Project Number AAL-2016-049	**Active and Assisted Living Programme** **AAL-2016 – Living with Dementia**	

Carelink

An Intelligent Location Monitoring System

Deliverable D2.2

Hardware Requirements: Platform and Devices

Work package:	WP2 – Requirements and Design
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CARELINK Project Profile

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Partners

TSSG	WATERFORD INSTITUTE OF TECHNOLOGY (WIT) - [COORDINATOR]	IRELAND
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Document Control

This deliverable is the responsibility of the Work Package Leader. It is subject to internal review and formal authorisation procedures in line with ISO 9001 international quality standard procedures.

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1.0	01/10/2020	Gary McManus	Approved version release.

Executive Summary

Objectives

This deliverable relies on a survey that provides a critical source of data and insights about a number of existing Assistive Technologies (ATs) and supportive services and potential hardware that can be potentially used to improve the quality of life of the ageing People with Dementia (PwD).

The main goals of this deliverable are including:

- Reviewing, identifying, and documenting some commercially available ATs (with multiple and single capabilities) and supportive services that can help ensuring healthy lives and promote well-being for PwD.
- To nominate the best items of the identified ATs and supportive services (based on considered features) and using them as a base for designing and customizing a set of wearable technologies and supportive services for PwD under CARELINK project.
- To survey the state-of-the-art on hardware, including System-on-a-Chip integrations that include localization, communication, and sensing features, compatible with the incorporation in a sensor pack.
- To benefit from the findings of previous studies in setting the components of the sensor pack prototypes.

Results

This Deliverable addresses 86 potential ATs (39 technologies with multiple capabilities and 47 technologies with single capability), 15 supportive services, and 75 hardware that each of which (either alone or in conjunction) has potential application in assisting PwD in different circumstances. The results of this work provide an insight to the types, competitive capabilities, and unique features of the commercially available technologies and services which can lead to some possible solutions to better deal with day–to–day realities of dementia.

Among the five defined classes (cognitive enhancement, environmental, physiological, functional, Tele-information), cognitive enhancement was the most addressed issue for both ATs with single capability and supportive services. And functional was the most focused matter for ATs with multiple capabilities in reviewed studies.

The identified hardware with communication, localization and sensing capabilities can give aid for designing and developing wearable technologies that are customized with low energy consumption, low-cost, and small-sized features in response to the specific needs of PwD.

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1 INTRODUCTION

The number of people living with dementia is rising at an unprecedented rate, and no country will be spared. An approach to this emerging crisis is the development and deployment of intelligent ATs and supportive services that compensate for the specific physical and cognitive deficits of older adults with dementia, and thereby also reduce caregivers burden. Wearable technologies (e.g. smart phones and smartwatches), as example of ATs, trigger questions about how we can deliver better services, create efficiencies and improve the quality of life for PwD. Furthermore, systematic monitoring and evaluation of health and social care data provide evidence for policy development and service delivery, improve accessibility to and coordination of care for PwD. As such, adding specific hardware to ATs can expand their functions and would resolve many issues faced by PwD patients and would lead to improving their health, and safety.

Given that, this manuscript performs a review to document some available and potential ATs and supportive services to be used for both precise locations monitoring and tracking movement, and also checking the physiological signals of PwD body. Therefore, this deliverable identifies the:

1. 86 commercially available ATs and 15 different supportive services (among the others in the literature) which might find role in caring people suffering from dementia. They are classified in different classes and sub-classes (based on their capabilities and features) to make their understanding and evaluation easy.
2. 75 supportive hardware (e.g. wireless sensors, devices, chips and microchips) that have applications for both precise location monitoring and the tracking of physiological signals. In this regard the type of hardware, their specific features and capabilities (e.g. energy consumption, price, size), and the kind of tasks that they can perform (e.g. localization and communication) are analysed.

The results of the state-of-the-art lead to identifying group of potential ATs, supportive services, and supportive hardware which in turn can deliver possible solutions for specific needs of PwD. The rest of this deliverable is structured as follows: Section 2 addresses the used abbreviations and acronyms. Section 3 presents the state of the art of identified ATs and supportive services. Section 4 explains the supportive hardware that in integration with ATs can add new functions. The application and development of ATs such as smartwatch and smartphone are also explained in this section. The concluding remarks are presented in section 5.

2 ABBREVIATIONS AND ACRONYMS

Abbreviation	Description
AT	Assistive Technology
PwD	Person/People with Dementia
ECG	Electrocardiogram
BLE	Bluetooth Low Energy
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile communications
LoRa	Long Range (Long Range Wide Area Network communications)
LTE	Long-Term Evolution mobile communications
MQTT	Message Queue Telemetry Transport
TTFF	Time to First Fix

3 STATE OF THE ART

Those suffering from dementia exhibit impairments of memory, thought, and reasoning. It has been recognised that deployment of technological solutions and supportive services to address such impairments may have a major positive impact on the quality of life and can be used to help perform daily life activities hence maintaining a level of independence. On the other hand, neither decisive treatment nor effective medicines have already introduced for dementia. This work is motivated by the expanding demand and limited supply of long-term personal care for PwD, and supportive technologis and services as an alternative. Given that, this section presents an overview of the current state of the art of some identified and available ATs and supportive services that each have potential to provide specific support for PwD in particular circumstances.

3.1 Identified Assistive Technologies

3.1.1 Assistive Technologies with Multiple Capabilities

Various ATs can be configured to work together or independently as sensing modalities of PwD physical behaviour. Among the promising technologies for the purpose of this deliverable, our review of the literature identified 39 ATs with multiple capabilities, see Table 2. Based on the specific features and characteristics they are classified in five main classes namely, cognitive enhancement sensors, environmental sensors, physiological sensors, functional sensors, and tele information devices. According to the task/s that they can fulfil, each class is divided into some sub-classes. The proposed classes and sub-classes for identified ATs with multiple capabilities are presented in Table 1.

Table 1 – Proposed classes and sub-classes for identified ATs with multiple capabilities.

Table 2 – Identified ATs with multiple capabilities.

Proposed classes and sub-classes for identified ATs with multiple capabilities															
Cognitive enhancement sensors/devices				**Environmental sensors**		**Physiological sensors**			**Functional sensors**					**Tele info devices**
Capturing data from physical behaviors and communication	Support doing daily tasks	Tracking	Providing communication	Checking safety and generating alarm/alert	Controlling conditions of environment	Checking energy expenditure	Checking sleeping	Checking body condition	Monitoring activities	Checking performance	Tracking hand function	Detecting fall	Checking motion and/or gait	Telecare
Identified ATs with multiple capabilities														

CareMedia	Smart-carpet	PocketFinder	MagIC vest
COACH	NOTECASE	Spy Tec Mini GPS Tracker	Microsoft Sensecam
Mimamori-care system	Wandering Detection Algorithm	SPOT GEN3	CarePredict
Wearable and wireless camera system	ActionSLAM	GPS SmartSole	Sensor-derived physical activity
Physical activity monitor	Indoor Localization Network	Footprint by OwnFone	SIMBAD Project
Kognit	Nonintrusive pervasive computing model	Wearable NFC Wristband	Back-plaster sensor node
Sensor-based system	WearNET	MySOS from SkyGuard	low-cost fall intervention system
Complex Event Processing	SenSay	Mindme Alarm	Android Based Wearable Smart Locator Band
Buddi	Multi-accelerometer based systems	LESHP GPS Tr	Pervasive assistive solution
Ultra wideband system	iTraq	VTAM T-shirt	----

3.1.2 Assistive Technologies with Single Capabilities

In Table 3, the same classification is followed for ATs with single capability. However, in this classification the class of tele information devices is omitted, since we could not find in the literature any potential AT with single capability that can be placed in this class. It is noteworthy that the four defined classes in this table have, in some cases, different sub-classes in comparison with the Table 1.

Table 3 – Proposed classes and sub-classes for identified ATs with single capability.

Proposed classes and sub-classes for identified ATs with single capability									
Cognitive enhancement sensors/devices			Environmental sensors		Physiological sensors	Functional sensors		
Reminder	Tracking	Organizer, executive and assistant	Detector contact and proximity	Controlling environmental condition	Controlling body condition	Detecting motion and gait	Detecting fall	Improving human balance

Totally, 47 ATs with single capability are identified from the literature. These technologies have only one capability and can accomplish a single task. According to the features and characteristics, the identified ATs with single capability are listed in Table 4.

Table 4 – Identified ATs with single capability.

