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Industrial automation systems and integration — Standardized procedures for production systems engineering —

Part 5: Manufacturing change management

Systèmes d'automatisation industrielle et intégration — Procédures normalisées pour l'ingénierie des systèmes de production —

Partie 5: Gestion du changement de fabrication

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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 4, *Industrial data*.

A list of all parts in the ISO 18828 series can be found on the ISO website.

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Introduction

An increasingly dynamic business environment and the rapid changeover from a buyer's to a seller's market have gradually been increasing the complexity that companies are facing over the course of their product creation processes. Shortening product lifecycles, the extension of planning extents across global planning networks and an unwaveringly high expectation of process stability and quality have all turned change management within the product creation process into a vital success factor for internationally active manufacturers. In some of their departments, such as product development and the associated product data management, manufacturers have already begun responding to these developments by establishing sophisticated and technically supported processes that provide change-driven management within the product development process. However, this coordination and structural mapping of product changes [better known as engineering change management (ECM)] covers only a part of the relevant change processes occurring in digital product creation. Although ISO 10303, ISO 15531, ISO 19439 and IEC 62264 offer several data models, the current content of this document focuses on the area of production planning. Heterogeneous information technology (IT) systems and data models are common use due to the high amount of variations in the planning process. The data scheme in this document offers a generic method to structure the data and to present basic object types in order to implement manufacturing change management. In practice, the product systems required for the manufacturing and assembling of the products are likewise subject to many different changes. Some of these changes are preplanned and they are implemented specifically to achieve efficiency increases. Other changes, however, are subject to processes that are less structured or planned, which means that their practical repercussions and follow-up measures often cannot be adequately predicted. Typical for all of these types of change measures is the fact that the production system's applicable documentation and the actual state of production are temporarily or permanently inconsistent with each other, i.e. they are asynchronous (see Figure 1).

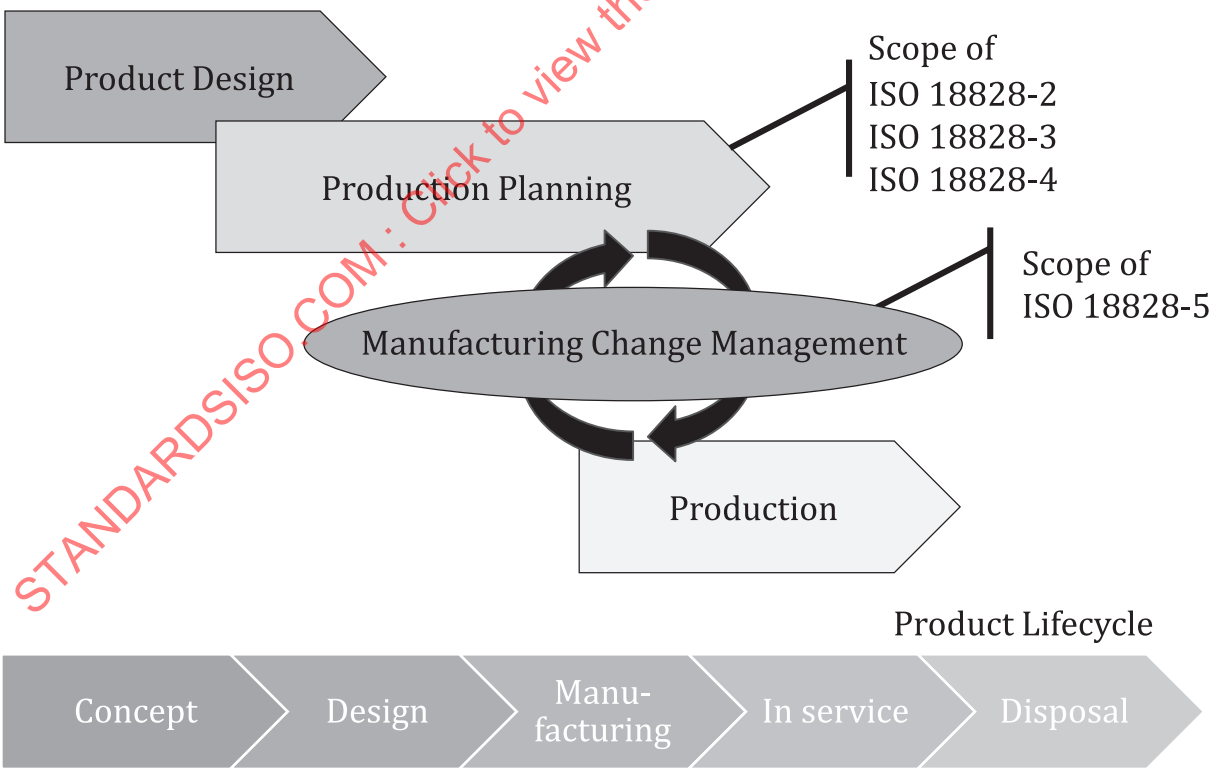

Figure 1 — Context of manufacturing change management

The applicable documentation for the creation, the commissioning and the operation of production systems is provided by the planning documentation. At the start of production, the documents and definitions of the planning departments serve as a reference for everything. Subsequently, some new measures typically emerge that are more practical than the originally planned ones, and they are the

ones that are ultimately implemented. Figure A.1 provides an example of how a system's actual state can deviate from the planned state over time. There are many different ways in which deviations from the planned state can occur. For example, ongoing improvements to the process often reduce the base time required for completing the process, thereby directly increasing its efficiency. Of course, there can also be entirely different adjustments, e.g. pertaining to ergonomics or machining capacities. These cannot be visually mapped and evaluated as easily. In addition, the triggers for changes can vary considerably and they can be identified and suggested by a wide variety of parties. Starting when the initial production process is implemented, the many changes that are introduced subsequently represent the actual manufacturing process at any given time. In the context of holistic production systems, the adaptability of manufacturing processes is crucial to competitiveness. Across-the-board efficiency increases are usually demanded on a yearly basis, creating a strong need for streamlining. In order to permanently adapt and optimize the process, the planning documentation necessarily deviates from the actual state of the production system sooner or later, i.e. all producers experience their manufacturing processes deviating from the original planning to some degree. However, in order to test, evaluate and reach the goals set in terms of quality, time required and cost-effectiveness, the planning needs to be constantly compared to the actual state. Any changes to the manufacturing process and planning take place over the course of an iterative process requiring the agreement of numerous participants.

Industrial automation systems and integration — Standardized procedures for production systems engineering —

Part 5: Manufacturing change management

1 Scope

This document specifies a formal description of the manufacturing change management (MCM) processes to provide an organizational and technical solution for the comprehensive mapping and processing of changes between production planning and operations. The aim of this document is to uniformly capture and track change measures, and to sensibly forecast and coordinate the capacities required for change processes in the planning and production departments.

This document presents a data-oriented view for implementation of MCM. The most important aspect of the data-oriented view is that the central change element is linked to the objects of the digital factory (i.e. the process, the product and the resource). The basis for MCM and the different views presented in this document are production planning processes.

ISO/TR 18828-1 gives an overview of the ISO 18828 series and links the MCM to the other parts of ISO 18828, focussing on production planning processes, as well as information flows and key performance indicators. The following aspects are covered within this document:

— processes of MCM;

— roles in MCM;

— data-oriented view of MCM;

— workflow of MCM.

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 terminological databases for use in standardization at the following addresses:

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

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

3.1
manufacturing change management
MCM
overall change management activities that apply for manufacturing

3.2
manufacturing change request
MCR
initial stage of the *manufacturing change management* (3.1) in which a request for a change is made and evaluated

3.3
manufacturing change order
MCO
final stage of the *manufacturing change management* (3.1) in which the implementation and accompanying steps of the requested manufacturing change are conducted

3.4
acquisition
steps from the change enquiry to the released change request

3.5
evaluation
clarification of and decision about a change request as well as the subsequent steps

3.6
receive change order
formal activity how a change order is obtained for further processing

3.7
plan change order
arrangement or updating of the product plan and the associated planning documentation

3.8
implement change order
realization of the manufacturing change in the production facility

3.9
inform participants
information of participants about the change to increase transparency

3.10
complete change order
update and documentation of the change status, as well as informing the initiators of the change request

3.11
create change enquiry
initial stage of the *acquisition* (3.4), where the change enquiry is initiated

3.12
process change enquiry
examination of the change enquiry

3.13
create change request
preparation of the change request

3.14
maintenance of manufacturing change list
updating and prioritizing the change requirements in the *manufacturing change list* (3.25)

3.15
compare affected objects
reconciliation of existing change requests and affected objects

3.16
clarify change request
examination of the change request

3.17
release change order
clearance of the change order

3.18
assign change order
identification of a suitable person and issuing responsibility

3.19
compare shopfloor and planning documentation
collation of workshop and planning document

3.20
production planning of change order
change order in regard of documentation required for the shopfloor

3.21
update change status
update of the change status in the documentation

3.22
inform change request initiator and creator
report of the conducted change to the request initiator and creator

3.23
manufacturing change management process
process consisting of two basic structural stages: the *manufacturing change request* (3.2) and the *manufacturing change order* (3.3)

3.24
manufacturing change management roles
relevant roles needed to ensure all functional and process-related operations for the *manufacturing change management process* (3.24)

3.25
manufacturing change list
MCL
relevant changes in the manufacturing environment (shop floor)

3.26
product structure
structure providing a functional classification of all items, parts, components, subassemblies and assemblies of a product

Note 1 to entry: The hierarchical "as-designed" product structure which is defined during product design allows the creation of an engineering bill of materials.

[SOURCE: ISO 18828-2: 2016, 3.1.9]

4 Abbreviated terms

ECM	engineering change management
CIP	continuous improvement process
IT	information technology

MCM manufacturing change management

MCO manufacturing change order

MCR manufacturing change request

MCL manufacturing change list

5 Process-oriented view of manufacturing change management

The process model of manufacturing change management is based on a multi-level structure. The model is detailed by progressive stages in a top down approach. The degree of abstraction decreases by drilling down through the levels. The number of available levels depends on the processes and the connected subprocesses. Here, the main processes are broken down into several sublevels. To reach an appropriate degree of abstraction, especially for the main change activities, four levels are defined. These levels are illustrated in Figure 2. The notation of the elements within the process represents their respective model level in order to reach a better orientation while going through the description of each process. Except for the root process 0 at model level 0, each process refers to the model level according to the number of numeric digits in the notation.

EXAMPLE 1 The process 112 contains three numeric digits and belongs to the model level 3.

The process number in each level includes the stage numbers of the upper-level-processes.

EXAMPLE 2 The process 112 (Process change enquiry) is derived from the processes 1 (Manufacturing change request) and 11 (Acquisition).

