# Framework for releasing preliminary information in product development

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# Framework for releasing preliminary information in product development

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**Abstract.** To reduce the throughput time of development processes, companies overlap phases by starting downstream processes on preliminary information. In practice, starting on preliminary information involves the release of preliminary documents to downstream processes. Current release and change control procedures are focused on avoiding risk and therefore seem not suitable for starting on preliminary information. This paper presents a conceptual framework of how companies can integrate working with preliminary documents into their traditional release and change control procedures. The framework is validated in two companies. The result is a normative framework that can be used by companies that want to reduce throughput time by starting on preliminary information in a controlled manner.

## 1 Preliminary information in product development

Products lifecycles have dramatically decreased in the last decades [1], [2]. As a result, companies have to increase their innovative capability and bring more new products to the market. Moreover, it has become more important to bring these new products to the market at the right time. If a product is introduced too late, it is introduced in a mature market and is it difficult to make a profit. To cope with these challenges, companies constantly try to improve the throughput time of their product development process, i.e. the time to bring a new product to the market [3], [4], [5], [6].

A widely adopted concept in this context is Concurrent Engineering [6], [7], [8]. [9], [10], [11], [12], [13], [14]. Traditionally a development process is performed sequentially, where the work is 'thrown over-the-wall' from one discipline to another. In a concurrent product development process the disciplines work closely together in so-called Multidisciplinary teams or Design-Build teams. To function properly it is important that there is frequent, face-to-face, bilateral communication of preliminary information between the team members [15]. The exchange of so-called preliminary information makes it possible to overlap phases in the development process, for example, start detailed engineering before concept engineering is completed and hence reduce the throughput time.

Preliminary information is information that is *tentative*, *untested* and *possibly incorrect* [16]. Using preliminary information introduces risks because there is a chance that the preliminary information changes, this will result in re-work and delays. Traditional procedures for releasing information avoid this risk, because they focus on the release of information that is *stable*, *consolidated* and *proven* [17]. Moreover, traditional change control procedures are used to assess the impact of

changes to released information, before processing such changes. In order to be able to reap the benefits of starting on preliminary information, companies need to change their traditional release and change control procedures.

This paper presents a conceptual framework that describes how starting on preliminary information can be incorporated into traditional release and change control procedures. Consequently, the framework is validated in two case studies, which lead to some adjustments to the original framework. Companies can use the result, i.e. validated framework, as a guideline for changing their release and change control procedures, in order to benefit from a reduced throughput time in product development.

## 2 Related work

Clark and Fujimoto [15] were the first authors to mention the concept of preliminary information to overlap processes in the product development process. Mainly two authors whose work is presented in this section further elaborated the concept. The first contribution is by Eppinger et al. [3] who present a framework that helps to determine how to disaggregate design information and overlap consecutive stages of a development process based on the properties of exchanged information. The properties involve the evolution of upstream information and the downstream information sensitivity. Evolution refers to the process in which upstream information is converted from its preliminary form to its finalised form. On the other hand, sensitivity refers to the impact that a change in upstream information can have on downstream processes. Each property can have a low and a high value resulting in four combinations of sensitivity and evolution and hence in four different strategies for overlapping consecutive stages of development processes (figure 1). Hence the framework helps to decide when and how development processes should be overlapped, depending on the evolution and sensitivity of the exchanged design information.

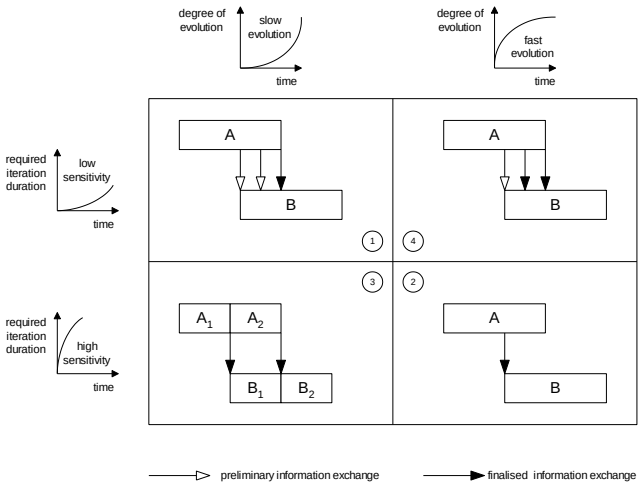

**Fig. 1.** Strategies for overlapping consecutive phases in development

The second contribution is by Hanssen [14] who developed an instrument to assist companies in deciding where to overlap processes in the development process by staring on preliminary information. An important assumption in the model is that it should be able:

- To determine the content of the preliminary information (what is exchanged).
- To predict the moment of the exchange (when is it exchanged).

