



Ectosense nv

# NightOwl Software

Instructions for Use



**IFUNOS-B-EN-1.202**

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14-Oct-19

**IMPORTANT**  
READ CAREFULLY BEFORE USE  
KEEP FOR FUTURE REFERENCE

## DISCLAIMER

Ectosense shall not be held accountable in any way for any injury and/or property damage arising from operation or use of NightOwl Software other than that which strictly adheres to the instructions and safety precautions contained herein.



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The latest version of the device (V1.202) was created in  2019 (date of manufacture) and the device (version) expiry date is set at the immediate moment succeeding the launch of an incremental version intended to replace the expiring version, or, 2 years after the latest version release. The Instructions for Use herein refer to the device version V1.202. The NightOwl Software device is serviced for one year after expiry date.

The Instructions for Use herein are available in the language(s) as specified at [www.ectosense.com/eifu](http://www.ectosense.com/eifu).

Note: The latest version of the NightOwl Software Instructions for Use in the abovementioned language(s) is available in electronic format in [www.ectosense.com/eifu](http://www.ectosense.com/eifu). A printed version can be requested by contacting the manufacturer through [info@ectosense.com](mailto:info@ectosense.com). Delivery will be made within 7 days after formal request and at no additional cost to the user.



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## Safety notices

 <b>CAUTION</b>	<b>Contra-indication: device should not be used on patients with known severe ventricular extra-systole, as this is likely to lead to insufficient clean data segments</b>
 <b>CAUTION</b>	<b>Total recording length of interpretable signal quality should be greater than 4 hours for diagnosis to be accurate</b>
 <b>CAUTION</b>	<b>Beginning and end of signal recordings should preferably be close to time of going to bed and getting up, respectively</b>
 <b>CAUTION</b>	<b>The NightOwl Software's Instructions for Use should be carefully studied by the device user and kept where it is easily accessible. Periodic review of the Instructions is recommended.</b>

# 1. General information

## 1.1. Scope

This IFU relates to the **NightOwl Software** stand-alone medical software device. It is the analytical engine that interprets signals from one or more physical sensor devices.

The NightOwl Software device has been validated to work with the **NightOwl Sensor** device, a separate medical device for the continuous recording of a patient's blood volume pulse waveform and motion during sleep or resting, in both the clinical and home environment. The sensor can be worn on the finger by adults or children aged 13 and over, without requiring direct supervision by a healthcare professional. You can operate the NightOwl Software device with, but also independently of, the NightOwl Sensor device.

Diagnostic results of the NightOwl Software device, which this Instructions for Use manual exclusively relates to, can be viewed in the **Ectosense Dashboard**, a portal made available through your web browser on [dashboard.ectosense.com/nightowl](https://dashboard.ectosense.com/nightowl). You can also view the diagnostic results independently of this portal, through the pdf format.

The Ectosense Dashboard incorporates other functionalities such as patient monitoring, diagnostic test ordering, and account management.

## 1.2. Intended use

The NightOwl Software is intended for physiological signal retrieval, visualisation, report generation, analysis and interpretation for the area of direct diagnosis and monitoring of obstructive sleep apnea.

### 1.2.1. Claims

The NightOwl Software device accurately diagnoses patients with obstructive sleep apnea based on an analysis of the peripheral arterial tonometry ('PAT'), amongst other channels. It provides the AHI as well as additional parameters relevant for the diagnosis such as total sleep time and an indication of cardiac irregularities. It displays photoplethysmography-derived signals and actigraphy.

### 1.2.2. Intended User

The NightOwl Software device has two user groups:

- (1) The Ectosense Operator: The NightOwl Software device is intended to be operated by a person explicitly authorised and qualified to oversee the automated software analysis.
- (2) The Healthcare Professional (HCP): The NightOwl Software device's output report (cf. **1.2.7**) is interpreted by a healthcare professional with knowledge of the patient's symptoms and on how to interpret them.

This IFU is developed for the latter user group only.

### 1.2.3. Intended use environment

The software device will be operated in or from within an environment where no patients or physicians are present, namely, the Ectosense premises.

The Healthcare Professional will have access to the analysis results through the Ectosense Dashboard, developed to view the diagnostic results as well as to track patients and order new tests.

### 1.2.4. Intended patient population

The intended population for the device usage encompasses all individuals aged 13 or older that are suspected of suffering from sleep disordered breathing.

