods)" and "Inventory (Work in Process)". Should the return Messages have a different name than SyncItemMaster and SyncInventoryBalance?
23	The Participant "Manufacturing (ERP)" is included twice in the Scenario Diagram.
23	The Participant "Costing" is included but is not involved in any exchange.
24	Participant "Supplier Party" is included but is not involved in any exchange.
27	Process, Change and Cancel can be depicted on parallel paths.
29	Process, Change and Cancel can be depicted on parallel paths.
31	The Exchange "ProcessSalesOrder" from Participant "Order Management" and Participant "Customer Service" is in the same direction than the Exchange "ConfirmBOD" between them. One exchange should be in response to another, therefore these two exchanges cannot be in the same direction.
35	Synchronization of Item Master, BOM, Routing and Production Order initiated by Manufacturing ERP to Manufacturing Production Planning, Manufacturing Execution and Manufacturing Analysis are consolidated. One Activity is issued to issue the synchronzation of one type to the 3 receiving parties.
36	Process, Change and Cancel can be depicted on parallel paths.
37	In Section 37.4 it is written: "SyncCatalog – This event is the publication from the order management system of a catalog to the Catalog Management System." However, in the scenario diagram, the exchange "SyncCatalog" is from Catalog Management to Order Management. Therefore, the description and the scenario seem to be contradictory.
37	Between Catalog Management and Purchasing, the ConfirmBOD exchange is shown before the SyncCatalog exchange.ConfirmBOD should follow the SyncCatalog exchange.
39	Change Activities wording to better link to Description in scenario document.
40	Change Activities wording to better link to Description in scenario document.
42	Text in section 42.4 Business Workflow (Sequence) does not correspond to the Scenario Diagram. Seems to be a copy/paste of Scenario 41.4
43	Following "ProcessSplitWip", there is two "AcknowledgeSplitWip" from Participant $Production" to Participant "Manufacturing Execution – MES". Is is a duplicate?

Scenario	Comments
45	ShowActualLedger should be in response to GetActualLedger and go from General Ledger to Sub Ledgers. If so, the Activities connecting this component should be reversed (Send and Receive)
47	Business Workflow documentation should refer to NotifyShipment BOD, rather than Show Delivery.
52	Cannot access the Scenario Description Web page in 9.6 folder
56	In addition to a linear Public Interface Collaboration diagram, a Public Interface Collaboration diagram has been created to reflect the fact that an Invoice Request can be requested either by the Customer Party <u>or</u> by the Supplier Party.
57	In addition to a linear Public Interface Collaboration diagram, a Public Interface Collaboration diagram has been created to illustrate that events updating a Request can be issued by the Customer Party, the Supplier Party or both.
58	In section 58.4 Business Workflow (Sequence), bullet 7) ProcessPurchaseOrder an bullet 8) AcknowledgePurchaseOrder should be 7) ProcessInvoice and 8) AcknowledgeInvoice.
58	Process, Change and Cancel can be depicted on parallel paths.
60	In section 60.3, four roles are identified, however in the diagram and in the section 60.4 the "Transportation Party (Carrier)" is identified. It should be included in section 60.3. This diagram shows a "role" that is not depicted at the top of the scenario diagram in a yellow box. The "Transportation Party" yellow box is located on the same vertical line than the "Distribution Center Party". Do we have to assume than all exchanges linked to this vertical line apply to the "Transportation Party" instead of the "Distribution Center Party" following its depiction in the diagram?
60	Collaboration diagrams assume that all exchanges following the appearance of the "Transportation Party" are linked to this role.
61	What is the involvement of the "Customer Hub"? Should it be depicted at the top of the diagram? Is it an addition to the "Customer Party" role identified at the top of the Scenario Diagram? In section 61.3 it is identified as the "Distribution Center Party". Section 61.4, bullet 13) NotifyShipmentUnit is the only exchange description involving the "Distribution Center Party (Customer Hub)". It is identified as the target of the exchange.
61	Section 61.4 bullet 14) NotifyReceiveDelivery identifies that the ReceiveDelivery communication is from the "Transportation Party (Carrier)" sent to the "Supplier Party". However, the Scenario Diagram depicts it from the "Customer Hub" to the "Supplier Party". Which one is the right one?

Scenario	Comments
61	Both Collaboration diagrams do not include the "Distribution Center Party (Customer Hub)" Pool, awaiting clarification from OAGI to map.
61	The "ProcessInvoice" description in 61.4 and depiction in 61.1 identifies that is has the "Supplier Party" as the source and the" Customer Party" as the target. The "AcknowledgeInvoice" has the same source and target. Should it be reversed, coming from the Customer to the Supplier (if it is in response to the "ProcessInvoice" exchange?
61	The Collaboration diagrams assume that the "AcknowledgeInvoice" is in reponse to the "ProcessInvoice".
62	Two notes are included in the OAGI diagram. They are included in the Collaboration diagram using Annotations, but they are not included yet in the Public Interface Collaboration diagram.
63	Two notes included in OAGI diagram are not included in BPMN diagrams. Awaiting decision to use Annotation.
64	It is three separate processes illustrated all together.
64	In scenario 64,The ProcessItemNonconformance BOD is used in 3 different ways (the return is not the same in each case)

Table 8: Suggested Changes to OAGIS