In other words the preliminary release should become part of the standard operating procedures and can be planned beforehand. If an opportunity meets the above mentioned criteria a (simple) mathematical model is used to make the trade-off between the advantage of overlapping the activities versus the associated risks and communication costs. If the outcome is positive the development process should be changed, i.e. one should start to exchange preliminary information.

The work from Hanssen can be seen as an addition to the work of Eppinger. First, Eppinger developed a management model to determine when and how to exchange preliminary information. Later, Hanssen developed an instrument to determine where overlapping phases is beneficial in the development process. This research takes it one step further by analysing how companies should incorporate the exchange of preliminary information in their formal release and change control procedures. The next section presents a conceptual framework for releasing information in product development processes.

# 3 Conceptual framework

## 3.1 Preliminary information in documents

In their paper, Eppinger et al. [3] define (design) information as *a collection of parameters*; examples are part dimensions and customer specifications. Consequently, Eppinger et al. [3] define preliminary information as a parameter that is still evolving to its final value. Before it reaches its final value, it is defined as an interval value. The status of the parameter in its evolution is referred to as the *maturity* of the parameter in this paper. If it has reached its final value it is called mature, otherwise it is called immature. Where immature can be described as: tentative, untested and possibly incorrect. Although Eppinger et al. [3] define preliminary information, they do not reveal in which form the preliminary information is exchanged. From the work from Hanssen [14] can be derived that preliminary information is exchanged in the form of documents that contain the preliminary information.

In our research, the same document-oriented view is applied. Consequently, the exchange of preliminary information is synonym to exchanging documents that contain the preliminary information. Or more precisely, it involves document versions containing the preliminary information, also referred to as preliminary document versions. In an organization there are rules and procedures for exchanging documents, generally known as release and change control procedures. These procedures especially apply to documents such as drawings, specifications, and data sheets, those are also referred to as product definition documents. Current release and change

control procedures are not capable of dealing with preliminary document as will be demonstrated in the next 2 sections.

### 3.2 Procedures for document release

Documents contain information that is used by downstream processes as input. If such documents contain errors or flaws this might lead to high costs in downstream processes, because of rework or even accidents. Therefore, companies try to avoid this situation by applying document release procedures. Document release involves the checking and approval of a document. It ensures that the content of a document is tested, consolidated and proven, before it is made available for use by others [17], [18], [19]. [20]. As a consequence, downstream processes are only allowed to use released documents.

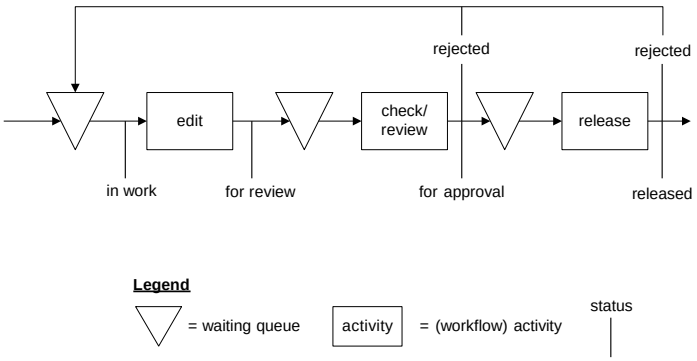


**Fig. 2.** Workflow of the document release process

In the following, the basic steps of a common release process are discussed as shown in figure 2 (based on [16], [20]). It starts with the creation of a document. At that moment the first document version is created which receives the status 'In Work' (or 'In Progress'). The status of a document is an indication of the *maturity* of the content of the document. After editing the document version it receives status 'In Review' and waits in the queue till the reviewer is available to conduct the review. A typical review comprehends the following checks: correctness of the content, basic assumptions that are used, acceptability of the content, consistency of the content (interfaces), and applications of standards [19]. In case the reviewers have comments, the author of the document has to incorporate the comments in a new document version with status 'In Work'. At the same time, the rejected document version receives the status 'Rejected'. The new document version is once again submitted for review. When there are no more comments it receives the status 'For Approval'. The approval involves the formal authorisation of the document version. After the approval, the document version receives the status 'Released' and is issued for use in downstream processes.

