MONITORING AND DIAGNOSIS OF ROTATING MACHINES

Predictive maintenance is a powerful leverage of competitiveness for all industrialists. As its benefits are now undeniable, it is involving different people within a same company, working together on the same data, but at different steps of the process.

NESTi4.0 is powerful and productive tool to manage the predictive maintenance. It can be managed even without specific vibration knowledge as it includes an automatic setup based on machine kinematic description. In addition, ACCUREX analysis method offers the possibility to get automatic diagnosis.

For the vibration specialist, it is a way to save of lot of time as he can focus on machines which really need to be look at in details. This analysis is also speed up with dedicated functions:

- The Health Matrix
- ACCUREX matrix
- SFx and HMx indexes
- Merged spectrum
- Shock finder filter

Main modules

MACHINE SETUP

Organize the data according to locations, sub-locations, and easily define machines through the drag & drop tool that can be used according to 2 modes (Template or ACCUREX)
- Template mode: fast measurement generation using predefined templates or customized by the user.
- ACCUREX mode (Automatic diagnosis): automatic generation of the measurements required to perform automatic diagnosis with the FALCON portable data collector

ANALYST

Powerful module, with several tools to speed up your analysis and recommendations:
- The ACCUREX Matrix display
- SFx and HMx indexes
- Merged spectrum
- Shock finder filter

ROUTE SETUP

Manages lists of machines that can be used as routes to load the data collector or as filter in Analyst. Reorder machines to optimize data collection.

COLLECT

Transfer route data to or from the data collector:
- direct link (USB, Ethernet, Wi-Fi)
- via Internet using intermediate files

INSTRUMENT

Manage the communication with EAGLE online wireless monitoring system.

ADMINISTRATION

Manage the databases and users

General Specifications

Centralized database	<u>Multi source</u>: FALCON portable device and EAGLE wireless Online sensor <u>Multi physical</u>: Vibration, Process, Electrical
Architecture	Two versions are available: • <u>Desktop</u>: a single installation is done on each computer with access to local data • <u>Network</u>: data are hosted on an application server connected to the network. All users are directly working on the same data through a network (LAN or WAN). It includes user management with access profiles.
International application	<u>Languages</u>: English, French, Simplified Chinese, Korean, Russian, Portuguese, Spanish, German, Dutch, Vietnamese, Indonesian, Japanese, Thai <u>Units</u>: Management of metric and imperial units. Can be adjusted at any time with user preference
User assistance	<u>Tooltip</u>: Tooltips are displayed to provide more information on functions or buttons according to the modules
Data exchange	<u>Import / Export</u>: Easily share data between several NESTi4.0 databases within the same or different factories.

Automatic reporting capabilities

To improve maintenance planning and operations, one needs to be able to display in a very easy way:
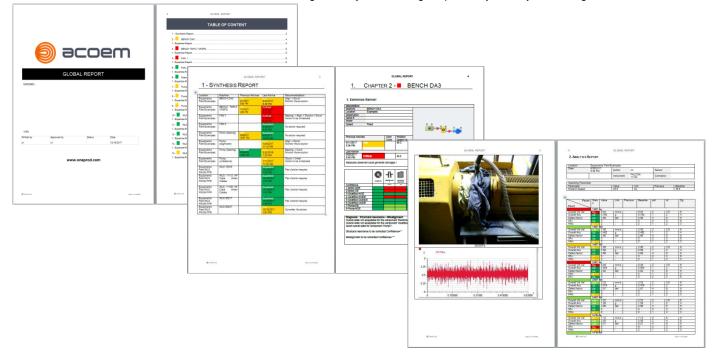- what has been detected through predictive maintenance technologies
- what has to be done
- when it should be done

NESTi4.0 provides reporting capabilities, automatically illustrated and easily accessible.

Analysis reports	• <u>Automatic reporting</u>: reports are automatically generated just in a touch of a button. They are available at any time, for a single machine or group of machines with an active table of contents. • <u>Selectable content</u>: Synthesis Information, Diagnosis & Recommendation, Analysis. • <u>ACCUREX matrix</u>: machine defects and their location visible at a glance • <u>Hide / display parameter</u>: Advanced parameters can be hidden automatically and not be printed out in the reports. They remain fully available in the ANALYST module for the expert users. • <u>Filtering and sorting</u>; machines can be easily filtered and sorted according to their name, status, advice, measurement date. • <u>Format</u>: DOCX and PDF • <u>Automatic picture insertion</u>: machine pictures, pictures attached in appendix (analysis, thermographic) or taken with FALCON data collector, are automatically printed out in the reports • <u>Template customization</u>: templates of prelisted report types can be modified to adjust the content automatically extracted from the database. It manages the layout, including the possibility to add your own logo.