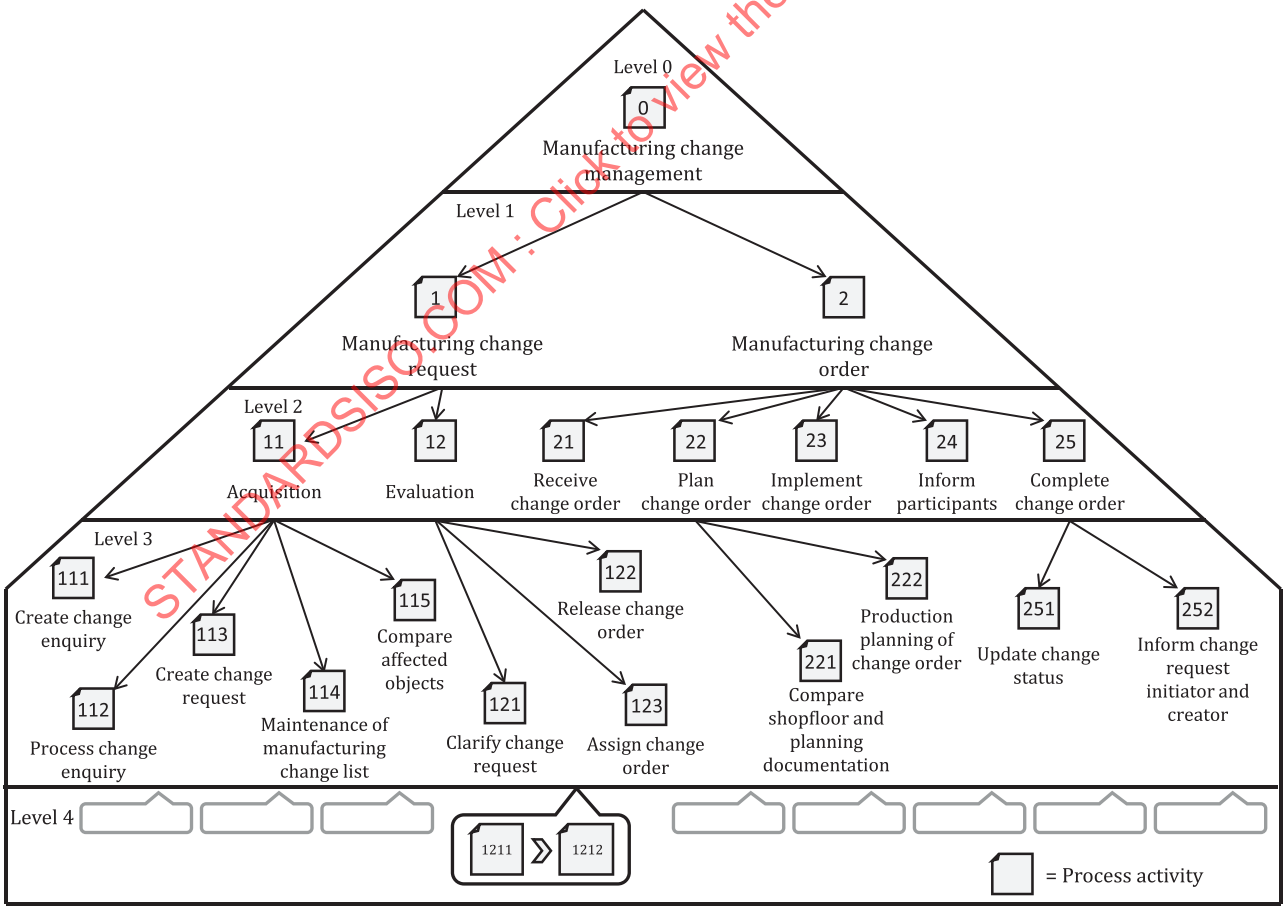

Figure 2 — Structure of manufacturing change management process model

The modelling makes use of combining recurrent functions and constraints into aggregated modules. As a result, clear structured processes consisting of input and output data have been modelled. The description of manufacturing change management is combined at the root level. This aggregation leads to a significant increase of clarity of description and enables a prioritized view for the user at the change management process. The description of the detailed model levels follows the same top down approach. First, the level with the highest degree of abstraction is described (referred to as level 0), following a description of the level consisting of the main function of the manufacturing change management process. In reference to this basis, every possible characteristic change activity is consecutively described. To ensure a consistent description of the different model levels, the detailed description of the levels contains the following structure:

— the graphical abstract of the detailed process activities using Structured Analysis and Design Technique (SADT) notation;

— the textual description of the process activities;

— the additional explanation of specific model details.

6 Detailed description of process 0

As illustrated in Figure 3, the manufacturing change management consists of two basic structural stages:

— the manufacturing change request (MCR) (1);

— the manufacturing change order (MCO) (2).

These two stages are described in greater detail in the following clauses.

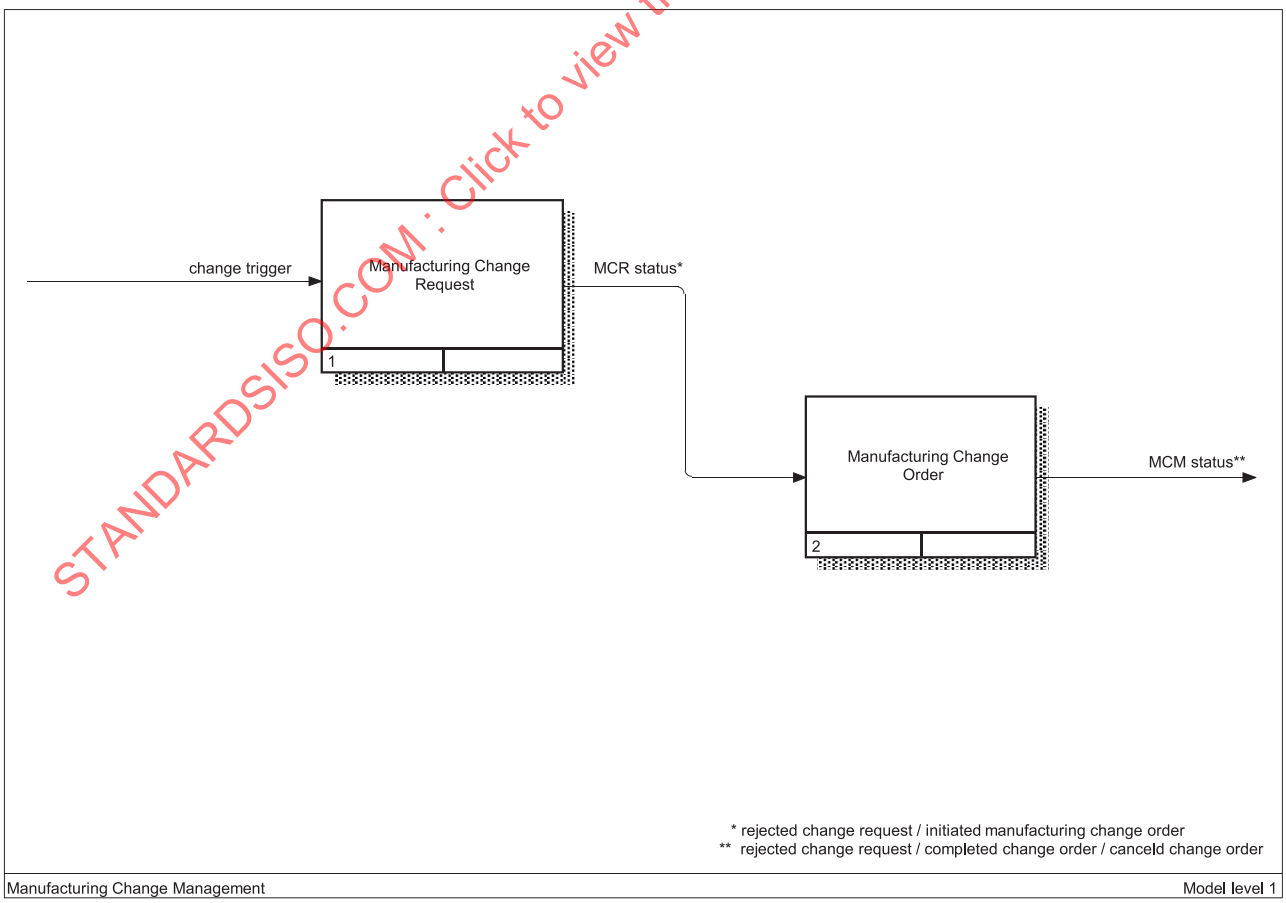

Figure 3 — Structure of "manufacturing change management" at model level 1

7 Detailed description of process 1

As illustrated in Figure 4, within the scope of the MCR, all of the manufacturing changes are captured and checked in terms of their permission to change the planning documentation, i.e. their permission to trigger an MCO. Within this first stage of the overall MCM process, both the initiators of the change enquiries and the employees who implement them are known; they are predefined as part of the company's in-house rules and modalities. Structurally, the MCR process can be subdivided into eight subprocess steps with varying levels of complexity. The first five steps (111, 112, 113, 114, 115) serve to fully capture the change enquiry (11), whereas the sixth to eighth steps (121, 122, 123) initiate and implement the enquiry's evaluation (12) in terms of downstream process flows within the overall MCM process. Within the given level of abstraction, these steps are context-independent and can be applied to any parties, i.e. any relevant MCM change enquiry.

The following clauses provide an overview of the steps of the MCR process, divided into the capturing and the evaluation of any given change enquiry.

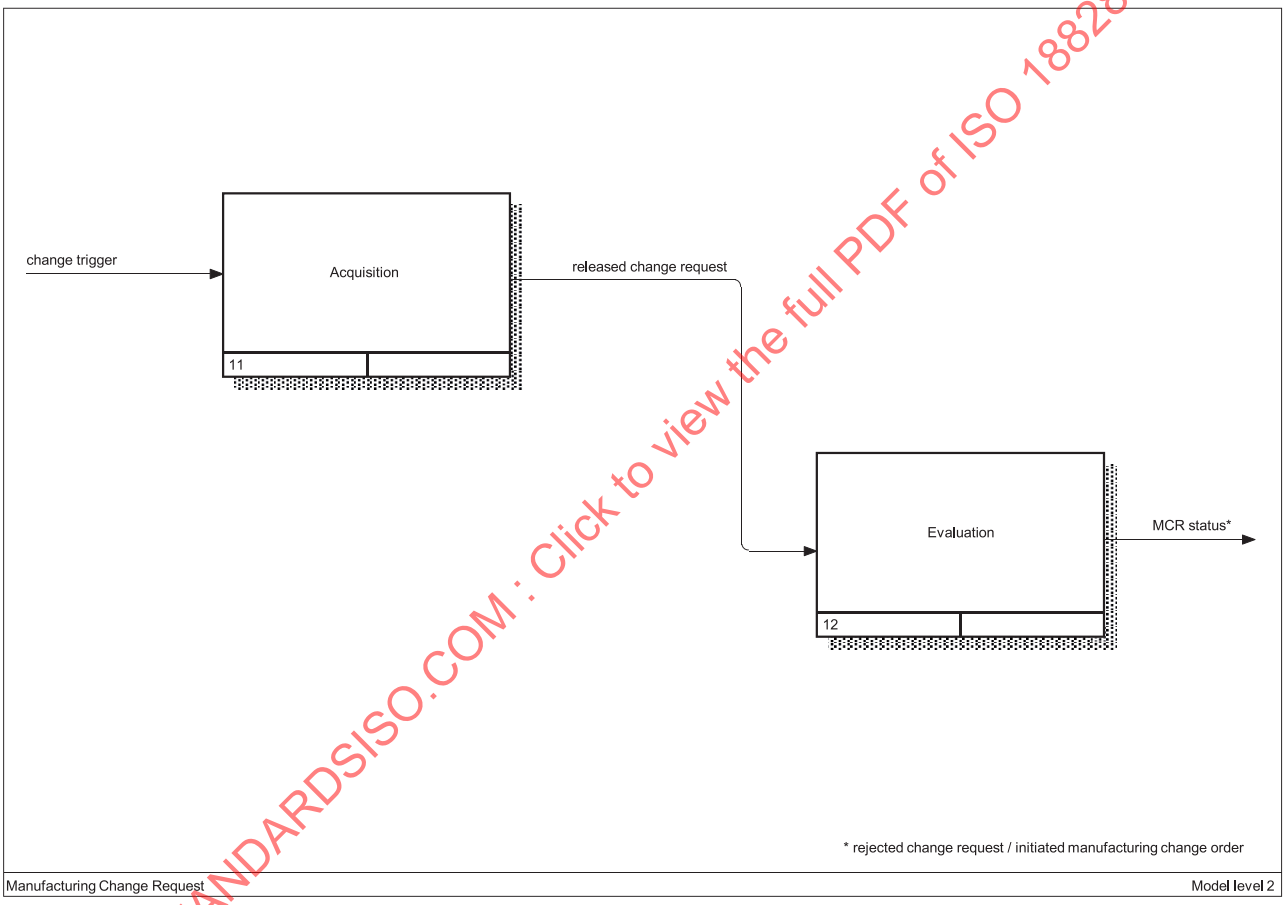

Figure 4 — Structure of "manufacturing change request" at model level 2

8 Detailed description of process 11

The detailed description of the MCR acquisition (11) is pictured in Figure 5 and is described in detail in the following. The capture procedure of the MCR begins where the initiator creates the change enquiry (111). As described above, both in-house areas such as product development and manufacturing or assembly planning as well as external parties such as suppliers or customers can act as initiators. In practice, these deploy different forms of communication. In terms of structure, they also map their ideas and requirements heterogeneously. What they all have in common, however, is that they issue a specific change enquiry to other parties of the change process.

