



# Data replication

Maintenance, analysis and replication of PIR system

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Bachelor's Thesis

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## BACHELOR'S THESIS

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### **Abstract**

This thesis has been done on behalf of Wärtsilä Finland Oy. The task assigned has been to analyse the data replication process that is in use in the Product Information Resolution system (PIR). This system is handling the product lists for Service Bulletin distribution. The product lists are stored in Microsoft SQL Server databases. In addition to the analysis, a new replication and data archiving model has been developed to improve the existing systems. The models that have been created are made with Microsoft Access as temporary solutions for testing purposes. The intention is that the new function shall be implemented in the existing SQL Server system after it has been concluded that the new process is working satisfactorily.

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Language: English Key words: databases, replication, PIR, CMA, Microsoft Access

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## EXAMENSARBETE

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Titel: *Datareplikering - Underhåll, analys and replikering av PIR-system*

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### Abstrakt

Detta examensarbete har gjorts åt Wärtsilä Finland Oy. Arbetsuppgiften har bestått av att analysera den datareplikeringsprocess som används i det PIR-system som hanterar produktlistor för Service Bulletiner. Produktlistan är en lista i en SQL-databas av de produkter som Service Bulletinen skall distribueras till. Utöver analysen har också nya datareplikerings- samt arkiveringsmodeller skapats för att förbättra de existerande systemen. Modellerna som har skapats är gjorda i Microsoft Access som temporära lösningar för testning av den nya processen. Dessa datareplikeringsfunktioner är tänkta att bli implementerad i PIR-systemets Microsoft SQL Server när man konstaterat att den nya replikeringsfunktionen fungerar tillfredsställande.

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Språk: engelska Nyckelord: databaser, replikering, PIR, CMA, Microsoft Access

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Tillgänglig: Theseus.fi och Tritonia, Vasa vetenskapliga bibliotek

## OPINNÄYTETYÖ

Tekijä: Niklas Nygård  
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Nimike: *Tietojen replikointi – PIR-järjestelmän huolto, analysointi ja replikointi*

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Päivämäärä 26.2.2013 Sivumäärä 29

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### Tiivistelmä

Tämä opinnäytetyö on tehty Wärtsilä Finland Oy:lle. Tehtävänä on ollut replikointiprosessin tietojen analysointi, joka on käytössä PIR-järjestelmässä. Tämä järjestelmä käsittelee Service Bulletin jakelun. Tuoteluettelot tallennetaan Microsoft SQL Server -tietokantaan. Sen lisäksi uusi replikointi- ja arkistointimalli on myös kehitetty parantamaan olemassa olevaa järjestelmää. Malleja on tehty Microsoft Accessiin väliaikaisena ratkaisuna testausta varten. Tarkoituksena on, että uusi toiminto toteutetaan nykyiseen SQL Server -järjestelmään, kun uusi prosessi toimii tyydyttävästi.

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Kieli: englanti Avainsanat: tietokanta, replikointi, PIR, CMA, Microsoft Access

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Arkistoidaan: Theseus.fi ja Tritonia, Vaasan tiedekirjasto

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# 1 INTRODUCTION

This Bachelor's thesis is made on behalf of Wärtsilä Finland Oy for Novia University of Applied Sciences. The Manager of the Service Bulletin team Stefan Knubb, at the Technical Information department, has been the contact person at Wärtsilä.

## 1.1 Wärtsilä

Wärtsilä was established in 1834 as a sawmill which was later on replaced by an iron mill in the north of Karelia, Finland. Working with smelting and steel milling they later started in the diesel engine era at the end of the 1930s. The first Wärtsilä diesel engine was manufactured in Turku in November 1942. The company has gone through a lot of mergers and name changes in its almost 200-year-long history. /1/



*Fig. 1. Wärtsilä's logo /2/*

Today Wärtsilä employs approximately 18,900 people in 70 countries around the world and can be divided into four main businesses:

- Power Plants
- Marine Solutions
- Services
- PowerTech.

Power Plants supplies flexible base load power plants operating on various liquid and gaseous fuels. Power Plants also provides solutions for grid stability, reserve, peaking, load following and intermittent power generation. The power plant portfolio covers a capacity range from 1 to more than 500 MWs and is customized. /3/

Marine Solutions supplies propulsion, powering and environmental solutions for merchants, cruises, ferries, navy vessels, special vessels and offshore oil rigs etc. The scope for their solutions includes for example engines, propulsion, scrubbers, ship design, NOx reducers and LNGpac. /4/

Services, which is the biggest business in Wärtsilä, provides the customer with service & support through the whole lifecycle of the Wärtsilä products. Some of the solutions Services provides are maintenance work, upgrade & conversion projects, providing spare parts and engine instruction manuals etc.

PowerTech is the business that takes care of the production of engines and generating sets. They are also responsible for the research and development of the products. PowerTech customers are the three other businesses: Power Plants, Marine Solutions and Services.

Wärtsilä key figures in 2012: /5/

- Net sales EUR 4,725 million
- Operating result EUR 515 million
- Order intake EUR 4,940 million
- Order book 31 December EUR 4,492 million.

## 1.2 Technical Information

Technical Information is one of many departments within Wärtsilä Services. The department is global but Technical Information in Finland has 4-stroke engine products as its responsibility. These Technical Information products are:

- Spare Part Catalogue (SPC)
- Instruction Manuals (Operation and maintenance manuals)
- Service Bulletins (SB)
- Record Book of Engine Parameters (RBoEP)
- Code Resolution File (CR).

In addition to these, Technical Information is also responsible for software used together with the products. For example Eldoc Intranet and Eldoc Online are systems used by internal and external customers. By these they can access the Spare Part Catalogue and Instruction Manual with an Internet browser. Correspondingly Bulletins Intranet and Bulletins Online are the systems for accessing Service Bulletins.

In Finland around 50 people are working at Technical Information 4-Stroke Products. The offices of most of them are located in Vaasa, Runsor, while a few have their office in Turku. See Figure 2 on the next page for Technical Information's organisation setup.



