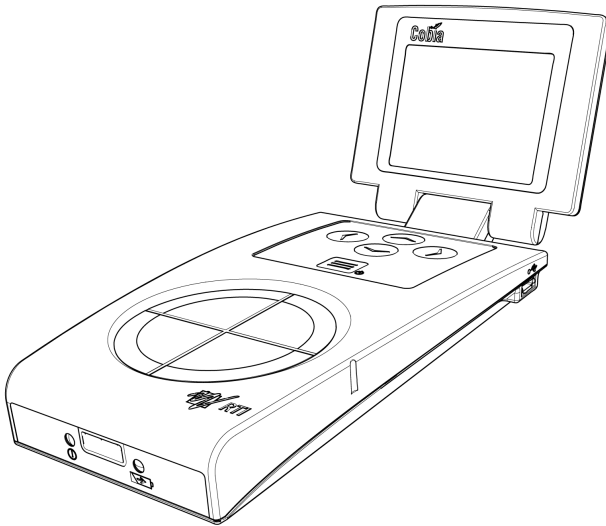# Cobia

Reference Manual - English - v2019.12A

Welcome to the Cobia

The Cobia is an X-ray Analyser/Multimeter for everybody working with Quality Assurance and Service of X-ray systems.

INDEPENDENT X-RAY
QUALITY ASSURANCE

NOTICE

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Contact Information - World Headquarters

RTI Group AB
Flöjelbergsgatan 8 C
SE-431 37 MÖLNDAL
Sweden

Phone: Int. +46 31 7463600

E-mail
Sales: sales@rtigroup.com
Support: support@rtigroup.com
Service: service@rtigroup.com

Web site: http://www.rtigroup.com

Contact Information - United States

RTI Electronics Inc.
33 Jacksonville Road, Bldg. 1,
Towaco, NJ 07082,
USA

Phone: 800-222-7537 (Toll free)
*   Int. +1-973-439-0242*
Fax: Int. +1-973-439-0248

E-mail
Sales: sales.us@rtigroup.com
Support: support.us@rtigroup.com
Service: service.us@rtigroup.com

Web site: http://www.rtigroup.com

Intended Use of the Cobia System

Accessory to diagnostic X-ray equipment to be used as an electrometer. Together with external probes it is to be used for independent service and quality control, as well as measurements of kerma, kerma rate, kVp, tube current, exposure time, luminance, and illuminance within limitations stated below.

If installed according to accompanying documents, the product is intended to be used together with all diagnostic X-ray equipment except for:
- therapeutical X-ray sources.
- X-ray equipment with tube potential below 18 kV.
- X-ray equipment on which the instrument cannot be mounted properly, e.g. equipment where the beam field size is narrower than the active part of the detector.
- specific types of X-ray equipment listed in the instructions for use or in additional information from the manufacturer.

With the X-ray installation in stand-by conditions without patients present, the product is intended to be used:
- to provide the operator with information on radiation beam parameters that might influence further steps in an examination but not an ongoing exposure.
- for assessing the performance of the X-ray equipment.
- for evaluation of examination techniques and procedures.
- for service and maintenance measurements.
- for quality control measurements.
- for educational purposes, authority supervision etc.

The product is intended to be used by hospital physicists, X-ray engineers, manufacturer's service teams, and other professionals with similar tasks and competencies. The operator needs a short training to be able to use the product as intended. This training can be achieved either by careful study of the manual, studies of the built-in help function in measurement software or, on request, in a short course ordered from the manufacturer.

The product is intended to be used inside X-ray rooms ready for clinical use and can safely be left switched on and in any measuring mode in the vicinity of patients.

The product is NOT intended to be used:
- for direct control of diagnostic X-ray equipment performance during irradiation of a patient.
- so that patients or other unqualified persons can change settings of operating parameters during and immediately before and after measurements.

In Germany, the Cobia can also be used for dose measurements in the context of legal metrology (see the German user manual for more information).

Table of Contents

Chapter 1
Introduction

1   Introduction

1.1   About this Manual

This manual is divided into a few main parts.

1.   A general description of the Cobia.
2.   Some theoretical background and basic principles.
3.   Descriptions on performing measurements with the system for different modalities.
4.   Troubleshooting tips and a glossary.

Users who use the Cobia with only a PC and Ocean 2014 are recommended to read at least the following topics:

- Introduction
- Description of the Cobia
- Measurements with the Cobia System

For the Cobia system, calibration data is stored inside the system.

Typographical Rules
Terms in **bold** face are references to texts on screenshots, like buttons and texts, and menu items. Other special terms are *italicized*.

1.2   Introduction to the Cobia

Congratulations to your purchase of a Cobia. You have now in your hand the most user-friendly tool for X-ray analysis. It has been carefully designed to meet the needs of both standard QA applications as well as advanced service/repair/calibration of modern X-ray systems, while still being very simple and intuitive to use. Depending on model, it can measure all the required parameters such as kVp, exposure time, dose, HVL, Total Filtration, dose/pulse, dose rate, tube current, mAs, waveforms, and much more.

To get to know your specific Cobia model, please read the User Manual that was included with your meter. That manual is available in numerous languages.
This manual covers all models of the Cobia. An overview table of the capabilities of the different models are given in section <u>General</u> 30.

The Cobia can be used in different ways:

- All models can be used as a "meter" with the built-in display.
- Some models can be used as a complete "QA-system" together with a PC and the Ocean 2014 software.
- Some models can be used as a measurement device for connecting and obtaining data into your own software (using specified communication protocol)

This manual describes the Cobia by itself. The PC software, Ocean 2014, is described in a separate manual.

The Cobia system's main features are:

- Very easy and intuitive to use
- Accurate
- Active Compensation - No manual corrections are needed
- Automatic measuring modes for pulsed waveforms
- Compact
- USB and Bluetooth interface (some models)
- Free upgrade of firmware
- New and unique design

Free upgrades of the firmware (the software resident in the cabinet and measuring modules) are available on RTI Web site at http://www.rtigroup.com.
If you have questions, comments, or feel that some functionality is missing, you are welcome to contact us at RTI at support@rtigroup.com. You can of course also call or send a fax (see notice section for details).

1.3   Computer Requirements

To run the Ocean 2014 Windows software, there are some requirements. Please see the Ocean 2014 manual for details.

In normal case when the Cobia runs standalone, no computer is required. But if the system of the Cobia shall be updated, a special part of the Cobia that is called Cobia Updater is used. This Cobia Updater requires a computer with the following requirements:

Minimum requirements
Computer with USB port, with support for USB mass storage devices (sometimes called USB stick or USB memory)
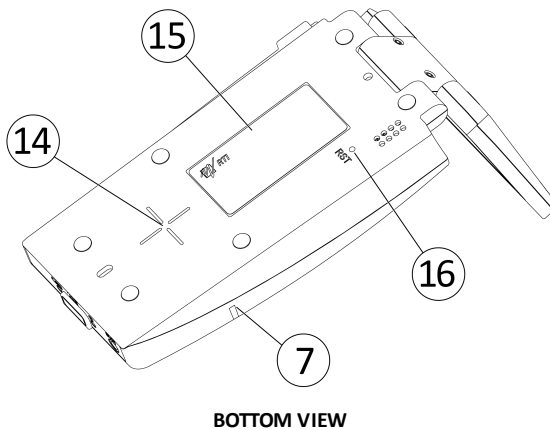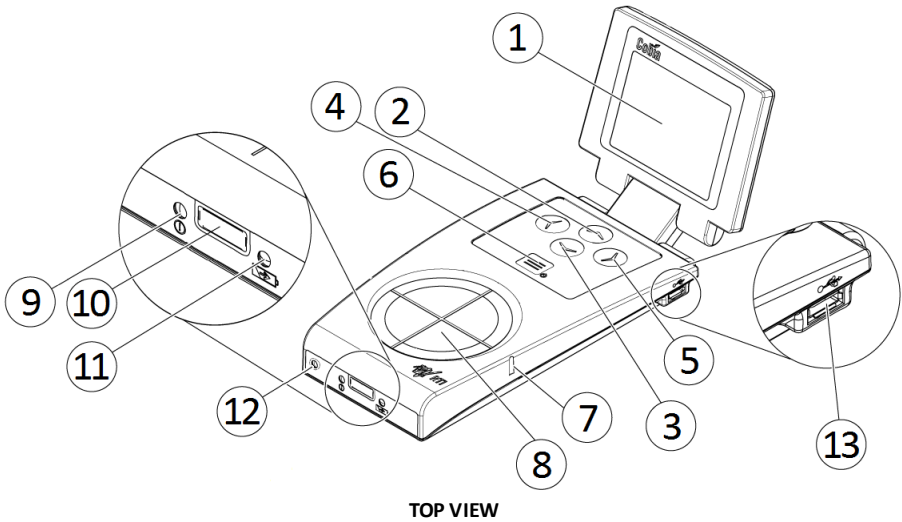Examples: Windows 7 or newer (32-bit, or 64-bit), Apple Mac OS/X, Linux, etc.

Chapter 2
Description of the Cobia

2   Description of the Cobia

2.1   Product Overview

The Cobia comes in a lot of different models, the external design is basically the same for all models (except for the External Probe port).

TOP VIEW

BOTTOM VIEW

#	Name	Description
1	Display	Cobia display. See section *Screen Description* 10
2	Up arrow button	Used to move up in the user interface. See section *Keyboard Operation* 16
3	Down arrow button	Used to move down in the user interface. See section *Keyboard Operation* 16
4	Left arrow button	Used to move left/back in the user interface. See section *Keyboard Operation* 16
5	Right arrow button	Used to move right or make a selection in the user interface. See section *Keyboard Operation* 16
6	Menu and On/Off button	Used to start and power off the Cobia, and display the system menu. See section *Keyboard Operation* 16
7	Positioning marker	Marks the position of the radiation detector's active volume below the measurement surface.
8	Measurement surface	Circular entrance surface for the measurement sensors (some models only)
9	Status indicator	Indicates functional status of the Cobia. It flashes during system start-up and lights up when there is a signal triggering the measurement system
10	External detector input	Used to attach external measurement detectors or probes (some models only)
11	Battery charging indicator	The orange battery charging indicator is lit when the battery is charging. See section *Battery Charging Details* 31 . Note that charging is possible even when the unit is off
12	Optional MAS connector	Used to attach invasive MAS cable (selected models). See section *Connecting the MAS Cable* 23
13	Micro-USB connector	Used both to charge and to connect the Cobia to a computer. See sections *Charging the Battery* 17 , *Updating the System* 59 , and *Communicating with a PC* 44
14	Measurement center marking	Marks the center position of the radiation measurement on the bottom side
15	Product label	Displays detailed information about the product and model (on the bottom side)
16	Reset hole	Used to do a hardware reset of the Cobia. Marked "RST"(on the bottom side)

The **USB port** is used when using Cobia Updater to update the internal firmware. It can also be used when the Cobia Flex or Cobia Sense PC is used together with a PC running the QA software Ocean 2014. The system is then powered from the PC via the USB cable. The PC however have a limited USB power output, so when fast charging is needed the power supply needs to be connected here. This is also possible when using the Bluetooth link to communicate with a computer. The port is marked with the **USB** symbol ( ).

Below block diagrams of the different Cobia models are shown.
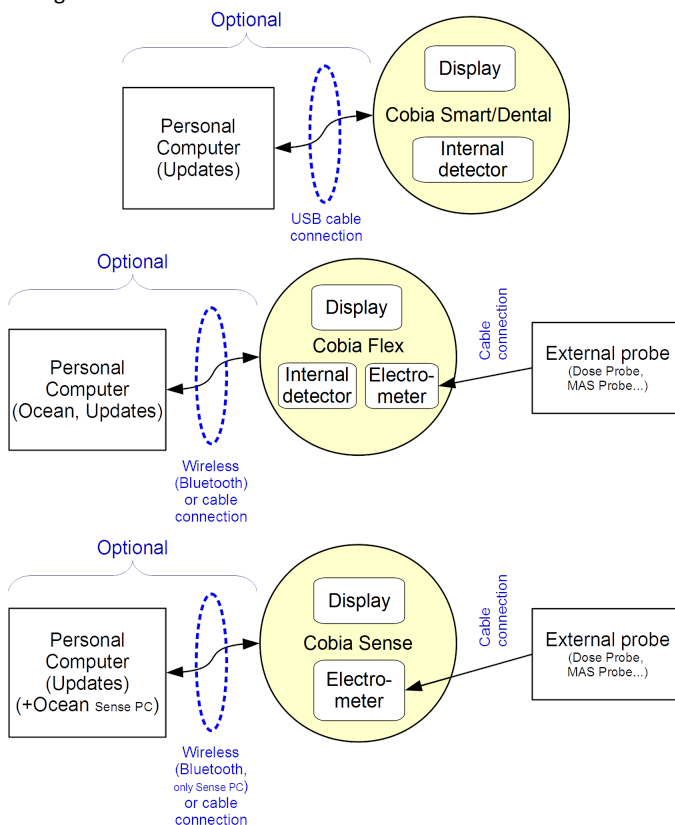
2.1.1 User Interface

2.1.1.1 Screen Description
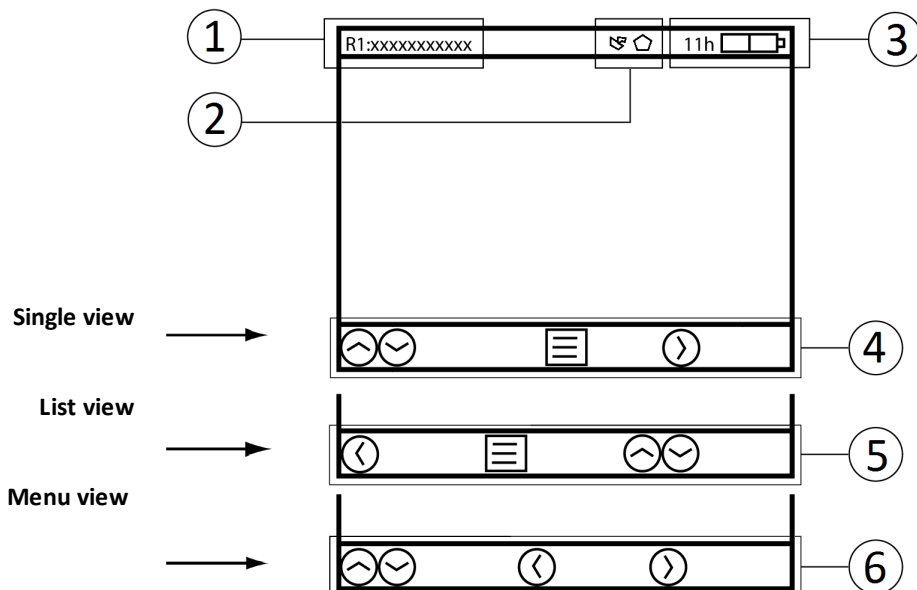
A status field is displayed at the top of the screen. The left side of the field shows the Radiation or Measurement Quality Code and a description of the active range (1). The middle part of the field displays icons for when an external detector and/or internal MAS cable is attached as well as warning symbols for when any settings are set to non-standard values (2). The right side of the field displays an icon for power supply and an indicator for the battery level (3). See section Screen Indicators 12 for details.

