SISTER SHIPS APPLICABILITY IN THE SHIPBUILDING ENTERPRISE CAD/PLM TOOLSET

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SUMMARY

As a result of the increased pressure to reduce cost and delivery times of modern ships and submarines, many shipyards are revising their processes and toolsets to optimize the management of sister ships.

This paper describes how a strong CAD-PLM integration with efficient functionality on the CAD side, ensures a better design and production in a multi-vessel context

In order to address this complex challenge, and after having several years of experience in the development of the FORAN CAD/CAM System that is used in many important naval programs, SENER identified some remarkable assumptions to be considered :

- In a sister ships environment, each vessel or unit will have a CAD project.
- There will exist a Class project to centralize the CAD locking and applicability data.
- The existence of an item in the CAD project is considered as an item occurrence in that project.
- Modifications on an item will be done from a single project, but all other projects sharing the item with the same applicability will also be locked, to prevent modification on them by other user.
- Once the modification changes are applied, the CAD will update them in all projects sharing the items applicability (multi-save concept).
- The use of applicability on an item within a sister ship series might be to all vessels (e.g. 1-UP), to all vessels newer than a specific one (e.g. 3-UP), to some vessels specifically (e.g. 1-UP), a combination of the above (e.g. 1-UP) and if no applicability is set, it means “effective for all vessels” (1-UP).

The FORAN System already had functionality related to sister ships management in the past, but it has been notably improved with the complete FORAN-PLM integration. This paper presents in detail the architecture of the applicability solution as well as the expected advantages and benefits for the commercial and naval shipyards.

1. SHIPBUILDING CAD SYSTEMS IN NAVAL ENVIRONMENTS

The use of specialized shipbuilding CAD Systems in naval environments is crucial for the efficient design and manufacturing of surface ships and submarines.

The heart of a shipbuilding CAD System as FORAN is a relational database (ORACLE) where the vessel CAD product model is stored. The product model includes geometry, topology, specialized technological and manufacturing information for all vessel disciplines and many relationships between the vessel items.

Shipbuilding CAD Systems working in naval environments offer significant advantages over other generic CAD applications, some of which can be relevant for the purpose of this paper:

- Specifically developed for shipbuilding.
- Availability of shipbuilding smart modelling tools.
- Incorporation of many years of shipbuilding knowledge.
- Outputs adapted to shipbuilding manufacturing processes.
- Proven scalability.
- Proven performance.
- Adapted to military shipbuilding requirements [1].
- Reduction of design and manufacturing hours over generic CAD applications.

The scalability refers to both the number of CAD users and to the number of vessel items to be handled.

Military vessels are very complex products that may be composed of millions of items, requiring a large number of designers, accessing concurrently to the vessel product model. The design cycles of these vessels are usually very long and there are many design changes along the whole vessel lifecycle.

Performance is another critical requirement, especially in the detail design and manufacturing stages, when the detail design is almost complete, there are hundreds of users working on the model, model changes are constant and information for the production processes must be provided continuously.

2. MANAGEMENT OF BOAT UNIT SERIES

The main objective is to enable FORAN to support management of Boat Unit Series of projects. For this purpose, the FDBA utility (FORAN Database Administrator) will be enhanced to allow the creation of a new boat series and the management of the projects included in it, representing the different boat units.