Identified ATs with single capability			
Cognitive enhancement sensors/devices	**Environmental sensors**	**Physiological sensors**	**Functional sensors**
Memory Glasses	Contact sensor	Bedwetting alarms	Motion detector
MemoClip	Proximity detector	BodyMedia (SenseWear® Pro Armband)	Radiofrequency
Cook's Collage	Voice activation sensors	Garmin Forerunner	VTT gait monitor
Komihu	Light sensor	Medical mood ring	Displacement sensor
Memofy	Temperature and heat sensor	Tadiran's MDkeeper	CareWatch
IMP	Force sensor	Ciclosport Alpin	Fall detector
Opportunity Knocks	Pressure sensor	Boardbug	Floor vibration-based fall detector
Activity Compas	Door and window sensor	Sensvest	Accelerometers
Trax	Leak and spill detector	OFSETH	Vibrating gel insoles
Yepzon One Personal GPS Locator	Glass break detectors	----	----
PAL	Vibration/ sound detectors	----	-----
PEAT	Electrical usage sensors	----	----
ISAAC	Water/sewer usage sensor	----	----
AutoMinder	----	----	----
Integration of pervasive computing, big data processing and machine learning	----	----	----
Calm computing and implicit guiding cues	----	----	----

3.2 Identified Supportive Services

Dementia is a progressive syndrome that can affect a person's memory, thinking, orientation and comprehension, combined with deteriorating senses (sight, touch, taste, smell and hearing). It can cause huge changes in a person's life and in the lives of those around them.

To reduce the burden of dementia, there are different service providers around the word (national or international, governmental or private) that deliver variety of supports for PwD, their families, and carers. The total of 15 supportive services are identified and listed in Table 6.

The developed classification for the supportive services is nearly similar to the recommended classification for ATs in Table 1 and Table 3. But in this classification, there are some differences in terms of number of sub-classes (either some are added or deleted). Furthermore, some sub-classes are introduced with different names, see Table 5. Except the similar addressed classes in this classification, one new class (named "type of care") is added to this table. This class is defined to indicate that in which place the service can be possibly provided: indoor, outdoor, or both. Note that every identified supportive service can, at least, cover one proposed sub-class in Table 5, and in some cases more than one class or sub-class.

Table 5 – Proposed classes and sub-classes for identified supportive services.

Proposed classes and sub-classes for identified supportive services													
Type of care	**Cognitive enhancement services**				**Environmental services**		**Physiological services**		**Functional services**			**Tele info devices**
Indoor / outdoor	Capturing data from physical behaviors & communication	Support doing daily tasks	Tracking	Providing communication	Finding orientation and navigation	Reminding or altering events	Checking diaper	Checking body condition	Monitoring activities	Checking performance	Detecting fall	Telecare

In order to maintain unity for the documented ATs and supportive services in this deliverable, nearly equal classification is considered (but the number of classes, sub-classes, and also the type of sub-classes are not exactly the same in all cases). It is believed that such classification not only can facilitate identifying and evaluating the considered ATs and supportive services, but also represents the most concerning issues in the context of monitoring the health, safety, and welfare of affected persons.

Table 6 – Identified supportive services.

Identified supportive services			
Wearable device monitoring services (WDMS)	Reminder Service (RS)	Portable projection-based display system PiTaSu	Indoor residence monitoring mode
Data Acquisition and Wireless Event Forwarding Service (DAWEFS)	Calm computing and implicit guiding cues	National emergency response service	Emergency rescue

Ambient Sensor Monitoring Service (ASMS)	Smart assistive living	PROACT	Remote monitoring mode
Initialization and caregiver support service (ICSS)	Smart wireless continence management system	Outdoor activity area monitoring	----

3.3 Analysing Collected Data

In this section the identified ATs and supportive services are separately analysed. This analyse relies on the types and percentages of their application or consideration in reviewed references. Given the above-mentioned ATs with multiple functionalities it can be seen that among the five defined classes (cognitive enhancement sensors/devices, environmental sensors, physiological sensors, functional sensors, tele info devices), the most applied class is functional sensors group with (46.08%). It is followed with the class of cognitive enhancement sensors with (31.73%), the class of environmental sensors with (13.48%), and the class of physiological sensors with (7.13%). The class of tele information devices (with 1.58%) is the less applied group of technologies in this classification. The types and percentages of defined classes and sub-classes are illustrated in Figure1.

From the findings of this classification it can be said that:

- The technologies and sensors that are designed to monitor PwD's activities and also to find and track his location are the most concerned technologies (in considered references).
- Those technologies and sensors that check the rate of energy expenditure, and track hand function do not receive attention as much as the others (in considered references).

In Figure 1, the types and percentages of proposed classes and sub-classes for the identified ATs with multiple functionalities are demonstrated.

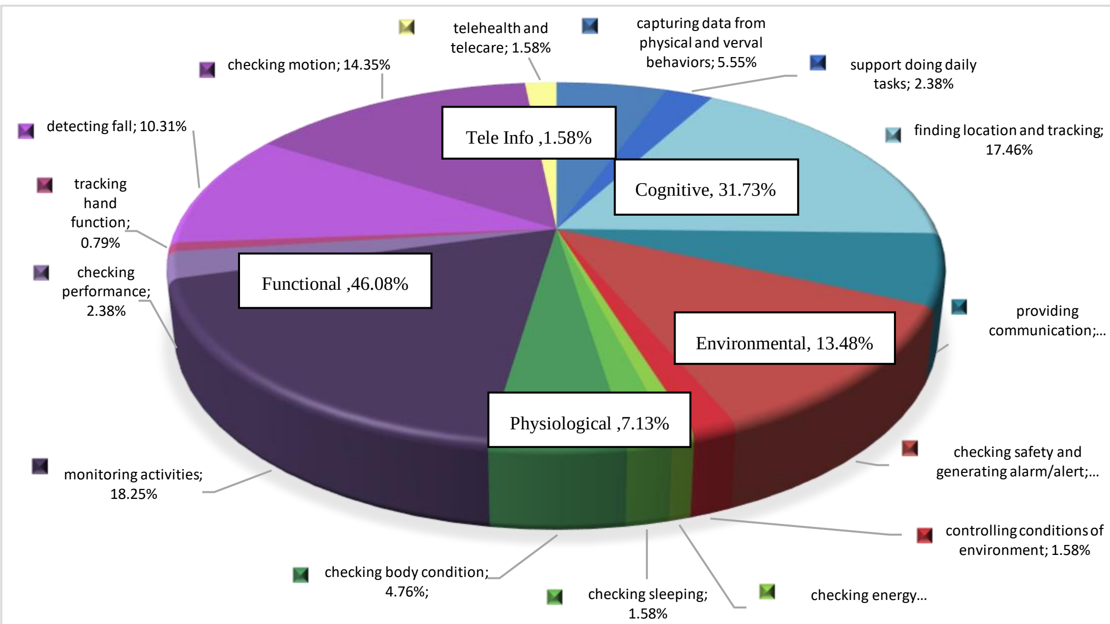

Figure 1. Types and percentages of proposed classes and sub-classes for technologies with multiple functionalities.

Taking into account the above classification for ATs with single functionalities, it can be seen that cognitive enhancement sensors are the most applied (34.04%), followed by environmental sensors (27.66%). The results also show that both physiological sensors and functional sensors received equal attention (16.15%). Among the sub-classes, sensors for controlling environmental condition with (21.27%), and sensors for controlling body condition with (19.15%) are respectively the most applied sensors. But, sensors for improving human balance with (2.13%s) are not under consideration as much as other addressed technologies.

In Figure 2, the types and percentages of proposed classes and sub-classes for the identified ATs with single functionality are demonstrated.

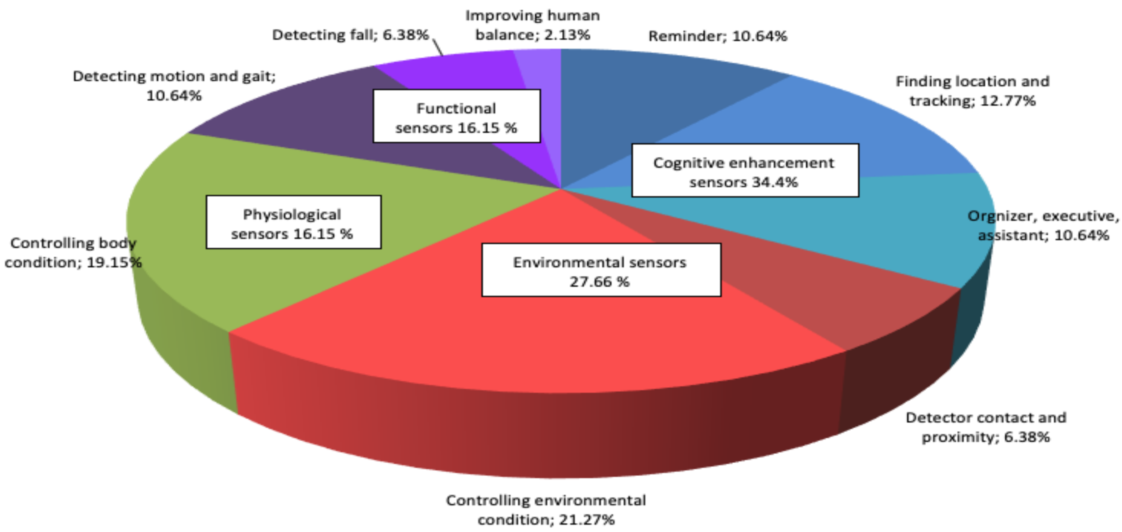

Figure 2. Types and percentages of proposed classes and sub-classes for technologies with single functionality.