A simple user guide is displayed at the bottom of the screen. For each view, the buttons that are functional in this view are shown, together with a short text or symbol describing the function of the buttons (4-6).
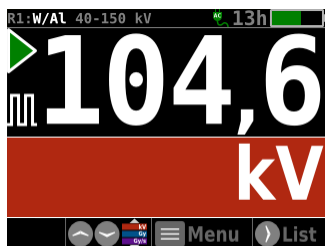
Single view

In the Single view, only one active parameter is displayed, represented by the value and its unit. Each unit is shown by a specific color. Pressing the up/down arrow buttons ⌃/⌄ will change the active parameter. When using the internal tube current socket (MAS) or an external detector (EXT), a

corresponding indicator will appear in the leftmost side of the unit field (not shown).

Note! The shown parameters may vary depending on the model of the Cobia. The example picture shows a tube voltage measurement with Cobia Flex R/F kV & Dose.

Located to the left of the value, two symbols may be visible:

1A. A play symbol (triangle) is visible during the measurement. It is filled (green) during the radiation detection, and will then stay contoured while the Cobia accepts continued measurement during the *Restart Delay*.

1B. When using the optional parameter cycling, a rotating indicator will appear just above the play symbol when the cycling is in progress.

2. A pulse indicator is shown below the play symbol. This indicator is turned on when pulses are detected, resulting in the display of additional pulse parameters.
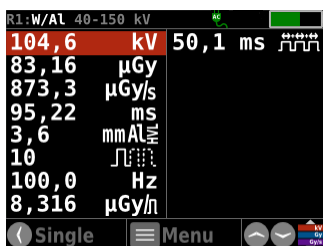
List view
In the List view, all the available parameters are shown simultaneously. The active parameter (displayed in the Single view) is indicated in color. If a measurement is started when the Cobia is in the List view, the display will switch to the Single view during the measurement

and then return to the List view after completion. For models with external input, parameters from MAS or EXT are marked accordingly.

Note! The available parameters may vary depending on the model of the Cobia and attached detectors. The example picture shows a pulsed measurement with Cobia Flex R/F kV & Dose.

Main Menu view
The Menu view displays a set of available functions, selected by pressing the right arrow button ◗. *Reset Measurement* zeroes and resets the measurement. *Prev. Measurements* recalls the results of earlier measurements (see section for a detailed description).
Settings is for viewing and modifying the measurement settings. *Preferences* is for viewing and adjusting personal preferences. Any setting change that can affect the measurement results will be shown in the status field (top of screen). *System Info* gives detailed information about the Cobia, needed during support. *Power Off* turns the Cobia off. When using an external detector or probe, there will be an extra menu item, *Ext.Detector*, that displays detector information and settings as described below. See section for a graphical overview.

EXT AC 11h

Select Calibration
▶R1 W/3 mm Al
 R2 W/23 mm Al
 R5 RQR

Type: Dose Probe
S/N: 13021234

◗ Back   ◗ Select
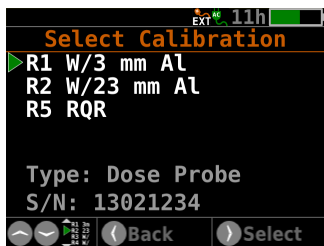
Select External Detector Calibration
When an external detector containing more than one calibration is connected to the Cobia, a selection screen will be shown (left).
For later calibration changes, the selection screen is also available via the Menu ☰.

2.1.1.2   Screen Indicators

Below is an overview of all on-screen symbols and what they mean.
See also section <u>Error & Display Messages</u> 27 for details relating to the measurement results.

Top Of Screen Status Icons

AC	The external power supply is attached (fast charging).
USB	The Cobia is powered from a PC via USB (or non-compliant power supply).
EXT	An external detector is attached to the EXT connector (some models).
MAS	An external MAS cable is attached to the MAS connector (some models).
EXT + MAS	Both external detector and MAS cable are attached.
D W !	The user has changed measurement settings that can affect the result.
AMX4	The user has selected AMX-4 kV setting.
kVp AUTO	The user has selected Auto tube voltage setting.
kV PPV	The user has selected PPV tube voltage setting.
⚠	A measurement value was measured with reduced accuracy, but can be manually corrected for normal accuracy (see <u>Manual Energy Correction, Cobia</u> 38 or the RTI Dose Probe manual).

Trig and Screen Cycling Indicators

The system has trigged and is actively collecting data.

The system has trigged off and is ready to continue the same measurement (Restart delay is running).

The system is still ready to continue the same measurement (Restart delay is running), but it has started the parameter cycling, indicated by a rotating symbol.

The system has ended the measurement and cannot continue the same measurement (Restart delay is over), but it continues with the parameter cycling, indicated by the rotating symbol.

The system has ended the measurement and the parameter cycling.

Pulse Indicator

To the left of the measurement figures on the single view screen, a symbol is lit when the Cobia detects at least 3 pulses in the waveform.

Signal Source Indicator

To the left of the unit field on the single view screen and to the left of each parameter data on the List view screen, a symbol will indicate the source of the parameter. Cobia If no symbol is shown, the parameter originates from the internal detector.

The parameter is measured from the detector attached to the EXT input.

The parameter is measured from the detector attached to the MAS input.

Unit Symbols

Symbol for pulse, for instance dose per pulse.

Symbol for pulse width (parameter P11).

Symbol for duty cycle (parameter P12). In pulsed waveform the percentage the waveform is above 50 % per cycle.

Symbol for effective time (parameter P13). For a pulsed waveform the total time the waveform is above 50 %.

Symbol for number of pulses (parameter P7). For a pulsed waveform the total number of pulses/frames in the waveform.

2.1.1.3 Menu Overview
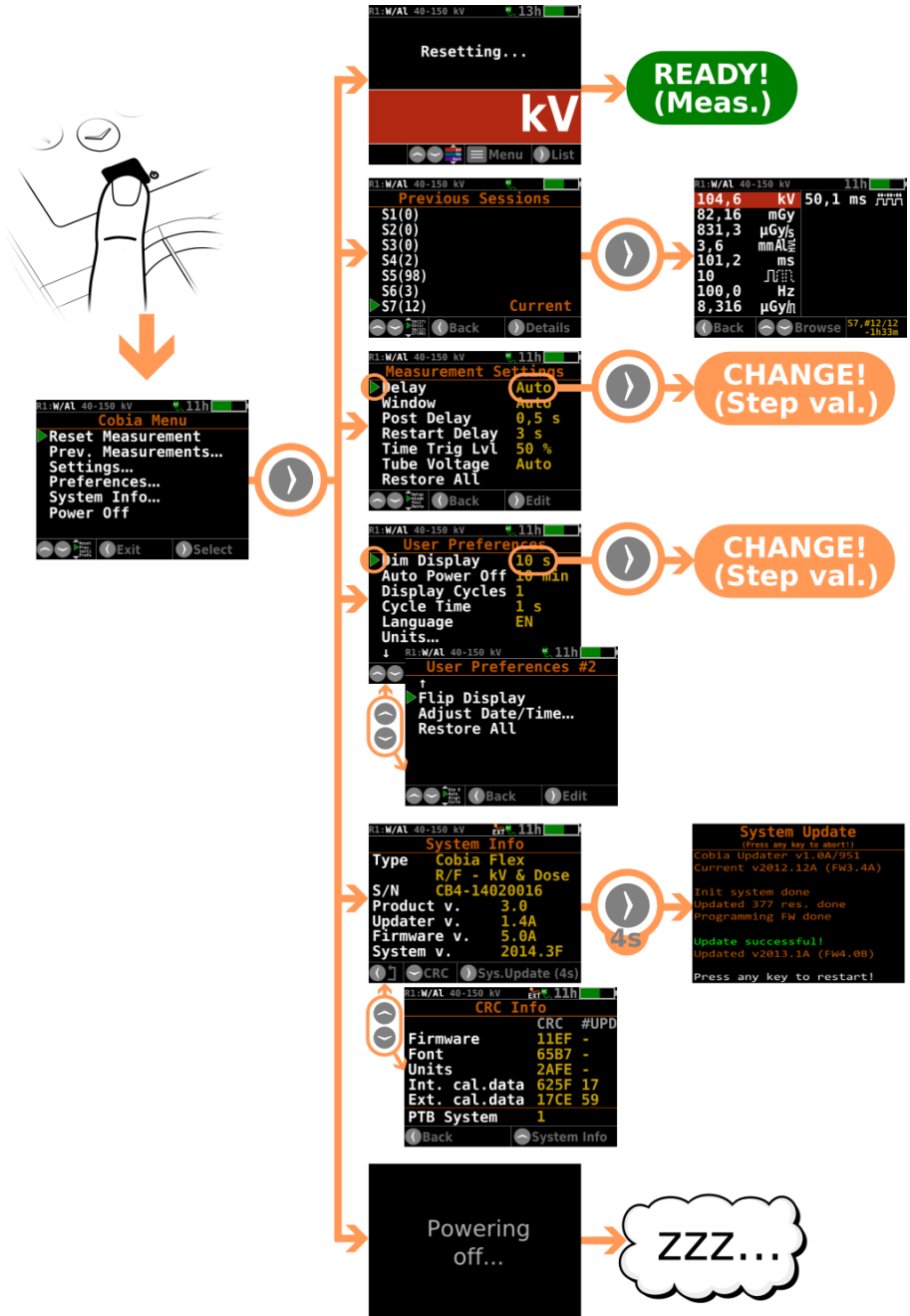
For a Cobia where an external detector is attached, another menu item will appear. There you can read the data for that detector and change radiation quality (if more than one are available).

2.1.1.4 Keyboard Operation

1

Menu and On/Off button
If Power = Off: Press once to start the Cobia
If Power = On: Press once to display the menu. Press and hold to switch off the Cobia
In Menu view: Closes the menu

2-3

Up and Down arrow buttons
In Single view: Changes the active parameter shown
In List view: Changes the highlighted (active) parameter
In Menu view: Moves the marker

4

Right arrow button
In Single view: Switches the display to the List view
In Menu view: Activates the marked menu item
In the Settings or Preferences menus: Changes the set value (displayed in yellow) or activates the menu item

5

Left arrow button
In List view: Switches the display back to the Single view
In Menu view: switches the display back to the previous menu or screen

2.1.1.5 Previous Measurements

On the main menu you can access your old measurement data.
The function displays the 7 last sessions containing up to 99 measurements per session.

Every time the Cobia is started a new session is created, unless the last session was empty (no empty sessions). The oldest session is then automatically deleted.
Every time you perform a measurement the measurement is automatically saved. This is done after the Restart delay, i.e. when the triangle disappears.
For light measurements, however, there is a special save button.

The details of viewing a previous measurement is given below.
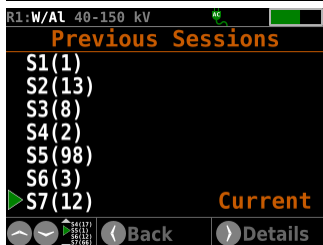
Previous sessions view

You enter the function through *Prev. Measurements* on the Menu view.

The first screen then displays a list of the available sessions. The last one (S7) is always the current session. To view the measurement details, choose the desired session as highlighted by the arrow and enter with the right arrow button ◗.
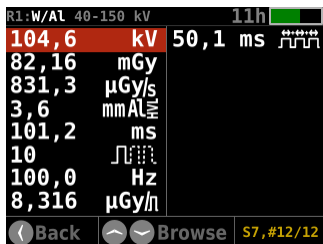
Previous measurements view

This screen looks like a normal *List view*, with the difference that in the rightmost bottom corner the session and measurement number are shown. The measurement numbers are in chronological order, so the highest number is always the last measurement within the active session.

You can step between the measurements with the up and down arrow buttons ◓◒, or go back to the Previous session screen using the back arrow button ◖.

Note! If you enter the menu while a measurement is not entirely finished, the measurement is aborted, and not saved to Previous measurements.

2.2 Setting Up the Cobia for the First Time

Before you use your Cobia for the first time, please do the following:

- Attach the external power supply.

- Charge the system for 16 hours.

Then continue according to the following section.

2.3 Getting Started

2.3.1 Before Starting the Cobia for the First Time

Before using the Cobia for the first time, make sure the unit is charged. See *Charging the Battery* 17.

2.3.2 Charging the Battery

The battery can be charged in two ways:

- Via the USB cable connected to a PC.
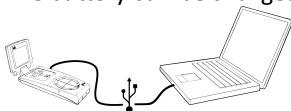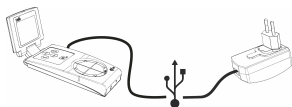
- Via the USB cable connected to the included external charger. This is the fastest way of charging.

These charging methods are indicated by two separate screen indicators. See section Screen Indicators 12. For charging and typical running times, see section Power & Communication Specifications 32.

2.4 Performing a Measurement

2.4.1 Measuring with the Internal Detector

The pictures below show how to position the Cobia in different types of X-ray units.
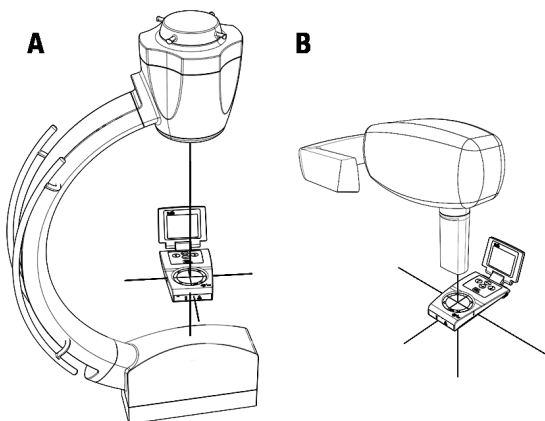
A = Radiography X-ray unit   B = Dental X-ray unit

1. Start the X-ray unit.
2. Prepare the X-ray unit for the testing of desired settings.
3. Start the Cobia.
4. Select the beam quality if needed. See the section Select Beam Quality.
5. Place the Cobia under the X-ray source at a clinically relevant distance (typically 50 - 100 cm from the source).
6. Make sure that the radiation field covers (at least) the entire Cobia detector surface.
7. Start an exposure.
8. When the measurement is over, the recorded values are by default cycled on the Cobia display. Press the right arrow button to go to the List view for an overview.
9. Compare the parameters displayed by the Cobia with the test settings for the X-ray unit.
10. Record the results.
11. To repeat, adjust the settings and start over from Step 6.

Note!
The Cobia internal detector area is circular, which means that it does not need to be orientated in any particular direction related to the anode/cathode axis. It will automatically give an error if the field is too uneven. This may happen if the unit is very close to the tube and the tube voltage is 70 kV or higher. In that case try to increase the distance to the tube or move it to position where the heel effect is less strong (typically towards the cathode side).

Recommended field size is 80×80 mm.