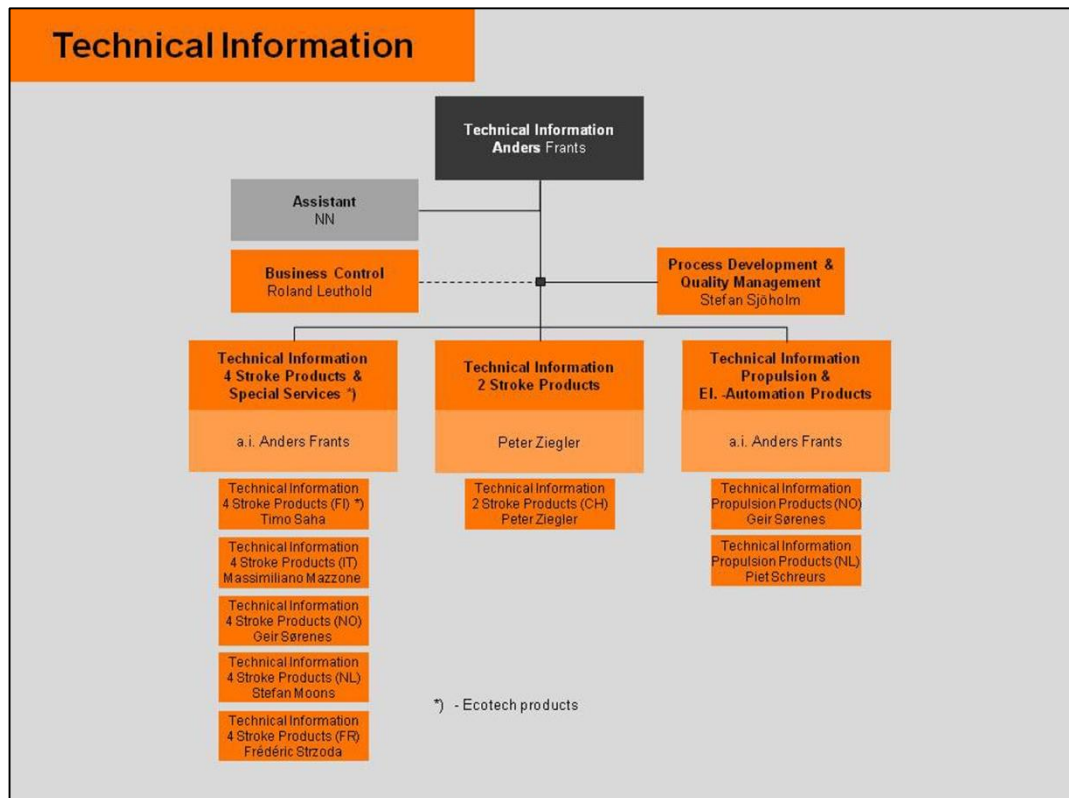


Fig. 2. Organisation chart for Technical Information /6/

Technical Information in Finland is currently supporting about 19 000 4-stroke engines, which are in different stages of their lifecycle.

The supported engines range from old engines manufactured in the early 1960s, but which are still in operation, to new engines that are in the manufacturing process.

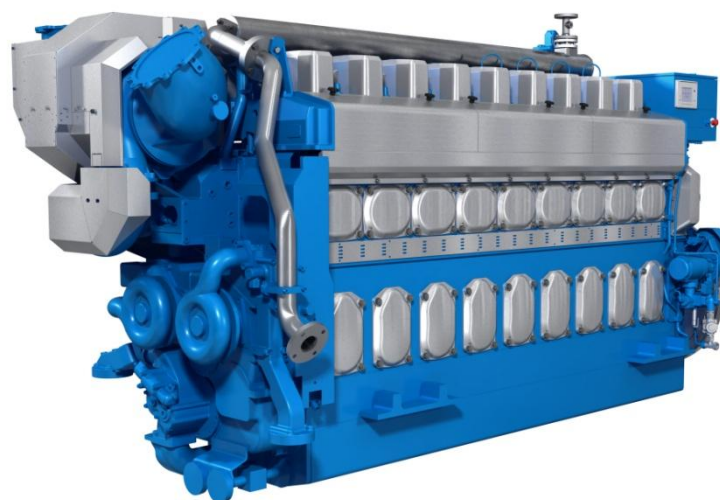


Fig. 3. The WÄRTSILÄ® 20DF (Dual-Fuel) engine /7/

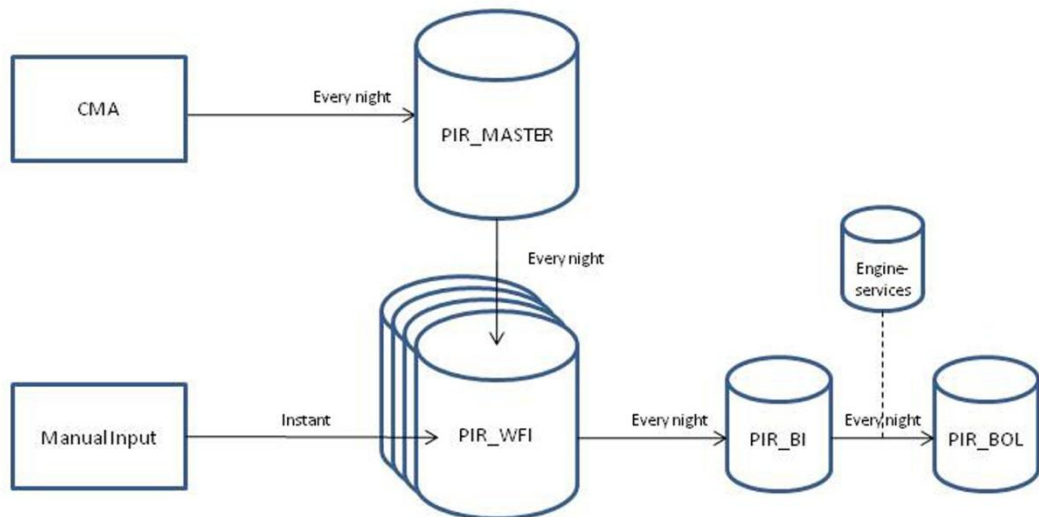
### 1.3 Task

The task I was assigned by the Service Bulletin team was to:

- Analyze the data replication processes in the Product Information Resolution (PIR) system
- Identify weaknesses in the system
- Create a model for replicating data between two of the databases
- Create a model for archiving obsolete data
- Identify data quality issues related to the replication process.

The data in the PIR system are used for Service Bulletin distribution. It is important that the data are correct to ensure the distribution of Service Bulletins to the customers concerned.

The PIR system is based on SQL and Oracle databases. The analysis and the model for replication and archiving data have been made with Microsoft Access. The idea is that the replication model that is created should later on be implemented in the production system.



*Fig. 4. The PIR system*

## 2 SERVICE BULLETINS

The purpose of Service Bulletins is to provide Wärtsilä's end customers, i.e. owners and operators, Wärtsilä Services offices, as well as colleagues concerned with both updated and new information on Wärtsilä's products and services.