Data Presentation

NESTi4.0 offers a user-friendly interface, providing an easy access to relevant information, whatever the number of machines monitored is, and whoever is using the software

Structure
- Data structure: within a single database, it is possible to organize machines into several locations and sub locations to have them displayed in a quick and easy format.
- Data browsing tools: the navigation from the top site view to the detailed analysis view and reports can be made through different ways. One or several tools are available according to the NESTi4.0 module in use:
  - Classic drill-in
  - Navigation toolbar
  - Tree structure

Presentation
- Location picture: pictures can be added to locations and sub locations
- Machine position: the machine can be positioned on the location picture to provide an easy access to the machine monitoring data
- Machine picture: picture of the machine can be added for a better presentation of the results. If none is available, a schematic view can automatically be generated from the MACHINE SETUP module.
- Measurement point position: measurement points can be positioned on the machine picture or schematics to provide a very visual presentation of the results.
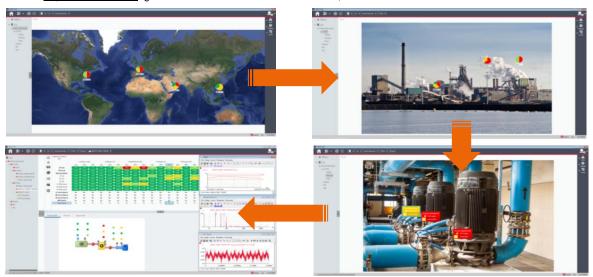
Display modes
- Map mode: display on a map or image for a navigation that is as visual and intuitive as possible
- Icons: display as icons for a better balance between detailed information and visual information
- List: display as a list, for maximum details and multiple sorting possibilities for the available information
- Tree structure: A tree structure is also available in all NESTi4.0 modules

Machine information
- Bearing reference: the machine bearings can be selected from the bearing database. Bearing characteristics are then automatically imported and frequencies of interests automatically displayed in the graphic tool
- Custom. Bearing: the bearing database can be completed by the end user, if the bearing reference cannot be found.
- File attachment: documents such as drawings or other document that might be useful at the analysis step can be attached to each machine
- User notes: one can input written description notes associated to each machine.

Data mining
- Type of information displayed: the machines can be displayed according to several types of information in the, in order to help the user quickly finding machines of interest:
  - The ADVICE view presents the machines according to the last expert advice. The 3 previous advices are also displayed
  - The ALARM view presents the machines according to their alarm status. This view also shows the number of alerts and the number of days of measurement delay.
- FLAT view: the FLAT view corresponds to the powerful capability of displaying a whole factory into a single view. It is then possible to sort and filter the machines displayed according to several criteria: name, measurement date, status, advice, …
- Filter on machines: filters can be applied on machines from the ANALYST modules to only display given machines, with selectable filter options: alarm status, expert advice, not measured, route, machine name
- Filter on measurement history: filters can be automatically applied on the measurement history of a given machine to enable productive analysis. The applicable filters are declined according the data filters tags available: Expert advice, Measurement with or without signal, Operating condition, N last days, from D1 to D2.
- Measurement history tag display: to find easily an event in the history, it listed with machine alarm status, the expert advice, the operating condition, the presence of signal (EAGLE), triggering information
- Export in csv format: general information of selected machines, overall value histories of selected machines

Portable data collection dedicated features

NESTi4.0 provides all features required to organize the assets into data collection routes.

The routes contain all information required to make productive and easy measurements: location pictures, machines pictures, machines and measurement points' position on the pictures...

Route creation
- Definition of the list of machines: selection of the machines contained in a route
- Modification of the order of the measurement points: It is possible to rearrange the order of the measurement points so that they are presented automatically in the most productive way once the operator is in front of the machine.
- Smart reorder: organise the route in the order it has been measured during the previous collect.
- Split machines: As the focus is given to the measurement points, it is possible to split machines in the data collection process (e.g. measuring of machine A and B on the left side, before measuring machine A and B on the right side…)

Quick launch
- Single machine: a quick launch feature is provided to send a machine to a FALCON portable data collector by touching a button, without pre-creating a route. It makes it very convenient for quick testing.
- Multiple machines: it is possible to send several machines at once in this mode. The machines are displayed as individual machines and not as part of the same route.