### 3.3 Procedures for change control

Due to the dynamic nature of the product development process and the fact that people make mistakes, there is always a chance that there is change to a document that already has been released. Changes can have severe impact on downstream processes using the released document [21]. Therefore, it is important to analyse the impact of a change before processing it. If the benefits outweigh the costs, the change can be processed. Companies use formal change control procedures to manage changes [22]. In practice, these procedures function as a barrier. They prevent organisations from making changes too easily before its consequences for downstream processes are known.

There are several standards that prescribe change control processes such as ISO 10007 standard for Configuration Management and the Military Handbook for Configuration Management [23]. Typically, these change control processes consist of three steps: change request (CR), change order (CO) and change notification (CN). The change request motivates the desired change and is submitted to a Change Control Board. They decide about the change by assessing the impact and benefits of the change. If the Change Control Board advises positively about the change, they issue a change order to make the change as described in the change request. Processing the change order results in a new document version that replaces the previous one. Finally, a change notification is published to inform everybody using a previous version of the changed document.

### 3.4 Conceptual framework for starting on preliminary information

In this section a conceptual framework is constructed, using the concepts of release and change control as introduced in the previous sections. The framework describes how companies should adapt their procedures for release and change control, in order to facilitate the exchange of preliminary documents to overlap phases in development.

Overlapping phases of the product development process is only possible, if information is exchanged earlier at an earlier stage then in the case of a sequential process. If the information is exchanged in the form of documents, then overlapping phases in product development requires the release of one ore more preliminary document versions before releasing the final document version (figure 3). This impacts the basic concepts of a traditional release because preliminary document versions introduce risk, where the goal of a release procedure is to avoid risk. Therefore, traditional release processes need to be changed into a release process that incorporate the use of preliminary document versions.

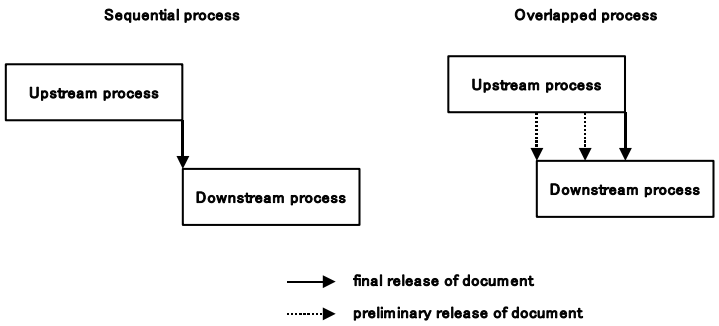


**Fig. 3.** Overlapped process versions traditional, sequential process

In a traditional release process a document is checked and approved before it is released. These steps should guarantee that the content is mature and that downstream processes can use the information as input. In the case of releasing preliminary documents there should also be some kind of checking and approval procedure. However, in this case the procedures should guarantee that the content is mature enough, i.e. but still immature, to start downstream processes with a low risk. To further minimize the risk of mistakes or confusion, the preliminary releases should be clearly defined. In other words, it should be clear to the receiver of the preliminary document what is allowed to do with the document. Therefore, it might be helpful to express the immaturity of the document in the document status (in figure 4 indicated with the extension 'for X'). Summarizing, the traditional process should be transformed into a process with several preliminary releases before the final release. In figure 4 it is illustrated how the tradition release process, as illustrated in figure 2, should be extended.