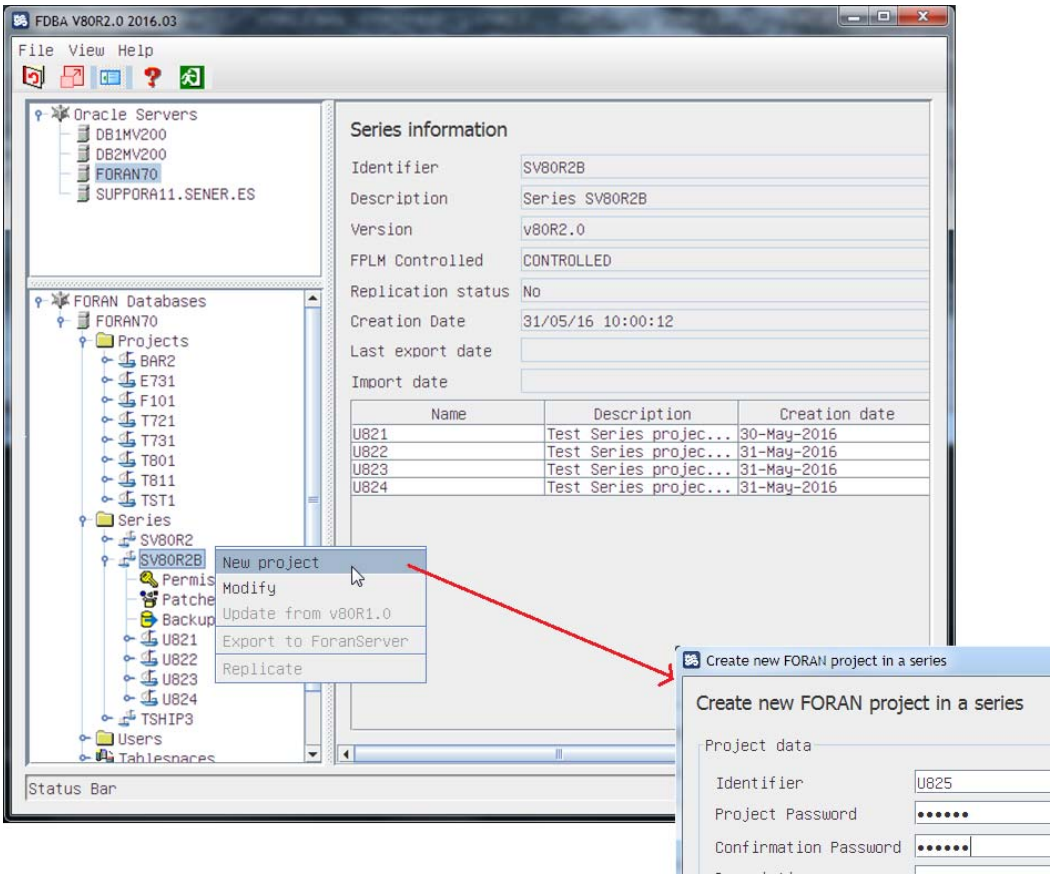

Figure 1. Create a new FORAN project in a series

In the database, these projects will be managed internally in different schemas, but being linked to each other, having a schema with objects that are common in the series, like item applicability and locking management, and several schemas with the items data related to each boat.

The attributes defined for a series will be, at least, the name and description of the series.
Within the scope of the series, the following database objects will be commonly managed for all projects in the series and will belong to the series project schema:

- Oracle sequences.
- Table of projects included in the series.
- Locking tables.

Applicability of items in the series (FORAN_APPLICABILITY). This table will include all related data about the boat units in which the entities subject of applicability in a range will exist.

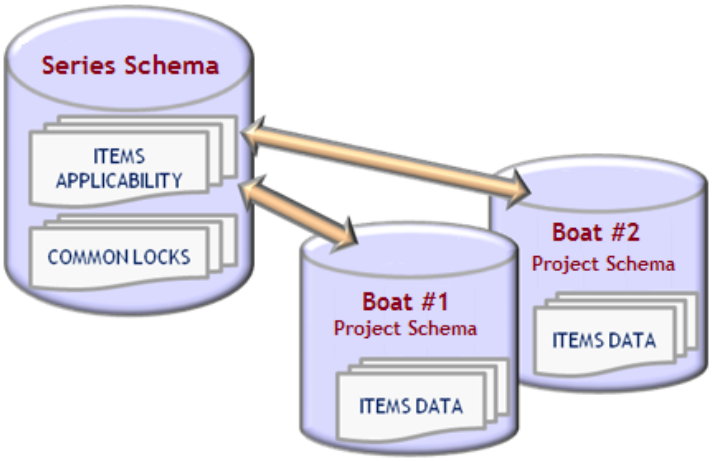

Figure 2. Series Schema and Boat Unit projects

2.1 DATABASE STRUCTURE IN A MULTI-BOAT SERIES

In the case of a multi-boat series, the FORAN database is structured in the following components:

- The FORAN Series Schema.
- The FORAN Project schemas. There is one specific FORAN project schema for each boat in the series.

