THE Open GROUP

ArchiMetal Case Study

Version 3.2

A Case Study by:

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Executive Summary

This Case Study demonstrates the value of the ArchiMate® 3.2 modeling language, a standard of The Open Group, for planning and expressing complex business transformation. The Case Study is about a fictitious manufacturer named ArchiMetal. Through high-level architecture modeling, the ArchiMate language illuminates the coherence between an organization, and its processes, applications, and technology. This Case Study presents examples of ArchiMate models that can be elaborated as necessary for analysis, communication, decision support, and implementation.

This Case Study first describes ArchiMetal's baseline state, focusing on its Customer Relationship Management (CRM) challenges. It shows how these challenges can be addressed through changes to the company's organizational structure, business processes, and application portfolio. In the process, it thoroughly demonstrates the use of the ArchiMate language, including its Business, Application, and Technology core layers, as well as its Motivation and Implementation and Migration elements.

This Case Study is designed for Enterprise and Solution Architects interested in systematic approaches to architecture in general, and the ArchiMate language in particular. It supports The Open Group vision of Boundaryless Information Flow™ by demonstrating how an open, standard, widely-used visual modeling language can be used to guide complex business transformation.

Even though the concepts and approach provided in this Case Study can be applied to several industries, the particular examples are aimed to support the Manufacturing industry.

Introduction

The right Enterprise Architecture can enable a manufacturer to improve operational efficiency and reduce risks while increasing customer satisfaction.

The right Enterprise Architecture can enable a manufacturer to improve operational efficiency and reduce risks while increasing customer satisfaction. Enterprise Architecture development uses principles, methods, and models for the design and realization of organizational structure, business processes, information systems, and technology. This Case Study illustrates the value of the ArchiMate® 3.2 modeling language [1] for Enterprise Architecture development and implementation within ArchiMetal, a fictitious metal parts manufacturer. It primarily illustrates the Business and Application core layers of the ArchiMate language, along with its two extensions: Motivation and Implementation and Migration.

ArchiMetal uses standards-based Enterprise Architecture methods to drive organizational change. One of the Enterprise Architecture standards the company uses internally is the ArchiMate 3.2 Specification, a standard of The Open Group. The ArchiMate language is uniquely designed specifically for Enterprise Architecture. The language is also closely aligned with the TOGAF® framework, a standard of The Open Group. The Core Concepts section of this standard [2] defines architecture in the context of the TOGAF standard. This section gives architecture two meanings, depending on the context in which it is used:

- A formal description of a system, or a detailed plan of the system at component level to guide its implementation
- The structure of components, their inter-relationships, and the principles and guidelines governing their design and evolution over time

This advanced Case Study assumes a strong familiarity with the TOGAF standard, the ArchiMate modeling language, the ISA-95 standard for integrating manufacturing systems [3], and Customer Relationship Management (CRM) application functions. Readers desiring an introduction to any of these topics should consult Appendix A: Core Concepts and Standards.

In the Case Study, the improvement of ArchiMetal operations, using models of baseline and target architectures, is discussed. By enabling high-level architecture modeling, the ArchiMate language illuminates the coherence between organizations, processes, applications, and technology. ArchiMate models can be elaborated as necessary for analysis, communication, decision support, and implementation.

To demonstrate the value of the ArchiMate modeling language, the Case Study focuses on integrating and sharing customer data across customer-centric processes in order to optimize coordination, decision-making, and customer experience within ArchiMetal. In addition, it demonstrates how the ArchiMate language can be used with domain-specific standards such as ISA-95, which is used for integrating Enterprise Resource Planning (ERP) systems with Manufacturing Execution Systems (MES) that control manufacturing equipment and processes.

The fictitious manufacturing enterprise used for this study is a simplification of what would be expected in a real-life scenario. While reducing the complexity was required to keep the study simple and illustrative for the given goal, an effort has been made to keep the study as realistic as possible. The most important simplifications concern the organizational structure, and the focus of the study on the coordination between

Sales and Distribution and Production, instead of the entirety of supply chain management. These limitations are elaborated in the Case Study. This document also identifies some opportunities for further work.

In summary, the Case Study describes the ArchiMetal baseline state, analyzes the challenges faced by the company, and presents a vision for addressing them. It then presents the target architectures necessary to realize the vision. Finally, it presents a manufacturing scenario using ISA-95 standard messages to process an urgent customer order, and a more detailed version of the target state with new customer services, the redesign of several business processes, and the rationalization of the application landscape.

ArchiMetal Transformation Challenges

ArchiMetal faces several challenges as it serves its customers and seeks to expand.

ArchiMetal faces several challenges as it serves its customers and seeks to expand. This section describes the company's strategy, structure, and operations, along with the difficulties it must surmount if it is to meet its objectives.

Company Background

ArchiMetal is a mid-sized European company that produces steel products used in building construction and other industries, such as beams, wire, and pipes. The company has recently developed the capability to produce high-quality flat steel products and plans to sell them to manufacturers of automotive parts. To succeed in this highly competitive market, ArchiMetal needs to improve its CRM capability and develop new customer services. To this end, company leaders have launched a business transformation program to improve overall business performance by changing the way ArchiMetal interacts with its customers.

To be competitive in the automotive supply market, ArchiMetal needs to reduce the time it takes to fulfill orders and, in general, to increase the quality, efficiency, and flexibility of its order-handling activities. ArchiMetal has lost customers because it took longer than promised to fulfill their orders, and did not keep them up to date about the status of their orders. Customers are increasingly complaining about the quality of ArchiMetal's services, and have been downgrading the company in customer satisfaction surveys conducted regularly by industry analysts.

ArchiMetal management intends to reverse this trend and retain all existing, win back former, and acquire new customers. Therefore, the transformation program must improve sales and order fulfillment to reduce the time it takes to fulfill orders, consistently deliver on the date promised, and immediately warn customers of any circumstances that could delay their orders. The program must also improve customer satisfaction and launch new services that delight customers.

Organizational Structure

ArchiMetal has one Production Center (PC) and several Distribution Centers (DCs) as shown in Figure 1. However, a real-life manufacturing enterprise, complex enough to require ERP and MES, would likely have multiple PCs. ArchiMetal's fictional operating model allows autonomous DCs in Spain, Belgium, and Romania to focus on customer needs while concentrating manufacturing at its PC in Poland. DC Benelux in Belgium and DC Spain serve the company's construction sector customers, while DC East Europe in Romania covers other sectors, located mainly in eastern and southeastern Europe. The ArchiMetal Headquarters (HQ) in Luxembourg houses top management, as well as the Finance, Quality Management, Product Development, and Human Resources (HR) departments.

The Finance department defines policies and procedures and rules that the DCs must follow when they set prices and assess the credit risk associated with individual customers.

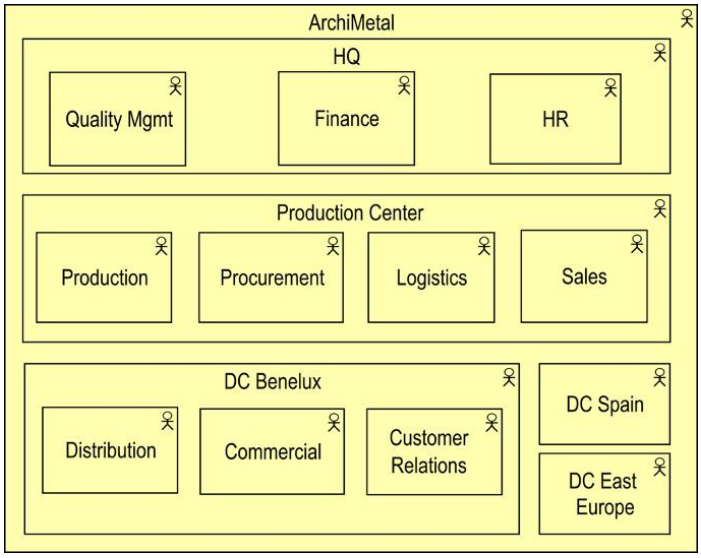

Figure 1: ArchiMetal Business Units include its Headquarters (HQ), Production Center (PC), and a Network of Distribution Centers (DCs) Responsible for Sales and Customer Service

The Customer Relations function in each DC assesses credit risk, works with sales representatives to negotiate contracts, leads responses to customer complaints, ensures collection of accounts payable, and manages customer master data. The sales function is responsible for sales activities, including handling customer orders from their registration in the system until the invoicing, which is the responsibility of the Finance function. The Distribution function is in charge of transporting the finished goods to the customer.

The PC procures raw materials and uses them to manufacture products, which it stores in warehouses and distributes to DCs. The PC Sales function forecasts sales, takes consolidated orders from DCs, and shares them with the Manufacturing and Logistics functions. The PC Procurement function selects suppliers and negotiates contracts with them. The function also forecasts demand for raw materials, orders them, and manages inventory levels, relying heavily on information from the Sales and Production functions. The Logistics function transports and stores both raw materials and finished goods. The PC Production function plans, executes, and monitors manufacturing, and also plans, designs, constructs, and maintains manufacturing facilities.

Value Stream

The value stream of ArchiMetal is that of any typical manufacturing company. Raw materials are procured, products are manufactured from these, and those products are stored, sold to customers, and distributed there. This value stream is shown in Figure 2. The stages in this value stream are realized by business functions and technology processes, outlined in the next sections.

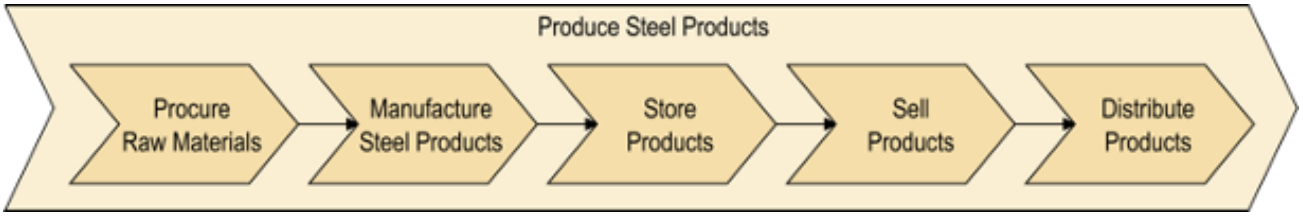

Figure 2: Value Stream of ArchiMetal

Manufacturing Processes

To provide you with some context of the primary processes of ArchiMetal, Figure 3 provides a high-level overview of its production and logistics. Figure 4 provides a more detailed view of the physical production, using the physical elements of the ArchiMate 3.2 Specification. Raw materials are processed, these are turned into liquid iron by a blast furnace, which in turn is cast and rolled to create finished steel products, which are stored in a warehouse. Rail transport is used to move the intermediate and finished products across the plant site, and also for distribution to the customer (not shown in the figure).

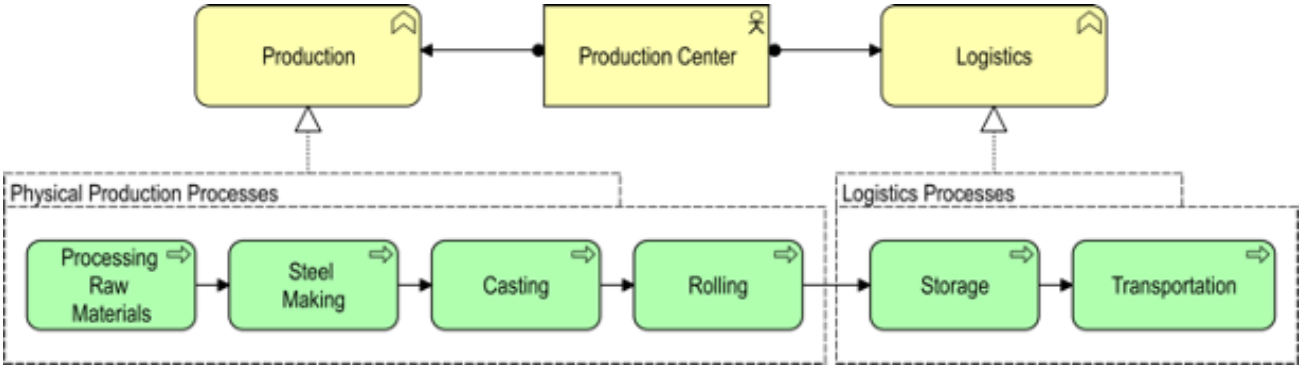

Figure 3: Production and Logistics of ArchiMetal

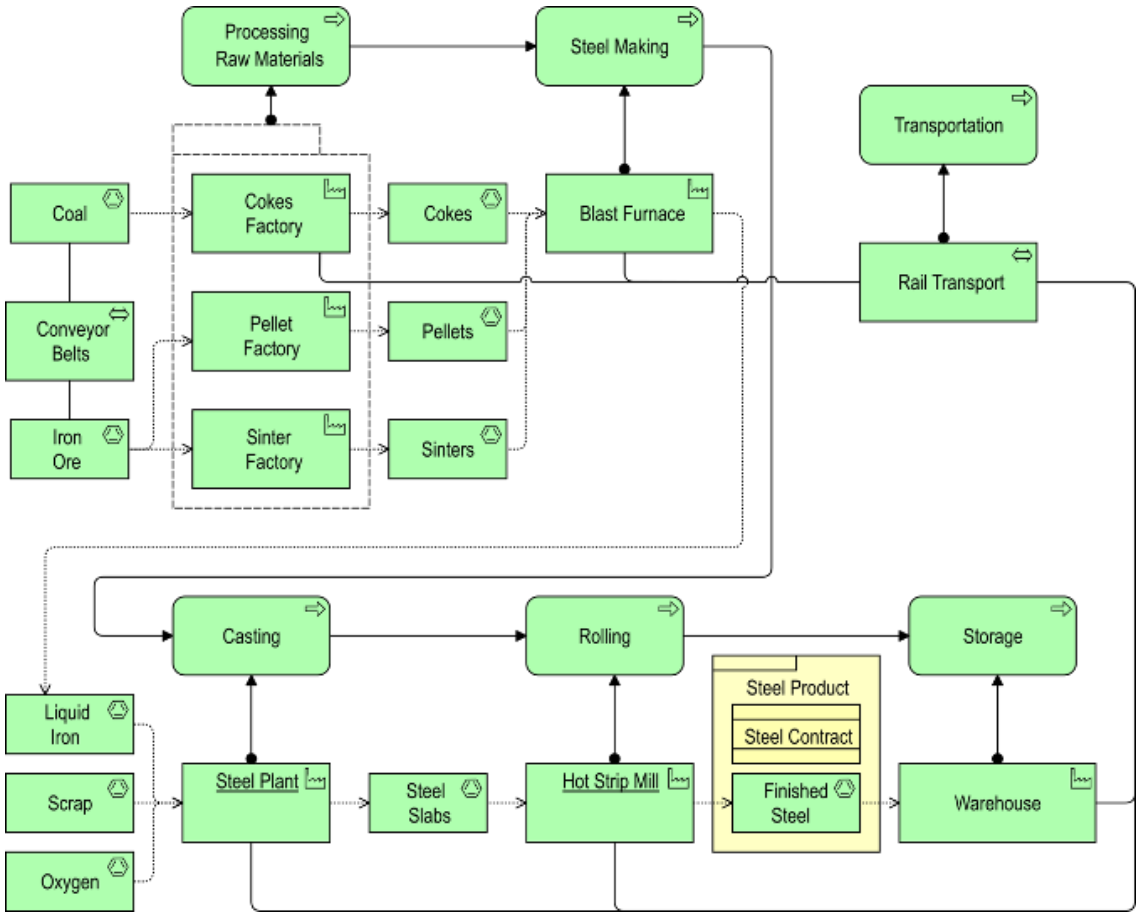

Figure 4 Steel Production

You can also zoom in on the individual facilities, as exhibited in Figure 5. This shows that the computer-controlled Hot strip mill contains a Roll line, which in turn consists of a computer Roll, with Process control software. This shows how you can use the ArchiMate 3.2 language to model the interplay between physical and information technology.

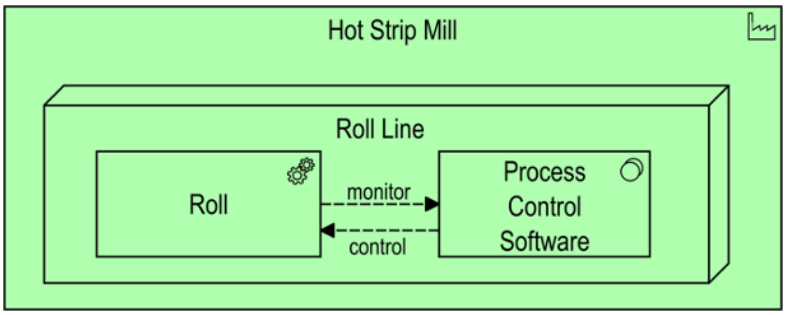

Figure 5: Hot Strip Mill in More Detail

Problem Analysis

The leaders of the ArchiMetal transformation effort have analyzed the challenges that their program must address: *business performance*, and *customer satisfaction and service quality*.[1] Figure 6 and Figure 7 depict, using ArchiMate Motivation views, the drivers that most concern ArchiMetal management and the assessments regarding those drivers.

ArchiMetal's business performance suffers from defects in its Business Architecture …

ArchiMetal's *business performance* suffers from flaws in its Business Architecture resulting in a disjointed approach to customer service and CRM. These flaws are also reflected in the inadequate architecture of its applications and information. In particular, ArchiMetal's staff has disparate views of the customer base across various departments. The customer databases and applications of the different DCs do not work together. In addition, the formats of customer master data vary across the company. These two factors make it difficult to maintain consistent and accurate data. This decreases the quality of the customer experience, expends resources for redundant data collection and cleanup, and exposes ArchiMetal to a variety of risks. In several cases, a DC had extended credit to customers who were missing payments on credit already extended by other DCs. In addition to inaccurately assessing customer creditworthiness, DCs have extended credit in violation of policies set by the HQ Finance Department. The HQ Finance Department has had limited control over the credit operations of DCs, intervening only in cases where the DCs themselves have escalated exceptionally high-risk situations.