As addressed in Table 2, 15 supportive services for PwD are identified. The majority of those considered references focused more on the issue of cognitive enhancement. Thus, this class has the highest percentage of application (35.48%) among the others while the physiological issues have the lowest degree (6.45%) of application. More detailed information is illustrated in Figure 3.

Given the considered classification, it can be concluded that:

- Services for finding location and tracking, and services for reminding or altering the events are equally the most applied services with (19.35%).
- Those services that provide communication, find orientation and navigation, check diaper, or check body condition, show the lowest percentage of application (3.22%).
- Some of the proposed services in Table 2 are made for indoor care and some for outdoor care. Their analysis shows that among all 15 addressed services in this table, 9 services are developed for indoor care, 1 service for outdoor care, and 5 services for both purposes (indoor and outdoor care).

The types and percentages of proposed classes and sub-classes for the identified supportive services are demonstrated in Figure 3.

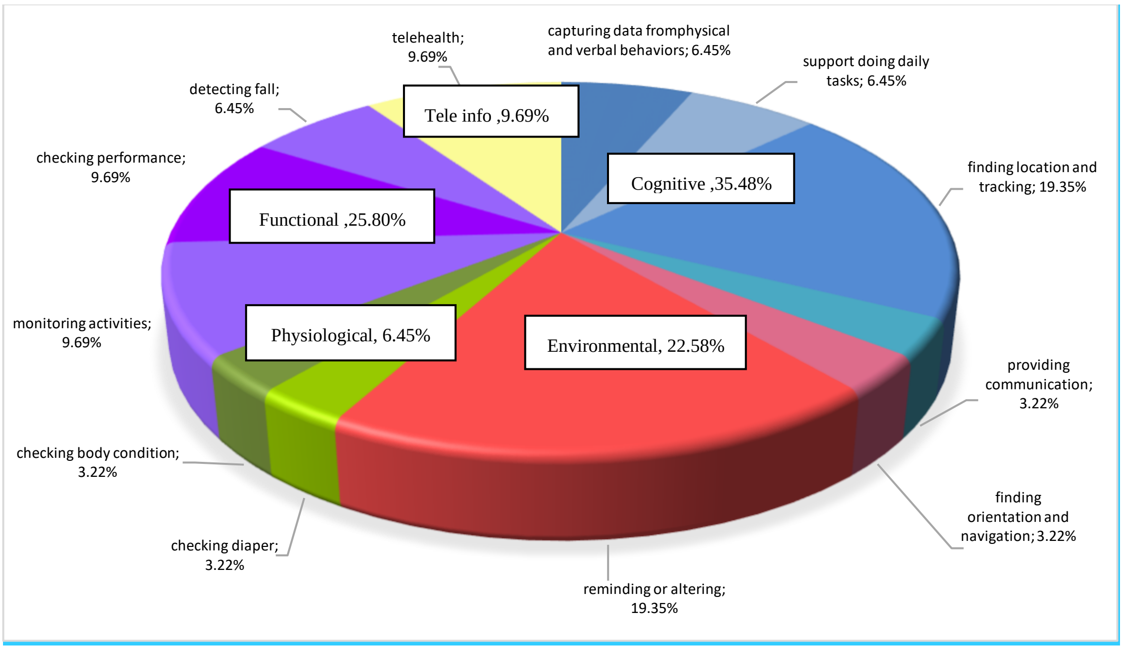

Figure 3. Types and percentages of proposed classes and sub-classes for the supportive services.

4 SUPPORTIVE HARDWARE

Advances in new age of supportive hardware (e.g. wireless sensors, devices, chips, and microchips) that are using for dementia has facilitated measuring variety of variables. As for instance, it has brought good opportunities for monitoring physical and environmental conditions. Furthermore, grouping and packing such kind of hardware and networking them with together can, for example, reform the way and speed of information gathering and also promote target yields and quality. Evidences show that the developed network has high potential, for example, to support location monitoring, building wireless communication, monitoring physical and physiological condition of patients (e.g., heart rate, oxygen saturation, temperature, blood pressure, etc.), accelerating the process, and transmitting the collected and proceed data in a timely fashion to some remote location without human intervention.

As such, attaching specific sensors on home, vehicles, body, or ATs not only could bring some possibilities for monitoring health and body conditions, but also could help collecting wide range of environmental data that can be used in detecting PwD's real-time location and current movements.

Given that, a number of suited hardware with communication, localization and sensing capabilities are identified and documented in this section to give aid for designing and developing customized wearable technologies in response to the specific needs of PwD.

4.1 Hardware Features

The requirement to have a sensor pack suitable for wearability with helpful features in assistance of PwD's biometrics checking and wandering detection (and possibly other additional dementia issues and side effects) justifies the need for:

A. *Localization technology* – helps reliable tracking of the PwD that can be used for route prediction,

B. *Local communications* – help continually accessing to device data (e.g. data from inside the PwD's home),

C. *Mobile communication* – help continually accessing to device data (e.g. data from outside the PwD's home),

D. *Sensors* – help collecting data from the PwD biometrics, and also forecasting common side effects of dementia such as wandering and accidental fall.

These needed technical features and technologies are explained in follow:

A. Localization

For localization and tracking the PwD, both GNSS and GPS are applied.

- *GNSS* (*Global Navigation Satellite System*) – is an umbrella term for a system that provides signals from space that transmits navigation, positioning, timing data, and other services to GNSS receivers.
- *GPS* (*Global Positioning System*) – is a space-based satellite navigation and precise-positioning tool that provides positioning, navigation, and timing (PNT) services in all weather conditions, anywhere in the world or near the Earth, 24 hours a day.

➢ *GPS Specific Characteristics*

- *TTFF (Time to First Fix)* – refers to the time that GPS device/receiver needs to find the position. The TTFF involves three major scenarios: (a) Hot or standby: at this point the receiver has valid value of time, position, almanac, and ephemeris data which lead to a rapid acquisition of satellite signals. (b) Warm or normal: at this point the receiver can predict the current time within 20 seconds, the current position within 100 kilometres, and its velocity within 25 m/s, and it has valid almanac data. (c) Cold or factory: at this point the receiver does not have accurate prediction of its position, velocity, the time, or the visibility of any of the GPS satellites.
- *GPS accuracy* – refers to the degree of closeness of indicated readings to the actual position. The accuracy of GPS data depends on several factors including, quality of the GPS receiver, satellite geometry, satellite signals, propagation delay, characteristics of the surroundings, internal clock errors, selective availability, etc.

B. Local Communication

For local communication and accessing device data from inside the PwD's home, both Wi-Fi and Bluetooth are applied.

- *Wi-Fi* – is a wireless networking protocol that uses radio frequency signals and radio waves. It allows nearby devices such as, PCs, laptops, smart phones, tablet devices or printers to connect at high speed to the internet and each other without the need for a physical wired connection. There are three types of Wi-Fi or wireless protocols namely, long range (is measured in miles), medium range (is measured in tens or hundreds of feet), and short-range (is less than 10 feet).
- *Bluetooth* – is an open wireless communication technology that is made for exchanging data through fixed and/or mobile electronic device (e.g., as mobile phones, computers, and peripherals). It is used for building personal area networks (PANs) specifically over short distances, close range, and low power communication.

C. Mobile Communication

For mobile communication and accessing device data from outside the PwD's home, both GSM and LTE are used.

- *GSM* (*Global System for Mobile communications*) – is an international standard for developing a digital mobile communication system, and to describe the protocols for second-generation digital cellular networks used by mobile devices such as tablets.
- *LTE* (*Long Term Evolution*) – is a standard for 4G wireless broadband technology that offers increased network capacity and speed to mobile device users, based on the GSM/EDGE and UMTS/HSPA technologies.

D. Sensors

In order to control the PwD's vital biometrics, the following four items are considered:

- *Heart rate* – also known as pulse, is the speed of the heartbeat and the number of times per minute that the heart contracts. It is one of the important indicators and 'vital signs,' of health in the human body.
- *Temperature* – human body temperature (known as Normothermia or Euthermia) is a measure of the body's ability to generate and/or get rid of heat. It varies by person, age, activity, and time of day.
- *ECG* (*Electrocardiogram*) – is the process of recording and displaying the electrical signals, rate, rhythm, and muscular functions of the heart during a cardiac cycle to show whether it is working normally or not.

- *Accelerometer* – is defined as rate of change of velocity with respect to time. Accelerometer is an electromechanical device used to detect changes in gravitational acceleration and tilt in numerous devices by measuring the force associated with translational motion.

4.2 Considered Hardware Characteristics

- *Power consumption* – refers to the actual electrical energy demand of device for operation.
- *Size* – refers to the physical dimensions of device that can be measured as length, width, height.
- *Operating temperature* – refers to the specified temperature range, at which the device operates effectively. This operating temperature ranges from a minimum, to a maximum, and outside which, the power supply may fail.
- *Price* – refers to the amount of payment for buying the device.
- *Interface* – refers to a system or device that connect those entities (e.g., boards, chips) using for interaction and communication. There are different communication protocols used in embedded systems including, USART, UART, RS232, USB, SPI, I2C, TTL, etc.

