# The

# MAINTENANCE MANAGER

# User Manual for the Demonstration Version

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#### Acknowledgement

This report is part of the project entitled "*Development of a Maintenance Information System for Wind Turbines*" which has been carried out in co-operation with Baas & Roost Maintenance Consult BV. This User Manual belongs to the CD-ROM with the demonstration version of the Maintenance Manager

The development of the demonstration version was partly financed by NOVEM, partly by ECN and partly by Baas & Roost Maintenance Consult BV. .

ECN project number	: 7.4087 and 7.4117
Novem contract number	: 224.321-9957

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# 1. INTRODUCTION

#### 1.1 About the Demonstration Version

ECN and Baas & Roost Maintenance Consult (B&R) have made a demonstration version of the Maintenance Manager. The purpose of this demonstration version is to offer possible users of the Maintenance Manager (among others: wind turbine manufacturers, service departments, operators, and technical managers of wind farms) the opportunity to familiarise with the system.

The demonstration version is the result of a project entitled "Development of a Maintenance Information System for Wind Turbines". The project was carried out between October 1999 and November 2000 by ECN, B&R and Lagerwey the WindMaster. A major part of the work was sponsored by the Dutch Organisation for Energy and Environment (Novem) in the Netherlands. Apart from this demonstration version, the reports [17], [18], (both in Dutch) and [19] have been published within this project. When working with the demonstration version, please note the following.

- The demonstration version of the Maintenance Manager reflects the status of the program of November 2000. The development of the program is still ongoing and many improvements have already been made. ECN, B&R and Lagerwey the WindMaster are now carrying out a second project that will run until November 2002. In this project, the system is going to be implemented at the service department of Lagerwey the WindMaster. ECN and B&R are using the operating experience of Lagerwey to improve the Maintenance Manager. Furthermore, ECN and B&R are building synchronisation routines to automate data transfer from the central version of the Maintenance Manager to the regional version and to the local version; and for data transfer in the opposite direction.
- The demonstration version is not completely free of errors and bugs. At present, many problems have already been solved. Some problems you have to be aware of when working with the demonstration version are:
  - The print options and the options to export the data in the "Definition Module" do not function. These options in the analysis module however do function. This problem is already solved in the present developments
  - Some of the text is in English and some in Dutch since the original version of the Maintenance Manager has been developed in Dutch. In the final version, the language can be adjusted to the requirements of the customers. The default language will be English.
  - The lay out of some screens and the working of some input fields have to be improved. This is being done in the current project, based on specific requirements of the users. The lay-out and the input modules will become more user friendly in the final version.
  - The list with possible analysis options is only a first guess of ECN and B&R and is definitely not complete. Based on the requirements of the users and based on the feedback that ECN and B&R may obtain from experiences with the demonstration version, the list can either be extended or adjusted to the needs of a specific customer.
  - It is not possible to make adjustments in the list with consumables. The list with consumables (and also the spare parts lists) is so client specific that ECN and B&R have decided not to implement it in the demonstration version. In the final version, the list with consumables and spare parts will be provided in an Excel format that can be put into the Maintenance Manager.

- The selection of parks and turbines in the "Analysis Module" sometimes seems not to work properly. However, the final analyses results are correct.
- The modules for maintenance planning and scheduling which is especially of great interest for operators do function but is in fact not appropriate for the specific wind turbine needs. In the currently ongoing project, this part of the program is going to be improved. It is recommended not to use these modules. Moreover, most of the language is still Dutch.

In the demonstration version, ECN has defined some fictive turbines, parks, and failure data. This gives you the opportunity to start immediately with the data logging module and the data analysis module. These are the two modules that will be used most frequently in daily practice by maintenance technicians, operators, R&D departments, and the managers. The definition module will be used only now and than by very few users, e.g. to adjust the FMEA data.

## 1.2 About the Manual

The user manual contains the following:

- A description of the turbines and parks in the demonstration version.
- Some hints to get started
- An explanation of the data logging module.
- An explanation of the analysis module.
- An explanation of the definition module.

ECN and B&R wish you success with the demonstration version of the Maintenance Manager.

If you have any comments or suggestions, or you wish to have more information, don't hesitate to contact:

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# 2. CASE STUDY

ECN has filled in already some fictive turbines, parks and failure data in the Maintenance Manager. In this chapter, the case studies are presented.

A manufacturer sells three types of turbines:

- 1. 750 kW turbine, IEC class 2
- 2. 1000 kW turbine, IEC class 1, direct drive
- 3. 1000 kW turbine, IEC class 2, direct drive

The turbines designed for IEC class 1 differ from those for IEC class 2 that they have a larger rotor diameter and a somewhat higher hub height.

To keep the case studies simple, each turbine consists of only three building blocks:

- 1. Rotor
- 2. Nacelle
- 3. Tower

The typical structural breakdown of the 1000 kW class II turbine is given below.

Turbine type	Building Blocks	Components	Tag nr.	Component ID	Specification
1000 kW-II	Rotor	Blade 1 Blade 2 Blade 3	BL1 BL2 BL3	BL28 BL28 BL28	28 m 28 m 28 m
		Pitch motor 1 Pitch motor 2 Pitch motor 3	M1.1 M1.2 M1.3	PM1000_B PM1000_B PM1000_B	M-10 M-10 M-10
		Pitching gearb 1 Pitching gearb 2 Pitching gearb 3	G2.1 G2.2 G2.3	PG1000 PG1000 PG1000	PG-10 PG-10 PG-10
		Pitch bearing 1 Pitch bearing 2 Pitch bearing 3	B1.1 B1.2 B1.3	PB PB PB	PB-10 PB-10 PB-10
	Nacelle	Generator Pitch relay Yaw relay PLC Yaw brake Yaw motor	GEN K1 K2 PLC YB1 M2.1	GN1000 RE RE PLC YB YM	Direct drive
	Tower	Cylindrical part Top flange	TW TF	CYL70 TF	H = 70 m D = 3 m

The three types of turbines have been sold to two regions (WS North and WS South) between 1990 and 1996.

WS North consists of only one park

• Park North Trend, 4 turbines 750 kW-II

WS South consists of four parks

- Park South Supplier 8 turbines 1000 kW-I
- Park South Single 1 1 turbine 750 kW-II
- Park South Single 2 1 turbine 1000kW-II
- Park South Start Date 6 turbines 750 kW-II

The turbines are being maintained by the two maintenance departments, one for each region.

O&M data has been filled in only for the parks "Park North Trend" and "Park South Supplier".

# 3. GETTING STARTED

# 3.1 Start-up

Password:

demo1

🚮 Raamwerk Demo		
		-
	R Welcome screen	
	User code: DEMO	
	Password: Reason	
	QK Cancel	
User code:	DEMO	

After entering the user code and the password the following screen will show up. Furthermore, you will find "Raamwerk Demo" and "OnderhoudsManager Demo" your task bar.



The button "properties" will be used most frequently. By clicking this button you are able to perform the following:

"LOG ECN"

- Definition of a wind turbine "definition WT"
  Performance of an FMECA "FMECA"
- Reporting failures and O&M data
  - Analysing failures and O&M data "Analysis"

Furthermore, you will find the options for *maintenance scheduling* and *maintenance planning*. Presently they are being revised to meet the of wind turbine applications. They will not be discussed in this manual furthermore.

The buttons "edit", "reports", "special" and "help" are not relevant for the demonstration version and are not being discussed here.

If you open the window "Raamwerk Demo" in the task bar you are able to modify the reference tables and financial tables under the button "Administration". The reference tables contain information about e.g. manufacturers, regions, kind of employee (with costs), or root causes. The figure below shows the root causes. <u>Note that the program should be re-started after the reference tables are modified!</u> Otherwise the program continuous to work with the original reference tables. After modification of the financial tables, a restart is not required.

🚜 Raamwerk Demo			
Administration Reports Applica	ation <u>S</u> pecial <u>H</u> elp		
🙀 Referentietabellen			
	0.1.1		
Program: j	Undernoudsmanager		
Tables: M	faintenance		
Kind of employee	Description	Active	<b>_</b>
MTTF	Lightning (E)	1	
MTTr	Storm, Severe wind (E)	1	ا بيم
Main Libraries	Debris (E)	1	<u>800</u>
Maintenance strategy	Incorrect assembly (H)	1	<u>C</u> hange
Manufacturer	Incorrect repair (H)	1	Delete
Material	Wear, Ageing	1	Delete
Medium	Overload (I)	1	
Uperator			
Uther Losts			
Dwner L			
Prioritu			
Productiederwingskosten			
Project libraries			Afdrukken
Bandyoorw (Conditions)			
Region			Atdrukken alle
Root cause			
Routescheme's			
Security			
Selection classifs (new)			
Service centre			<b>—</b>
Shift 💌			Close

# 4. LOGGING FAILURE AND MAINTENANCE DATA

#### 4.1 Screens and Buttons

To record the failure and maintenance data select "LOG-ECN" from "Properties". The screen looks as follows.