The PC also suffers from a lack of customer visibility. Its planners cannot observe and assess the *pipeline* of contacts, leads, opportunities, and deals that ultimately drives demand for manufactured products. This lack of advanced planning often leads to delays in fulfilling customer orders due to unanticipated shortages of raw materials and limited production capacity, and increased costs due to excess of raw materials or expensive purchases on the spot market rather than through planned procurement. From a customer satisfaction perspective, the main pain points are long lead-times to fulfill orders, poor customer service, and lack of flexibility in dealing with orders (i.e., enquiries, changes, etc.). Order management across the DCs to the PC is also problematic. Once each day, DCs aggregate customer orders and then relay them to the PC. These aggregate orders do not include any information on the customers that have placed the original orders. Therefore, individual customer orders are not visible in PC systems, and customer order data is partially duplicated in different DC and PC order management applications. This lack of complete and timely customer order information further hinders production planning. In addition there is no standard for unique order identification across ArchiMetal, which further complicates order management as well as the tracking and analyzing of customer behavior.

Therefore, ArchiMetal cannot develop accurate customer profiles and engagement journeys. Nor can it make strategic predictions and preparations for future demand. Similarly, it is difficult for ArchiMetal product managers to use the available data to perform product lifecycle management; i.e., to determine whether to

[1] For the sake of simplicity, the problem analysis focuses on coordination between Sales and Distribution and Production. It disregards the potential impact of the issues that may exist within the Procurement and Demand Management functions. These aspects of the fictitious ArchiMetal organization could be considered in further work.

alter or retire existing products, or to introduce new ones. This lack of data also inhibits marketing as well as the management of customer relationships to maximize profitable sales and avoid money-losing situations.

Another impact of these various customer information problems is an inferior customer experience relative to that of its competitors. Not only is ArchiMetal losing customers, but its reputation has suffered to the point that it must often discount its prices more deeply than its competitors to win new or repeat orders.

Figure 6 and Figure 7 depict, using ArchiMate Motivation views, the drivers that most concern ArchiMetal management and the assessments regarding those drivers.

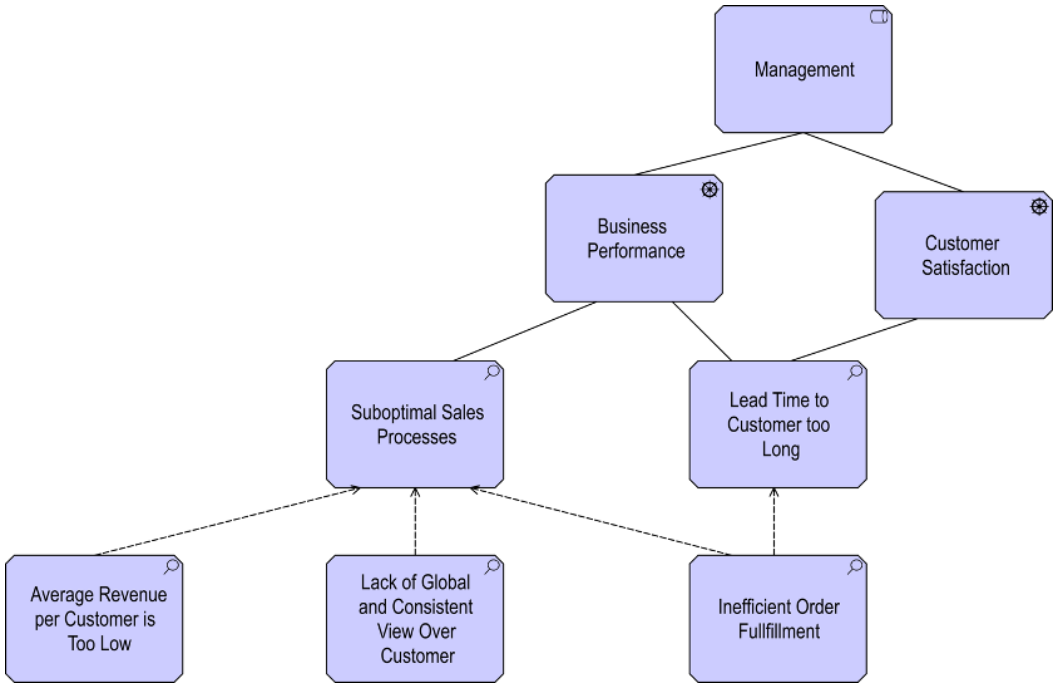

Figure 6: ArchiMate Motivation View Describing the Overall Challenges Facing ArchiMetal

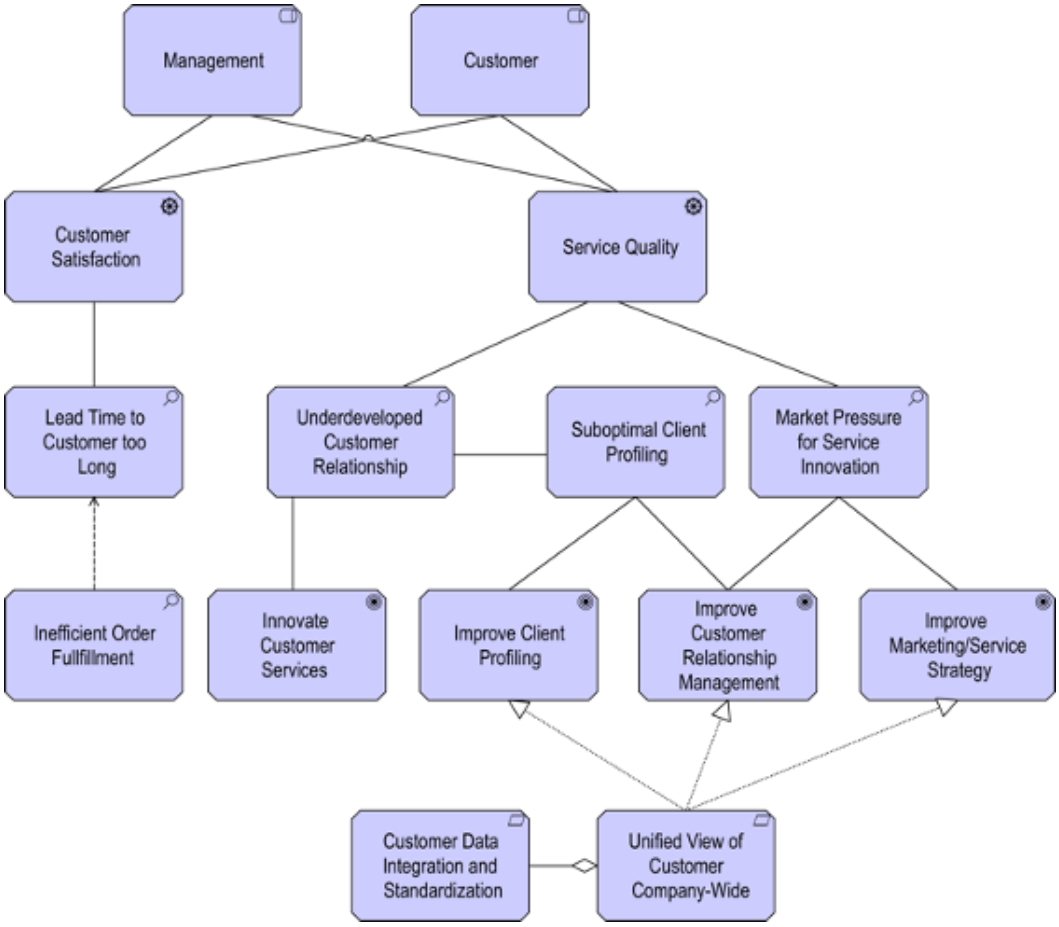

Figure 7: ArchiMate Motivation View Describing the Customer Satisfaction and Service Quality Challenges Facing ArchiMetal

ArchiMetal's CRM Vision

A group of leaders from across ArchiMetal got together and envisioned a successful CRM implementation (Figure 8). They visualized the entire company collaborating to delight their customers and build lucrative relationships with them by sharing information in real time. They envisioned a customer-centric organization in which each department set measurable goals for serving customers and measured their progress through real-time dashboards.

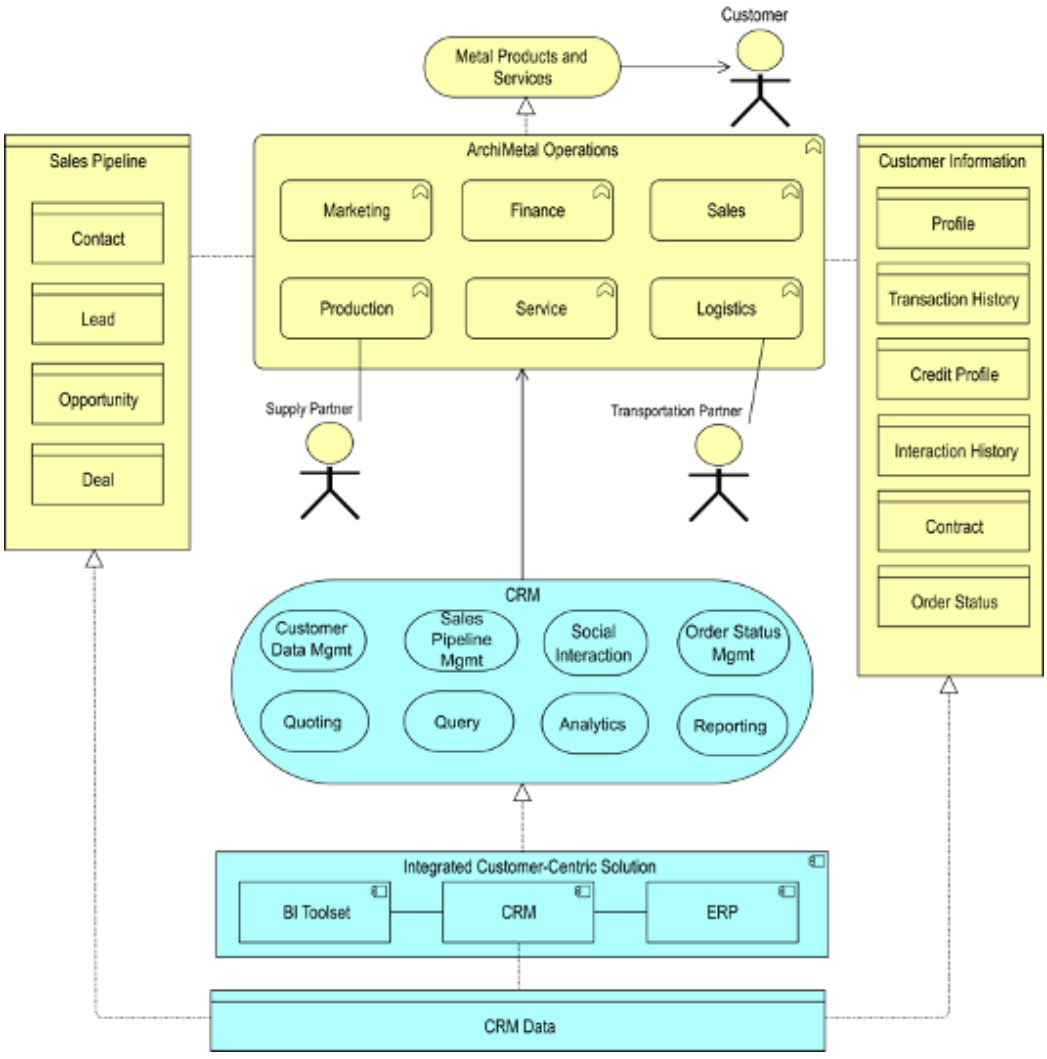

Figure 8: ArchiMetal's CRM Vision

ArchiMetal Transformation Overview

This section provides an overview of the ArchiMetal transformation program with high-level models of the company's baseline and target Enterprise Architecture.

Baseline Enterprise Architecture

The simplified baseline Enterprise Architecture models presented depict the communication between the HQ, PC, and one of the DCs. Based on the challenges facing ArchiMetal, the models focus on customer-facing processes.

Business Architecture

The organizational structure of ArchiMetal has already been introduced in Figure 1. Figure 9 identifies key services ArchiMetal provides to its customers through its DCs, along with the business processes that realize these services.

DCs act as profit centers, and enjoy significant autonomy within the bounds of mandatory ArchiMetal policies and procedures. They add value through customer intimacy and their ability to do business in their designated regions. Therefore, DCs adapt their business processes to specific regions and customer segments, which precludes standardization across ArchiMetal.

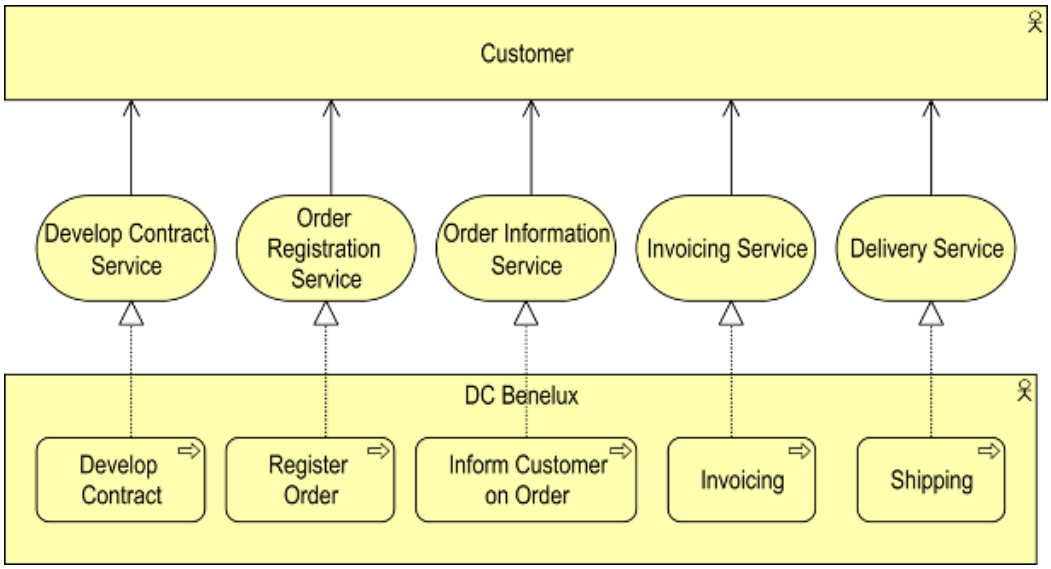

Figure 9: Customer Services Provided by DC Benelux

Figure 10 portrays the inter-dependencies between the key business processes related to sales. Figure 11 presents the details of information flows underlying these processes.

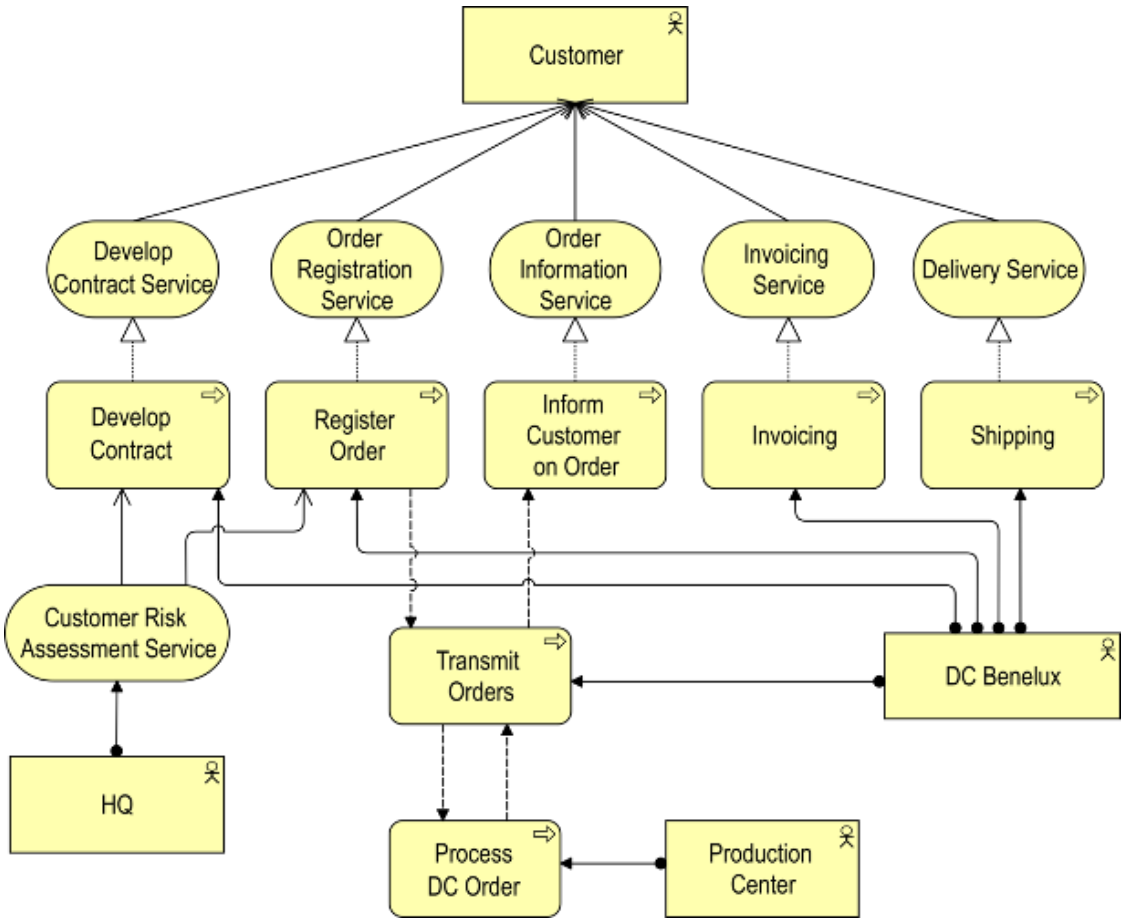

Figure 10: Inter-Dependencies between the Key Sales Processes in DC Benelux, PC, and HQ