The FORAN Project Schemas in a series context are identical to those FORAN project schemas, except that the COM_LOCK table is not used, as locking is controlled and centralized in the Series schema COM_LOCK table. Each FORAN project schema contains all model and PLM data for the boat it belongs to. The entities data identical among more than one boat (sharing the applicability range), is copied identically and automatically by the multi-save FORAN device when a user working in a particular project in the series saves the data.

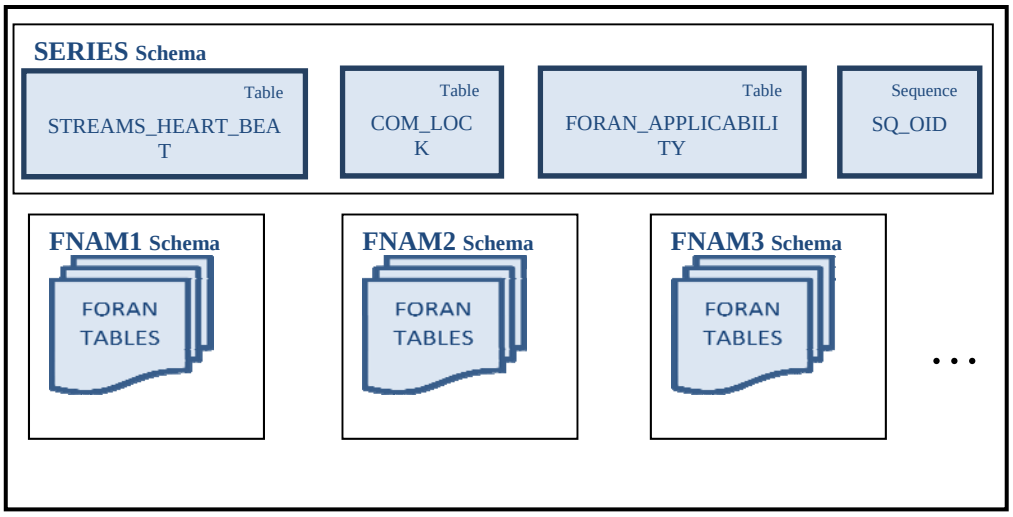

Figure 3. Data controlled in Series Project.

3. CHANGES IN FORAN DESIGN MODULES

3.1 STORING DESIGN CHANGES IN PROJECT ENTITIES

When a user is working in a FORAN design module in a project belonging to a series and is going to store the changes applied on an entity, the system will behave differently depending on the entity type.
If the entity is of a type not included in the applicability management, and so it is no subject of multi-saving, then the data will only be stored in the working project.
If the entity is of a type included in applicability management, and so it is subject of multi-saving, it will be required to implement a procedure, before the storing takes place, which will obtain the information related to the boat units in the

series that share the same applicability range with the current boat unit for the entity. Then, the changes to be stored will be done identically in all database schemas for those boat units.
With this purpose, the corresponding multi-saving actions will be implemented in all commands that handle entities subject of applicability.
In the case of deletion actions, after removing the entities, it will also be required to remove the register corresponding to the applicability range in the FORAN_APPLICABILITY table.
After the changes are stored, they will be visible from then on, by any other user accessing any other project in which the modified entity was applicable.