📆 OnderhoudsManager Demo	_ 🗆 ×
<u>Properties</u> <u>Edit</u> <u>Reports</u> <u>Special</u> <u>H</u> elp	
🕂 Log -RCM - DEMO GEBRUIKER / ECN-test-1	
Log       Failure data       Specifications       Reports         Event       Registr. nr.:       Registr. nr.:         Time:       · · · · : :       Melder:       Image: Specification in the specification in th	
Wind Turbine: Type:	ICN
Alarmnr. Energy prod. 0	<u>P</u> rint
Failure: Solution:	Duplicate
Priority: <geen> Discipline: <geen></geen></geen>	<u>Change</u>
Status: Description Date / time	
Action: Description Date / time	<u> </u>
	Close

For the demonstration version, only the tabs "Log", "Failure data" and "Specifications" will be used. (The tab "Reports" was originally used to perform various analyses. In the current demonstration version for wind energy, the analyses can be best performed with the option "Analysis" under "Properties"! In the final version, the tab Reports will be used to generate standard reports.)

As soon as the failure is being noticed by either the operator, the service company, or a technician, he can fill in the administrative data in the tab "Log". The person who restores the failure has to fill in the tab "Failure Data" and the tab "Specifications". In the tab "Failure Data" background on the failed component can be reported. In "Specifications", the costs (labour, consumables, parts, and others) can be reported. First the subsequent tab's will be explained. In Section 4.2, it will be illustrated how a failure should be reported.

#### 4.1.1 Tab "Log"

The tab Log is being used to report the administrative information as soon as a failure is noticed by an operator, a service centre, or a maintenance technician. Th fields have the following meaning:

- Time: date and time the failure is recorded (default: present time)
- Melder: Name of person who reports the failure (default: login name)

Registr. Nr. Unique code (default: code starts with abbreviation of login name)

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Wind Turbine:	Identification of failed turbine (combo box)
Туре:	Type of event during which the failure is detected (combo box)
Alarmnr:	If a failure is detected by an alarm, the alarm code should be filled in
Energy prod:	The number of kWh's produced by the turbine at the moment of recording

All other fields are not relevant and obligatory for the demonstration version. However, some of them will be discussed here. Later on, some of these fields will be used to plan the pending actions.

Failure:	Free format to report some background information for the technician (default value of filed "type")
Solution:	Free format to give some background information on how the failure is repaired.
Priority:	Combo box to select if a failure has a high or low priority.
Discipline:	Combo box to select the required type of technician or external assistance.
Status:	Combo box to report if a failure is pending, solved, etc.
Action:	Free format to report any other action to solve the problem.

#### 4.1.2 Tab "Failure Data"

The tab "Failure Data" is being used to report the background information on the failure in a structured manner that is suited for automated analysis afterwards.

🛞 OnderhoudsManager Demo	_ 🗆 ×
Properties Edit Reports Special Help	
K Log -RCM - DEMO GEBRUIKER / ECN-test-1	
Log Failure data Specifications Beports	
Alarmnr.	RCN
Stand still: 🕞 : : (dd-mm-yyyy hh:mm) follow-up melding 🗖	
Start repair: 💽 💼 (dd-mm-yyyy hh:mm)	Erint
Restart:	Duplicate
FMECA Properties	
Failure mode:	Cancel
Failure cause:	Delete
Root Cause: <unknown></unknown>	
	<b>—</b>
Work done Reset	Find
	Close

Alarm nr. If an alarm code is already filled in in tab "Log" the alarm code will be generated automatically in this field.

Component: Combo box to select the failed component

Stand still: Date and time of shut down

Start repair: Date and time at which the technician starts with repair (or failure investigation).

Restart Date and time at which the turbine is started again.

These three fields are necessary for the downtime analysis.

- Failure mode (and cause): By clicking on the button, the FMECA data of the failed component shows up. By double clicking on the appropriate failure mode and cause, the field is filled in.
- Root Cause: Combo box with the most likely root causes of the failure mode

Comments FMECA Data Free format for background information

Work done Combo box with four most commonly used types of work to restore the failure.

#### 4.1.3 Tab "Specifications"

The tab "Specifications" is meant to add the costs to the failure.

ConderhoudsMar	nager Demo				
Log -RCM - DE	MO GEBRUIKER /	ECN-test-1			
Log Eailure data	<u>Specifications</u>	eports			
Wages:	Kind employee	Hourly wage:	Duration [hr.]:	Costs: 🔺	
				Ţ	ECN
			Total wages:	0.00	Print
Consumables:	Article:	Price:	Amount	Costs: 📥	Prove Prove to
					Dupicate
				7	Add
		Tot	al costs consumables:	0.00	<u>C</u> hange
Parts:	Name:	Price:	Amount:	Costs: 📥	<u>D</u> elete
				<u> </u>	
			Total costs parts:	0.00	<u> </u>
Other:	Description:			Costs: 📥	<b>—</b>
				<b>v</b>	
			Total other costs:	0.00	Eind
			Total costs:	0.00	Close

It consists of four types of costs: Wages, Consumables, Parts, and Other costs. The fields can be filled in as follows.

- 1. Highlight the grey bar of the field by clicking on the mouse. The grey bar will turn black.
- 2. Click "Add"
- 3. Click on the left column and a pull down menu will show up with the various choices. Costs are linked to the various articles, employees, etc.



- 4. Fill in the Duration (or: Amount in case of the other fields) and the program will calculate the costs.
- 5. Click "Save" to save the costs.
- 6. All costs should be filled in in the same manner and one by one!

If the tables with employees and costs have to be changed, act as follows:

- 1. Go to reference table "Kind of employee" (window "Raamwerk" in the task bar!) and add, change, or delete the desired types of employees involved. Exit and restart the program.
- 2. Go to the "Financial tables" (window "Raamwerk" in the task bar, select "Financial tables" under "Administration").

Administration Reports Application Special Help	
🔀 Financial tables	
Wages Productiedervingskosten Other costs Currency	
Sort employee: Sr Techn working hours Sr Techn working hours Jr. Techn. travel hours From Untidr. Techn. working hours r hour	ECN Afdrukken
01-01-2000 01-(Sr. Techn. travelhours 80.00	
	Add
	<u>C</u> hange
	<u>D</u> elete
	-
From: 01-01-2000 Untill: 01-01-2010 Costs per hour: 80.00 ==	<b>Z</b>

- 3. Select the appropriate type of employee, click "Change", "Add" or "Delete" and adjust the
  - time period (field "From" and "Until")
  - "Costs per hour"
  - at the bottom of the sreen. Return to the screen "OnderhoudsManager".

The same procedure should be followed to adjust the "Other costs". (Change the type of "Other costs" in the reference tables and the costs per item in the financial tables.)

<u>Note</u>: The information behind the pull down menus "Parts" and "Consumables" cannot be changed in the demonstration version. In the final version, parts lists and lists with consumables can be put in the Maintenance Mangers in an Excel format, including internally used codes and prices.

#### 4.2 Alarm with Reset

Alarms that can be reset remotely occur very frequently. The related costs are the revenue losses and the costs of the help desk employee. Here an example is how such an event should be recorded.

1. Select the wind park in which the faulted turbine is located under "Edit". In this case "Park South Supplier" in the field "Actual Wind Park". Ignore the two selection windows and click "OK".

🙀 OnderhoudsManager Demo	<b>_</b> 🗆 🗵
<u>Properties Edit Reports Special Help</u>	
A Select Wind Park - DEMO GEBRUIKER	X
Actual Wind Park	
Park South Supplier         Contest-1         CON-test-1         Park North Trend Residence South Single 2         Park North Trend Residence South Single 2         Park North Trend Residence Park South         Park South Start DatrResidence Park South         Park South Single Residence Park South         Park South Star DatrResidence PS1         Park South Star Residence Pa         Park South Suppler Residence PS1         Park South Sup Residence Pa         Park South Sup Residence PS         Park South Sup Residence PS	
<u>D</u> K Cancel	

- 2. Select "LOG ECN" under "Properties" and click "Add"
- 3. Select the failed wind turbine in the field "Wind Turbine". (In this case S-Supplier-1000-I-002.)
- 4. Select the type of event. (In this case "Alarm with reset")
- 5. Fill in the alarm code or number. (In this case "12")

🚮 OnderhoudsMa	nager Demo	
<u>Properties</u> <u>E</u> dit <u>R</u>	eports <u>S</u> pecial <u>H</u> elp	
🛃 Log -RCM - DI	MO GEBRUIKER / Park South Supplier	
Log Eailure dat	a <u>Specifications</u> <u>R</u> eports	
	Event Registr. nr.:	
Time:	23-05-2001 10:01 Melder: Demogebruiker 💌 DEM0318	50,000
Wind Turbine:	S-Supplier-1000-I-I - Type: Alarm with reset	<u> </u>
Alarmnr.	Energy prod. Alarm with failure	<u>Print</u>
Failure:	Alarm with reset Failure	lunlicate
Solution:	Modification Preventive maintenance	, sipine and
		Save
Priority:	<pre><geen></geen></pre>	Cancel
	Actual information of this event	Delete
Status:	Description Date / time	
Antion	Description Data Ution	
Action.		
	<b></b>	Eind
		Close

All the other fields are not mandatory. As can be seen, the "Melder" and "Registr. Nr." and "Time" are generated automatically.