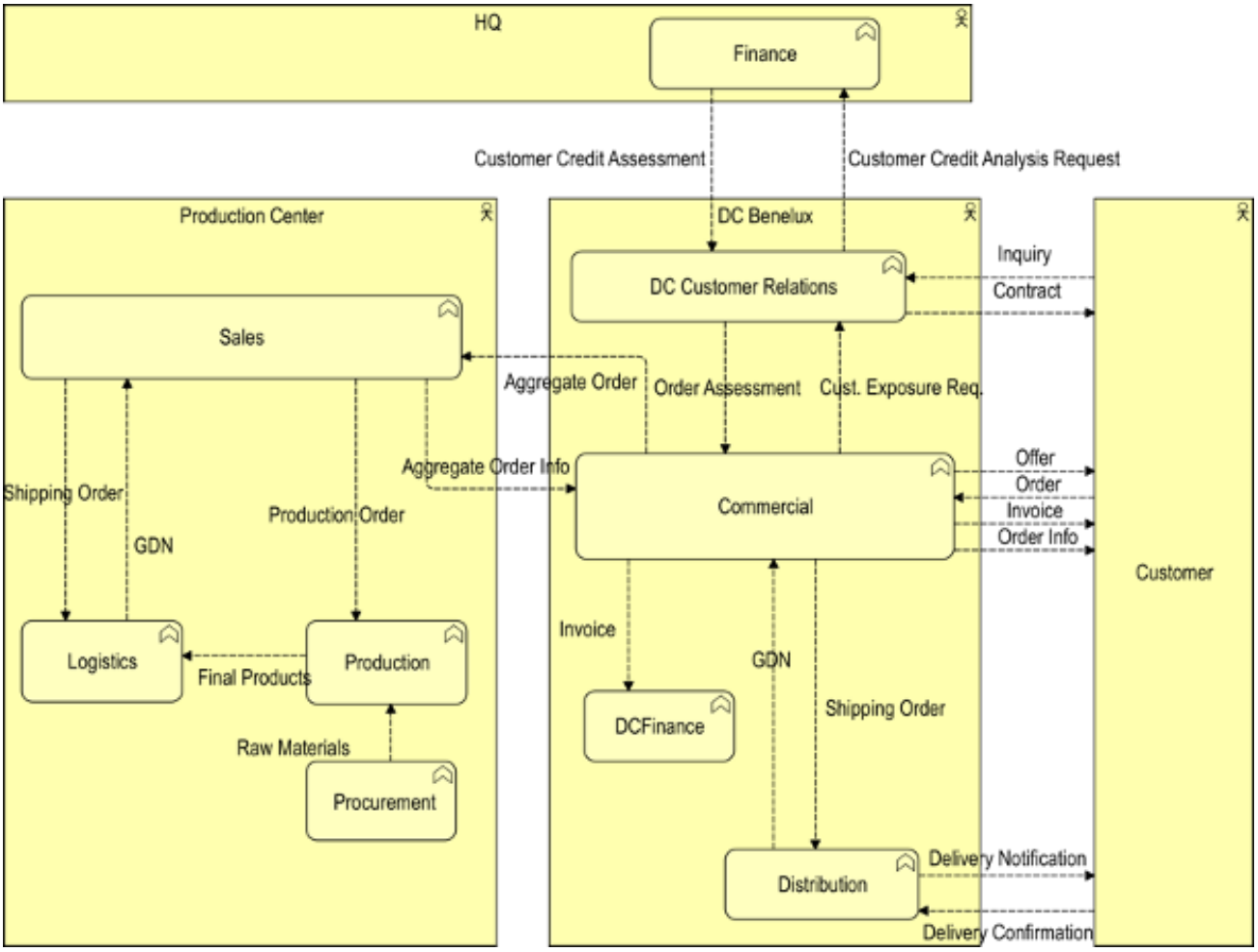

Figure 11: Most Important Information Flows between the Units

In this figure, DCs receive customers' orders. HQ assesses the risk involved in some of these orders. PC receives aggregate orders from DCs for use in production.

Baseline Application Architecture

The Application Cooperation view in Figure 12 shows the information flows between applications in the HQ, DC Benelux, and PC. Figure 12 is an ArchiMate application landscape diagram that shows the usage of applications by different departments or business units within ArchiMetal.

DC Benelux uses its own customer data management applications for maintaining customer data, contract creation, and printing, and for supporting credit risk analysis. The order management application at DC Benelux administers orders and exchanges data with a PC system for order management. As noted earlier, only aggregate order information is exchanged, with no information about individual orders. The DC also uses its own shipping and invoicing applications, along with a financial application that manages receivables.

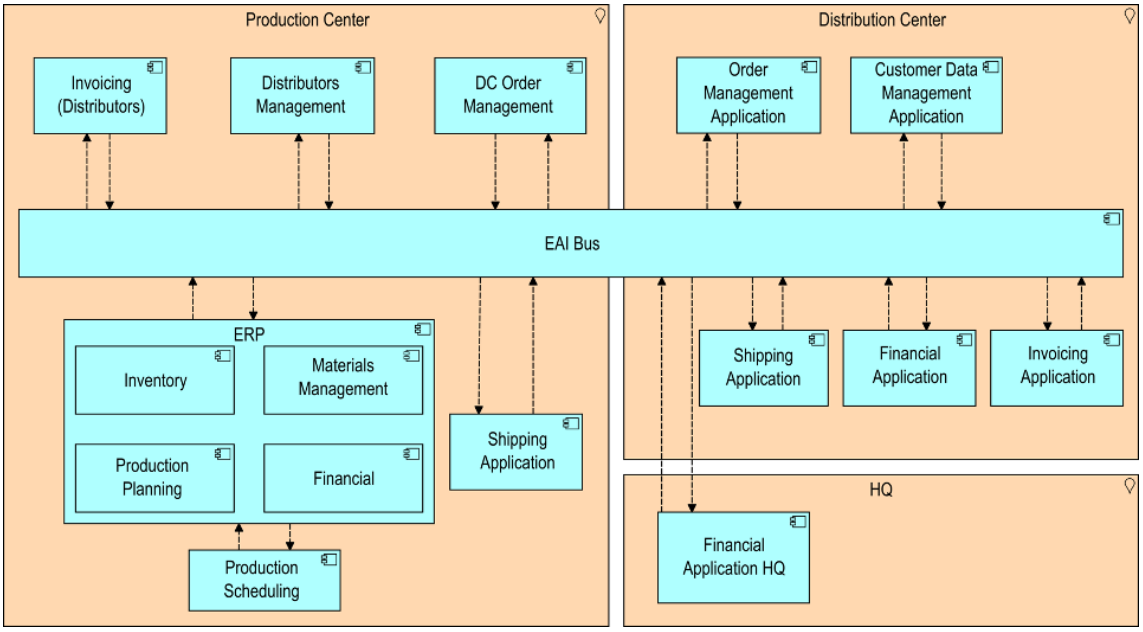

Figure 12: Application Landscape of ArchiMetal

In this figure, integration between the different applications is enabled with an Enterprise Application Integration (EAI) bus. Customer-related data is not standardized at the company level.

PC has its own application for managing DC orders, which communicates via the EAI bus with the DC's order management applications. The PC uses an application to invoice distributors for the bulk orders fulfilled. The PC also has an ERP solution with components for inventory and materials management, production planning, and financial management, including the maintenance of a general ledger.

The DC order management application integrates with the ERP solution so that its users can verify whether there are enough finished goods or products on hand to fulfill a bulk order, and to schedule additional production as necessary. Once there are enough products on hand to complete a bulk order, the order management application works with the shipping application to initiate delivery.

The EAI bus manages communication between the applications. Since there is no standard format for customer data, unique transformation logic exists for each pair of applications that must work together to serve customers. The IT organization must perform extensive specification, development, and quality assurance across many modules of code for even the simplest of data enhancements. This makes it difficult for ArchiMetal to respond to new customer requirements or other changes in the business environment.

Technology

The ArchiMetal IT infrastructure includes a Wide Area Network (WAN) that connects the HQ, PC, and the DCs, a corporate data center at HQ, a manufacturing data center at the PC, and smaller computing facilities for local file servers and applications at each DC. Each data center has a data center network, and each site has a Local Area Network (LAN). Figure 13 shows aspects of the corporate data center, which is based on a mainframe and additional distributed servers. The mainframe is divided into multiple partitions. Each partition consists of hardware and software, including a Database Management System (DBMS) and reliable messaging queuing software, which provide services to applications. The distributed servers run UNIX®

operating systems and DBMS software, and provide additional services, including centralized authentication and authorization for a variety of applications on ArchiMetal networks.

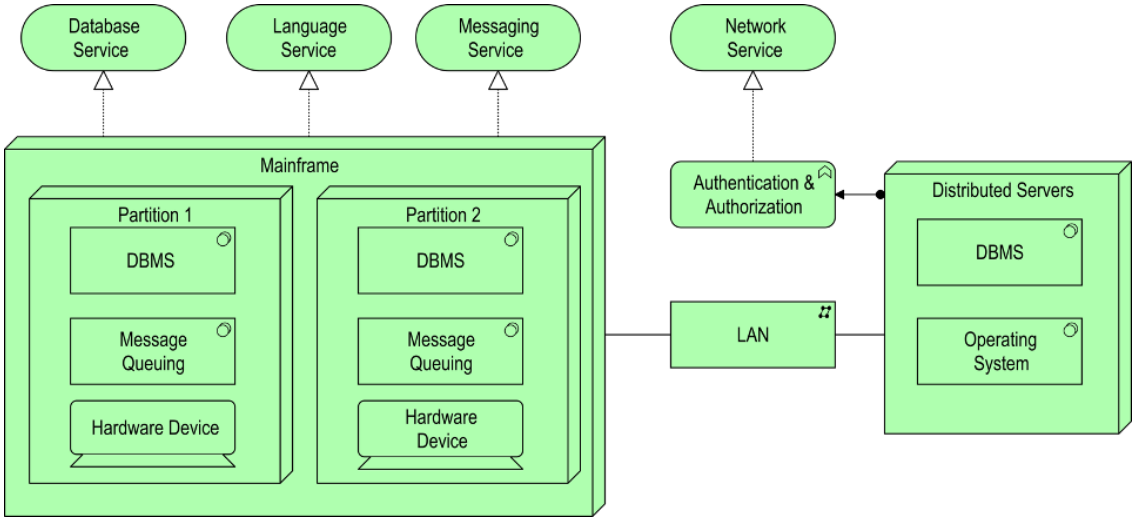

Figure 13: Key Aspects of the ArchiMetal Corporate Data Center Infrastructure

Target Enterprise Architecture

The target Enterprise Architecture realizes the CRM vision by providing ArchiMetal with a single shared view of the customer base. A new CRM application centrally manages customer data while working with the ERP system and other applications. ArchiMetal staff use the CRM application to better coordinate sales, order fulfillment, and service processes across the company.

Target Business Architecture

The target Enterprise Architecture adds a Customer Service department to ArchiMetal HQ (Figure 14). This department defines the structure of customer master data and manages a central customer database, including overseeing how that data is shared with ERP processes and systems. Customer Service regularly audits the quality of customer data and works to improve processes that promote data quality. The department also has a team of information analysts that analyze the customer data to inform marketing, sales, and service activities across the company. The Customer Service department also manages a new service to track customer orders from initial submission to payment, and assists DCs with collections of delinquent accounts receivable. Most importantly, the Customer Service department operates a consolidated Contact Center to assist and inform customers.

These changes allow the DCs to concentrate on sales while taking advantage of improved customer data and analytics, rather than collecting and managing customer data and dealing with routine questions and issues. In addition, they give HQ greater visibility and control over DC pricing and credit practices as sales contracts are negotiated.

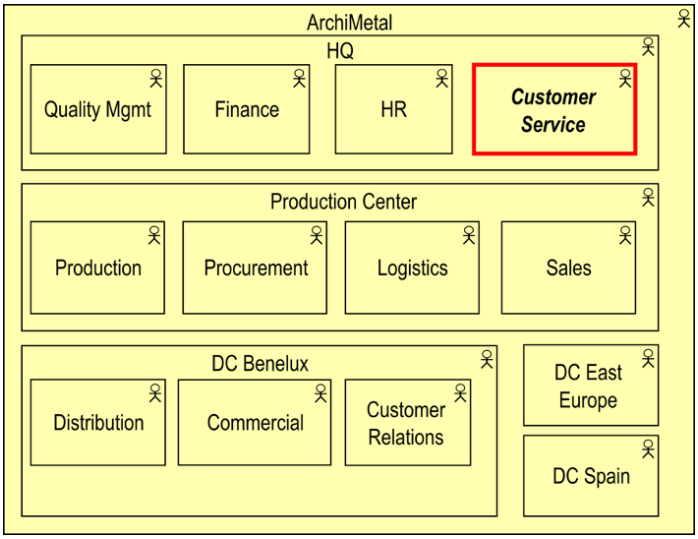

Figure 14: Changes to ArchiMetal Organization Structure, including New Department: Customer Service

The target Enterprise Architecture also centralizes order data and provides integrated IT support for order management through the CRM system. This makes customer behavior more visible across ArchiMetal and makes it easier to keep customers informed about the progress of their orders. In addition, centralized customer data and analytics improves sales forecasting, and enables continuous improvement of the product portfolio as well as production and procurement plans based on customer behavior.

The target Enterprise Architecture also improves coordination of order processing. Instead of transmitting aggregated orders, DCs transmit individual orders to the PC, which monitors and publishes a status for each of them. This speeds fulfillment of customer orders, and eases accommodation of special requests such as urgent orders. Figure 15 shows the simplified information flows that enable these improvements. Figure 16 provides a high-level view of the key elements of the target Enterprise Architecture, which also pinpoints enhanced coordination and alignment between the business processes as well as with their application support.

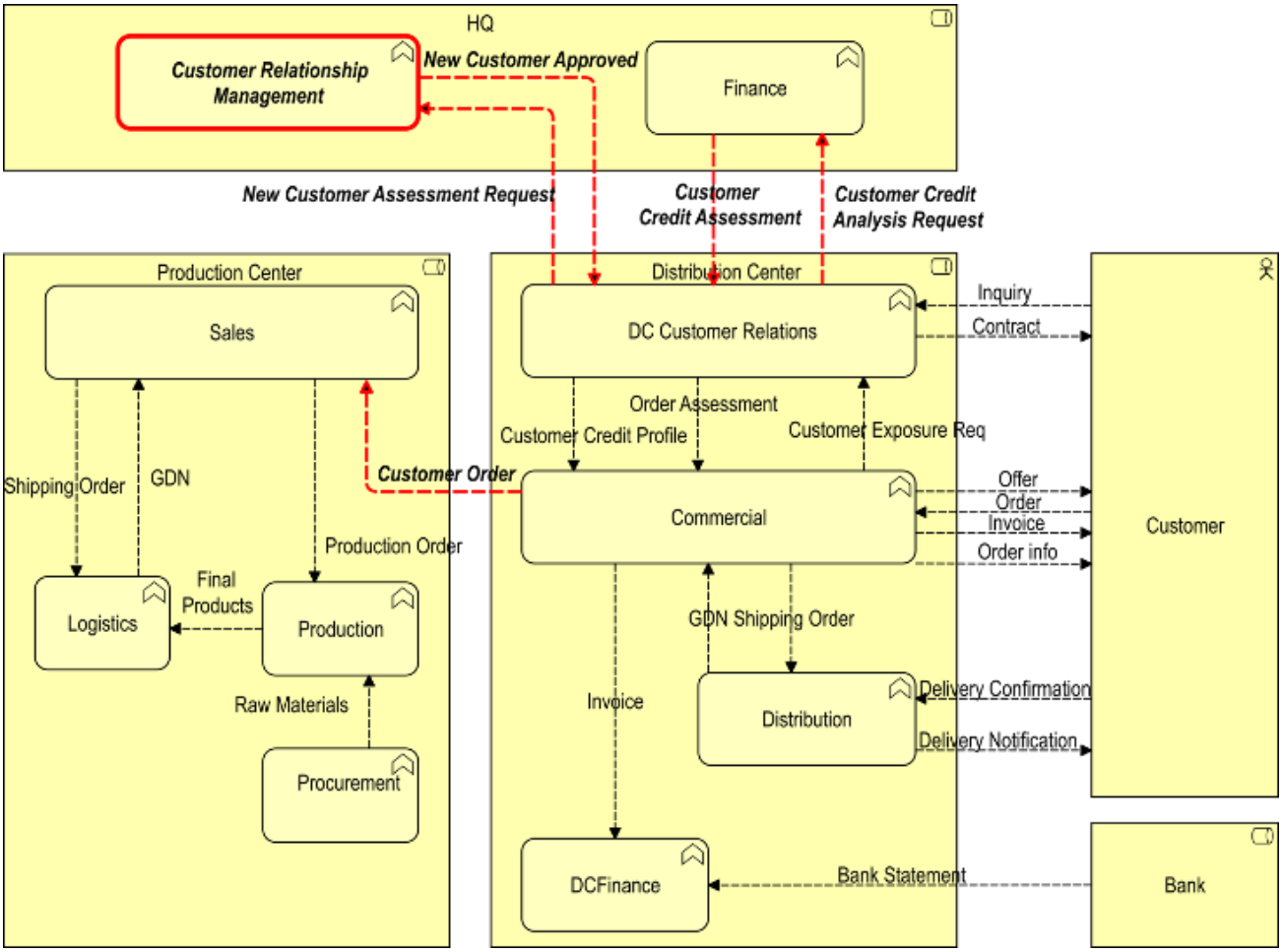

Figure 15: Relevant Information Flows between Business Units

In this figure, new flows and functions are marked with bold type or red lines.