### 1.2.5. Clinical indications for use

The device is to be used for the benefit of patients with sleep disorder symptoms and a high risk for sleep apnea and/or with sleep apnea symptoms.

The American Academy of Sleep Medicine (AASM) identifies the following risk factors and symptoms that warrant a sleep study (Epstein et al., 2009) (**Table 1**):

*Table 1 Risk factors and symptoms of obstructive sleep apnea*

High Risk for Sleep Apnea	Sleep Apnea Symptoms
Obesity (BMI > 35)	Witnessed apnea
Congestive heart failure	Snoring
Atrial fibrillation	Gasping/choking at night
Treatment refractory hypertension	Excessive sleepiness not explained by other factors
Type 2 diabetes	Non-refreshing sleep
Nocturnal dysrhythmias	Total sleep amount
Stroke	Sleep fragmentation/maintenance insomnia
Pulmonary hypertension	Nocturia
High-risk driving populations	Morning headaches
Preoperative for bariatric surgery	Decreased concentration
	Memory loss
	Decreased libido
	Irritability

### 1.2.6. Clinical contra-indications for use

The device should not be used on patients with known severe ventricular extrasystole (VES) as this is likely to lead to insufficient clean data segments and therefore a Failure Report, similar to the challenges faced by a polysomnographic examination of such patients. The inclusion of a patient with known and severe VES does not lead to a significantly increased risk related to the device.

### 1.2.7. Data generated by the NightOwl Software device

The NightOwl Software device generates a diagnostic report containing information on the apnea-hypopnea index (AHI) severity category, the oxygen saturation index (ODI) using both the

≥3% rule and the ≥4% rule for the classification of desaturations (ODI3% and ODI4%, respectively), the total sleep time (TST), the presence or absence of a substantial changes in peripheral arterial tone (PAT) caused by, for example, sympathetic activation, the presence of irregular heart rhythms. It also contains information on the location of desaturations and signal artifacts.

### 1.2.8. Clinical performance data

In order to perform its intended function, the device must receive data collected from signal acquisition devices.

The NightOwl Software’s accuracies for parameters such as the Apnea-Hypopnea Index (AHI) and total sleep time (TST) are described in Massie et al., 2018, Journal of Clinical Sleep Medicine.

The software further calculates or provides the Oxygen Desaturation Index (ODI), changes in the peripheral arterial tone (PAT), the blood oxygen saturation (SpO<sub>2</sub>) from photoplethysmography as well as pulse rate and deterministic derivations thereof.

### 1.2.9. Precautions

- Ensure a total recording length of more than 4 hours.
- Ensure that the start and stop of the signal acquisition device is as close to the actual going to bed for sleep.
- The NightOwl Software device’s Instructions for Use should be carefully studied by the healthcare professional and kept where it is easily accessible. Periodic review of the Instructions is recommended.

## 1.3. Medical device classification

The NightOwl Software device is a Class IIa medical device under Rule 10 of Annex X of MDD 93/42/EEC, amended by 2007/47/EEC.

## 1.4. Quality Assurance System

The Ectosense NightOwl Software device is compliant with the following standards.

	<b>STANDARD TITLE</b>	<b>STANDARD NUMBER</b>
1.	Medical Device Software – Software Life Cycle Processes	EN IEC 62304:2006
2.	Medical devices – Quality management systems. Requirements for regulatory purposes	EN ISO 13485:2016
3.	Medical devices – Application of risk management to medical devices	EN ISO 14971:2012
4.	Medical devices – Symbols to be used with the medical device labels, labelling and information to be supplied. General Requirements	ISO 15233-1:2016
5.	Medical Device Directive	MDD 93/42/EEC MDD 2007/47/EC

## 1.5. CE compliance

 The product complies with MDD 93/42/EEC and amendments 2007/47/EC (Medical Device Directive) requirements.  
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## 1.6. Conventions used in these instructions

 <b>WARNING</b>	<b>Warnings</b> are used to identify conditions or actions which, if instructions are ignored, may violate patient safety, or cause malfunction of the device, resulting in non-recoverable loss of data.
 <b>CAUTION</b>	<b>Cautions</b> are used to identify conditions or actions which could impair study results.