6. Select tab "Failure Data". As can be seen, you do not have to fill in any details about a component. The alarm nr. is copied from the tab "Log"

🙀 OnderhoudsManager Demo	
Properties Edit Reports Special Help	
K Log -RCM - DEMO GEBRUIKER / Park South Supplier	_ 🗆 🛛
Log Eailure data Specifications Beports Alarm with reset	
Alarmnr. 12 Alarm	ECN
Stand still: 20-05-2001 13:00 (dd-mm-yyyy hh:mm) follow-up melding	Erint
Restart: 20-05-2001 17:00 (dd-mm-yyyy hh:mm)	Duplicate
FMECA Properties	Save
	Cancel
<ul> <li>(unknown)</li> </ul>	Delete
Cunknown>	
Incorrect assembly (H)	
Incorrect repair (H)	<b>—</b>
Lightning (E.)	<b>_</b>
Storm, Severe wind (E)	
Work done Reset	Ema
	Close

- 7. Fill in the data for the down time analyses. The fields to be filled in for the FMECA properties depends on the "Failure type". In case of "alarm with reset", no additional information is required. The type of work is in this case default "Reset" but can be adjusted if necessary.
- 8. Click "Save" and select tab "Specifications". Please note that there is only one type of costs to be filled in: "Wages".

🔀 OnderhoudsManager Demo	_ 🗆 🗵
Properties Edit Reports Special Help	
McLog -RCM - DEMO GEBRUIKER / Park South Supplier	
Log       Failure data       Specifications       Reports         Wages:       Kind employee       Hourly wage       Duration [hr.]:       Costs:         St Techn working hours       30.00       0.00       0.00         Jr. Techn. travel hours       Jr. Techn. travelhours       Total wages:       0.00         St. Techn. travelhours       Help desk employee       Help desk employee	ECN Print Duplicate Save Cancel Delete Cancel Delete Cancel C
Total costs: 0.00	Eind Close

9. Select the help desk employee and fill in the number of hours. (If the help desk employee is not present in the selection options, try to add the employee in the reference tables and in the financial tables. Don't forget to restart the program after modification of the reference table(s). The procedure is described in Section 4.1.3). Click "Save"

#### 4.3 Alarm with Failure

In this case, an alarm is generated by the turbine. The Help desk employee (logged in as DEMO) reports the failure to the Sr technician who has to travel 2 hours and carry out the repair for 3 hours. (The Sr technician is logged in as ECN).

1. Select the wind park and turbine as demonstrated in Section 4.2, step 1, 2, 3, and 4 and select event "Failure with alarm". Fill in alarm nr. 13.

<mark> Onderhouds</mark> Ma	nager Demo	
Properties Edit H	eports Special Help	
Log Eailure dat	a <u>Specifications</u> <u>R</u> eports	
	Event	
Time:	Registr. nr.: 23-05-2001 11:36 Melder: Demogebruiker ▼ DEM0319	
Wind Turbine:	S-Supplier-1000-I-I  Type: Alarm with failure	ECN
Alarmnr.	13 Energy prod. 0	Erint
Failure:	Alarm with failure	- Prove Prove to
Solution:		Duplicate
		Save
Prioritu		Cancel
	Actual information of this event	Delete
Status:	Description Date / time	
		<b></b>
Action		
Action:		
		Find
		Close

It appears that the help desk employee is not able to reset the turbine. He informs the Sr. Technician and gives him the alarm nr. (13) and the Registr. nr. (DEMO319). He saves the data and fills in the time he spent in tab "Specifications".

The Sr. Technician carries out the repair and fills in the tab "Log" identical to the help desk employee. He has to change the registration number manually.

2. Select tab "Failure data" and fill in the data (In this case a failed pitch motor).

🚮 OnderhoudsManager Demo	
Properties Edit Reports Special Help	
🔀 Log -RCM - DEMO GEBRUIKER / Park South Supplie	er 📃 🖂 🗡
Log Eailure data Specifications Reports Alarm with failure	
Alarmnr. 13 Alarm Componen	
Stand still:         21-05-2001 13:00         (dd-mm-yyyy hh: Start repair:         21-05-2001 15:00         (dd-mm-yyyy hh:	mm) follow-up melding <b>F</b>
Restart: 21-05-2001 18:00 (dd-mm-yyyy hh:r	mm) Duplicate
FMECA P	lata component Pitch motor 2 M1.2 📃 🖾 🗧
Failure mode: fails to run at rated speed Failure mode	de Failure cause 🦰 –
Failure cause: control error failure cause:	at rated control error
Root Cause: Wear, Ageing fails to run	mechancal failure
Moisture detected in the p	motor burned
	loose contact
Work done Repair \ Cleaning	Find
	Close

3. Click "Save" and select tab "Specifications". Fill in the appropriate data and close the window.

🚮 OnderhoudsMar	nager Demo				
<u>P</u> roperties <u>E</u> dit <u>R</u> eports <u>S</u> pecial <u>H</u> elp					
🚮 Log -RCM - DE	MO GEBRUIKER 7	Park South St	upplier		
Log Failure data	<u>Specifications</u>	ports			1-
Wages:	Kind employee	Hourly wage:	Duration [hr.]:	Costs: 📥	
	Sr. Techn. travelhours	80.00	2.00	160.00	50 000
	Sr Techn working hou	80.00	3.00	240.00 💌	ECR
			Total wages	: 400.00	<u>P</u> rint
Consumables:	Article:	Price:	Amount:	Costs: 🔺	
	Cable 4x2.5mm	72.50	1	72.50	Duplicate
				<b>•</b>	Add
		To	tal costs consumable:	s: 72.50	Change
Parts:	Name:	Price:	Amount	Costs: 📥	Delete
				$\mathbf{\nabla}$	
			Total costs parts:	: 0.00	
Other:	Description:			Costs: 📥	<b>•</b>
					<b>_</b>
				<b>V</b>	
			Total other costs:	: 0.00	Eind
			Total costs:	: 472.50	Close

# 5. DATA ANALYSIS

#### 5.1 General

The operation of the analysis module can be best demonstrated by means of the case studies. ECN has filled the demonstration version already with some fictive O&M data. ECN did not fill in data for all parks so sometimes you will find zero maintenance actions or downtimes which is correct. The same holds for the maintenance costs. Only in some cases the maintenance costs have been filled in. The data will be analysed from different persons with different point of views.

Please feel free to try all the other options too but take into account that no failure data is recorded for some turbines.

#### 5.2 Management of Turbine Manufacturer

*Situation 1:* The management wants to compare the "O&M performances" of region WS North with that of WS South. for the WS 750 kW-II turbines (Note that no data is available in region WS South. You may fill in some data in the Log-module yourself for these turbines in 1998.)

- i The number of failures per region (per turbine)
- ii The downtimes (logistics and repair) per region

Carry out the following steps

- 1. Properties  $\rightarrow$  Analysis
- 2. Type of WT: "WS 750 kW-II"
- 3. Regions : All (= Workshop North, Workshop South)  $\rightarrow$  next

🚮 OnderhoudsManager	Demo		
Properties Edit Reports	<u>Special</u> <u>H</u> elp		
🚮 Analysis-tool			
Type of Wind Turbine WS 750 kW-II Other regions	Select a Grou	of Wind Turbines Selected regions Workshop North Vorkshop South	ECN
Other Wind Parks	Ă	Selected Wind Parks  Park North Trend Park South Single 1 Park South Single 2 Park South Start Date Park South Supplier	Uitvaer Acces
Other Wind Turbines		Selected Wind Turbines	
	×	▶         N1-750-II-001           ▶         N1-750-II-002           N1-750-II-003         N1-750-II           ▼         S-Single-1-750-II	Next Back



All available data in 01/01/1998 – 31/12/1998

# 5. Ranking $\rightarrow$ next

🙀 OnderhoudsHanager Demo	
<u>Properties</u> <u>Edit</u> <u>Reports</u> <u>Special</u> <u>Help</u>	
🚯 Analysis-tool	
Select the period and Type of analysis	
Select the period of analysis	
C All available failure data.	ecn
All failure data within this period:     From: 01/01/1998 Untill: 31/12/1998     (dd/mm/yyyy) (dd/mm/yyyy)	Export file
C All failure data between these working hours From: Untill: Untill:	Uitvoer Acces
Select the type of analysis           Image: The select the type of analysis           Image: The select the type of analysis	
C Statiscal analysis	
C Trend Analysis	Next
C Component data	<u>B</u> ack
	Close

6. Regio  $\rightarrow$  next

🙀 OnderhoudsManager Demo	
Properties Edit Reports Special Help	
🙀 Analysis-tool	
Select level for Ranking	
Level for ranking	
Regio	IF CON
C Windpark	16010
C Windturbine	
C Building block	
C Group of components	Export file
	Liitvoer Acces
	01/06/20066
O Des ara para huidinableate	
Cher Britishe Ricela	
Uner building blocks Selected Building Blocks	
Rator A	
Tower	
	Next
	Back
	Close

#### 7. i Number of maintenance actions







#### 9. ii $\rightarrow$ back, downtime $\rightarrow$ next





## 5.3 Service Manager of a Region

*Situation 2:* The region manager of WS South wants the O&M performance of the first two operational tears of the WS 1000 kW class I turbine.