The process of capturing the change enquiry entails supplementing and completing the existing information, frequently using queries, detailed process know-how, or employee expertise (112) (see Figure B.1). In addition, the enquiry is checked for its general validity in terms of changes within the company, which can involve examining the enquiring party's area of responsibility or the general framework conditions. A first plausibility test is also to be run at this time in order to efficiently pre-filter the submitted enquiries. Enquiries that do not pass this test are rejected: they are returned to the enquiring party with an explanatory message and they are excluded from the subsequent activities of the MCR process. Enquiries that do pass the test are classified according to their extent of change and an estimate of their attainability.

In general, the implementation of the subtasks involves a variety of persons and departments within the company, such as expert committees or core teams. Applied to day-to-day company operations, this might involve a visual inspection by the foreman, or a report being compiled by the planning team. Assuming the change enquiry has been captured in full, the change request is prepared in the next activity of the MCR process (113) (see Figure B.2). Most importantly, this activity is used to identify the planning objects and responsible parties affected by the planned manufacturing changes. In practice, these might be machines, tools, workplaces, or work plans, as well as foremen, operators, or planners. Only once these have been identified can the processing timespan be estimated and the responsible parties assigned to the request.

To create and maintain a superordinate and central manufacturing change list (MCL) is particularly relevant in practice (114) (see Figure B.3). This list makes it possible to precisely control and manage changes in a wide range of areas, as well as precisely track the change request within a master list of manufacturing changes and document its status. A transparent overview of all the request changes is vital to each decision-making process in order to enable sensible overall schedule planning and prioritizing of individual orders. Besides the management and maintenance of current change requests, the MCL makes it possible to capture and evaluate rejected change requests in a separate list. The analysis of rejected requests sometimes yields very valuable insights.

Following analysis of the objects affected, the current change requests are sighted in the next activity, where they are also reconciled with existing change requests within the manufacturing change that pertain to the same objects (115) (see Figure B.4). Time estimates can be confirmed and any overlap between current and/or planned changes can be identified. In practice, this might be instantiated via a standard monthly communication from management, experts communicating via social networks, weekly launch management meetings, or quarterly workshop schedules.

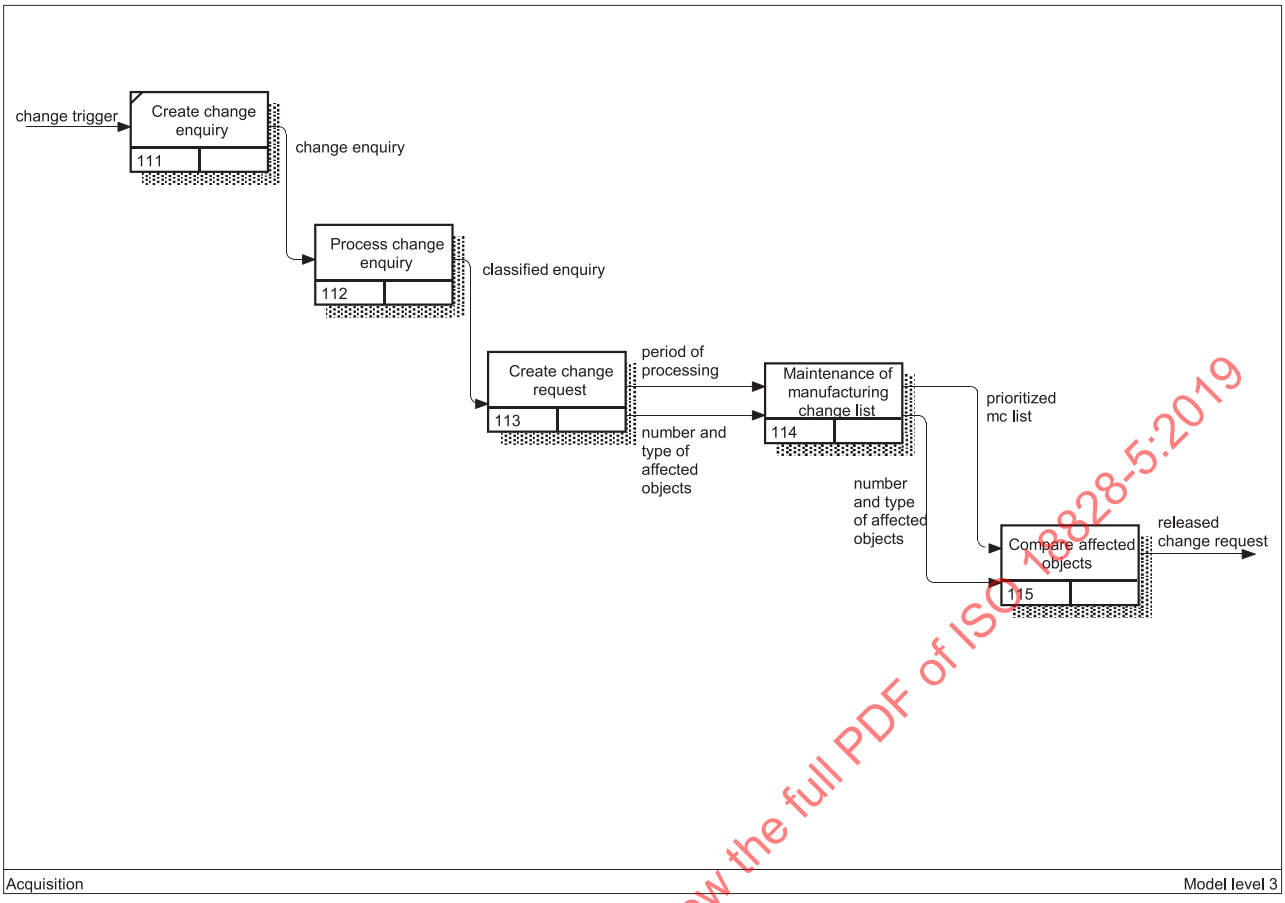

Figure 5 — Structure of "acquisition" at model level 3

9 Detailed description of process 12

Within the following three activities of the MCR process illustrated in Figure 6, the change request is evaluated. The objective of this evaluation is to make an informed decision about whether a change order is issued. To this end, the sixth step (121) is used to clarify the participants of the change request (see Figure B.5). This includes identifying the decision makers required for instating a qualified decision-making process. The decision-making process itself and its organizational implementation are both subject to a wide and varying range of external conditions that frequently hinder this process from being properly mapped within the MCM reference sequence. Accordingly, the reference sequence does not entail mapping the decision-making process; nevertheless, its outcomes do also inform the subsequent steps of the MCR process.

The next activity comprises the processing of the change enquiry, which ends with the change request either being approved or rejected (122). A formal specification of how the decision is documented and conveyed has not yet established itself in practice, which means that the approvals and rejections are issued by parties such as planners (with or without reports), or verbally within workshops or team meetings. In addition, the initiator and creator of the request are informed about the decision, regardless of its outcome.

The last activity of the MCR process is to prepare the change order. Essentially, this step (123) comprises two implementation tasks (see Figure B.6). Firstly, a suitable contact person needs to be chosen for implementing the change request. This person acts as the MCO operator and is responsible for all subsequent processing of the change request. It is important to distinguish here that this refers to the organizational responsibility for the further processing and maintenance of the change request, not the responsibility for physically implementing the change within the production and planning system. After the MCO operator is assigned, the change order itself (the MCO) is issued.

Having uniform management and tracking of change requests provides a significant advantage, namely the reinforcement of standards within the improvement of standardized production systems. Approved changes to the production system can offer significant opportunities of improvement for other system areas – or even other departments or company sites – that are identical or similar. When this is the case, the structural MCM process not only facilitates the approval of the individual change at hand but also the triggering of further MCRs for similar instances where the process can be applied in the same way. The last step of the MCR process is to prepare the change order. Essentially, this step comprises two implementation tasks. Firstly, a suitable contact person needs to be chosen for implementing the change request. This person acts as the MCO operator and is responsible for all subsequent processing of the change request. It is important to distinguish here that this refers to the organizational responsibility for the further processing and maintenance of the change request, not the responsibility for physically implementing the change within the production and planning system. After the MCO operator is assigned, the change order itself (the MCO) is issued. The MCO specifies the implementation of the requested manufacturing change. The individual steps and associated tasks of the MCO are summarized in the following clauses. Note that the main overall stages of documentation and implementation cannot always be completed in sequence.

