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Mass customization value chain management —

Part 1: Framework

Management de la chaîne de valeur de la personnalisation de masse —

Partie 1: Cadre

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Foreword

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This document was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 5, *Interoperability, integration, and architectures for enterprise systems and automation applications*.

A list of all parts in the ISO 24644 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Along with the generalization and popularization of Internet technologies, Internet of Things (IoT), flexible manufacturing technologies and modern logistics, individualized customization services have become embedded into all industrial and service sectors. Users can, by means of Internet platforms, determine and customize their own products upon their own demands. Mass customization is becoming a new mode in the manufacturing industry, and value chains will be ultimately driven by the users. Cooperation among enterprises is required by utilizing quick-response Internet platforms to provide a wide range of products and services in small lots to satisfy the users with various individualized demands.

From the user perspective, as the users directly interact with enterprises for customized products, they want to participate in the creation process of their individualized product and also to obtain or receive information about the progress of the product.

From the enterprise perspective, mass customization assists the enterprises in realizing the real-time and accurate understanding of the user's demands. Customized products increase the premium value of products for enterprises. Because of accurately estimated a priori information from customized product demand and requirements from the users, the enterprises can reduce or eliminate the inventory-related costs by appropriately conducting large-scale procurement or production.

Mass customization value chain management —

Part 1:
Framework

1 Scope

This document specifies a framework for mass customization value chain management, including the framework model, functions and information flow of mass customization.

This document does not describe interoperability at a system level or interoperability throughout the life cycle in detail.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
domain
functional area

[SOURCE: ISO 24097-1:2017, 3.1.2, modified — “in a policy assertion” has been deleted from the definition. The EXAMPLE has been deleted.]

3.2
information flow
transfer of information from an information-source-object to an information-destination-object

[SOURCE: ISO/IEC 16500-1:1999, 3.30]

3.3
interaction
exchange of information between a user and a system via the human-system interface to achieve the intended goal

[SOURCE: ISO 11064-5:2008, 3.20, modified — term "dialogue" was removed.]

3.4
mass customization
production mode that provides customized products and services according to the individualized demands of users with the cost and efficiency in mass production

3.5
user experience
person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service

[SOURCE: ISO/IEC 30071-1:2019, 3.1.6, modified — Notes 1 and 2 to entry were removed.]

3.6
value-added service
service that is offered in addition to the core service in question thus creating additional value

[SOURCE: ISO/TS 17573-2:2020, 3.231]

3.7
value chain
range of activities or parties that create or receive value in the form of products or services

[SOURCE: ISO 22948:2020, 3.2.11]

4 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

APS	Advanced Planning and Scheduling
BOM	Bill of Material
B2B	Business to Business
CAX	Computer Aided X
CBL	Collaboration layer
CP	Configuration Partner
CRM	Customer Relationship Management
CTL	Control layer
CTO	Configure to Order
DTS	Delivery-to-Service
EML	Equipment layer
ENDO	Bare unit on which customization can be configured through assembly. Transceiver is set in working assembly form.
EPL	Enterprise layer
ERP	Enterprise Resource Planning
EVI	Early Vendor Involvement
FIFO	First-In-First-Out
IT&OT	Information technology and operational technology
M&S	Modelling and simulation

MRP	Material Requirements Planning
MTO	Mind-to-Order
OTD	Order-to-Delivery
PLM	Product Lifecycle Management
R&D	Research and Development
TMS	Transportation Management System
WMS	Warehouse Management System
WSL	Workshop layer

5 Mass customization value chain management overview

For mass customization value chain management, the value activities of mass customization can be divided into domains from the perspective of life cycle and system, and the contents of each activity and the information transmitted between activities should be clearly defined. The framework of mass customization value chain management consists of the framework model, functions and information flow of mass customization.

This document falls in the constructs of function view, according to the definition of enterprise activity and function view in ISO 19439.

According to ISO 19439:2006 5.3.2, the function view shall represent the business processes of the enterprise domain, their functionality, behaviour, inputs and outputs. The function view shall describe the assembly of single processing steps as a collection of processes (business processes and enterprise activities) structured as a network of activities reflecting their logical connection and interdependencies.

According to ISO 19439:2006 3.19, enterprise activity is all, or part, of process functionality that consists of elementary tasks performed in the enterprise that consume inputs and allocate time and resources to produce outputs.

With the definitions and concepts of enterprise activity and function view, the framework is generated referring to the enterprise modelling concepts defined in ISO 19439, which conforms with the requirement of ISO 15704. Specifically, the framework corresponds with the domain identification, concept definitions and requirements definition of the function view at the generic level as shown in the dash area of Figure 1. The modelling concepts are reused in ISO 19440, which is built upon ISO 19439, to identify and specify constructs necessary for users that model enterprises.

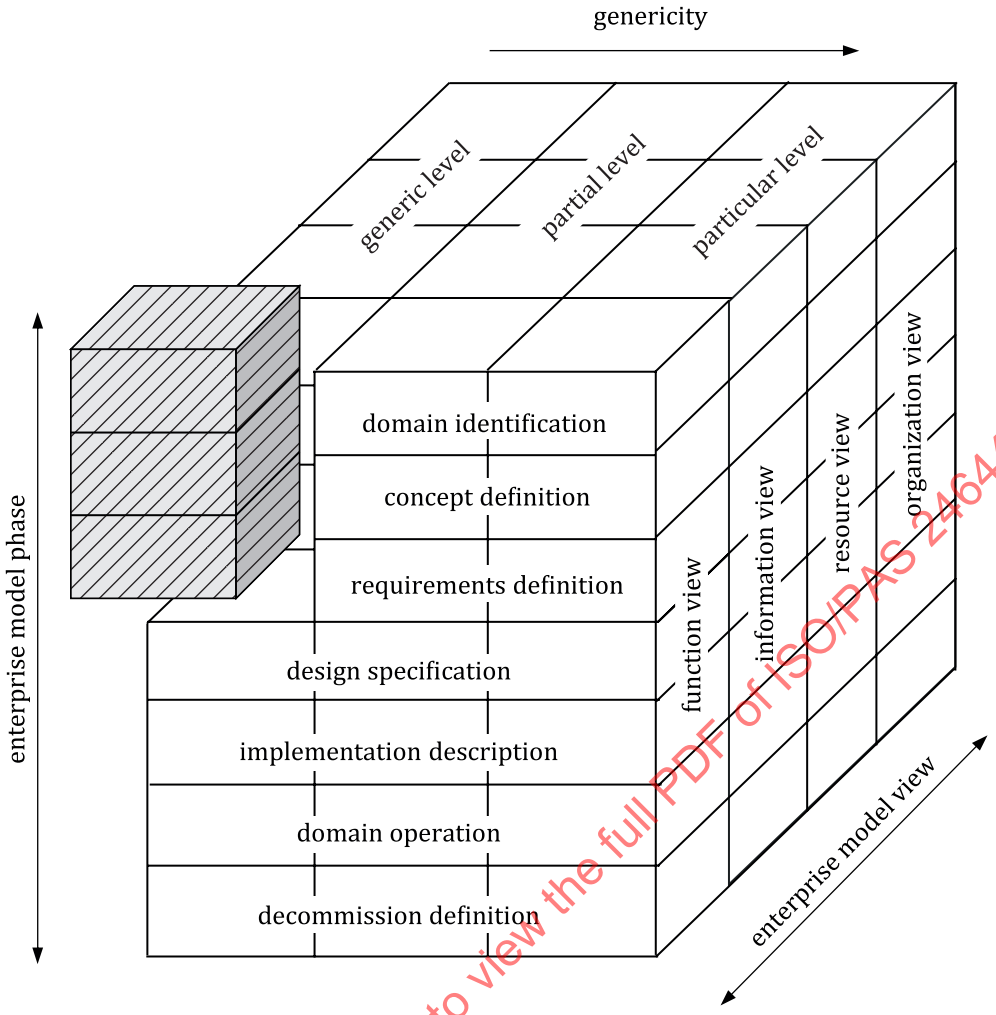


Figure 1 — Overview of the framework for enterprise modelling

NOTE Figure 1 is taken from ISO 19439:2006, Figure 5.

6 Framework model

6.1 General description of the framework model

The framework model of mass customization consists of two dimensions, namely system level and life cycle. The vertical axis in Figure 2 presents the system level, which includes equipment layer (EML), control layer (CTL), workshop layer (WSL), enterprise layer (EPL), and collaboration layer (CBL) as referenced in IEC 62264-1. The horizontal axis in Figure 2 covers the whole life cycle of a product, which includes seven activities, i.e. interaction, research and development (R&D), marketing and sales, sourcing and planning, production, logistics, and service.

System level in Figure 2 is divided into five layers according to the organizational structure related to enterprise production activities, in which:

— EML is applied by an enterprise to realize the actual physical process, and perceive and operate it by means of sensor, instrument, machine and device and others;

— CTL is used for handling information, and realizing the monitoring and controlling physical process within an enterprise;

— WSL is applicable for realizing production management within a factory or a workshop;

— EPL aims to realize enterprise-oriented business management;

— CBL is applied to realizing the interconnectivity and sharing of internal and external information in an enterprise and the business coordination between enterprises.

Mass customization domains include mind-to-order (MTO) domain, order-to-delivery (OTD) domain, and delivery-to-service (DTS) domain.

As shown in Figure 2, the MTO domain covers four activities from the life cycle, i.e. interaction, R&D, marketing and sales, and sourcing and planning, and it contains WSL and CBL from the system level.

The OTD domain includes the production activity and logistic activity. The production activity covers the EML, CTL, WSL and EPL. The logistics activity includes all five system layers.

The DTS domain covers the service activity from the life cycle and it contains the EPL and CBL from the system level.