- i Number of failures per turbine
- ii Downtime per turbines
- iii Maintenance costs per turbine
- 1. Properties  $\rightarrow$  Analysis
- 2. Type of WT: WS 1000 kW-I
- 3. Regions : Workshop South
- 4. Wind Parks : Park South Supplier
- 5. WT : All  $\rightarrow$  next
- 6. All data between 0 en 17500 working hours
- 7. Ranking  $\rightarrow$  next
- 8. Windturbine  $\rightarrow$  next
- 9. i Number of maintenance actions  $\rightarrow$  next
- 10. ii  $\rightarrow$  back, downtime $\rightarrow$  next
- 11. iii  $\rightarrow$  back, maintenance costs
- 12. You may try the other options too!
- 13. Close

*Situation 3:* The manager of region WS South also wants to know how often "lightning" is the root cause for events in "Park South Supplier"

- 1. Properties  $\rightarrow$  Analysis
- 2. Type of WT: WS 1000 kW-I
- 3. Regions : Workshop South
- 4. Wind Parks : Park South Supplier
- 5. WT : All  $\rightarrow$  next
- 6. All available data
- 7. Component data  $\rightarrow$  next
- 8. Componets : all
- 9. Root cause number of occurances  $\rightarrow$  next
- 10. Close

Situation 4: The manager of region WS South wants to identify the most vulnerable

- i building blocks
- ii components
- in "Park South Supplier"

1.	Properties $\rightarrow$ Analysis
1.	rioperties / marysis

- 2. Type of WT: WS 1000 kW-I
- 3. Regions : Workshop South
- 4. Wind Parks : Park South Supplier
- 5. WT : All  $\rightarrow$  next
- 6. All available data
- 7. Ranking  $\rightarrow$  next
- 8. i Building block  $\rightarrow$  next
- 9. Number of maintenance action  $\rightarrow$  next
- 10. Back→downtime→next
- 11. ii  $\rightarrow$  back  $\rightarrow$  back group of components
- 12.  $all \rightarrow next$
- 13. Number of maintenance action  $\rightarrow$  next
- 14. Back→downtime→next
- 15. Close

*Situation 5:* The manager of region South wants detailed information about the pitch motors in "Park South Supplier"

- i failure modes
- ii failure causes
- iii suppliers
- 1. Properties  $\rightarrow$  Analysis
- 2. Type of WT: WS 1000 kW-I
- 3. Regions : Workshop South
- 4. Wind Parks : Park South Supplier
- 5. WT : All  $\rightarrow$  next

6.	All available data
7.	Component data→ next
8.	Componnets : Pitch motor 1, 2, 3
9.	Failure mode – number of occurances $\rightarrow$ next
10.	$\rightarrow$ back, Failure cause – number of occurances $\rightarrow$ next
11.	$\rightarrow$ back, supplier – fraction of maintenace actions $\rightarrow$ next
12.	Close

#### 5.4 R&D Department of Manufacturer

The R&D department wants to know the MTTF (Mean Time To Failure) for a yaw brake of a 750 kW class II turbine. Note that the MTTF data is only relevant for estimating the failure rate of new designs if it is constant over the time. This means that first a trend analysis should be performed.

- 1. Properties  $\rightarrow$  Analysis
- 2. Type of WT: WS 750 kW-II
- 3. Regions : Workshop North
- 4. Wind Parks : Park North Trend
- 5. WT : All  $\rightarrow$  next
- 6. i All available data
- 7. Trend analyse  $\rightarrow$  next
- 8. components: yaw brake  $\rightarrow$  next



(Note that the curve of the failure intensity is constant in between say 14.000 and 66.000 hrs. of operation, which corresponds to approximately 1,6 and 7,5 years.

- 9. ii  $\rightarrow$ back,  $\rightarrow$ back,
- 10. all availbale data between 12000 and 87000

11. statistical analysis  $\rightarrow$  next

#### 12. components, yaw brake $\rightarrow$ next

Properties Edit Beports Special Help         Calculation results statistical analysis         General data:         Period between 1-1-80 and: 23-5-01         Selected type of Windturbine. WS 750 kW4         Total Population: 12         Total Number of failures: 0         Number of censured values: 4         Percent of total: 33         Censured values included:         Censured values included:         MTTF 18535         Standard deviation (N-1) 166         Export file         Uitvoer Acces         Standard deviation (N-1) 15826303         Variance (N-1) 1125826303         Variance (N-1) 143572918         Selected Wind Turbines         Selected Wind Turbines         Selected Wind Turbines         N1-750-II-001         N1-750-II-003         N1-750-II-004	🚯 OnderhoudsManager Demo		_ <b>_</b> ×
Calculation results statistical analysis         General data:       Mean time to repair:         Period between 1-1-80 and: 23-5-01       Standard deviation (N) 8         Selected type of Windturbine. WS 750 kW4       MTTR 8.333         Total Population: 12       Standard deviation (N-1) 8         Total Number of failures: 0       Variance (N) 61         Number of censured values: 4       Variance (N-1) 66         Percent of total: 33       Censured values not included:         Censured values included:       Censured values not included:         MTTF 18535       Standard deviation (N) 11208         Standard deviation (N-1) 16617       Variance (N) 125626303         Variance (N-1) 276115410       Variance (N-1) 143572918         Selected Wind Turbines       Selected Components         N1-750-II-001       Yaw brake         N1-750-II-003       Yaw brake	<u>Properties Edit Reports Special Help</u>		
Calculation results statistical analysis         General data:       Mean time to repair:         Period between 1-1-80 and: 23-5-01       MEan time to repair:         Selected type of Windturbine. WS 750 kWil       MTTR 8.333         Standard deviation (N) 8       Standard deviation (N-1) 8         Total Number of failures: 0       Variance (N) 61         Number of censured values: 4       Variance (N-1) 66         Percent of total: 33       Censured values not included:         Censured values included:       Censured values not included:         MTTF 18535       Standard deviation (N) 11208         Standard deviation (N-1) 16617       Variance (N-1) 11982         Variance (N-1) 255105792       Variance (N-1) 125526303         Variance (N-1) 276115410       Variance (N-1) 143572918         Selected Wind Turbines       Selected Components         N1-750-II-001       Yaw brake         N1-750-II-003       Yaw brake	🙀 Analysis-tool		
General data:       Mean time to repair:         Period between 1-1-80 and: 23-5-01       MTTR 8.333         Selected type of Windtuctine. WS 750 kW-I       MTTR 8.333         Total Population: 12       Standard deviation (N) 8         Total Number of failures: 0       Variance (N) 61         Number of censured values: 4       Variance (N-1) 66         Percent of total: 33       Censured values not included:         Censured values included:       Censured values not included:         MTTF 18535       Standard deviation (N) 11208         Standard deviation (N-1) 16617       Variance (N) 125626303         Variance (N-1) 276115410       Variance (N-1) 143572918         Selected Wind Turbines       Selected Components         N1-750-II-001       Yaw brake         N1-750-II-003       Yaw brake	Calculation results	statistical analusis	
General data:       Mean time to repair:         Period between 1-1-80 and: 23-5-01       MITER 8.333         Selected type of Windturbine. WS 750 kW-I       Standard deviation (N) 8         Total Population: 12       Standard deviation (N-1) 8         Total Population: 12       Variance (N) 61         Number of calures: 0       Variance (N-1) 66         Number of calures: 12       Censured values: 14         Percent of total: 33       Censured values not included:         Censured values included:       Censured values not included:         MTTF 18535       Standard deviation (N) 115093         Standard deviation (N-1) 16617       Variance (N) 125626303         Variance (N-1) 276115410       Variance (N-1) 143572918         Selected Wind Turbines       Selected Components         N1-750-II-001       Yaw brake         N1-750-II-003       Yaw brake		,	
Period between 1-1-80       and: 23-5-01         Selected type of Windturbine.       WS 750 kW-l         Total Population:       12         Total Number of failures:       0         Number of censured values:       4         Percent of total:       33         Censured values included:       Censured values not included:         MTTF 18535       Standard deviation (N-1)         Standard deviation (N-1)       15863         Standard deviation (N-1)       15863         Standard deviation (N-1)       11208         Standard deviation (N-1)       11208         Standard deviation (N-1)       15626303         Variance (N-1)       125626303         Variance (N-1)       143572918         Selected Wind Turbines       Selected Components         N1-750-II-001       Yaw brake         N1-750-II-003       Yaw brake	General data:	Mean time to repair:	
Selected type of Windturbine.       WS 750 kW-l         Total Population:       12         Total Number of failures:       0         Number of censured values:       4         Percent of total:       33         Censured values included:       Censured values not included:         MTTF 18535       Standard deviation (N-1) 1108         Standard deviation (N) 15909       Standard deviation (N-1) 1108         Standard deviation (N-1) 16617       Variance (N) 125626303         Variance (N-1) 276115410       Variance (N-1) 143572918         Selected Wind Turbines       Selected Components         N1-750-II-001       Yaw brake         N1-750-II-004       Yaw brake	Period between 1-1-80 and: 23-5-01	MTTR 8.333	ECN
Total Population: 12       Standard deviation (N-1) 8         Total Number of failures: 0       Variance (N) 61         Number of censured values: 4       Variance (N-1) 66         Percent of total: 33       Censured values included:         Censured values included:       Censured values not included:         MTTF 18535       Standard deviation (N) 15909         Standard deviation (N-1) 16617       MTTF 15863         Variance (N) 253105732       Variance (N) 125626303         Variance (N-1) 276115410       Variance (N-1) 143572918         Selected Wind Turbines       Selected Components         N1-750-II-001       Yaw brake         N1-750-II-003       Yaw brake	Selected type of Windturbine. WS 750 kW-I	Standard deviation (N) 8	2921
Total Number of failures:       0       Variance (N) 61         Number of censured values:       4       Variance (N-1) 66         Percent of total:       33       Censured values included:       Export file         Censured values included:       Censured values not included:       Uitvoer Acces         MTTF 18535       Standard deviation (N) 15909       Standard deviation (N) 11008       Standard deviation (N) 11008         Standard deviation (N-1) 16617       Variance (N) 125626303       Variance (N) 125626303       Variance (N-1) 143572918         Variance (N-1) 276115410       Variance (N-1) 143572918       Variance (N-1) 143572918       Mext         Selected Wind Turbines       Selected Components       Mext       Back         N1-750-II-001       Variance       Yaw brake       Back	Total Population: 12	Standard deviation (N-1) 8	
Number of censured values: 4 Percent of total: 33       Variance (N-1) 66         Censured values included:       Censured values not included.:         MTTF 18535 Standard deviation (N) 15909 Standard deviation (N-1) 16617 Variance (N) 253105792 Variance (N-1) 276115410       MTTF 15863 Standard deviation (N) 11208 Standard deviation (N-1) 11982 Variance (N-1) 276115410         Selected Wind Turbines       Selected Components         N1-750-II-001 N1-750-II-002 N1-750-II-004       Yaw brake	Total Number of failures: 0	Variance (N) 61	
Percent of total:       33         Censured values included:       Censured values not included.:         MTTF 18535       MTTF 15863         Standard deviation (N) 15909       Standard deviation (N) 11208         Standard deviation (N-1) 16617       Variance (N) 253105792         Variance (N-1) 276115410       Variance (N-1) 125626303         Variance (N-1) 276115410       Variance (N-1) 143572918         Selected Wind Turbines       Selected Components         N1-750-II-001       Yaw brake         N1-750-II-003       Yaw brake	Number of censured values: 4	Variance (N-1) 66	Europt Blo
Censured values included:       Censured values not included.:       Uitvoer Acces         MTTF 18535       MTTF 15863         Standard deviation (N) 15909       Standard deviation (N) 11208         Standard deviation (N-1) 16617       Standard deviation (N-1) 11982         Variance (N) 253105792       Variance (N) 125626303         Variance (N-1) 276115410       Variance (N-1) 143572918         Selected Wind Turbines       Selected Components         N1-750-II-001       Yaw brake         N1-750-II-003       Yaw brake	Percent of total: 33		
MTTF         18535         MTTF         15863           Standard deviation (N)         15909         Standard deviation (N)         11208           Standard deviation (N-1)         16617         Standard deviation (N-1)         11982           Variance (N)         253105792         Variance (N)         125626303           Variance (N-1)         276115410         Variance (N-1)         143572918           Selected Wind Turbines           Selected Components           N1-750-II-001         Yaw brake         Back           N1-750-II-003         Yaw brake         Back	Censured values included:	Censured values not included.:	Uitvoer Acces
Standard deviation (N)         15909         Standard deviation (N)         11208           Standard deviation (N-1)         16617         Standard deviation (N-1)         11982           Variance (N)         253105792         Variance (N)         125626303           Variance (N-1)         276115410         Variance (N-1)         143572918           Selected Wind Turbines           Selected Wind Turbines         Selected Components         Mext           N1-750-II-001         Variance         Back	MTTF 18535	MTTF 15863	
Standard deviation (N-1) 16617         Standard deviation (N-1) 11982           Variance (N) 253105792         Variance (N) 125626303           Variance (N-1) 276115410         Variance (N-1) 143572918           Selected Wind Turbines         Selected Components           N1-750-II-001         Yaw brake           N1-750-II-003         Yaw brake	Standard deviation (N) 15909	Standard deviation (N) 11208	
Variance (N)         253105792         Variance (N)         125626303           Variance (N-1)         276115410         Variance (N-1)         143572918           Selected Wind Turbines         Selected Components         Mext         Back           N1-750-II-001         Variance         Variance         Variance         Variance           N1-750-II-003         Variance         Variance         Variance         Variance	Standard deviation (N-1) 16617	Standard deviation (N-1) 11982	
Variance (N-1)         276115410         Variance (N-1)         143572918           Selected Wind Turbines         Selected Components         Mext         Back           N1-750-II-002         Yaw brake         Back         Back	Variance (N) 253105792	Variance (N) 125626303	
Selected Wind Turbines Selected Components N1-750-II-002 N1-750-II-003 N1-750-II-004	Variance (N-1) 276115410	Variance (N-1) 143572918	
Selected Wind Turbines Selected Components N1-750-II-001 N1-750-II-003 N1-750-II-004 Vaw brake December 2			
N1-750-II-001         Next           N1-750-II-002         Back           N1-750-II-003         Chose	Selected Wind Turbines	Selected Components	
N1-750-II-002 N1-750-II-003 N1-750-II-004	N1-750-II-001	Yaw brake	Next
N1-750-II-003 N1-750-II-004	N1-750-II-002		Back
N1-750-II-004	N1-750-II-003		
llose	N1-750-II-004		
			Close