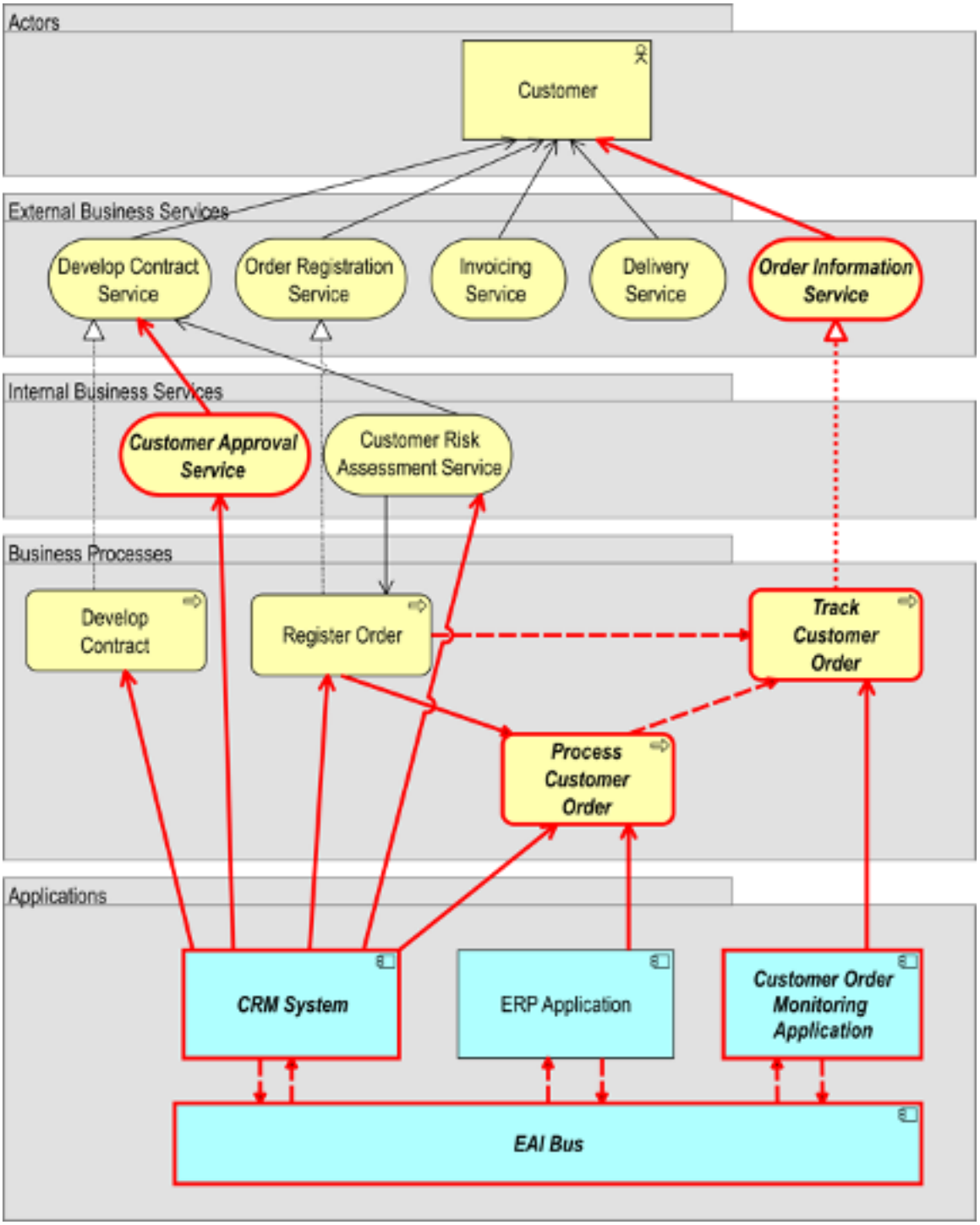

Figure 16: Overview of the Key Changes in the Overall Enterprise Architecture of ArchiMetal

This figure shows the alignment between new processes, services, information flows, and applications. These changes are elaborated throughout this section.

As illustrated in Figure 17, ArchiMetal introduces an Order information service. Customers can now choose the events about which they are notified, as well as the types of notifications they receive, such as emails or Electronic Data Interchange (EDI) messages. Figure 18 shows in more detail the realization of this service by a new process.

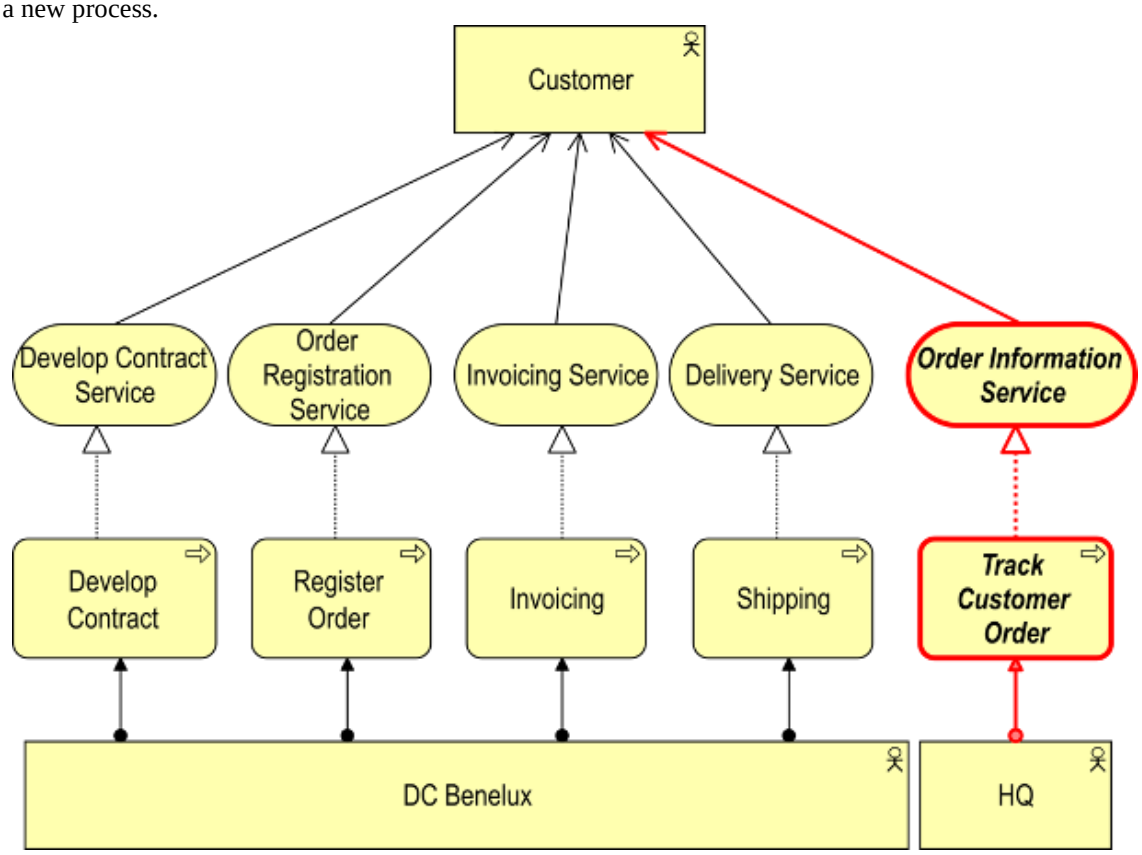

Figure 17: New Customer Service Enables Real-Time Monitoring of Customer Orders

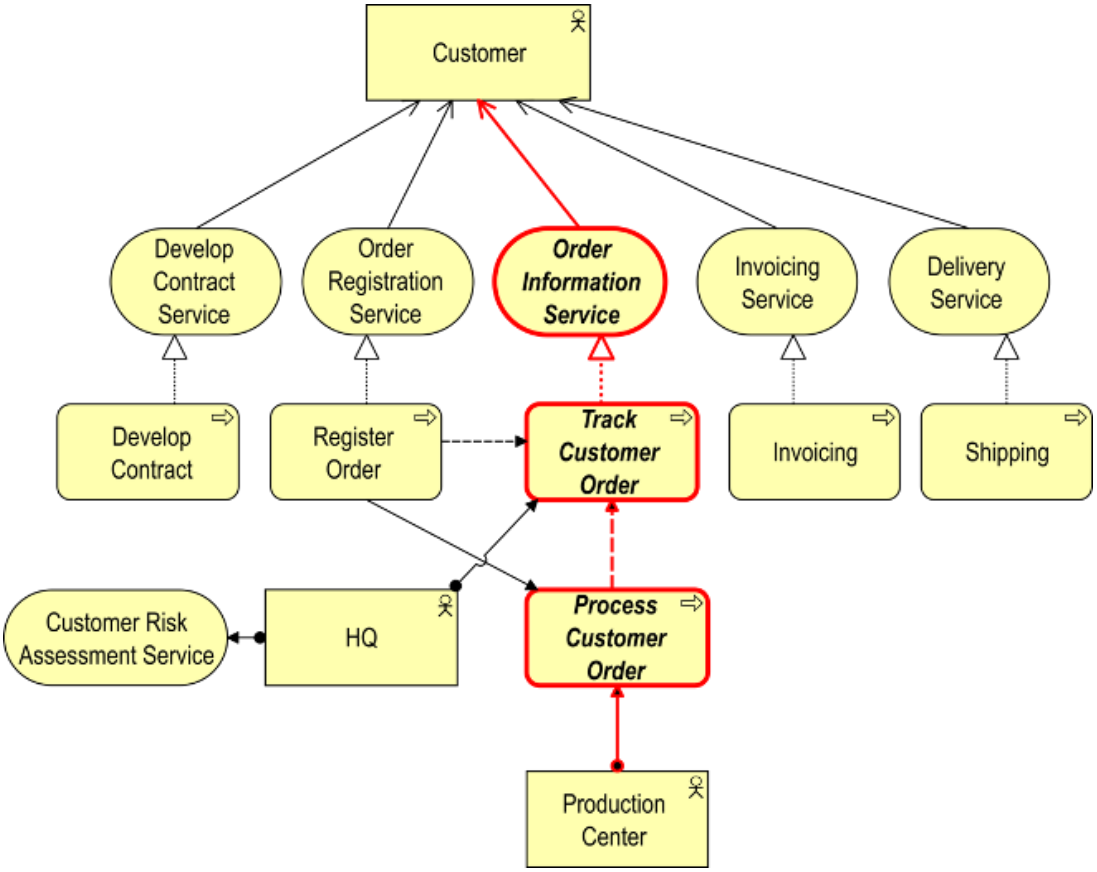

Figure 18: New Processes and their Inter-Dependencies with Existing Processes

The fact that all processes handling customer orders deal directly with individual customer orders allows for better coordination between them, and also allows more precise and efficient tracking of each customer order's status.

Application Architecture

The target architecture introduces CRM and customer order monitoring applications. These applications share customer data through an EAI bus.

The central HQ CRM system replaces the functionality of previous, per-DC customer data management applications. Now, DCs have limited edit rights over customer data, since assuring the correctness and uniqueness of customer entries is the responsibility of the Customer Service department within HQ.

The CRM system also manages customer orders and thus replaces regional order management applications and the Sales order management application used by the PC.

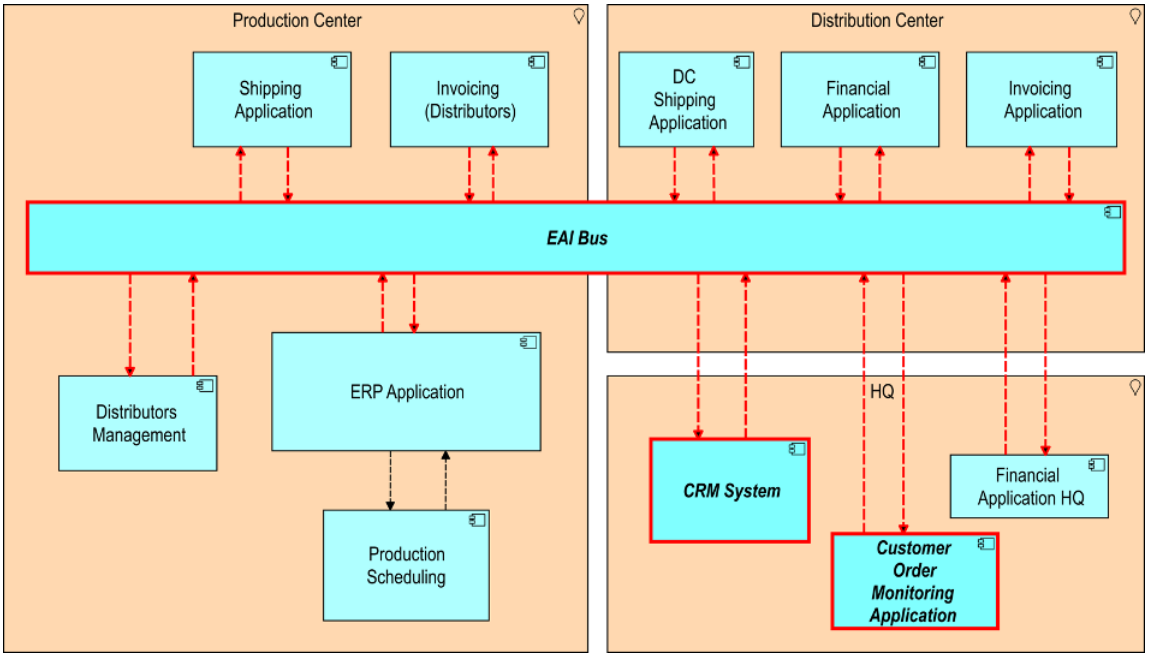

Figure 19: New Application Landscape with the CRM System Sharing Centralized Customer Data through an EAI Bus

In Figure 19, the customer order monitoring application implements the Order information service.

To enable the sharing of customer master data, new interfaces are defined and implemented on the EAI bus. For the purposes of order management, the CRM system interfaces through the bus with ERP components. The production and shipping order management used by the PC includes information about individual customer orders.

The DC invoicing applications now use shared master customer data managed by the CRM system, instead of relying on customer data stored in the separate databases owned by each DC. Reports on total customer debt are produced by invoicing applications in conjunction with the CRM system, which therefore requires new interfaces with the EAI bus.

Finally, the new Customer order monitoring application automates the Order Information service described above in the target Business Architecture. It makes key functionality directly available to customers with a web user interface. This application combines data from the HQ central CRM system and the regional shipping applications, and interfaces with them via the EAI bus (Figure 19).

Infrastructure

Compared to the baseline (Figure 13), the target infrastructure has similar components and delivers the same types of services. Additional application and database servers are added to the corporate data center for the new CRM application.

Implementation and Migration

Figure 20 summarizes how ArchiMetal achieves its transformation through a program composed of two successive projects, each with distinct deliverables that achieve a sequence of plateaus, or stable system

states. The first project implements the CRM application, and the second implements customer order monitoring. Figure 20 is a high-level view; it does not show the initial pilots and incremental rollouts used by each project to mitigate risks of business interruption and processing errors.

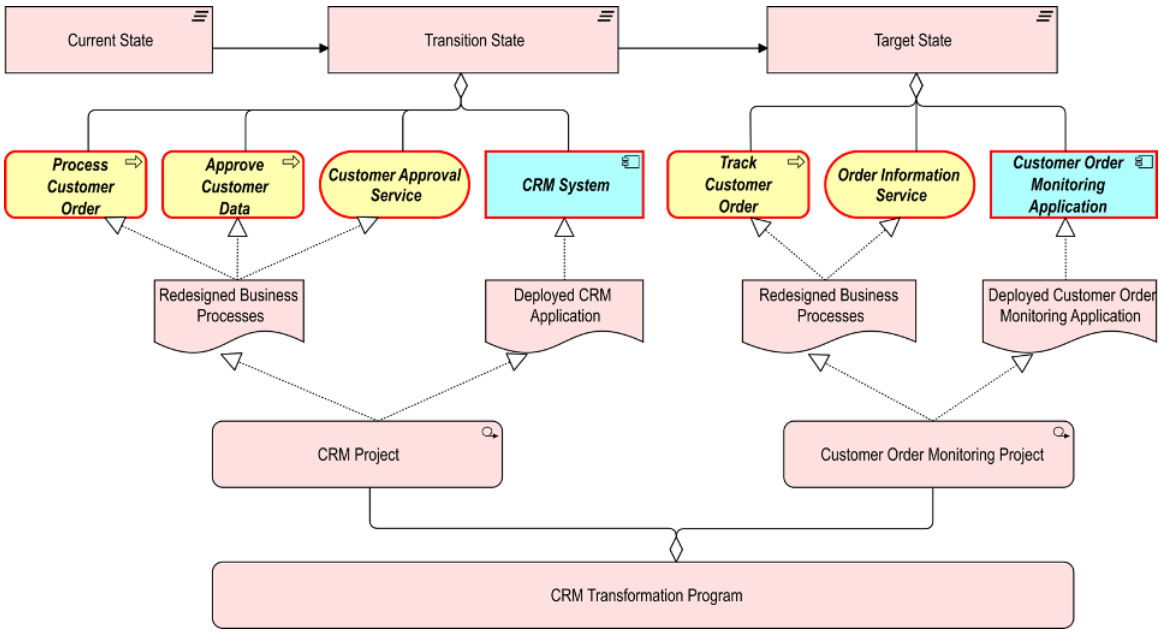

Figure 20: Implementation and Migration View for ArchiMetal CRM Transformation Program

Detailed Target Enterprise Architecture

This section provides additional details about the target Enterprise Architecture, including an urgent order scenario that illustrates the use of the ArchiMate language together with a key standard for manufacturing systems integration.

Business Processes and Applications Usage

The CRM transformation affects in particular the processes of Develop contract, Register order, Track customer order, and Process customer order, which were introduced in Figure 18.

To model these processes and their application support in more detail, two viewpoints defined by the ArchiMate standard are used: Business Process and Application.

Develop Contract

The process of contracting with new customers remains the responsibility of regional DCs since their sales forces are closest to the customer, and know regional languages and laws.

The changes to the existing process are emphasized in red in Figure 21. There is now formal verification of the data for each new customer (Approve customer data, assigned to HQ). This verification prevents duplication of customers in the shared master customer data examined by this process.

Figure 22 shows how the process Develop Contract is supported by the new CRM system, instead of by DC-specific applications and databases. In the new system DCs are still able to enter new customers and edit certain customer data (fields).