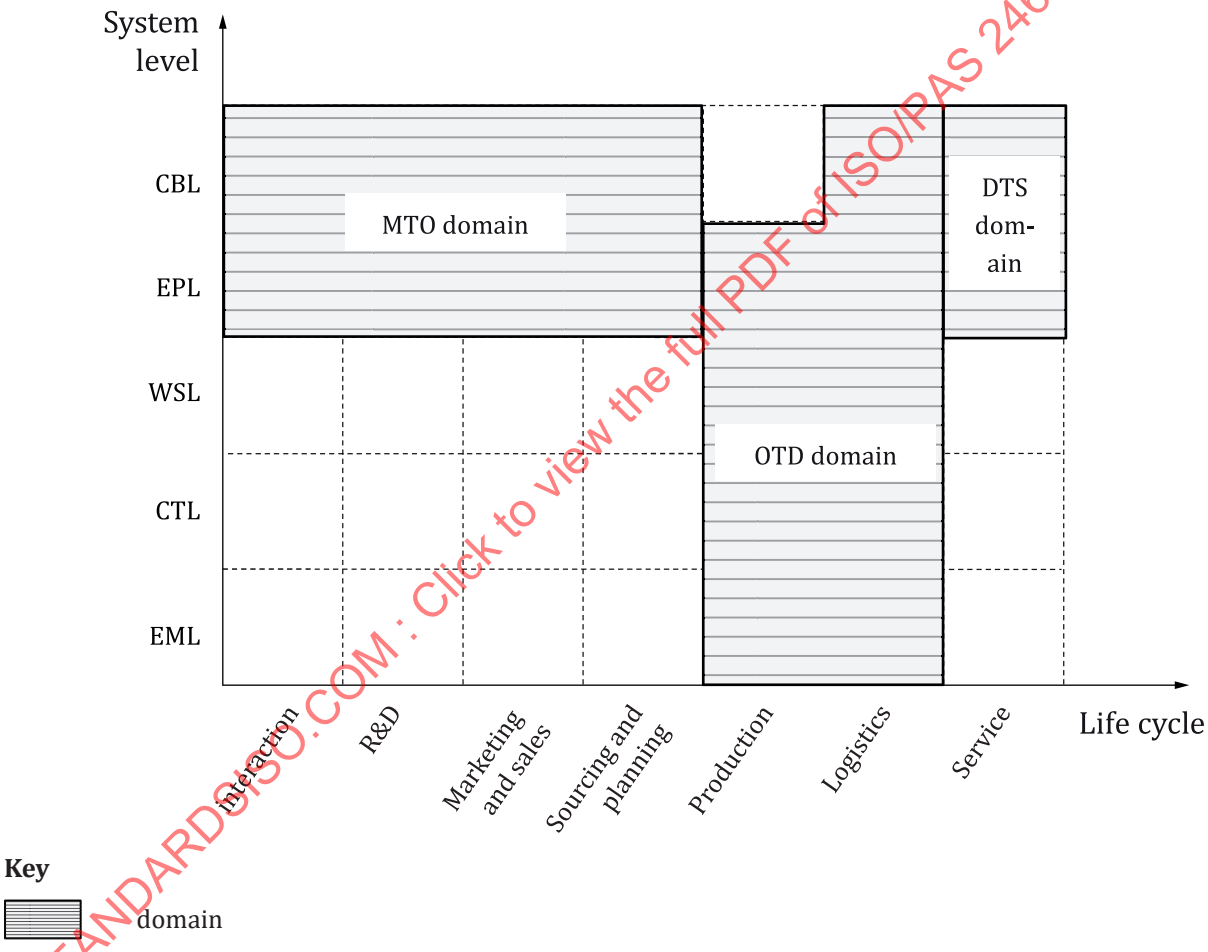


Figure 2 — Mass customization domains

6.2 Framework model domain

In the MTO domain, enterprises shall focus on user demands, output product schemes through the interaction and R&D activities. User orders are generated through the marketing and sales activity. Enterprises shall arrange a master production schedule according to the product scheme and the user orders and find suitable suppliers through the sourcing and planning activity to ensure commodity[1)]

1) In this document, commodity includes raw material and purchasing parts from suppliers.

supply. The contents of a user order include, e.g. user basic information, customization information, expected delivery date and place, product model, payment information.

In the interaction activity, enterprises shall collect user demands, and interact with users and ecosystem partners, conduct user demands analysis and screening, and output customized demands. The interaction methods include user interfaces, networks (e.g. user interactions with enterprises by surfing the Internet using search engines), social networking (e.g. user interaction with enterprises through social media), web, apps, etc.

In the R&D activity, enterprises shall conduct customized demands classification, assessment, and transformation, and output product solutions after simulation verification.

In the marketing and sales activity, enterprises shall conduct product positioning and pricing, and this activity shall obtain user orders through precision marketing.

In the sourcing and planning activity, enterprises shall find suitable material suppliers for source searching demands and procurement demands.

In the OTD domain, factories shall conduct the production activity to produce customized products and deliver them to users through the logistics activity.

In the production activity, factories shall arrange a detailed production plan according to the master production schedule and material status (including material in stock or its expected arrival time), and this activity shall execute manufacturing according to the detailed production plan.

In the logistics activity, enterprises shall arrange a reasonable delivery route and deliver the customized products to the designated place at the appointed time through logistics management.

In the DTS domain, enterprises shall obtain user experience information through the service activity, conduct online or offline diagnosis to get the status information of products, and this activity shall provide after-sales and value-added services for users.

The user experience information and new demands obtained from the DTS domain shall be fed back to the MTO domain to promote product optimization and iteration.

Figure 3 depicts mass customization domains, elements and functions, and information flow showing the interaction between the users and domains, pictorially summarizing the dynamics of the MTO, OTD, and DTS domains.

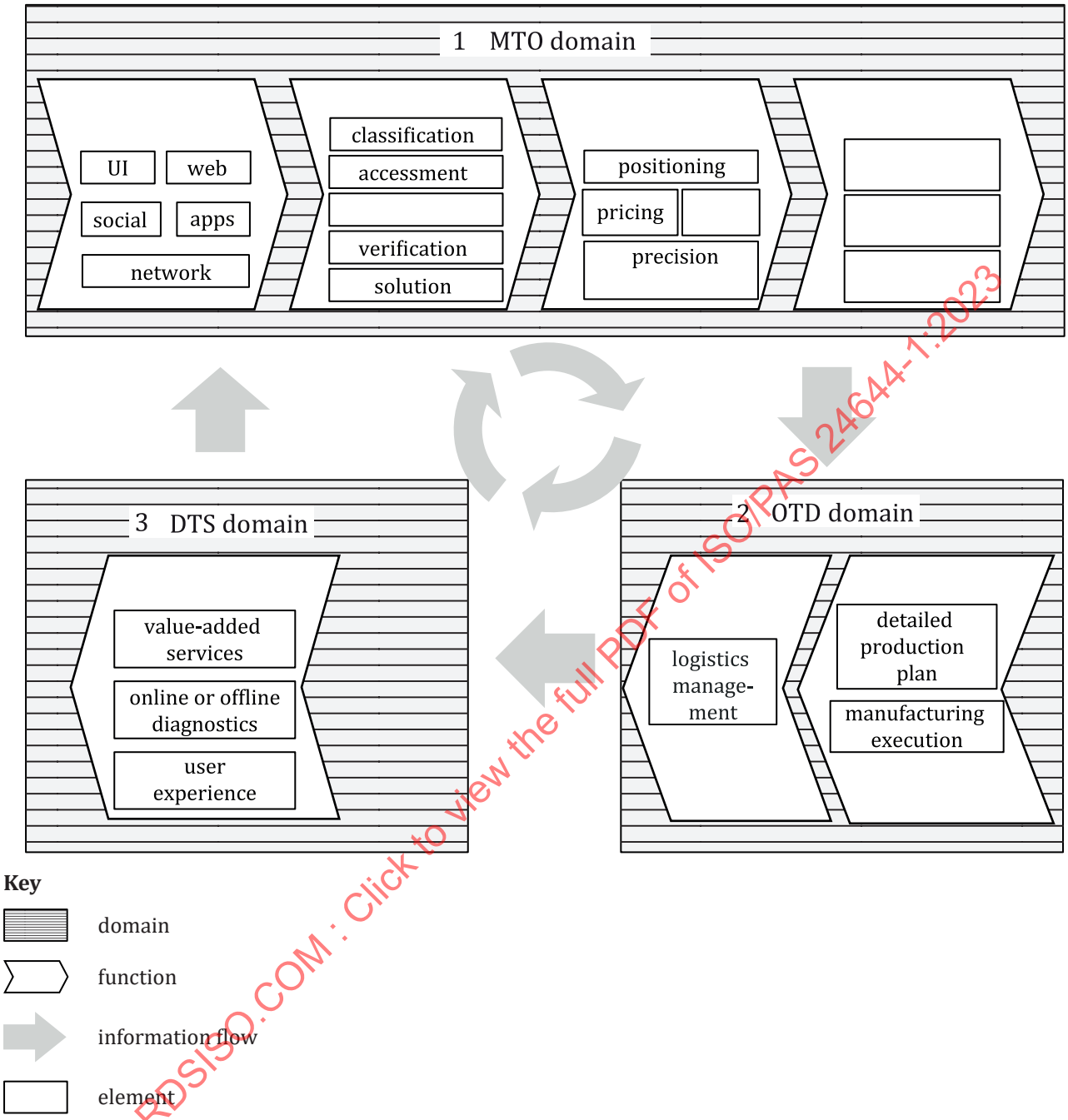


Figure 3 — Mass customization domains and functions

7 Functional model

7.1 Functional model notation

The notations used in the mass customization functional model shown in Figure 4 and the interaction workflow of seven activities, i.e. interaction, R&D, marketing and sales, sourcing and planning, production, logistics and service, shown in Figure 5 are described in Table 1.

Table 1 — Notation used in functional model and workflow of seven activities

Symbol	Name	Definition
	users	Any entity (e.g. person, group) who makes usage of either the customized services or products, or both.
	activity	A set of actions that consumes time and resources and whose performance is necessary to achieve, or contribute to, the realization of one or more outcomes.
	input/output information	Information which transfers into/out of workflow.
	database	The representation of all information that is dealt within an information system, taken together.
	element	A necessary or typical part of workflow.
	information flow	Transfer of information from an information-source-object to an information-destination-object.

7.2 General description of functional model

As shown in Figure 4, the mass customization functional model is a synthesis of user-centred functions covering seven activities in the customization life cycle. In Figure 4, "Users" is shown at the centre; the rectangle boxes in the perimeter represent the lifecycle activities; and the solid arrows represent the information flow between "Users" and the activities and also between the adjacent activities. The activities do not need to completely correspond to a department or departments of the enterprise. Different enterprises may place one or more activities in different departments or with external entrust third parties.

Mass customization enterprises need to establish a unified platform or system not only to support the horizontal integration and interoperability of the seven activities, but also to acquire users' immediate and overall satisfaction from creativity to product development, production, delivery and service. In mass customization, the relationship among activities is many-to-many, which means that multiple entities (e.g. enterprises or departments) may take the same role carrying out the same activity simultaneously, and they may interact with another entity or a group of entities. The reason for taking the same role or the same activity simultaneously is to meet a high demand of customized products in a short period of time.

To ensure the proper data is transmitted between different entities, the input and output of each activity can be seen as the data which should be exchanged or accessed through a common interface from/to other activities. The users of this document can build their own uniform semantic/format models of data and interface accordingly, which can be helpful to establish an interoperable[2)] mass customization system.

2) The method of achieving interoperability in the functional model of mass customization is described in ISO 15704.