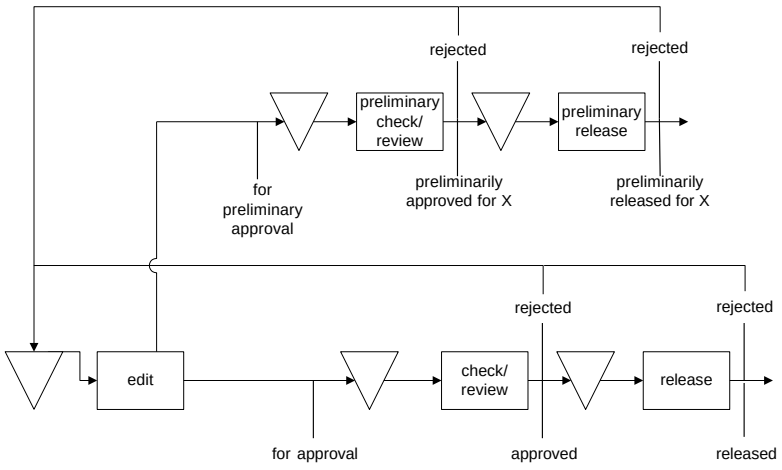


**Fig. 4.** Workflow of the preliminary document release process

Once a preliminary document version is released it should also be put under change control. In case there is a change, it is critical that the impact is determined quickly, even more critical than in a traditional release process, and that everybody is

notified about the change instantaneously. This reduces the risk of re-work or accidents to a minimum. This would not require a change in the change control process itself, because the traditional procedure is simply applied to preliminary documents as well.

The statements and models presented in this section represent the conceptual framework for starting on preliminary information. To validate the framework it is applied in two companies that already overlap processes using preliminary information. The results of the two case studies are presented in the next section.

# 4 Case studies

## 4.1 Approach

The goal of the research presented in this paper, was to collect empirical data on how companies release preliminary information. Because the concept of releasing preliminary information is not widely known and there is not a solid theory available, it is appropriate to use a case study approach [24]. We decided to do two case studies because it offers the opportunity to compare the results, which provides a better ground for (analytical) generalization [24]. To further improve the (analytical) generalization, the technique of maximum variation is used as well [25]. In such a set-up, two companies with totally different characteristics are selected. The case studies that were selected differed on the following characteristics.

- industry/market in which the company operates
- product that is developed by the company
- production method of the company

The first company is referred to as Aero and is specialised in designing, developing, manufacturing and servicing structural airframe components, assemblies and systems of commercial and military aircrafts and helicopters. Some examples of their products are wheel doors, pressure bulkheads, and J-noses. The second company is referred to as Chemical and is an international EPC (Engineering, Procurement and Construction) Contractor with a strong technology base of more than 50 process technologies, providing the process industry worldwide with a full range of services. Examples of the products they design and construct involve refineries, process plants, offshore platforms, and onshore gas and oil handling and production facilities. The two case study companies comply with the maximum variation criterion as is explained in table 1. The table shows that the companies differ on three aspects industry, product and production method.

**Table 1.** Difference between case study companies

| | **Aero** | **Chemical** |
|---|---|---|
| Industry | aerospace industry | process industry |
| Product | structural parts of an airplane | complete chemical plants |
| Production method | series production | one-of-a-kind production |

Data is collected at the case study companies using techniques as structured interviews, based on the conceptual framework, and document analysis. Several employees from different disciplines and management levels have been interviewed. This resulted in a description of how these companies release preliminary information to overlap their product development process. The people that provided the input have checked the correctness of this description.

The following two sections give an overview of the case study results. Each section is structured in the same way. First, the type of document is introduced that is released preliminary. Next, a description of the basic release process is provided. Finally, the release of preliminary document versions is discussed and whether change control is applied to these preliminary document versions.

### 4.2 Case: Aero

Aero releases preliminary information to overlap the engineering phase with the production phase. As a consequence, production can start as early as possible. The preliminary release involves several types of documents such as Design Principles, 3D models, Production drawings and Bill of Materials (BoM). The case study description focuses on the Design Principles, drawings that define the rough outline of the geometry of the product.