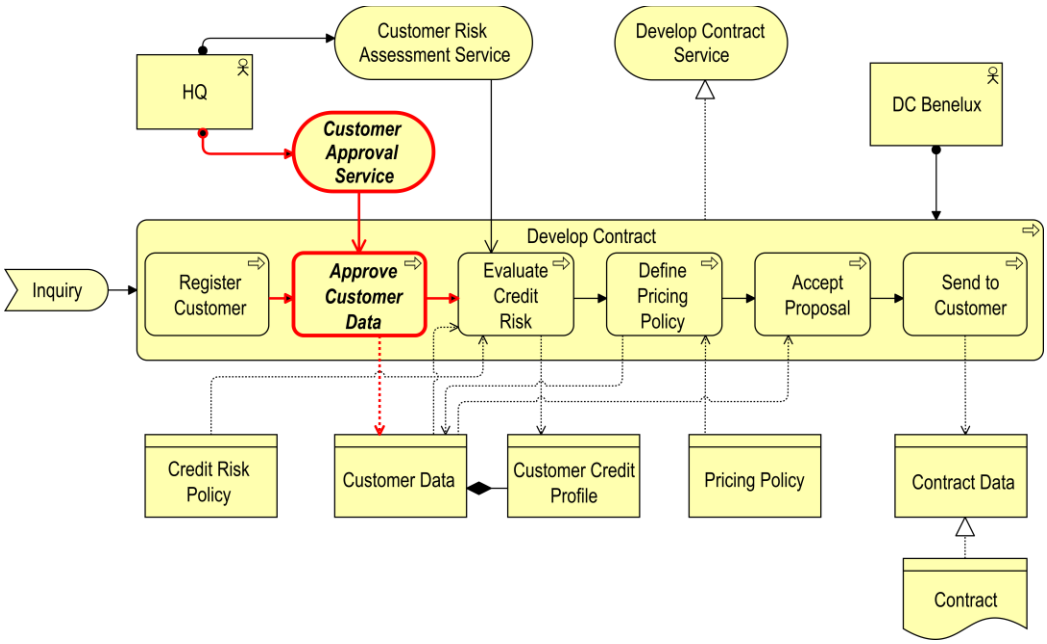

Figure 21: Registration of a New Customer

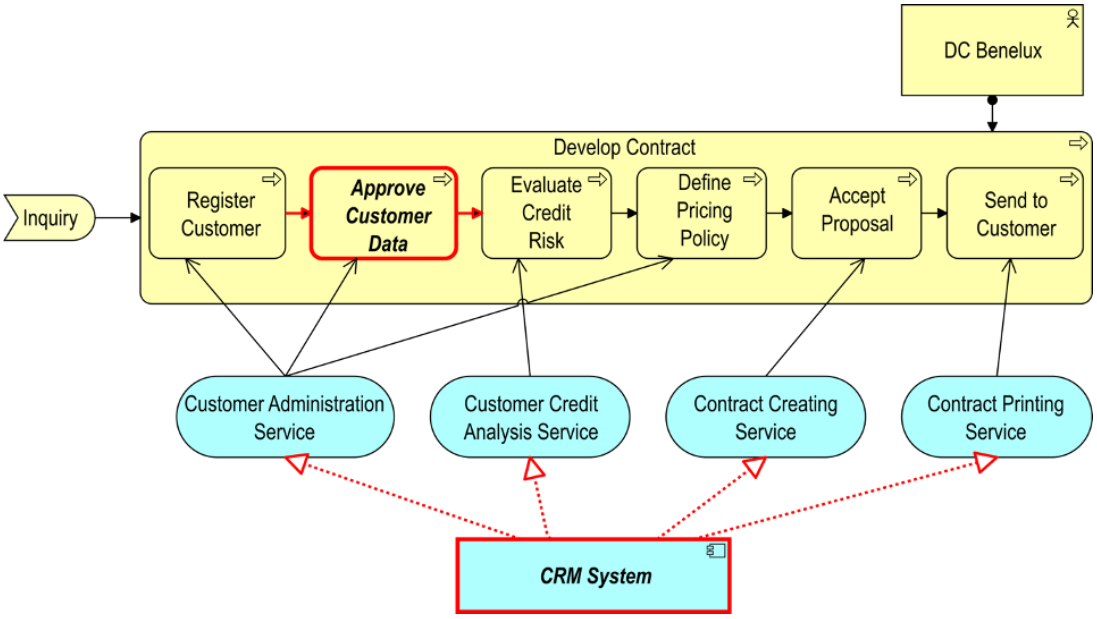

Figure 22: Support for the Develop Contract Process

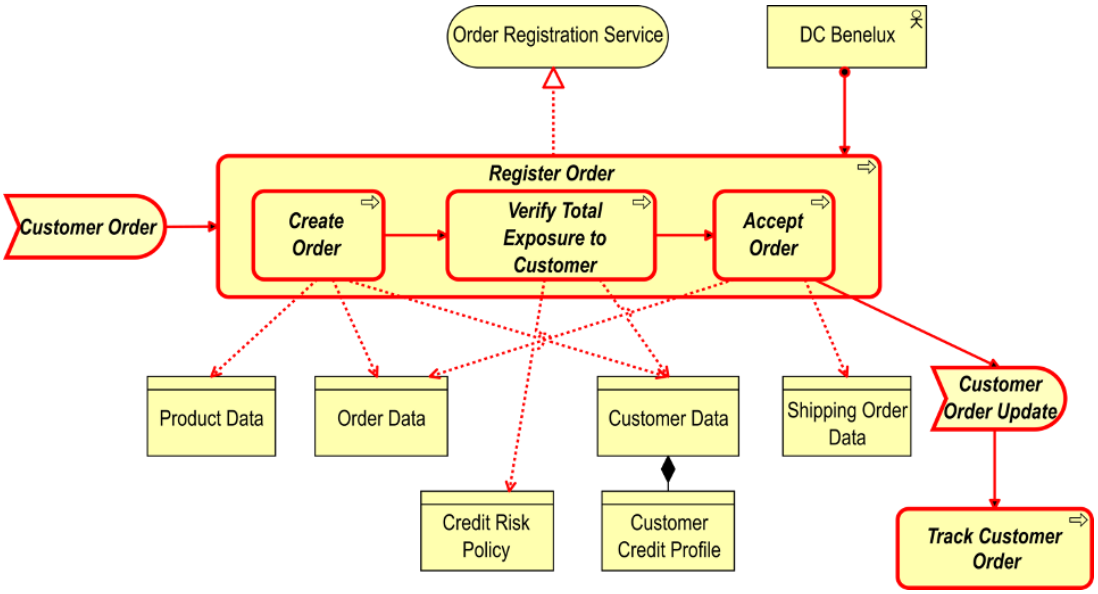

Figure 23: Registration of Customer Order

Register Order

The process of registering new customer orders remains the responsibility of regional DCs. As illustrated in Figure 23, the customer order is accepted upon the verification of customer credit exposure (i.e., after total exposure per customer *versus* assigned credit limit and collection history is analyzed). While retaining autonomy to accept orders, the DC must still request, from HQ, the approval of orders with potentially high

payment collection risk. Upon the registration of the customer order, the tracking of its status is automatically initiated.

Customer orders are managed in the CRM module for Customer order management (Figure 24). Communication with other systems such as shipping regarding the customer order is done via the EAI bus through new application interfaces.

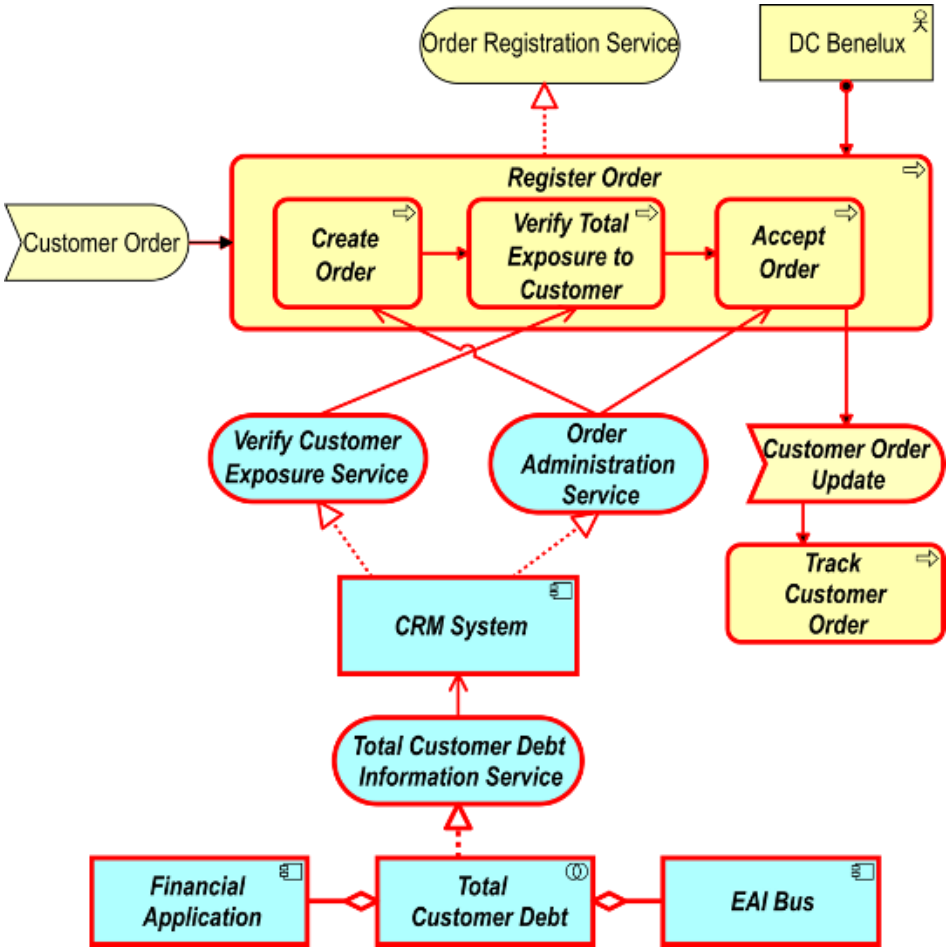

Figure 24: Application Usage by Register Order Process

Track Customer Order

The new Track customer order process (Figure 25) realizes the Order information service, which provides order status to customers in real time.

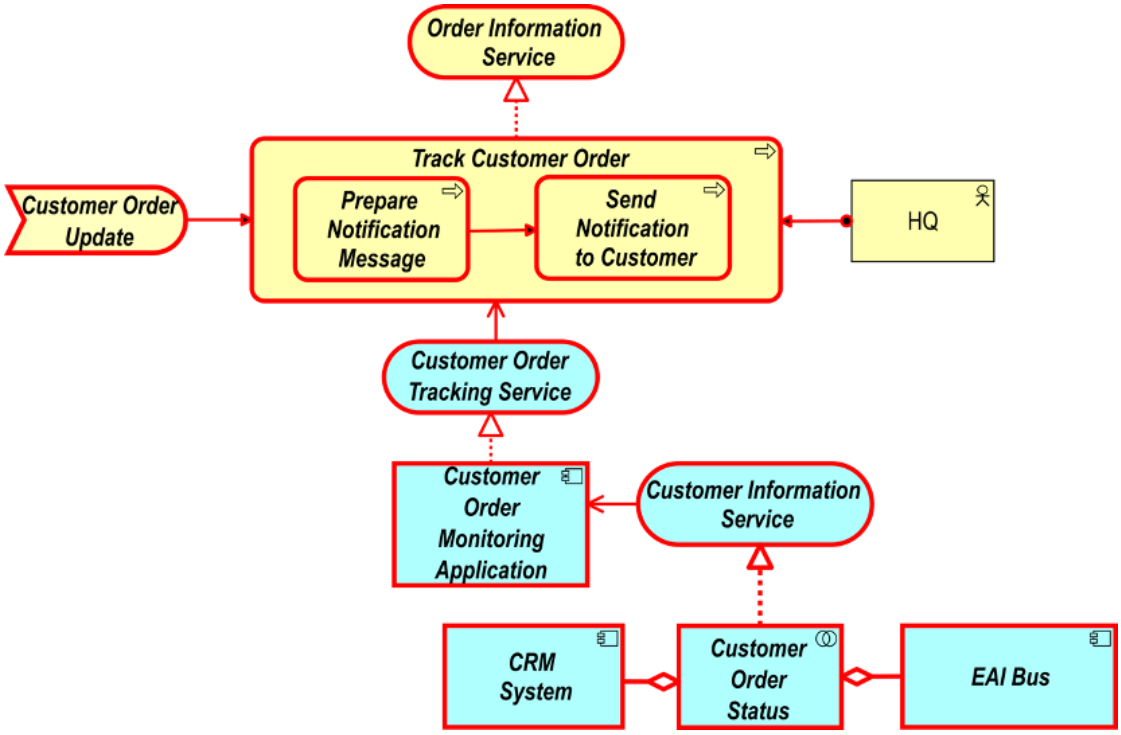

Figure 25: Track Customer Order Process

A subscription to the Order information service may be established along with a customer contract or as each order is placed. The customer may also at any time subscribe to this service on ArchiMetal's website. Notifications to the customer about the status of his order can be sent for any of these events:

- Order accepted
- Order received by PC
- Production estimate available
- Order in production
- Delivery estimate available
- Order shipped from the PC
- Order arrived at the DC
- Order shipped to customer

The customer notifications are generated by the Customer order monitoring application based on these events. This application manages the customer subscription to the tracking service, which includes the requested event notifications, as well as the channels (interfaces) through which the information should be sent to the customer.

The Customer Service department is responsible for the Order information service and for the Customer order monitoring application.

Process Customer Order

The new process, Process customer order (Figure 26), replaces the previous process, PC Sales order processing. This new process handles individual rather than aggregated customer orders. Relating production and shipping to the individual customer order allows for the company-wide visibility of customer and order-related data. In addition, such transparency enables manufacturing flexibility, and lays ground for offering advanced customer services, such as urgent and prioritized order placement, and late order modification.

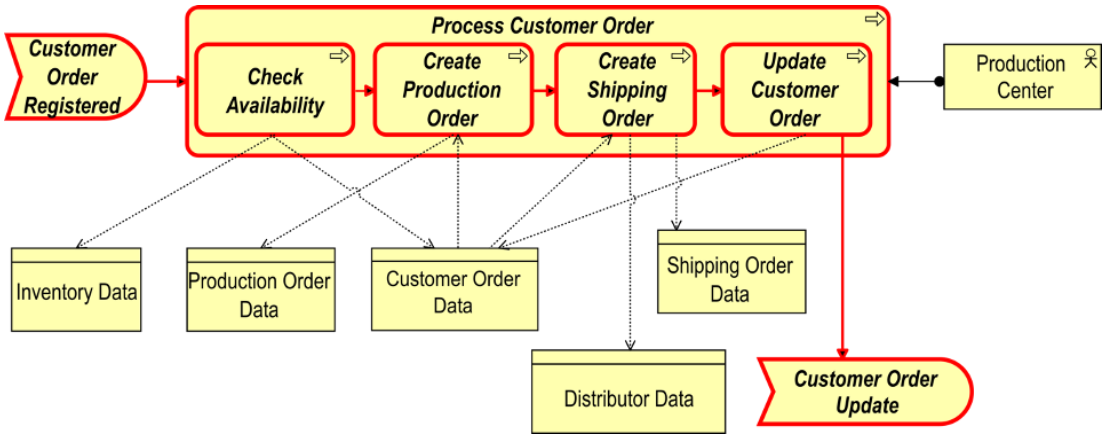

Figure 26: Process Customer Order Process

The Process Customer Order process uses customer order data provided by the central CRM system (Figure 27), instead of relying on local databases at each DC, as was the case in the baseline architecture. Within this process, the production and shipping orders are generated for each customer order.

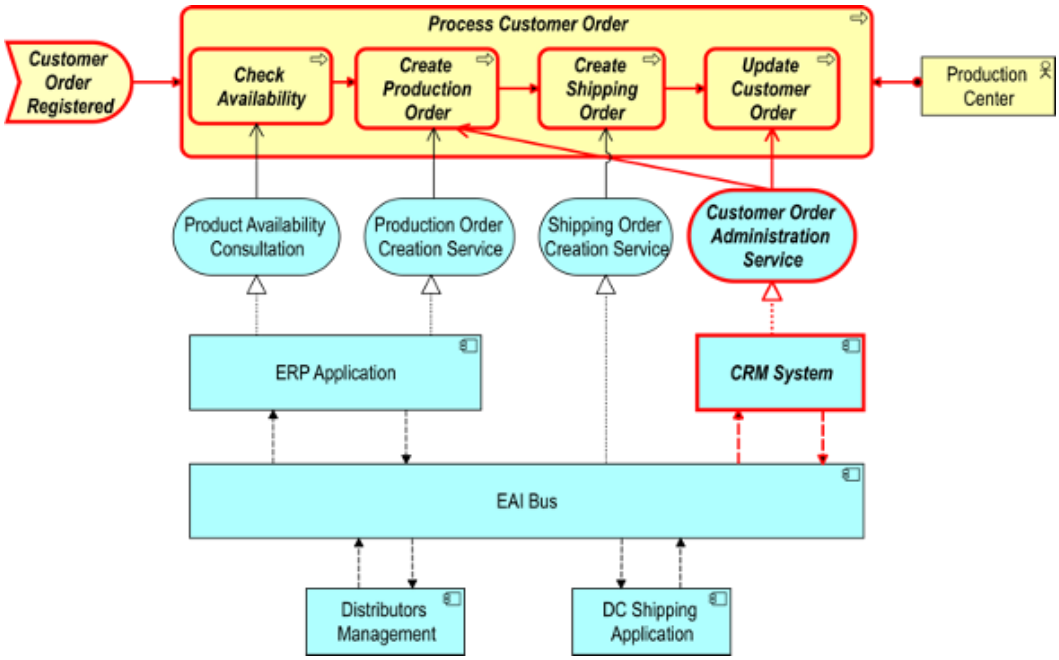

Figure 27: Applications Usage by the Process Customer Order Process

Target State Scenario: Processing an Urgent Customer Order

This scenario demonstrates the use of the ArchiMate language with the ISA-95 standard.