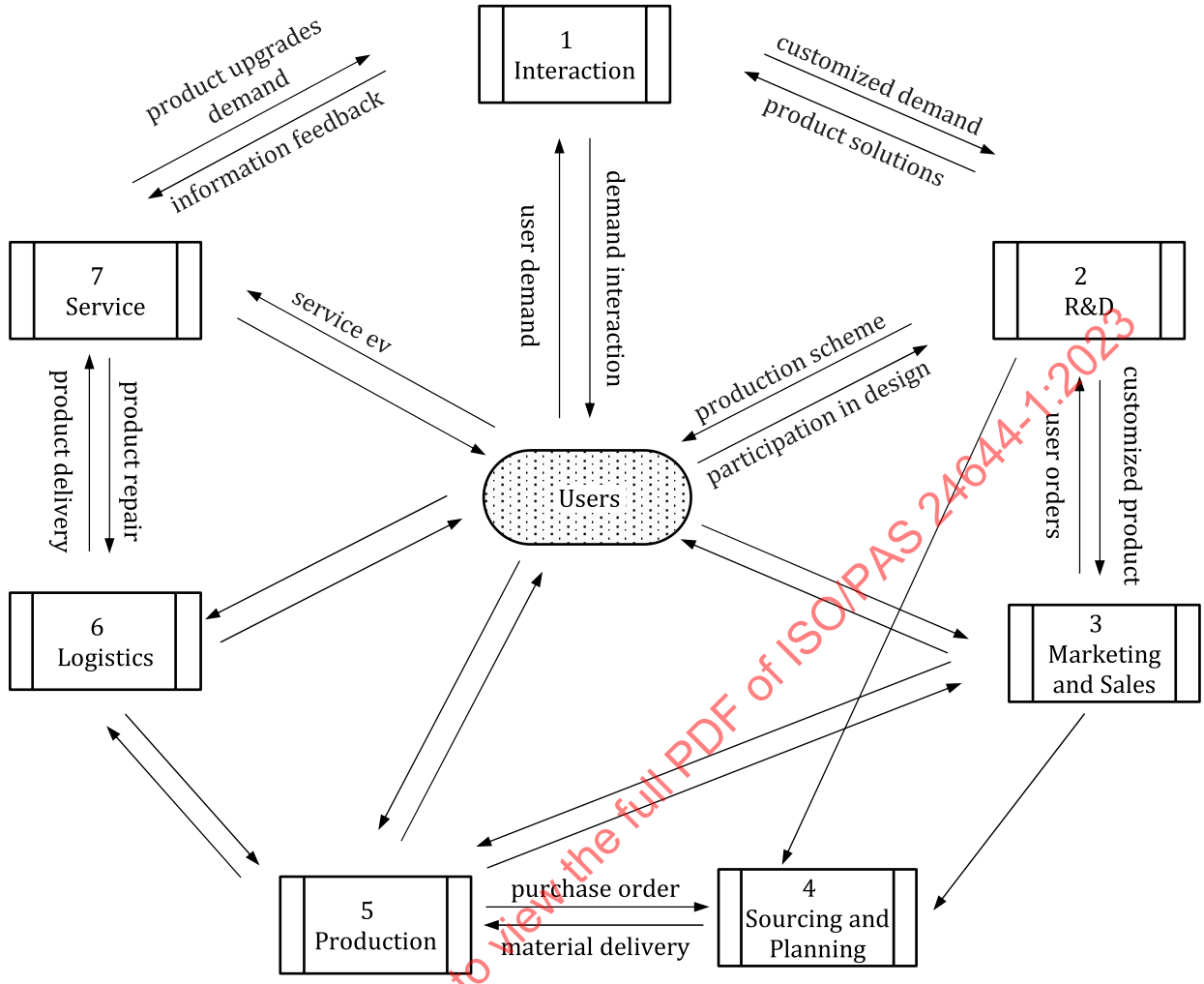


Figure 4 — Functional model

7.3 Interaction

Interaction is an activity which specifies reciprocal actions, including recognizing information, making inputs, making selections and receiving outputs, required by users to achieve a goal. The workflow of the interaction activity is shown in Figure 5.

An interaction platform shall aggregate user resources (e.g. a multitude of user information collected from the users via the interaction platform) by introducing the users being targeted for mass customization. Then the platform carries out categorizing the users to form social communities for demand interaction. In each social community, experts, key opinion leaders, enterprises and resource parties shall provide high-quality and relevant topics for community discussion and also supply professional information for reference to the community members. After demand interaction, the platform shall conduct demand analysis and screening from the perspective of cost, outcome, scale, etc. Customized demands shall be output of the interaction activity.

Meanwhile, the new product/service demands proposed by the users from the service activity shall be sent to the interaction activity to be included in the demand interaction.

Through the repository and reutilization of interaction data of different social communities, the platform shall achieve a unified analysis and utilization of these data, such as output of user profiles. The output of the customized demand from the interaction activity shall be transmitted to the R&D activity for demand creation.

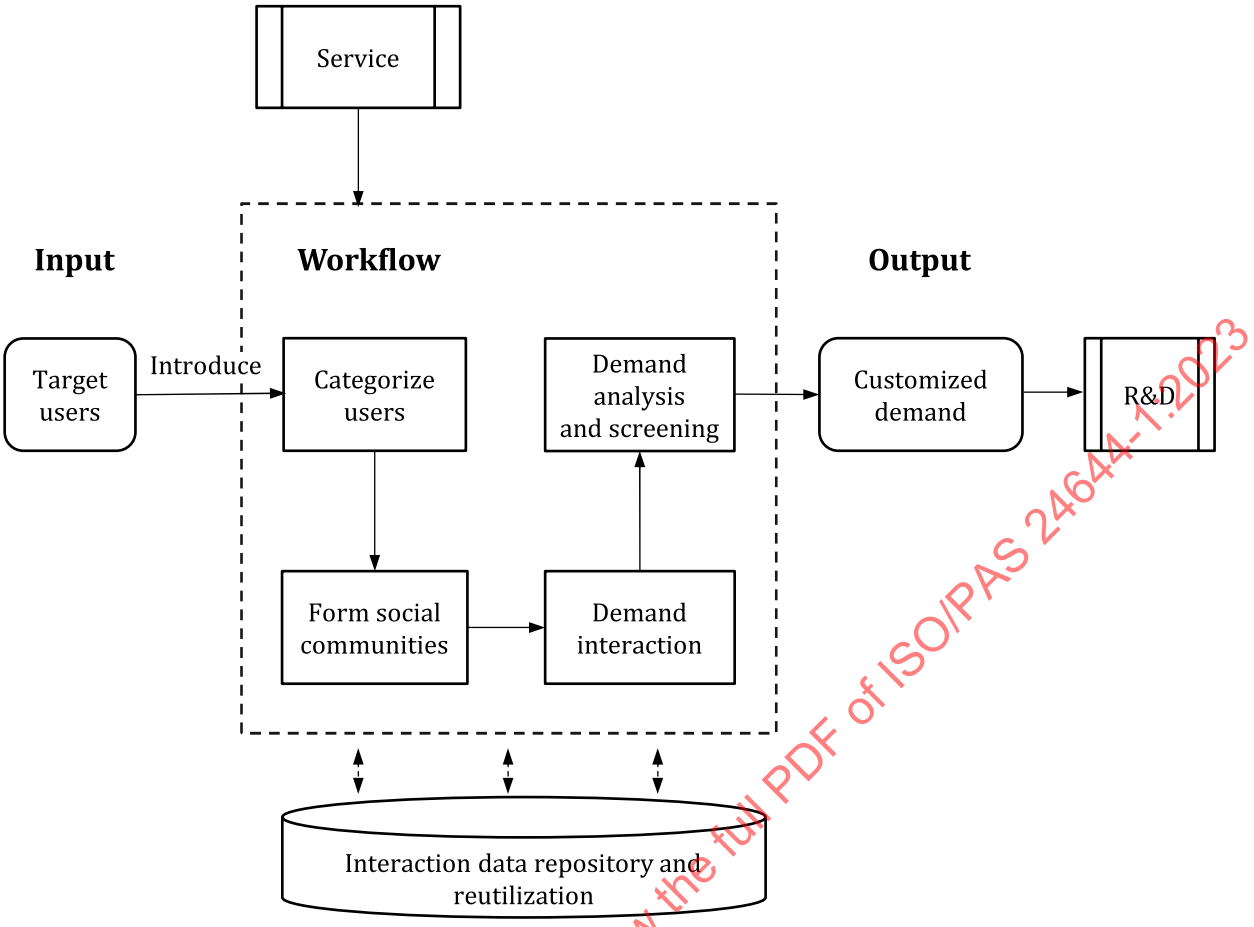


Figure 5 — Workflow of the interaction activity

7.4 R&D

R&D includes activities that enterprises undertake to innovate and introduce new products and services. R&D defines the product scheme based on the customized demands and the resources, and then publishes the product scheme to the marketing and sales activity and the sourcing and planning activity. The workflow of the R&D activity is shown in Figure 6.

R&D, in the mass customization, shall refine the users' primary demand and transform it into a quantifiable demand. R&D shall then distribute the quantifiable demand to appropriate resource providers, including but are not limited to, technical resources, design resources, supplier resources, corresponding to the quantifiable demand classifications, e.g. function, appearance, and module. The providers shall then design customized products according to the quantifiable demand distributed to them, and the design shall be verified and optimized through the interactions with the users. Once the final design for the customized products is approved, modular design, development and test processes shall be carried out and then the customized product can be available on the market.

The interactivity of the demand distribution and resource matching process should be considered while implementing the mass customization system. Enterprises shall build mechanisms for timely release of the demand to the providers and collection of the response from the providers.

It should be noted that the modular design takes an important role in mass customization because it balances "mass production" and "customized craft" by linking the customized demand to different process configurations or different combinations of modules for productizing. On the one hand, considerations should be given in the module design process to ensure that the configurability will not affect product functionality. Considerations also should be given to whether or not the designed module can easily be used for large-scale production while balancing customizability and cost.

Moreover, the process data generated by R&D should be comprehensively recorded in a data store (e.g. R&D data repository and reutilization) as reusable resources/knowledge-base for possible process reengineering, system upgrade or product iterations.

The customized demand, i.e. the input to R&D, is from the interaction activity. The customized products produced by an approved design shall be output to the marketing and sales activity, while the sourcing and planning activity receives the source search demand and procurement demand from the R&D activity.