4.3 Identified Hardware

A total of 75 available and potential hardware (e.g. sensors, devices, chips, and microchips) are identified from the literature. They are listed in the following tables based on their application, and specific features and characteristics:

Table 7 – Identified GNSS and GPS devices.

Identified GNSS and GPS devices			
Multi-GNSS Receiver Chip eRideOPUS 7Model ePV7010B	Multi-GNSS Receiver Chip eRideOPUS 7Model ePV7000B	A2200-A	Flora Wearable Ultimate GPS Module 1059
MTK3339 (FGPMMOPA6H)	Trimble Copernicus II	Venus638FLPx-L 20Hz	BX305
RXM-GPS-RM-B	7DLTS0075	UBX-M8230-CT	----

For the 11 devices addressed in Table 7, the following characteristics are considered: current consumption, supply voltage, power consumption, size, temperature, price, interface, accuracy, and TTFF. Among the devices, BX305 has the best accuracy, and UBX-M8230-CT has the lowest power consumption, size, and TTFF. See appendix (Table 7).

Table 8 – Identified Wi-Fi / Wireless devices.

Identified Wi-Fi / Wireless devices			
MOD-WIFI-ESP8266	ESP8285	ESP8266EX	CleO35-WiFi1

RTL8710	88MW302	WE935B00	ST60-SIPT-C
Atheros AR9331	CC3100R11MRGCR	CC3100MOD R11 MAMOBR	----

For the 11 devices addressed in Table 8, the following characteristics are considered: current consumption, supply voltage, power consumption, size, temperature, price, interface, and protocol. Among the devices, MOD-WIFI-ESP8266, ESP8285, and ESP8266EX have equally the smallest size, and 88MW302 has the lowest power consumption. See appendix (Table 8).

Table 9– Identified Bluetooth devices.

Identified Bluetooth devices			
RN4020-V/RMBEC133	ATBTLC1000A-MU-Y	MKW30Z160VHM4	CC2560BYFVR
CC2640R2FRGZT	CC2564BRVMR	nRF52810-QFAA-R	nRF8001-R2Q32-T
nRF52832-QFAB-R	BLUENRG-132	SKB369A	BLE (ISP1807)

For the 12 devices addressed in Table 9, the following characteristics are considered: current consumption, supply voltage, power consumption, size, temperature, price, interface, and protocol. Among the devices, ATBTLC1000A-MU-Y and CC2640R2FRGZT have equally the smallest size, and SKB369A has the lowest power consumption. See appendix (Table 9).

Table 10– Identified GSM and LTE devices.

Identified GSM and LTE devices			
FiPy	Adafruit Feather 32u4 FONA	Particle Electron	SIM7000E
Hologram Dash	SIM900 Quad Band GSM GPRS Shield	LinkIt ONE (-102030002)	SIM900 GSM/GPRS shield for Arduino

For the 8 devices addressed in Table 10, the following characteristics are considered: current consumption, supply voltage, power consumption, size, temperature, price, interface, and protocol. Among the devices, FiPy has the lowest power consumption, and Particle Electron has the smallest size. See appendix (Table 10).

Table 11– Identified heart rate sensors.

Identified heart rate sensors			
BH1790GLC-E2	AD8232ACPZ-R7	PIC16F1779-E/PT	ATSAMB11-ZR210CA-ND
SFH 7070	SFH 7051	SI1143-M01-GMR	AFE4403YZPT

SparkFun Particle Sensor Breakout – MAX30105	----	----	----

For the 9 devices addressed in Table 11, the following characteristics are considered: current consumption, supply voltage, power consumption, size, temperature, price, and interface. Among the devices, BH1790GLC-E2 has the smallest size, and PIC16F1779-E/PT has the lowest power consumption. See appendix (Table 11).

Table 12– Identified body temperature measuring sensors.

Identified body temperature measuring sensors			
MAX30205MTA+	Fever click (MIKROE-2554)	BMP180	HDC2010YPAR
TMP116NAIDRVR	MLX90614ESF	SI7051-A20-IM	----

For the 7 devices addressed in Table 12, the following characteristics are considered: current consumption, supply voltage, power consumption, size, temperature, price, interface, and accuracy. Among the devices, TMP116NAIDRVR and SI7051-A20-IM have equally the smallest size, and TMP116NAIDRVR has also the lowest power consumption. See appendix (Table 12).

Table 13– Identified measuring ECG sensors.

Identified measuring ECG sensors			
AD8232ACPZ-R7	AD8232ACPZ-RL	MAX86150EFF+T	MAX30003CTI+
PS25205B	PS25251	Si1171	ADS1298RIZXGR
Micro ECG	----	----	----

For the 9 devices addressed in Table 13, the following characteristics are considered: current consumption, supply voltage, power consumption, size, temperature, price, and interface. Among the devices, AD8232ACPZ-R7 has the smallest size, and MAX30003CTI+ has the lowest power consumption. See appendix (Table 13).

Table 14– Identified accelerometer sensors.

Identified accelerometer sensors			
MPU 9255	AIS1120SXTR	H3LIS331DLTR	ADXL335BCPZ
EVAL-ADXL335Z	101020051	MMA8452QR1	BMA400

For the 8 devices addressed in Table 14, the following characteristics are considered: current consumption, supply voltage, power consumption, size, temperature, price, interface, and range. Among the devices, BMA400 has both the smallest size and the lowest power consumption. See appendix (Table 14).

The selection criteria for above-mentioned hardware is based on considered characteristics in terms of *low energy consumption rates* (for extending the autonomy of the device battery as much as possible); *small-sized* (due to the usability requirement, the smaller the chip size the more adaptable the device form-factor can be); and *lower-cost* (in order to maintain an affordable price for the device's consumer targets).

4.4 Smartwatch and Smartphone Based Sensor Pack System

Wearable technologies such as smartphone and smartwatches are a fashion statement for some, a neat piece of technology for others. But for the PwD, they transcend any 'cool factor' and can be genuinely useful. For instance, they can provide medication reminders, track daily activity and even alert loved ones of any emergency. Smartphone and smartwatch present exciting opportunities for monitoring behaviour using widely available sensor data. This could support clinical research and practice aimed at improving quality of life among the growing number of PwD. However, it requires suitable tools for measuring behaviour in a natural real-life setting that can be easily implemented by others. Smartphones and smartwatches, as example of ATs that have considered hardware characteristics mentioned in section 4.2 (except the size and price), have high potential to help PwD for example in monitoring their location, tracking related wandering behaviours, and detecting accidental falls.

The functionality of smartphones and smartwatches can be developed by adding some supportive hardware (explained in part 4.1.1). For example, including accelerometers and gyroscopes can help identifying risky situations associated with falling or fainting. In such situations, they can send an alarm, notification, or message to the family members and/or caregiver for checking the situation, and if needed, to provide appropriate health support. This feature is implemented using a machine learning algorithm for fall detection that can analyse data resulting from the movements of a person in order to detect if a fall event has occurred or is occurring. The developed function help establishing an architecture that uses the smartwatch's sensors as input and performs a real-time assessment of risk.

In a case study, a Huawei 2 smartwatch is used for fall detection and location monitoring. For developing the smartwatch functions, the Gyroscope and Axial Accelerometers are used to detect fall, and GPS is used to evaluate the PwD's position and request help if wandering is occurred.

For analysing the collected data from the hardware, algorithms and neural networks is used. In the process of analyse, the position of PwD is verified against known routes and is then stored in a data base which may contain routes or geofences of places. In the case of geofences, a map with possible or forbidden positions must be previously established. In the case of routes, a buffer establishes the premises beyond the situations that the person is wandering. New routes can be also added.

5 CONCLUSIONS

This Deliverable focuses on identifying and documenting the necessary requirements (e.g. ATs, supportive services, and supportive hardware) to design appropriate wearable technologies (e.g. smartwatch and necklaces) for PwD in the CARELINK project. The designed devices can collect and configure the biological and environmental data and information from PwD's tracking, monitoring, pattern recognition algorithm, and their caregiver's alert. The output of this Deliverable, as a potential solution, will be then used in the implementation stage.

Therefore, this work reviews and addresses 86 potential ATs, 15 supportive services, and 75 supportive hardware. The results of this work provide an insight to the types and competitive capabilities and features of the commercially available technologies and services which can lead to some possible solutions to better deal with day–to–day realities of dementia.

The results show that the identified ATs and supportive services from the literature have each the potential to provide specific support for PwD in different circumstances. The identified hardware with **communication, localization and sensing capabilities** can give aid for designing and developing wearable technologies that **customized with low energy consumption, low-cost, and small-sized features** in response to the specific needs of PwD. Smartphone and smartwatch, as wearable technologies, are ideal for health care interventions, because they include multiple functions, such as Internet access, mobile telecommunication, sensors, notifications, and the ability to install applications that are clinically focused. Evidences show that smartphone and smartwatch are effective means for health and environment monitoring particularly for those suffering from dementia.