Service Bulletins are grouped into seven different categories based on the purpose. The table below shows the different Service Bulletins categories with explanations of what kind of information the bulletin may contain:

*Table 1. Service Bulletin categories*

<b>Category</b>	<b>Purpose</b>
General Information	Organizational and commercial information
Service Letter	A temporary instruction with a request or a recommendation for necessary actions to be taken by the customers.
Technical Bulletin	Information about product or service development where a solution is provided, e.g. modifications, upgrading packages.
Instructions	Various additional or amended instructions related to installations, operation or maintenance. They can e.g. be called maintenance-, operating-, reconditioning- or refurbishing instructions.
Spare Part Notice	Updating of spare parts catalogues and general new information about spare parts and tools.
Data & Specifications	Product specification updating.
Records	Various types of forms for filling in performance measurement and testing data. Alignment records, application sheets etc.

Bulletins are furthermore divided into the following two divisions depending on the targeted group the bulletin is published for:

- External
- Internal.

Internal bulletins are visible in Bulletins Intranet for the Wärtsilä personnel. For example, this could be additional ordering instructions for the sales organization or installation instructions for service engineers.

External bulletins are intended for the customers operating specific product. The external bulletins are visible in Bulletins Intranet for the Wärtsilä personnel and in Bulletins Online for the customers with an agreement. The customers can use Bulletins Online to check if a new bulletin has been released or if a bulletin has been revised.

The screenshot displays the Wärtsilä Bulletins Intranet interface. At the top, there is a navigation bar with tabs for 'Bulletins', 'Settings', 'Notifications', 'Distribution', 'Create', and 'Help'. Below this is a search and filter section with various dropdown menus and checkboxes. The main content area features the Wärtsilä logo and a prominent orange box labeled 'SPARE PART NOTICE'. Below the logo, there is a table with the following data:

Engine section	Engine type	Ref.	Date	Issue	Document No.	Page
14 Valve Mechanism	32	WFL-S	20.01.2007	01	3216P125	1(2)

The title of the notice is 'Stud for rocker arm bracket'. Under the 'Engine type' section, it states: 'This spare part notice concerns WÄRTSILÄ® Vasa 32 engines equipped with a short stud for the rocker arm bracket.' Under the 'General' section, it states: 'For standardisation reasons, only one length of the stud 120 031 is supplied today. This stud is 110 mm long and fits all cylinder heads for above mentioned engine type. The old stud was shorter.'

Below the text, there is a technical drawing of a stud with a dimension line indicating a length of 110 mm. To the right of the drawing is a diagram of an engine component, with a red line pointing from the stud to its location in the engine assembly.

Fig. 5. Example of a Spare Part Notice in Bulletins Intranet /8/

The table on the next page shows a summary of Service Bulletins grouped by bulletin category, which are the responsibility of Technical Information 4-Stroke Finland. All these bulletins are active, meaning that the product list for the bulletins should be maintained.

*Table 2. Summary of active bulletins /9/*

<b>Bulletin Type</b>	<b>External</b>
General Information	102
Service Letter	243
Technical Bulletin	172
Instruction	176
Spare Parts Notice	162
Data & Specifications	117
Measurement Record	125
<b>Total</b>	<b>1097</b>

In addition, maintenance of bulletins includes checking if the bulletin is still valid, needs to be revised or can be made obsolete.

Apart from the maintenance of bulletins and its product lists, the creation of new bulletins is always under work. The creation of bulletins is done in cooperation with Technical Service and the Service Bulletin team. Technical Service is the owner of the bulletin, i.e. they are the ones who request that a Service Bulletin is made.

## **2.1 Distribution**

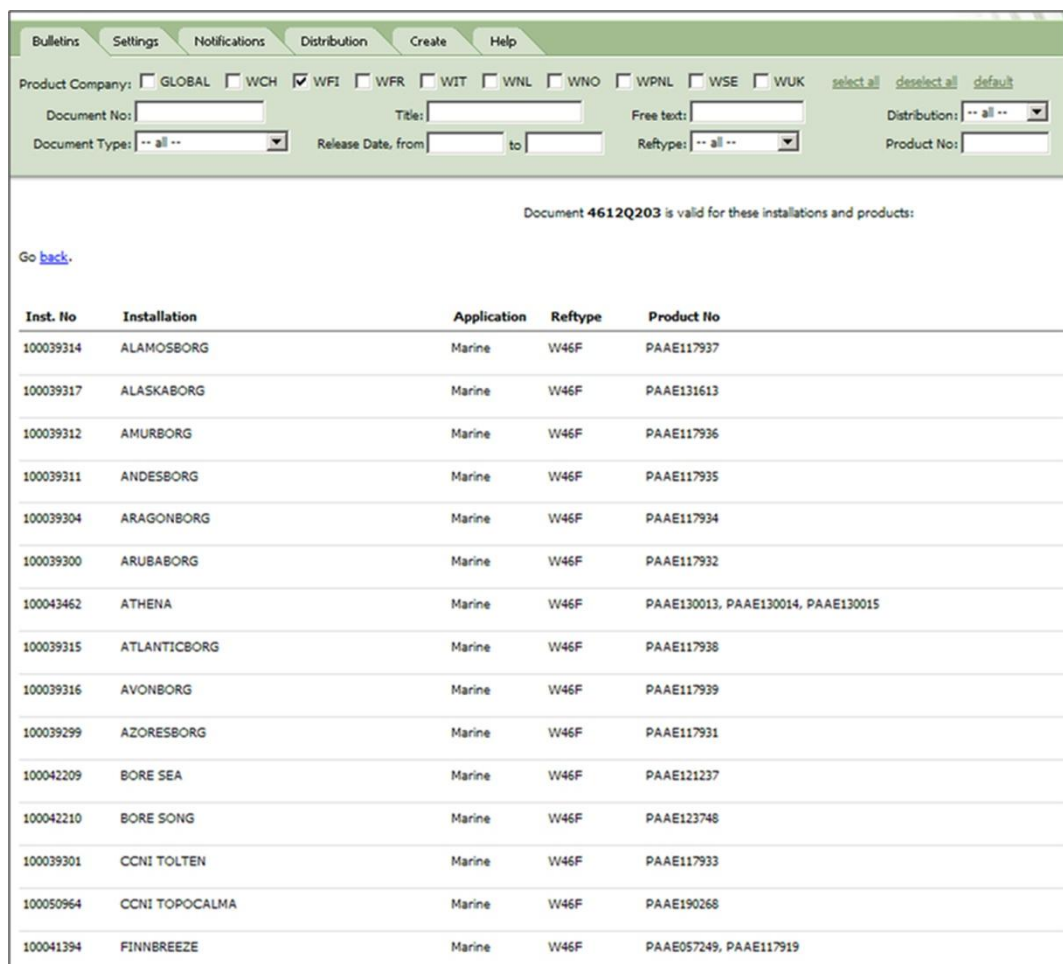
The external Service Bulletins are distributed via the Wärtsilä Services Networks. In addition, customers with an agreement can access the bulletin online.