## 1.7. Symbols used on the Instructions for Use and on the Product Labels

	ISO 7000-2493	Catalogue number
	ISO 7000-3082	Manufacturer
	ISO 7000-2497	Year of manufacture
	ISO 7000-1641	Consult Instructions for Use
	ISO 7000-0434A	Caution

## 1.8. Product labels



Electronic instructions for use at [www.ectosense.com/eifu](http://www.ectosense.com/eifu)

Free hard copy within 7 days contact [info@ectosense.com](mailto:info@ectosense.com)

Located on NightOwl Software Static Diagnostic Report

## 2. Overview

Affecting 4 to 7% of the general population, sleep apnea is a highly prevalent sleep disorder and is characterised by partial or complete collapse of the upper airway resulting in an interruption of breathing during sleep. This often leads to hypoxaemia and hypercapnia and/or autonomic arousals (sympathetic nervous system – SNS – activation).

Three main types of sleep apnea exist: obstructive sleep apnea (OSA – the vast majority of cases), central sleep apnea (CSA – a small proportion of cases) and mixed sleep apnea. The distinction between obstructive and central apnea is described by the presence or absence of respiratory effort during apnea, respectively.

The diagnosis of sleep apnea is typically based on the number of apnea and hypopnea per hour of sleep, i.e. the Apnea-Hypopnea Index (AHI). Other relevant parameters include, the oxygen desaturation index (ODI) and the total sleep time (TST). Furthermore, a measure of SNS activation is informative: high sympathetic activation throughout the night despite a low AHI might indicate the presence of a sleep disorder other than sleep apnea.

Common consequences of sleep apnea include excessive daytime sleepiness, increased propensity to accidents and decreased productivity. Prevalent co-morbidities are chronic cardiovascular conditions (arterial hypertension, heart failure, cardiac ischaemia or cardiac arrhythmia) or metabolic conditions (diabetes mellitus or obesity).

The NightOwl Software device is used by providing it with two input signals. Specifically, it receives as an input:

- A double-wavelength photoplethysmography trace
- An accelerometer trace

The NightOwl Software device uses the above signals to derive the severity of sleep apnea (AHI severity category), the ODI, the TST. The NightOwl Software device outputs comprehensive reports of the overnight recordings, including the above parameters and graphic representation of the data and detected events. The full night data is displayed and can be visually analysed.

### 3. Diagnostic report interpretation

#### 3.1. Report types

The NightOwl Software generates single-night diagnostic reports and summary diagnostic reports, the latter aggregating the results of multiple single-night reports.

The diagnostic reports are electronic documents in PDF format that have been optimized for printing.

#### 3.2. Single night diagnostic report output interpretation

*Table 2 Single-night diagnostic report parameters and interpretation*

Parameter type	Parameter	Interpretation
Trace	Blood oxygen saturation (SpO <sub>2</sub> (%))	Blood oxygen saturation refers to the fraction of oxygen-saturated haemoglobin relative to the total amount of haemoglobin in the blood. It is expressed in percentage of total haemoglobin and physiological values are usually in the 95-100% range.
	Photoplethysmogram (PPG)	The PPG is an optically obtained volumetric measurement of an organ. It monitors the perfusion of blood in the dermis and subcutaneous tissue of the skin.
	Heart Rate (HR(bpm))	Because the skin is so richly perfused, it is easy to derive the pulsatile component of the cardiac cycle from the PPG. Each PPG peak corresponds to a systole while each PPG trough corresponds to a diastole. As such, heart rate is derived by detecting all peaks. Heart rate is expressed in beats per minute (bpm). Physiological values during sleep are usually in the 40-100 bpm range. HR values below 40 bpm (bradycardia) or above 100 bpm (tachycardia) are considered pathological.
	Activity	Motion, in combination with PPG, is used to estimate sleep parameters and sleep/wake patterns. Spikes in the activity trace should be interpreted as detected motion (e.g. limb movement, position changes etc.)
Figure	Poincaré plot	This plot sets out the time interval between two neighbouring PPG pulse peaks on the horizontal axis to the subsequent neighbouring PPG pulse peaks on the vertical axis.
Events	Blood oxygen desaturations	Collapse of the upper airway reduces oxygen supply and decreases the percentage of saturated haemoglobin. The desaturations displayed over the SpO <sub>2</sub> trace correspond to ≥3% drops in oxygen saturation from pre-event baseline.