Transfer mode
- Direct USB connection: the files are transferred to a FALCON connected directly to the computer with its USB cable
- Local network: the files are transferred to a FALCON connected to the network with an Ethernet plug or through a Wi-Fi connection.
- Transfer through intermediate files: the use of intermediate files allows for transferring routes through a USB stick, and, for example, after a transfer by e-mail

Route setup pictures
- Automatic insertion of pictures taken with FALCON: FALCON offers the unique possibility to add route related pictures to the machine setup. Once a picture of a machine or location is taken on the field with FALCON, it is automatically uploaded and stored into the NESTi4.0 software when the measurement data are uploaded.

Route related information
- Audio note: audio notes recorded on the field while measuring with FALCON are automatically uploaded to the NESTi4.0 database and available to any user at the analysis step
- Written note: notes typed in the field while measuring with FALCON are automatically uploaded to the NESTi4.0 database and available to any user at the analysis step. Written notes can be automatically printed in the data collection reports.
- Predefined notes: loaded in the data collector to make the input easier and faster.
- Inspection picture: inspection pictures taken in the field while measuring with FALCON are automatically uploaded to the NESTi4.0 database, available to any user at the analysis step, and printed out automatically in the reports.

Off-Route management
- Machines uploading from FALCON Off-Route mode: machines are automatically created in NESTi4.0 database.
- Merge Off-Route measurements with existing machines.

EAGLE wireless On-line dedicated features

NESTi4.0 NETWORK version provides all features required to manage measurements with EAGLE wireless on-line monitoring system: it provides vibration (1 or 3 axis) and temperature measurement. EAGLE is easy-to-deploy as it eliminates the wiring for each sensor. Monitored data can be supplied to third party system through Modbus TCP.
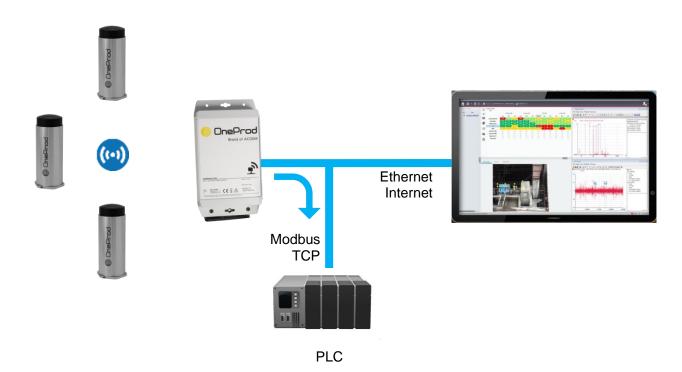
Instrument setup	• Connection with EAGLE gateways • Modbus output address settings

Machine setup	• Measurement strategy
	    o Periodicity for overall levels
	    o Periodicity for spectrum and time wave
	    o Acquisition triggered on aggravating alarm status change
	• Measurement managed by EAGLE: Temperature, Overall vibration velocity and acceleration, spectrum, envelope, time wave
	• Sensor connection.
	• Smart triaxial sensor management based on sensor positioning

Analyst	• Alert counter: this counter shows if some changes have occurred on a machine since last Advice. It is automatically reset if an expert filled in his/her advice tag

Ethernet
Internet

Modbus
TCP

PLC

Assistance to machine setup

NESTi4.0 offers all tools required to perform fast and easy measurement setup. The FALCON automatic diagnosis capabilities, coupled to the NESTi4.0 automatic measurement setup, puts vibration analysis at the grasp of anyone, but NESTi4.0 also offers various productivity tools for expert users.
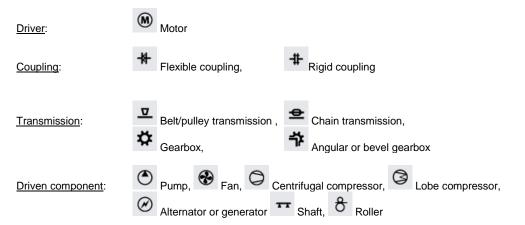
Automatic setup

Accurex mode (automatic diagnosis): The drag & drop tool allows for an easy graphic description of the machine. The measurements required to perform FALCON automatic diagnosis are then automatically generated.