The distribution lists are created with Bulletins Intranet and the system sends e-mail notifications to the Service Bulletin coordinators at the Wärtsilä Services Networks around the world. The Services Networks are then responsible for contacting the customers in their own area and distributing the bulletins to them.

## 2.2 Product Information Resolution (PIR)

The Wärtsilä Services Networks require a list of customers to know where to distribute the Service Bulletins. This is done by making a product list for every Service Bulletin which is to be distributed. This product list is uploaded to what is called Product Information Resolution (PIR). The key fields in the product list are the product reference type, the product number and the Service Bulletin document number.

The PIR data is combined by Bulletins Intranet with installation and customer data from other data systems to create the final distribution lists. Figure 6 below shows an example of an installation and product list for a Service Bulletin where PIR data and installation data have been combined.



Document 4612Q203 is valid for these installations and products:

[Go back.](#)

Inst. No	Installation	Application	Reftype	Product No
100039314	ALAMOSBORG	Marine	W46F	PAAE117937
100039317	ALASKABORG	Marine	W46F	PAAE131613
100039312	AMURBORG	Marine	W46F	PAAE117936
100039311	ANDESBORG	Marine	W46F	PAAE117935
100039304	ARAGONBORG	Marine	W46F	PAAE117934
100039300	ARUBABORG	Marine	W46F	PAAE117932
100043462	ATHENA	Marine	W46F	PAAE130013, PAAE130014, PAAE130015
100039315	ATLANTICBORG	Marine	W46F	PAAE117938
100039316	AVONBORG	Marine	W46F	PAAE117939
100039299	AZORESBOG	Marine	W46F	PAAE117931
100042209	BORE SEA	Marine	W46F	PAAE121237
100042210	BORE SONG	Marine	W46F	PAAE123748
100039301	CCNI TOLTEN	Marine	W46F	PAAE117933
100050964	CCNI TOPOCALMA	Marine	W46F	PAAE190268
100041394	FINNBREEZE	Marine	W46F	PAAE057249, PAAE117919

Fig. 6. An installation and product list in Bulletins Intranet for a bulletin /10/

### 3 CREATION OF PRODUCT LISTS

After a Service Bulletin has been approved it will be uploaded to Wärtsilä's Integrated Document Management system (IDM) and will be visible in Bulletins Intranet the following day. The product list is normally uploaded to the PIR system at the same time.

The product list can be made in two different ways:

#### 1. With the Content Management Automation (CMA) tool (dynamic)

Product lists with CMA are used where simple rules apply when creating the product list e.g. products of certain product types, products which contain a certain material number etc. Product lists with CMA are also dynamic, i.e. the list adds and removes products according to the rules that are chosen.

#### 2. By uploading a manually made list to PIR (static)

Manual product lists are chosen when a static list is wanted and when the complexity of the product list criteria cannot be handled by CMA.

The decision regarding which way the product list is made is mainly based on the rules that are to be used for creating the list and the need for including new products in the list in the future.

#### 3.1 Manually made product lists

A product list can be made by combining relevant information from different sources. The list is manually analyzed and filtered according to the Service Bulletin criteria. After the list has been prepared, the user uploads the product list to a database with an Access application. The product list is then available in Bulletins Intranet the following day.

Manually made product lists are static. They stay the same until someone alters them. This means that installations with products manufactured after the Service Bulletin was made will not be included in the product list. This can be both an advantage and a disadvantage depending on the Service Bulletin.

Advantages with manually made product lists:

- Full control of the products linked to the Service Bulletin
- Flexibility, information from many different sources can be used when creating the list
- Visible in Bulletins Intranet at the same time as the bulletin is published.

Disadvantages with manually made product lists:

- The main disadvantage is that the product list must be updated if new products are to be included
- Can be time consuming to create
- Requires a good knowledge of system and tools for combining data and creating the list.

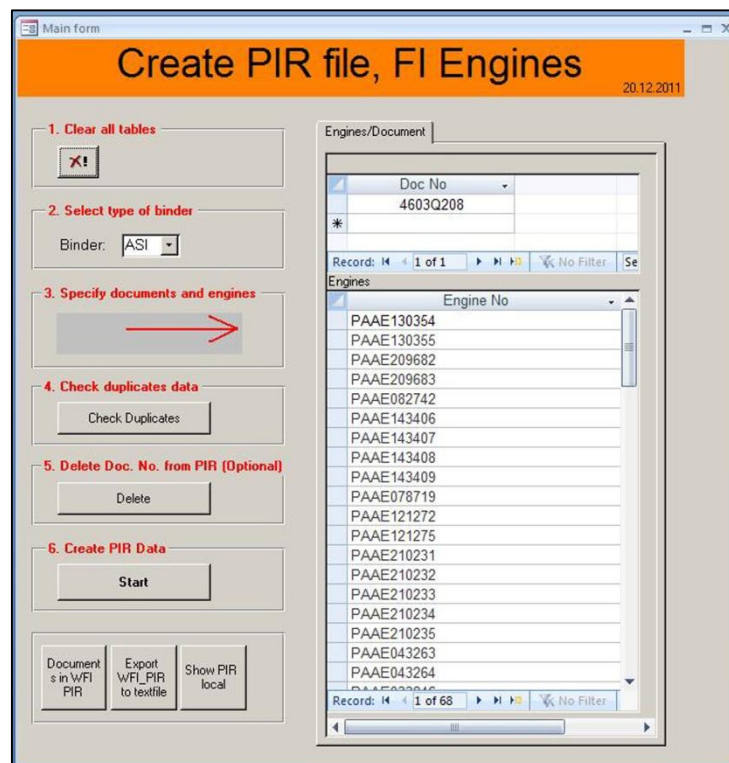


Fig. 7. The application for uploading manual product lists to PIR



## 3.2 Automatic product lists with CMA

The product list can also be made with a tool called CMA. This tool lets the user select a product type and define the criteria that are valid for a Service Bulletin. CMA then automatically creates the product list and uploads it to PIR\_MASTER (as described in chapter 3.3). CMA runs on a daily basis so if new products are added and are valid for the Service Bulletin, the system automatically updates the product list.

Advantages of product lists made with CMA:

- Automatically maintains the product list
- Requires less work
- Does not require advanced data processing knowledge.

Disadvantages of product lists made with CMA:

- Cannot handle complex criteria
- Ignores the operating status of the product
- Tracking is lost when a product has been added to the product list, due to the fact that the product lists are recreated every day
- More difficult to verify the product list before it is published
- Rules have to be maintained if e.g. new product reference types are to be included
- The product list is available two days after the bulletin is visible in Bulletins Intranet.