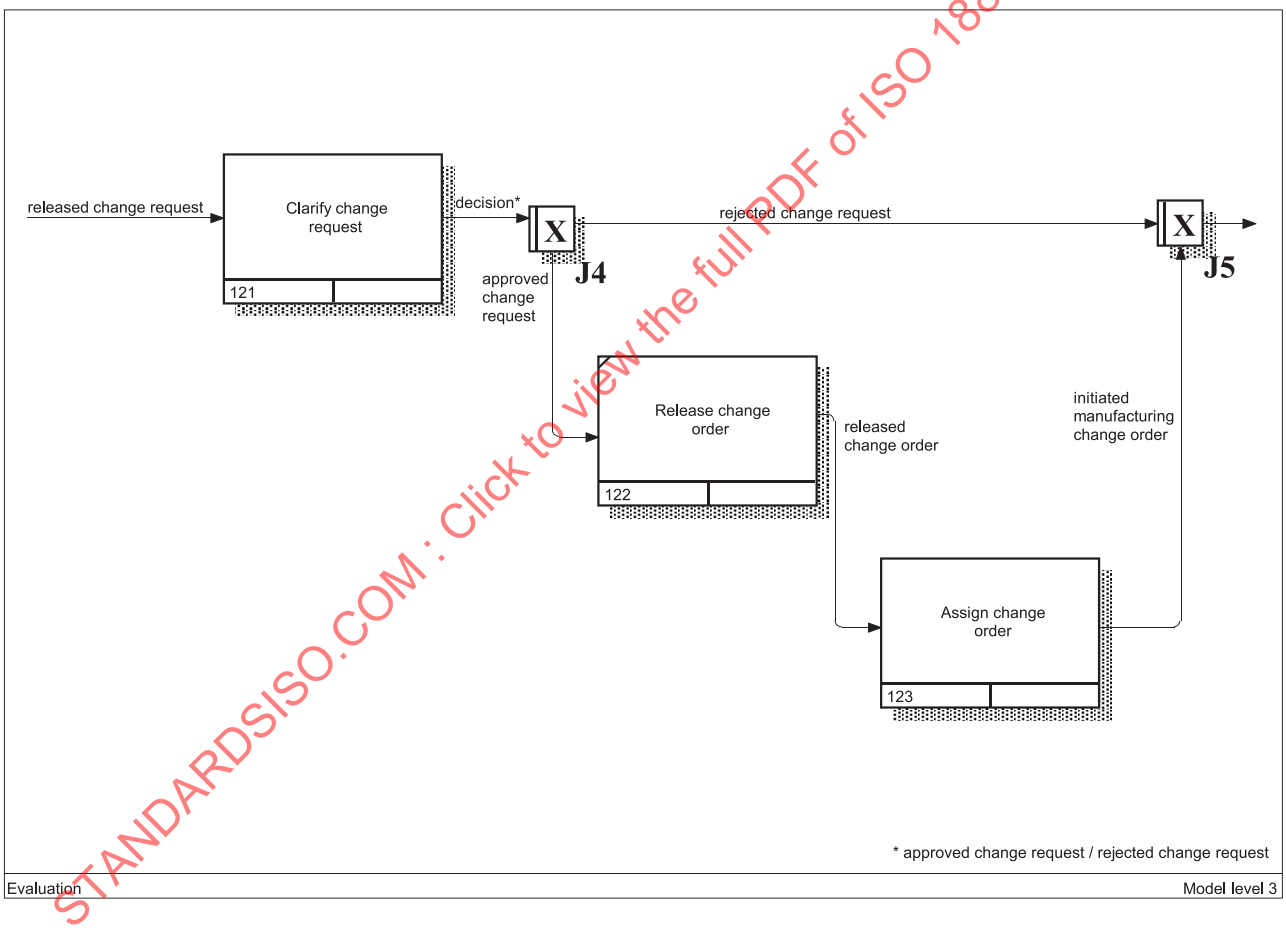

Figure 6 — Structure of "evaluation" at model level 3

10 Detailed description of process 2

The first activity of the MCO, as illustrated in Figure 7, is purely formal. It is for the change order to be accepted by a person who subsequently acts as the MCO operator and assumes responsibility for processing the manufacturing change (21). In day-to-day operations, this assignment might take place as part of a regular status meeting or team meeting. The second activity entails the required re-planning or updating of the product plan and associated planning documentation (22) (see Figure B.7). This applies not only to the detailed planning documents, digital models and analyses, but also to the documentation required for the shop floor (e.g. work plan).

In the third activity, the actual implementation at the production site takes place (23). This can comprise manufacturing as well as assembly processes. This step has been formalized so that the manufacturing process can be based on the most up-to-date planning documentation just as it did when the original plans were implemented. If possible and where necessary, this can be done together with the production planner in charge or with one of the core production teams. This ensures the process capability, and any further changes that might result from implementation can be reported back to production planning so that the documentation can be updated.

The fourth and fifth activities (24, 25) represent the completion of the MCO (see Figure B.8). While this can seem like a mere formality, it is in fact quite important to ensure the transparency of the given manufacturing change within the MCM information process. The MCO operator is tasked to confirm that the change has been implemented and the documentation updated, and to formally close the MCM process. In addition, the manufacturing change needs to be documented as "completed" within the MCL. The completed manufacturing change represents the latest version of the overall MCL, and with it, the latest status of simultaneously planned other manufacturing changes on the same line or station. The defined structural steps form the basis for adequate IT support on the one hand, and on the other, for the transparent management of other manufacturing changes being triggered from different areas, which can overlap both in terms of content and timing.

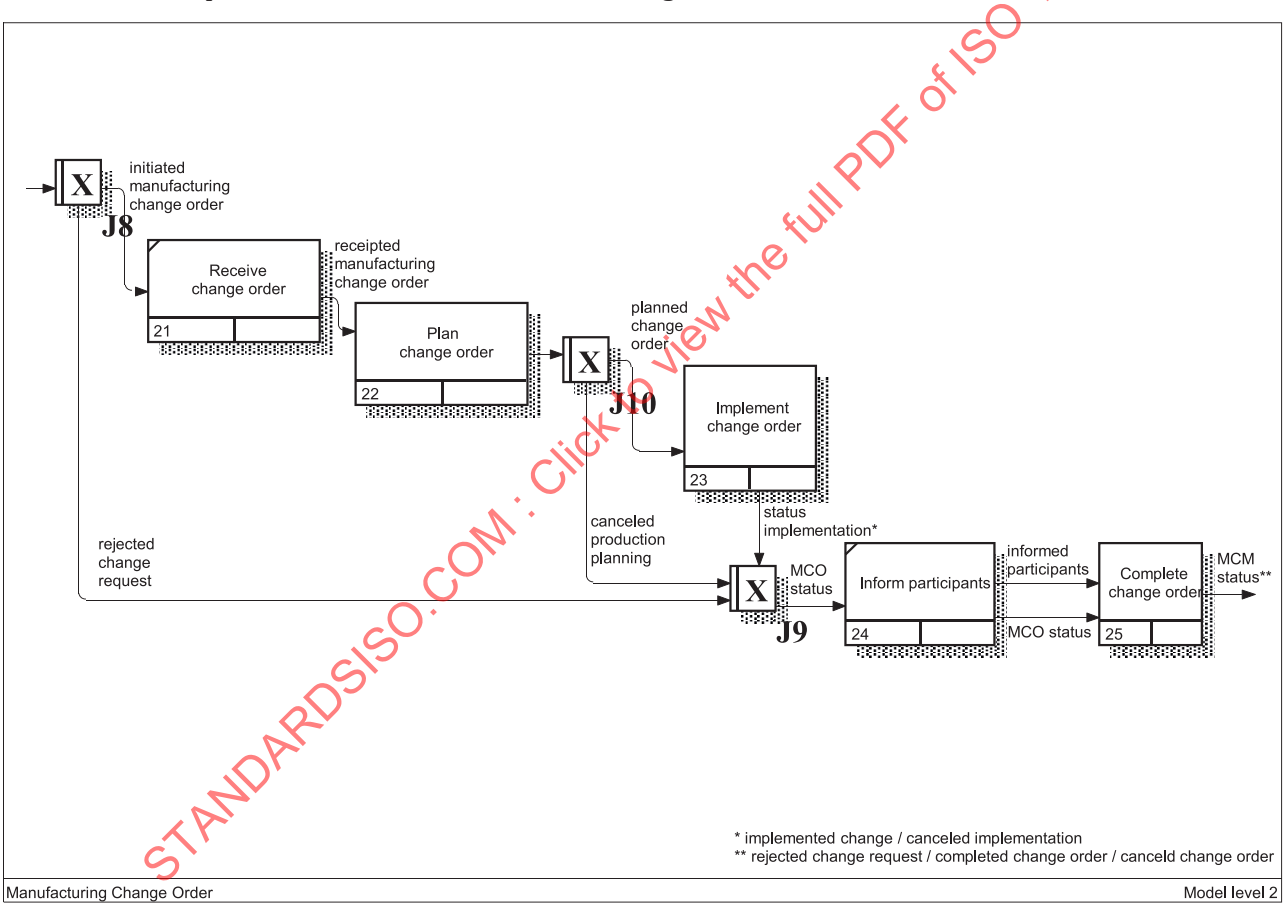

Figure 7 — Structure of "manufacturing change order" at model level 2

11 Manufacturing change management roles

To be implemented, however, MCM should not entail the creation of any new departments or units, but rather be integrated into the existing organizational structures for planning and production. Changes that can have considerable consequences for production require unambiguous documentation and assignment of responsibilities. In some areas, such as ideas management (company suggestion system), these approaches are being applied already. A guided change process for planning and production relies on a predefined role concept that details the required tasks and responsibilities. In terms of the MCM

stages, this suggests two employee roles for MCR and MCO operation respectively. The MCR operator is responsible for the request stage of the manufacturing changes, while the MCO operator is responsible for their implementation stage. Depending on the types and extents of the changes, the groups of employees relevant to these roles vary considerably. Almost all organizational structures already have dedicated tasks and responsibilities for these.

The responsibilities of the MCR and MCO operators are derived from the requirements of day-to-day production, which in many cases are identical to the responsibilities of the organizational structure for planning. Implementing the role concept within the MCM process does not necessitate any additional staffing. The advantages of a clearly-defined role concept, on the other hand, are obvious. Existing procedures for changes in production and planning are brought together within a single concept, and the undocumented changes can also be captured, eliminating any divergences between the current state of planning and the actual system state. The significant roles within the MCM concept, as illustrated in Table 1, are only briefly sketched in.

Table 1 — Significant roles in the MCM concept

Roll designations	Short description
MCM initiator	Records and formalizes changes
MCM coordinator	Coordinates and prioritizes changes
MCM responsibility holder	Tracks and steers changes
MCM business administrator	Administers the system from a business view
MCM system administrator	Administers the technical infrastructure

The MCM initiator is the most frequent role and is significant for a later implementation of the concept. The integration of information capture and provision within the scope of the MCM process during other day-to-day tasks is characteristic for the MCM initiator. This leads to the assumption that time-consuming documentation or networking tasks are only carried out on site under organizational pressure, or not at all.

Coordinating the different change requests and change orders on the strategic level requires an instance that prepares decisions about change measures, covers conflicts between planning objects and contributes to clarification of the overall change. To identify change conflicts, in particular to prepare for the requisite decisions, this MCM coordinator needs comprehensive information about changes of all relevant business areas, as well as additional information about the persons involved in implementing the change, so company-internal clarification is initiated as required.

If a positive decision has been made to implement the change measures, the status of the implementation needs to be kept transparent among the MCM responsibility holders, who are often numerous. The MCM responsibility holder primarily ensures continuation of the company-specific configured status of the MCM process. With a special filtering of the changes relevant for the respective employee, synchronizing the physical implementation of change measures with the digital representation of the MCL can be simplified.

To be able to ensure a specialized engagement with the MCM general conditions and processes for this function, the role of an MCM business administrator in production operation is helpful. The administrator undertakes data and software maintenance, derives corresponding change management processes and maintains and develops the roles and rights management in the MCM concept. In the process, the administrator takes the expert view of the participating structures and is directly involved in the MCM process.

One of the key requirements for the effective implementation of the MCM methodology is the integration of structural data from primary IT systems. The MCM business administrator, working alongside the IT managers, also accordingly carries out the complex task of data synchronization for linking and managing changes in the MCM software. A further requirement includes the ability to feed key information back from change management to established data management workflows, which

could take the form of workflow support, for example. Developing alternative solutions and adapting workflows to meet the requirements for MCM usage can only be effectively performed by the MCM business administrator.

The role of the System Administrator is required for configuration and maintenance of the MCM system as a supplement to the above roles, which participate directly in the MCM process. This administrator manages the users and undertakes system updating and maintenance in the existing IT landscape (e.g. security concepts, interfaces). The tasks are restricted to provision and maintenance of the infrastructure necessary for the MCM process.

12 Data-oriented view of manufacturing change management

The manufacturing change process facilitates several structures:

— product structure;

— process structures;

— resource structures;

— production structures.

The structures are set up and stored in diverse native systems, usually using heterogenous data schemes (see Figure 8). Mostly the exchange of data between them occurs through specialised data interfaces. Data interface formats have been developed and shaped in order to seamlessly and securely transfer all information stored in the main entities (e.g. object types). In addition, homogenous solution providers developed and implemented general data structures that contain all different aspects (e.g. states, lifecycles, relations, maturity degrees) that can be required by a change management data artefact.

Figure 8 depicts the four main structures. The production structure has been broken down into three main entities, i.e. Production Site, (Production) Line and (Production) Station.