Templates mode: The drag & drop tool allows for an easy graphic description of the machine.
- Visual Health Matrix based manual setup
- The measurement generated can be generated from one or several templates. Templates are supplied by ACOEM and can be fully adjusted by the user.
- Modification on multiple selection of parameters on a machine
- Management of measurement for accelerometer, velocimeter or proximity probes

Triaxial / uniaxial sensor: automatic management of the type of sensor

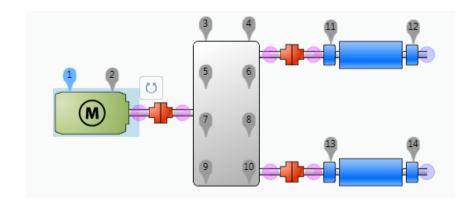**Available components in the drag & drop tool**

Driver: Ⓜ Motor

Coupling: ╫ Flexible coupling, ╫ Rigid coupling

Transmission: ⊻ Belt/pulley transmission , ⊜ Chain transmission, ✿ Gearbox, ⚙ Angular or bevel gearbox

Driven component: ◐ Pump, ✸ Fan, ⊖ Centrifugal compressor, ⊃ Lobe compressor, ⊘ Alternator or generator ┳ Shaft, 8 Roller

Custom component

This type of component is used to create any machines which are not listed above: custom labelling, 1 to 8 bearings, 1 or 2 outputs to connect it to other components.

Machine management

Machine copy / paste: it is very easy to create one or several machines at a time just by simple copy/paste of other machines

Import / Export: Easily share data between several NESTi4.0 databases within the same or different factories

Analysis & diagnosis capabilities

When it comes to analysis and diagnosis, NESTi4.0 is certainly the most productive tool on the market, featuring the unique Health matrix and ACCUREX matrix presentations.

Health Matrix
- The most productive data presentation available on the market for diagnosis purposes. All monitoring and diagnosis indicators are presented into a single matrix view: Measurement locations are presented in columns and parameters in rows with their alarm status. Once alarm thresholds are adjusted, the user can know at a glance if there is a defect and where it is located on the machine.

ACCUREX Matrix
- Diagnosis at a glance: the ACCUREX matrix shows the machine defects and their location at a glance. It is also more than that as it can be used by the expert to publish his own assessment and then automatically generate diagnosis and recommendations in only one click. .

Trending
- Trending capabilities: trends can be displayed on the whole measurement history for each parameter or on the filtered measurement history.
- Several plots can be added on a trend and information related to each plot is displayed.

Standard Parameters
- Scalar data: Running speed, Overall vibration level (acceleration, velocity, displacement), bearing defect factor, Kurtosis, process data (temperature, load, pressure or any other type of data from a DC voltage or keyboard input)
- Dynamic data: vibration data accessible in the health matrix or any other dynamic data (current, pressure, torque, …) displayed in the process data area
- Tri-axial accelerometer: Management of tri-axial measurements for FALCON portable data collector

Type of signals

Spectrum, Zoom, Envelope spectrum, Time waveform, Phased spectrum

ACOEM technology
- Defect factor: Indicator embedding ACOEM expertise and representative of the bearing health condition of the machine
- SFx: Shock Finder index is based on the ACOEM Shock Finder technology. You can see at a glance the location on the machine generating shocks without the need to analyse in detail every time waves
- HMx: Harmonic index indicates if low or medium frequency spectra include significant harmonic families. You can see at a glance the location on the machine generating high level of harmonics without the need to analyse in detail every spectra

Automatic post-processing
- On FFT: Peak amplitude value; Broadband energy calculation
- On Envelope spectrum: Peak amplitude value; Broadband energy calculation
- On phased spectrum: Peak amplitude and phase values
- On time waveforms: Kurtosis, Statistics.
- Parameter combination: +, -, *, /, quadratic sum and difference, AND, OR
- On measurement history: Post-processing indicators can be defined at any time. NESTi4.0 offers the possibility to calculate the value of this indicator on the whole measurement history, thus providing you the ability to trend it over time, even if it has never been measured before.
- Modification of the rotation speed: If the rotation speed was not measured, it can be modified by the expert. All post-processing can be automatically recalculated for the given measurement date, taking into account the adequate rotation speed.
  It is also possible to run manually the Accurex diagnosis to reprocess machines measured with FALCON in case of rotation speed adjustment.
- Relative alarms: Automatic advanced alarms can be post-processed: evolution compared to the previous date, evolution compared to baseline.