Having selected the suitable technologies and services for the purpose of this work and following the validation of the prototypes, the next step is realizing the user (PwD) needs and comfort. The focus is on reduction of the dimensions of the modules, adopting a format suitable for wearable integration, and the arrangement towards acceptance of the technologies. Taking it into account, the design of the specifications of a fully proprietary hardware solution is initiated in order to make sure the production of a device for the final user, after the conclusion of the CARELINK project, is useful. In the requirements process, tests and trials with end-users focus groups and early friendly user trials will be conducted to gather the requirements and feedback.

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7 APPENDIX

Appendix – Detailed Tables of State-of-the-Art Hardware

In this appendix, 8 tables are demonstrated, detailing the characteristics of the state-of-the-art hardware components, defined in section 4.1, namely SoC's for GNSS/GPS, Wi-Fi/Wireless, Bluetooth, GSM/LTE, heart rate, temperature, accelerometer and ECG sensors. The specific characteristics of the devices are detailed in section 4.2, and the analysis of the identified hardware are presented in section 4.3.

Table 7. Proposed GNSS/GPS devices and characteristics details.

GNSS/GPS											
Characteristics											
No	Products	Manufacturer	Current Consumption	Supply Voltage	Power Consumption	Size	Temperature	Price	Interface	Accuracy	Time to First Fix (TTFF)
1	*Multi-GNSS Receiver Chip eRideOPUS 7Model ePV7010B*	FURUNO Electric Co., Ltd.	Acquisition Mode: 61 mA (@ DC 3.3V)	1.8VDC / 3.3VDC	0.2013	7.0 x 7.0 mm	-40℃ to +85℃	N/A	UART, I2C, Forward /Reverse signal, Speed Pulse, Time Pulse, Clock	GPS: 2.5m (CEP) GPS + SBAS: 2.0m (CEP) GPS + SBAS + GLONASS: 2.0m (CEP)	Hot Start: <1sec Warm Start: 30 sec Cold Start: 33 sec
References		[1]	[1]	[1]		[1]	[1]		[1]	[1]	[1]
[1] http://www.furuno.com/en/products/gnss-chip/ePV7010B#Freespace0											
2	*Multi-GNSS Receiver Chip eRideOPUS 7Model ePV7000B*	FURUNO Electric Co., Ltd.	Acquisition Mode: 61 mA (@ DC 3.3V	1.8VDC / 3.3VDC	0.2013	110 x 112 x 30 mm	-40℃ to +85℃	N/A	UART, I2C, Forward /Reverse signal, Speed Pulse, Time Pulse, Clock	GPS: 2.5m (CEP) GPS + SBAS: 2.0m (CEP) GPS + SBAS + GLONASS: 2.0m (CEP)	Hot Start: <1sec Warm Start: 30 sec Cold Start: 33 sec
References		[1]	[1]	[1]		[1]	[1]		[1]	[1]	[1]
[1] http://www.furuno.com/en/products/gnss-chip/ePV7000B											
3	*A2200-A*	Maestro Wireless Solutions	41mA	3.3 V	0.1353	14 x 10.2 x 2.5 mm	-40℃ to +85℃	Qt 1:13,44 € Qt 25:13,44 € Qt 100: 10,68 €	UART, SPI	< 2.5 m CEP (autonomous) < 2.0 m CEP SBAS	Hot Start2) < 1sec Warm Start2) < 35 sec Cold Start2) < 35 sec
References		[1]	[2]	[2]		[2]	[3]	[2]	[2]	[3]	[3]
[1] http://www.maestro-wireless.com/ [2] https://pt.mouser.com/ProductDetail/Maestro-Wireless-Solutions/A2200-A?qs=sGAEpiMZZMsjLMBIknjmktYVBsgslotygEY%252bXiYuHgE%3d [3] https://pt.mouser.com/datasheet/2/251/Maestro_A2200_GPS_Module_Product_Brief_v14-2-1109224.pdf											
4	*Flora Wearable Ultimate GPS Module 1059*	Adafruit	4mA ~ 20mA at 3.3V	3 to 4.3 V	0.066	15 x 15 x 4mm	N/A	Qt 1: 32,76 € (with adafruit board)	N/A	< 3 meters	Hot start: 1sec Warm start: 33 sec Cold start: 35 sec
References		[1]	[4]	[2]		[2]		[2]	[2]	[3]	[4]
[1] https://www.adafruit.com/ [2] https://eu.mouser.com/ProductDetail/Adafruit/1059?qs=sGAEpiMZZMtH%2fBOfAD3t9Y4oFpO%2f%252bm4qFwlqiNZOYgVbuD6C5xOMEQ== [3] https://www.adafruit.com/product/1059 [4] https://cdn-shop.adafruit.com/datasheets/GlobalTop-FGPMMOPA6H-Datasheet-V0A.pdf											
5	*MTK3339 (FGPMMOPA6H)*	Adafruit	Acquisition: 19 mA Tracking: 16 mA	3.3V	0.0627 0.0528	16 x 16 x 5 mm	-40℃ to +85℃	Qt 1: 29,95 €	UART(TTL)	< 3 meters	Hot start: 1sec Warm start: 33 sec Cold start: 35 sec
References		[1]	[2]	[1]		[1]	[2]	[1]	[2]	[1]	[3]
[1] https://www.adafruit.com/product/790 [2] https://pt.aliexpress.com/item/MTK3339-ultra-small-GPS-Module-with-Dual-Antenna-FGPMMOPA6C-PA6C/531702544.html [3] https://cdn-shop.adafruit.com/datasheets/GlobalTop-FGPMMOPA6H-Datasheet-V0A.pdf											
6	*Trimble Copernicus II*	Diamond Point International	Consumption: (typ.) 44 mA (132 mW) @	+2.7 VDC to 3.3 VDC	0.132	19 x 19 x 2.54 mm	-40℃ to +85℃	N/A	28 surface-mount edge castellations 2 serial 3.0 V CMOS-compatible pulse, once per second	Horizontal: <2.5 meters (50%), <5 meters (90%)	Cold start: 38 sec
References		[1]	[1]	[1]		[1]	[1]		[2]	[1]	[2]
[1] http://www.dpie.com/gps/embedded/trimble-copernicus-ii-gps-receiver [2] http://www.dpie.com/datasheets/gps/022542-012A_Copernicus-II_DS_0809_A4_lr.pdf											
7	*Venus638FLPx-L 20Hz*	Proto-PIC	Enhanced Acquisition: 68 mA @ 3.3V Low Power Acquisition: 50mA @	2.8V ~ 3.6V	0.22 0.165	10 x 10 x 1.3mm	-40℃ to +85℃	Qt 1: 36.00 £	UART LVTTL level	2.5 m CEP	Hot start: 1sec AGPS: 3.5 sec Cold start: 29 sec
References		[1]	[2]	[2]		[1]	[2]	[1]	[2]	[2]	[2]
[1] https://www.proto-pic.co.uk/gps-module-venus638flpx-l-20hz-14-channel.html [2] https://dlnmh9ip6v2uc.cloudfront.net/datasheets/Sensors/GPS/Venus638FLPx.pdf											
8	*BX305*	Tersus	(312 mA *calculated)	5V DC	1.56	92 x 54 x 13 mm	-40℃ to +85℃	Qt 1: $999.00 (BX305 GNSS RTK Board) (857.451€)	N/A	Horizontal (RMS): 10 mm+1ppm Vertical (RMS): 15 mm+1ppm	Warm Start: <30sec Cold Start: <50sec
References		[1]	[1]	[2]		[1]	[1]	[3]		[1]	[2]
[1] https://www.tersus-gnss.com/product/bx305-oem-board [2] https://www.tersus-gnss.com/assets/upload/file/20180731133334787.pdf [3] https://www.tersus-gnss.store/products/oem-board-bx305											
9	*RXM-GPS-RM-B*	Linx Technologies	Acquisition: 14mA Tracking: 12mA Standby: 0.135mA	Min: 3V Typ: 3.3V Max: 4.3 V	0.0462 0.396 0.004455	15 x 13 x 2.2 mm	-40℃ to +85℃	Qt 1: 16,51€ Qt 25:13,82 €	Serial	3 m	Hot Start: 30 sec Cold Start: 32 sec
References		[1]	[2]	[2]		[2]	[2]	[2]	[2]	[2]	[3]
[1] https://linxtechnologies.com/wp/ [2] https://eu.mouser.com/ProductDetail/Linx-Technologies/RXM-GPS-RM-B?qs=sGAEpiMZZMsjLMBIknjmkswlEeXPOvfi1dzUiVe5nAtO%252bq%252bNQoEK9g%3d%3d [3] https://eu.mouser.com/datasheet/2/238/RXM-GPS-RM%20Data%20Guide%20131017-1175148.pdf											
10	*7DLTS0075*	Japan Radio Co., Ltd	Icc: 42mA typ. (DC3.3V, +25℃.	DC3.3V	0.1386	6 × 6 × 1.2 mm	-40℃ to +85℃	N/A	N/A	2.2 m CEP	Hot Start: 2 sec Warm Start: 8 sec Cold Start: 35 sec
References		[1]	[1]	[1]		[1]	[1]			[1]	[1]
[1] http://www.jrc.co.jp/eng/product/lineup/7dlts0075/index.html											
11	*UBX-M8230-CT*	u-blox	36 mA @ 1.4 V	1.4 V to 3.6 V	0.054	2.99 x 3.21 x 0.36 mm	-40℃ to +85℃	N/A	ART USB SPI DDC (I2C compliant)	3.5 m CEP	Hot Start: 1sec Aided Start: 2 sec Cold Start: 26 sec
References		[1]	[2]	[2]		[1]	[1]		[2]	[2]	[2]
[1] https://www.u-blox.com/en/product/ubx-m8230-ct-chip [2] https://www.u-blox.com/sites/default/files/UBX-M8230-CT_ProductSummary_%28UBX-16017340%29.pdf											

Table 8. Proposed Wi-Fi / Wireless devices and characteristics details.