2.4.2   Measuring with a General External Detector

The description below describes how to use an external detector with the Cobia Sense or Flex.

1. Start the X-ray unit and start the Cobia.
2. Set up the external detector unit. For an external dose probe, place the detector at a clinically relevant distance (typically 50 - 100 cm from the source), as described by the manual of the detector.
3. If not already attached, attach the external detector (shown below). For the Sense model you will be requested to attach it with the following screen.

4. If needed, select among the available calibrations (shown below).
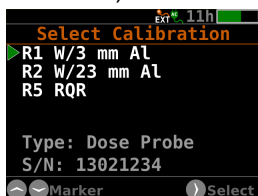
5. Adjust the X-ray unit to the desired settings.
6. Start an exposure (or other signal).
7. When the measurement is over, the recorded values are by default cycled on the Cobia display. Press the right arrow button ❱ to go to the List view. All measurement results from the external input are marked with an EXT symbol.
8. Record the results.
9. To repeat, start over from Step 6.

Below follows descriptions of handling of special probes.

2.4.3 Measuring with a Light Probe

In-depth instructions on how to use a Light Probe are found in the separate Light Probe manual.

Attach the light probe monitor adapter (pictured below, left) for measuring the luminance of a monitor or light box, or the lux adapter (below right) for measuring illuminance (ambient light).

Position the probe in the desired location and read the result.

When using the luminance adapter, the recorded value is automatically saved to the log function when using the shutter button. For illuminance measurements, the down arrow button ⬇ has to be pressed for a value to be saved to the log.

Please note that there is no need to perform a reset before using the Light Probe.

More information is available in the guide for *Measuring with an External Detector* 21 .

The importance of cleaning and care of the Light probe is described in Product Note, PN_Acc_002_RTI Light Probe Cleaning Instructions.

2.4.4 Measuring with the Optional Internal MAS

The description below describes how to use the optional internal MAS cable with the Cobia + MAS model.

CAUTION!	Users of Invasive mAs meters must be aware of the potential damage to generators and electrical hazards to human in the event of improper connection or failure of any part of the meter circuit. The Cobia MAS is intended for use only by those skilled in the calibration and repair of X-ray machines. Please read the section *Tube Current Safety Precautions* 24 for more safety rules.

1. Prepare the unit that is to be tested.
2. Connect the Cobia MAS Cable, as described in the section *Connecting the MAS Cable* 23 .
3. The tube current parameters are added to the List view, as shown below.

4. Start an exposure.
5. When the measurement is over, the recorded values are by default cycled on the Cobia display. Press the right arrow button ◑ to go to the List view. All measurement results from the internal MAS input are marked with an MAS symbol (shown below).
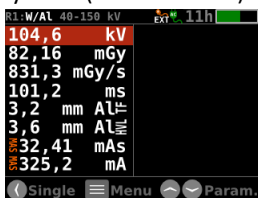
6. Record the results.
7. To repeat, change the settings and start over from Step 5.

2.4.4.1 Connecting the MAS Cable

Please be aware that high voltage may occur if the mAs probe is not properly connected. Read the *Tube Current Safety Precautions* 24 section before starting the measurement.

1. Power down the X-ray generator and wait for the recommended amount of time to allow for generator discharge according to the generator manufacturer's specifications.
2. Remove the jumper from the mAs measuring socket of the generator.
3. Connect the Cobia MAS Cable to the mAs measuring socket using the safety cables included, observing the polarity (see picture below). If necessary, use the adapters included.
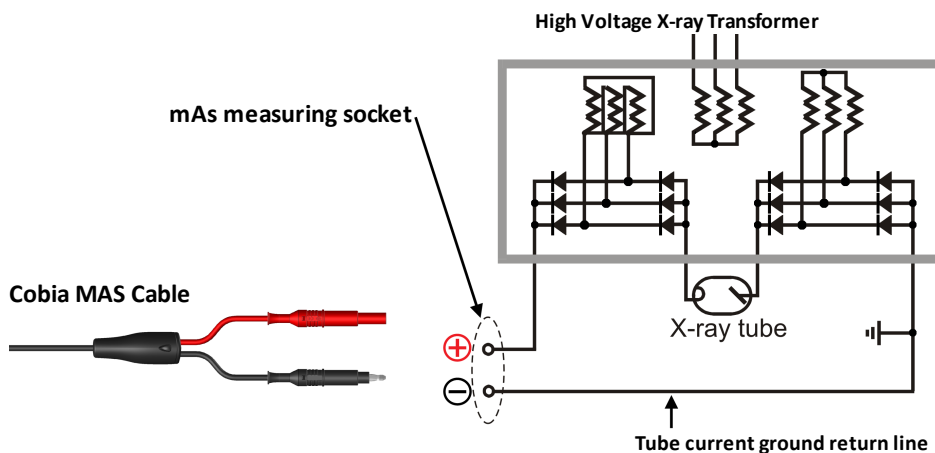
4. Connect the other end of the Cobia MAS Cable to the MAS input of the Cobia.

> **Caution!**
> Do not forget to replace the mAs socket jumper when removing the
> Cobia MAS Cable.

2.4.4.2 Tube Current Safety Precautions

Only use the Cobia Internal MAS if you are authorized and skilled to make invasive measurements using the X-ray generator mAs measuring socket.

Please be aware that high voltage may occur on the Cobia Internal MAS if the cable connection to the X-ray generator mAs socket is broken. Always wait approximately one minute after switching off the X-ray generator before connecting or disconnecting the cables between the Cobia Internal MAS and the mAs measuring socket.
Always check that the short circuit path (jumper) normally connected to the mAs measuring socket is reapplied after using of the Cobia Internal MAS and before the X-ray generator is switched on again.
Important!

- Do NOT connect the Cobia Internal MAS to the filament current circuitry. The Cobia Internal MAS is only intended for measuring the tube mA and mAs.
- Do NOT use the Cobia Internal MAS in contact with a patient.
- Do NOT use the Cobia Internal MAS on a circuit with a voltage higher than 90 V DC or 600 V AC.
- Do NOT expose the instrument to direct sunlight, extremes of temperature and humidity, or dew fall.
- Do NOT exceed the maximum tube current input (1000 mA).

> **Note!**
> The Cobia Internal MAS is intended for the servicing and quality control of diagnostic X-ray equipment. It is not intended for use during diagnostic examinations of patients.

RTI Group AB takes no responsibility for the misuse of the Cobia Internal MAS or use together with products that the Cobia Internal MAS is not intended for.
RTI Group AB assumes no responsibility in the event of customers not following these safety precautions.

2.4.5   Measurement Settings

Here general measurement settings for the Cobia are shown. You will find these setting by pressing the menu button, as described in section <u>Menu Description</u> 15 .
For an graphical overview of the settings, see section <u>Waveforms and Triggers</u> 62 .

Delay   The delay time defines how long time the Cobia shall wait before starting to measure kVp after that radiation has been detected. Default value is always "Auto" which means that the delay normally will be 5 ms. If the measurements is very short however, the delay will automatically be shortened to 0 ms.

Available settings are: Auto (default), 0 ms, 2 ms, 5 ms, 10 ms, 50 ms, 100 ms, 200 ms, 500 ms, 1000 ms, and 2000 ms.

Window   This gives the possibility to define a fixed time that Cobia measures kVp after that the delay time has expired. Default value is always "Auto" which means until trig off.

Available settings are: Auto (default), 5 ms, 10 ms, 50 ms, 100 ms, 200 ms, 500 ms, 1000 ms, and 2000 ms.

Post Delay   The post delay time defines how long time the Cobia shall wait until it starts displaying the measurement values. Default value is 250 ms. The post-delay may be needed when measuring on units with some kind of pre-pulse or for pulsed exposures.

Available settings are: 0 s, 0,25 s (default), 0,5 s, 1 s, 2 s, 4 s, and 6 s.

Restart Delay   The restart delay time defines how long time the Cobia shall "look for more" after detecting what can be considered to be "the end of the exposure".

Available settings are: 0,1 s, 3 s (default), 6 s, and 15 s.

Trig level (time) Here you can set the level used for irradiation time measurements. "Trig level (time)" (TL) is normally set to 50 % of the peak waveform (S_{PEAK}), but can be set to 2 (low), 10, 25, 50 (default), and 75 %. The irradiation time is then calculated as the end time minus the start time.

- The start time is the first time the signal goes above $TL{\times}S_{PEAK}$.

- The end time is the last time the signal goes below $TL{\times}S_{PEAK}$.

See example below.
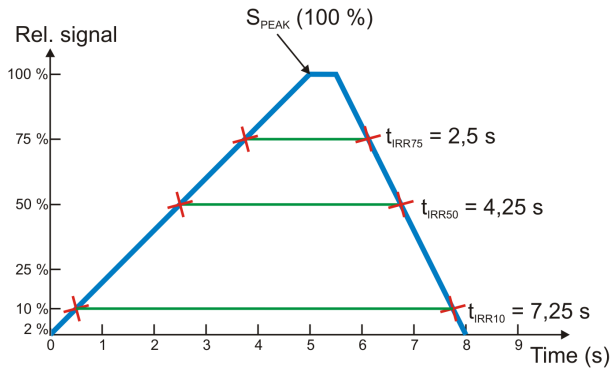
kV Mode   This is used to set the kV mode for the Internal detector.
The mode can be set to: Auto (default), kV (PPV), and AMX-4.

- Auto - Depending on signal level, kVp (if signal enough) or kV (PPV)

- kV (PPV) - Always PPV

- AMX-4 - Special mode for GE unit, see below.

AMX-4

The difficulties when measuring tube voltage on a GE AMX-4 is a well-known problem. Due to high kV ripple at a frequency of 2 kHz it is hard for most non-invasive kVp-meters to follow the kV waveform correctly.

This waveform type has an agreement with measurements made with the Keithley Triad System 37946C mobile filter pack (50-135 kV), which is the only filter package recommended by GE. According to GE, the use of the standard Keithley 37617C W-R filter pack (50-150 kV) is not good enough. The results have further been verified with measurements with a traceable high voltage divider that has sufficient bandwidth to accurately follow the kV ripple from the AMX-4.
Therefore it is important to select the **AMX-4** waveform (as shown above).
More about the AMX-4 correction can be found in the Application Note 1-AN-52020-1 from RTI.

2.4.6   Error & Display Messages

If you get an error message, you can just measure again to get a new result. There is no need to perform a reset for a new measurement.
See below for tips if you get the same error.
If you want to clear the display, please do a **Reset** to clear the message.

Measuring Error

Measuring Error
1. The tube voltage and filtration could not be calculated. This can be caused by too low signal or too low/high filtration/tube voltage. Adjust one of them and try again.
2. You may also get this error message for really short measurements, if the auto-range function of the Cobia cannot handle the signal. The the error will disappear if you make a longer measurement or lower the signal.

Negative Signal

Negative Signal
The electrometer module detects a negative signal.

- Most common is that the mAs-probe have been connected in the opposite direction on the HV cable. Please change the polarity of the current probe to correct the problem.
- Also small negative drift created from the detector source, typically initially after reset can give this message. Special care should be taken when using ionization chambers, since it may take a few minutes before the initial drift of the electrometer and detector has stabilized.

Too Low Signal

Too Low Signal
The Cobia detects a signal but it is too low to present a reliable result.

- Increase the output, i.e. mA and/or decrease the distance from X-ray tube to detector.

Too High Signal

Too High Signal
One or several detectors have too high signal.

- Lower the set sensitivity under settings.
- Reduce the mA and/or increase the distance from tube to detector.

Too Low Voltage

Too Low Voltage
Measured tube voltage is lower than that of the selected kV-range.

- Change to a lower kV-range.

Too High Voltage

Too High Voltage
Measured tube voltage is higher than that of the selected kV-range.

- Change to a higher kV-range.

Too Low Filtr.

Too Low Filtration
Measured TF or HVL is lower than the low end of the available range, so no kV/TF can be calculated.

- Increase the filtration, by adding a filter in the beam.

Too High Filtr.

Too High Filtration
Measured TF or HVL is higher than the high end of the available range, so no kV/TF can be calculated.

- Decrease the filtration, by removing filter material in the beam.

Too Low Frequency

Too Low Frequency
The frequency of the waveform is lower than the low end of the available range, so no pulse frequency can be given.

Too High Frequency

Too High Frequency
The frequency of the waveform is higher than the high end of the available range, so no pulse frequency can be given.

Exposure < Delay

Exp. < Delay
The exposure time is too short compared to the delay time. This can only happen if the user manually has changed the *Delay* setting from the default value of "Auto".

- Increase the exposure time and/or reduce the values of delay and/or window time.

Too Long Exposure

Too Long Exposure
The time of the measurement is above the high end of the available range, so no time can be given.

Field Error

Field Error
The radiation signal on the detector area is not even enough. The most common reason for this is that the detector area is only partially irradiated, the detector is tilted, or the filtration differs (e.g. heel effect).

- Remove blocking obstacles.
- Increase field size

- Change the field size or move the detector into the central beam.

Repeat Exposure
When exposure time is too short to display a reliable value, the Cobia adjust settings if possible and then asks to repeat the exposure. For the repeated exposure the Cobia will display a reliable value if possible.

Warnings and other display symbols

If you get this warning triangle in front of the measurement value it means that the parameter is shown with reduced accuracy. For instance, if no kV/TF could be found, the Cobia will display uncorrected dose and dose rate values, but mark them with this triangle. Then you can manually make the energy corrections according to the table in section Manual Energy Correction, Cobia 38.
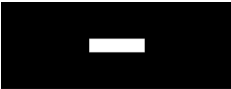
Not Available
This display is shown if there is no value available for this parameter.

Wait for value...
This display is shown during the measurement if the value is calculated after trig off (no value yet).

This character is shown if an illegal character is used. Please contact RTI.

2.5   Hardware and Specifications

Specifications are valid after a warm-up time of one minute and presuming reference conditions. All specifications for external detectors are for use together with the Cobia unless otherwise stated. All specifications can be changed without prior notice. RTI Group AB assumes no responsibility for any errors or consequential damages that may result from the misuse or misinterpretation of any information contained in these specifications.

2.5.1   Parameter IDs

Below is a list of all possible parameters and the parameter ID used by the communication protocol and in the specifications. It also list the possible source of the parameter, INT = the internal detector, MAS = the MAS connector, EXT = the external detector connector.
The actual number of available parameters depends on the model of your Cobia, the art of the measurement, and what kind of external probes you have with your meter.