This scenario demonstrates the use of the ArchiMate language with the ISA-95 standard for communication between ERP systems and MES. Several years ago, ArchiBuilder, a construction company that regularly purchases steel beams from ArchiMetal, began work on a new building. However, early in the construction process, the local market for commercial real estate experienced a severe downturn, and the building's developer could not obtain sufficient financing to continue construction. Since then, the local market has improved, and the developer has just obtained sufficient financing to continue. However, this financing is contingent on an ambitious schedule for leasing and completing the building, so that tenants can move in and begin making lease payments. Therefore, ArchiBuilder has an immediate requirement for a set of steel beams that have already been designed by a structural engineer and priced by ArchiMetal. ArchiBuilder therefore places an urgent order for the beams with ArchiMetal. The order references a previous order that ArchiBuilder canceled when the construction process stalled due to a lack of financing. This scenario describes how ArchiMetal receives and fulfills this order.

A purchasing agent at ArchiBuilder phones his ArchiMetal sales representative, who takes the call at his office in DC Benelux. The representative is new to ArchiMetal, and therefore is not aware of the previously cancelled order. However, while he is on the phone, he uses the new CRM application to review the history of the cancelled order while the ArchiBuilder purchasing agent discusses the need for its reinstatement. Once the ArchiMetal representative understands the situation, he clicks on a link in the CRM system, which automatically signs him on to the ArchiMetal ERP system and displays information about the cancelled order. Then, he creates a new order based on a copy of the cancelled order. Since it has been several years since ArchiMetal priced the cancelled order, it must be re-priced based on current market conditions and also on an accelerated production schedule that ArchiBuilder has requested. The Stakeholder view in Figure 28 uses concepts and relationships from the ArchiMate Motivation extension to express this situation. This Stakeholder view shows the relationships between the Builder (ArchiBuilder) and the Building products manufacturer (ArchiMetal).

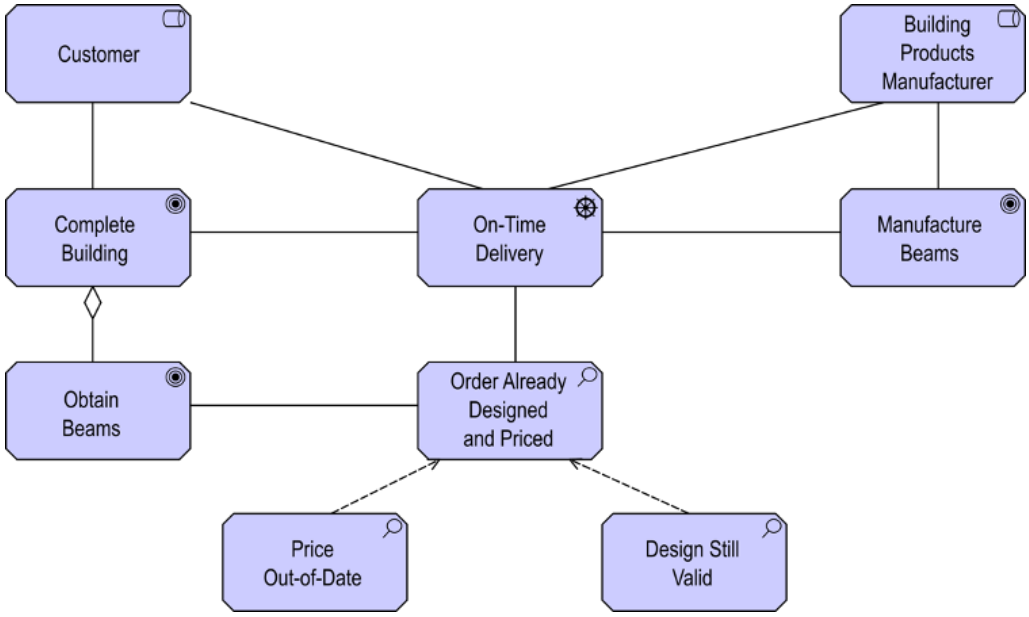

Figure 28: Stakeholder View

The ArchiMetal representative triggers a workflow to re-price the order and generate the necessary contracts. The workflow begins with two parallel steps. An engineer in the manufacturing department at PC uses the ERP system to plan the manufacture of the ArchiBuilder order, including the amounts and prices of all required materials, and all necessary tooling and set-up, and a proposed delivery schedule for the beams. At the same time, a credit specialist at the HQ Finance Department evaluates ArchiBuilder and determines the rules by which ArchiMetal should extend credit. Once both of these steps are complete, a proposal specialist collaborates with the account manager for ArchiBuilder to develop a proposal to manufacture the beams. Then, they present the proposal to the responsible sales and production managers, who may require changes before they approve it. Once approvals are complete, the account manager delivers the proposal to the ArchiBuilder procurement manager. A few days later, ArchiBuilder accepts the proposal by sending an electronically signed contract to ArchiMetal. The Business Process Cooperation view in Figure 29 describes the process for converting an order to a contract at ArchiBuilder. In that view, both the CRM and ERP application services are externally visible, aggregated behaviors of application components mentioned elsewhere in this Case Study.

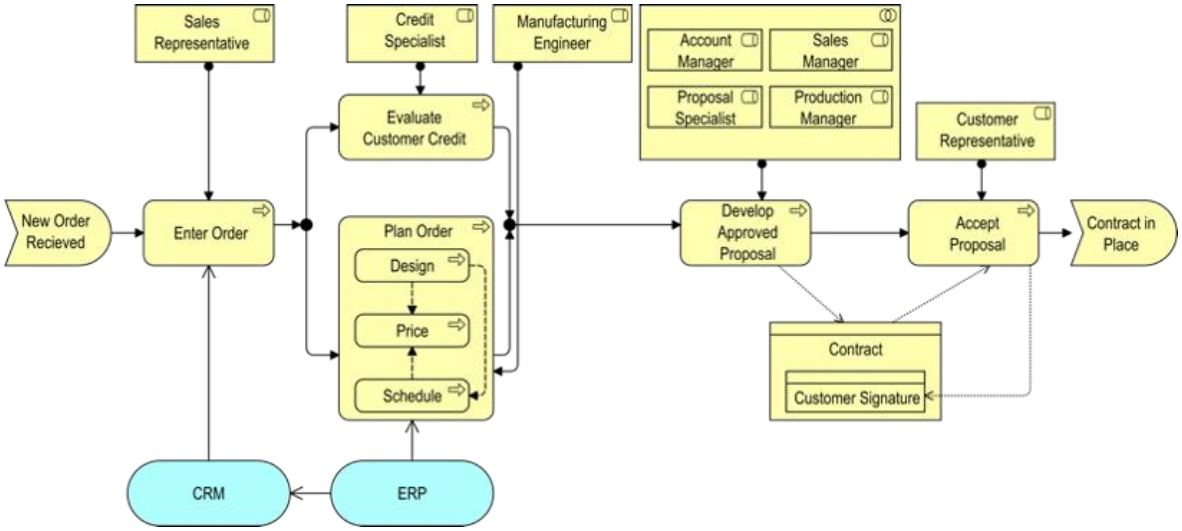

Figure 29: Business Process Cooperation – Converting an Order to a Contract

Once ArchiMetal receives an order, a Sales Representative uses the CRM application service to record it. Then a Credit Specialist and a Manufacturing Engineer work in parallel to complete customer credit vetting and plan the order. Order planning involves design, pricing, and scheduling, and uses the ERP application service. Once credit vetting and order planning are completed, a Proposal Specialist works with Account, Sales, and Production Managers to develop and approve a proposal, which a Customer Representative must accept before it is placed as an order. The CRM application service uses the ERP application service to display information about prior orders. Once the form is received, ArchiMetal prepares to fulfill this urgent order. A production planner uses the ERP system to activate the plan for beam manufacture, a logistics planner uses the ERP system to activate the delivery schedule, which includes sending orders to preferred freight transportation companies, and a manufacturing engineer begins the process of readying an available production line to manufacture the beams. The Business Process Cooperation view in Figure 30 below shows how ArchiMetal fulfills an order.

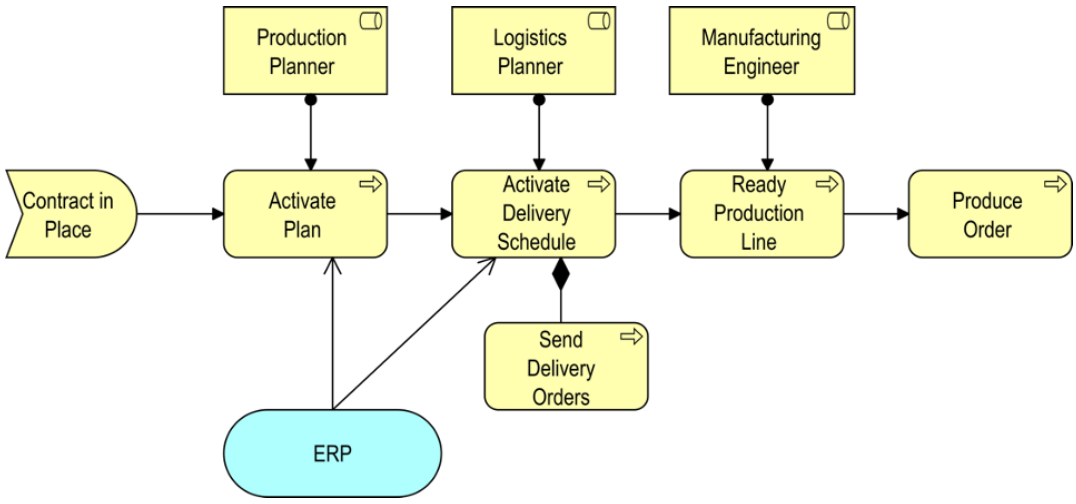

Figure 30: Business Process Cooperation – Fulfillment of an Order at ArchiMetal

Once the production line is ready, the ERP planning module uses the ISA-95 standard messages to direct the MES that controls production. Specifically, the planning module uses a PROCESS message[2] to transmit the schedule for the first production run, and the MES sends back an ACKNOWLEDGE – ACCEPTED message to acknowledge that the message was received. As production continues, the ERP monitoring module requests status from the MES using a GET message, to which the MES responds with a SHOW message. The ERP relays key status updates to the CRM system used by the marketing and sales functions, so that their staff have up-to-date information as they work with their ArchiBuilder contacts. Production proceeds as planned until the third production run, when a material shortage malfunction suspends production for several hours. The ERP uses a SYNC CHANGE message to communicate the revised schedule to the MES, which uses a RESPOND message to indicate that it has implemented the change. The Business Process view in Figure 31 below shows how ArchiBuilder Enterprise and Control business functions exchange messages in order to change a production schedule. Business Process views may show business functions as well as processes.

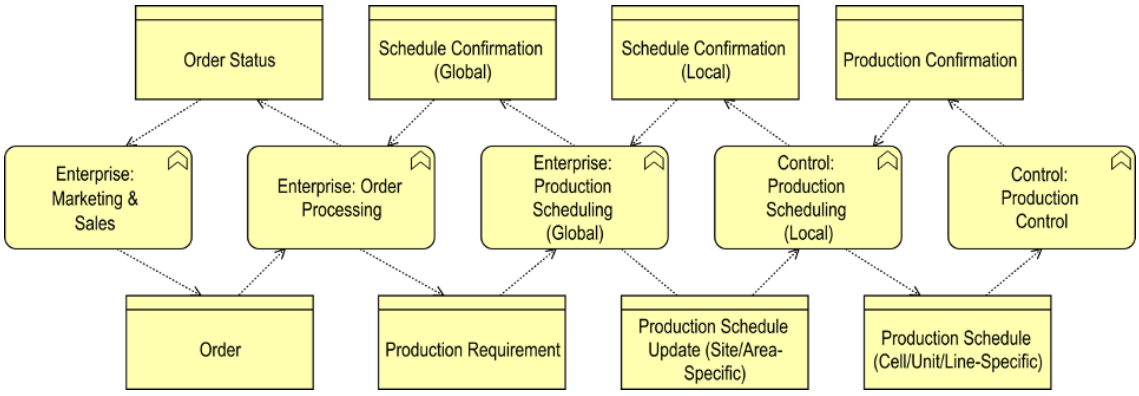

Figure 31: Business Process View

While the MES is executing this revised schedule, ArchiMetal receives an urgent message from ArchiBuilder: a minor redesign to the building requires additional beams quickly. Once ArchiMetal processes this change order, the ERP system sends a SYNC CHANGE message to the MES to revise the production schedule again, along with a pair of PROCESS messages. The first PROCESS message instructs the MES to add a new production schedule for the additional beams. The second PROCESS message instructs the MES to add additional equipment to meet the new schedule. In response, the MES issues a RESPOND message for the SYNC CHANGE, along with two ACKNOWLEDGE messages for the PROCESS messages. The first ACKNOWLEDGE returns the Identifier (ID) that the MES has assigned to the new production schedule, and the second ACKNOWLEDGE returns the IDs of the equipment that the MES has added to meet the new schedule. The Information Structure view in Figure 32 shows how messages handled by applications realize the messages exchanged between the ArchiBuilder Enterprise and Control business functions in this scenario. Business objects are realized by data objects. Request-response pairs are connected with association relationships.

[2] This scenario identifies message types using the names of the ISA-95 verb they include; e.g., a PROCESS message includes the PROCESS verb.

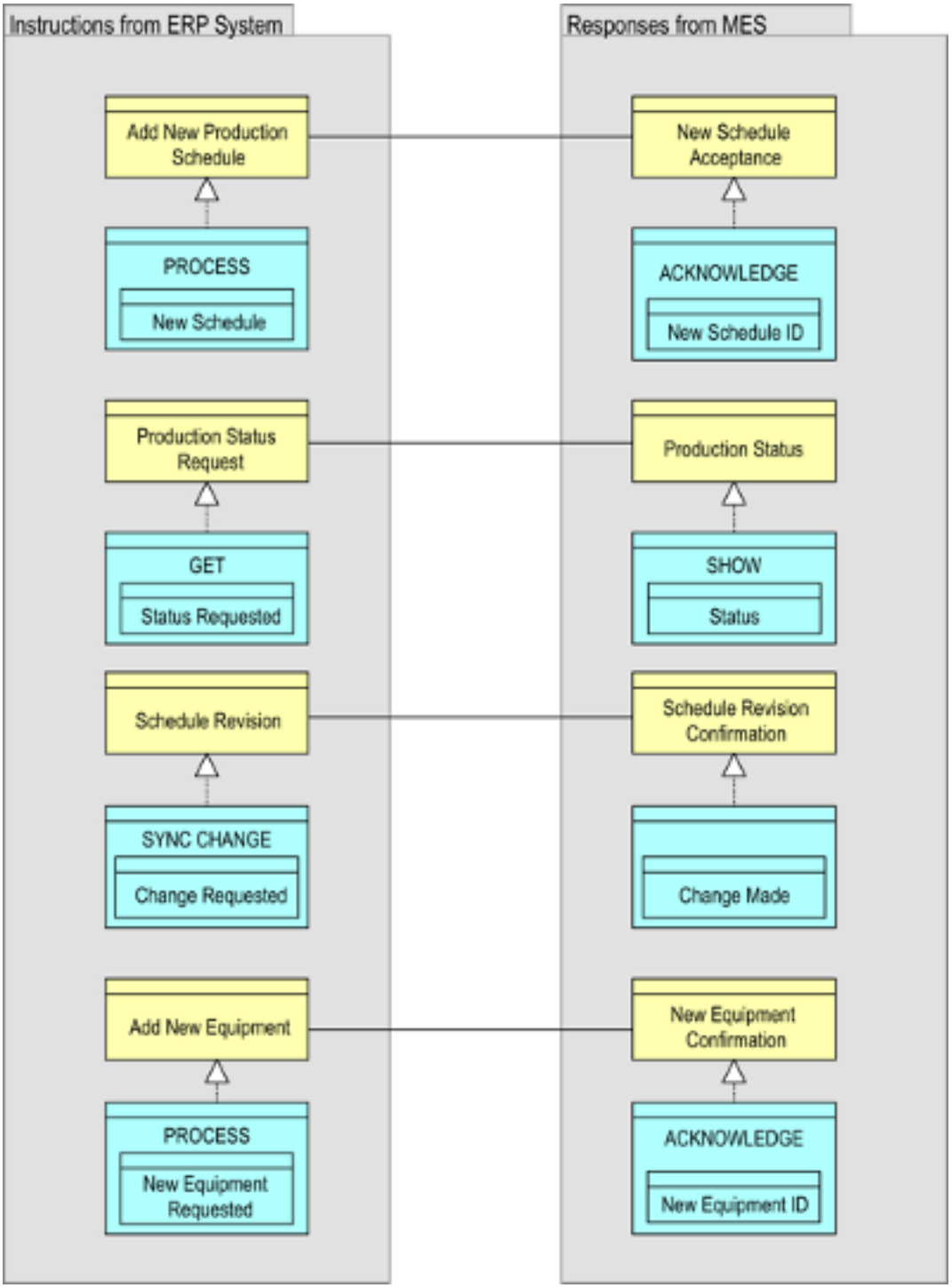

Figure 32: Information Structure View

Benefits of Enterprise Architecture with the ArchiMate Language

The shared customer view and coordinated customer services processes implemented through the transformation initiative described in this Case Study have improved ArchiMetal's customer service and satisfaction. ArchiMetal's customers, on average, rate the company much higher on periodic satisfaction surveys, and are much less likely to choose alternate suppliers. The shared customer view has also enabled ArchiMetal to coordinate customer negotiation, order fulfillment, and problem resolution across the enterprise. As a result, conflicting and duplicate efforts in these areas have been eliminated, and labor costs have consequently declined. ArchiMetal can now negotiate with customers, forecast demand, and resolve delivery issues as one company, which has resulted in more profitable customer contracts with accelerated delivery schedules.

These achievements have increased ArchiMetal's revenue and decreased its costs. Upon recognizing the enhancement in business performance was due to fundamental and sustainable internal changes, ArchiMetal's management ordered a comparison study of ArchiMetal's financial performance and customer satisfaction with publicly available information within the automative supply market. A team of ArchiMetal's financial, manufacturing, service, and marketing experts found that ArchiMetal was performing at a level comparable to automotive supply market leaders. ArchiMetal management then tasked the same team with a plan to enter that market.