Wi-Fi / Wireless Characteristics										
No	**Products**	**Manufacturer**	**Current Consumption**	**Supply Voltage**	**Power Consumption**	**Size**	**Temperature**	**Price**	**Interface**	**Protocol**
1	**MOD-WIFI-ESP8266**	Olimex Ltd.	80 mA	3.3 V	0.264	5 x 5 mm	0℃ to +70℃	Qt 1: 5,45 €	I2C, SDIO 2.0, SPI, UART	802.11b/g/n
References		[1]	[3]	[3]		[3]	[2]	[2]	[2]	[3]
[1] https://www.olimex.com/										
[2] https://eu.mouser.com/ProductDetail/Olimex-Ltd/MOD-WIFI-ESP8266?qs=sGAEpiMZZMu6TJb8E8Cjr8THuSBlwx5fq2tykGKhxvg%3d										
[3] https://eu.mouser.com/datasheet/2/306/0a-esp8266_datasheet_en_v4.4-1095238.pdf										
2	**ESP8285**	Espressif Systems	80 mA	2.7 V to 3.6 V	0.288	5 x 5 mm	-40℃ to +125℃	Qt 1: 1,48 €	ADC, GPIO, I2C, I2S, PWM, SDIO, SPI, UART	802.11b/g/n/e/i
References		[1]	[3]	[2]		[3]	[2]	[2]	[2]	[2]
[1] https://www.espressif.com/										
[2] https://eu.mouser.com/ProductDetail/Espressif-Systems/ESP8285?qs=chTDxNqvsyn49Ad%252bqWdhlQ%3D%3D										
[3] https://www.espressif.com/sites/default/files/documentation/0a-esp8285_datasheet_en.pdf										
3	**ESP8266EX**	Espressif Systems	80 mA	2.5 V to 3.6 V	0.288	5 x 5 mm	-40℃ to +125℃	Qt 1: 1,31 €	UART/SDIO/SPI/I2C	802.11b/g/n/e/i
References		[1]	[3]	[2]		[2]	[2]	[2]	[2]	[3]
[1] https://www.espressif.com/										
[2] https://eu.mouser.com/ProductDetail/Espressif-Systems/ESP8266EX?qs=sGAEpiMZZMve4%2fbfQkoj%252bGif8WCprhV4ngk1mHM9Xjs%3d										
[3] https://eu.mouser.com/datasheet/2/891/0a-esp8266ex_datasheet_en-1223899.pdf										
4	**CleO35-WiFi1**	Bridgetek	80 mA	3.3 V	0.264	35.3 x 31.6 x 4.6 mm	-40℃ to +85℃	Qt 1: 18,66 €	UART	802.11b mode
References		[1]	[3]	[2]		[2]	[2]	[2]	[2]	[3]
[1] http://brtchip.com/										
[2] https://eu.mouser.com/ProductDetail/Bridgetek/CleO35-WiFi1?qs=sGAEpiMZZMve4%2fbfQkoj%252bIZJxVbenzFUHA%2f9OS0EUx4%3d										
[3] https://eu.mouser.com/datasheet/2/880/DS_CleO35_WIFI-1140601.pdf										
5	**RTL8710**	Realtek Semiconductor	80 mA	3.0~3.6 V	0.288	24 x 16x 0.8 mm	-20℃ to +125℃	Qt 1: $3.99	HSPI, UART, I2C, I2S, IR Remote Control, PWM, GPIO	802.11b modle
References		[3]	[1]	[1]		[1]	[1]	[2]	[1]	[1]
[1] http://aitendo3.sakura.ne.jp/aitendo_data/product_img/wireless/2.4G/RTL-00/RTL8710%20wifi%20module%20specification.pdf										
[2] https://www.seeedstudio.com/RTL8710-WiFi-Module-p-2793.html										
[3] http://www.realtek.com.tw/products/productsView.aspx?Langid=1&PNid=33&PFid=45&Level=4&Conn=3&ProdID=361										
6	**88MW302**	Marvell	4.5 mA	3.3 V	0.01485	8 x 8 mm	-40℃ to +85℃	N/A	SSP/SPI/I2S, UART, I2C	802.11n/g/b
References		[1]	[2]	[2]		[2]	[2]		[2]	[2]
[1] http://www.marvell.com/										
[2] https://www.marvell.com/microcontrollers/assets/MV-S109936-01C.pdf										
7	**WE935B00**	Wi2Wi	N/A	3.3V	N/A	15 x 16.5 x 1.86 mm	-40℃ to +85℃	N/A	UART, SPI & USB*	IEEE 802.11b/g/n
References		[1]		[1]		[1]	[1]		[1]	[1]
[1] http://www.wi2wi.com/wireless-connectivity/embedded-series/wi-fi/we935b00										
8	**ST60-SIPT-C**	Laird	620 mA *Maximum Current	3.3 V	2.046	13 x 14 x 1.87 mm	-30℃ to +85℃	Qt 1: 23,41 €	PCIe 3.0, SDIO, UART, USB2.0	802.11a/b/g/n/ac
References		[1]	[3]	[2]		[3]	[2]	[2]	[2]	[2]
[1] https://www.lairdtech.com/										
[2] https://eu.mouser.com/ProductDetail/Laird/ST60-SIPT-C?qs=%2fha2pyFaduiJvLpW1FR2z%2fxU8H3gaof0zuMF8J%2fvsuO3uv9tnyFLUw%3d%3d										
[3] https://eu.mouser.com/datasheet/2/223/Datasheet_-_60-SIPT_v1_8-1316891.pdf										
9	**Atheros AR9331**	Qualcomm	373mA (@3.3V)* *Max.	1.2 to 3.3 VDC	1.2309	12 x 12 mm	0 to 110 ℃	N/A	JTAG, UART, GPIO, I2S/S-PDIF, SLIC (VoIP/PCM) 2 x	802.11b/g/n
References		[4]	[3]	[2]		[1]	[1]		[1], [2]	[3]
[1] https://wikidevi.com/wiki/Atheros_AR9331										
[2] https://www.ezsbc.com/index.php/news1/openwrt-ar9331-development-board/#.WypmB9JKiJB										
[3] https://www.openhacks.com/uploadsproductos/ar9331_datasheet.pdf										
[4] http://www.qca.qualcomm.com/										
10	**CC3100R11MRGCR**	Texas Instruments	53 mA	2.1V to 3.6 V	0.1908	1 x 9.15 x 9.15 mm	-40℃ to +85℃	Qt 1: 6,17 € Qt 25:5,16 € Qt 100: 4,62 €	SPI, UART	802.11b/g/n
References		[1]	[2]	[2]		[2]	[2]	[2]	[2]	[3]
[1] http://www.ti.com/										
[2] https://eu.mouser.com/ProductDetail/Texas-Instruments/CC3100R11MRGCR?qs=sGAEpiMZZMvxVoyCXc2K7jP6tCXIusP8K4wPDJQSMkg%3d										
[3] http://www.ti.com/lit/ds/symlink/cc3100.pdf										
11	**CC3100MOD R11 MAMOBR**	Texas Instruments	54 mA	2.3 V to 3.6 V	0.1944	1.27×20.5 ×17.5-mm	-20℃ to +70℃	Qt 1: 10,59 € Qt 25:9,23 € Qt 100: 8,22 €	SPI	802.11b/g/n
References		[1]	[3]	[2]		[3	[2]	[2	[3]	[3]
[1] http://www.ti.com/										
[2] https://eu.mouser.com/ProductDetail/Texas-Instruments/CC3100MODR11MAMOBR?qs=sGAEpiMZZMu58sUZeT0O%2fgUxvwueOh7K4x%252bDgoEc9lk%3d										
[3] http://www.ti.com/lit/ds/symlink/cc3100mod.pdf										

Table 9. Proposed Bluetooth devices and characteristics details.