Parameter type		Parameter	Interpretation
		Artifacts	Motion artifacts strongly affecting PPG and SpO <sub>2</sub> signal quality are flagged.
		Disconnections	Highlights recording episodes during which the sensor was disconnected.
Index	AHI	AHI Category (AASM)	The sleep apnea severity category as indicated by the AHI, following the 2012 AASM guidelines. The four possible values for this index are “Not relevant” (AHI below 5 events per hour), “Mild” sleep apnea (AHI of 5 or more and below 15 events per hour), “Moderate” sleep apnea (AHI of 15 or more and below 30 events per hour) and “Severe” sleep apnea (AHI of 30 events per hour or more)
		AHI	The AHI defined according to the 2012 AASM guidelines.
	SpO <sub>2</sub>	ODI (≥3%)	Number of ≥3% oxygen desaturations per hour of sleep (oxygen desaturation index)
		ODI (≥4%)	Number of ≥4% oxygen desaturations per hour of sleep (oxygen desaturation index)
		Minimum SpO <sub>2</sub>	Minimum blood oxygen desaturation value recorded during the full recording
		Maximum SpO <sub>2</sub>	Maximum blood oxygen desaturation value recorded during the full recording
		T90	Time below 90% oxygen saturation as a percentage of total sleep time
	Heart Rate	Mean HR	Mean heart rate during the full recording
		Beats > 100 bpm	Percentage of heart beats where the instantaneous heart rate was above 100 bpm
		Beats < 40 bpm	Percentage of heart beats where the instantaneous heart rate was below 40 bpm
		% of ectopic beats	The percentage of inter-beat-intervals that was labelled as ectopic
	Total Sleep Time	TST	Total amount of time spent sleeping (total sleep time)
		SE	Total sleep time divided by the total duration of the interpretable part of the recording.
	Other	Rejected recording	The percentage of the total recording that was rejected from the analysis because it was of insufficient quality for interpretation

### 3.3. Summary Diagnostic report

The summary diagnostic report contains straightforward aggregations of the parameters displayed in the single-night report.

## 4. Troubleshooting guide

Diagnostic errors which arise during the operation of the NightOwl Software device are tracked by means of the output report. In case of an error, this report will almost always be output, and takes the form of a failure report. The failure report can contain one of the messages described

in the following table. When one of the described errors is met, perform the recommended actions.

*Table 3 Interpretation of possible failure reports and actions to undertake to fix problem (for the operator and for the healthcare professional)*

<b>Error message</b>	<b>Possible reason</b>	<b>Action</b>
No diagnostic report was generated since the total recording time was less than 4 hours. We noticed that the patient's smartphone had forced the NightOwl Companion App to shut down. Please advise the patient to use a different smartphone or tablet next night.	Smartphone force killed the NightOwl Companion App.	Use a different smartphone or tablet next night.
No diagnostic report was generated since the total recording time was less than 4 hours. We noticed issues with the stability of the Bluetooth connection between the patient's smartphone and the NightOwl sensor. Please advise the patient to either make sure that the phone is within 2 meters of the sensor for the large majority of the night or to use a different smartphone if this was already the case.	Bluetooth connection issues between smartphone and sensor.	Position the phone closer (within 2 meters) of the sensor during the large majority of the night or use a different smartphone if this was already the case.
No diagnostic report was generated since the total recording time was less than 4 hours.	The recording is too short. This was probably caused by improper application of the sensor.	Make sure to properly follow the instructions for application in the app.
No diagnostic report was generated since the total recording time was less than 4 hours. Please advise the patient to attempt sleeping longer next night.	The patient did not sleep long enough.	Try to sleep longer or go to bed earlier.
No diagnostic report was generated since there was less than 4 hours of analysable signal available.	The amount of analysable data was too short. This was probably caused by improper application of the sensor.	Make sure to properly follow the instructions for application in the app.

Error message	Possible reason	Action
No diagnostic report was generated since there was less than 4 hours of analysable signal available. We noticed issues with the stability of the Bluetooth connection between the patient's smartphone and the NightOwl sensor. Please advise the patient to either make sure that the phone is within 2 meters of the sensor for the large majority of the night or to use a different smartphone if this was already the case.	Bluetooth connection issues between smartphone and sensor.	Position the phone closer (within 2 meters) of the sensor during the large majority of the night or use a different smartphone if this was already the case.
No diagnostic report was generated since there was less than 4 hours of analysable signal available. We noticed that the patient's smartphone had forced the NightOwl Companion App to shut down. Please advise the patient to use a different smartphone or tablet next night.	The amount of analysable data was too short. This was due to the smartphone force killing the app.	Use a different smartphone or tablet next night.
The total sleep time was less than 2 hours; hence we could not generate a diagnostic report. Please advise the patient to attempt sleeping longer next night.	The total sleep time was less than 2 hours, probably because the patient had restless sleep.	If possible, try to sleep longer or go to bed earlier.