… participants cited draft and final deliverables that enabled all stakeholders to collaborate regardless of their background, and provided a clear foundation for the work of specialists …

During a routine cross-disciplinary review of the entire transformation initiative soon after it completed, all participating stakeholders agreed that the work had gone more smoothly than comparable efforts in the past. They attributed this largely to better Enterprise Architecture. In particular, participants cited draft and final deliverables that enabled all stakeholders to collaborate regardless of their background, and provided a clear foundation for the work of specialists in areas such as software, database, and business process design. The ArchiMate views in the figures and tables of this Case Study were key elements of those deliverables.

Conclusion

This Case Study demonstrates the value that a formal Enterprise Architecture approach, with standardized visual modeling, provides to operational business improvement, using techniques that are applicable to any manufacturing organization.

ArchiMate models provide the big picture of business processes and their underlying IT, while intentionally leaving out the design details …

Enterprise Architecture provides a holistic view of the enterprise, and captures essentials of the business, its information systems, and their evolution. As such, it is a crucial component of enterprise transformation initiatives. The Case Study illustrates in particular how The Open Group ArchiMate standard for high-level architectural modeling can be used to analyze, design, and guide enterprise transformation processes. ArchiMate models provide the big picture of business processes and their underlying IT, while intentionally leaving out the design details of processes, applications, and technical infrastructure. The ArchiMate modeling language instead focuses on the global structure of these domains and on the relationships between them. This helps stakeholders ranging from business executives to engineers understand the alignment between components such as business processes and their supporting applications.

The concepts of the ArchiMate modeling language are sufficiently generic and expressive to model many aspects of business structure, motivation, and function, along with the structure and function of supporting technology. However, the ArchiMate language is not designed to replace languages for specific and detailed design, such as BPMN™ [4] for business processes or UML® [5] for software. Rather, the ArchiMate language frames and integrates work between levels through high-level architecture models.

The ArchiMate language can also be used with standards specific to business domains. In this Case Study, ArchiMate is used with the ISA-95 standard [3]for integrating information systems used in manufacturing enterprises. ISA-95 governs the exchange of information between enterprise systems and control systems for production, maintenance, and quality.

Like the fictional ArchiMetal, virtually all organizations must change significantly at some point – if not continuously – in order to survive or prosper. The ArchiMate language is a powerful tool for developing and communicating the motivations, business, application, and technology transitions, and implementation approaches for complex, mission-critical transformations.

Opportunities for Further Work

As previously discussed, the ArchiMetal organization used for this Case Study is simpler than typical real-life scenarios. The most important simplifications concern the organizational structure, and the focus on sales, production, and distribution instead of the entire supply chain.

In the scenario described here, ArchiMetal only has one PC. For a company large enough to require integrated ERP and MES capabilities, multiple PCs are more likely. For example, if multiple PCs were making the same products, then enterprise-level production planning would require some way of forecasting aggregate capacity. This would have an impact on ArchiMetal's ability to promise product delivery to customers. This dimension could be taken into account in future versions of the Case Study.

... future versions of this Case Study may consider the entire supply chain ...

The scenario in this Case Study focuses on the sales, production, and distribution capabilities of ArchiMetal. In particular, the provisioning of raw materials and semi-finished goods to the PC and its relationship to production planning and sales is not discussed. However, future versions of this Case Study may consider the entire supply chain in order to address all the factors involved in promising and delivering products.

A more complete treatment of the supply chain could also consider the *bullwhip effect* [6] of increasingly wide swings in inventory as shifts in customer demand ripple upstream in the supply chain. The lack of coordination between sales and distribution and production planning described in this Case Study can trigger this effect. Future versions of the ArchiMetal scenario could include the collaborative forecasting and distribution techniques that organizations use to avoid such volatility.

Furthermore, the Case Study currently only addresses physical production and logistics in a cursory manner, showing how these can be modeled using the physical elements of the ArchiMate 3.2 Specification. In a future version, the Case Study could be expanded to include both the physical production and logistics in more detail, and the computer-controlled nature of modern manufacturing operations in an "Industry 4.0" world. An end-to-end integrated model of the product, information, and value streams within the entire supply chain would provide a useful analysis instrument for many different purposes.

Appendix A: Core Concepts and Standards

This section introduces the Enterprise Architecture, manufacturing, and CRM concepts and standards at the heart of the ArchiMetal Case Study.

Enterprise Architecture

At the core of this work is the concept of an enterprise. According to [7]:

An enterprise is a complex, socio-technical system that comprises inter-dependent resources of people, information, and technology that must interact with each other and their environment in support of a common mission.

In the Case Study, the enterprise is ArchiMetal, a fictitious manufacturer of metal products. The Case Study describes the baseline and target states of the ArchiMetal enterprise within each of the four TOGAF Enterprise Architecture domains. Each domain has different areas of concern [2].

Table 1: TOGAF Enterprise Architecture Domains and their Concerns

TOGAF Architecture Domain	Areas of Concern
Business	Business strategy, governance, organization, and key business processes
Data	Structure of logical and physical data assets and data management resources
Application	Applications, their interactions, and their relations to core business processes
Technology	Logical software and hardware capabilities required to support the other domains

The TOGAF standard specifies an Architecture Development Method (ADM) for developing Enterprise Architectures, turning them into actionable plans, and managing them as business and technical circumstances evolve over time (Figure 33). There is a direct correspondence between the Enterprise Architecture domains defined by the TOGAF standard and the three ADM phases. Phase B (Business Architecture) and Phase D (Technology Architecture) guide the development of the Business and Technology domains, respectively, while Phase C (Information Systems Architectures) guides the development of the Data and Application domains.

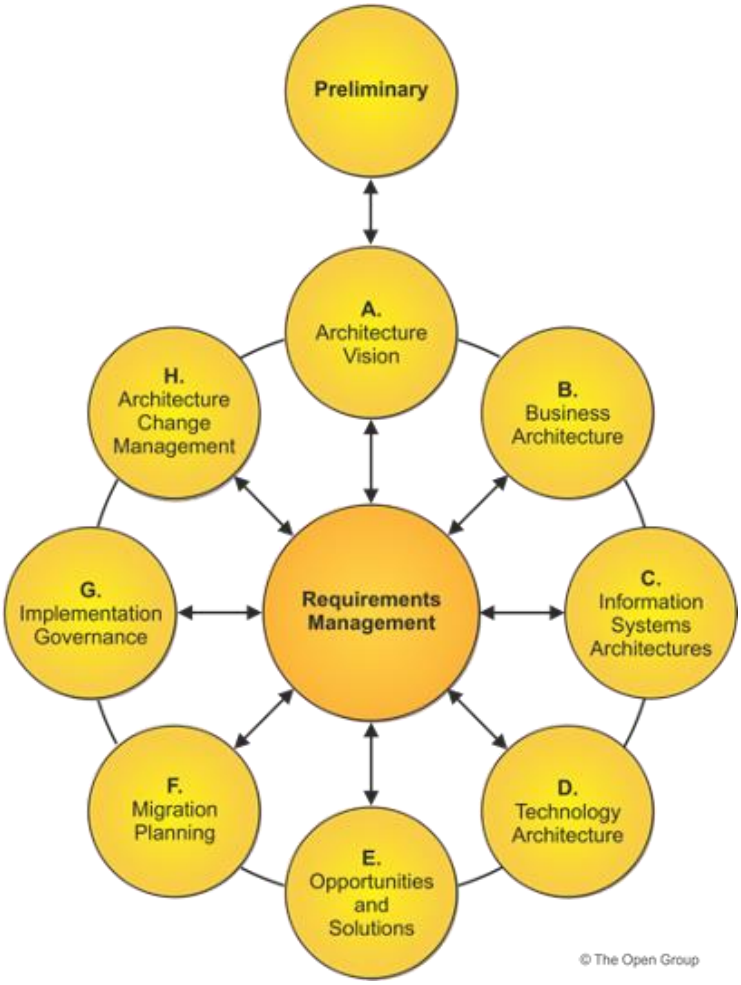

Figure 33: TOGAF Architecture Development Method

The ArchiMate language [1] is closely aligned with the TOGAF standard (Figure 34). It supports the ADM Phases B through D by modeling its three aspects of Passive Structure, Behavior, and Active Structure at each of its three core layers: Business, Application, and Technology. In addition, it includes two extensions. The Strategy and the Motivation elements support the Preliminary, Requirements Management, Phase A, and Phase H with such concepts as capabilities, resources, stakeholders, drivers, assessments, goals, and requirements. The Implementation and Migration elements address the ADM Phase E (Opportunities and Solutions), Phase F (Migration Planning), and Phase G (Implementation Governance), with concepts such as work packages, gaps, deliverables, and plateaus, which are stable system states.

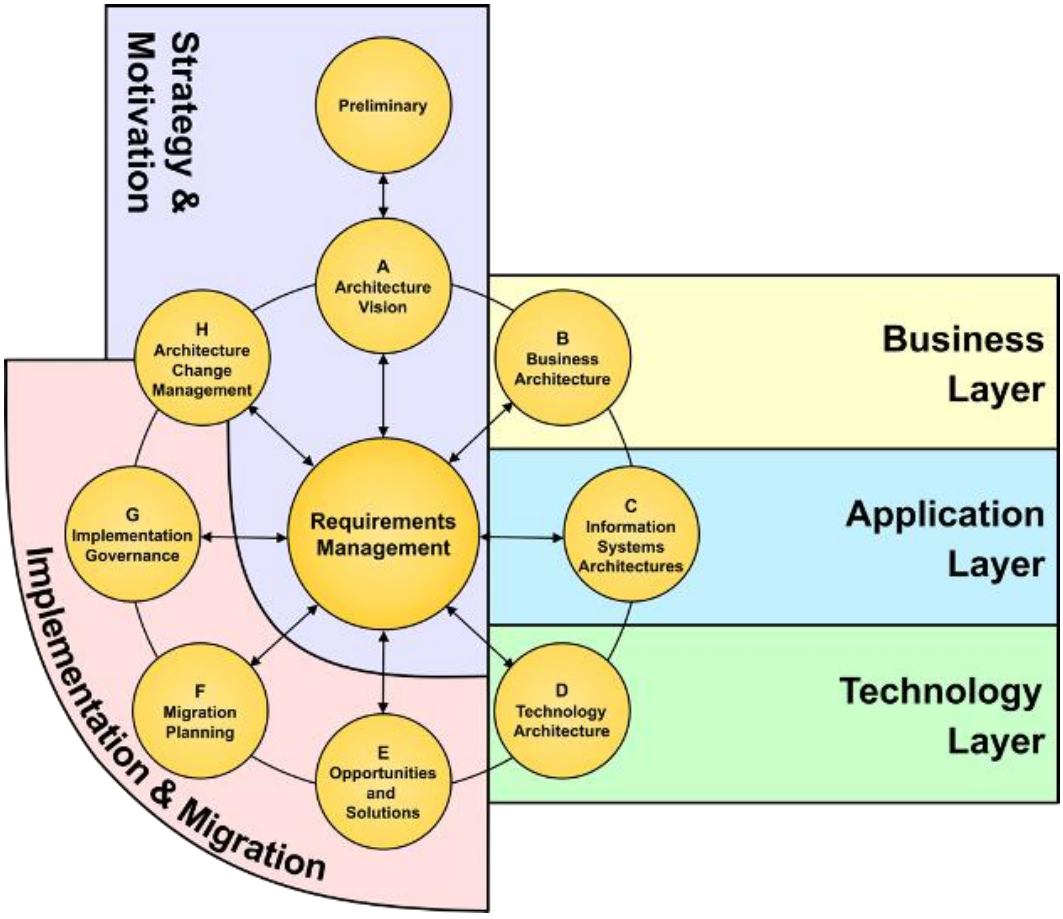

Figure 34: Alignment between the TOGAF Standard and the ArchiMate Language

Entities modeled with the Implementation and Migration elements realize core elements such as business processes, application components, and server hardware. These core elements in turn can be shown to realize Motivation elements such as requirements and goals. Figure 35 provides a generic example of relationships between ArchiMate core and other elements. It models business transformation and IT projects as ArchiMate work packages that realize business and application services, respectively. Those services in turn realize business and IT goals. The business service is realized (provided) by a business process. A server (hardware device) realizes (hosts) an application component, which in turn realizes (provides) the application service used by the business process.

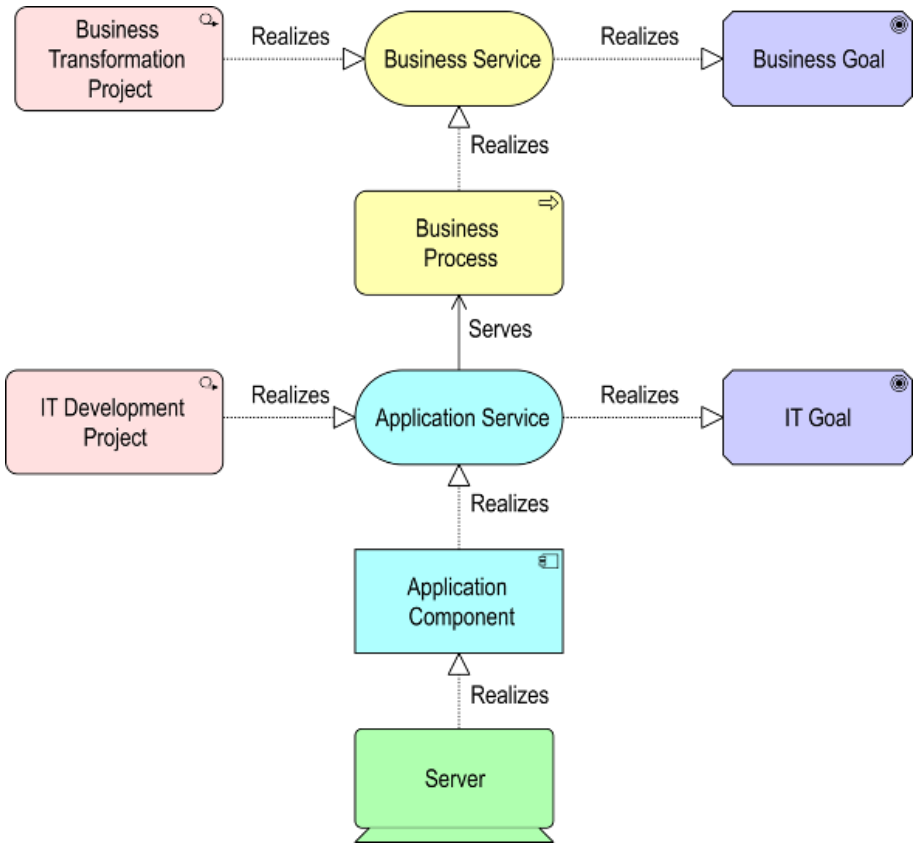

Figure 35: Generic Example of ArchiMate Core Layers and Extensions

In Figure 35, Business layer elements are yellow, Application layer elements are blue, and the Technology layer element is green. Motivation extension concepts are purple, and Implementation and Migration extension concepts are pink.

Manufacturing

The combination of the TOGAF standard and the ArchiMate language yields a versatile Enterprise Architecture approach applicable to a broad range of business transformation challenges. This Case Study complements these compatible paradigms with ISA-95 [3], which is a standard for integrating systems used in manufacturing enterprises. ISA-95 governs the exchange of information between enterprise[3] systems such as those that support sales, finance, and logistics with control systems for production, maintenance, and quality.

[3] Note that the term "enterprise", as it relates to ISA-95, describes systems that support common business functions, as opposed to the systems that support functions specific to manufacturing, which are known as control systems.

ISA-95 has broad industry support. It is managed by the International Society for Automation [8], which is a professional organization that claims over 30,000 members. ISA-95 is supported in products from major IT suppliers, such as IBM [9], SAP [10], and Oracle [11], and is also the basis for IEC 62241.[4] The Business to Manufacturing Markup Language (B2MML) [12] implements ISA-95 in XML, and is also the basis for IEC 62264. [5]

Table 2: Structure of the ISA-95 Standard for Enterprise-Control System Integration

Part Identifier	Title	Contents
ANSI-ISA 95 00 01 2000	Part 1: Models and Terminology	Describes relevant functions in the enterprise and control domains, and the objects typically exchanged between them.
ANSI-ISA 95 00 02 2001	Part 2: Object Model Attributes	Defines the details of the interface objects identified in Part 1.
ANSI-ISA 95 00 03 2005	Part 3: Activity Models of Manufacturing Operations Management	Defines the production work flow management interactions between the enterprise and control domain and identifies some of the data these interactions exchange.
ANSI-ISA 95 00 04 2007	Part 4: Objects and Attributes for Manufacturing Operations Management Integration	For the interactions identified in Part 3, defines the object model and attributes of the data they exchange.
ANSI-ISA 95 00 05 2007	Part 5: Business-to-Manufacturing Transactions	Defines the transactions used to interface business and manufacturing activities, including the exact structures of the messages used in these transactions.

The ISA-95 standard has five parts (Table 2). This Case Study uses ISA-95 Part 1 to provide an overall functional model of the enterprise-control system interface, Part 3 to model workflow management interactions across that interface, and the higher-level information in Part 5 to identify transactions; i.e., message sequences that flow across the interface. The information in Parts 2 and 4, as well as the field-level message elements and detailed transaction specifications in Part 5, are too detailed for Enterprise Architecture.

The general-purpose ArchiMate language readily adapts to the manufacturing domain. Figure 36 below is a summary ArchiMate functional enterprise-control model based on ISA-95. In this figure, the arrows show the usage relationships between business and application functions, services, and interfaces. Figure 37 and Figure 38, respectively, show the ISA-95 enterprise and control business functions. ISA-95 uses a five-level functional model of manufacturing. Level 4 comprises the enterprise functions for business planning and logistics; Level 3 comprises the manufacturing operations and control (often shortened to just "control") functions; and Levels 2, 1, and 0 define functions for manufacturing cell or line supervision, operations, and

[4] IEC 62261: Nuclear Power Plants – Main Control Room – Alarm Functions and Presentation.

[5] IEC 62264: Enterprise-Control System Integration.

process control. ISA-95 is concerned with the interface between Levels 3 and 4; i.e., the enterprise-control interface.