Bluetooth										
Characteristics										
No	Products	Manufacturer	Current Consumption	Supply Voltage	Power Consumption	Size	Temperature	Price	Interface	Protocol
1	***RN4020-V/RMBEC133***	Microchip Technology	16 mA	18 V to 3.6 V	0.0576	11.5 x 19.5 x 2.5 mm	-30℃ to +85℃	Qt 1: 8,69 € Qt 10:7.97 € Qt 25: 7,02 €	I2C, UART	Bluetooth 4.1
References		[1]	[3]	[2]		[2]	[2]	[2]	[2]	[2]
[1] https://www.microchip.com/										
[2] https://eu.mouser.com/ProductDetail/Microchip-Technology/RN4020-V-RMBEC133?qs=sGAEpiMZZMve4%2fbfQkoj%252bP9drDq8Y7PD813vXG6U%2fns%3d										
[3] https://eu.mouser.com/datasheet/2/268/50002279B-846406.pdf										
2	***ATBTLC1000A-MU-Y***	Microchip Technology / Atmel	3.0 mA peak TX current (0dBm, 3.6V)	18 V to 4.3 V	0.0108	4 x 4 mm	-40℃ to +85℃	Qt 1: 3,81€ Qt 25:3,06 € Qt 100: 2,79 €	SPI, UART	Bluetooth V4.1
References		[1]	[3]	[2]		[2]	[2]	[2]	[2]	[3]
[1] http://www.microchip.com/										
[2] https://eu.mouser.com/ProductDetail/Microchip-Technology-Atmel/ATBTLC1000A-MU-Y?qs=sGAEpiMZZMtWugglubTlf5ZDrkWU%252bYChlpK3n%2fkr7i0%3d										
[3] https://eu.mouser.com/datasheet/2/268/Atmel-42409-ATBTLC1000-QFN-SoC_Datasheet-1368657.pdf										
3	***MKW30Z160VHM4***	NXP / Freescale	6.5 mA (DCDC in buck mode, 3.6 V supply)	3.6 V	0.0234	5 x5 x1 mm	-40℃ to +85℃	Qt 1: 2,74 € Qt 25:2,22 € Qt 100: 2,05 €	I2C, SPI, UART	Bluetooth 4.1
References		[1]	[3]	[2]		[3]	[2]	[2]	[2]	[3]
[1] https://www.nxp.com/										
[2] https://eu.mouser.com/ProductDetail/NXP-Freescale/MKW30Z160VHM4?qs=dTI%2FGK1lAHLpOr9j8bhz9w%3D%3D										
[3] https://eu.mouser.com/datasheet/2/302/MKW40Z160-1127201.pdf										
4	***CC2560BYFVR***	Texas Instruments	1 mA	2.2 V to 4.8 V	0.0036	8.0 mm × 8.0 mm × 0.6 mm	-40℃ to +85℃	Qt 1: 3,92 € Qt 10:2,53 € Qt 100: 2,89 €	I2S	Bluetooth 4.1
References		[1]	[3]	[2]		[3]	[2]	[2]	[2]	[3]
[1] http://www.ti.com/										
[2] https://eu.mouser.com/ProductDetail/Texas-Instruments/CC2560BYFVR?qs=sGAEpiMZZMvzv9EAOJZmO3vh8DpPqXXjniLSboR6CnQ%3d										
[3] http://www.ti.com/lit/ds/symlink/cc2560.pdf										
5	***CC2640R2FRGZT***	Texas Instruments	145 mA + 31 µA/MHz	18 V to 3.8 V	0.00435	4 × 4 mm	-40℃ to +85℃	Qt 1: 4,58 € Qt 10:4,11 € Qt 100: 3,37 €	I2C, I2S, SSI, UART	Bluetooth 4.2/5
References		[1]	[3]	[2]		[3	[2]	[2]	[2]	[3]
[1] http://www.ti.com/										
[2] https://eu.mouser.com/ProductDetail/Texas-Instruments/CC2640R2FRGZT?qs=sGAEpiMZZMutXGli8Ay4kMxm20n7fW7lOa5xjbpKcv4%3d										
[3] http://www.ti.com/lit/ds/symlink/cc2640r2f.pdf										
6	***CC2564BRVMR***	Texas Instruments	1 mA	2.2 V to 4.8 V	0.0036	8 x 8 mm	-40℃ to +85℃	Qt 1: 4,09 € Qt 10:3,68 € Qt 100: 3,02 €	UART PCM-I2S	Bluetooth v4.1 (BLE) + EDR
References		[1]	[3]	[2]		[3]	[2]	[2]	[2]. [3]	[4]
[1] http://www.ti.com/										
[2] https://eu.mouser.com/ProductDetail/Texas-Instruments/CC2564BRVMR?qs=sGAEpiMZZMvcRsgoMFfeP89Kk1YI3KKSpdBXG9W0d%252bE%3d										
[3] http://www.ti.com/lit/ds/symlink/cc2564.pdf										
[4] https://www.arrow.com/en/products/cc2564brvmr/texas-instruments										
7	***nRF52810-QFAA-R***	Nordic Semiconductor	0.3 mA no RAM retention 14 mA All peripherals in IDLE 18 µA All peripherals in IDLE 40 nA per 4kB RAM retention	17 V to 3.6 V	0.00108 0.00504 0.00000648 0.000000144	6 x 6 x.85 mm	-40℃ to +85℃	Qt 1: 3,06 € Qt 10:2,46 € Qt 100: 2,24 €	2-Wire, SPI, UART	Bluetooth 5/ANT/2.4GHz proprietary
References		[1]	[3]	[2]		[3]	[2	[2]	[2]	[3]
[1] http://www.nordicsemi.com/										
[2] https://eu.mouser.com/ProductDetail/Nordic-Semiconductor/nRF52810-QFAA-R?qs=sGAEpiMZZMuReUCzg6bfTAYIATJbN4OcwChsSBSYU068BdhvtBzxnw%3d%3d										
[3] http://infocenter.nordicsemi.com/pdf/nRF52810_PS_v1.2.pdf										
8	***nRF8001-R2Q32-T***	Nordic Semiconductor	11 mA Active TX peak current at 12.5 mA Active RX peak current	19 V to 3.6 V	0.0396 0.045	5 x 5 mm	-40℃ to +85℃	Qt 1: 3,49 € Qt 10:2,80 € Qt 100: 2,55 €	I²C, SPI, UART	Bluetooth v4.0
References		[1]	[3]	[2]		3]	[2]	[2]	[4]	[4]
[1] http://www.nordicsemi.com/										
[2] https://eu.mouser.com/ProductDetail/Nordic-Semiconductor/nRF8001-R2Q32-T?qs=%2fha2pyFaduhJLVpg4RENFhlHh2j8dxvYAlTsOr850lhkxKRkgnc4SQ%3d%3d										
[3] https://www.nordicsemi.com/eng/content/download/2981/38488/file/nRF8001_PS_v1.3.pdf										
[4] https://www.digikey.pt/product-detail/en/nordic-semiconductor-asa/NRF8001-R2Q32-T/1490-1026-ND/4626390										
9	***nRF52832-QFAB-R***	Nordic Semiconductor	0.3 µA at 3 V in OFF mode 0.7 µA at 3 V in OFF mode with 19 µA at 3 V in ON mode, no	17 V to 3.6 V	0.0000009 0.0000021 0.0000057	6 × 6 mm	-40℃ to +85℃	Qt 1: 4,37 € Qt 10:3,51 € Qt 100: 3,20 €	2 Wire, I2C, I2S, PDM, PPI, SPI, UART	Support for concurrent multi-protocol
References		[1]	[3]	[2]		[3]	[2]	[2]	[2]	[3]
[1] http://www.nordicsemi.com/										
[2] https://eu.mouser.com/ProductDetail/Nordic-Semiconductor/nRF52832-QFAB-R?qs=sGAEpiMZZMuKfYsiLTlqmFeogZzM9xEMAZBdNaGWL9g%3d										
[3] https://eu.mouser.com/datasheet/2/297/nRF52832_PS_v1.3-1117956.pdf										
10	***BLUENRG-132***	STMicroelectronics	8.3 mA TX current (@ -2 dBm, 3.0 V)	17 V to 3.6 V	0.0249	5 x 5 mm	-40℃ to +105℃	Qt 1: 3,26 € Qt 10:2,77 € Qt 100: 2,40 €	I2C, SPI, UART	N/A
References		[1]	[3]	[2]		[2]	[2]	[2]	[2]	
[1] https://www.st.com/										
[2] https://eu.mouser.com/ProductDetail/STMicroelectronics/BLUENRG-132?qs=sGAEpiMZZMu3xu3GWjvQiPxHf6%252b6mhpnSi4T1hsVoKs%3d										
[3] https://eu.mouser.com/datasheet/2/389/bluenrg-1-973935.pdf										
11	***SKB369A***	Skylab	TX Peak @4dBm 7.5mA* RX Peak 5.4mA* Sleep Mode (avg.) 0.4uA* Idle Mode (avg.) 1.2uA* *Current(peak) @3V	17 V~3.6V	0.0225 0.0162 0.0000012 0.0000036	17.4 × 13.7 × 1.9 mm	-40℃ to +85℃	N/A	SPI, I2C, UART (CTS/RTS), CPU	Bluetooth 4.2
References		[1]	[2]	[2]		[2]	[2]		[3]	[3]
[1] http://www.skylabmodule.com/										
[2] http://www.skylabmodule.com/wp-content/uploads/SkyLab_SKB369_V1.07_datasheet.pdf										
[3] http://www.skylabmodule.com/nfcant-bluetooth-4-2-module-skb369/										
12	***BLE (ISP1807)***	Insight SiP	Peak current, Rx active 5.4 mA Peak current, Tx @0dBm 4.9 Peak current, Tx @+8dBm 14.1 Deep sleep current 0.4 µA	17 V to 5.5 V	0.0297 0.02695 0.07755 0.0000022	8.0 x 8.0 x 1.0 mm	-40℃ to +85℃ C	N/A	USB, SPI, UART, PDM, I2C	BLE & ANT protocol
References		[1]	[1]	[1]		[1]	[1]		[1]	[1]
[1] https://www.insightsip.com/products/bluetooth-smart-modules/isp1807										

Table 10. Proposed GSM/LTE devices and characteristics details.