The biggest disadvantage with CMA is that it ignores the product operating status. This means for example that products that are not yet manufactured or installed are included in the product list. This is something that is not wanted. Another disadvantage with CMA is that it cannot be used for all product lists due to limitation of the complexity of the criteria.

Figure 8 below shows the CMA interface and a list of criteria that can be used when defining the rules for creating the product list.

**Update PIR automation connections for document**

**4611V005 - Crankshaft deflection (Measurement Record)**

Valid for : W46, W46F, W46GD, W50DF, W50SG

Active	Reftype	Fuel type	Interval	Criteria	Value 1	Value 2	
	W46			all products	ALL	-	set
	W46F			all products	ALL	-	set
	W46GD			all products	ALL	-	set
	W50DF			all products	ALL	-	set
	W50SG			all products	ALL	-	set

New

-

add

close window

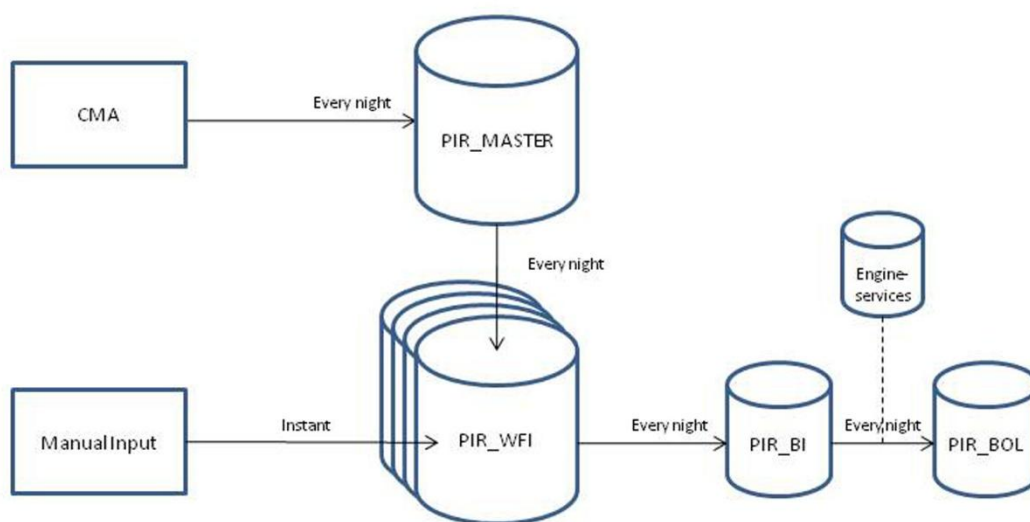
- all products
- contains partcode
- contains specific CR section
- does NOT contain partcode
- contains material no
- contains two material nos
- of fueltype
- of cylinderspec
- of specific product type
- with product type extension (ETE)
- of specific engine version
- with engine rating
- valid only for product no
- with product number in range
- use below with care! -----
- with commission date in range
- of specific product type (wildcard)
- in application (PP, ME, AE etc)
- 
- manually created list

Fig. 8. The CMA interface /11/

### 3.3 Replication of data

CMA creates and updates the product lists on a daily basis. It gathers data from different sources and stores the product list in a database called PIR\_MASTER. The product lists in the database are replicated to a table called PIR\_WFI. Technical Information in other countries have their own similar PIR tables and data from these are combined and replicated to PIR\_BI during the night. The database used by Bulletins Intranet is called PIR\_BI while the database used by Bulletins Online is called PIR\_BOL, which is the last database in the replication chain. See Figure 9 on the next page.

The database which is called Engine-Services stores the information about Bulletin Online agreements. Only the records for the products that are included in an agreement are replicated to PIR\_BOL. This is just to keep the database as small as possible and avoid unnecessary data that is not used.



*Fig. 9. Flowchart of the replication process*

From the flowchart above it can also be seen that the manually made product lists are visible in Bulletins Intranet as early as one day after they have been added to PIR\_WFI, while product lists with CMA require three days to be visible in Bulletins Intranet. However, if the product list is required to be available at the same time as the bulletin in Bulletins Intranet, it can always be added manually first and then later activated with CMA. In this way the list is ready the following day while CMA will update the list in the future.

Another option with CMA is to create the product list with CMA, after the list is in the system CMA can be deactivated for the bulletin to keep a static list. In this way CMA is utilized to easily create a product list.

## 4 ANALYZING THE REPLICATION PROCESS

The replication process has been analyzed by running reports from the PIR database to see where records for a product list are missing or if there are unnecessary records found in the database. The idea with the analysis was to find weaknesses in the replication process and to find possible corrective measures to improve the process and thus also to improve the quality of the product lists.

The following table shows some of the possible cases where problems have occurred in the replication process:

*Table 3. Cases where the replication process might cause errors in the product lists*

<b>Case</b>	<b>Description</b>	<b>Chapter</b>
1	Tracking when a record has been added to the product list	4.1 4.2
2	Products not in operation are added to the product list with CMA (Operating status N and P)	4.1 4.2
3	Product lists have been lost in PIR	4.1 4.2
4	Installations are laid up or scrapped	4.3
5	Engines are upgraded / reconditioned	4.4
6	Engines are modified (Fuel conversions, lowNOx conversions etc.)	4.5

These cases have been analysed further and are discussed in the following chapters, which are mentioned in the table above.

## 4.1 Data replication from PIR\_MASTER to PIR\_WFI

The data replication from PIR\_MASTER to PIR\_WFI was working so it deleted all the records in PIR\_WFI for the bulletins where CMA was activated, where after it copied all the records for that bulletin from PIR\_MASTER to PIR\_WFI. Therefore, since CMA is updated daily, a new date stamp is always added to the records in PIR\_WFI. In this way it becomes impossible to track when a record was added to the database the first time, which is something that is important to know for traceability reasons.

Another issue related to this is that there have been cases when the source data that CMA is using have been missing. This problem has then consequently resulted in product lists in PIR\_MASTER being lost and product lists disappearing from Bulletins Intranet.

Because of these problems and the fact that CMA includes products that are not in operation in the product list, it was decided to deactivate the automatic replication of data from PIR\_MASTER to PIR\_WFI.

Without the replication of the 4-stroke products in Finland, CMA data could not be used and a new replication model was to be created. The new model has been created and tested in the production environment and is currently being run manually on a weekly basis. The new replication model works according to the following principles:

- It only includes products with the status “In operation”.
- It only includes active bulletins with the distribution type “External”.
- It only includes products linked to a valid installation.
- It replicates if the record does not already exist in PIR\_WFI.

As can be seen, this replication model only includes the records which should be on the product list and it excludes e.g. the engines which are not yet installed. Also, since no records are removed from PIR\_WFI and the new records are only replicated if the data does not already exist, the problem of tracking data from the date stamps has been fixed.