ID	Parameter	Possible Source
P1	Tube voltage	INT
P2	Dose	INT/EXT
P3	Dose rate	INT/EXT
P4	Total filtration (TF)	INT
P5	Half Value Layer (HVL)	INT
P6	Irradiation time	INT/MAS/EXT
P7	Number of pulses	INT/MAS/EXT
P8	Pulse frequency (Hz)	INT/MAS/EXT
P9	Dose /pulse	INT/EXT
P10	Doserate /pulse	INT/EXT
P11	Pulse width	INT/MAS/EXT
P12	Duty cycle (% high per cycle)	INT/MAS/EXT
P13	Effective time	INT/MAS/EXT
P14	Tube charge (mAs)	MAS/EXT
P15	Tube current (mA)	MAS/EXT
P16	Tube charge/pulse	MAS/EXT
P17	Tube current/pulse	MAS/EXT
P18	Luminance (cd/m2)	EXT
P19	Illuminance (lux)	EXT
P20	Dose length product	EXT
P21	Dose length product rate	EXT
P22	Dose area product	EXT
P23	Dose area product rate	EXT

2.5.2   Cobia Internal

2.5.2.1   General

With the Cobia internal detector you will manage most of your measurements. Tube voltage, irradiation time, dose, and dose rate are measured for conventional radiography, fluoroscopy, pulsed fluoroscopy, cine, dental and panoramic dental. In one exposure, the detector provides tube voltage, time, dose, dose rate, estimated total filtration, and quick-HVL. On pulsed radiation and cine, also dose per pulse, doserate per pulse, effective time, and pulse rate are measured. The Cobia internal detector is very sensitive and can measure peak tube voltage for as low outputs as 50 kV / 0.2 mA at 50 cm. The exact parameters depends on the Cobia, as shown in the table below.

Cobia type	Model	Article number	Tube voltage (kV) (P1)	Dose (P2)	Doserate (P3)	Total Filtration (P4)	Half Value Layer (P5)	Time (P6)	# Pulses (P7)	Pulse rate (P8)	Dose/pulse (P9)	Doserate/pulse (P10)	Pulse width (P11)	Duty cycle (P12)	Effective time (P13)	Tube current (P14)	Tube charge (P15)	Tube curr./pulse (P16)	Tube ch./pulse (P17)	Luminance (P18)	Illuminance (P19)	Dose length (P20)	Dose length rate (P21)	Dose area (P22)	Dose area rate (P23)	Dose profile support	Internal MAS support	External RTI probe support	USB/Bluetooth communication	Ocean support
Smart R/F	kV & Dose	9661003	INT	INT	INT	INT	INT	INT	INT	INT	INT				INT														×	×
Sense	Sense PC	9663002		EXT				EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	Ocean		×	×	×
Flex R/F	kV & Dose	9662003	INT	I/E	INT	INT	INT	INT	I/E	I/E	I/E	I/E	I/E	I/E	I/E	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	Ocean		×	×	×
	kV & Dose + MAS	9662004	INT	I/E	INT	INT	INT	ALL	I/E	I/E	ALL	ALL	I/E	I/E	ALL	E/M	E/M	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	Ocean	×	×	×	×
Dental Intraoral/ CBCT	kV & Dose	9664003	INT	INT	INT	INT	INT	INT	INT	INT	INT				INT														×	×
	kV & Dose + EXT	9664013	INT	I/E	INT	INT	INT	I/E	I/E	I/E	I/E	I/E	I/E	I/E	I/E	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	Ocean		×	×	×
	kV & Dose + MAS + EXT	9664014	INT	I/E	INT	INT	INT	ALL	I/E	I/E	ALL	ALL	I/E	I/E	ALL	E/M	E/M	EXT	EXT	EXT	EXT	EXT	EXT	EXT	EXT	Ocean	×	×	×	×

Legend	
×	Included
INT	With internal detector (only)
EXT	With optional external detector (only)
MAS	Internal MAS (using invasive cable)
I/E	Internal or external
I/M	Internal or internal MAS
E/M	External or internal MAS
ALL	Internal, external, or internal MAS
Ocean	Requires Ocean software

Typically the measurement time has to be at least 5 ms to get a kVp value but it depends on the waveform. On modern X-ray generators (high-frequency with fast rise and fall times) the peak tube voltage can normally be measured with times as short as 1 ms. Dose and time values will be given for even shorter times.

The estimations of total filtration and Quick-HVL are done from one single exposure using a combination of detector and filters in the Cobia. In situations when the total filtration cannot be automatically estimated, a "standard" HVL measurement may be required. All measured kVp and dose values measured with the Cobia are automatically compensated for the actual beam/radiation quality. This means that no manual corrections of measured data is needed.

2.5.2.2   Power & Communication Specifications

Power Source

Power supply	1. 5 V External power supply connected via Micro-USB cable 2. Micro-USB cable from PC (slower charging, see table below) 3. Internal battery
Battery operation	One 2000 mAh Li-Ion battery. Operation time typically 15 hours. Typical charging times are listed below.
External power	100-240 V AC 50/60 Hz with external adapter.

The section describes how the Cobia battery is charged. On the front face of the Cobia, there is an orange battery charging indicator, marked . The indicator is lit when the battery is actively charging. It will gradually turn

off when the battery is getting closer to being fully charged. Charging is also possible when the Cobia is powered off.

Typical Battery Charging and Running Times

Capacity	Running time	Charging time		
		Using Power supply	USB, Cobia OFF	USB, Cobia ON
50 %	7½ h	1½ h (90 min)	3½ h	17 h
80 %	12 h	2½ (150 min)	6 h	27 h
90 %	13½ h	3¼ h (195 min)	7 h	30 h
100 %	15 h	5 h (300 min)	8½ h	32 h

Communication

USB CDC (virtual serial port)	Max 12 Mbit/s (USB v2.0)
Bluetooth SPP (serial port profile)	recommended 230 kbit/s

Battery Warnings

Warnings are shown when the battery is starting to run low (see below). After the second warning, the system can suddenly shut down due to an empty battery.
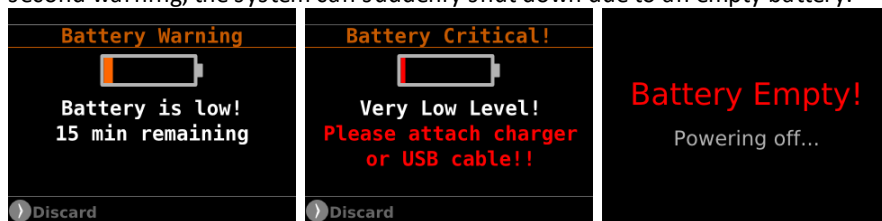
2.5.2.3   Specifications, Cobia

The inaccuracy is here defined as the root of the square sum of systematic errors, which has not been eliminated, and random errors (dispersion around a mean value). The calculation of the inaccuracy is based on 15 different measurements and with a confidence level of 95 %. Of the total inaccuracy, random error is 20 % and general inaccuracy is 80 %.
Note: Irradiation time is often called exposure time in daily use.

General

Operating temperature and relative humidity	15 − 35 °C at <80 % relative humidity
Storage temperature	−10 °C to +50 °C
Operating air pressure	Minimum 80 − 106 kPa
PTB Type-certification ID	DE-15-M-PTB-0005 (Valid for all Cobias measuring Dose)
Source to Detector Dist.	>30 cm

Reference Conditions

Temperature	+20 °C
Relative humidity	50 %
Air pressure	101.3 kPa
X-ray field size	Outside the Cobia circular label. Calibration is done with field size typically 10 mm wider than the size of the circular label.
Radiation quality	W target, 70 kV, 2.5 mm Al

Note: The reference conditions are given in reference to the IEC61674 standard.

Physical Dimensions

Detector area	Ø49 mm
Dose detector position	8 mm below the circular marking of the top panel, as indicated in figure below and by depth markings on the 2 long edges.
Size	140 × 78 × 28 mm (5.5" × 3.1" × 1.1")
Weight (approx.)	Flex: 280 g Smart & Dental: 275 (or 280) g Sense: 225 (or 280) g
Screen	LCD 230 × 240 pixels, LED backlight, 36.7 × 49 mm (2.4"), 350 cd/m²
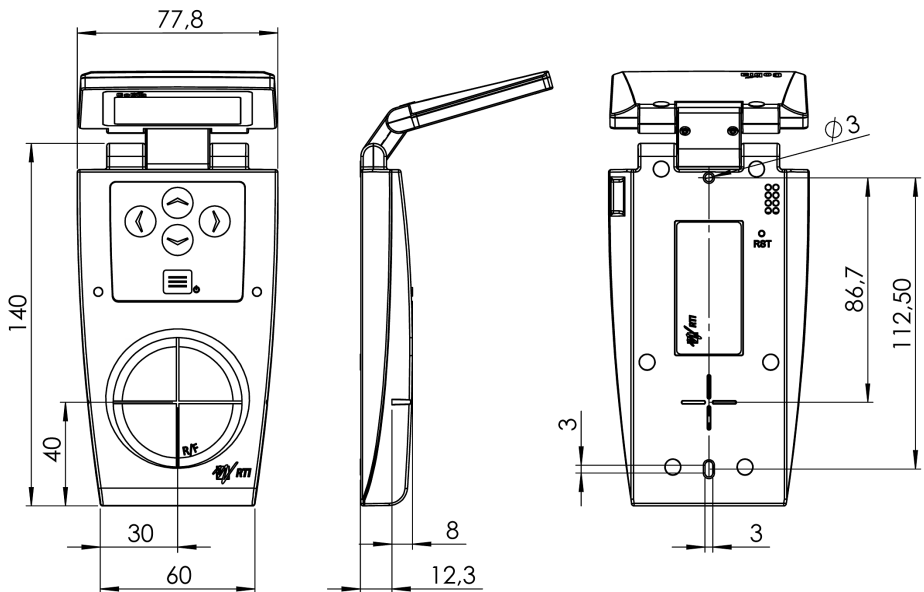
All figures are in millimeters.

Main Parameters and Waveforms

Tube voltage (kV) (P1)	The average of all samples. Used at lower signal levels and when the signal contains no ripple. (default method)
Tube voltage (kVp) (P1)	Sum of all peak samples over a certain level (typically 97 %) and 100 % of max. (used when ripple and the signal is high enough)
Air kerma (Dose) (P2)	Measured air kerma (may be called dose or air kerma in this manual)
Air kerma rate (Dose rate) (P3)	Average air kerma rate (may be called dose rate or air kerma rate in this manual)
Total Filtration (P4)	Estimation of total filtration
Quick-HVL (P5)	Estimation of Half Value Layer (for conventional radiography, fluoroscopy, and dental)
Half Value Layer	Standard HVL using filters for evaluation on radiography, fluoroscopy, and dental (all for both pulsed and conventional)
Time (P6)	Irradiation time (Exposure time)
kV waveform (P1)	Waveform is calculated based on detector signals measured after different thickness of filtration.
Dose rate waveform (P3)	Signal measured from radiation detector (ionization chamber or solid-state detector).

Note 1: The actual parameters available, depends on the Cobia Model, see section <u>General</u> 30.

Measuring range and inaccuracy

Radiography, Fluoroscopy, and Dental - Basic Parameters

Parameter	RQ	Range	Inaccuracy	Resolution
kVp Smart/Flex (P1) W / 3 mm Al	R1	38 – 155 kV	±2 %	4 digits (10 or 100 V)
kVp Dental (P1) W / 3 mm Al	R1	45 – 105 kV	±2 %	As above
Irradiation time (P6)		0.33 ms – 9999 s	±1 % or ±0.33 ms	0.01 ms (1/3 ms < 1 ms)
Minimum irradiation time		0.1 ms	Min display value 0.33 ms	
Air kerma (Dose) (P2)		70 nGy – 1700 Gy 600 nGy – 1700 Gy (PTB) 8 μR – 200 kR	±5 %	0.2 nGy 0.02 μR
Air kerma rate (P3) (Dose rate)		2.5 μGy/s – 175 mGy/s [2, 4] 0.3 mR/s – 20 R/s 17 mR/min – 1.2 kR/min	±5 % or ±25 nGy/s ±5 % or ±2.5 μGy/s ±5 % or ±0.15 mR/min (for Irr. time >20 ms)	50 nGy/s 5 μR/s 0.3 mR/min Typ. noise (1 s): ±10 nGy/s WF@3kSa/s : ±9 μGy/s
Minimum triggable air kerma + rate		67 nGy and 25 μGy/s or 110 nGy and 2.5 μGy/s	-	-
Estimated total filtration (P4)		1.0 – 90 mm Al (full kV range)	±10 % or ±0.3 mm ±15 % >50 mm Al (HF/DC, >10 μGy/s)	2 digits (0.1 or 1 mm)
Quick-HVL (P5)		1.2 – 14 mm Al [3] (50 – 150 kV)	±10 % or ±0.2 mm (HF/DC, >10 μGy/s) [1]	3 digits (0.01 or 0.1 mm)
Auto-Compensation	All dose parameters are automatically compensated for using measured kVp and TF over their specified ranges.			

Note 1: This is valid for a tube with 14° anode angle. The HVL for a 22° anode is typically 0,5 mm lower (@ 80 kV, 3 mm TF).
Note 2: The Kerma rate is calculated as the Kerma (Dose) divided by the Irradiation time. See also <u>Waveforms and Triggers</u> [62].
Note 3: The HVL range is valid if also the TF is within its specified range. For high TF at high kV the HVL range may be limited by this.
Note 4: At exposure time below 5 ms the maximum dose rate is limited to 17 mGy/s.

Radiography, Fluoroscopy, and Dental - Pulse Parameters

Parameter	Range	Inaccuracy	Resolution
Number of pulses (P7)	3 – 9999 pulses	±1 pulse	1 pulse
Pulse frequency (P8)	1/6 – 260 Hz	±1 %	0.01 Hz
Dose/pulse (P9)	10 nGy/pulse - 600 mGy/pulse [1] 1.1 μR/pulse - 66 R/pulse	±5 %	0.2 nGy/pulse 0.02 μR/pulse

Parameter	Range	Inaccuracy	Resolution
Dose rate/pulse (P10)	Same as for air kerma rate	±5 %	See air kerma rate (P3)
Pulse width (P11) Effective time (P13)	0.33 ms – 6 s	±1 % or ±0.33 ms	0.01 ms
Duty cycle (P12)	2 - 100 %	±1 %	0.1 %
Minimum pulse width	pulse width (min. dose rate) 1.33 ms (10 µGy/s) / 0.33 ms (40 µGy/s)		
Minimum ripple for pulse detection (pulse top to bottom)	50 %		

Note 1: Max dose/pulse depends on the pulse length.
Note 2: All kerma and kerma rate ranges, inaccuracy, and resolution figures are valid for product version 2 and higher of the Cobia.

Sampling Rate and Waveform Recording Time

Waveform Recoding Time (s)	Sampling Rate (Hz)	Resolution (ms)	Comment
7	3 000	1/3 (333 µs)	**Max sampling rate**
14	1 000	1	
24	500	2	
45	250	4	
88	125	8	
130	83.33	12	**Minimum sampling rate**

Note! Waveforms and thus the setting for *Waveform recording time* is only available from Ocean PC software or by using the external communication protocol (see Cobia Communication Protocol 44). For the Cobia this setting never affects the Irradiation time calculation as may happen in previous products.