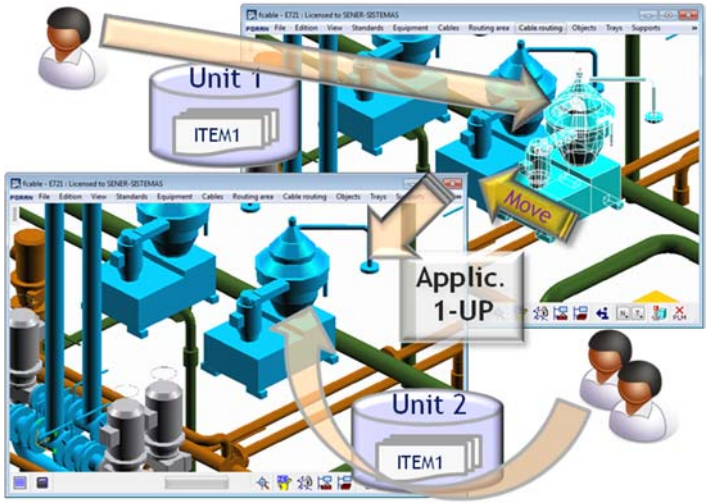

Figure 4. Applicability when creating ad updating entities

3.2 UNIQUE LOCK MANAGEMENT OF ENTITIES IN THE SERIES

It is required to modify FORAN locking system in order to be common to all projects in the series, so if a user locks an entity to work with it in a specific project, this locking must be effective in all projects sharing the applicability range of the entity.
For example, if a user is working in boat unit #1 and tries to modify an equipment with applicability 1-UP and this element is being modified by another use working in boat unit #2, the system will not allow the item edition by the first user and will show a message to this first user, as it can be seen in the following image.

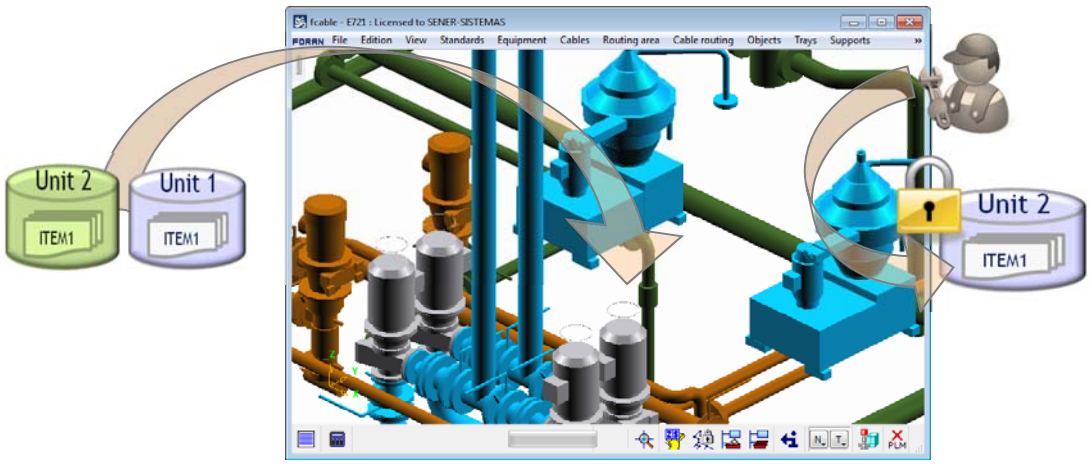

Figure 5. Entity locking mechanism when working in a series context

If this happens, the system will not allow the item edition by the first user.
To enable this, it will be necessary to add the applicability range to the existing locking keys in FORAN DB. This will apply to all entity types subject of applicability as well as to the standards.

3.3 MANAGING UNIQUE IDENTIFICATION OF ENTITIES IN THE SERIES

The general identification generator system will be modified to be common to all projects in the series, so if a user creates an entity in a project of the series, the system will guarantee that the entity identification will be also unique in all projects in the series.
This will apply to the manual introduction of identifications as well as to automatic numbering templates. If these uniqueness rules are violated when trying to create an entity, a message will be shown to the user.

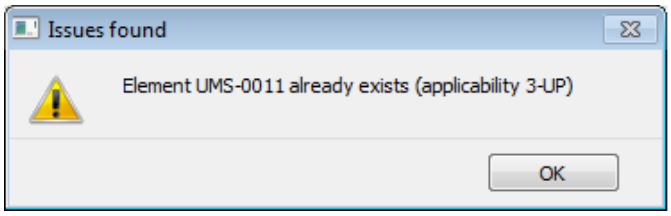

Figure 6. Warning message, when a user tries to reuse an existing identification

The default behavior will be to not to allow the operation. However, there are some cases in which this could be feasible:

- The case in which an entity was created in the past and then was deleted. The system will allow re-creation of the entity, depending on the entity type and the proper constraints that apply in each case. If the entity was removed in all boat unit projects, it could be re-created again if no other restrictions apply, but if the entity was removed within an applicability range but not in another one, the entity will only be allowed to be re-created in the current working boat unit project, in order to not interfere with the other projects in which it still exists. In all cases, the entity will have to be of the same type as the former deleted one.
- The case in which an entity never existed in the current boat unit project, but it does exist in others with different applicability range. In this case, the entity will be allowed to be created, except if some specific constraints apply to it, by default with applicability just in the current boat unit project, but optionally in some others as well, with the only restriction of not being applicable to other boat unit projects in which an entity of the same type and identification already exists.

With respect to the restrictions and constraints that could prevent an entity, in one of the previous mentioned cases, to be created or re-created, they will depend on the entity type and situation. Entities that rely on the existence of other entities to exist (e.g. Cables) will be more restricted than others than can exist by themselves (e.g. Equipment Elements). In addition, this will also depend on the context. For example, an Equipment Element can be created or re-created without further applicability constraints from FPIPE module, but if it is created or re-created in a diagram in FSYSD, applicability will have to be restricted to that of the diagram, to avoid potential conflicts with other boat units in which the diagram is not applicable.
The detailed description of which creation operations could be done in each case, depending on the entity type, will be incorporated to official FORAN documentation for each module.
In case of entity modification, if another entity of the same type already exists with the same identification, the operation of changing the Id will not be allowed.

4. APPLICABILITY MANAGEMENT OF ENTITIES IN THE SERIES

In FORAN system, it will be possible to manage the item applicability in the different boat units. This means that:

- It will be possible to determine in which boat units an item exists (applicability).
- It will be possible to determine the applicability range in which an item will have the same features (applicability range).
- A change in an item will be stored exactly in the same way in the whole applicability range (in all boat units within the same applicability range), regardless the project in which the user is applying the change.
- If, due to any unexpected issue, the change cannot be applied to some projects within the range, the modification will not be stored for any of them. So, the storing operation among the projects in the series will be transactional.

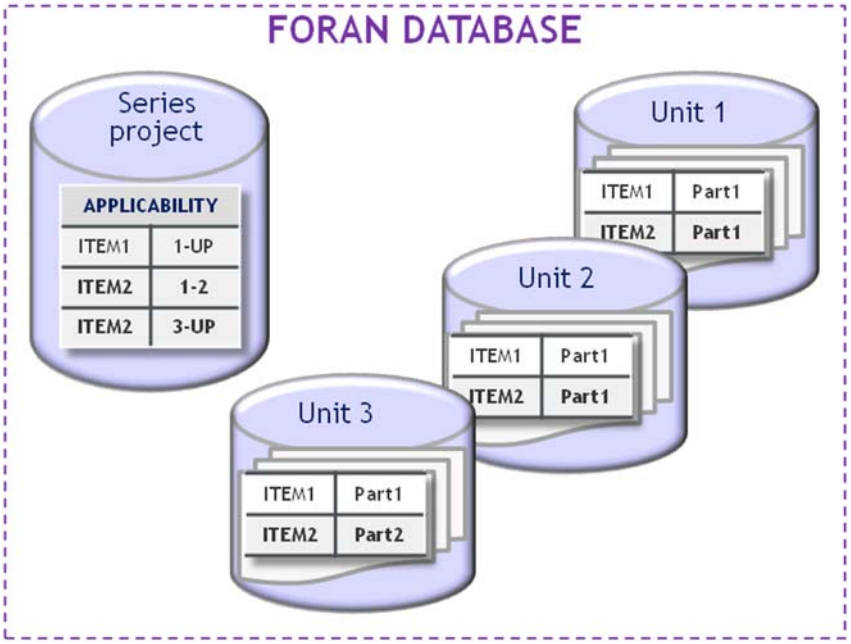

Figure 7. Series and unit projects in FORAN database

4.1 STORE APPLICABILITY IN DATABASE

The applicability values of an item in the series are stored in a new table called FORAN_APPLICABILITY. This table will include the OID (database object identifier) of the entity in FORAN. In addition, it will hold information about the applicability range for each entity.