If an unknown error occurs, the manufacturer will also be notified and adopt the required measures to fix the problem. Contact the manufacturer to assess the problem fix status.

For communicating a complaint, noting a malfunction of the device or a customer service query, healthcare professionals should contact the manufacturer through [www.ectosense.com/support](http://www.ectosense.com/support).

## 5. Appendix A: report illustrations

### 5.1. Single-night report

Index page

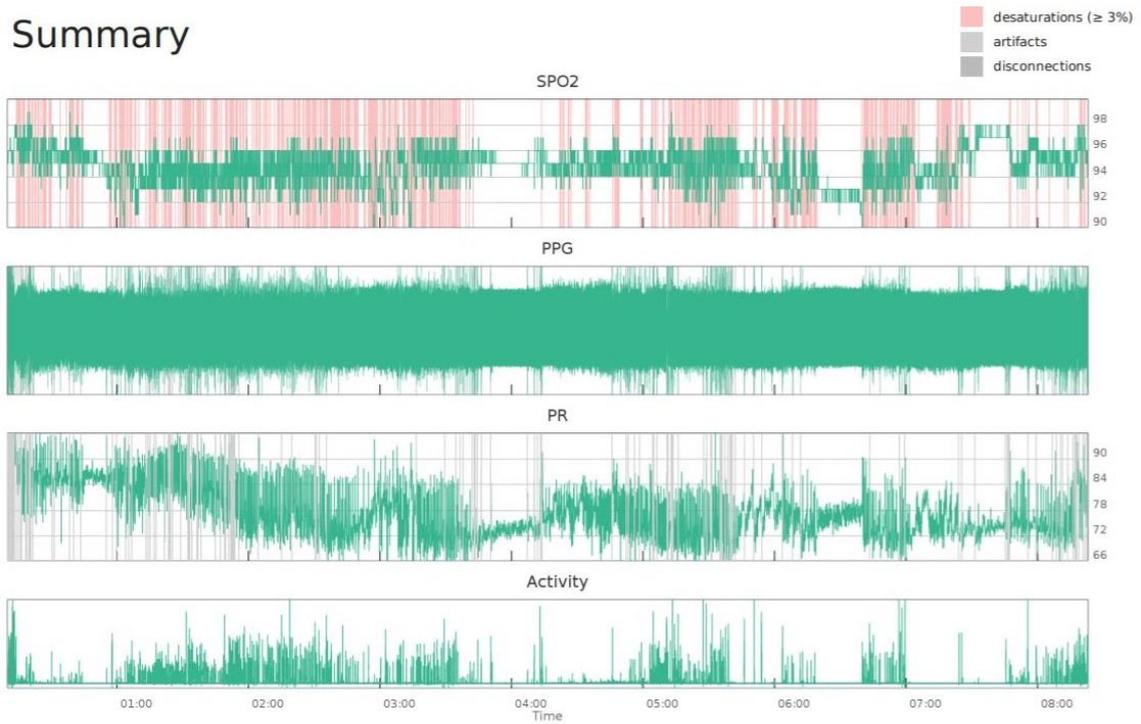
## NIGHTOWL® Examination Report



Recording Info		Apnea-Hypopnea Index		Other	
Patient ID	[REDACTED]			Rejected recording	0%
Recording start	2019-10-13 00:09	<b>AHI category (AASM)</b> Severe <b>AHI</b> 56			
Heart Rate		SpO <sub>2</sub>		Total Sleep Time	
Mean HR	77 bpm	ODI (≥ 3%)	46 events/h	TST	07:38
Beats > 100 bpm	0%	ODI (≥ 4%)	24 events/h	SE	93%
Beats < 40 bpm	0%	T90	0%		
Ectopic beats	0%	Minimum SpO <sub>2</sub>	82%		
		Maximum SpO <sub>2</sub>	99%		
Comments:					