- Cobia Internal MAS, Invasive mAs cable

Module type	Range	Inaccuracy	Resolution
Tube charge (P14)	0.1 mAs – 999 As	±1 % (for time > 0.1 ms)	0.01 mAs
Tube current (P15)	1 – 930 mA	±1 % or ±0.1 mA (for time >100 ms)	0.1 mA
Charge/pulse (P16)	0.01 mAs/p – 999 As/p	±1 %	0.001 mAs/p
Pulse tube current (P17)	1 – 930 mA/p	same as tube current.	0.1 mA/p
Time (P6) $_1$	0.33 ms – 9999 s	±1 % or ±0.33 ms	0.01 ms (1/3 ms)
Pulses (P7)	3 – 9999 pulses	±1 pulse	1 pulse
Minimum pulse time	0.1 ms	-	-

Note 1: When the Cobia internal detector or external dose detector is used simultaneously, the default mode of operation is to use that detector for time measurement.

Note 2: The tube current is calculated as the tube charge divided by the time. See also Waveforms and Triggers 62.

2.5.2.4   Typical Response, Cobia

The table below shows the typical response for the Cobia at standardised radiation qualities.

Radiography, Fluoroscopy, and Dental (measured using RTI RQ Code R1, W/Al)

Radiation quality	Mean energy air kerma (keV)	Total Filtration (mm Al)	Air kerma measurement	
ISO 4037 IEC 61267			HVL (mm Al)	Factor kQ (Rel. RQR 5)
RQR 2	26,38	2,49	1,42	1,004
RQR 3	29,14	2,46	1,77	0,997
RQR 4	32,14	2,68	2,19	0,998
RQR 5	34,84	2,83	2,57	1
RQR 6	37,88	2,99	3,01	1,001
RQR 7	41,1	3,18	3,48	1,005
RQR 8	44,33	3,36	3,96	1,007
RQR 9	50,86	3,73	5,00	1,011
RQR 10	61,47	4,38	6,55	1,020

Note: These values are typical values measured at PTB in Germany in 2014.

Radiation quality	Mean energy air kerma (keV)	Total Filtration (mm Al)	Air kerma measurement	
ISO 4037 IEC 61267			HVL (mm Al)	Factor kQ (Rel. RQA 5)
RQA2	30,22	6,49	2,2	0,980
RQA 3	38,02	12,5	3,74	1,006
RQA 4	45,02	18,7	5,32	1,003
RQA 5	51,27	23,8	6,73	1
RQA 6	57,71	29,0	8,12	1,007
RQA 7	63,27	33,2	9,21	1,006
RQA 8	68,57	37,4	10,10	1,020
RQA 9	78,83	43,7	11,59	1,025
RQA 10	94,32	49,4	13,23	1,014

Note: These values are typical values measured at PTB in Germany in 2014.

2.5.2.5   Manual Energy Correction, Cobia

If the Cobia cannot measure tube voltage and total filtration, the dose values from the internal detector are left uncorrected. This is indicated by the yellow triangle ⚠. This can happen at very low dose rates.

The user can then manually correct the dose values from the internal detector by multiplying with the corresponding value from the table below.

Radiography, Fluoroscopy, and Dental (measured using RTI RQ Code R1, W/Al)

Tube voltage (kV)	Total filtration (mm Al)															
	1	2	3	4	6	8	11	15	20	28	35	50	60	70	80	90
35	1,164	1,117	1,070	1,034	0,984	0,957	0,932	0,925	0,929	0,950	0,957	0,976	0,995	1,000	1,013	1,025
40	1,146	1,099	1,052	1,018	0,973	0,958	0,939	0,935	0,939	0,960	0,970	0,990	1,003	1,016	1,030	1,043
45	1,120	1,078	1,037	1,001	0,966	0,956	0,944	0,942	0,948	0,972	0,984	1,006	1,021	1,036	1,051	1,066
50	1,092	1,055	1,018	0,991	0,961	0,956	0,952	0,950	0,960	0,990	1,002	1,022	1,036	1,049	1,063	1,077
55	1,069	1,039	1,010	0,983	0,958	0,955	0,957	0,958	0,973	0,999	1,020	1,041	1,055	1,069	1,082	1,096
60	1,052	1,028	1,004	0,980	0,956	0,958	0,961	0,965	0,986	1,014	1,031	1,057	1,074	1,091	1,108	1,125
70	1,028	1,011	1	0,979	0,957	0,966	0,980	0,990	1,010	1,033	1,056	1,091	1,114	1,137	1,160	1,183
80	1,018	1,010	1,003	0,985	0,971	0,984	1,009	1,022	1,045	1,079	1,101	1,138	1,162	1,187	1,211	1,236
90	1,015	1,014	1,010	0,995	0,990	1,005	1,042	1,052	1,079	1,123	1,148	1,189	1,220	1,244	1,271	1,298
100	1,016	1,020	1,024	1,015	1,013	1,033	1,074	1,087	1,114	1,169	1,205	1,247	1,275	1,303	1,331	1,359
110	1,020	1,031	1,041	1,033	1,032	1,060	1,102	1,124	1,155	1,215	1,265	1,311	1,342	1,373	1,404	1,434
120	1,028	1,043	1,055	1,052	1,056	1,088	1,138	1,158	1,196	1,266	1,315	1,378	1,419	1,461	1,503	1,544
130	1,034	1,052	1,066	1,073	1,080	1,114	1,161	1,194	1,236	1,317	1,369	1,440	1,488	1,535	1,583	1,630
140	1,040	1,060	1,080	1,093	1,107	1,140	1,200	1,229	1,274	1,363	1,431	1,504	1,553	1,602	1,651	1,699
155	1,052	1,075	1,100	1,120	1,141	1,185	1,239	1,278	1,337	1,450	1,527	1,601	1,660	1,699	1,749	1,798

Note! This is only for energy compensation of the Cobia internal detector. For external detectors, like the RTI Dose Probe, see their respective manuals.

2.5.3 Cobia External Probes

The inaccuracy is here defined as the root of the square sum of systematic errors, which has not been eliminated, and random errors (dispersion around a mean value). The calculation of the inaccuracy is based on 15 different measurements and with a confidence level of 95 %. Of the total inaccuracy, random error is 20 % and general inaccuracy is 80 %.

Note: Irradiation time is often called exposure time in daily use.

Reference conditions

Temperature	+18 °C to +23 °C
Relative humidity	50 %
Air pressure	101.3 kPa
Radiation quality	W target, 70 kV, 2.5 mm Al

Note: The reference conditions are given in reference to the IEC61674 standard.

General

Connector type	Hirose ST40X-10S with built-in detector identification.

Measuring range and inaccuracy

The resolution is the maximum display resolution.

- RTI External Dose Probe (typical sensitivity +55 µC/Gy)

Parameter	Range	Inaccuracy	Resolution
Air kerma (Dose) (P2)	6 nGy – 2 kGy 660 nR – 250 kR	±5 % (for time > 0.1 ms)	0.02 nGy 2 nR
Air kerma rate (Dose rate) (P3)	220 nGy/s – 220 mGy/s [3] 540 nGy/s – 78 mGy/s (PTB) 25 µR/s – 25 R/s 1,5 mR/min – 1,5 kR/min 90 mR/h – 90 kR/h	±5 % or ±10 nGy/s ±5 % or ±1 µR/s ±5 % or ±60 µR/min ±5 % or ±3,6 mR/h (valid for Irr. time >20 ms)	2 nGy/s 0.2 µR/s 0.01 mR/min 1 mR/h Typ. noise (1 s): ±1 nGy/s WF@3kSa/s : ±0.7 µGy/s
Minimum triggable air kerma + rate	6 nGy and 2.2 µGy/s or 9 nGy and 0.22 µGy/s	-	-
Irradiation time (P6)	0.33 ms – 9999 s	±1 % or ±0.33 ms	0.01 ms (1/3 ms < 1 ms)
Minimum irradiation time	0.1 ms	Min display value 0.33 ms	
Pulses (P7)	3 – 9999 pulses	±1 pulse	1 pulse
Pulse rate/frequency (P8)	1/6 – 260 Hz	±1 %	0.01 Hz
Pulse width (P11) Effective time (P13)	0.33 – 6 s	±1 % or ±0.33 ms	0.01 ms
Duty cycle (P12)	0.02 – 100 %	±1 %	0.001

Note 1: The air kerma rate is calculated as the air kerma divided by the time. See also Waveforms and Triggers 62.
Note 2: The standard calibration for the RTI External Dose Probe is W/23 mm Al. This calibration was chosen since the main use of the detector is to measure the dose to the image intensifier, after the phantom. However, you can just as well use this probe for measurements of skin dose. The detector is very linear in its energy response and will not be affected much by different filtration.
Note 3: At exposure time below 5 ms the maximum dose rate is limited to 2 mGy/s.

Pulses

Parameter	Range
Dose/pulse (P9)	1 nGy/pulse - 3 kGy/pulse [1]
Pulse dose rate (P10)	Lower limit 10 µGy/s (70 mR/min), otherwise same as for air kerma rate.
Minimum ripple (pulse top to bottom)	50 %

Note 1: Max dose/pulse depends on the pulse length.

Sampling Rate and Waveform recording time

At max sampling rate	7.000 s (3 kSa/s)

For more details of available times, please see section Specifications, Cobia 36 (internal detector).

Typical Response

The table below shows the typical response for the RTI External Dose Probe at standardized radiation qualities.

Radiation quality	Mean energy air kerma (keV)	Total Filtration (mm Al)	Air kerma measurement	
ISO 4037 IEC 61267: 2005-11			HVL (mm Al)	Factor kQ (Rel. RQR 5)
RQR 2	26,38	2,49	1,42	1,087
RQR 3	29,0	2,46	1,77	1,044
RQR 4	32,0	2,68	2,19	1,013
RQR 5	34,8	2,83	2,57	1
RQR 6	37,8	2,99	3,01	0,993
RQR 7	41,0	3,18	3,48	0,988
RQR 8	44,2	3,36	3,96	0,986
RQR 9	50,8	3,73	5,00	0,986
RQR 10	61,2	4,38	6,55	1,002

Note: These values are typical values measured with Piranha at PTB in Germany in 2009 and verified with Cobia in 2015.

- RTI T20 Dose Probe (typical sensitivity +8 µC/Gy)

Parameter	Range	Inaccuracy	Resolution
Air kerma (Dose) (P2)	40 nGy – 15 kGy 4.6 µR – 1700 kR	±5 % (for time > 0.1 ms)	0.1 nGy 10 nR
Air kerma rate (Dose rate) (P3)	1.5 µGy/s – 1.5 Gy/s 170 µR/s – 170 R/s 10 mR/min – 10 kR/min 0.6 R/h – 600 kR/h	(valid for Irr. time >20 ms) ±5 % or ±50 nGy/s ±5 % or ±5 µR/s ±5 % or ±300 µR/min ±5 % or ±18 mR/h	10 nGy/s 1 µR/s 0.05 mR/min 3 mR/h
Irradiation time (P6)	0.1 ms – 9999 s (display 0.33 ms –)	±1 % or ±0.33 ms	0.01 ms (1/3 ms)
Pulses (P7)	3 – 9999 pulses	±1 pulse	1 pulse
Pulse rate/frequency (P8)	1/6 – 260 Hz	±1 %	0.01 Hz
Pulse width (P11) Effective time (P13)	0.33 – 6 s	±1 % or ±0.33 ms	0.01 ms
Duty cycle (P12)	0.02 – 100 %	±1 %	0.001

Note 1: The air kerma rate is calculated as the air kerma divided by the time. See also Waveforms and Triggers 62 .

- RTI MAS-1 Probe, Invasive mAs probe (sensitivity 1 nC/mAs)

Module type	Range	Inaccuracy	Resolution
Tube charge (P14)	0.001 mAs – 999 As	±1 % (for time > 0.1 ms)	0.001 mAs
Tube current (P15)	0.1 – 3000 mA	±1 % or ±10 µA (for time >100 ms)	0.01 mA
Pulse tube current (P17)	Lower limit 1 mA, otherwise same as tube current.	Same as tube current.	0.01 mA
Time (P6) $_1$ (P7)	0.1 ms – 9999 s 3 – 9999 pulses	±1 % or ±0.33 ms ±1 pulse	0.01 ms (1/3 ms)

Note 1: When the Cobia internal detector is used simultaneously, the default mode of operation is to use the internal detector for time measurement.
Note 2: The tube current is calculated as the tube charge divided by the time. See also <u>Waveforms and Triggers</u> 62.

- RTI MAS-2 Probe, Non-invasive mAs probe (sensitivity 1 nC/mAs)

Module type	Range	Inaccuracy	Resolution
Tube charge (P14)	0.1 mAs –	±5 % (for time > 0.1 ms)	0.01 mAs
Tube current (P15)	10 – 4000 mA	±5 % or ±2 mA (for time > 20 ms) (±3 % at 250 mA)	1 mA
Pulse tube current (P17)	Lower limit 50 mA, otherwise same as tube current.	Same as tube current.	1 mA

Note 1: The MAS-2 will only work if the Cobia internal detector is used simultaneously.
Note 2: See also note 1 and 2 for the RTI MAS-1.

For Cobia Internal MAS, please see <u>Specifications, Cobia</u> 36.

- RTI Light Probe, Light detector (typical sensitivity 67 pA/(cd/m²) or 167 pA/lx)

Module type	Range	Inaccuracy	Resolution
Luminance (P18)	0.2 – 180 000 cd/m²	±5 % or ±0.04 cd/m²	0.01 cd/m²
Illuminance (P19)	0.08 – 70 000 lx	±5 % or ±0.02 lx	0.005 lx

- CT-DP, CT Dose Profiler (typical sensitivity 3.6 μC/Gy)

Module type	Range	Inaccuracy	Resolution
Air kerma (Dose) (P2)	80 nGy – 33 kGy 9 μR – 3.8 MR	±5 % ±5 %	0.2 nGy 0.02 μR
Air kerma rate (Dose rate) (P3)	3.3 μGy/s – 3.3 Gy/s 0.4 mR/s – 380 R/s 23 mR/min – 23 kR/min 1.4 R/h – 1350 kR/h	±5 % or ±0.3 nGy/s ±5 % or ±1.6 μR/s ±5 % or ±0.1 mR/min ±5 % or ±6 mR/h	0.02 μGy/s 2 μR/s 0.1 mR/min 0.01 R/

2.6   Cobia Communication Protocol

The following describes the communication protocol for the Cobia with firmware version 5.9A. This communication protocol is available in all models of Cobia Flex and in the Cobia Sense PC model (not Cobia Sense). For an overview of the capabilities in the different models, see section <u>General</u> 30.

2.6.1   General

The basic principle for the Cobia communication protocol is that a **command** (including possible additional parameters) is passed to the Cobia from the connected computer. The Cobia then sends a **reply** (one or more) back to the computer.
If the Cobia did not manage to interpret the command or the parameters were correct an error is given as reply.
If the reply from the Cobia to the command given takes some time to compute or is the result of an external action that can happen later, the Cobia first (immediately) sends back an acknowledgment of the command and later the normal reply.

The exact details of the **commands** and **replies** are given in the coming sections.

Commands and parameters may only contain printable characters with ASCII value 32-125 and is case-sensitive.