The prototype was created as a simple Microsoft Access form to show the user which records are going to be replicated. The form works with SQL queries and VBA code (Visual Basic for Applications). The form can be seen in Figure 10 and shows a number of records which are ready to be replicated with the tool.

The screenshot shows a Microsoft Access form titled "Replicate" with an "Event Log" tab. At the top, there is a "Document No" dropdown menu set to "4610Q002" and a "Bulletins Intranet" label with a link to "4610Q002". A "Replicate all records" button is visible on the right. Below this is a "Summary for Bulletin:" section with a table:

linkid	reftype	extension	records
4610Q002	W46	GD	24

Below the summary is a navigation bar with "Record: 1 of 1" and a search field. The main area is titled "All Records to be Replicated to PIR\*" and contains a table with 7 columns: reftype, extension, engineno, linkid, binder, groupid, and added. The table lists 24 records, all with a timestamp of 6.2.2013 16:11:59. The records are grouped by reftype (W46 and PAAE013981-013983) and extension (GD).

reftype	extension	engineno	linkid	binder	groupid	added
W46	GD	9692	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9693	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9867	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9868	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9869	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9870	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9871	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9872	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9922	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9976	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9977	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9978	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9979	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9980	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9981	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9986	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9996	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	9997	4610Q002	ASI		6.2.2013 16:11:59
W46	GD	PAAE013981	4610V003	ASI		6.2.2013 16:11:59
W46	GD	PAAE013981	4610V004	ASI		6.2.2013 16:11:59
W46	GD	PAAE013981	4611V008	ASI		6.2.2013 16:11:59
W46	GD	PAAE013981	4612V002	ASI		6.2.2013 16:11:59
W46	GD	PAAE013982	4610V003	ASI		6.2.2013 16:11:59
W46	GD	PAAE013982	4610V004	ASI		6.2.2013 16:11:59
W46	GD	PAAE013982	4611V008	ASI		6.2.2013 16:11:59
W46	GD	PAAE013982	4612V002	ASI		6.2.2013 16:11:59
W46	GD	PAAE013983	4610V003	ASI		6.2.2013 16:11:59
W46	GD	PAAE013983	4610V004	ASI		6.2.2013 16:11:59

At the bottom, there is a navigation bar with "Record: 1 of 120" and a search field.

Fig. 10. Form showing the records that are to be replicated

This application is run manually at least once a week and each time the replication is run it creates an event in a log. This event log stores the time and the amount of records that have been replicated. However, the intention is to implement this new replication model in a Microsoft SQL server as a scheduled process in the future.

## 4.2 Archiving of data in PIR\_WFI

Since the new replication process does not delete any records in PIR\_WFI and while, at the same time, there is a steadily increasing number of Service Bulletins and thus also product lists, the PIR\_WFI database tends to grow bigger and bigger. Therefore the database should be cleaned at regular intervals. Also, product lists which are based on CMA criteria with for example material numbers must be checked and records that no longer belong on the product lists must be removed.

Instead of simply deleting records that do not seem to be valid anymore, it was decided to create an archiving tool. This decision was made because it has been noticed that it would be good to be able to track if a certain product has been on a product list. This can also be used to add the records back if a product reappears. The archiving tool adds a time stamp to the archived record with a note why it has been archived. In this way the complete change log for a product and a product list can be seen.

The archiving tool moves the records from PIR\_WFI to the archive if any of these rules apply:

- The Service Bulletin is no longer active.
- The product is no longer found or has the status “Not in operation” (N).
- The product is no longer linked to a valid installation.
- The bulletin no longer applies to the product on the basis of the CMA criteria.

This tool was created as an Access application where the user can view the records that fulfil the archiving rules and choose manually which records that should be archived and which ones that should not be archived. Figure 11 on the next page shows one of the views of the archiving tool where the user can browse records by engine number, which fulfils the archiving rules.

reftype	extension	engineno	linkid	binder	groupid	added	To Be Archived?	ENGOPR	Valid Installation?	Valid Bulletin?
W20		PAAE025404	WS03Q026	ASI		19.11.2012 10:52:55	<input type="checkbox"/>	N	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
W20		PAAE025404	WS19S017	ASI		19.11.2012 10:52:55	<input type="checkbox"/>	N	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
W20		PAAE025404	WV98V091	ASI		19.11.2012 10:52:55	<input type="checkbox"/>	N	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
W20		PAAE025404	WV98V041	ASI		19.11.2012 10:52:55	<input type="checkbox"/>	N	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
W20		PAAE025404	WS02N002	ASI		19.11.2012 10:52:55	<input type="checkbox"/>	N	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
W20		PAAE025404	WV98V030	ASI		19.11.2012 10:52:55	<input type="checkbox"/>	N	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
W20		PAAE025404	WV91V088	ASI		19.11.2012 10:52:55	<input type="checkbox"/>	N	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
W20		PAAE025404	WV91V087	ASI		19.11.2012 10:52:55	<input type="checkbox"/>	N	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
W20		PAAE025404	WV11V109	ASI		19.11.2012 10:52:55	<input type="checkbox"/>	N	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
W20		PAAE025404	WV98V089	ASI		19.11.2012 10:52:55	<input type="checkbox"/>	N	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Fig. 11. The archiving tool

As a result of the changes in the replication process and the use of the archiving tool in the PIR system, the flowchart for the PIR system is modified. See Figure 12.