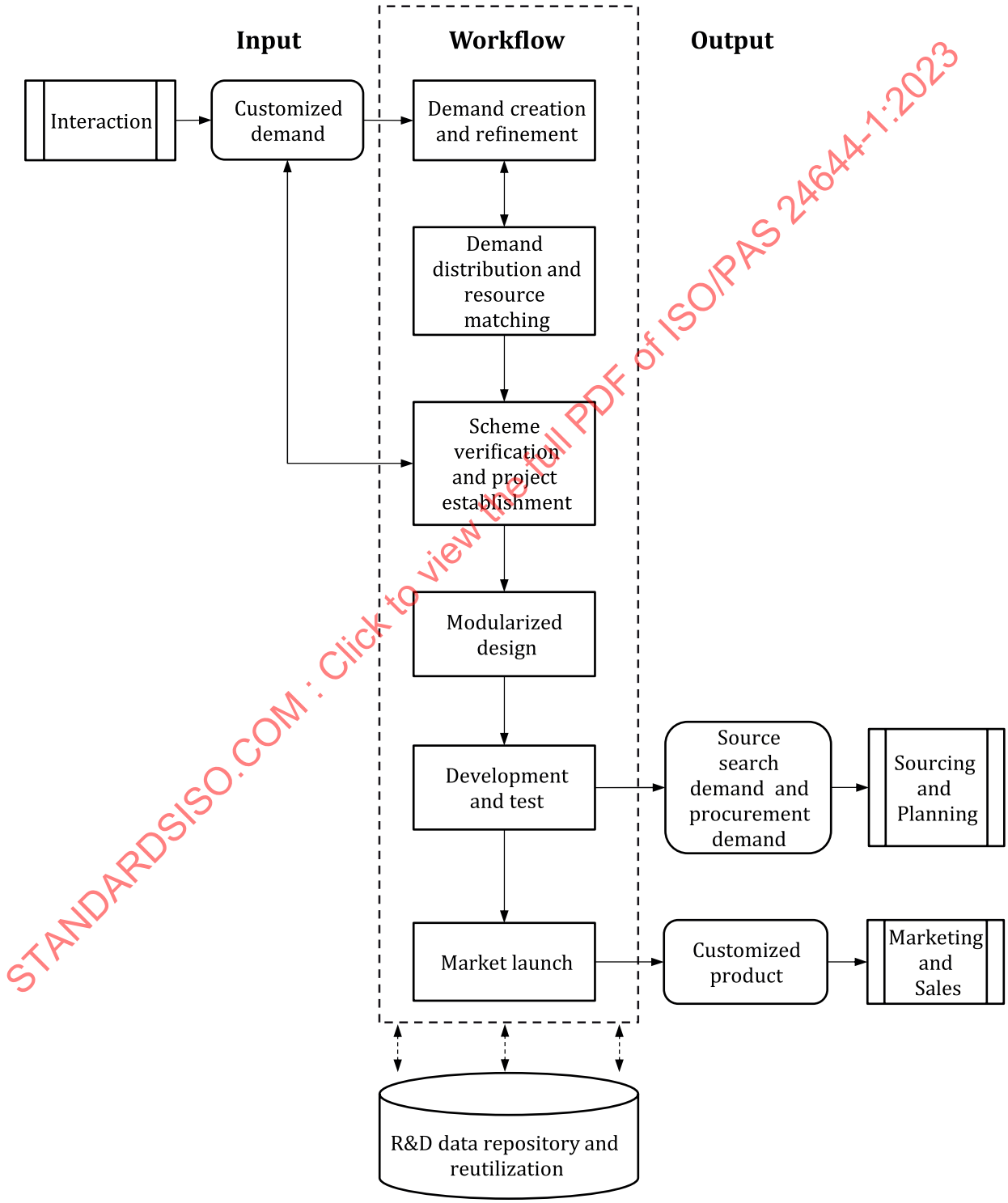


Figure 6 — Workflow of the R&D activity

7.5 Marketing and sales

Marketing and sales is an activity that informs users about a product, gaining their curiosity and interest in it, and leading them to purchase it. The workflow of the marketing and sales activity is shown in Figure 7.

The information on the customized products, i.e. the output from R&D, shall be transmitted to the marketing and sales activity for product positioning and pricing. The customized products shall be promoted to target users through precision marketing. The users who have an intention to purchase shall select their choices from the customized products. Upon placing orders and paying for the products, user orders shall be generated.

The products purchasing demand, i.e. the output from the service, shall be transmitted to marketing and sales for demand matching. If there is a matching product in the product library, the user places an order directly, and then the purchase is completed when the user pays for the products. Otherwise, the demand information shall be transmitted to the interaction activity to drive a new round of interaction and R&D activities.

Through reutilizing the marketing and sales data in the repository, enterprises shall achieve unified analysis of these data, such as membership management. After the user orders are generated, the marketing and sales activity shall output the source search demand or procurement demand for the orders. This demand shall be transmitted to the sourcing and planning activity for supplier sourcing.

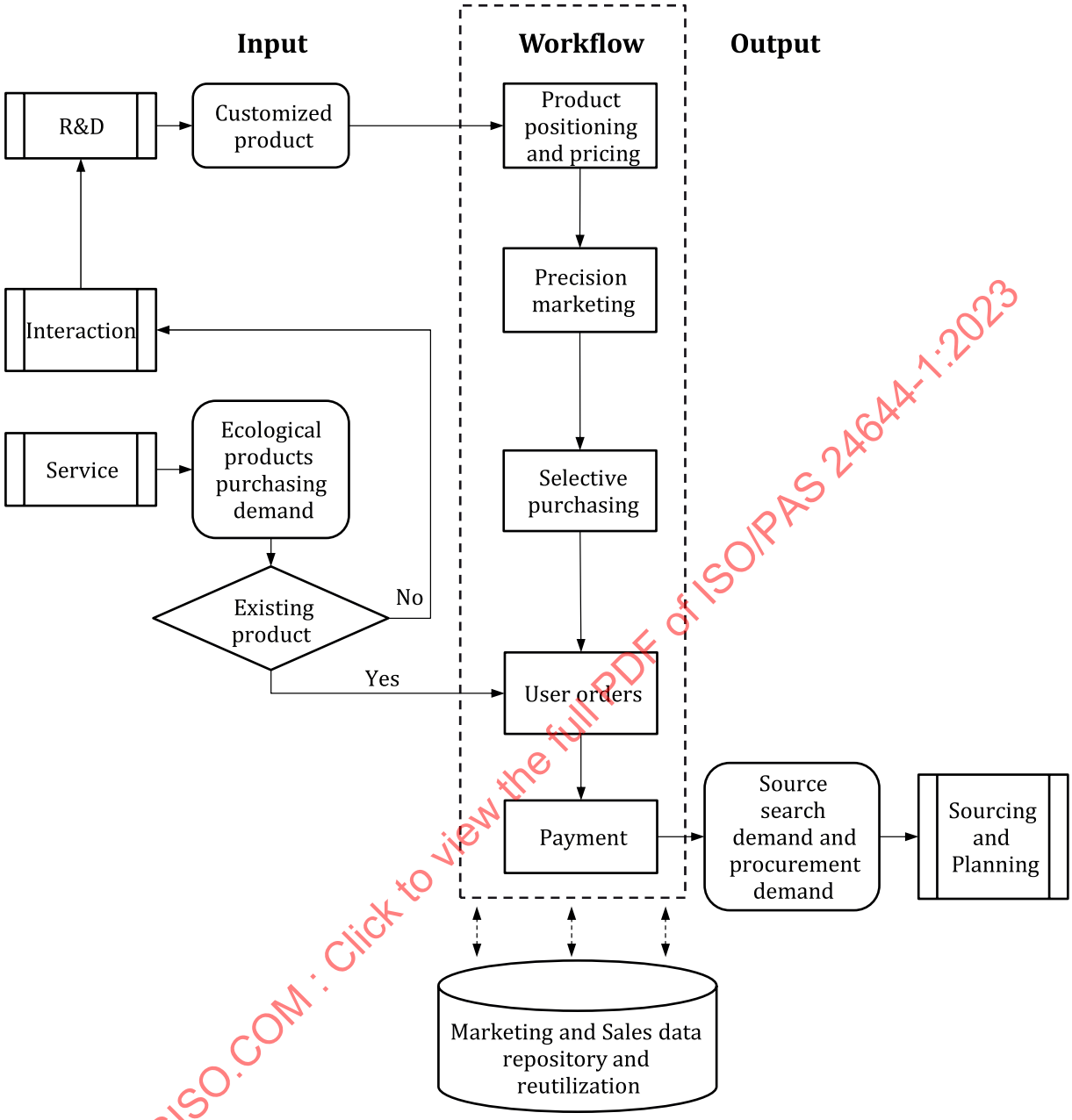


Figure 7 — Workflow of the marketing and sales activity

7.6 Sourcing and planning

The activities in R&D and marketing and sales shall trigger the master production scheduling. The workflow of sourcing and planning activity is shown in Figure 8.

The procurement demand required for the user orders shall be released from the master production schedule. Whether the available suppliers can meet the procurement demand shall be evaluated. If available suppliers cannot meet the procurement demand, new supplier source search demands are issued. New suppliers respond to the demand and then the suppliers shall be evaluated. If the available suppliers can meet the procurement demand, the demand is released to available suppliers for the demand interaction. Purchasing mechanisms such as bidding mechanisms shall be carried out during the supplier selection. The suppliers shall deliver the commodity to the factory through the logistics activity.

The master production schedule, commodity in stock and their lead time from the sourcing and planning activity shall be transmitted to the production activity. The sourcing and planning related data shall be stored and analysed to optimize this activity.

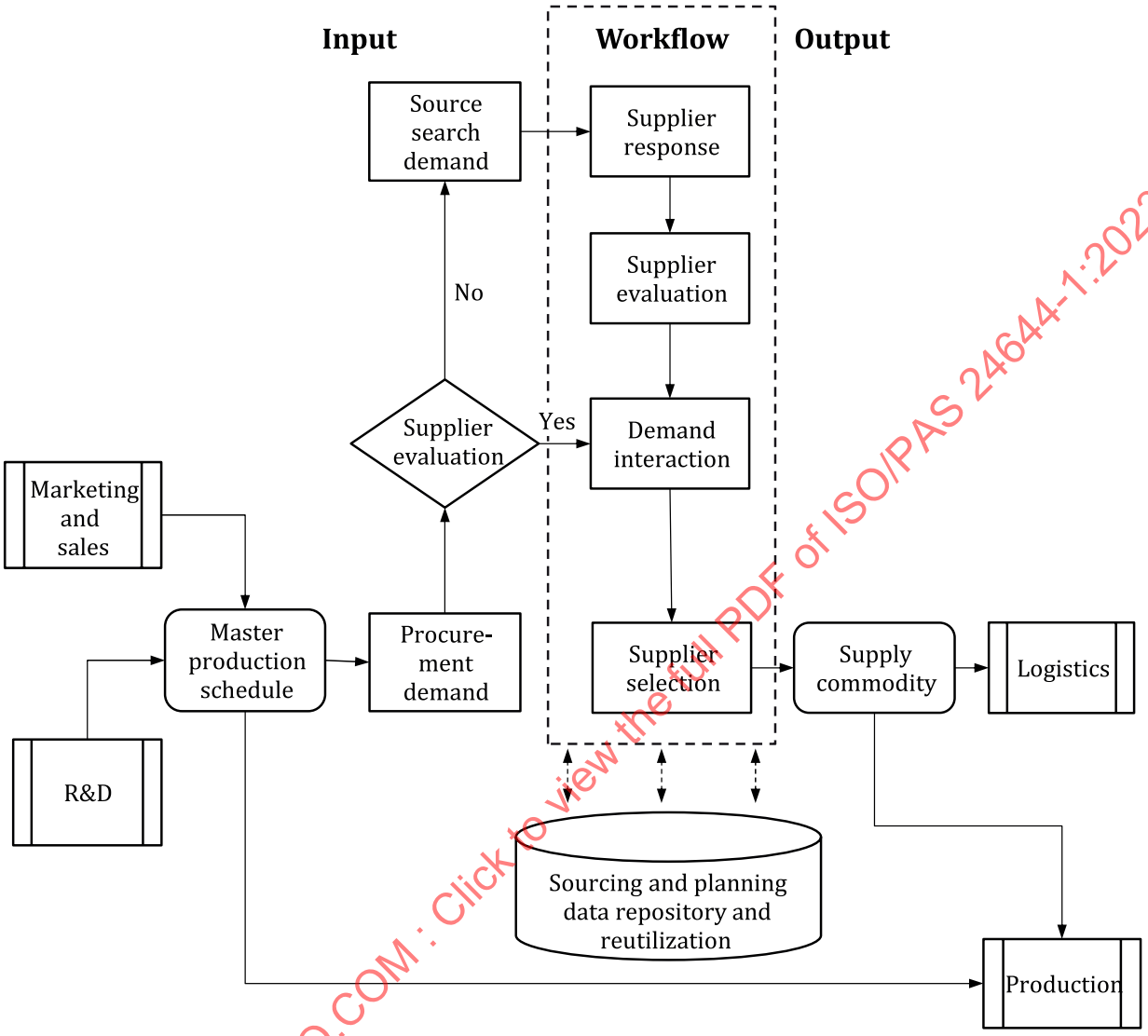


Figure 8 — Workflow of the sourcing and planning activity

7.7 Production

The production activity executes the actual manufacturing process and shall interact with the sourcing and planning activity and the logistics activity. The workflow of the production activity is shown in Figure 9.