FORAN_APPLICABILITY				
FORAN_OID	UNIT1	UNIT2	. . .	UNITn

Table 1. FORAN_APPLICABILITY table. Simplified schema

General behavior of this table will be the following:

- There will be at least one register representing the applicability context of the entities subject of applicability or the minimum container entity.
- In the case of entities that have more than one applicability context, there will be one register (table row) for each applicability context.
- For a single entity, it will be required to verify that applicability ranges do not overlap.
- When a new item is created in FORAN, a new register will be inserted in FORAN_APPLICABILITY table.
- When an item is deleted from a boat unit in FORAN, the register representing the item in the applicability context belonging to that unit will be deleted from the table.

4.2 APPLICABILITY VALUE CRITERIA FOR NEW PROJECT ITEMS

At the time a new item is created in FORAN, according to what is stated in the former section, the item will already hold applicability info.
As a general rule, the default value will be that of the boat unit corresponding to the working project.
If the entity is created in the last boat unit in the series, the applicability will be [n-UP], so it will also exist in all future units added to the series.

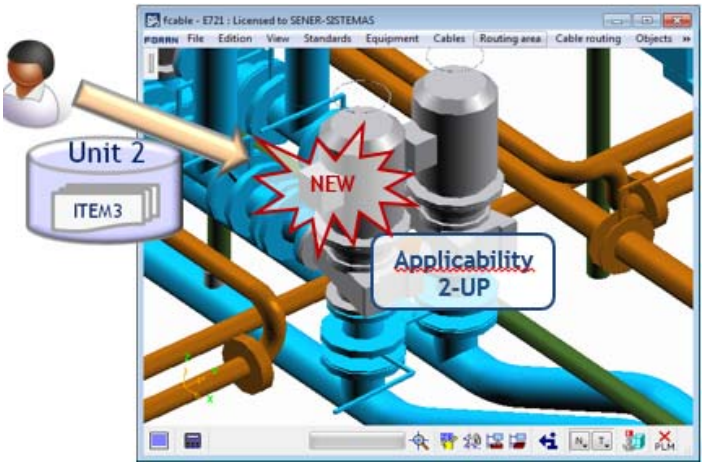

Figure 8. Applicability for new items

In some cases, according to the entity type and the applicability of the items related with the new item, the range could be expanded to other boat units. E.g.: if a new Equipment is to be created in a Diagram, the new equipment applicability could match the applicability of the Diagram.
In the case of items that depend on other items at creation time, it cannot be guaranteed that the items related will also exist in other boat units different from the current one, and so, the applicability will be by default restricted to the current boat unit. E.g.: Cables respect to their related equipment, Supports respect to routed elements supported, etc. Depending on each case, applicability value could be wider if it is checked and verify that does not create conflict or is not constrained by the existence or not of the entities they depend.
In the case of entities not depending on other items to be created (e.g. Equipment elements not being created from a Diagram in FSYSD), applicability could receive any value (1-UP, n-UP n, etc.).
If an entity is to be created as a result of a synchronization, applicability will be determined by the value included in the synchronization message for that entity. It will also possible that the applicability value for new items to create will be directly indicated by an ECN. In this case, applicability values of the new entity and that of the ECN must be compatible. See ICD for further details.

4.3. APPLICABILITY CHANGE OF PROJECT ITEMS

During a series project design stage, there could be several reasons to make necessary a change of applicability values:

- An item is not required anymore from a specific boat unit on (cutback applicability).
- From a specific boat unit on, using a different applicability standard is required, for example because the old library part being used is not provided anymore and needs to be replaced by a similar new one.
- The item position must be different in some boat units.
- In general, some item properties differ in some boat units with respect to the others.

In other words, applying some changes differently for an item in one boat unit with respect to the others, it will be necessary to previously perform a change in the item applicability range, so that, once the range division is done, design changes could then be done on the item inside the necessary applicability context, without affecting the boat units in the other ranges.