*Basic release process*

The Chief Engineer determines how many Design Principles (DPs) are required for a particular project and assigns the DPs to his engineers. When an engineer starts working on the DP, using a 2D CAD tool, the DP receives status ‘In Progress’. After completing the DP the engineer sends the DP to colleagues for checking. At that moment the status of the DP changes to ‘In Review’. The purpose of the check step is to check the correctness and completeness of the DP. After checking the DP it is send for approval to the reviewers. The approval step consists of three sub-steps, which are conducted sequentially by three different persons. These sub-steps involve approval of the overall design, its strength and its manufacturability. After completing the review, each reviewer fills out a report and sends the DP to the next reviewer. The last reviewer sends the DP to the Design-Build-Team (DBT) leader. He checks the comments of the reviewers and if he agrees, the DP is authorised and released to production. At that moment the DP changes to status ‘Release 0’. The basic release process is also shown at the bottom of figure 5.

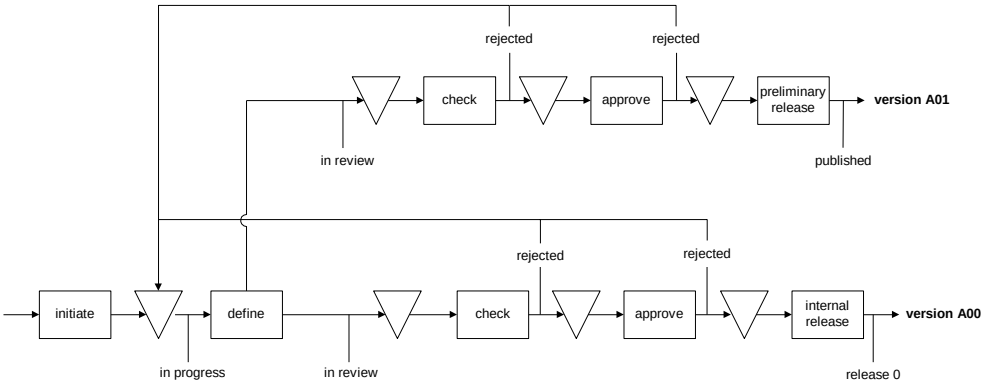


**Fig. 5.** Preliminary release of Design Principles

*Release of preliminary document versions*

There is no well-defined procedure for releasing preliminary document versions at Aero. However, employees from engineering and production indicated that several preliminary releases can be identified that are frequently used in projects:

- In a first preliminary release they derive BoM information from the Design Principles to order raw materials such as sheets and profiles (both are long lead items).
- In a second preliminary release they derive a list of fasteners from the Design Principle that should be ordered (fasteners are long lead items too).
- In a third preliminary release the drawings of the Design Principles are provided to production to determine the location of the tooling holes for the design of assembly tooling.
- In a fourth preliminary release the drawings of the Design Principles are once again provided to production to design tooling such as drilling moulds.

Although it is not documented in a procedure it is known what should be released, when it should be released and also why it should be released. Before a preliminary version of a DP is released it has to go through all the check and approval steps, just like in the basic release process. During this process the DP has similar status changes, except for the last one. A preliminary version of a DP receives the status Published and version number A01, instead of Release 0 and version number A00 (see also figure 5).

There are also some problems with this process at Aero. First, the status ‘Published’ does not reveal which of the preliminary releases it concerns, which can lead to confusion for the receivers of the preliminary version of the DP. Because the purpose is not clear, production sometimes starts activities that are not allowed or does not start activities when it is allowed. This supports the idea that a preliminary release process should be formalized. Second, Engineering does not automatically release a preliminary version of a DP. The main reason is that the release of a preliminary document version takes time. It not only takes extra time for distributing a preliminary document version, it also takes time to check and approve a preliminary document version. Therefore, Engineering only releases preliminary document versions if Production asks for it in a DBT meeting, a so-called pull mechanism,

Engineering will then decide if it can already release a preliminary version. By only releasing preliminary versions of DPs that are requested by production, additional work for preliminary releases is limited.

*Change control for preliminary document versions*

At Aero the change control procedure is only applied to DPs after their final release, i.e. Release 0. This is not surprising, because officially there is no procedure for releasing preliminary versions of a DP. The informal process for making changes to a preliminary version of a DP is explained using the three basic steps of a change control procedure.