#### 13. Close

#### 5.5 Final Remarks

The following remarks should be made to better interpret the analysis results.

- The number of maintenance actions means the number of actions for which the technician had to go to the turbine. The failure could not be solved by a reset from the helpdesk.
- The difference between "failure rate" and "failure intensity" requires some understanding of the theory on reliability and safety analyses. It is beyond the scope of this report to go into more detail.
- All the results are "normalised" to [per turbine] in order to compare the O&M performances independent from the size of the population of a region or park.
- If you go from a certain screen back to the previous on by clicking "Back", you will notice that the button "Next" is disabled. You are obliged to make your selection again. This is done to avoid errors by clicking too fast through the various screens.

# 6. DEFINING NEW TURBINES

#### 6.1 Screens and Buttons

To define new turbines, open the option "Definition WT" under "Properties". The screen below will show up.

🔒 OnderhoudsManager Demo				
Properties Edit Reports Special	<u>H</u> elp			
🚜 Wind park - DEMO GEBRUI	KER / Park So	uth Single 1		_ 🗆 ×
Wind Parks Wind Turbi Building B In region: Region: Wor Description : Den	IIC Component Su Wind Park of kshop South nonstration	b Comp. Data	<u>C</u> onsum.	ECN <u>Print</u>
				<u>S</u> equence
Wind park	Residence	Address	<u>^</u>	Duplicate.
Park South Supplier	Residence PS1	Adress Park South 1		
Park South Single 1	Residence South	Adress South Single 1		
Park South Single 2	Residence South	Adress South Single 2		<u>C</u> hange
Park South Start Date	Residence Park	Adress Park South Start Date		Delete
Park North Trend	Residence Park	Adress Park North 1		
				<b>A</b>
				-
				<b>_</b>
			-	Eind
	·	•		Close

To define each turbine in a unique manner it is necessary to define the:

- Wind park
- Wind turbine
- Building blocks (or main system) of each turbine
- Components of each building block

These items correspond with the "tab's" of the definition screen. The tab "Sub-comp." is not being used in this demonstration version. The tab "Comp. Data" can be used to define spare parts and the tab "Consum." to define consumables.

As already stated in the introduction, Chapter 1, three types of turbines are already defined in the Maintenance Manager. To see what information is attached to the wind park "Park South Supplier", you should click on the park and than on the button "Change". The screen on the following page will show up.

🚮 OnderhoudsManager Demo		_ 🗆 ×
Properties Edit Reports Special Help		
Wind park - DEMO GEBRUIKER .	/ Park South Single 1	_ 🗆 🗵
Change Wind Park		
Wind P		
	Wind park:	
Name:	Park South Supplier	1000
Region:	Workshop South	
Location: Address:	Adress Park South 1	L. 1
Residence:	Residence PS1	IT IL
Country:	NL	ence
Tel.:	0224 564943	icate.
Description:	8 turbines, 1000 kW, class 1	44
Terrain:	hily 🔽	
Wind Conditions:	class 1	nge
Owner:	OWN2	ete
Operator:	OPR2	- 1
Service Centre:	SC2	
Remarks:	ECN service	
	SC2	E.
ок 1	Cancel	ad
		Tose

The items Region, Terrain, Wind Conditions, Owner, Operator, and Service Centre work as combo boxes. The options to choose can partly be set in the corresponding reference tables (See chapter 2). Terrain and wind condition options are standard and cannot be changed.

By clicking the tab "wind turbine" you can see that the wind park "Park South Supplier" consists of 8 times 1MW class 1 turbines.

🛃 OnderhoudsMana	ger Demo					_ <b>D</b> ×
<u>Properties</u> <u>E</u> dit <u>R</u> epo	<u>Properties</u> <u>E</u> dit <u>R</u> eports <u>S</u> pecial <u>H</u> elp					
🙀 Wind park - DEM	O GEBRL	JIKER / Park 9	South Single 1			_ 🗆 🗙
Wind Parks Wind Iur	bi Building	Blc Component	<u>S</u> ub Comp.	Comp. Data	<u>C</u> onsum.	(
			bine of:			
Wind	l park: Pa	rk South Supplier				ECN
Resid	lence:  Re	sidence PS1			_	Dia
Desci	ription: 8 t	urbines, 1000 kV	/, class 1			Enne
		[	<b>D</b> :::			<u>S</u> equence
Wind Lurbine	01.001	Location	Description			<u>D</u> uplicate.
S-Supplier-Too	04-001	Foundation 1	1000 kW turbine			Add
S-Supplier-100	0.1.003	Foundation 2	1000 kW turbine			Change
S-Supplier-100	0-1-003	Foundation 4	1000 kW turbine		-	
S-Supplier-100	04-005	Foundation 5	1000 kW turbine		-	Delete
S-Supplier-100	0-1-006	Foundation 6	1000 kW turbine		-	
S-Supplier-100	0-1-007	Foundation 7	1000 kW turbine		-	
S-Supplier-100	0-1-008	Foundation 8	1000 kW turbine			
						<b></b>
					_	Eind
						Close

With the button "Change" you can change the background information of the turbines, e.g. the date the turbine is taken in operation, or you can add some unique characteristics to the turbine (rotor diameter, special feautures, rated power, etc.)