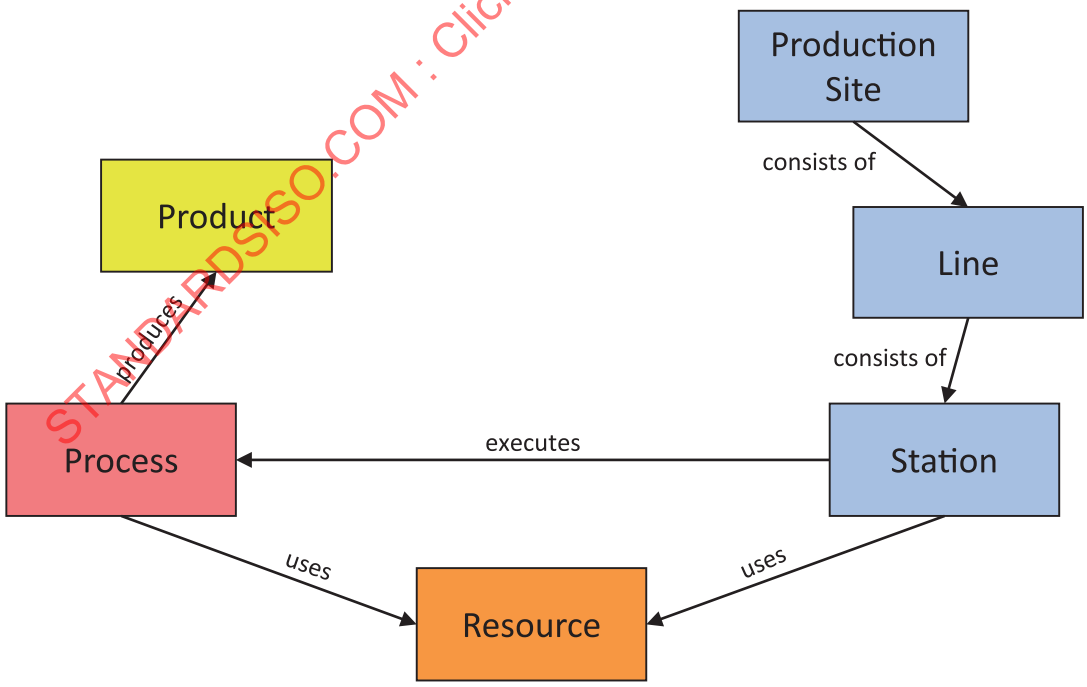

Figure 8 — Relationship of different structures required in the MCM process

Each structural element interacts at least with one another. All inter-relations usually apply from the data stored in the object instances of the structure.

However, in manufacturing, all structures are important and hold certain information that is useful and necessary in order to produce the product. Figure 9 integrates an object called “manufacturing change”. A manufacturing change affects a product in the design phase, it affects a process as a manufacturing process step might be added, omitted or changed and it affects a resource that is used by the manufacturing process. A manufacturing change can occur either at a production site (i.e. a factory), a (production) line or a (production) station.

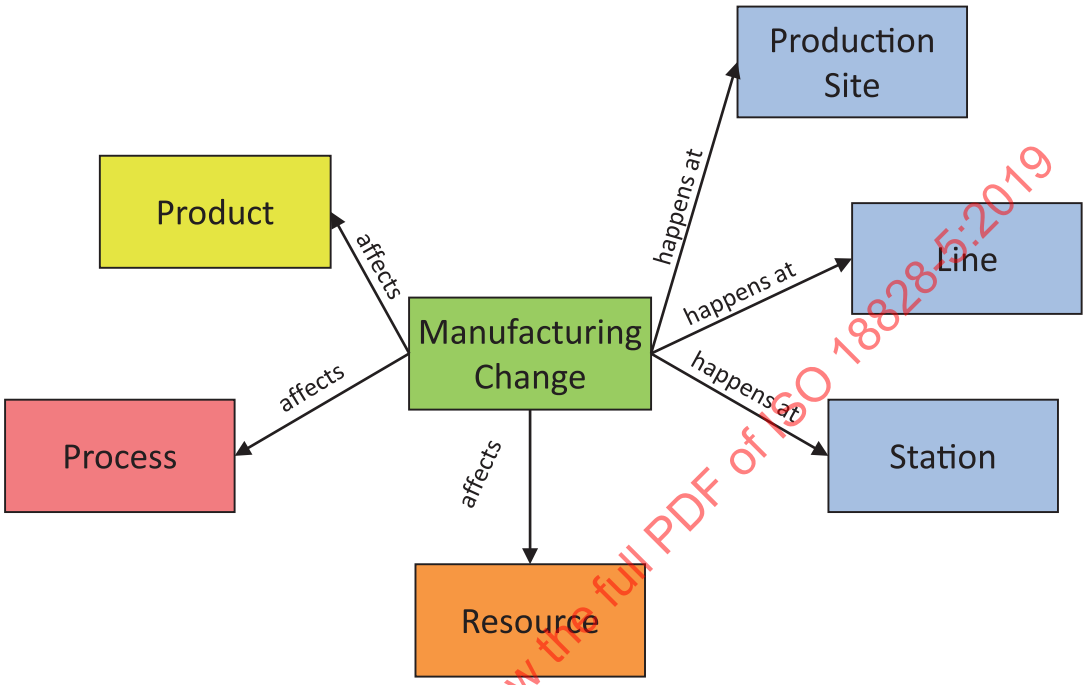

Figure 9 — Relationship between the main structures and a manufacturing change

The interrelations that occur during a change and its effects on the existing data objects of the static structures are of importance when considering a data scheme for manufacturing change management.

The central element of the MCM data scheme is the manufacturing change object. An instance of the manufacturing change object represents one individual manufacturing change. The MCL derives technically from many instantiations of the manufacturing change object in the context of one production site. The manufacturing change object is created and persistently stored within the first step of the MCM process – the creation of the change enquiry (see Figure 10).

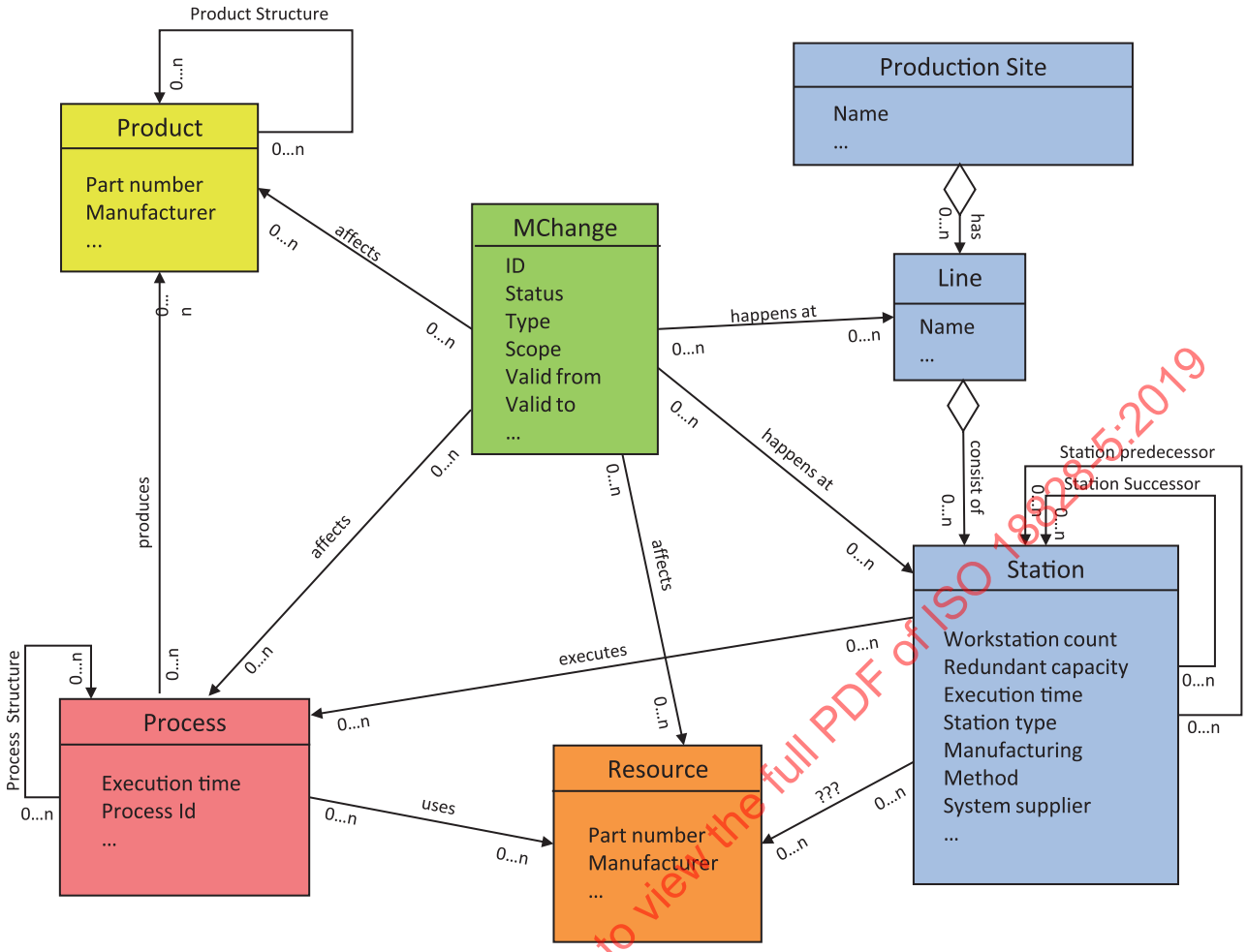

Figure 10 — Data-oriented view on the MCM process

Throughout the MCM process, the manufacturing change object is populated with attributes and links to other objects. Besides the unique ID, the status is the object's most important attribute, as this is used to map the progress of processing the manufacturing change within the MCM sequence of steps.

NOTE The status can also be used as the key characteristic of a workflow engine controlling the MCM process.

Further attributes of the manufacturing change object include type, scope, responsible party and planning periods. "Type" indicates the type of the manufacturing change. In the MCM prototype at hand, the values stored here include engineering change management (ECM) and continuous improvement process (CIP). "Scope" contains a more detailed description of the planned or ordered change. The "responsible party" attribute indicates the person responsible for the change, which usually is the assigned MCR or MCO operator. At the point of creating the change, it is possible that the "valid to... from" period is not yet defined, so the entries here are optional and can be estimated. Over the course of the MCM process, this attribute needs to be updated and locked down, as it is needed for defining the time axis when mapping a series of planned changes.

The most important aspect of the data scheme is that the central manufacturing change element is linked to the objects of the information model, i.e. the process, the product and the resource. The resource is particularly important in this context and its use is expanded. By distinguishing between resources such as machines and tools – as well as between manufacturing structures such as lines and stations – it is possible to consolidate resource uses and see how resources are linked to manufacturing changes (e.g. all the manufacturing change objects linked to a particular station can be determined this way). Similarly, this process can be consolidated to determine and display all the stations of a line, as well as the manufacturing change objects linked to the line itself. Single resources such as tools can be

allocated to multiple stations and conversely multiple tools to a single station, and again they can also be linked to the manufacturing change object directly. The product and process structures are mapped in the same way, permitting context-specific views of planned manufacturing changes currently being implemented, as well as future planned manufacturing changes. For each product and each component contained within the product structure, the allocated manufacturing change objects can be viewed. The same applies for the processes and process structures. In addition, the products, processes and stations are linked together. This makes it possible to determine the processes allocated to a product, as well as the stations allocated to the processes where these are being implemented.