## Trace summary page

### Summary

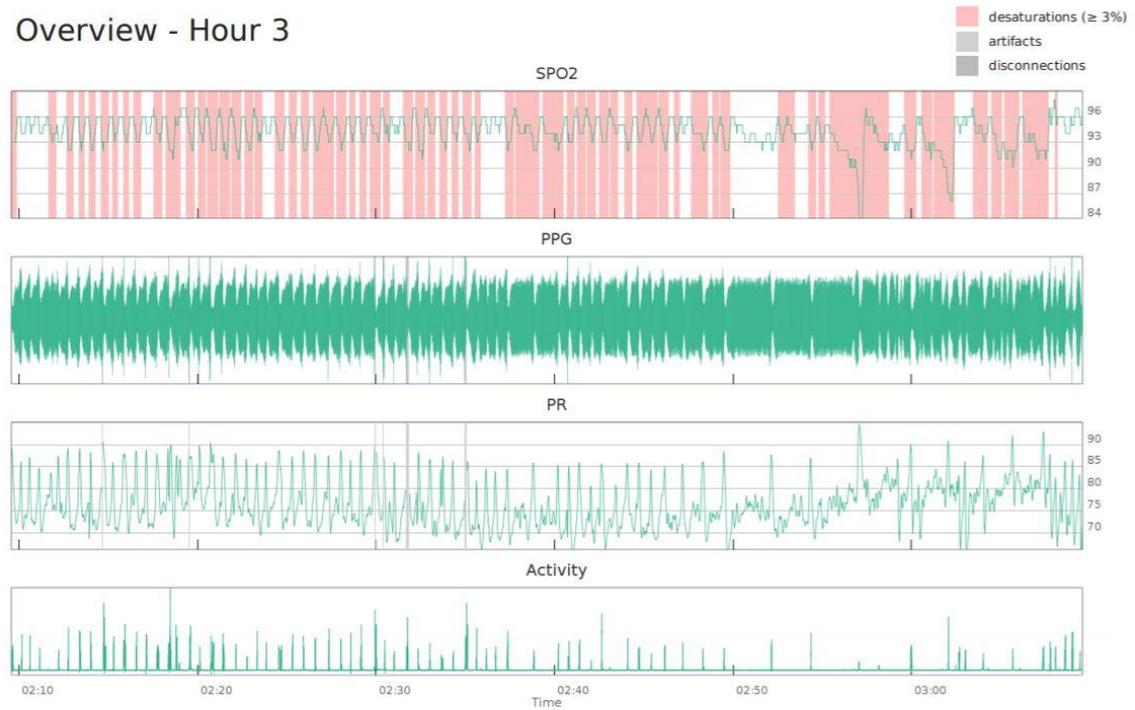


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## One-hour trace page

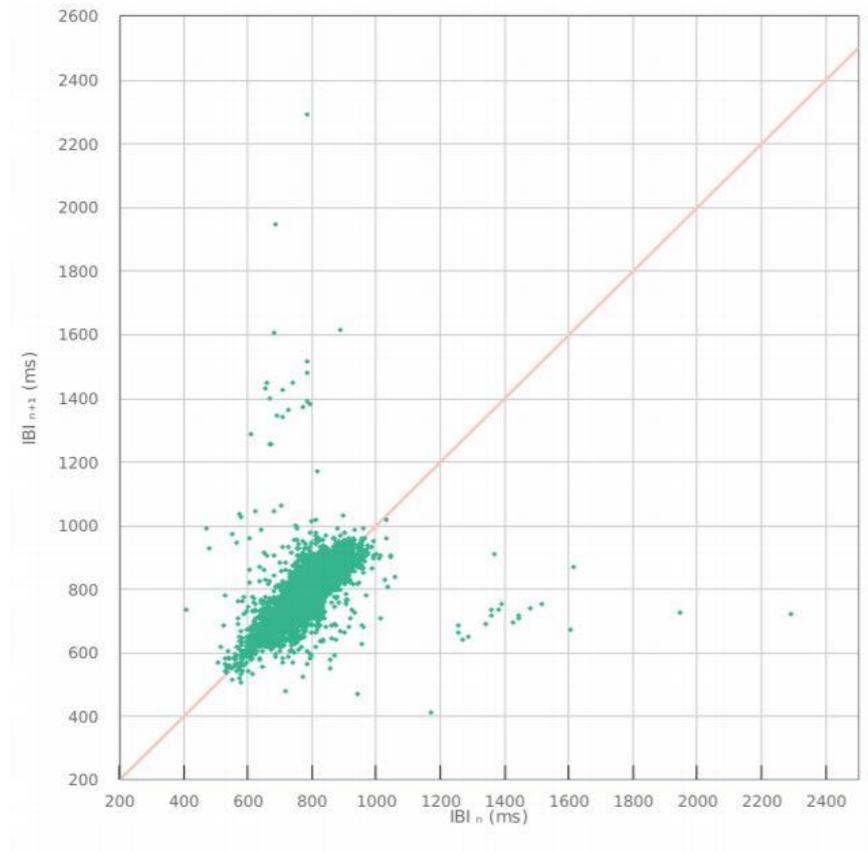
### Overview - Hour 3



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Poincaré plot page  
Poincaré plot



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## 5.2. Summary report

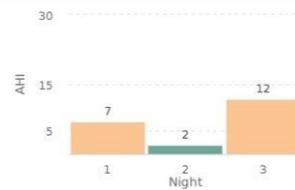
Index page

# NIGHTOWL® Examination Report



Test Info		Heart Rate	
<b>Patient ID</b>	[REDACTED]	<b>Mean HR</b>	63 bpm
<b>Number of nights</b>	3	<b>Beats &gt; 100 bpm</b>	0%
<b>Number of failed nights</b>	0	<b>Beats &lt; 40 bpm</b>	0%
<b>Mean percentage of rejected recording</b>	4 %	<b>Ectopic beats</b>	0% of beats

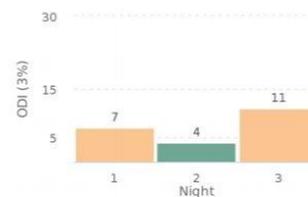
Apnea-Hypopnea Index	
<b>Max severity</b>	Mild
<b>Median severity</b>	Mild
<b>Severity of mean AHI</b>	Mild
<b>Max AHI</b>	12 events/h