The Maintenance Manager - User Manual for the Demonstration Version

🚮 Onderhou	dsManager Demo		
<u>Properties</u> <u>E</u> d	lit <u>R</u> eports <u>S</u> pecial <u>H</u> e	P	
🛃 Wind parl	k - DEMO GEBRUIKER	/ Park South Single 1	
Sufficient Dealer	Wind Turbi Duata - pulles		
	Change Wind Turbine		
		Wind Turbine:	
	Name:	S-Supplier-1000-I-002	181
	Location:	Foundation 2	
	Description:	1000 kW turbine	int
	Manufacturer:	MNF1 Date in u	ise:
	Туре:	WS 1000 kW-I 🔹 01-04-199	15 cate.
	Characteristic 1:	55	ва
	Characteristic 2:	50	nge
	Characteristic3:		oto
	Characteristic 4:		
	Characteristic 5:		
			-
-	<u>о</u> к	Cancel	z
+			
			Eind
			Close

Each turbine in this demonstration version consists of three building blocks: rotor, nacelle and tower. This can be seen by clicking on tab "Building Block".

🚮 Ond	lerhoudsManag	jer Demo		
<u>P</u> roperti	ies <u>E</u> dit <u>R</u> epor	ts <u>S</u> pecial <u>H</u> elp		
🚮 Wi	nd park - DEM	O GEBRUIKER / Park	South Single 1	
<u>W</u> ine	d Park: Wind <u>T</u> urt	bi <u>Suilding Bl</u> Component	Sub Comp Comp. DataConsum.	
		Building	Block of:	
	Wind Tu	rbine: S-Supplier-1000-I-0	002	FCN
	Loc	ation: Foundation 2		
	Descri	iption: 1000 kW turbine		<u>P</u> rint
		1		<u>S</u> equence
	Building Block	Configuration ID	Description 🔺	<u>D</u> uplicate.
	Rotor	Original design	Rotor for WS Turbines	Add
	Nacelle	Uriginal design	Nacelle for WS turbines	<u></u>
	lower	Uriginal design	Tower for WS turbines	<u>C</u> hange
			<u> </u>	<u>D</u> elete
			<u> </u>	
				<u> </u>
			<b>_</b>	Find
	↓			Close

By "Change" you can change for instance the supplier of a main system or the configuration identification.

🔒 Onderhouds	Manager Demo			
<u>Properties</u> <u>E</u> dit	<u>Reports</u> Special <u>H</u> e	lp		
🚮 Wind park	- DEMO GEBRUIKER	7 Park South Single 1		_ 🗆 🗙
Wind Parks W	/ind <u>T</u> urbi <u>B</u> uilding Blc C	omponen Sub Comp.	Comp. Data Consum.	
		Building Block of::		
	hange Building Block			
		Building Block:		
	Name:	Hotor		ence
H		r		cate.
⊢ <b>₽</b>	Description:	Rotor for WS Turbines		- Ha
	Supplier:	WS Rotor supplier		nge
T T	Configuration ID:	Config 1		ete
		proto Config 1		
Ц		Config 2		
-	<u>0</u> K	Cancel		
				<b>_</b>
				Find
		+	Þ	Close

Each building block consists of various components. E.g. the rotor consists of three blades, three pitch motors, etc. A complete list can be found under tab "Component". Each component is defined uniquely by its tag nr. So "Pitch motor 1" corresponds to pitch motor 1 on the electrical schematics. (The "component level" is also the level at which the FMEA is being performed and at which data should be recorded for further analysis. This will be discussed later on.)

🚮 Ond	erhoudsManager [	)emo			
Properti	es <u>E</u> dit <u>R</u> eports j	<u>Special H</u> elp			
🚮 Wi	nd park - DEMO G	EBRUIKER 7 F	<sup>p</sup> ark South Single	1	_ 🗆 ×
<u>W</u> ind	Park: Wind <u>T</u> urbi <u>B</u>	uilding Blc Comp	oneni <u>S</u> ub Comp.	Comp. Data Consur	
		Ci	omponent of:		
	Building Block	c Rotor			ECN
	Configuration ID	: Original desig	n		
	Description	Rotor for WS	Turbines		<u>P</u> rint
		-			<u>S</u> equence
	Component	TAG-number	Component ID	Description 🔺	Duplicate.
	Blade 3	BL3	BL25	blade	
	Pitch motor 1	M1.1	PM1000_B	de motor	Add
	Pitch motor 2	M1.2	PM1000_A	dc motor	<u>C</u> hange
	Pitch motor 3	M1.3	PM1000_A	dc motor	Delete
	Pitching gearbox 1	G2.1	PG1000	gearbox	
	Pitching gearbox 2	G2.2	PG1000	gearbox	
	Pitching gearbox 3	G2.3	PG1000	gearbox	
	Pitch bearing 1	B1.1	PB	bearing	<b>•</b>
	Pitch bearing 2	B1.2	PB	bearing	
	Pitch bearing 3	B1.3	PB	bearing	
				<b></b>	<u> </u>
					Close

By "Change" it is possible to change o.a. the following:

- Name, tag nr, description, etc.

- Type and object are two fields that can be used to make various cross-sections through the database. E.g. you can select all electrical motors during the analysis if you add the option "electrical motor" to the component. Or all electrical equipment can be compared with hydraulic equipment. The possibilities for type and object can be defined in the reference tables (*type of object* and *type of component*).

🚮 Onderhoud	sManager Demo		
Properties Edit	: <u>R</u> eports <u>S</u> pecial <u>H</u> elp	) )	
🛃 Wind park	- DEMO GEBRUIKER	/ Park South Single 1	
Nicera D 📆 🕻	Change Component		
		Component:	
	Name:	Pitch motor 1	
	TAG-number:	M1.1	1 12.17
	Description:	dc motor	p II 🔨
	Type:	electrical 💽 💽 New Datum in gbr	int
	Object:	electrical motor old 28-09-2000	lence
$\Box$	Function describtion:	driving pitching gearbox and blades	icate.
	Component ID:	▼ PM1000_B ▼	Hd
•	Serial nr.:		inge
	Specification1:		lete
	Specification2:		
$\vdash$	Specification3:		
	Library reference:	<none> &lt;</none>	-
			<u> </u>
	<u>0</u> K	Cancel	nd
			lose

The field "Component ID" is meant to select the ID from the spare parts list or from the stock. In the case of the pitch motor, you can use a pitch motor from supplier A (PM 1000\_A) or B (PM 1000\_A). You can select the data in two ways: the full name (1000 kW pitch motor, left hand field) or the code (PM 1000\_A, right hand field). The list with component ID's and their codes is defined under tab "Comp. Dat."

🚮 Onder	houdsManager De	mo		_ <b>_</b> ×
<u>P</u> roperties	<u>E</u> dit <u>R</u> eports <u>Sp</u>	ecial <u>H</u> elp		
🚮 Wind	park - DEMO GEB	RUIKER / Park So	uth Single 1	
<u>W</u> ind P	ark: Wind <u>T</u> urbi <u>B</u> uild	ting Blc C <u>o</u> mponent <u>S</u> u	Ib Comp. Dats Consum.	
	Component ID	Part	Description 📃	
	BL21	21 m blade	blade for 750 kW turbine with diameter	ECN
	BL24	24 m blade	blade for 750 kW turbine with diameter	
	BL25	25 m blade	blade for 1000 kW turbine with diamete	<u>Print</u>
	BL28	28 m blade	blade for 1000 kW turbine with diamete	<u>S</u> equence
	PM750-sub1	750 kW pitch motor	de motor	Dunlicate
Þ	PM1000_A	1000 kW pitch motor	dc motor from company A	
	PM1000_B	1000 kW pitch motor	dc motor from company B	Add
	PG750	750 kW pitching geart	gearbox	<u>C</u> hange
	PG1000	1000 kW pitching gea	gearbox	Delete
	MG750	750 kW main gearbox	main gearbox	
	MG1000	1000 kW main gearbo	main gearbox	
	GN750	Generator 750 kW	generator	
	GN1000	Generator 1000 kW	generator	
	RE	Relay	24 Vdc relay	
	PLC	PLC	plc for control system	
		U 8 1		Eind
				Close

**Note:** The list with components will be tailor made for each individual customer. The customer should provide the data in a digital format. Since this is not the case in this demonstration version, the option does presently not work properly and will be improved.

Furthermore, you can define the serial number of a component. In practice, this will only be done for major components, not for smaller components.