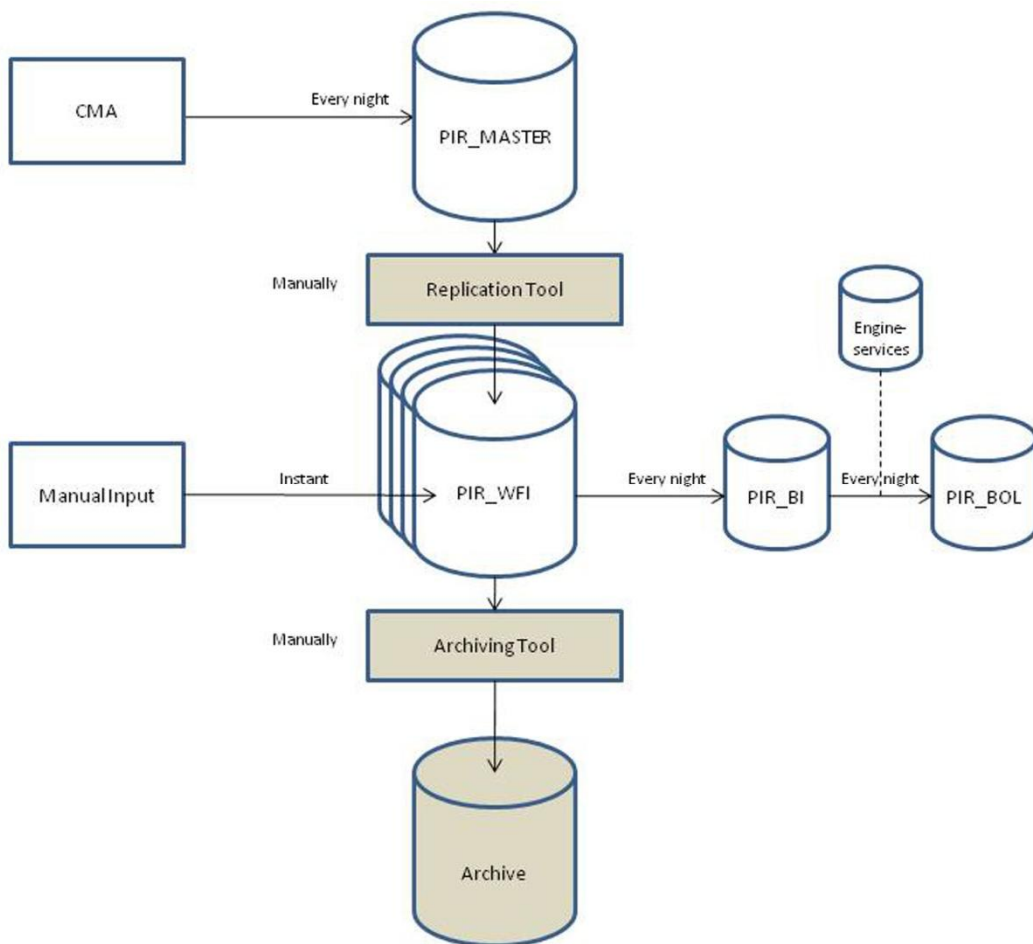


Fig. 12. Flowchart of the modified replication process



### **4.3 Installations are laid up or scrapped**

When an installation is scrapped the engines might be sold or moved if they are still in good condition. The engines' operating status is then changed to "Not in operation" until they are installed in a new application. This means that the archiving tool archives the engine's PIR records. Once the engine is back in operation, CMA automatically adds the records back for the bulletins where CMA is used for the product list. But where a manual list is used, the bulletins for the engine are not automatically added back.

The same scenario happens when a ship or a vessel is laid up for a longer period due to it being for example unprofitable to run the ship. Now the question is what to do with the records that are archived and not added back when the engine is back in operation?

Whether or not the bulletins should be added for the engines is something that must be decided case by case. The archiving tool stores the records in a database so they can easily be restored to the PIR system manually.

### **4.4 Engines are reconditioned**

Older Wärtsilä engines are sometimes modified or reconditioned to give for example a higher output or to keep up-to-date with the increasingly strict environmental rules that can apply to ships. As a result of these modifications on the engines, the product number also sometimes changes.

These modifications are then impacting on the PIR system in the following way:

- The old bulletin list for the engine is archived due to the fact that the old engine number is removed from the system.
- The new bulletin list is automatically added by CMA.
- A manually created bulletin list for the old engine number is not automatically transferred to the new engine number.

The new bulletin list which is added for the engine is okay. But something to consider is if the manually created bulletin list, which is archived should be added for the new product number.

## 4.5 Engines are converted

Wärtsilä also offers different kinds of engine conversions. Examples of engine conversions are:

Fuel conversion:

- DF conversion. A diesel engine is upgraded with Dual-Fuel technology.
- GD conversion. A diesel engine is upgraded with Gas-Diesel technology /12/.

LowNox conversion:

- An older diesel engine is modified for less emissions.

Below is a list of different Gas & Fuel conversions that Wärtsilä offers.

GAS & FUEL CONVERSIONS	
PRODUCTS	
<b>GAS CONVERSION (GD)</b>	Diesel engine conversion to natural gas operation. Benefits include high efficiency and very low emissions. Diesel operation still possible with unchanged performance.
<b>GAS CONVERSION (SG)</b>	Conversion of Wärtsilä VASA 32 and 32LN to Wärtsilä 34SG specification makes it possible to utilize the benefits of low-pressure natural gas. The converted engine offers the same benefits as the factory made Wärtsilä 34SG: high efficiency, low NO <sub>x</sub> emissions, lean-burn, state-of-the-art design.
<b>DUAL-FUEL CONVERSION (DF)</b>	Conversion to dual-fuel operation makes it possible to utilize the benefits of natural gas with only 1% LFO pilot fuel (for Wärtsilä 25 5% LFO pilot fuel).
<b>FUEL CONVERSION</b>	Many of the diesel engines can run on both LFO and HFO. If you only use one type of fuel, we are able to re-engineer your installation so that it can run on either or both of them for financial reasons (HFO) or environmental requirements (LFO).

Fig. 13. Gas & Fuel conversions /13/

The effect of these modifications is that the product extension changes for the engines. The short reference type and the product extension are what identify the engine type in the PIR system. These two are combined into the product reference type according to the following formula:

**Short reference type + Extension = Product reference type**

Example:

**W34 + SG = W34SG**

If the engine in the example above were converted to use Dual-Fuel technology instead of the Spark ignited Gas technology (SG), the product reference type would change from W34SG to W34DF. This means that when the product reference type is changed the product lists could also be affected, since bulletins are made on product reference type level:

- More Service Bulletins linked to the engine with CMA
- Some engine bulletins might become obsolete.

The newly added records are okay but the existing product list for the engine should be checked to clarify whether or not the engine should be on the product list for all those bulletins.

## 4.6 Summary of the analysis

The conclusion of the analysis and the new models created indicates that the replication process has been improved:

- Existing records are not deleted and recreated, which means that the time stamp is not lost.
- New products are automatically added.
- Only engines with the status “In operation” are added.

The archiving tool is also a nice way to move records which should not be on the product list anymore. However, some problems can occur when archiving data as described in cases 4 to 6. It would also be hard to make the system deal with these cases automatically, since it really depends on the case whether or not the relevant records should be kept in the archive or not. However, reports can be run to get the listed cases from the system. These must then be analysed manually and it has to be decided case by case what should be done.

Another approach to ensure that the product lists are okay for bulletins with a manually made product list could be to check and update the product list for important bulletins at regular intervals. In other words, to update the product lists on the Service Bulletin level instead of updating them engine by engine.

## 5 RESULT AND DISCUSSION

### 5.1 Result

The result of my thesis is a new replication model which I have made using Microsoft Access and VBA (Visual Basic for Application) code. This new model handles the replication of data from PIR\_MASTER to PIR\_WFI. The model has been working as intended and has solved the issues of the earlier replication process.

The archiving tool which I have also made is working well. However, some issues have been noticed due to the cases discussed in the last chapter. But these cases are not that common and not that critical.