Diagnosis-related features
- Expert Recommendation: Summary and free description text to be filled in by the expert, associated to a measurement control date of the machine.
- Expert full diagnosis: Summary and free description text to be filled in by the expert, associated to a measurement control date of the machine.
- Automatic screenshot attachment: Measurement and diagnosis can be illustrated by adding screenshots of the graphic tool by a touch of a button. These pictures are automatically printed out in the reports
- Inspection picture attachment: Inspection pictures can be attached to a control date, either manually by the user or automatically if the measurement is coming from FALCON portable data collector. These pictures are printed out automatically in the reports
- Audio comment: Listen to the FALCON audio comment recorded in situ
- Expert advice tag: Once the analysis is done, the expert can tag the measurement control with his/her advice, which will prevail on the alarm status of the machine according to the type of display selected in NEST: EXCELLENT, GOOD, FAIR, CRITICAL. Each advice tag is represented by a different colour code (GREEN, LIGHT GREEN, ORANGE, RED)

NESTi4.0 Graphic tool capabilities

NESTi4.0 graphic analysis tool offers powerful diagnosis capabilities, leaving the experts with the certainty to have all they need at hand to issue the most accurate diagnosis.

In addition to standard tools, NESTi4.0 users also benefit from dedicated technology relying on years of experience in the field of vibration analysis of rotating machines
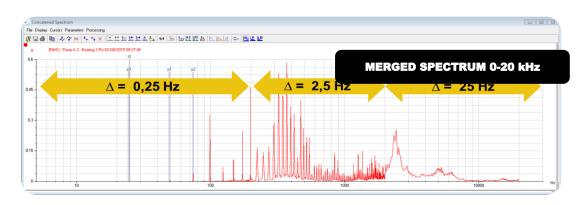
ACOEM dedicated technology
- Merged spectrum: displays for the analysis of a single plot including all spectra from a point with the best resolution (e.g., merging low frequency, middle frequency and high frequency spectra that were basically measured separately).
- Shock Finder Filter: it can be applied manually by post-processing in the NESTi4.0 graphic tool. It embeds ACOEM expertise to highlight the presence of abnormal periodic shocks and reveals mechanical faults at a very early stage.
- Bode Ellipse spectrum: Patented display allowing for reliable critical speed characterization when measuring the run-up / coast-down phase with FALCON
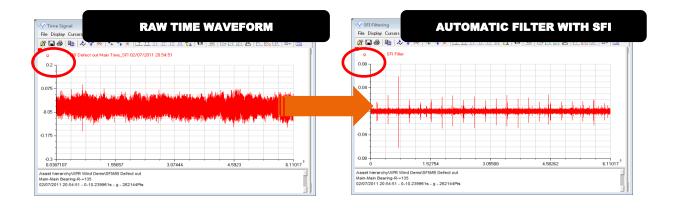
Data comparison
- Baseline: The baseline date can be defined by the user to facilitate the comparison with other data. It can be modified at any time, e.g., after each maintenance operation
- Superposition:
  - o Manual superposition of signals from the same measurement (different measurement location) or from different measurement controls in the history
  - o Automatic superposition with the baseline measurement control date
  - o Automatic superposition with the previous measurement control date
  - o Automatic 3D waterfall view on the measurement history
  - o Quick display of single spectrum from the waterfall view

General display option
- Multiple windows: Each signal is opened in a new window. Superposition is done manually
- Frequency unit: Hz, RPM or Order
- Vibration unit preferences: IS or Imperial
- Cursor customization: Colour, thickness, texture, number of harmonics, number of sidebands, elementary displacement step
- Other settings: Background colour, X and Y gradation grid, gradation numerical format, printer margins
- User notes area: Possibility to add comments on any graph to be printed.