The master production schedule from the upstream, material in stock and its lead time information from the sourcing and planning activity shall be transmitted to the production activity. After the demand and capacity are balanced by the scheduling system, a detailed production plan and a material demand plan shall be automatically aligned to generate an executable master production plan. In the process of mass customization, the master production schedule shall be changed according to the users' demand.

The suppliers shall produce and deliver the materials according to the material demand plan. The factory shall produce products according to the executable production plan. Intelligent manufacturing technologies, e.g. information technology and operational technology (IT&OT) integration, technology grouping, may be applied to increase production efficiency and flexibility. After the ordered products

are rolled off the production line, they shall be automatically moved and stored in a warehouse. As the products enter a warehouse and are registered with a warehouse management system (WMS), the product information, e.g. product name, identification, location, is immediately transmitted to a logistics platform to begin the process of product delivery.

Production data repository and reutilization shall be deployed to optimize the key indicators in the manufacturing process, such as production efficiency, manufacturing costs, and product quality.

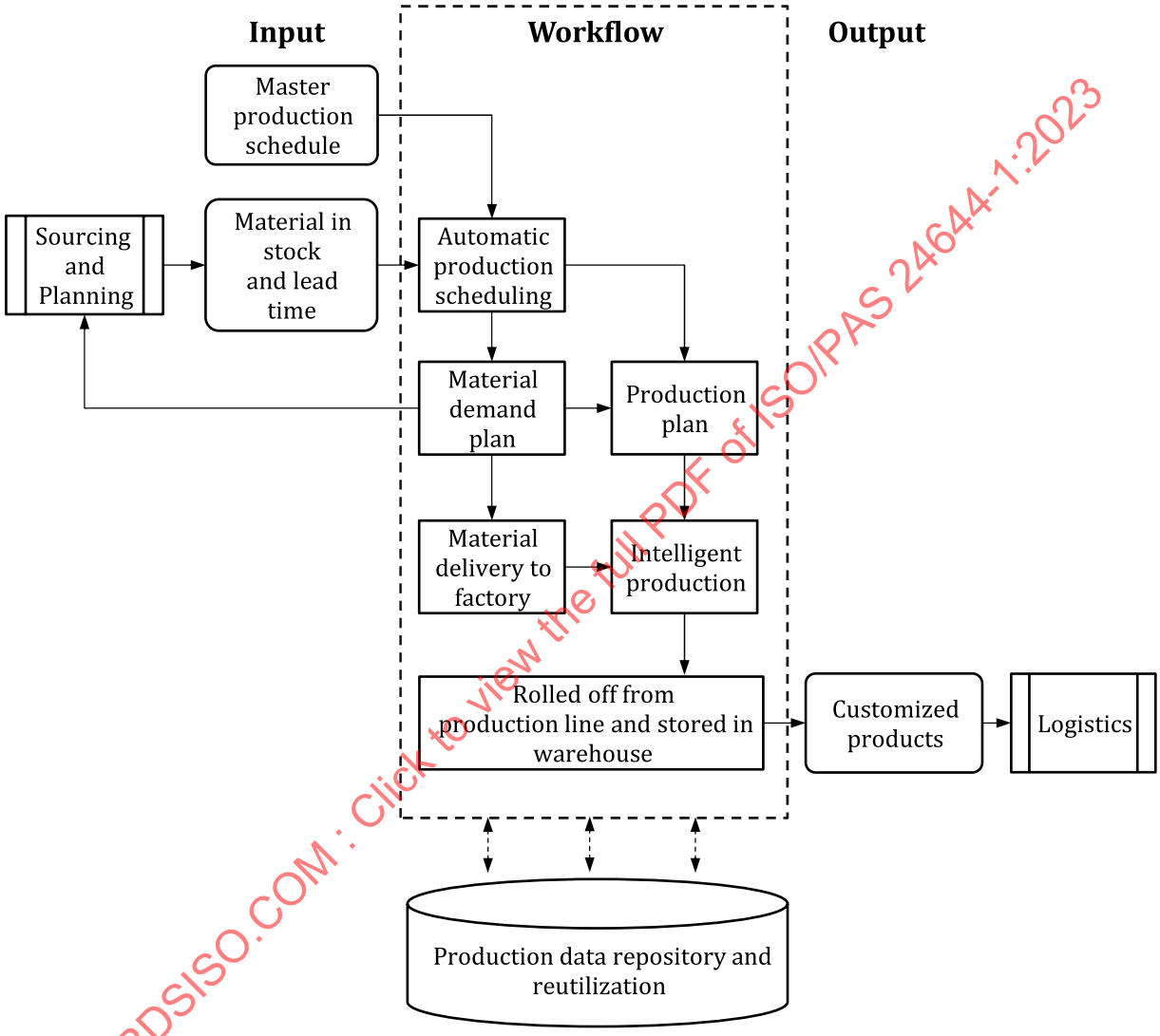


Figure 9 — Workflow of the production activity

7.8 Logistics

Logistics in this document refers to off-site logistics, which includes planning, execution and control of the movement and placement of materials, while on-site logistics is included as part of the production activity. The workflow of the logistics activity is shown in Figure 10.

The commodity supply information output from the sourcing and planning activity shall be transmitted to the logistics activity for distribution. After the factory receives the commodity, the commodity delivery information shall be sent to the souring and planning activity.

The production activity shall output a customized product distribution order after completing the production of the ordered products. The logistics activity shall generate a delivery schedule, including loading and vehicles' route plans, etc., for customized products according to the individualized demands

ordered by the users. The delivery time to each delivery location in the route plan is estimated by using predictive algorithm engines, real-time optimization by simulation engines, etc. The logistics activity shall obtain real-time delivery vehicle location data and real-time traffic information to update the delivery schedule, called an intelligent vehicle scheduling, to improve the delivery efficiency to guarantee the arrival of the customized products on schedule. The updated delivery time to each delivery location is also sent to the users at delivery locations.

The arrival of commodities information shall be sent back to sourcing and planning activity.

Storing the logistics data in a repository for reutilization shall be performed during the process of product distribution. The logistics activity shall produce the arrival information of each customized product, and the arrival information shall be transmitted to the service activity.

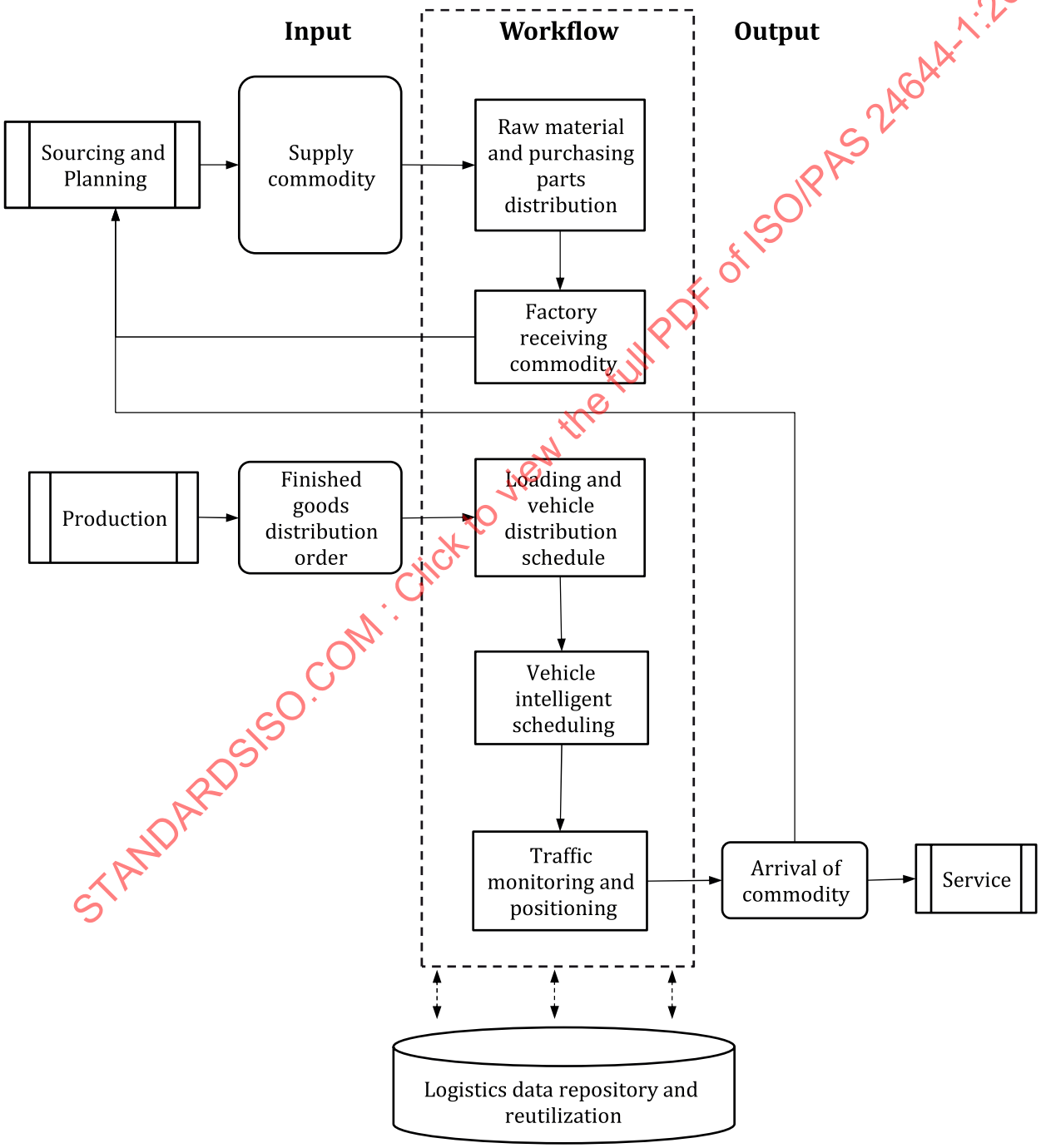


Figure 10 — Workflow of the logistics activity

7.9 Service

Service is a series of activities such as maintenance, product upgrading and value-added actions which shall be provided by enterprises after product delivery. The workflow of the service activity is shown in Figure 11.

After the completion of product delivery and with users' permission, the enterprise can conduct online diagnostics and operation data analysis of the products, provide users with remote fault diagnoses and usage suggestions, and execute remote preventive maintenance services according to users' customized demands.

The enterprise should provide relevant after-sales services according to users' service demands or the subsequent events driven by the initial services. At the same time, through the collection and analysis of product data and user service data, the enterprise shall form product and service upgrade plans and feed them back to the interaction activity in order to continuously upgrade customized products and optimize customized services.

Enterprises shall recommend or provide value-added customized services to users according to user demands or product usage scenarios or combine third-party resources to recommend or provide third-party customized value-added services to the users.

Through the repository and reutilization of service data after product deliveries, enterprises shall continuously update their service modes and models to improve user satisfaction.