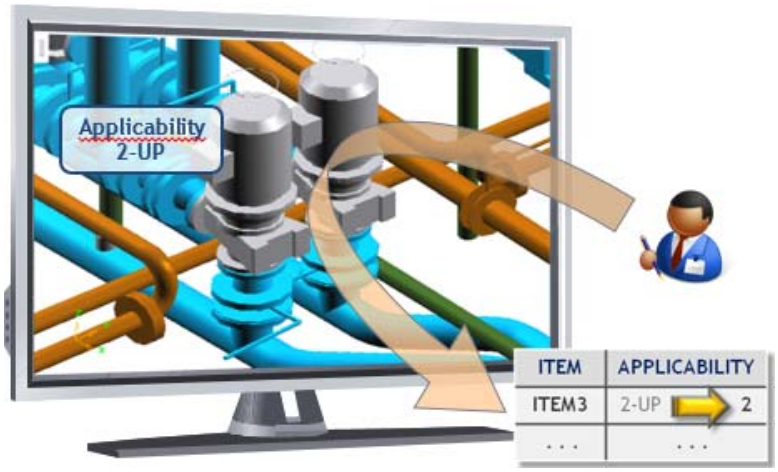

Figure 9. Changing item applicability.

For this purpose, a new utility will exist to allow an authorized user to change the item applicability values. This utility will be a common use tool in all requiring FORAN modules, which will be accessible from the corresponding entity edition Managers.
From that utility, the following tasks could be performed:

- Add a new applicability range. This will allow to divide a former range into two new ones.
- Change a boat unit to a new range or merge ranges.

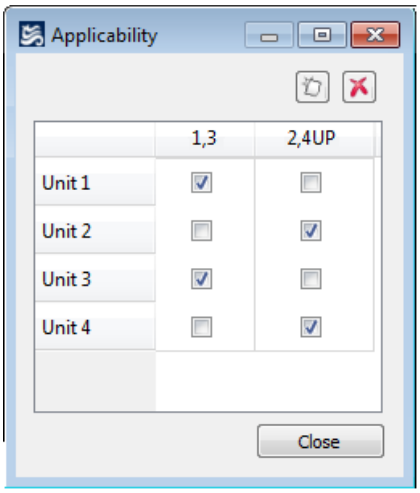

Figure 10. GUI for changing applicability

The following actions could not be directly done from this tool:

- Remove boat unit applicability from a range, because this means the entity removal form those boat units. If this operation is required, it will have to be done in two steps: 1- Divide the applicability range and 2- Remove the entity.
- Extend item applicability to other units, because it means the entity creation in those boat units and this common usage tool does not have the necessary information required to create an entity in FORAN, as the specific entity Manager is the only FORAN tool that knows the necessary info to create the entity.

In addition, a new tool will be available in FCM module to allow accessing the items applicability data and the multiple edition of their values.
Applicability cutback can only be performed by FORAN users with the Applicability Manager role. When performing an applicability cutback of an entity, ensure that this operation is required to fulfill a design change and is done by the appropriate users. Once an applicability cutback is completed, ranges cannot be merged again, except if no data saving operations have been done.
For performing an applicability cutback operation, it is not required to previously unlock the involved FORAN items.

5. CONCLUSIONS

This paper presents a solution for the applicability of a shipbuilding specific CAD System (FORAN) with an advanced PLM System in a Naval Shipbuilding environment.

The proposed integration presents several important advantages:

- Takes profit of the experience and results of previous integration of FORAN with different PLM Systems.
- Incorporates the most outstanding requirements for the CAD – PLM integration coming from some relevant European shipbuilding companies, designing and manufacturing surface ships and submarines.
- Improves predictability by providing a single point of truth for the whole organization.
- The design of the integration has been done with the objective of limiting the degree of coupling between the CAD and the PLM, with several important aims in mind:
  - To reduce to a minimum the impact of the integration on the performance of both systems (the CAD and the PLM).
  - To produce a scalable solution able to work with hundreds of designers in the CAD Engineering side and with thousands of PLM users in the whole shipbuilding organization.
- It would allow the PLM to take benefit of all the vessel information handled by the CAD from the early stages of the design.

The proposed integration is now under implementation for several important European Naval Shipbuilder.

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