2.6.2   Use Cases

The following use cases have been considered for the design of the Cobia Communication Protocol:

- The user must be able to connect to the Cobia Flex or Cobia Sense PC from a computer.

- After a measurement, the user must be able to retrieve all the data values to be displayed.

- All settings that can affect the measurement result is to be retrieved.

- The user must also be able to download an instantaneous value of the dose rate from external detector.

- Data should easily be integrated into the user's own program.

- The system can be shut off (quiescence) via the command interface.

- The user must be able to control "everything" that you normally do with the keypad.

The following requirements have been raised for the design of the Cobia Communication Protocol:

- The customer must be able to connect to the Cobia Flex or Cobia Sense PC from any computer via USB and Bluetooth.

- If possible, use the serial communication also via USB (CDC).

- A response is always sent to the same route that the command came through.

- Data (response of Cobia) are transferred as plain text in a modern, simple and easily interpreted format, XML.

2.6.3 Requirements

The following requirements apply:
- The Cobia can be controlled via a virtual COM port over either USB or Bluetooth.
- For USB under Windows, a special CDC driver needs to be installed (included in the update package that can be downloaded from the RTI web page www.rtigroup.com).
- For Bluetooth, the computer Bluetooth driver must support a virtual COM port (SPP/Serial Port Profile).
- For the communication port or terminal software, the following settings are needed:
  Data bits=8, Stop bits=1, No parity (8N1)
  Bit rate: recommended is 230 400 b/s or higher
  Flow control: hardware (RTS/CTS)

2.6.4 Command Structure

[CobiaC-DDDDCCCC-ZZZ]

where:

DDDD = ID (this ID is sent back in the reply). Always 4 characters (each 0-9 or A-F). If you do not use this, please set it to 0000.
CCCC = CRC16 checksum in Hex format. If you do not use, please set it to XXXX. With this the Cobia can verify that nothing was corrupted during the transfer.
ZZZ = command (case sensitive) – see list below
optional parameters are separated by a semicolon.

A reply is always sent. If no data is to be returned, OK is sent.

2.6.5 Reply Protocol, Simple

<CobiaR CobiaC="PPP" ID="SSSS" CRC="TTTT">XXXX</CobiaR>

where:

PPP = command incl. optional parameters.
SSSS = ID (this is the same set of characters as included with the command that trigged this reply). 4 chars (each 0-9 or A-F).
TTTT = checksum CRC16 in hexformat for the complete reply message (supported from FW v5.5 and above).
XXXX = The actual reply data.

A reply is always sent. If no data needs to be answered or the reply takes longer time than "at once", i.e. it takes more than 50 ms to send the data, a reply with OK only is sent. The end of the reply is always terminated with CR + LF (0x13 0x10)

2.6.6 Reply Protocol, Multi-line

<CobiaR CobiaC="PPP" ID="SSSS" CRC="">
<P1 src="int" unit="V">VV</D1>
<P3 src="int" unit="Gy">XX</D2>
…

<CRC2>TTTT</CRC2>
</CobiaR>

where:

PPP = command (including possible parameters belonging to the command)
SSSS = ID (this is the same set of characters as included with the command). 4 characters.
TTTT = CRC16 checksum in Hex format for the entire reply message (supported from firmware v5.5 and above).
VV = Parameter P1 data
XX = Parameter P3 data, etc.

Replies to a command are always sent, see the simple reply above. All the rows in the reply is always terminated by CR + LF (0x13 0x10), as well as the last row.

2.6.7 Parameter IDs

All communication protocol parameters are referenced through their parameter ID. You will find a full list of all parameters and their IDs in section . There you can also see the possible source of the parameter.
The actual number of available parameters depends on the model of your Cobia (see section), the art of the measurement, and what kind of external probes you have with your meter.

2.6.8   Reply Protocol, Errors

If the Cobia model does not support PC communication all commands, except SystemInfo, gets the following reply:

<CobiaR CobiaC="PPP" ID="SSSS" CRC="TTTT">CommSupportError!</CobiaR>

If the command structure is correct (ie, "[CobiaC *]", but the command does not exist, the following reply is sent:

<CobiaR CobiaC="PPP" ID="SSSS" CRC="TTTT">CError!</CobiaR>

If the command structure and the command is correct but the parameter is not recognized, the following reply is sent:

<CobiaR CobiaC="PPP" ID="SSSS" CRC="TTTT">PError!</CobiaR>

If the CRC of the command is incorrect, the following reply is sent:

<CobiaR CobiaC="PPP" ID="SSSS" CRC="TTTT">CRCError!</CobiaR>

If a command does not begin with "[CobiaC*]", the following reply is sent:

<CobiaR>CError!;Type "[CobiaC-0000XXXX-List]" for help.</CobiaR>, as described in section List of Commands 48.

Error/Warning/Message in data attribute (when fetching data)

Attribute and value	Internal Code	Description
Error="1"	EC01	Error: General measurement error
Error="2"	EC02	Error: Measuring error! Repeat exposure
Error="3"	EC03	Error: Too Low Signal
Error="4"	EC04	Error: Too High Signal
Error="5"	EC05	Error: Too Low Voltage
Error="6"	EC06	Error: Too High Voltage
Error="7"	EC07	Error: Too Low TF/HVL
Error="8"	EC08	Error: Too High TF/HVL
Error="9"	EC09	Error: Too Low Frequency
Error="10"	EC0A	Error: Too High Frequency
Error="11"	EC0B	Error: Exposure < Delay
Error="12"	EC0C	Error: Too Long Exposure
Error="13"	EC0D	Error: Field Error/Reposition Detector
Error="14"	-	Error: No waveform data available
Warning="1"	EF9D	Warning: Manual energy correction needs to be performed
Warning="10"	-	Warning: Samples missing in waveform.
Message="1"	EC1F (...)	Message (for P11, P12, P13): No calculated data for the measurement (yet).
Message="2"	EC1E (-)	Message (for P11): No valid data for the measurement.

Attribute and value	Internal Code	Description
Message="3"	-	Message: No parameter data available
Message="4"	-	Message (for pulse parameters): No pulses detected (no pulse related data available)

Error/Info when connecting the external detector

Error Type	Code	Description
Detector Error	ED01	Error: Read error! Please try again
Detector Error	ED02	Error: Detector data corrupt!
Detector Error	ED03	Error: Detector not supported, system update needed!
Detector Error	ED04	Error: Detector type not supported!
Detector Error	ED05	Error: Detector data missing!
Detector Error	ED06	Error: No calibration data!
Detector Error	ED07	Error: Detector data too big!
Detector Error	ED08	Error: No detector data found!
Detector Error	ED99	Error: Only one MAS meter at a time!
Info	-	The tag message <Info>No EXT connected</Info> is added when trying to fetch external detector data when no connector is attached.

2.6.9   List of Commands

The following table lists the available commands in firmware version 5.9A. The column **Intr.** lists the firmware version where this command was introduced.
When the reply column says "OK" it means that the Cobia will respond with OK in the standard format. See example for Alive command below:
Command from you: [CobiaC-2423XXXX-Alive]<CR><LF>
Reply from Cobia: <CobiaR CobiaC="Alive" ID="2423"
CRC="EED2">OK</CobiaR><CR><LF>

Actual example replies are shown in *italics*.

Command	Intr.	Reply	Function/Use
Alive	5.0A	OK/busy/locked If "Busy" is sent that is always followed up with an "OK" when the system is fully up and running..	Check if the system is running and responsive. Before the system is fully up and running a "Busy" or no response at all is sent.
List Help	5.0A	Help text	Lists all supported commands in text form
SystemInfo	5.0A (Adj. 5.8A)	*<CobiaR CobiaC="SystemInfo" ID="1234" CRC="">* *<ProtocolVersion>1.0</ProtocolVersion>* *<ProductName>Cobia</ProductName>* *<ProductID>2004</ProductID>* *<ProductModel>Flex R/F - kV & Dose + MAS</ProductModel>* *<ProductVersion>3.0</ProductVersion>* *<SN>CB4-14010045</SN>*	Lists the system properties. They are: structural version, product, type, model, s / n, system version, firmware (FW) version, Updater firmware version communication

Command	Intr.	Reply	Function/Use
		<SystemVersion>2016.12A</SystemVersion> *<FirmwareVersion>5.9A(4640) </FirmwareVersion>* *<UpdaterVersion>1.4A(2964)</UpdaterVersion>* *<CommType>USB</CommType>* *<BT-MAC>30E4F00076458900</BT-MAC>* *<ID-1W>67458900</ID-1W>* *<CommSupport>on</CommSupport>* *<SpecialModel>Demo Unit/PTB/LM</SpecialModel>* - *Note: Only for special models* *<CRC2>F23E</CRC2>* *</CobiaR>*	modes (USB / BT), BT ID, 1W ID, PC communication flag, and special model ID (row only included for these special models). Added in v5.8A: This command works on all Cobia models, but the models without PC communication support will respond by "<CommSupport>off</CommSupport>".

DetInfo	5.0A	*<CobiaR CobiaC="DetInfo" ID="1234" CRC="">*
		  <ProbeType>XX</ProbeType>
		  <SN>YY</SN>
		 <CRC2>CCCC</CRC2>
		 </CobiaR>Product, s/n, calibration date, calibration lab
		 where XX is the type and YY is the serial number of the external detector attached
			Lists the external detector properties

DetStatus; ?	5.1A	*<CobiaR CobiaC="DetStatus" ID="0000"* *CRC="5585">XX</CobiaR>* where XX represents the external devices that are connected: 0 = none, 1 = external only, 2 = internal MAS only, 3 = ext + iMAS.	What is connected?
DetCal;?/list/set;X;Y	5.1A	? gives selected detector and calibration (+calibration date and lab id) *list* - lists all selectable detectors and its selectable calibrations *set;X;Y* - change detector to X and calibration to Y	Select detector / calibration
IntCal;?	5.3A	? gives selected calibration *<CobiaR CobiaC="IntCal" ID="1234" CRC="">* *<Mq UnitType="P1" Caption1="XX" Caption2=" YY"* *CalLab="RTI-AB3" CalDate="2000-01-01">ZZ</Mq>* *<CRC2>467C</CRC2>* *</CobiaR>* where XX is the tube target and filter combination, YY is the text for the kV range, and ZZ the radiation quality code. These are the same texts displayed at the top left corner of the Cobia screen.	Read the data of the calibration for the internal detector.
MeasData	5.0A	P1-P19 Ex: *<P8 src="EXT" unit="Hz">6.600e-01</P8>* Attributes: unit = the basic unit for the parameter src = source of the measurement value (int / ext / mas) warning/error = as specified in table Reply Protocol, Errors 47	Measurement data, only the parameters that are displayed in the GUI list view are sent over. *MeasDataAll* gives all parameters. See section Parameter IDs 46 for a list of possible parameters.
ExtRate	5.0A	As MeasData, but only values for P3 and P6 from ext probe. P6 is time counter from Trigger point.	Instantaneous value for dose rate.

Command	Intr.	Reply	Function/Use
Settings;?/ list;X/set; X;Y	Partl y 5.0A 5.7A (Z) 5.8A (?)	*?* lists all measurement settings (i.e. Delay, Window, kV method etc.) *list;X* - lists all possible settings for X *set;X;Y(;Z)* - temporarily modifies the setting X to value Y, optional parameter Z (perm/temp) which decides if the setting is permanent or temporary (temporary resets at system restart). If it is temp setting, a Temp="true" tag will indicate this in the ? response.	Handles all measurement settings that may affect the measurement results
Prefs;?/list ;X/set;X;Y	Partl y 5.0A	*?* lists all user preferences (i.e. the language code + selected device, etc.) *list;X* - lists all possible settings for X *set;X;Y* - modifies the setting X to value Y	Handles all user preferences
TrigMsg;?/ on/off	5.0A	*?* gives selected mode *<CobiaR CobiaC="TrigMsg">STATUS </CobiaR>* where STATUS is "on" or "off" When STATUS=on and a TRIGGER event occurs in the system, the following events are automatically reported (in the same reply form as above, where STATUS is indicated below): - "TrigOn" - When the trigger goes on (triangle lights up) - "TrigUpd" - When the system has been updated values? - "TrigOff" - When the trigger goes off (triangle outline.) - "TrigEnd" - When meas. can not continue (triangle gone.) - "TrigDisabled" - When meas. turned off (eg menu.) - "TrigEnabled" - When meas. activated	Activate or check status of the trigger indication
SysMsg;?/ on/off	5.1A 5.3A 5.3A 5.3A 5.3A	*<CobiaR CobiaC="SysMsg">STATUS </CobiaR>* where STATUS is "on" or "off" At a system event and STATUS = on, a message is sent, where STATUS is: - "SysOff" - When the system begins a shut-down. - "SysRestart" - When the system begins a restart. - "ExtAttach" - When the external detector is connected. - "ExtListReady" - When the external detector is ready for calibration selection (if choice needed). - "ExtReady" - When the external detector is ready for measurement (detector+calibration selected + reset done). - "ExtError;XX" - When the external detector is not working, together with error code XX (see error table in section <u>Reply Protocol, Errors</u> 47). - "ExtDetach" - When the external detector is disconnected. - "MasAttach" - When the internal MAS cable is connected. - "MasDetach" - When the internal MAS cable is disconnected. -"BattLow" - When low battery warning is given. -"BattCritical" - When critical battery warning is given. - "Batt Empty" - When the battery has run out and the system shuts down.	Activate/deactivate or check status of the system event indication

Command	Intr.	Reply	Function/Use
		-"ResetMeasOn" - When measurement reset starts (display=Resetting...). -"ResetMeasOff" - When measurement reset is finished.	
DecimalSep;?/set;X	5.0A	*<CobiaR CobiaC="DecimalSep">SEP</CobiaR>* where SEP is e.g. "." or ","	Read or set decimal character. Default is the point "."
ResetMeas	5.0A	1: "OK" directly 2: "Done" when system is ready	Perform reset of measuring function
PowerOff	5.0A	OK	Shut down the system
PowerStatus;?	5.5	*<CobiaR CobiaC="PowerStatus;?" ID="2423" CRC="">* *<Src>X</Src>* *<Level>YY</Level>* *<RunningTime>HH:MM</RunningTime>* *<CRC2>CCCC</CRC2>* *</CobiaR>* where X is the power source: 0 = battery, 1 = USB, 2 = charger, YY is the battery level in percent, and HH:MM is the expected battery running time (not yet implemented).	Check what is the power source, battery level and battery life?
Restart	5.0A	OK	Reboot the system
RemoteLock;?/on/hide/off	5.1A	*<CobiaR CobiaC="RemoteLock">STATUS </CobiaR>* where STATUS is "on" or "off" When "on", the keypad is off, and the display shows a message that the system is in remote mode. When "hide" the same as "on", but the GUI is hidden. When "off" the system works as usual, i.e. both via keypad and remote control.	Turn off the instrument's physical UI
WFInfo	5.3A	*<CobiaR CobiaC="WFInfo" ID="2423" CRC="">* *<P3 Src="EXT" Unit="Gy/s">6.922E-02</P3>* *<Samples>465</Samples>* *<SampleRate>3000</SampleRate>* *<CRC2>3515</CRC2>* *</CobiaR>* If any samples were lost the warning attribute 10 is sent and the tag <Sample Missing> XX </ S ...> is added, where XX is the number of missing data points.	Lists the parameters that has a waveform, e.g. P1, P3, (P4) P3/EXT, P18, P19, P15/MAS. Also, as well as the maximum datapoint value for that parameter. Also listed are the number of samples and sample frequency in Hz.
WFLock;?/on/off	5.3A	*<CobiaR CobiaC = "WFLock">STATUS</CobiaR>* where the STATUS is "on" or "off"	Command to block accidental erase of the waveform. The Cobia have room for two waveforms. When the system trigs with a new measurement, that waveform data is stored and after that "the other" waveform is erased to prepare for next measurement. This command temporarily