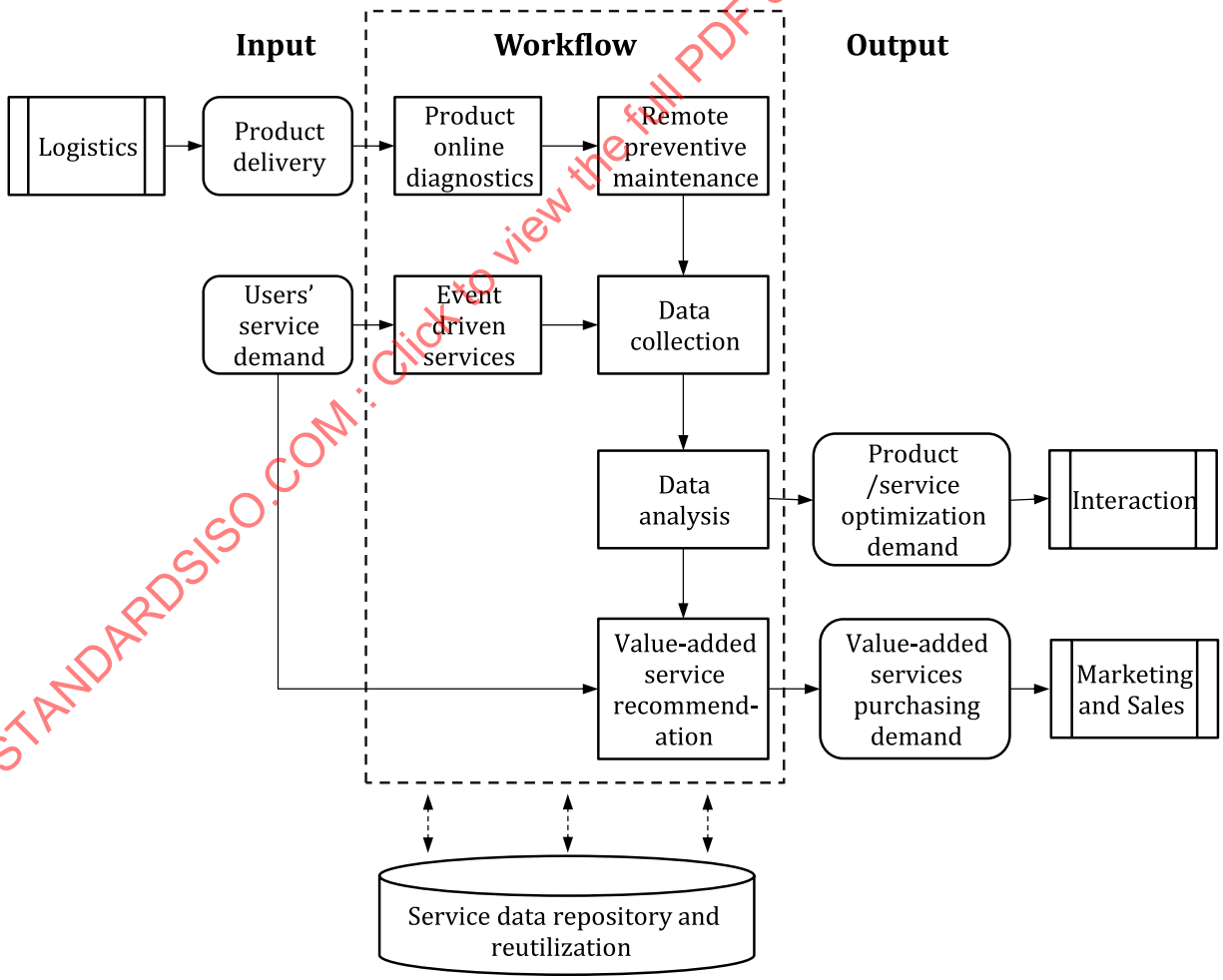


Figure 11 — Workflow of the service activity

8 Information flow of mass customization

The centre of mass customization is the users who participate in the activities of interaction, R&D, marketing and sales, production, logistics, and service. The information flow of mass customization between different activities is shown in Figure 12, and it may include the following:

a) In the interaction activity, a user interacts with a mass customization product provider to initiate the user's concept discussion. Based on the concept, and a creative solution or solutions in terms of the product concepts that shall be shaped and iteratively adjusted according to the feedback of users. After the creative solution, i.e. the concept design, is confirmed by the users, the solution shall be transmitted to the R&D activity.

b) The R&D department develops product design plans based on creative solutions. The product design scheme shall be adjusted according to the users' demand feedback and also to its validation by modelling and simulation (M&S). Finally, a bill of material (BOM) of a customized product shall be developed.

c) User orders are generated by precision marketing. After the user places an order for payment, a user order is created. The enterprise collects user data/information from the user orders and enters the data/information into a membership management database.

d) A master production schedule is derived from the user orders. After the master production schedule is generated, it triggers the production activity of customized products.

e) The commodity purchase orders are generated by the master production schedule. Material suppliers shall evaluate the purchase orders to ensure that the delivery of material can meet the production activity requirements.

f) The detailed and executable production plans are derived from the master production schedule and the lead time of the material. The enterprise carries out flexible production as planned.

g) After the customized product is rolled out from the production line, the products shall be moved and stored automatically in a warehouse, and the data about the customized product, e.g. product name and identifier, location, is sent and synchronized to the logistics activity.

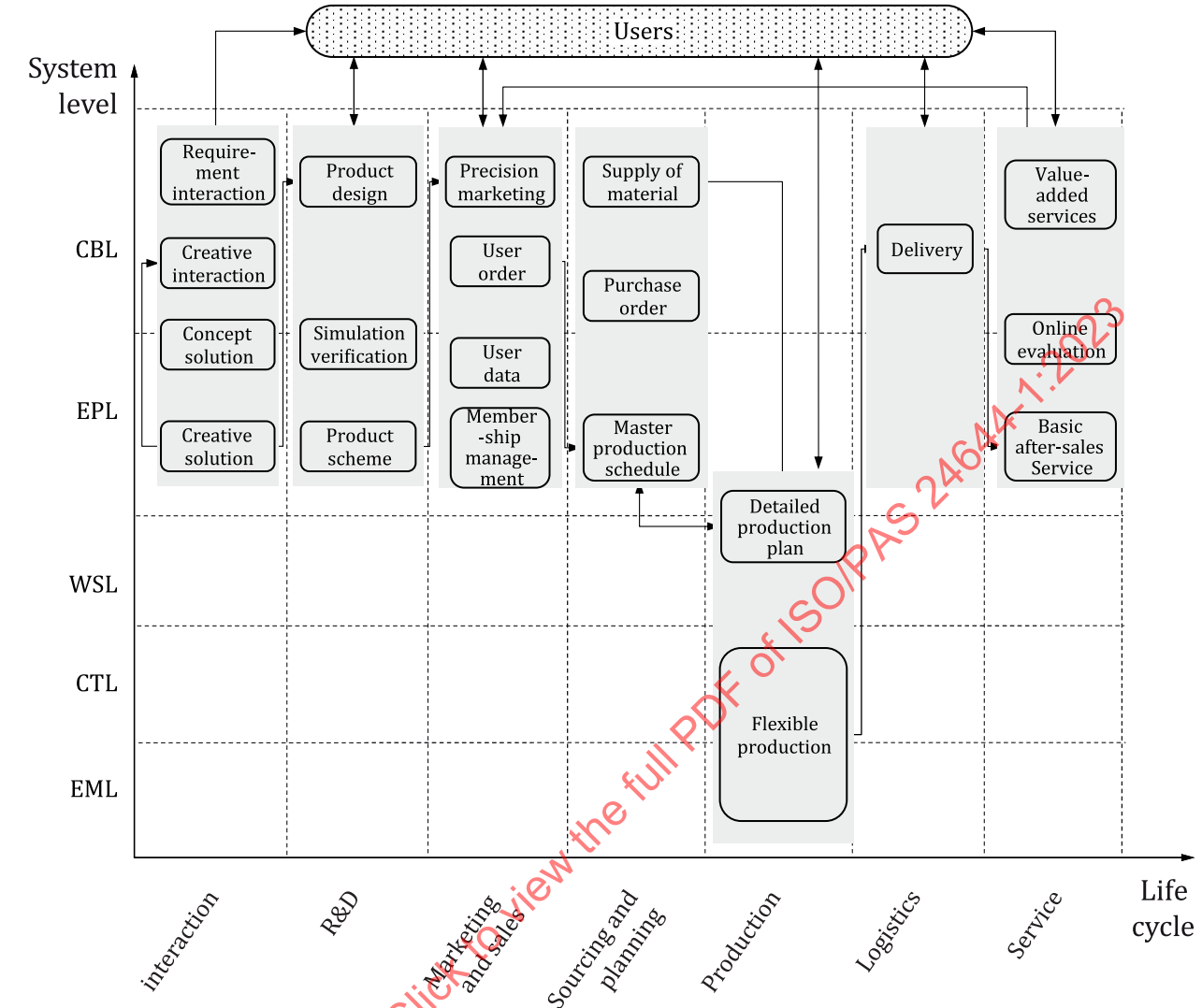
h) The customized products shall be delivered to the users through the logistics activity. Enterprises shall send and update the product delivery information to the users in real-time.

i) The enterprise shall provide after-sales and value-added services to the users based on online or offline evaluation of the product's diagnostics and operations data.

j) The enterprise shall continuously interact with the users via the service activity, obtain users' requirements and suggestions based on their experiences in using the products, and facilitate product iteration.

In Figure 12, the vertical axis presents the interoperability of user experience, industrial knowledge and data among enterprise and external affiliates. The horizontal axis covers the whole life cycle of the product which is represented by a series of mutually connected value creation activities from the mass customization interaction to service.

Because the application of mass customization varies in different industries, it is described in detail in Annexes A to D for four different industries, namely, consumer electronics, iron and steel, electrical products, and reverse customization, respectively.



Key

component

information flow

Figure 12 — Information flow of mass customization

Annex A
(informative)

Mass customization value chain management — Consumer electronics industry

A.1 Business challenges

Consumer electronics manufacturers face the following challenges:

a) diversification of user demands;

b) long design time and high costs;