At last the connection between the process-oriented and the data-oriented view on MCM is required to relate data objects to the processes. The connection is described for level 1 of the MCM process model, the MCR (see Figure C.1) and the MCO (see Figure C.2), using UML sequence diagrams. An explanation for the UML notation is shown in Figure D.1, Figure D.2, Figure D.3 and Figure D.4.

Annex A
(informative)

Deviation of current states of real system and planning

A.1 General

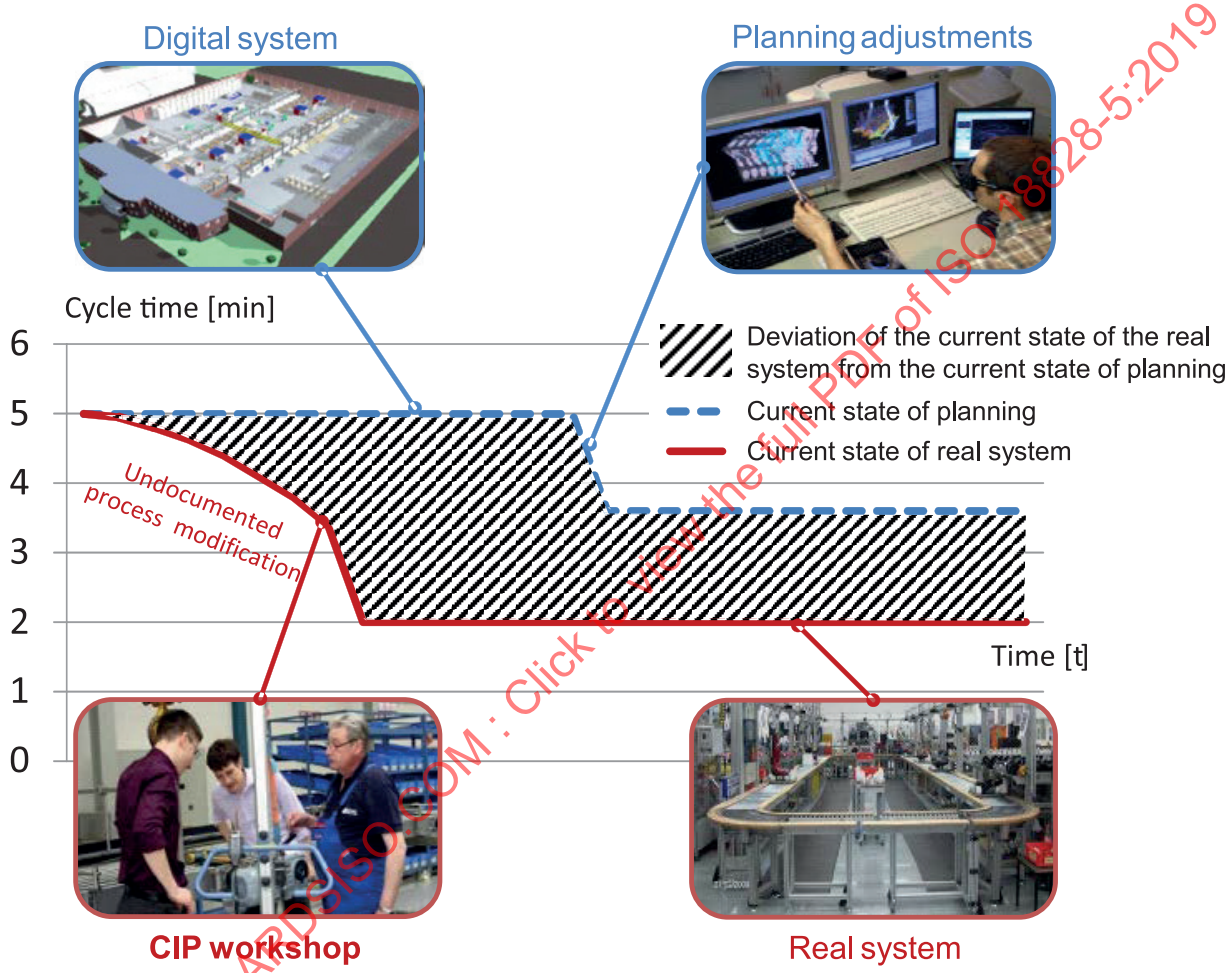

Figure A.1 — Deviation of current states of real system and planning

Annex B
(informative)

Detailed processes of MCM (IDEF3)