<b>Mean AHI</b>	7 events/h
<b>Min AHI</b>	2 events/h



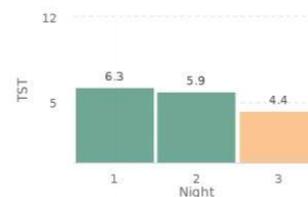
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SpO <sub>2</sub>	
<b>Max ODI ≥ 3%</b>	11 events/h
<b>Mean ODI ≥ 3%</b>	7 events/h
<b>Min ODI ≥ 3%</b>	4 events/h
<b>Max ODI ≥ 4%</b>	4 events/h
<b>Mean ODI ≥ 4%</b>	2 events/h
<b>Min ODI ≥ 4%</b>	1 events/h
<b>Mean T90</b>	0%
<b>Minimum SpO<sub>2</sub></b>	85%
<b>Maximum SpO<sub>2</sub></b>	99%



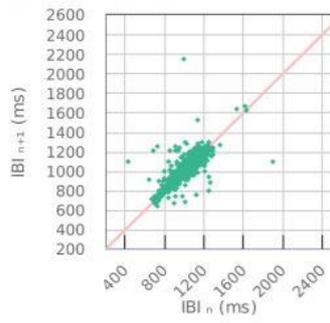
Total Sleep Time	
<b>Max TST</b>	06:18
<b>Mean TST</b>	05:31
<b>Min TST</b>	04:20
<b>Max SE</b>	95%
<b>Mean SE</b>	90%
<b>Min SE</b>	83%



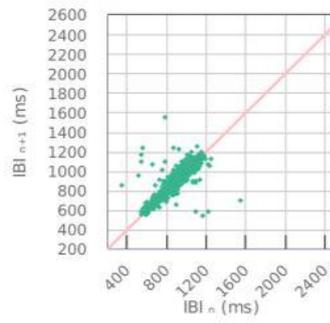
# Poincaré plots page

## Poincaré plot

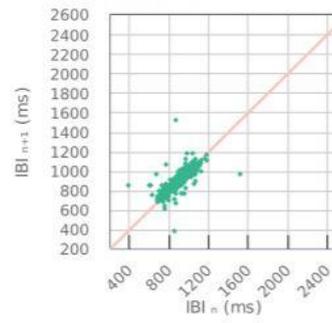
Night 1 - 2019-10-10



Night 2 - 2019-10-11



Night 3 - 2019-10-13



# Single-night summary page

## Summary - Night 3 - 2019-10-13



**TST = 04:20**   **ODI = 11 /h**   **AHI = 12 /h**