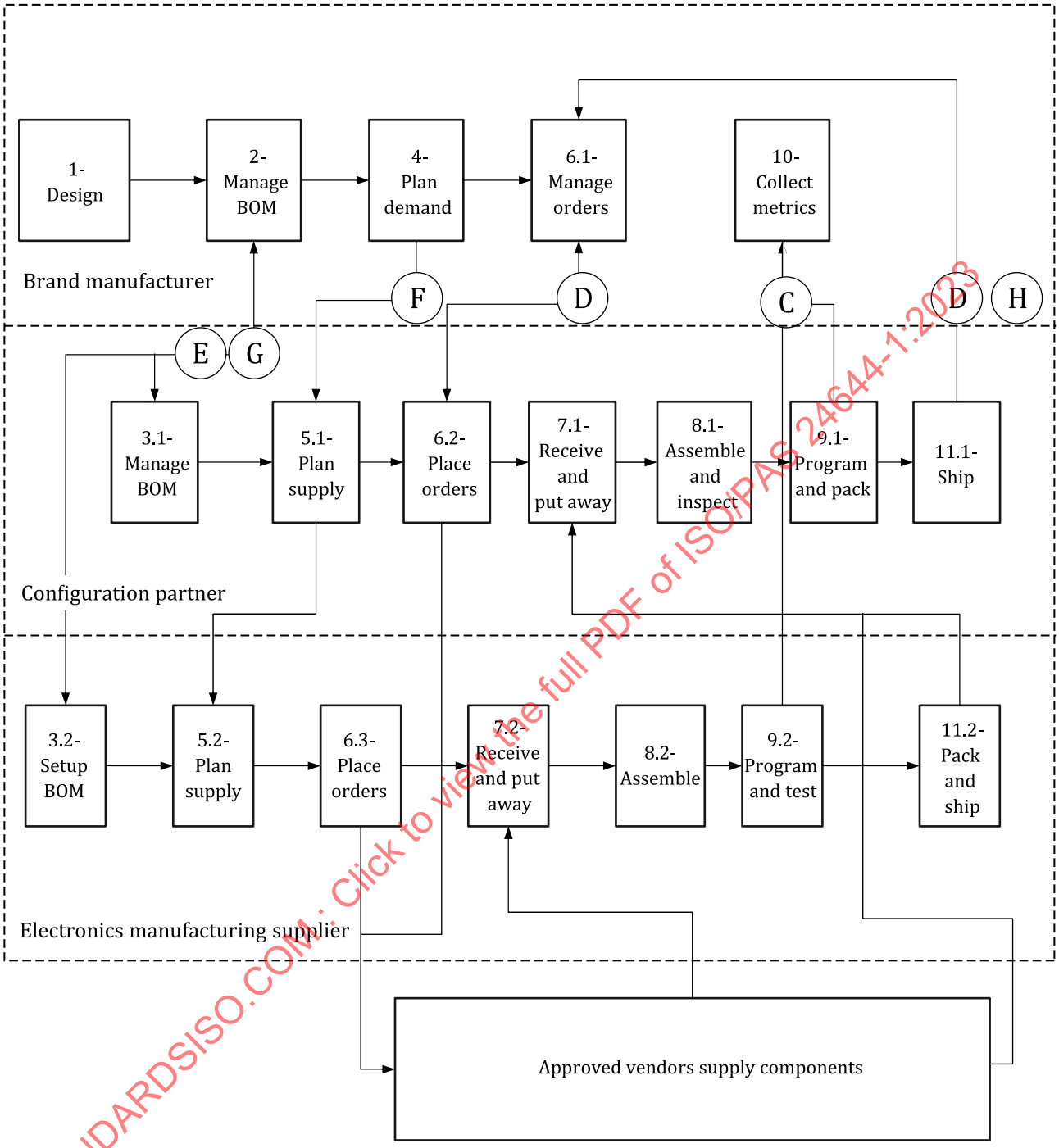
c) difficult supply chain management;

d) differentiation of after-sales service.

A.2 Solutions

A.2.1 Process flow

Process ownership is divided into three domains: manufacturer; configuration partner (CP); and electronics manufacturing supplier. Each domain is shown in Figure A.1 as the layers separated by the horizontal dotted lines. The numbers in the boxes in Figure A.1 represent the sequential activities of process flow.



Key

C quality data
D order management interface
E product data management interface
F planning data
G prints, specs, CAD
H performance data and reports

Figure A.1 — Process flow

A.2.1.1 R&D activity

This activity contains the design module, denoted by "1-Design," in Figure A.1.

For consumer electronics, most R&D activities are associated with design verifications. The verification test strategy consists of configuration test, assembly test, system test, and acceptance test. The test plans include manufacturer test plan, partner test plan, and integration test plan.

A.2.1.2 Scheduling activity

Scheduling activity contains the manage BOM module (see "2-Manage BOM" and "3.1-Manage BOM"), the setup BOM module (see 3.2-Setup BOM), the plan demand module (see "4-Plan demand") and the plan supply module (see "5.1-Plan supply" and "5.2-Plan supply") as shown in Figure A.1.

The CP sets up and manages product items and BOMs in their product data management system. A brand manufacturer is the source and the final approver for any changes in scheduling. The brand manufacturer develops planning requirements and transmits them to its partner sites via a secure interface. The CP receives a 52-week-rolling-demand from the brand manufacturer bi-weekly. The brand manufacturer assumes CP's commitment to all items on forecast within lead time. The CP then provides the demands to electronics manufacturing supplier designated by the brand manufacturer for bare units. The CP provides the visibility report of all supplies as defined by the brand manufacturer via a secure interface.

A.2.1.3 Production activity

The production activities include the manage orders module (see "6.1-Manage orders"), the place orders module (see "6.2-Place orders" and "6.3-Place orders"), the receive and put away module (see "7.1-Receive and put away" and "7.2-Receive and put away"), the assemble and inspect module (see "8.1-Assemble and inspect"), and the program and pack module (see "9.1-Program and pack") shown in Figure A.1.

The brand manufacturer sends purchase orders to the CP via a standard sales-and-purchase order interface. The CP places the orders of piece parts with designated consumer electronics suppliers with the terms and conditions flown down from the brand manufacturer in its award agreements. The CP purchases the bare units from the electronics manufacturing supplier on consignment in accordance with the terms defined by the brand manufacturer. The CP provides status updates on all orders in conformity with the consumer electronics order management interface. The CP tracks all items received to meet the first-in-first-out (FIFO) requirements. The CP uses a WMS to track materials in their facility. The CP assembles units, including pick to light, laser etching, and inspection, using the factory control system provided by the brand manufacturer. The CP programs and packs the assembled units by using the brand manufacturer's systems.

A.2.1.4 Inspection activity

The inspection activity consists of the collecting metrics module (see "10-Collect metrics") shown in Figure A.1.

Part, unit, and service quality data indicators of the CP and electronics manufacturing suppliers are collected using the brand manufacturer's system.

A.2.1.5 Transportation activity

The transportation activity contains the pack and ship module (see "9.1-Program and pack," "11.1-Ship" and "11.2-Pack and ship") shown in Figure A.1.

The brand manufacturer provides its delivery commitments to users based on available inventory. The CP assembles the products in the FIFO order to meet the agreed date to the users. The CP sends shipment confirmation to the brand manufacturer via a format and interface defined by the brand manufacturer. The CP consolidates the orders and arranges shipment with the transport providers designated by the

brand manufacturer. The CP is responsible for business-to-business (B2B) integration with transport carriers. Shipment terms and conditions are delivered with the transportation duty paid. The brand manufacturer provides the CP with all necessary data to create commercial invoices. The CP prepares all other shipping documentation. Accounts payable to the partners are triggered when shipment is confirmed, and the payment for products is sent in accordance with the purchase order's terms and conditions.

A.2.2 Demand and supply planning

A.2.2.1 Demand activity

The demand activity consists of modules (1), (1a), (2), and (3) in Figure A.2.

The brand manufacturer publishes a 52-week demand request report weekly and transmits it to the CP via a secure interface. The BOM planning percentage report is generated on a weekly basis along with the demand request report. B2B and common e-commerce materials are purchased according to forecast, while unique e-commerce materials are purchased according to the minimum / maximum inventory level as prescribed by the brand manufacturer. The forecast shared by the CP with component suppliers is consolidated across B2B and e-commerce for common parts to satisfy the minimum order quantity where applicable. On a weekly basis, the CP provides supplier delivery metrics as defined by the brand manufacturer via a secure interface. Metrics are used to evaluate the supplier's performance in accordance with sourcing awards.

A.2.2.2 Supply activity

The supply activity consists of modules (4a), (4b), (5a), (5b), (6), (7), (8), (9) and (10) in Figure A.2.

The brand manufacturer huddles and allocates constrained materials that are shared across multiple products or sites. Partners are responsible for providing a consolidated view of constrained components across their sites to the brand manufacturer. The brand manufacturer needs to present bare unit demands to the electronics manufacturing supplier partners until a fulfilment partner has an appropriate agreement in place. If the CP has not yet established an agreement to directly purchase all materials to fulfil B2B and/or e-commerce orders, the brand manufacturer will need to continue to plan, purchase and sell such materials to the partner.

In addition, the brand manufacturer shares the minimum/maximum levels for configure-to-order (CTO) piece parts and e-commerce finished products as part of collaborative planning communications, and publishes finished products, CTO option, and packaging and inbox material shortage reports.

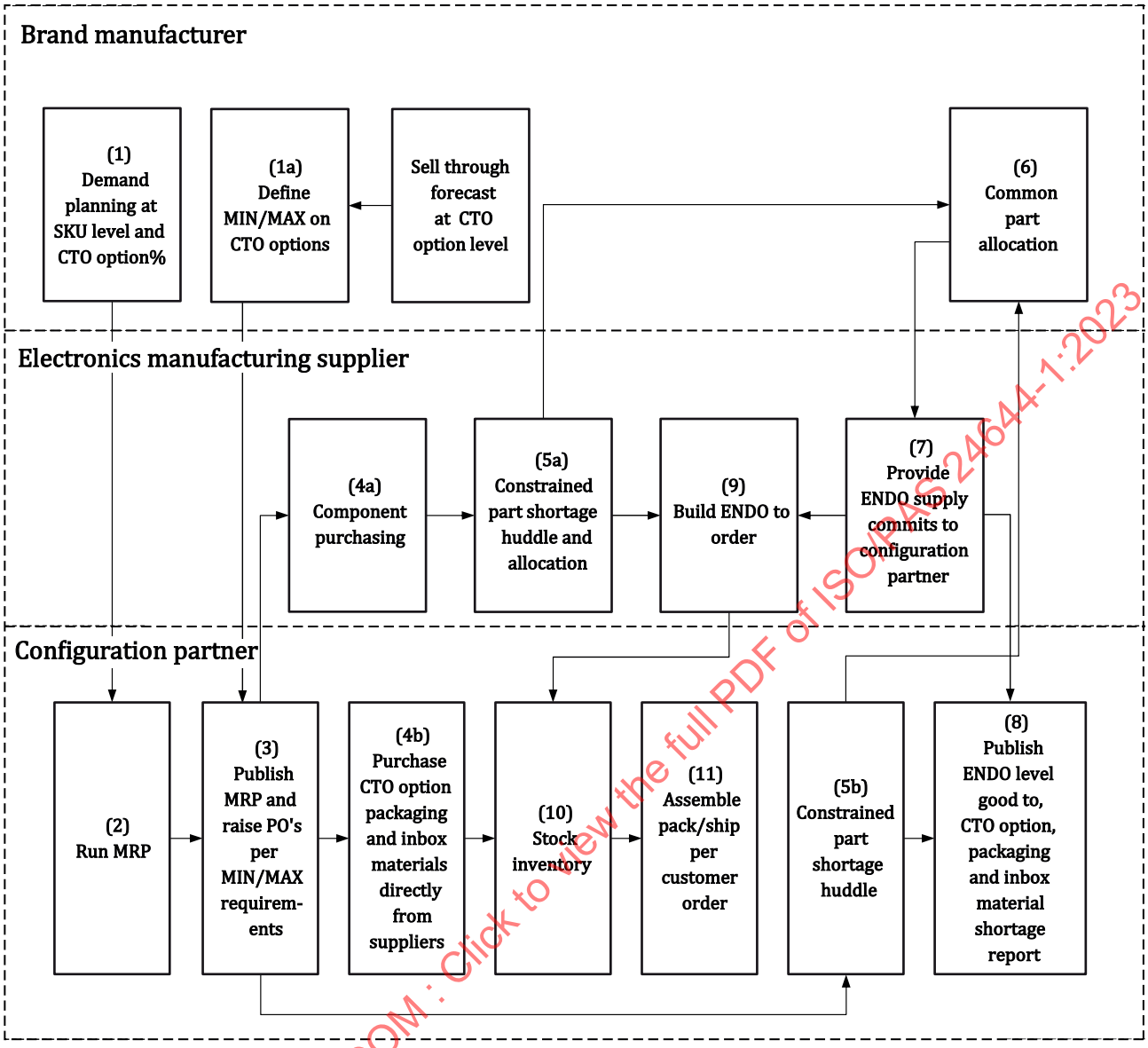


Figure A.2 — Demand and supply planning

A.3 Key performance indicators (KPIs)

Table A.1 shows the improved indexes after applying the mass customization.