Change request: Requests for making changes to preliminary released versions of a DP are submitted to the DBT leader. In practice this means an oral request, e.g. during the weekly DBT meeting, or an e-mail. The DBT leader will then discuss the change and assess its impact with his co-workers.

Change order: If the DBT leader decides positively on the suggested change, he will give oral permission to one of the team members to process the suggested change. Other stakeholders are informed about the change during the weekly DBT meeting or informally with a phone call or e-mail.

Change notice: After making the changes to the preliminary version of the DP, it is released preliminary for the second time. Team members are notified about the change because it is distributed according a pre-defined list.

### 4.3 Case: Chemical

Chemical releases preliminary information to overlap the Engineering, Procurement and Construction (EPC) phases of a project. The preliminary release involves several types of documents such as Process Engineering Flow Scheme (PEFS), Process Flow Diagrams (PFD) and Piping & Instrumentation Diagrams (P&ID). The case study description focuses on the PEFS, which contains a schematic representation of the equipment as well as the relations between the pieces of equipment of a plant.

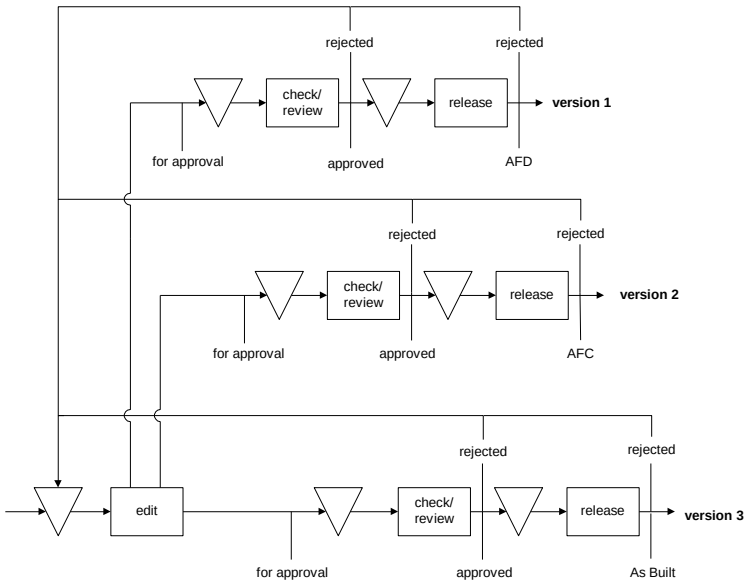


**Fig. 6.** Preliminary release process at Chemical

*Basic release process*

The process starts with the creation and editing of the PEFS using a 2D CAD tool. During its creation, the status of the PEFS is 'In Progress'. When the engineer completes his work on the PEFS, he sends the PEFS to the reviewers. The review process is usually conducted sequentially. If all reviewers approve the PEFS the lead engineer of the discipline changes the status of the PEFS to 'Approved', otherwise it is returned to the engineer to make the suggested changes and the status of the PEFS returns to 'In Progress'. After approval by the reviewers and the lead engineer, the project manager releases the document and hence changes the status of the PEFS to 'Final'. Once released, the document can be distributed to team members inside and outside the organization according to a pre-defined distribution list. The basic release process is also shown at the bottom of figure 6.

The release process is partly supported by the Product Data Management system (PDM) of Chemical. Each PEFS and each change in status of the PEFS is recorded in the Product Data Management system at Chemical. However, the system does not support the workflow of the release process. A special Document Control Group is responsible for distributing documents through the organization. Each time the status of a document changes, they receive a distribution request and take appropriate action.

*Release of preliminary document versions*

At Chemical, there is a well-defined procedure for the preliminary release of documents. The procedure is illustrated using the In-line Instrument Index, which is created by the Instrumentation discipline, as an example. An In-line Instrument Index is in fact a bill of material of all in-line instruments that are part of a plant, *e.g.* valves, orifices, and transmitters. The Piping discipline needs the In-line Instrument Index for making the Isometrics. Isometrics are drawings that provide an isometric view of the pipes in a plant. The pipes contain the in-line instruments as listed in the In-line

Instrument Index. In order to start as early as possible the Piping discipline uses preliminary versions of the In-line Instrument Index. The preliminary releases and the final release of the In-line Instrument Index are briefly discussed below.