MERGED SPECTRUM 0-20 kHz

RAW TIME WAVEFORM — AUTOMATIC FILTER WITH SFI

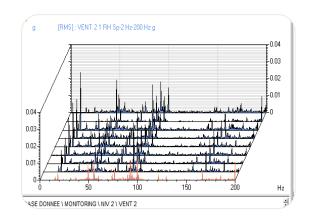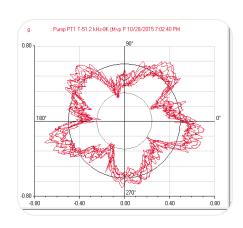|	
FFT	- Cursors: - Simple cursor with indication of frequency and amplitude in 3 units (acceleration, velocity and displacement). - Double cursor with indication of frequency and amplitude of each pointer and their distance. Indication of RMS value between cursors. - Copy/paste function to position other double cursors with the same distance. - Sideband cursor with adjustment of the number of lines - Copy/paste function to position other cursors with the same distance - Multi-cursor mode (several independent single cursors on the same graph) - FFT Display options: - Switch button to select the amplitude of the signal to display (automatic integration or derivation of the signal): acceleration, velocity or displacement - Linear or logarithmic X and Y scales - Frequency in Hz, RPM or Order - Scales: automatic, fixed, zoom - Amplitude in dB, EU or spectral density - Amplitude RMS / Peak / Peak-to-Peak - Post-processing: Cepstrum - Fault frequencies: Automatic prepositioning of expected frequencies of the point or the whole machine. Automatic adjustment by post-processing if the rotation speed is modified. - Bearing frequencies: Automatic prepositioning of bearing characteristic frequencies. Automatic adjustment by post-processing if the rotation speed is modified
Time waveform	- Display options: Standard view, Circular view - Orbit post-processing: 3 modes: unfiltered, harmonic (H1, H2, H3), low pass - Selection of time limits: manual or automatic (number of cycles) - Filter post-processing: High pass, low pass, band pass, band cut, Shock Finder - Auto spectrum post-processing: Automatic spectrum post-processing from the stored time waveform.
Order analysis display*	- Bode diagram: Selection of harmonic 1 to 10 with possible superimposition - Nyquist diagram: Selection of harmonic 1 to 10 with possible superimposition - FFT display: Simple or waterfall - Other type of display: Position (t), Position (RPM), Polar position, Orbit (filtered or not, with or without position), Ellipse spectrum, Ellipse Bode diagram, Waterfall Emax, rotation speed over time * on measurements coming from FALCON Run Up Coast Down
Cross channel analysis*	- Amplitude spectrum - Power spectrum - Coherence function 2/1 and 1/2 transfer functions, Cross-spectrum in modulus, phase, real part, imaginary part - Display on one or two plots - UFF export for structure analysis software * On measurements coming from FALCON FRF module

Data management

Compatibility
- Portable data collector: FALCON
- Online system: EAGLE wireless monitoring system

Backup
- Manual: A database backup makes a full copy of all data within the database.

Data volume limitation
- Manual deletion: Measurement dates can be manually deleted from the history.
- Data protection: Measurement dates of interest are automatically protected to avoid any hazardous deletion

System administration (Network version)

User management
- 5 default user profiles
- Configurable additional profiles
- Access level can be defined per user for each database
- Possibility to use LDAP directory

Encryption
- Possibility to use encrypted communication between server and client workstations

Technical specifications & hardware requirements

Operating system
- Desktop version: Windows 10 64 bits . (For FALCON portable acquisition device only)
- Network version: Windows Server 64 bits 2012 R2, 2016, 2019

Related software component
- Microsoft components: .NET Framework version 4.6.1 is included and installed with NESTi4.0
- Word processor to display DOCX reports (Microsoft Office 2010, LibreOffice, …)
- PDF reader or Web browser to display PDF report and user manual

Computer requirement
- Desktop version: Desktop computer minimal configuration: Intel® Core™ I3 processor or equivalent / RAM 2GB / Hard drive 160 GB, 7200 RPM / 1600x900 display / 1 free USB port.

- Network version:
    - Server minimal configuration: Intel® Core™ I7 processor or equivalent / RAM 8GB / Hard drive 512 GB, 7200 RPM / 1600x900 display / 1 free USB port.
    - Client minimal configuration: Intel® Core™ I3 processor or equivalent / RAM 2GB / Hard drive 160 GB, 7200 RPM / 1600x900 display / 1 free USB port.

Notes:
- These configurations may be upgraded for better performances
- Hard drive size to be adjusted to database size