Table A.1 — Key performance indicators (KPIs)

KPI	Description	Measurement	Goals
Dock to stock cycle time	Turn-around time started from products arrived at warehouse dock until inventory been updated into inventory system	6 h	98 % conformity/ month
Order processing cycle time	Turn-around time started from order received until shipment released to forwarder/user	Less than 24 h	98 % conformity/ month
Order fulfilment accuracy	Number of defect-free picked and packed	Error-free line/month-ly order line shipped	99 % conformity/ month

Table A.1 *(continued)*

KPI	Description	Measurement	Goals
Receiving accuracy	Number of defect-free receiving from supplier	Error-free shipment/ monthly inbound shipment	98 % conformity/ month
Inventory accuracy	Products count accuracy	Measurement of products count accuracy	99 % conformity/ month
On time delivery	Turn-around time started from order released to forwarder to the order is received by user	72 h	98 % conformity/ month

Annex B
(informative)

Mass customization value chain management — Iron and steel industry

Due to the changes in the supply side, the iron and steel industry has put forward individualized demands for product quality and delivery time, and users are increasingly strict with delivery time, expecting weekly deliveries. Therefore, in the value chain management of mass customization in the iron and steel industry, it is very important to realize the accuracy in business management to satisfy the users. It is more and more urgent to maximize the value of different life cycles for products, and to customize the distribution for the users on a large scale.

Figure B.1 shows three dimensions of mass customization value chain management in the iron and steel industry. The three dimensions are:

— business elements;

— production processes;

— life cycle.

The life cycle covers the MTO domain, the OTD domain, and the DTS domain during the customized procedure; the business elements list the objects realized by carrying out the functions in the MTO domain, the OTD domain, and the DTS domain; the production processes controls the working procedures of iron and steel that produce user-customized products.

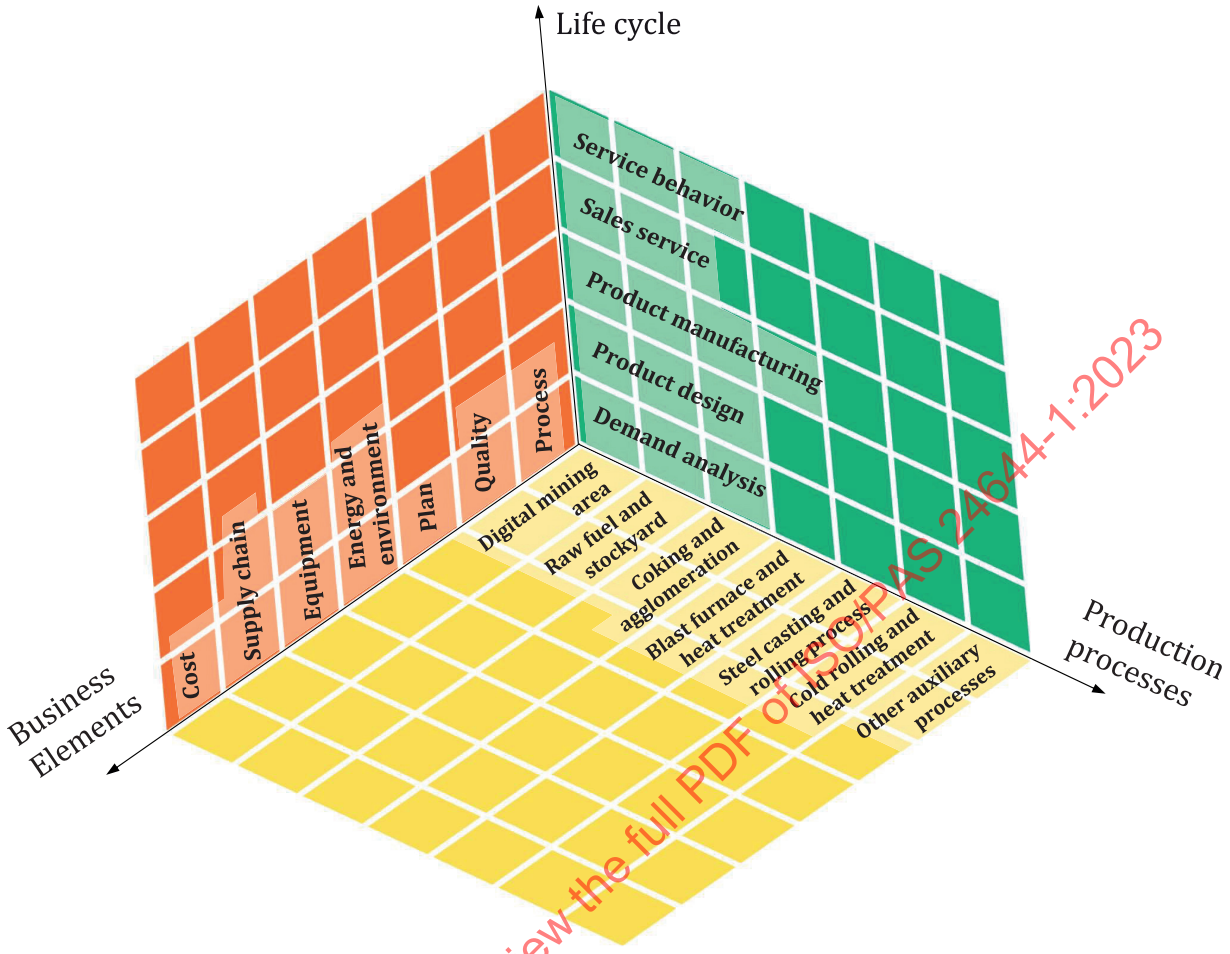


Figure B.1 — Management elements of mass customization value chain in the iron and steel industry

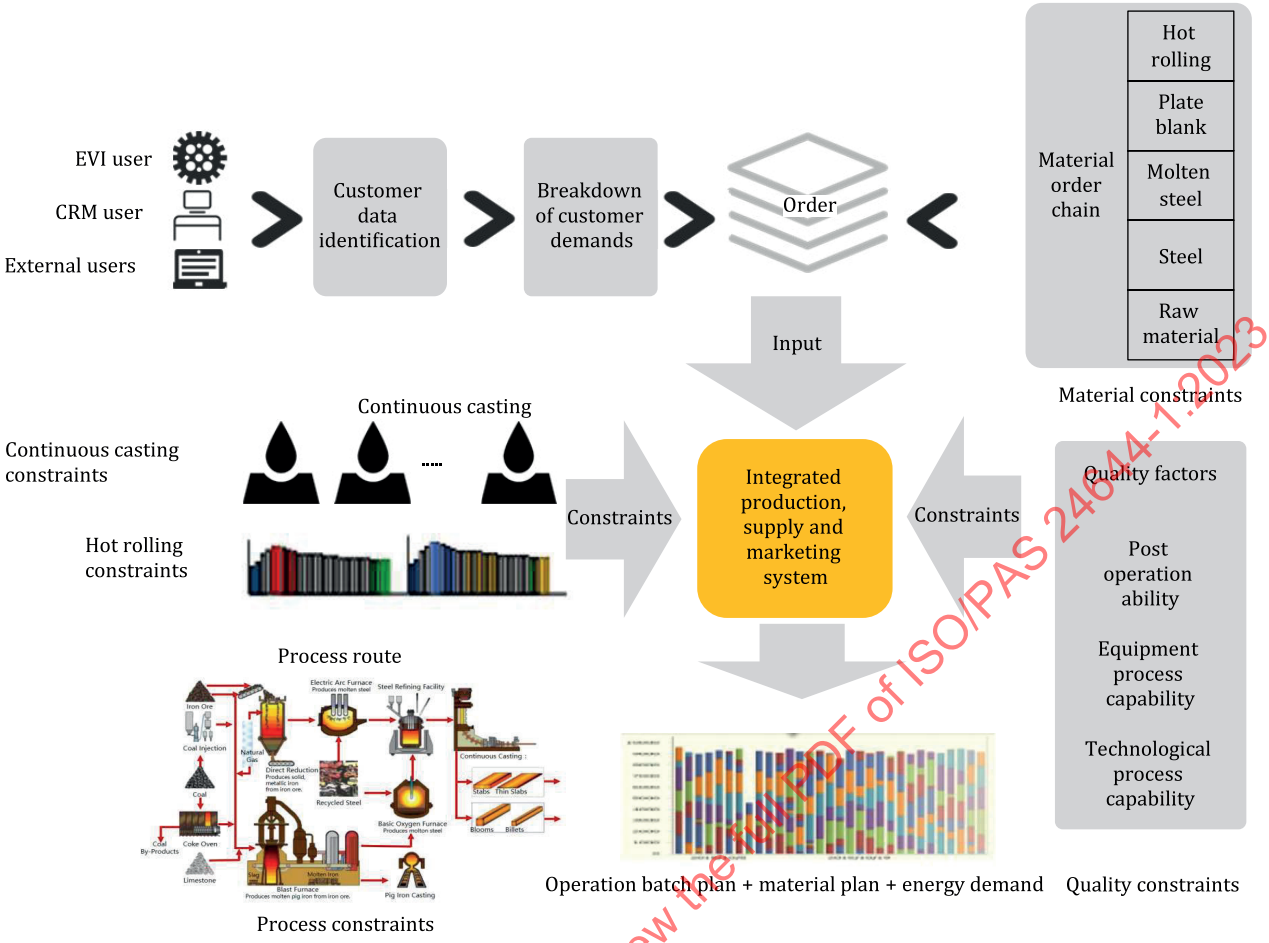


Figure B.2 — Mass customization process in the iron and steel industry

Figure B.2 shows the detailed process of mass customization value chain management in the iron and steel industry. Early vendor involvement (EVI) users, customer relationship management (CRM) users, and external users generate customized demands as the orders to the iron and steel factory. All functions in the MTO domain, the OTD domain, and the DTS domain are carried out among all collaborating enterprises as follows.

The mass customization process in the iron and steel industry mainly includes:

a) establishing an interface platform for EVI users, CRM users and network users; dynamically predicting market demands; preparing corresponding production plans according to users' customized orders; and optimizing various resources of different enterprises within the group;

b) mining the corresponding relationship between composition, microstructure, process and performance; establishing a digital twin model of product R&D and realizing the collaborative digital design of related products, processes and quality;

c) uniformly managing material location, quantity, status and value; and collaboratively optimizing manufacturing costs, resource cost and labour cost between processes and regions to realize a lean control of production cost;

d) establishing accurate quality control, dynamic optimization system, metallurgical specification, quality collaborative design, dynamic compensation optimization, abnormal cause judgment and traceability for the whole process to improve product quality stability;

e) building the relationship between marketing, production and investment, finding the weak links and uncertain factors in the value chain and formulating the lean strategic development plan of the enterprise by demonstrating and optimizing the connection between the value chains;

f) feeding back user experiences to improve the product quality and service ability.