## 6.2 Copying Existing Parks and Turbines

To define a new park with existing turbines you should carry out the following steps. 1. Properties  $\rightarrow$  Definition Windturbine

- 2. Select Tab "Wind Park"
- 3. Push button "Add" and fill in the data (in our example it is called ECN-test-1)

🚮 Onderhou	udsManager Demo		
<u>Properties</u> <u>E</u>	dit <u>R</u> eports <u>S</u> pecial <u>H</u> elp		
🚮 Wind pa	rk - DEMO GEBRUIKER /	Park South Single 1	_ IX
Sec. in 🌌	Change Wind Park		
<u>w</u> ina P		1. P. 1. 1.	
		wind park:	
	Name:	ECN-test-1	INT
	Region:	Workshop North	
	Location: Address:		int
	Hesidence:	EUN city	
	Country:	Netherlands	ence
H	I el.:	+31 224 564943	icate.
H	Description:	ECN test station	dd bb
H H	Terrain:	flat 🔽	nge
	Wind Conditions:	class 2	ete
	Uwner:		
	Uperator:	ECN operation	×
	Service Centre:	ECN service	
	Remarks:	Park to show definition of new park with existing turbines	
			E I
L L	<u> <u> </u></u>	Cancel	nd
<u> </u>			Close

- 4. Close the window by "OK" and notice that the park is added to the 5 other parks
- 5. Go to park "Park South Single 2" (this consists of the 1 MW class 2 turbines)
- 6. Go to tab "Wind Turbine" and select the turbine S-Single-2-1000-II.
- 7. Select "Duplicate"

🚮 Onderhouds	Manager Demo				
<u>Properties</u> <u>E</u> dit	<u>Reports</u> Special <u>H</u> e	lp			
🚮 Wind park	- DEMO GEBRUIKER	7 Park South Single	1		_ 🗆 🗵
Wind Parks W	/ind Turbi Building Bid Co uplicate Wind Turbin	e	Comp. Date	Consum	
	·		:		
	Name:	ECN-Test			N
	Location:	Foundation 1			
	Description:	1000 kW turbine			int
	Manufacturer:	MNF1	-	Date in use:	ence
	Туре:	WS 1000 kW-II	-	10-05-2001	cate.
<b>1</b>	Characteristic 1:	70			Ha
-	Characteristic 2:	56			
	Characteristic3:				nge
	Characteristic 4:				ete
	Characteristic 5:				<b></b>
	Plant:	ECN-test-1			
	<u></u> K	Park North Trend Park South Supplier Park South Single 1 Park South Single 2	, onderdelen en comp FMECA-g	oonenten overnen egevens overnen	nen 🔽
		Park South Start Date ECN-test-1			Close

- 8. Modify the name, date in use, etc.
- 9. Select the park in the combo box (in this case ECN-test-1)
- 10. Mark "Secties, onderdelen en componenten overnemen" to make sure that all components and building blocks are being copied
- 11. Mark "*FMECA-gegevens overnemen*" to make sure that the FMECA data of each component is being copied.
- 12. Select "OK"

Now select tab "Wind Park", go to ECN-test-1, go to tab "Wind Turbine" and see that the turbine is being copied. If you go to the building blocks and components you will see that all data is being copied. You now only have to modify the serial numbers for the main components if you want to ensure configuration control.

#### 6.3 Defining New Turbines and Parks

Here an example is given how to define a new turbine, which consists of only one component, the tip brake. The turbine is called "Turbine tip brake" Adding more components to the turbine means repeating the same action or copying existing data.

To define a new turbine you should do the following.

- 1. Select the reference table "Main Libraries" in "Raamwerk Demo"
- 2. Select "Add" and type the new name of the library (In this case "ECN-tip brake")
- 3. Follow the same procedure to define a new type of wind turbine. Add "ECN tip brake demo" to the reference table "type of wind turbines"
- 4. Select "Save" and restart the program to update the reference tables

🚜 Raamwerk Demo	_ 🗆 ×
Administration Reports Application Special Help	
🙀 Referentietabellen	
Program: OnderhoudsManager	
Tables:       Maintenance         Classification Component I       Name         Configuration-ID       WS Rotor         Countries       WS Nacelle         Currency       WS Tower         Detection       ECN-tip brake         Discipline       ECN-tip brake         Kind of employee       ECN-tip brake         MTTF       ECN-tip brake         Maintenance strategy       Maintenance strategy         Material       ECN-tip brake         Medium       ECN-tip brake         Operator       ECN-tip brake         Owner       ECN-tip brake         Periods       ECN-tip brake         Productiedervingskosten       ECN-tip brake	Save Cancel Delete Afdrukken Afdrukken alle
Randvoorw. (Conditions)	Close

- 5. Select "FMECA" from "Properties"
- 6. Select the "ECN-tip brake" library as shown below.

🔏 OnderhoudsManage	er Demo				
Properties Edit Report:	s <u>S</u> pecial <u>H</u> elp				
Bibliotheek FMECA	- DEMO GEBRUII	(ER / Risi	co-analyse Park No	th Trend	
FM-bibliotheek		Plant			12
ECN-tip brake	<b>-</b> U	nit:	N1-750-II-001	<u> </u>	
ECN-tip brake	L Se	ectie:	<alle></alle>	<b>_</b>	
WS Nacelle	Or	nderdeel:	<alle></alle>	-	
WS Rotor	То	ne/Obi ·			FCN
WS Tower		per e e p.	] (ano)) (an		
FM-bibliotheek Proje	eotbibliotheek 0	Inderdelen	Componenten	Risico-analyse	
	1 740	1		1.01	
Underdeel	TAG-nummer	la da	Umschrijving		R.Aopties
Blade 1 Blade 2	BLI BL2	blade		ICAI	B & Sectie
Blade 3	BL3	blade			
Cylindrical part	TW	cylindrical	part of tower	X I	Dunliceren
Generator	GEN	Generator		X	
Main Gearbox	G1	Gearbox		X	Торуордор
PLC	PLC	PLC		X	Toevoegen
Pitch bearing 1	B1.1	bearing		X	Wijzigen
Pitch bearing 2	B1.2	bearing		X	Vensiideren
Pitch bearing 3	B1.3	bearing		X	Telwigeren
Pitch motor 1	M1.1	dc motor		X	
Pitch motor 2	M1.2	dc motor		× 🛄	
Pitch motor 3	M1.3	dc motor		X	
Pitch relay	K1	relay		X	
Pitching gearbox 1	G2.1	gearbox			
Pitching gearbox 2	G2.2	gearbox			<u>S</u> luiten

- 7. Select tab "FM-bibliotheek" and select "Toevoegen" (which is Dutch for Add!)
- 8. Fill in the name of the component (Tip brake) and close the window
- 9. Double click on "tip brake"

OnderhoudsManager Demo     Properties Edit Reports Special H	Help	
Bibliotheek         FM-bibliotheek           FM-bibliotheek         ECN-tip brake           Projectbibliotheek         WS Rotor           FM-bibliotheek         Projectbibliotheek	EBRUIKER / Risico-analyse Park North Trend         Plant         Unit:       N1-750-II-001         Sectie: <alle>         Onderdeel:       <alle>         Type/Obj.:       <alle>         Onderdelen       Componenten         Risico-analyse</alle></alle></alle>	
Onderdeel Tip brake T	Omschrijving	R.A. opties R.A. Sectie Dupliceren <u>I</u> oevoegen <u>W</u> ijzigen <u>V</u> erwijderen
<	۲ ۲	<u>S</u> luiten

10. The FMEA sheet will show up

📆 OnderhoudsManage	r Demo			_ 🗆 🛛
Properties Edit Reports	<u>S</u> pecial <u>H</u> elp			
🚮 FM-bibliotheek WS	Rotor: Tip brake			_ 8 ×
🔚 <u>S</u> luiten				
Faalvorm	Faaloorzaak	Conditie van de foul Detectie	Reparatie Standtijd	Kost 🔺
▶ Koj Pla Pla	piëren jepen kken piëren faalvorm kken faalvorm			
Ver Ber Afd Afs	wijderen faalvorm waren Irukken Juiten			
↓ ▼				

- 11. Select the right mouse button and select "Toevoegen faalvorm" (Adding failure mode)
- 12. Fill in as much failure modes and causes as necessary (The last 5 columns are not being used in this demonstration version.) and close the FMECA screen by "Sluiten".

H	🖁 OnderhoudsManager Dem	0					-	
E	<u>Properties Edit R</u> eports <u>S</u> pec	cial <u>H</u> elp						
	🚯 FM-bibliotheek WS Rotor	: Tip brake					_	₽×
	🛃 <u>S</u> luiten							
L	Faalvorm	Faaloorzaak	Conditie van de fou	Detectie	Reparatie	Standtijd	ł	<ost td="" ▲<=""></ost>
	Fails to open	Debris	•	•	•		•	•
		Ice	•	•	-		•	•
F	emergency stop	Spring broker	-	•	-		•	•
ľ								
ľ								
ŀ								
┢								
┢								
Ŀ	•  •							•

- 13. Select "Definition WT",
- 14. Select tab "Wind Park" and select park "ECN-test 1
- 15. Select tab "Wind Turbine"
- 16. Select "Add"
- 17. Fill in all turbine data as shown below. Select "ECN-tip brake demo" as type of turbine.

🚮 Onderhoudsk	lanager Demo		
<u>P</u> roperties <u>E</u> dit	<u>Reports</u> <u>Special</u> <u>H</u> e	lp	
🄀 Wind park -	DEMO GEBRUIKER	7 Park North Trend	_ 🗆 🗙
Wind Parts Wir	d Wind Turbine	amonenii Sub Lomp I II - II Iomp Datai Lonsum III -	
		Wind Turbine:	
	Name:	Turbine tip brake	INI
	Location:	Foundation	
	Description:	Demo version with only one component	int
	Manufacturer:	MNF1 Date in use:	ence
	Туре:	ECN tip brake demo	cate.
<b>-</b>	Characteristic 1:	2 blades	Ьd
-	Characteristic 2:	D = 60 m	nge
	Characteristic3:	H = 80 m	oto
	Characteristic 4:	P = 1.2 MW	ete
-	Characteristic 5:		<u> </u>
			r
-	<u>0</u> K	Cancel	z
<del>   </del>			
	1		End
			Close

18. Click OK to return to the definition screen. You will notice that there are two turbines in park ECN-test-1.

- 19. Select tab "building block" and select "add"
- 20. Fill in an appropriate name, select the supplier and the configuration ID and click OK. You will notice that the turbine "Turbine tip brake" now consists of one building block.