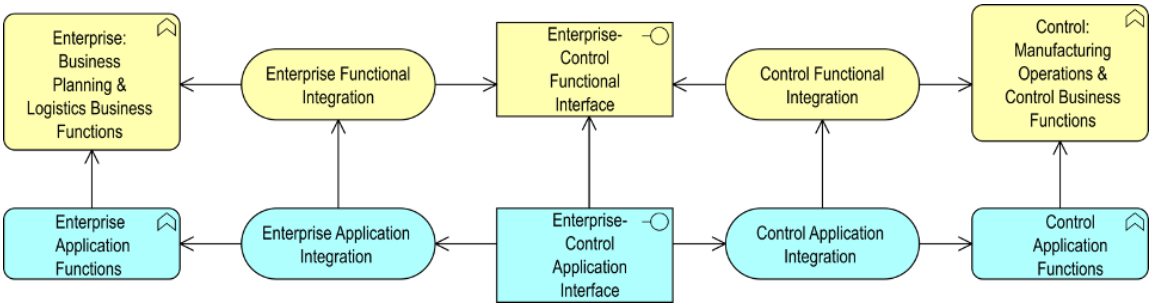

Figure 36: Summary Layered View of a Functional Enterprise-Control Model Based on ISA-95

Figure 36 uses three colors to denote different types of enterprise business functions. The yellow symbols represent the Level 4 enterprise business planning and logistics functions described in the ISA-95 standard. The orange symbols represent additional functions described by the standard that interact with the Level 4 functions. The green symbol represents an enterprise function – Customer Service – which is inserted in the functional model for the Case Study.

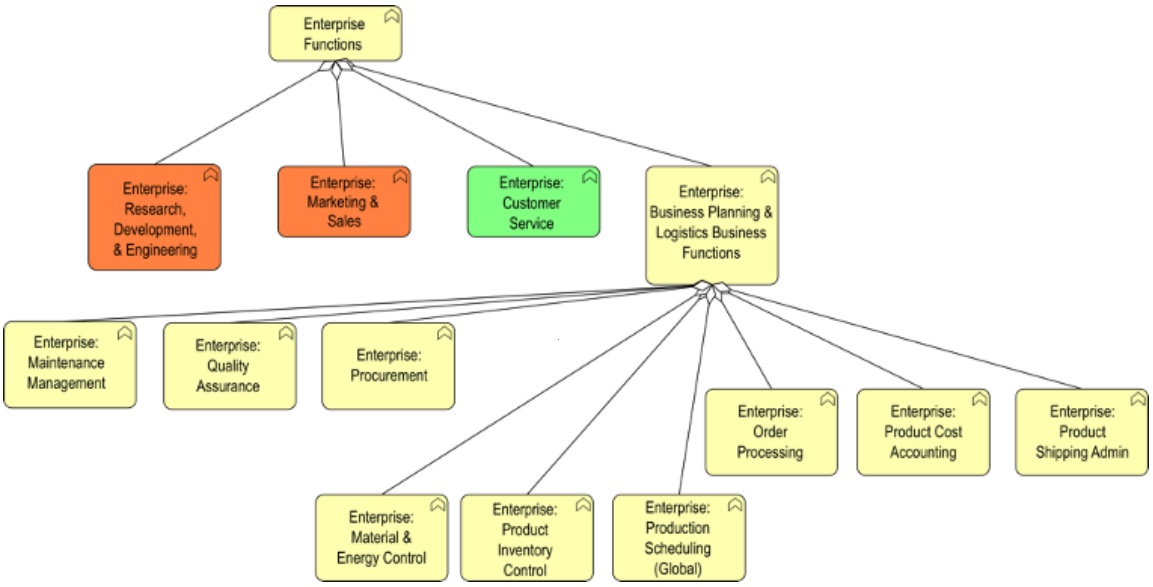

Figure 37: ISA-95 Level 4 Enterprise Business Functions

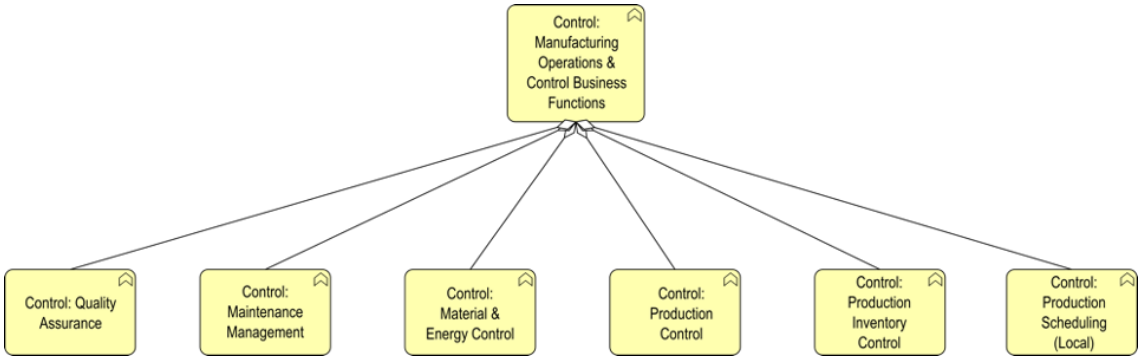

Figure 38: ISA-95 Level 3 Control Business Functions

Figure 38 illustrates the relationship between the ISA-95 enterprise and control functions and the physical manufacturing environment. The uppermost grouping in this figure shows that a site is used by an enterprise, and a site is composed of areas. Level 4, (enterprise) business functions, applies here. The next lower grouping shows the components that make up a manufacturing area, and their controllers, which are modeled as ArchiMate nodes. Level 3, (control) business functions, applies to this grouping. Level 0, 1, and 2 basic manufacturing activities nested in this grouping are assigned to components within manufacturing areas.

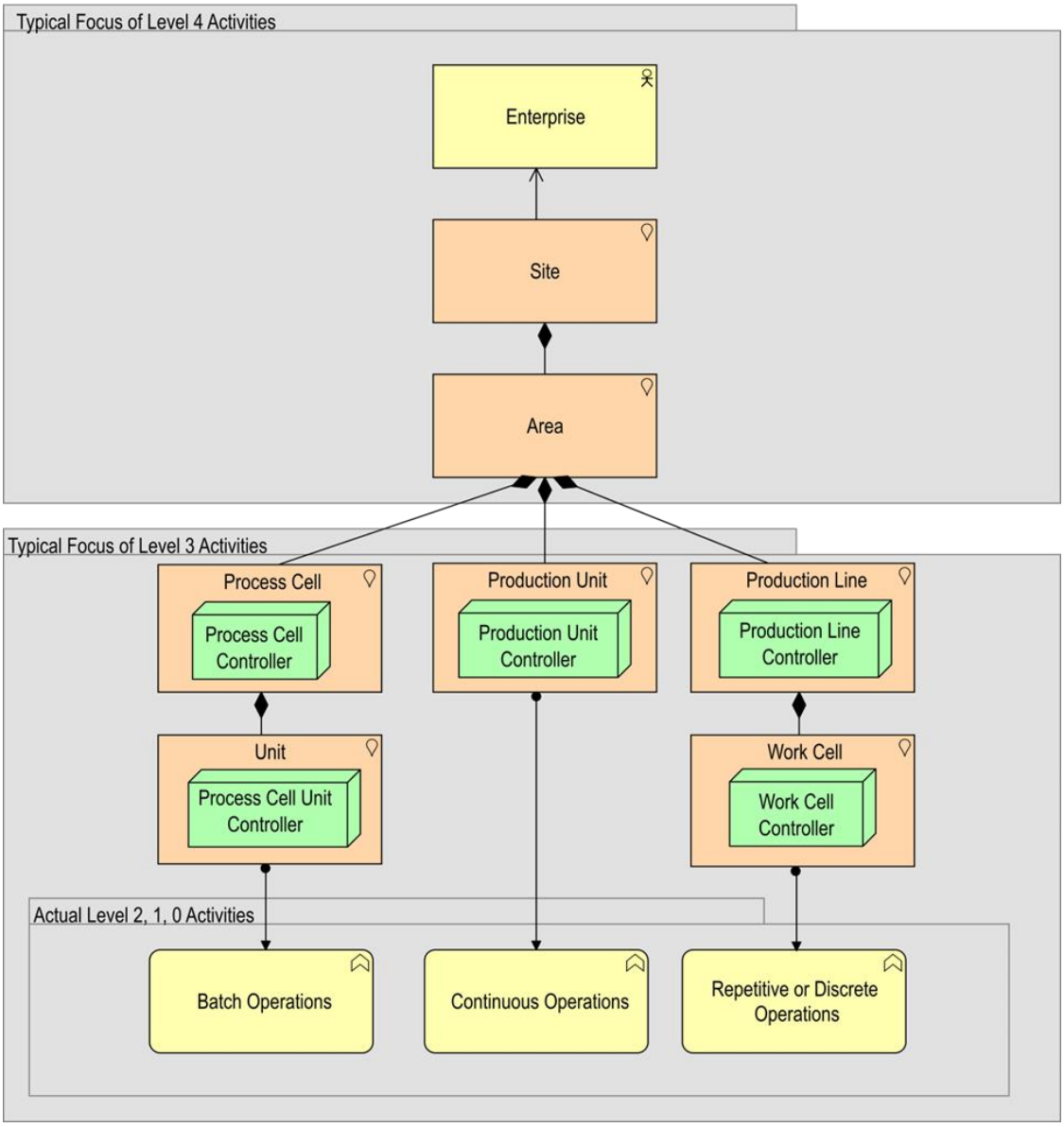

Figure 39: Equipment Hierarchy showing the Physical Footprints of the Functional Levels Defined in ISA-95

Part 5 of the ISA-95 standard defines business-to-manufacturing transactions. The standard defines transactions, messages, and verbs [3: Part 5, p.18]. There are three transaction models, each of which uses different verbs. There is a PUBLISH model, where a data owner publishes to multiple subscribers, a PULL model where a data user (human or machine) makes a request of a data provider, and a PUSH model, where a user provides data to another user and asks that user to perform a processing, changing, or canceling action on that data. Figure 40 shows ISA-95 verbs classified by the transaction model they support. The CONFIRM verb is used to complete transactions in all three models.

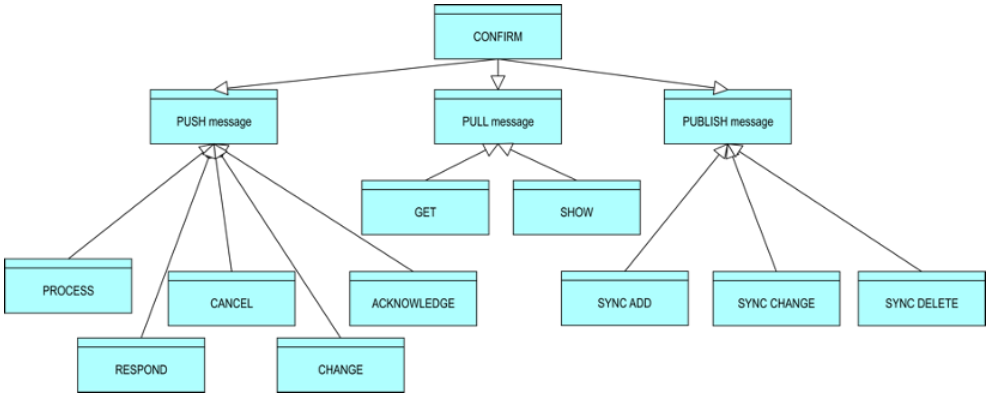

Figure 40: ISA-95 Verbs Classified by the Transaction Model They Support

Figure 41 depicts a scenario that uses a number of the concepts described in this section. A customer requests a large, urgent order from a manufacturer. To fill this order, the manufacturer must alter production schedules at multiple manufacturing locations. This event triggers a chain of information exchanges between the Enterprise Marketing and Sales, Order Processing, and Global Production Scheduling functions. The Global Production Schedule function uses a PUBLISH model transaction message with a SYNC CHANGE verb to align multiple local production schedules with the newly changed global schedule. This transaction crosses the enterprise-control interface, and triggers information exchanges between the local production scheduling and production control functions. Once the new schedule is implemented, a series of confirmation messages moves between the business functions in the reverse direction. To complete the PUBLISH model transaction, a transaction message with a CONFIRM verb crosses back over the enterprise-control interface. This scenario is also used later in this Case Study as part of a more extensive scenario.

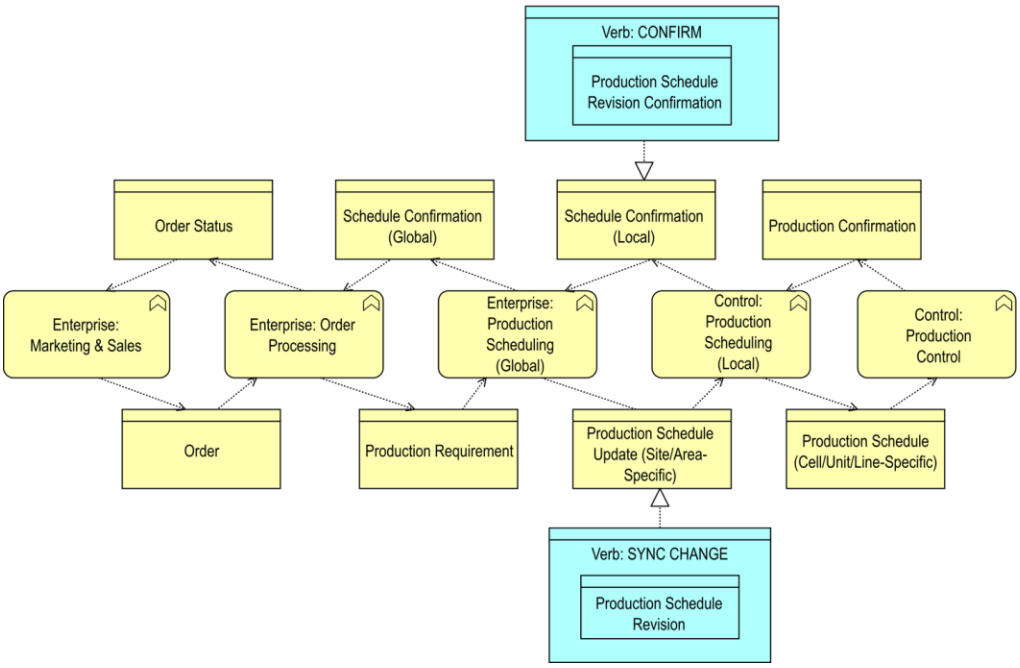

Figure 41: A Model of the Activity that Ensues when a Large, Urgent Order Triggers a Production Schedule Change

Customer Relationship Management (CRM)

Since ISA-95 does not describe the role of CRM systems in manufacturing enterprises, this Case Study uses the model in Figure 42 to complement the ISA-95 manufacturing models.

Figure 42 shows the taxonomy of typical CRM application functions. CRM applications typically have functions for customer acquisition and retention, as well as for customer understanding, which is often called business intelligence. Figure 43 shows how these functions are used by the Enterprise Marketing and Sales and the Enterprise Customer Service functions in this expanded model. These diagrams illustrate how the ArchiMate language can be used to combine and adapt diverse paradigms for use in Enterprise Architecture.

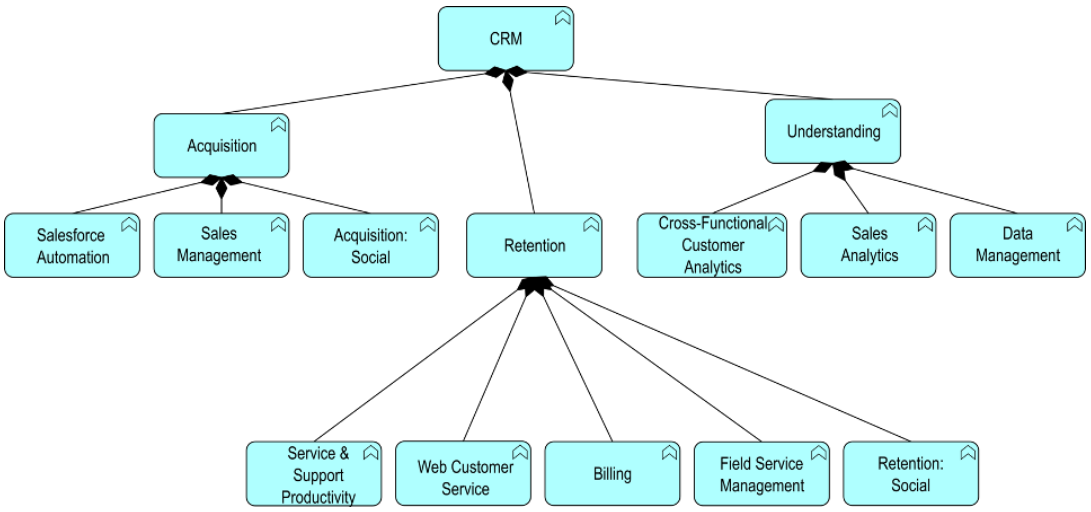

Figure 42: A Taxonomy of Typical CRM Application Functions

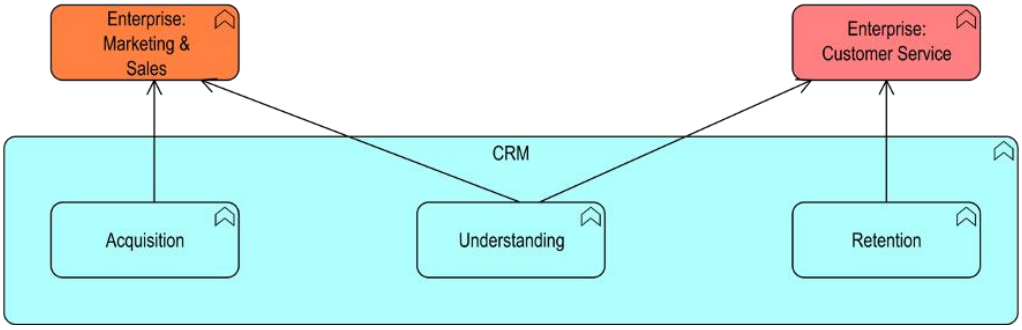

Figure 43: Enterprise Business Function Usage of CRM Application Functions

References

(Please note that the links below are good at the time of writing but cannot be guaranteed for the future.)

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