B.1 General

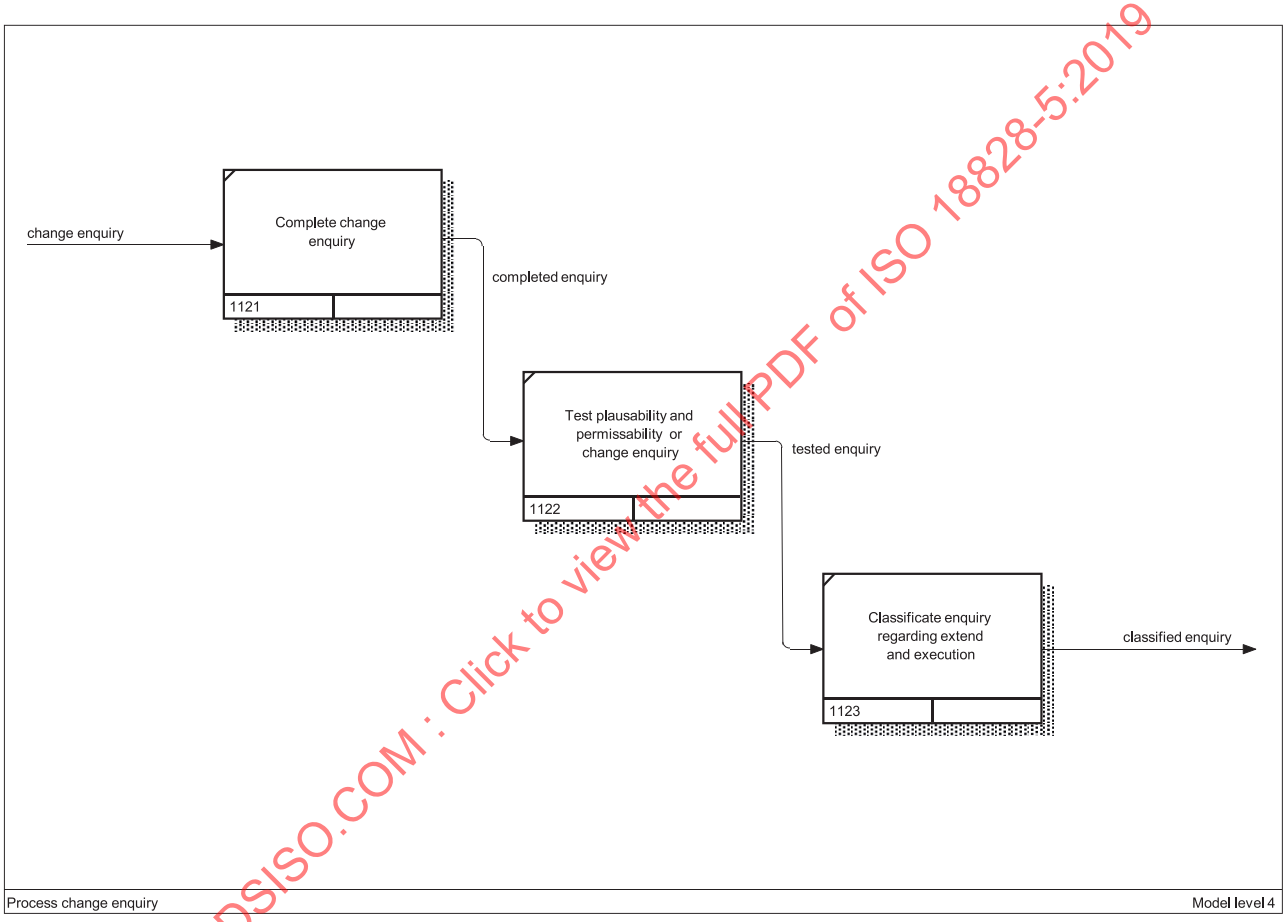

Figure B.1 — Structure of "process change enquiry" at model level 4

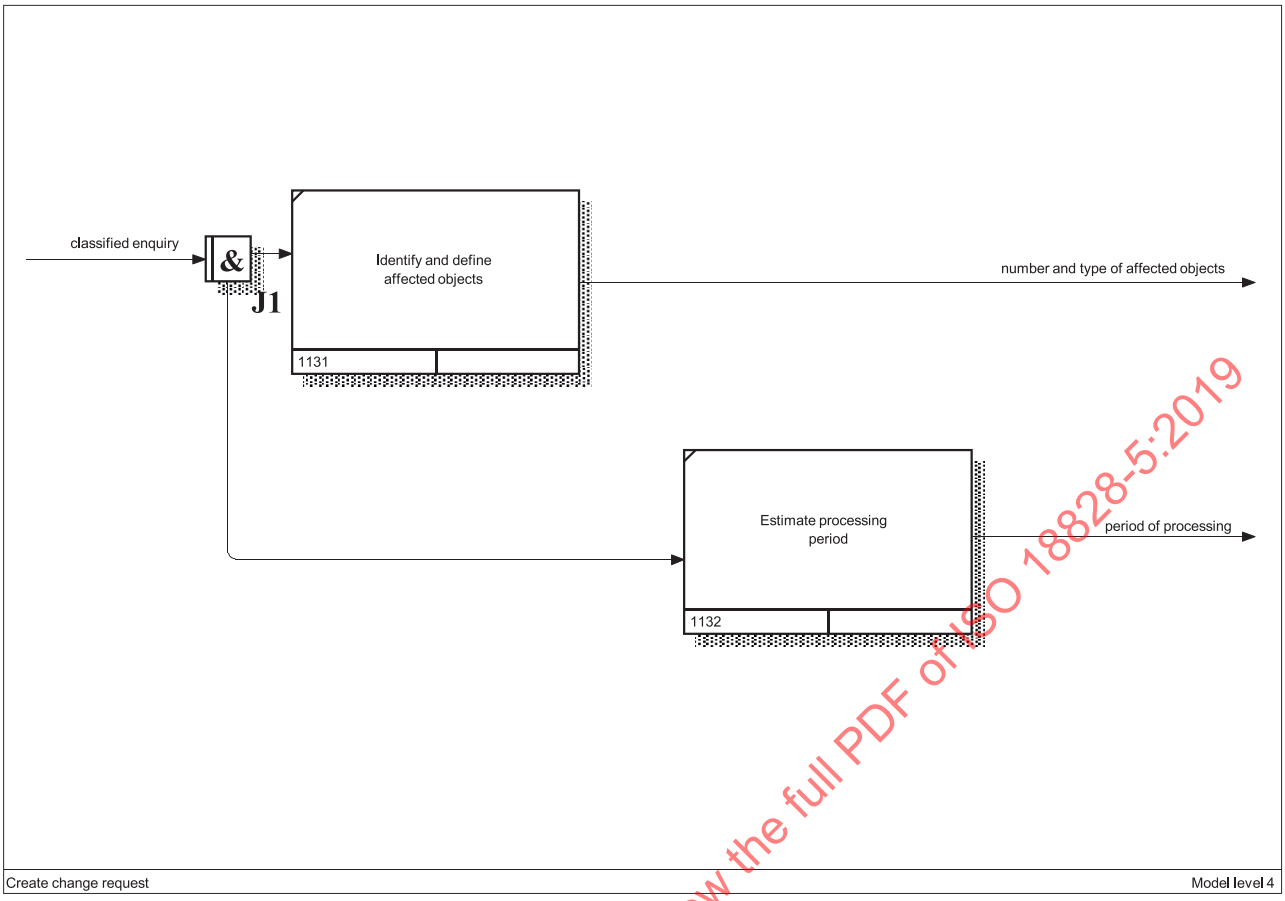

Figure B.2 — Structure of "create change request" at model level 4

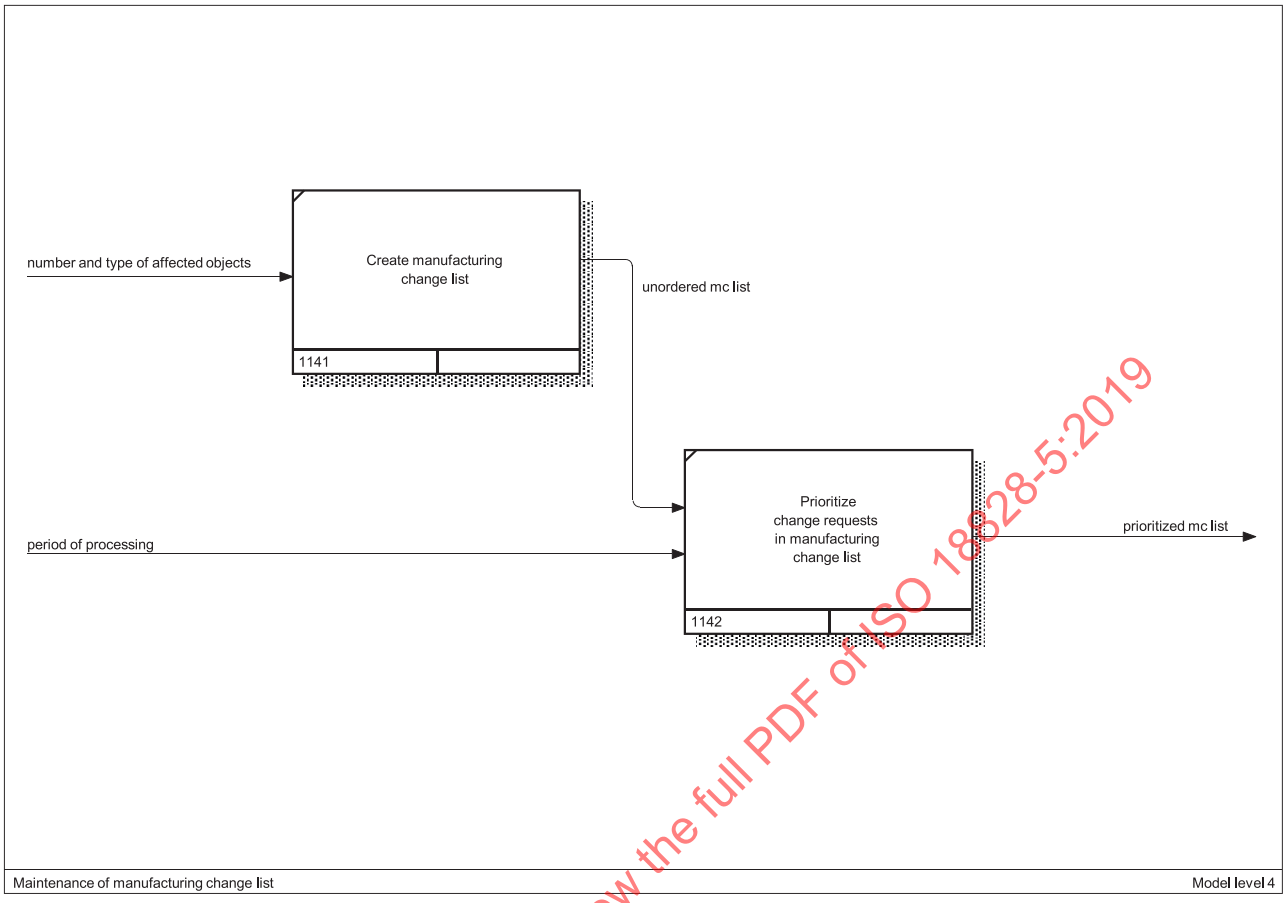

Figure B.3 — Structure of "maintenance of manufacturing change list" at model level 4