Command	Intr.	Reply	Function/Use
			blocks that erase so the full waveform of "the first" can be retrieved.
WFPrep;Param;Src;Bits;DP;Format	5.3A	Responds with: 1. The selected parameter and the waveform calibration factor for this parameter. 2. The number of data points it will be coming out with the selected settings (DataPoints tag) 3. how many samples (integer) a data point corresponds to (SamplesPerDP tag), and 4. how many data packets for the full waveform (DataBlocks tag) (A block consists of a maximum of 1024 bytes)	Sets the parameter (Param) and source (Src) that is read out and bit depth (Bits) and the desired number of data points (DP) to be read out. Ch / channel - see WFInfo BitDepth - 8 DP - number of data points requested (can be less than number of samples) Format - the format of the output data (BIN / HEX)
WFGet;Datablock#(;#Blocks)	5.3A 5.7A	Responds with: 1. parameter 2. time for the first data point in the package (Start Time) 3. time last data point in the package (EndTime) 4. waveform data values (in binary or Hex format) 5. checksum for the packet (CRC2) A data packet consists of a maximum of 1024 characters, ie 1024-160 = max 864 characters of data. From FW v5.7A there is an optional second parameter for how many blocks to include in each transfer, this increases transfer speed significantly.	This function retrieves the waveform data, a data packet at a time in the format set by the WFPrep.
WFMode;?/normal/long;T	5.3A (Adj. 5.6A)	Responds with: 1. Status = Normal / long 2. Time = max waveform length in seconds Available times: Normal gives 7 s (3000 Hz) T up to 7 gives 7 s (3000 Hz) T = 8-14 gives the 14 s (1000 Hz) T = 15-24 gives 24 s (500 Hz) T = 25-45 gives 45 s (250 Hz) T = 46-88 gives 88 s (125 Hz) T = 89-130 gives 130 s (83.33 Hz) T above 130 gives 130 s (83.33 Hz) + *<Message> Maximum time 130 s </Message>*	Command to check and adjust the waveform mode. normal = normal mode, maximum 7 s waveform long; T = special mode with adjustable waveform recording time. T is an integer that sets the waveform recording (in seconds). The Cobia chooses the first available time setting just above the sent value. Above the maximum time (130 s), 130 is selected, and a message is sent stating this.
Trig;set;?/TRIGMODE	5.3A	*set;?* gives selected calibration TRIGMODE *<CobiaR CobiaC="Trig;set">TRIGMODE</CobiaR>* where TRIGMODE is: -normalOn - Standard mode (normal trig by signal)	Reads or sets the trigger mode for the Cobia. Note! The trigmodes *timeOn* and *manualOn*

Command	Intr.	Reply	Function/Use
		-timeOn;X - timed mode, start immediately but ends after the set time X [time in s] -manualOn - manual mode -normalTimeOn;X - normal start trig but ends after the set time X [time in s] -off - ends manual or cancels timed modes	starts measuring immediately when this command is given.
All others	5.0A	*<CobiaR>CError!;Type "[CobiaC-0000XXXX-List]" for help.</CobiaR>*	Error message and help

2.6.10   Cobia Start-Up

During system startup, when all processes are not started, response data may be incorrect. Therefore it is always answered with "Busy" until the system is fully up and running. Use the command "alive" and the system will notify when it is fully up and running by following up the "Busy" response with an "OK".

2.6.11   CRC-Calculation

All responses, and optionally in the commands a checksum is included. This can be used to verify that no data has been corrupted during transmission. There are also requirements for this by external parts, for example from the PTB.

It is calculated according to the following procedure:
1. First the command or the response is built up as a text in which the CRC code are replaced by four space characters (0x20).
2. Then the CRC16 value is calculated for the entire body of text (including internal line breaks (CR=0x13+LF=0x10) etc..
   For a command it means from **[** to **]**.
   For a reply it means from **<CobiaR** to **</CobiaR>**.
3. The CRC data value (16 bits) is then converted into Hex format (4 characters 0-9, AF). These four chars then replaces the four space characters.
4. Done!

Technical info: If you want to implement this, it uses Standard CRC16 with CRC-polynomial $P(x) = x^{16} + x^{15} + x^2 + x^0$, which correspond to hex code 0x8005.

2.6.12   Examples of Communication

Command: [**CobiaC-0000XXXX-ExtRate**]

Response:

```
<CobiaR CobiaC="ExtRate" ID="0000" CRC="">
    <P3 Src="EXT" unit="Gy/s">10,41E-3</P3>
    <P6 Src="EXT" unit="s">100,2E-3</P6>
<CRC2>0A58</CRC2>
</CobiaR>
```

Command: **[CobiaC-1234XXXX-MeasData]**

Response:

```
<CobiaR CobiaC="MeasData" ID="1234" CRC="">
    <P2 Src="EXT" unit="Gy">10,41E-3</P3>
    <P3 Src="EXT" unit="Gy/s">10,38E-3</P3>
    <P6 Src="EXT" unit="s">100,2E-3</P6>
<CRC2>5A7F</CRC2>
</CobiaR>
```

Command: **[CobiaC-1234XXXX-SystemInfo]**

Response:

```
<CobiaR CobiaC="SystemInfo" ID="1234" CRC="">
    <ProtocolVersion>1.1</ProtocolVersion>
    <ProductName>Cobia</ProductName>
    <ProductID>2003</ProductID>
    <ProductModel>Flex R/F - kV & Dose</ProductModel>
    <ProductVersion>3.0</ProductVersion>
    <SN>CB4-14010045</SN>
    <SystemVersion>2016.5A</SystemVersion>
    <FirmwareVersion>5.8A(4625)</FirmwareVersion>
    <UpdaterVersion>1.4A</UpdaterVersion>
    <CommType>USB</CommType>
    <BT-MAC>30E4F00076458900</BT-MAC>
    <1W-ID>67458900</1W-ID>
    <CommSupport>on</CommSupport>
<CRC2>FA7B</CRC2>
</CobiaR>
```

2.7 Standards and Compliances

Hereafter you can find declarations of conformity, as well as documents describing the intended use of the Cobia system.

2.7.1 Waste Electrical and Electronic Equipment (WEEE)

The European Union Directive 2002/96/EC on Waste from Electrical and Electronic Equipment (WEEE) places an obligation on manufacturers, distributors, and retailers to take back electronics products at the end of their useful life.
The WEEE directive covers all RTI products being sold into the European Union (EU) as of August 13, 2005. Manufacturers, distributors, and retailers are obliged to finance the cost of recovery from municipal collection points, reuse, and recycling of specified percentages per the WEEE requirements.

Instructions for disposal of WEEE by Users in the European Union

The symbol, shown left, is marked on the product, which indicates that this product must not be disposed of with other waste. Instead, it is the user's responsibility to dispose of the user's waste equipment by handing it over to a designated collection point for the recycling of waste electrical and electronic equipment. The separate collection and recycling of waste equipment at the time of disposal will help to conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment. For more information about where you can drop off your waste equipment for recycling, please contact your local distributor from whom you purchased the product.

2.7.2 Waste Batteries and Accumulators

The European Union Directive 2006/66/EC on Waste from Batteries and Accumulators places an obligation on manufacturers, distributors, and retailers to report and take back battery products at the end of their useful life.
The battery directive covers all RTI products being sold into the European Union (EU) as of September 26, 2009. Manufacturers, distributors, and retailers are obliged to finance the cost of recovery from municipal collection points, reuse, and recycling of specified percentages per the Union Directive requirements.

Instructions for disposal of batteries by Users in the European Union

The symbol, shown left, is marked on the battery, which indicates that this product must not be disposed of with other waste. Instead, it is the user's responsibility to dispose of the user's waste equipment by handing it over to a designated collection point for the recycling of batteries. The separate collection and recycling of batteries at the time of disposal will help to conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment. For more information about where you can drop off your batteries for recycling, please contact your local distributor from whom you purchased the product.

2.7.3 Manufacturer's Declaration of Conformity

Declaration of Conformity

We, RTI Group AB, Flöjelbergsg. 8 C, SE-431 37 MÖLNDAL, Sweden, declare under our sole responsibility that the product:

Product name:	Cobia
Model name:	Smart, Dental, Sense, Flex
Type of equipment:	kV- & Electrometer
Intended use of this product:	See separate document no: 2-CE-9620000-0, "Intended use of the Barracuda, Piranha, and Cobia"

is in conformity with the provisions of the following EC Directive(s):

- **2014/30/EU Electromagnetic Compatibility** (EMC) **Directive**
- **2014/35/EU Low Voltage Directive** (LVD)
- **2015/863/EU Restriction of Hazardous Substances in EEE Directive** (RoHS 3)

and that the following standards and/or technical specifications referenced below have been applied:

EN 55032/B, EN 55014, EN 55024, EN 60950-1, EN 61000-3-2, EN 61000-3-3, EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6, EN 61000-4-11, EN 62368-1 + AC1:2015, ETS 300 342-1

$\mathsf{C}\,\mathsf{E}$

Mölndal, 2019-11-11

....
Fredrik Ljungberg, President

2.7.4   Intended Use

Intended Use of the Barracuda, Piranha, and Cobia

Accessory to diagnostic X-ray equipment to be used as an electrometer. Together with external probes it is to be used for independent service and quality control, as well as measurements of kerma, kerma rate, kVp, tube current, exposure time, luminance, and illuminance within limitations stated below.

If installed according to accompanying documents, the product is intended to be used together with all diagnostic X-ray equipment except for:
- therapeutical X-ray sources.
- X-ray equipment with tube potential below 20 kV.
- X-ray equipment on which the instrument cannot be mounted properly, e.g. equipment where the beam field size is narrower than the active part of the detector.
- specific types of X-ray equipment listed in the instructions for use or in additional information from the manufacturer.

With the X-ray installation in stand-by conditions without patients present the product is intended to be used:
- to provide the operator with information on radiation beam parameters that might influence further steps in an examination but not an ongoing exposure.
- for assessing the performance of the X-ray equipment.
- for evaluation of examination techniques and procedures.
- for service and maintenance measurements.
- for quality control measurements.
- for educational purposes, authority supervision etc.

The product is intended to be used by hospital physicists, X-ray engineers, manufacturer's service teams, and other professionals with similar tasks and competencies. The operator needs a short training to be able to use the product as intended. This training can be achieved either by careful study of the manual, studies of the built-in help function in measurement software, or in a short course ordered from the manufacturer.

The product is intended to be used inside X-ray rooms ready for clinical use and can safely be left switched on and in any measuring mode in the vicinity of patients.

The product is **NOT** intended to be used:
- for direct control of diagnostic X-ray equipment performance during irradiation of a patient.
- so that patients or other unqualified persons can change settings of operating parameters during and immediately before and after measurements.

2.7.5 FCC Certification

The Cobia models Flex and Sense PC contains an FCC certified transmitter module (Bluetooth).

FCC ID R47F2M03GX
This device has been tested and found to comply with the limits for a Class-B digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used according with the instruction manual, may cause harmful interference to radio communication. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

2.7.6 German Measurement and Verification Act (PTB Type Certificate)

Instruments used for dose measurements according to §§ 3, 4, and 16 of the German X-ray Ordinance (RöV) (e.g. dose measurements for acceptance tests of medical diagnostic X-ray devices) shall comply with the German Measurement and Verification Act (MessEG). The conformity of the Cobia with the requirements of this German act was documented by a German 'Type-examination Certificate' of measuring instruments according to the Measures and Verification Ordinance (MessEV), Module B issued from the Physikalisch-Technische Bundesanstalt (PTB) as a result of a type examination followed by a verification for each instrument by use of Module F according to the same Ordinance. The Type-examination Certificate is issued if an instrument used as a diagnostic dosimeter complies with the technical requirements of EN/IEC 61674, basic requirements on measuring instruments according to appendix 2 of the Measures and Verification Ordinance and Software requirements according to WELMEC Guide 7.2, Risk Class C.

The Type-examination Certificate number for Cobia is: DE-15-M-PTB-0005

If the Cobia is intended to be used for these legally regulated types of measurements in Germany, the user is referred to the corresponding German user manual for the Cobia. Note that there is no further description of this special application in this English Reference Manual.
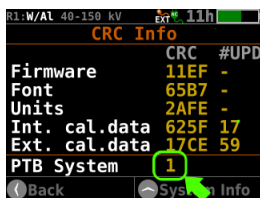
For these verified measurements according to German X-ray Ordinance, special settings, requirements, and verifications are needed. These settings are controlled by a configuration setting called "PTB System", which is shown on the CRC Info screen on all Cobias, as highlighted by the circle and arrow in the figure to the left.

If the "PTB System" setting is "1", the following restrictions apply:
- Units for dose and dose rate is fixed to Gy and Gy/s respectively.
- No dose values are shown (-) if on a normal system the warning sign for uncorrected dose is active.
- No system updates are possible.

- No measurements are possible if a CRC error is found during system start-up.

Such a system is also identifiable by special marking labels on the back of the Cobia (and Dose Probe), as shown below. Full descriptions of the different labels are given in the table further below. On a non-PTB system, only labels 1 and 2 are normally present.

#	Description
1	RTI product marking label (on all systems)
2	RTI ISO 17025 Calibrations Accreditation label (on all systems)
3	PTB Type-examination Certificate ID (MessEG Module B)
4	Technical instrument and firmware data for PTB Type-examination
5	Label for the *Eichamt* approval for use (MessEG Module F)
6	Optional s/n of Ext. Dose Probe included in verification (only possible for Flex or Sense models)
7	*Eichamt* verification label (added after 2 years initial use)
8	Security seal for the *Eichamt* approval for use

2.8   Maintenance

2.8.1   Scheduled Calibration

RTI recommends that the Cobia is calibrated every 24 months. Send your Cobia to your local RTI distributor, who will send it to our service department in Mölndal, Sweden, or New Jersey, USA. For contact details, please see the back of this manual or the list of local RTI distributors on the RTI website (www.rtigroup.com).

2.8.2   Updating the System

The Cobia system update can easily be done on any computer with support for USB memories.

Note! The update function is disabled on a german PTB system, please see the CRC Screen in section <u>Menu Description</u> 15 .