- The preliminary release step is Approved for Design. An In-Line Instrument Index that is released AFD shows all the in-line instruments that are identified, but their specifications are not precisely known yet. The exact specifications become available if Instrumentation has selected suppliers for the identified in-line instruments. However, the Piping discipline does not want to wait till the specification become available. Therefore, they start to create the Isometrics (i.e. isometric drawings) on basis of the AFD version of the index. Such Isometrics already indicate the position of in-line instruments in each pipe, but the details of each in-line instrument are not mentioned yet.
- The final release step is Approved for Construction (AFD). As soon as Instrumentation receives the exact specification of the in-line instruments from the suppliers, they update the In-Line Instrument Index and release it for AFC. Consequently, the Piping discipline uses the AFC version of the In-Line Instrument Index to update their Isometrics. Besides the positions of the in-line instruments in each pipe, the Isometrics now also contain details about each in-line instrument.

Every document, to which the formal release process is applied, goes through the status AFD and AFC. However, some documents also go through one or more optional statuses. The purposes of the optional status are pre-defined, examples are ‘For Enquiry Only’ and ‘For 10% Cost Estimate’. When a document version is released preliminary as ‘For 10% Cost Estimate’ it is released for making a 10% cost estimate only. A document is typically released for this purpose if waiting for the next preliminary release would cause a delay in the project schedule. Besides pre-defined optional statuses, there are also more general optional statuses; examples are ‘For Information’ or ‘Preliminary’. There can be various reasons why somebody already wants to have such a preliminary version of a document. Therefore, the provider and the receiver of the information have to agree on the purpose for which the document is released.

There are also some problems with this process at Chemical. Some employees at Chemical object to the preliminary release of documents and postpone a preliminary release if possible. The reason for this behavior is twofold. First of all, a preliminary document needs to be checked before it can be released preliminary. At Chemical, a preliminary version of the document undergoes the same checks as the final version of a document. Moreover, engineers must keep track of all the changes after the preliminary release of the document. Secondly, each preliminary release of a document requires distribution of the document on paper, such a distribution process is rather time consuming.

*Change control to preliminary document versions*

At Chemical, a formal change control procedure is applied to all preliminary and final releases of a document, except when a document is released ‘For information’ or ‘Preliminary’. Once a document is put under change control, making changes to the document is restricted. The person that wants to make a significant change has to submit a Change Notice. A Change Notice is a standard form on which the submitter indicates the reason for the change, the number of man-hours that rare required to

process the change and so on. When the project manager approves the Change Notice, the changes should be made as specified in the Change Notice. This finally results in the (preliminary) release of a new version of the affected documents. The employees that are on the distribution list of that document receive the new version of the document and are hence notified about the change.

# 5 Findings and discussion

The previous section provided a description of how two different companies start on preliminary information to overlap phases in the development process. In this description the conceptual framework has been applied for validation puroses. The results of the validation are described in this section by discussing the major deviations from the framework, followed by suggestions to improve the framework. Finally, the issue of generalization is discussed in order to demonstrate that the conceptual framework can also be applied to other companies then the 2 case study companies as presented in this paper.

The first finding is related to the assumption that a formal release process is required, in order to control the risk of starting downstream processes on preliminary information. In fact, the case study at Aero shows that problems arise when there is no formal description of the preliminary releases that are used in practice. Moreover, similar problems were not found at Chemical that uses a formalized process for starting on preliminary information. On the other hand, the case study at Chemical demonstrates that a formal release process should not be synonym with an inflexible release process. In some cases, it is required to extend the release process with additional, pre-defined preliminary document releases. Whether such an extension is required, depends on the circumstances.