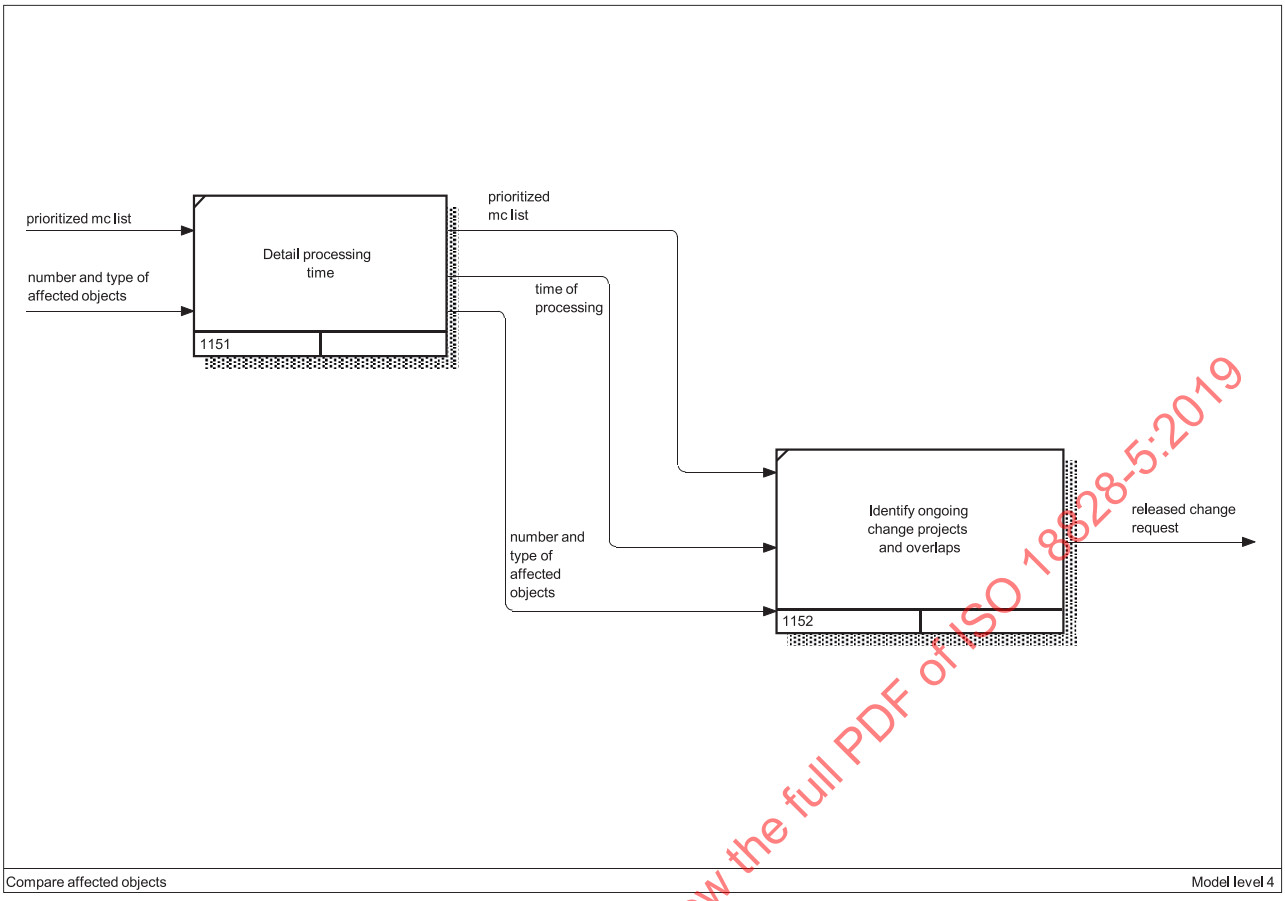

Figure B.4 — Structure of "compare affected objects" at model level 4

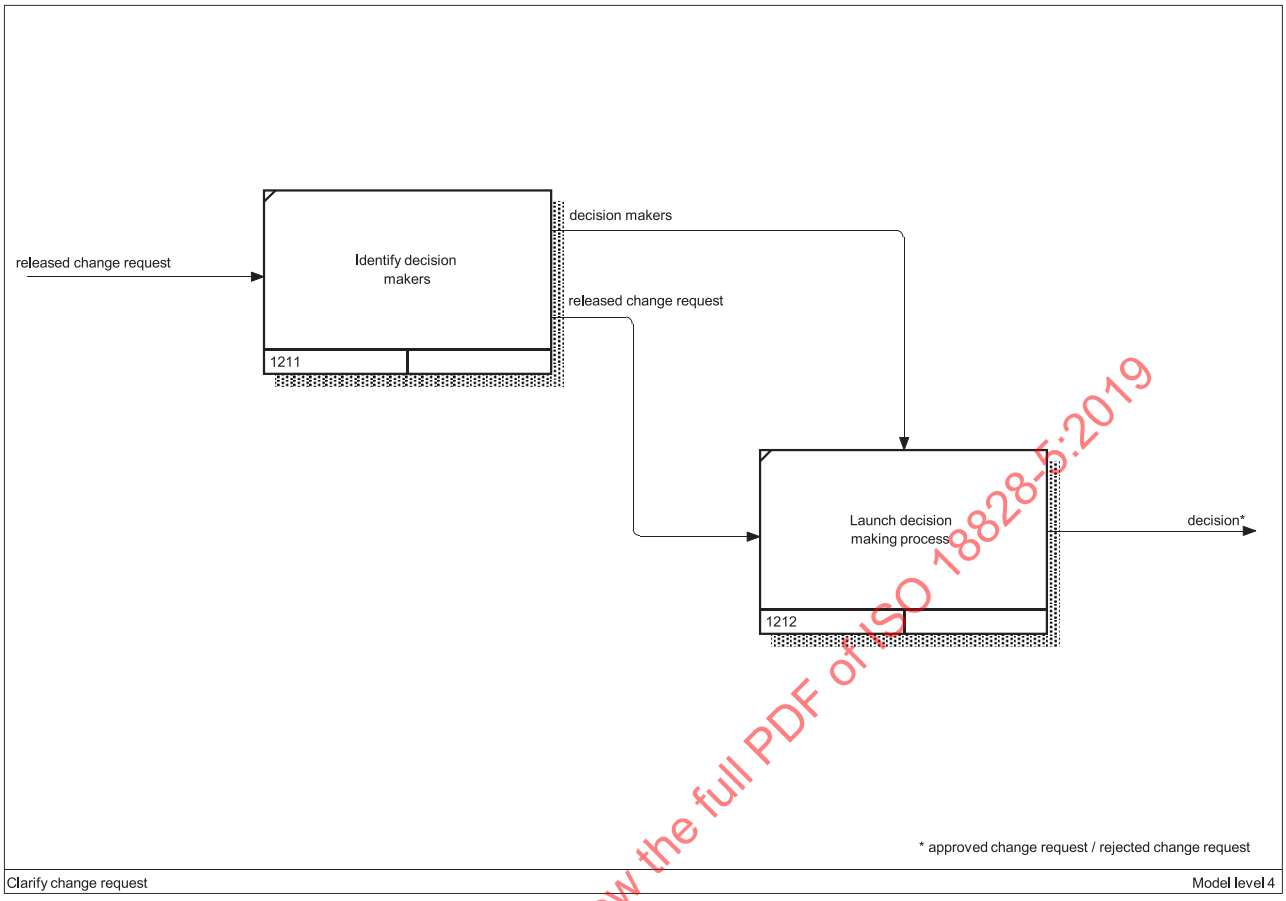

Figure B.5 — Structure of "clarify change request" at model level 4

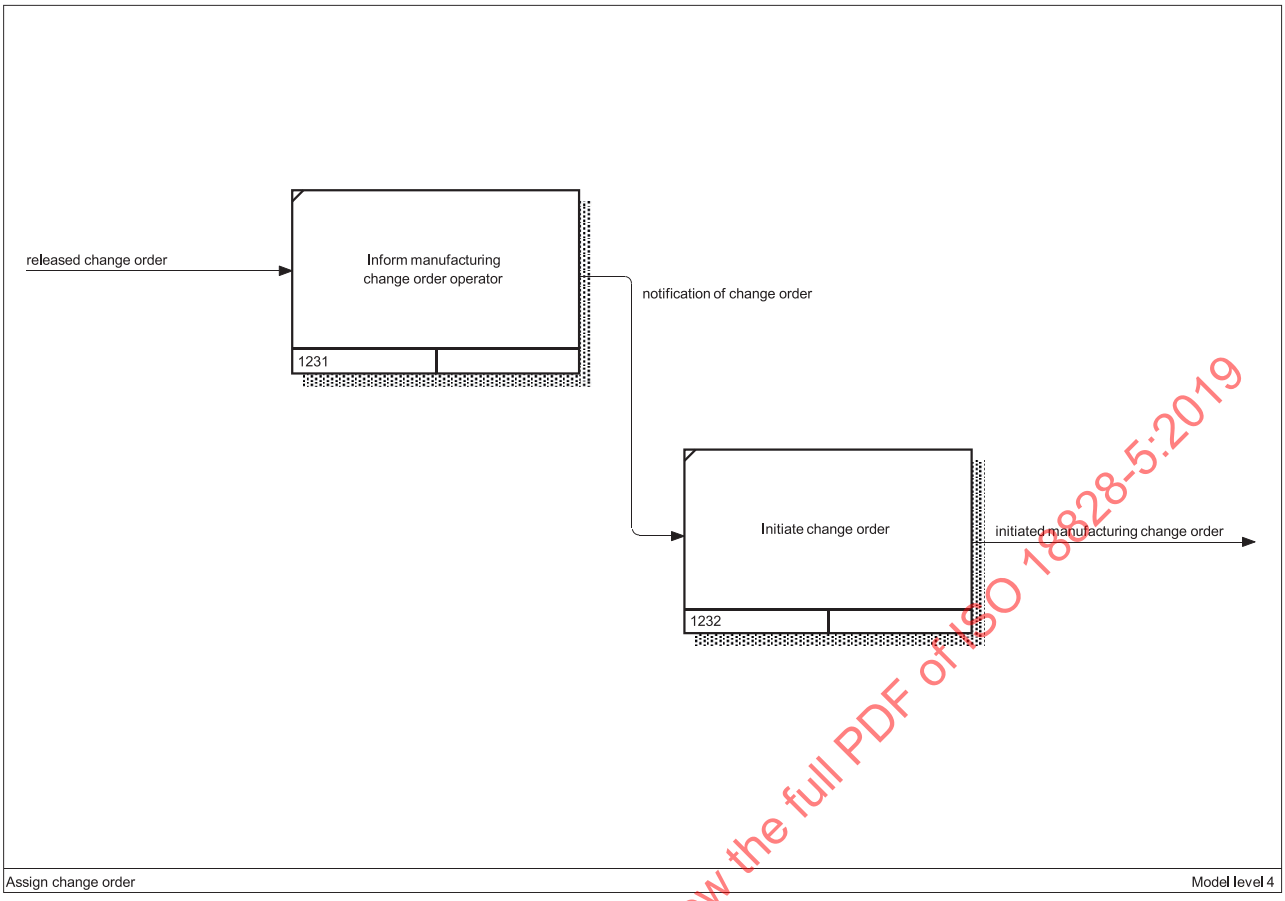

Figure B.6 — Structure of "assign change order" at model level 4

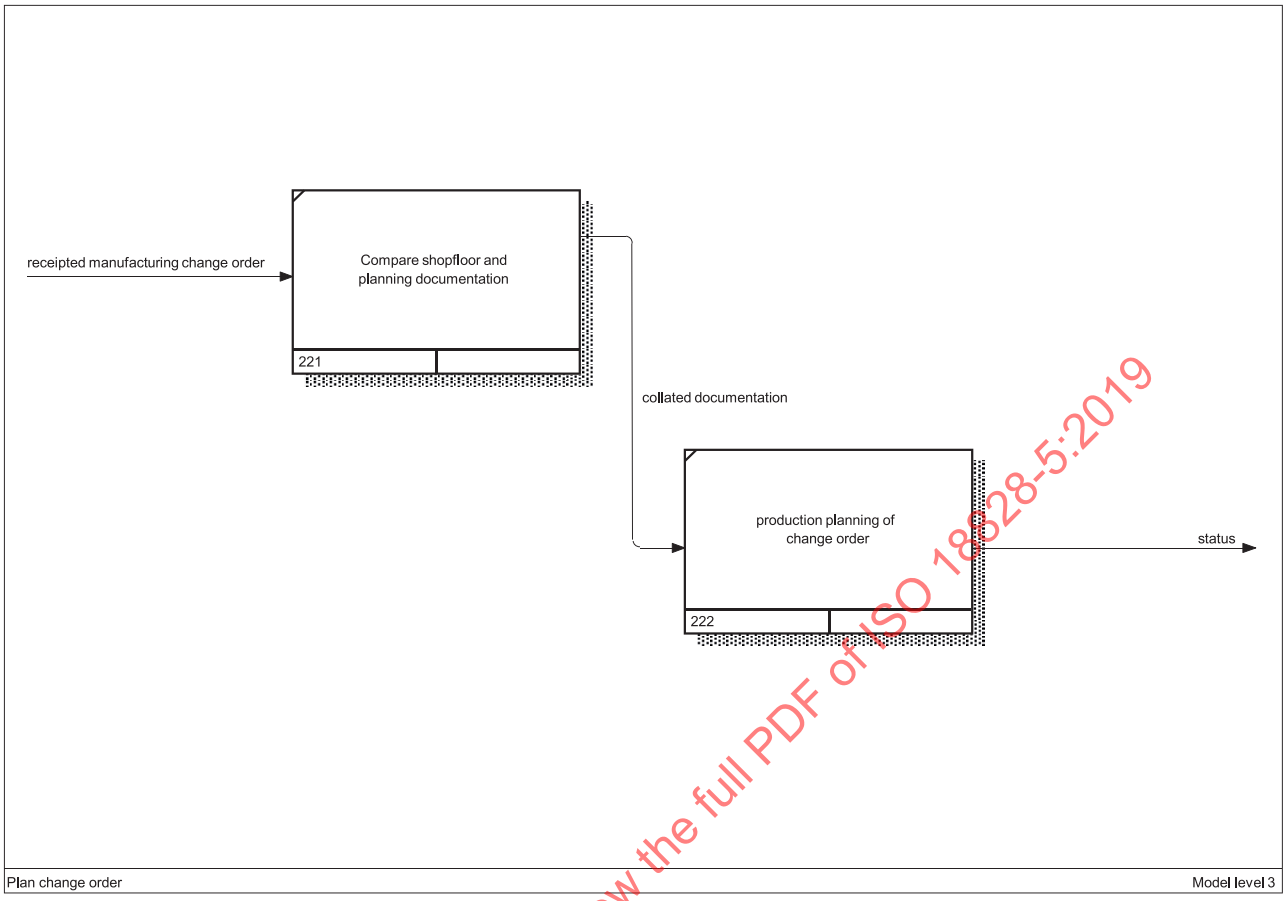

Figure B.7 — Structure of "plan change order" at model level 3

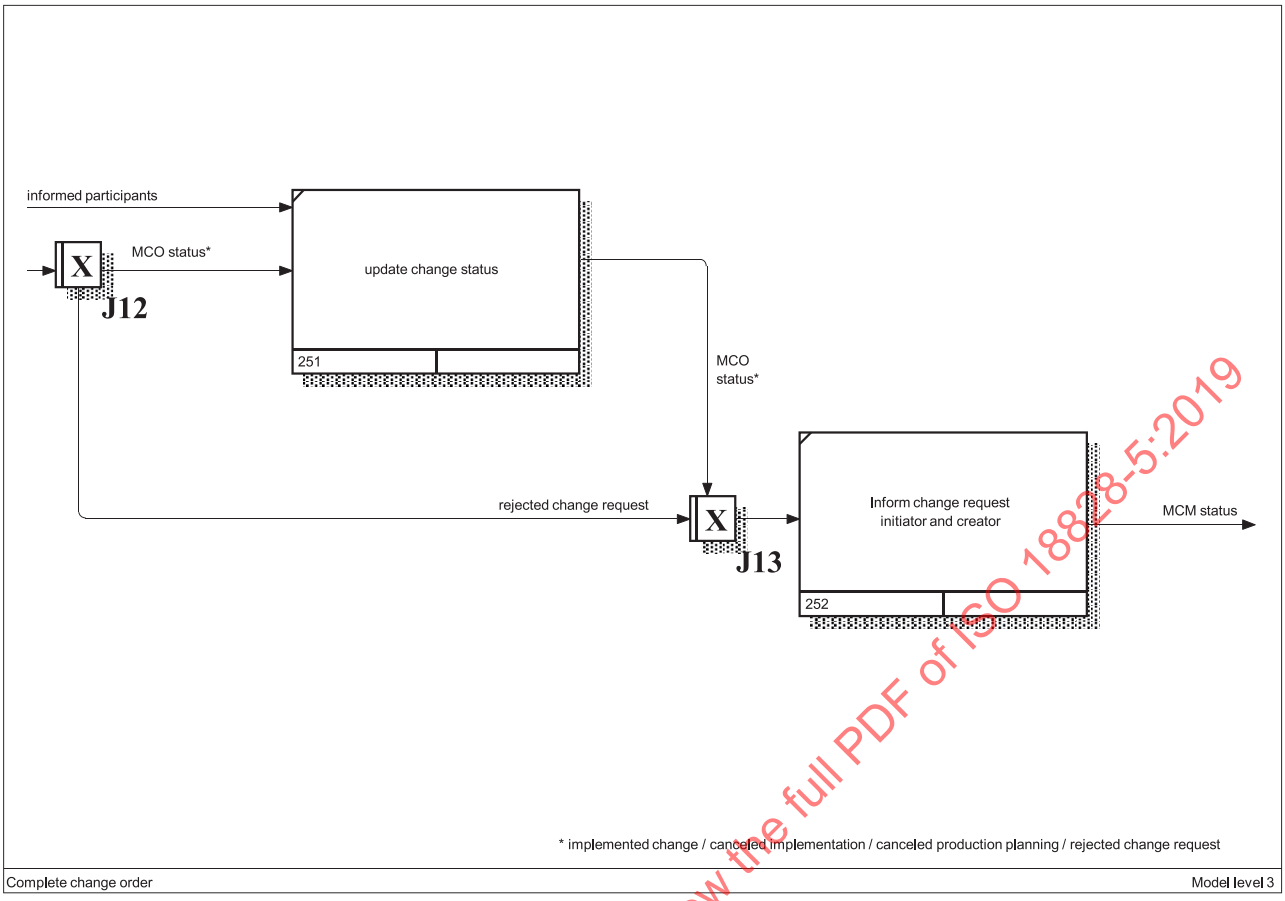

Figure B.8 — Structure of "complete change order" at model level 3