Below is a step-by-step guide for when using a computer with Windows OS, but the procedure can be done on a computer with any OS, just as long as it has a USB port.

1. Start by downloading the latest versions from www.rtigroup.com/downloads, using a web browser.
2. On a Windows PC, start a File Explorer window (WIN+E) and unpack the downloaded Cobia Update zip file to a local drive.
3. Start the Cobia and connect the cable between the PC and the Cobia.
4. On the Cobia, press the menu button and enter the "System Info" menu.
   Note! Make sure that the update file contains a newer system version than already present in the system.
5. If so, press and hold down the right arrow button for approximately 4 seconds to start the update mode. See images below.
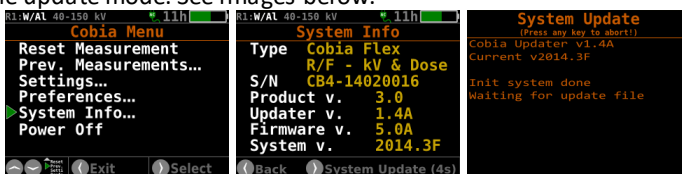
6. After a short while, a USB memory device named COBIA (as shown left) will appear in the File Explorer on the PC, and the Cobia display will show "Waiting for update file". Now, drag-and-drop the unpacked updater file (.cobia) from the PC local drive using the File Explorer to the USB device named COBIA.
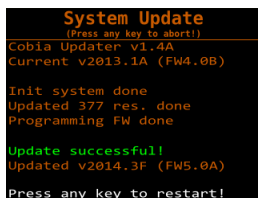
7. A counter will now start on the Cobia display during the resource file update procedure. It will take a few minutes. When the update is completed the screen to the left will appear:

8. Press any key to launch the updated Cobia firmware.

After the update, you may want to change the language of the Cobia user interface. You will find this setting by pressing the menu button, and then selecting User Preferences.

2.8.3   Changing the Battery

The battery is a customized rechargeable battery that automatically charges when the Cobia is attached to a power source. It can only be replaced by RTI authorized service centers.

Chapter 3
Measurement Principles & Theory

3 Measurement Principles & Theory

The Cobia has a number of measurement algorithms and applications built-in. This section describes some about the principles, how some values are calculated, and the basic use of such measurements.

3.1 Waveforms and Triggers

To get an understanding of how triggers, delays, and windows work, take a look at the waveform below. This is what happens during a standard radiation measurement:
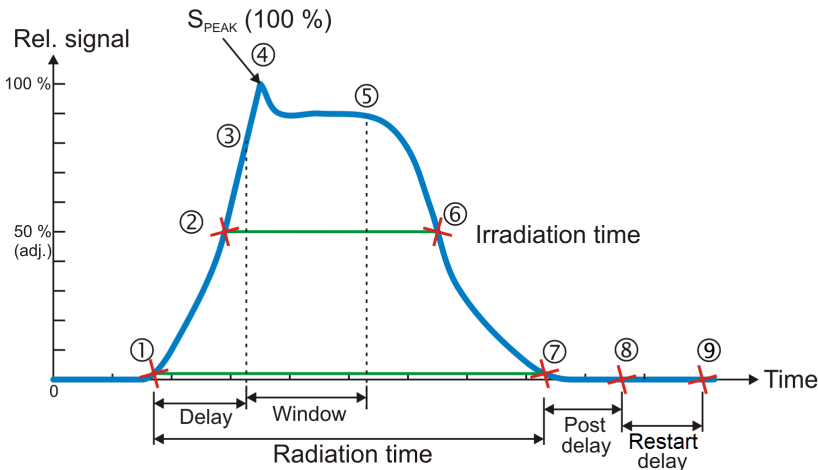
1. The radiation starts, i.e. it goes over the detector's lowest trig level. The play symbol gets displayed (filled).
2. The signal reaches 50 % of its maximum. This is the starting point for the irradiation time calculation. (The level is user adjustable.)
3. The *Delay* time is reached. (User adjustable.) kV integration window starts.
4. The signal reaches its maximum. The max value used for calculations is after Delay. This to ignore massive test peaks that some units give out.
5. The *Delay+Window* time is reached. (User adjustable.) kV integration window stops. For the default *Window* setting (infinite) this is normally at point 7.
6. The signal goes below 50 % of its maximum. This is the end point for the Irradiation time calculation. (The level is user adjustable.)
7. The radiation ends, i.e. it goes under the detector's lowest trig level.
8. If the signal has been below the trig level during all of *Post delay*, the exposure is considered finished. The play symbol gets contoured. All exposure readings are calculated and displayed.
9. If the signal has been below the trig level during all of *Post delay* and *Restart delay*, the exposure is considered permanently finished. All exposure readings are calculated and displayed. The play symbol disappears altogether.

Integrated signal (dose, mAs, etc.)
Is the integration of all signal which means the area below the curve above from point 1 to 7. During the measurement (exposure) the accumulated signal (dose, etc) is displayed where applicable.

Signal rate (dose rate, tube current, etc.)
When a normal length measurement is over, point 8 above, the mean signal for the whole measurement (except delay time) is displayed. This signal rate is calculated as all integrated signal after delay (from point 3 to 7 as described above) divided by the time from point 3 to 6.
When the measurement continues for more than two seconds, typically for fluoroscopy, the mean signal for the last two seconds is displayed every two seconds. When the measurement is over, the value from the second last update is displayed, to avoid trig off ramp effects in the last two seconds.

Tube voltage signal (kV, kVp)
The Cobia measures two "different" tube voltages.
1. The integrated tube voltage (unit kV). This value corresponds to the standardized PPV method, which intends to give a value that independently of waveform gives the same image quality and dose contrast for a standardized phantom. This value corresponds to a summation of the waveform samples between 3 and 4 in the pictures below. This value can "always" be calculated.
2. The peak tube voltage (unit kVp). This value corresponds to the technical peak voltage from the generator output, not at all representative of the resulting image aspects. Here only the top waveform values (over a certain percentage of the peak level) is included (out of the waveform samples between 3 and 4 in the pictures below). This value is thus much more sensitive to waveform noise, which means that at low signal, only kV can be given. In that case increase the output or shorten the distance to get a kVp reading.
The second methods disregards the samples during delay, to avoid overshoot or other regulating effects from the generator. The first method is not so sensitive to these effects.
As seen in the example pictures below, for a DC/HF generator with little HV waveform ripple, the values are the same, but for units with HV ripple they diverge.
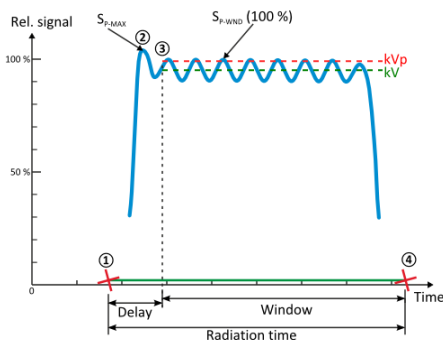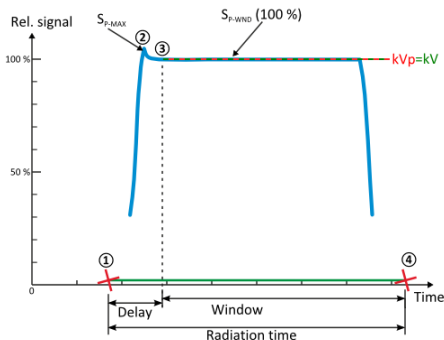
Note also that if the DC/HF output is pulsed, the kV and kVp is normally still the same.

3.2   Measurement Principle for the Cobia

The following are the key features of the Cobia design:

- Small size
- Very sensitive and wide dynamic range
- Auto sensitivity and Auto range selection.
- Single exposure estimation of total filtration and Quick-HVL

The detector packages consist of four separate electrometer channels connected to circularly shaped detectors D1, D2, D3, and D4 with varying radiation filters. The outermost detector (D4) is used only for tube voltages above 68 kV.

Using these four signals S1-S4 (from detectors D1 to D4) the Cobia can accurately calculate the corresponding tube voltage. The signal from detector D3 is designed to measure the dose. The D3 detector is positioned in the center of the cross in the middle of the round detector area on the top panel. The reference depth for the sensitive area of the dose detector is 8 mm under the round label on the Cobia top surface.

Additional signals are used to estimate the total filtration for the radiography range. Using these signals together more accurate dose and tube voltage readings can be obtained.

Since all signals is measured simultaneously and with a relative high speed, the Cobia can thus automatically compensate the kV and dose for the dependence of the waveform and inherent/added tube filtration.

3.3   Linearity

The output in mGy/mAs for different mAs stations should remain constant if the kVp and distance are maintained constant. This can be checked by measuring the coefficient of linearity. The coefficient of linearity is defined as:

$$L_{1\text{-}2} = \frac{|X_1 - X_2|}{X_1 + X_2}$$

where: $X = Dose/mAs$, and X_1 and X_2 (X_1 and X_2) are measured at adjacent mAs settings

To check the mAs linearity:

1. Place the detector on the table-top. If patient-equivalent phantom should be used it is recommend to use the Cobia HVL stand to simplify the set up. Use 2 pieces of 10 mm Al filter as "patient -equivalent" filter in the beam.

2. Set the X-ray generator to technique factors commonly used clinically.

3. If the display is unstable; press the Reset button.

4. Use some form to record your measurements.

5. Make exposures at different mAs settings and both for small and large focuses.

6. Calculate the coefficient of linearity for adjacent measurements.

An acceptable value for the coefficient of linearity is less than 0.10.

A short example:

measurement 1 : X_1 = 13 µGy/mAs
measurement 2 : X_2 = 14.6 µGy/mAs
measurement 3 : X_3 = 12.8 µGy/mAs

Then:

$$L_{1-2} = \frac{|13.0 - 14.6|}{13.0 + 14.6} = 1.6/27.6 = 0.05797$$

and:

$$L_{2-3} = \frac{|14.6 - 12.8|}{14.6 + 12.8} = 1.8/27.4 = 0.06569$$

Of which both is below the 0.10 limit.

3.4   Reproducibility

Reproducibility is checked to find out how constant the output is when an X-ray exposure is repeated many times. One method is to check the coefficient of variation. The coefficient of variation is defined as:

$$s = \frac{\sqrt{\dfrac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}}{\bar{x}}$$

where

X_i = Individual exposure readings

n = Number of readings

$\overline{X}$ = Mean value of readings

To check the output reproducibility:

1. Place the dose detector on the table-top (the patient-equivalent phantom is not necessary since this measurement can be made as a relative measurement).

2. Set the X-ray generator to technique factors commonly used clinically.

3. If the display is unstable, press the Reset button.

4. Use some form to record your measurements.

5. Make 5 to 10 exposures and record the reading for each exposure.

6. Calculate the mean value, difference from mean value and square of differences.

7. Add all squared values and divide by (n-1) to get the variance. In this case n=10.

8. Calculate the square of the variance, i.e. the standard deviation, and divide it by the mean value of the n measurements

An acceptable value for the coefficient of variation is less than 0.05.

Chapter 4

Problems and Solutions

4   Problems and Solutions

4.1   Troubleshooting

If you experience any problems with the Cobia, please go through the following steps before contacting your local RTI distributor or RTI:

A. Check the RTI website for system updates (www.rtigroup.com).

B. Go through through the checklist below.

The Cobia does not start:
If the Cobia does not start, try the following: Connect the charger and retry starting the Cobia. If it does start, then the battery was too low to start. If this does not help, try resetting the Cobia as described below.

The Cobia indicates a dose lower than anticipated:
If the dose readings are too low or if the irradiation times for short exposures are too short, check that the measurement is performed so that the radiation is perpendicular to the Cobia detector surface. Please also make sure that the entire surface is evenly irradiated.

The Cobia gives "Field Error":
The Cobia detector surface needs to be properly irradiated. Please make sure that the entire surface is irradiated, and that nothing is blocking the radiation.

The external detector gives false readings:
The external detector cable is very sensitive when using certain probe types. Try not to move the detector while attached to the Cobia. To reset false readings, use the Reset Measurement on the menu.

How do I reset the Cobia?
There is a reset hole on the bottom face of the Cobia, marked RST. Insert the end of a paper clip or similar to reset the Cobia.

The electrometer or Cobia gives too low dose rate
If you get too low dose rate readings or too short irradiation times for short exposures:
Check that you are measuring with a good geometry, where the incoming radiation is perpendicular to the detector surface. See Specifications, Cobia 32 for details.

Bluetooth only shows "Unknown device" when trying to connect
Depending on Windows version it may take a little while for the serial number to appear, the Cobia will appear as "Unknown device". Normally it will show the serial number if you wait a while.

How do I change from Gray to Röntgen units?
You can set this for all tests (**Menu | User prefs | Units**), see Units Setup 15 .

What is a CRC error?
All memory sections in the Cobia containing crucial firmware and calibration data
are protected by CRC checksums. If any of these data are corrupted, tampered, or in
any way modified, the Cobia may give incorrect measurements. Unless the Cobia is
a PTB system you can still continue measuring with the unit, but beware of the risks
of corrupt results! Firmware errors may be fixed by a system update, but to fix the
errors in calibration data the Cobia needs to be sent in to RTI for service.

C. Contact your local representative or see Notice for contact information to RTI. The
more information you supply will help us to get a quick solution to your problem.
Examples of useful information is screen pictures, exact error message texts, log
files, etc. You may also use the auto-report function described in the section How To
Report a Problem 69 .

4.2   Bluetooth

Bluetooth is a wireless way of communication between your PC/handheld and your
meter. Some Cobia models have built-in support for this. A PC may or may not have
built-in support for Bluetooth. If the PC does not have built-in Bluetooth support you
will need a Bluetooth adapter (that you usually connect to the USB port) for instance
the D-Link DBT-120 or DBT-122.

The range of Bluetooth is about 10 meters (32 feet) in free air for a class 2 Bluetooth
adapter (like the D-Link DBT-122), for a class 1 Bluetooth adapter (like the Targus
ACB20EU) the theoretical range is up to 100 metres. The useful range can be
significantly shorter if there are walls and other objects obstructing the signal.

If the environment is noisy and you get communcation issues using Bluetooth, you
can try using a USB cable between your PC and the meter. The USB connection is less
sensitive to disturbances.

4.2.1   Bluetooth Passkey

There is only one way to use Bluetooth with your Cobia, with a passkey (also called
PIN code, authentication, and Bluetooth security code). All meters delivered from RTI
are configured to use a passkey (0000).

4.3   How To Report a Problem

Eventhough we have done our outmost to create a excellent product, unexpected
things can happen. If so, please:
1. Send a detailed problem report to support@rtigroup.com, describing what you did,
what you got, and what you expected.
2. If Cobia is used together with the Ocean 2014 software, it is possible to send a
problem report via the built-in function of the Ocean 2014 software. That will help us
find the problem easier.

Chapter 5

Glossary

5   Glossary

In the HTML help version of the reference manual, you will find a radiology glossary.

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