The second finding is that preliminary releases introduce additional work. At both Aero and Chemical, engineers indicated that they like to postpone preliminary because each preliminary released document needs to be checked and distributed. Moreover, a preliminary released document is put under change control as well. This requires that all changes after its preliminary release are logged, which results in additional, administrative work. Therefore, at Aero they apply a pull mechanism for the release process instead of a push process. This means that a document is only preliminarily released if downstream processes request it. Consequently, the additional work is limited to those documents that are requested instead of all documents. To some extent this is similar to the philosophy of restricting the preliminary release steps to those documents on the critical path, as suggested by Hanssen (2000). This makes sense, because only the preliminary release of documents on the critical path results in a reduction in throughput time. Hence the additional work is limited to a selected group of documents, namely those on the critical path.

The third finding is related to the assumption that documents, which are preliminarily released in a formal way, should be put under formal change control. At Aero none of the preliminary releases is put under change control, but this is no surprise because the preliminary release process itself is informal as well. At Chemical, only part of the preliminary releases is put under change control, it depends on the type of preliminary release. Although the statuses ‘For information’ and

'Preliminary' are defined, they are not used for formal release purposes and hence no change control process is required. The fact that these informal releases exist demonstrates that there is a need for informal preliminary releases as well.

These findings demonstrate that the conceptual framework is, to a large extent, validated by the case studies. However, there are also some deviations that can be considered as improvements to the original framework. The following refinements of the conceptual framework are suggested, based on the validation in the case studies:

- A formalized preliminary release process should be used only in those situations, where the goal is to start downstream processes early in a controlled manner. In other cases, one can decide to use informal procedures instead in order to reduce the amount of administrative work.
- A preliminary release process should be formal but also flexible. Because in some cases an additional preliminary release might be required. A restriction is that additional releases are predefined.
- Preliminary release processes should not be applied to each and every document, because of the additional, administrative work. It should only be applied to those documents on the critical path. A variant of this concept is to use a pull mechanism for the preliminary release of documents.

It is of interest to know whether the conceptual framework, including the suggested refinements, is only valid for the two companies in the case studie or that it can be applied to a wider range of companies. If the latter is true the conceptual framework can be used as a normative framework to these companies. Although the study is limited to two case studies, there is no reason to assume that the results are strictly limited to these cases. First of all, release and change control procedures are widely used and accepted in many industries, not only in the process industry and aerospace industry. Secondly, the case studies reveal a similar pattern in how the companies incorporate releasing and using preliminary information in their release and change control procedures. The main difference that is found is the degree of formality of the procedures. Aero is less formal than Chemical because there is no formal procedure for the preliminary release process. Moreover, no formal change control is applied to preliminarily released document versions.

There is no reason to assume that the degree of formality is related to the different characteristics of the companies in terms of industry, product and production method (i.e. technique of maximum variation). On the contrary, the aerospace industry is known for its formal release and change control procedures [26]. It is more likely that the difference is caused by the size of the project and the complexity of the product. If both the size is small and the product is not very complex, it is expected that the need for a formal procedure is low. Summarising, it is expected that the presented conceptual framework, including its refinements can serve as a normative framework for other companies.

## 6 Conclusions and further work

Previous work on starting on preliminary information from Eppinger et al. and Hanssen provides a high level analysis of when, how and where to start on preliminary information. However, it does not describe how to integrate starting on

preliminary in the day-to-day-work of organizations. Therefore a conceptual framework is developed that is presented in this paper. The framework integrates starting on preliminary information into the release and change control procedures that are common in industry. By applying the conceptual framework in two case studies, the framework was validated. The findings of the case studies resulted in the refinement of the framework. The validity of the framework is not limited to the two case studies. It was demonstrated, by using analytical generalization, that it is likely that the framework can be applied to other companies as well. Hence, the conceptual framework has become a normative framework that can be used by other companies to integrate starting on preliminary information in their release and change control procedures.

During the case studies it was noticed that the release and change control process are hardly supported by any information system. Therefore, future research will focus on the suitability of Product Data Management systems to support the release and change control process. These systems are equipped to manage the flow of documents as is required for release and change control processes. Applying these systems might reduce the administrative work that is related to paper release and change control procedures. Ultimately, it might also increase the transparency of the release and change control process, enabling companies to make better decisions. This study should also pay attention to the workflow capabilities of PDM systems. Especially if it is possible to create flexible release workflows as were mentioned in this paper.

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