🚮 Onderhoud	sManager Demo				
<u>Properties</u> <u>E</u> dit	t <u>R</u> eports <u>S</u> pecial <u>H</u> e	lp			
🚮 Wind park	- DEMO GEBRUIKER	} / Park North Trend			- IX
Wind Parks V	Wind <u>T</u> urbi <u>B</u> uilding Blc	omponent Sub Comp.	<u>C</u> omp. Data	<u>C</u> onsum.	
		Building Block of::			
<b>-</b> 87	Add Building Block				N
		Building Block:			int
	Name:	Rotor			ence
					cate.
-	Description:	Two bladed rotor with tip brakes	3		44
H	Supplier:	WS Rotor supplier			nne
	Configuration ID:	Config 1			eie
					-
$\vdash$					
	<u> <u> </u></u>	Cancel			
				-	
					<u> </u>
				- 1	Eind
					Close

- 21. Select tab "component" and select "add"
- 22. Fill in the data as shown below. Since there are two tip brakes, this one is called Tip brake 1. To add the FMECA data to the component select "ECN-tip brake" from the library reference and "Tip brake" from the parts in this library. ("Component ID" is not obligatory.) Then select OK and notice that the building block "Rotor" has one tip brake.

🚮 Onderhoud	sManager Demo		_ 🗆 🛛
<u>Properties</u> <u>E</u> dit	: <u>R</u> eports <u>S</u> pecial <u>H</u> elp	p	
🚮 Wind park	- DEMO GEBRUIKER	/ Park North Trend	
	Add Component		
<u>w</u> ind P		Component:	
_	Name:	Tip brake 1	
	TAG-number:	TB1	15.97
	Description:	Tip brake of blade one	5 <u>I</u> N
	Туре:	<none></none>	int
	Object:	<none> C old 20-05-2001</none>	ience
Г	Function describtion:	Aerodynamic tip brake	icate.
-	Component ID:	▼ (geen> ▼	На
	Serial nr.:	TB 12345	nge
	Specification1:		lete
-	Specification2:		
-	Specification3:		
	Library reference:	ECN-tip brake	
-		<none></none>	z
<u> </u>	01	WS Nacelle	E
	<u> </u>	WS Rotor	nd
		WS Tower C	lose

23. To add the second tip brake to the rotor: highlight "Tip brake 1" and select "Duplicate". Now change the name, the tag nr., the description, and the serial number. Then, mark "include components" and "include FMECA-data" and close the window. You now have two tip brakes with the FMECA data attached.

🚮 Ond	lerhoudsMana	ger Demo				
Propert	ies <u>E</u> dit <u>R</u> epo	orts <u>S</u> pecial <u>H</u> el	Þ			
🚮 Wi	nd park - DE₩	IO GEBRUIKER	/ ECN-test-1			
<u>W</u> ine	d Parks Wind <u>I</u> u	rbi Building Blc Cg	mponent <u>S</u> ub Comp.	<u>C</u> omp. Data	Consum.	
	Building	Block: Rotor				াল ে মা
	Configurat	ion ID: Original d	esign			LC LN
	Desc	ription: Two blad	ed rotor with tip brakes		_	<u>P</u> rint
		· .	·			<u>S</u> equence
	Component	TAG-number	Component ID	Description	<u> </u>	Duplicate.
	Tip brake 1	TB1		Tip brake of blade one		
	Tip brake 2	TB2		Tip brake of blade two	_	<u></u>
					-	<u>U</u> hange
					-	<u>D</u> elete
						<b>—</b>
						<b>Z</b>
					<b>•</b>	Eind
					•	Close

Once you have built the first turbine (as is done at ECN many times), it is not necessary anymore to build a completely new turbine. In practice, the building blocks with the components will be downloaded as the parts lists from the manufacturers. The components will be linked to the various libraries with FMECA data.

# 7. Problem with installation

If any problems occur during the installation, try the procedure as described below:

 Double click on "Onh\_demo.exe" in the C:\ directory. Files will be extracted and the directory "Onh\_demo" with the sub directories "Frame" and "Onhmn" will be generated.

🔍 Exploring - C:\		_ 🗆 🗵
<u>File Edit View T</u> ools <u>H</u> elp		
All Folders	Contents of 'C:V'	
🔁 🔁 Onh_demo 🔺	Name	Size Type 🔺
Frame	Chh_demo.exe	4,961KB Application 🖵
	1	
1 object(s) selected 4.84MB		li.

2. Go to directory "Onh\_demo" and delete "P\_bnr.dbf"

💐 Exploring - C:\ONH	_DEMO				×
<u>F</u> ile <u>E</u> dit <u>V</u> iew <u>T</u> ools	<u>H</u> elp				
All Folders	Contents of 'C:\ONH_DEMO'				
i MSOffice	Name	Size	Туре	Modified	
i Mtm	🚞 Frame		File Folder	01/06/01 09:22	
My Documents	🚞 Onhmn		File Folder	01/06/01 09:22	
Onh_aoc	💓 Bnr.exe	29KB	Application	11/06/97 03:33	
UNH_CD_Klanter	🔊 Config.fpw	1KB	FPW File	24/11/98 16:02	
Unh_demo	🔊 Foxuser.dbf	1KB	DBF File	03/11/00 14:23	
Frame	🔊 Foxuser.fpt	4KB	FPT File	03/11/00 14:23	
⊡ Unnmn	📾 Frame.app	1,360KB	APP File	29/01/01 21:59	
	🛃 Logo.bmp	11KB	Bitmap Image	30/03/00 10:02	
Program Files	🖻 Logo.msk	11KB	MSK File	30/03/00 10:02	
Pw32	🔊 Onhfm.app	1,110KB	APP File	11/09/00 13:26	
Recycled	🔊 Onhmn.app	3,946KB	APP File	04/02/01 16:42	
SAPpc	🔊 Onhvb.app	1,882KB	APP File	28/08/00 16:54	
🦲 Sbpci 👘	🔊 Onhwm.app	1,708KB	APP File	07/02/01 11:32	
🧰 Temp	P_bnr.dbf	1KB	DBF File	11/05/01 09:02	
📋 Vijfde Kaderprogra	💌 V_bnr.dbf	1KB	DBF File	04/02/01 16:56	
ind 📃 📃	🔊 V_onhfm.dbf	1KB	DBF File	05/09/00 14:03	
😑 Windows	🔊 V_onhmn.dbf	1KB	DBF File	04/02/01 16:56	
📄 Windtesteveld Wi	🔊 V_onhvb.dbf	1KB	DBF File	04/02/01 16:56	
		4MD	DDC C1	04.000.001.10.50	١Ë
1 object(s) selected	502 bytes				

3. Double click on "Bnr.exe" and follow the instructions below

- 4. Change: M:\TEST\ into c:\onh\_demo\
- 5. Change: P:\TEST\FRAME\DATA\ into c:\onh\_demo\FRAME\DATA\

Status and Implementation

c:\



6. Change G:\UITLEVER\DEMO1\ in all fields into

\_ D × Microsoft Visual FoxPro <u>F</u>ile <u>E</u>dit <u>W</u>indow <u>H</u>elp Geef het centrale directory waar de programmatuur staat Sluit af met een '\'\_\_\_\_ c:\onh\_demo\ Geef het data directory van het frame in. Sluit af met een '\' 🚯 Directories Instellen \_ 🗆 × Geef de directories in: C:\onh\_demo\fram c:\onh\_demo\frame\zoekz c:\onh\_demo\frame\
 c:\onh\_demo\onhmn\zoek c:\onh\_demo\onhmn Tempdirectory c:\onh\_demo\ G:\UITLEVER\D 1<mark>lonh\_dem</mark> D\_params (D\_bnr!D\_params) Record: 2/2 Record Unlocked

Note: The directory C:\Temp must be created.

7. Close the window and fill in the user name and password

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	Date: 15-1-2001	Report number:	ECN-C01-0XX	
Title	The Maintenance Manager - Collecting and Analysing Maintenance Data of Wind Turbines			
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ECN project number Order number	7.4087 and 7.4117 224.321-9957			
Programme(s)	TWIN			

#### Abstract

ECN and Baas & Roost Maintenance Consult (B&R) have made a demonstration version of the Maintenance Manager. The purpose of this demonstration version is to offer possible users of the Maintenance Manager (among others: wind turbine manufacturers, service departments, operators, and technical managers of wind farms) the opportunity to familiarise with the system.

The demonstration version is the result of a project entitled "Development of a Maintenance Information System for Wind Turbines". The project was carried out between October 1999 and November 2000 by ECN, B&R and Lagerwey the WindMaster. The demonstration version of the Maintenance Manager reflects the status of the program of November 2000. The development of the program is still ongoing and many improvements have already been made.

This report contains the User Manual for the demonstration version of the Maintenance Manager.

Key words Wind energy, Reliability, Maintenance, Availability						
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