### 5.2 Further development

The table below lists the development phases of the replication process including some highlights of the past situation, the current situation and also the planned future development. The listed future development areas are briefly discussed in this chapter.

*Table 4. Highlights of the development phases in the replication process*

Area	Past	Current	Future
CMA to PIR_MASTER			Engine extension field
PIR_MASTER to PIR_WFI	No check on operating status	Filters on operating status	New engine checks
Manual Input	Import engine list	Option to delete existing record before importing	Archive obsolete records when importing

In addition to these development areas, the main future improvement is to implement the new replication model as part of the Microsoft SQL Server that is running the PIR system. The replication and archiving model should be implemented as a scheduled run process which could be run on a daily basis.

### 5.2.1 CMA to PIR\_MASTER

When CMA creates the engine list for PIR\_MASTER based on material numbers or spare part numbers that are in use on engines, it uses a system called Code Resolution (CR). In this system differences exist in the engine's extension field, i.e. the extension field in CR can differ from the extension fields in other engine databases.

These differences can result in engines missing from the engine lists that are made with CMA rules where material or spare part numbers are used. This is something that should be fixed in the process when CMA creates the engine lists. A solution could be that CMA should ignore the extension fields when combining the CR data with the engine data when the engine lists are created.

### 5.2.2 PIR\_MASTER to PIR\_WFI

As a further development of the data replication some additional checks could be implemented:

- If a new engine which does not already exist in PIR\_WFI is replicated from PIR\_MASTER, it should be checked if this engine has any records in the archive. If there are records in the archive, it indicates that an engine has changed status from "Not in operation" to "In operation". This event could be logged as an event which could be analysed to see if there are records which should be moved from the archive to PIR\_WFI.
- Records are archived due to the fact that an engine is not found in the system or is no longer linked to a valid installation. When this event occurs it should be logged so that the case can be analysed. This event could give indications of errors in related systems.
- Regular checks of records in PIR\_WFI should be carried out to see if there are differences in the engines' extension field or if the extension field is incorrect. These cases should be logged and they can indicate engine conversions which could be analysed to check if any actions are needed in the bulletins list of the engine in question. Incorrect extensions in PIR\_WFI could also be corrected.

### 5.2.3 Manual input

Currently the application for adding manually made product lists to PIR only has the option to add and delete records for a bulletin. This application should be modified so that when adding records to an existing bulletin, i.e. when updating the product list, it should archive the records not listed in the new product list. In other words, obsolete records should be archived and only the records the user is listing should be available for the bulletin. In this way the products that have been on the product list can be traced and user errors leading to invalid records left in the system are minimized.

The flowchart below is updated with the planned future development of the replication process.

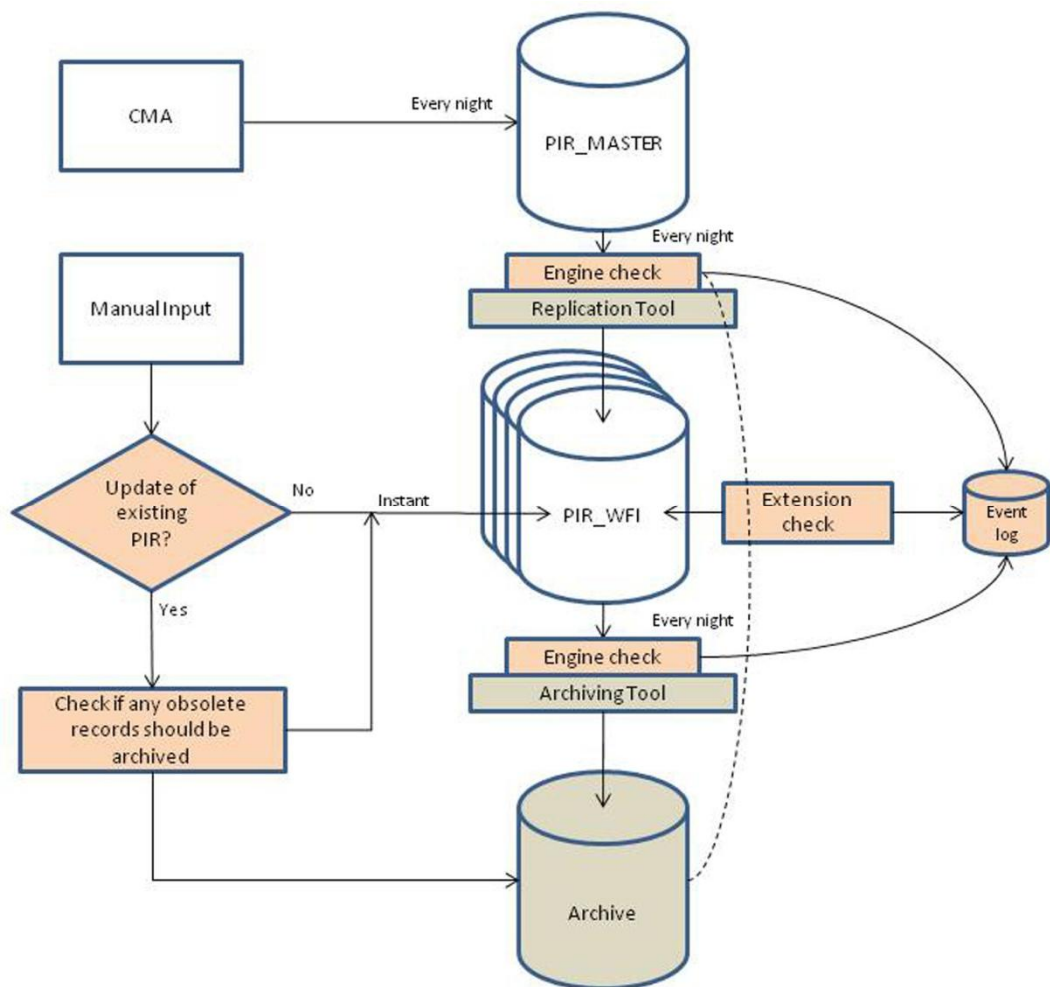


Fig. 14. Flowchart for future development of the replication process

### **5.3 Discussion**

This project has been both fun and instructive. I have learned a lot about how the whole data replication process is working in the system. I have learned not only how the systems which are directly discussed in this thesis are working, but also other systems which are connected to the PIR system but are outside the scope of the thesis.

I have also gained a lot of knowledge about how to use Microsoft Access since I was not that experienced with Microsoft Access before I started on this project. I also learned how to program in VBA since some of the tools needed some extra data processing, which was not possible to do with Microsoft Access queries and macros.

Finally I noticed that data quality issues in different data systems made the project more challenging.



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