GSM/LTE										
Characteristics										
No	Products	Manufacturer	Current Consumption	Supply Voltage	Power Consumption	Size	Temperature	Price	Interface	Protocol
1	FiPy	Pycom	Idle (no radios) 62.7 mA @5V	3.3 V – 5.5 V	0.3135	55 x 20 x 3. 5 mm	N/A	Qt 1: 54.00 €	UART, SPI, I2C, micro SD card	LTE-CAT M1/NB1, LoRa and Sigfox
			Deep Sleep 24mA @5V		0.12	(board)				
			LTE Tx 173 mA @5V		0.865					
			LTE Rx 74.5 mA @5V		0.3725					
References		[1]	[2]	[1]		[1]		[1]	[1]	[2]
[1] https://pycom.io/product/fipy/										
[2] https://docs.pycom.io/chapter/datasheets/downloads/fipy-specsheet.pdf										
2	Adafruit Feather 32u4 FONA	Adafruit	N/F	3.3 V	N/A	61x 23 x 7 mm (board)	N/A	Qt 1: $ 44.95 -38.56 €	I2C, SPI, USB	GSM GPRS
References		[1]	[1]	[1]		[1]		[1]	[1]	[1]
[1] https://www.adafruit.com/product/3027										
3	Particle Electron	U-blox	Power Off Mode 65 µA	3.9 V-12 VDC	0.00002535	26 x 16 x 3 mm	-40℃ to +85℃	Qt 1: $ 69.95	UART, SPI, I2S,	UMTS/HSPA
			Idle Mode 0.5mA		0.00195			(60 €) *Dev. Kit # 1	USB 2.0	
			HSDPA Connected Mode (Tx / Rx call enabled) 680mA		2.652			Qt 1: $138.50	GPIO	
								(118,80 €) *Dev. Kit		
References		[1]	[2]	[2]		[2]	[2]	[2]	[2]	[2]
[1] https://www.u-blox.com/en/product/sara-u2-series										
[2] https://www.u-blox.com/sites/default/files/SARA-U2_DataSheet_%28UBX-13005287%29.pdf										
[*] https://docs.particle.io/datasheets/electron-(cellular)/electron-datasheet/										
[*] https://www.sparkfun.com/products/14212										
[*] https://core-electronics.com.au/hologram-dash.html										
[*] https://hologram.io/docs/reference/dash/datasheet/										
4	SIM7000E	SIMCom Wireless Solutions Co.,Ltd.	Power off: 7 uA	3.0 V~4.3 V	0.0000301	24 X 24 X 2.6	-40℃ to +85℃	Qt 1: $ 38.20	UART, I2C , GPIO, ADC	GSM , GPRS, EDGE, LTE CAT M1
			PSM : 9 uA		0.0000387					
			Sleep: 1 mA		0.0043					
			Idle: 11 mA		0.0473					
References			[1]	[1]		[1]	[1]	[2]	[1]	[1]
[1]http://simcomm2m.com/En/module/detail.aspx?id=168										
[2] https://techship.com/products/simcom-sim7000e-cat-m-nb-iot-smt/										
5	Hologram Dash	Core Electronics	3.32 V / 250 mA	3.3 V	0.83	55 x 20 x 9 mm (board)	-40℃ to +85℃	Qt 1: $ 138.50	I2C, SPI, UART, CAN, analog	2G: GPRS / EDGE 3G: UMTS / HSPA
References		[1]	[2]	[2]		[2]		[1]	[1]	[1]
[1] https://core-electronics.com.au/hologram-dash.html										
[2] https://hologram.io/docs/reference/dash/datasheet/										
6	SIM900 Quad Band GSM GPRS Shield	PTROBOTICS	Sleep Mode: 15 mA	5 V~26 V	0.0075	85 x 55 x 15 mm	-40℃ to +85℃	Qt 1: 55,35 €	UART	GSM , GPRS
			Voice Call: 250 mA		125	(board)				
			GPRS Data Mode: 440		2.2					
References		[1]	[2]	[3]		[3]	[2]	[2]	[3]	[3]
[1] https://www.ptrobotics.com/										
[2] http://wiki.epalsite.com/index.php?title=SIM900_Quad-Band_GPRS_shield										
[3] https://www.ptrobotics.com/gsm/5711-sim900-quad-band-gsm-gprs-shield-development-board.html										
7	LinkIt ONE -102030002	Seeed Studio	1mA	3.3 V	0.0033	83.92 x 53.34	N/A	Qt 1: 48,38 €	Analog I/O, PWM , I2C, SPI, UART	GSM , GPRS
References		[1]	[5]	[3]		[3]		[2]	[3]	[4]. [5]
[1] https://www.seeedstudio.com/										
[2] https://eu.mouser.com/ProductDetail/Seeed-Studio/102030002?qs=SEIPoaY2y5J5VJm1KoeVOA%3d%3d										
[3] https://eu.mouser.com/new/seeedstudio/seeed-linkit-one/										
[4] https://docs.labs.mediatek.com/resource/linkit-one/en										
[5] https://eu.mouser.com/pdfdocs/102030002-776038.pdf										
8	SIM900 GSM/GPRS shield for	CRCibernética	Sleep Mode: 15 mA	9 V~20 V	0.0135	77.2 X 66.0 X 16	-40℃ to +85℃	Qt 1: $ 54.95	UART	GSM , GPRS
References		[1]	[1]	[2]		[2]	[1]	[1]	[2]	[2]
[1] http://www.crcibernetica.com/sim900-gsm-gprs-shield-for-arduino/										
[2] ftp://imall.iteadstudio.com/IM120417009_IComSat/DS_IM120417009_IComSat.pdf										

Table 11. Proposed heart rate devices and characteristics details.

Heart Rate									
Characteristics									
No	Products	Manufacturer	Current Consumption	Supply Voltage	Power Consumption	Size	Temperature	Price	Interface
1	BH1790GLC-E2	ROHM Semiconductor	Typ: 200 uA	17 V to 3.6 V	0.00072	2.80 x 2.80 x 100	-20℃ to +85℃	Qt 1: 5,47 € Qt 25:4,72 € Qt 100: 4,09 €	I2C
References		[1]	[2]	[3]		[4]	[3]	[2]	[3]
[1] https://www.rohm.com/									
[2] https://eu.mouser.com/ProductDetail/ROHM-Semiconductor/BH1790GLC-E2?qs=%2fha2pyFaduhskeYDgkK042%2fTkHTXfYdN3ir8ROMJiO1zY4pXds45pA%3d%3d									
[3] https://eu.mouser.com/datasheet/2/348/bh1790glc-e-1139225.pdf									
2	AD8232ACPZ-R7	Analog Devices	170 uA	2 V to 3.5 V	0.000595	4 × 4 mm	-40℃ to +85℃	Qt 1: 2,81€ Qt 25:2,26 € Qt 100: 2,06 €	N/A
References		[1]	[2]	[2]		[2]	[2	[2]	
[1] http://www.analog.com/en/index.html									
[2] https://eu.mouser.com/ProductDetail/Analog-Devices/AD8232ACPZ-R7?qs=sGAEpiMZZMv9Q1JI0Mo%2ftTwzkje34X4F									
3	PIC16F1779-E/PT	Microchip Technology	8 uA @ 31kHz, 18V 32 uA/MHz @ 18V	2.3 V to 5.5 V	0.0000144 0.0000576	5 x 5 x 0.5 mm	-40℃ to +85℃	Qt 1: 2,97 € Qt 25:2,40 € Qt 100: 2,17 €	I2C, SPI, USART
References		[1]	[3]	[2]		[3]	[2]	[2]	[2]
[1] https://www.microchip.com/									
[2] https://eu.mouser.com/ProductDetail/Microchip-Technology/PIC16F1779-E-PT?qs=%2fha2pyFadugaEp1sk%2fICGex4lO7BOU1nmtnlk2SgpFqqHsqHVvRFBQ%3d%3d									
[3] https://eu.mouser.com/datasheet/2/268/40001819B-1066584.pdf									
4	ATSAMB11-ZR210CA-ND	Microchip Technology / Atmel	Receiving: 5 mA Transmitting: 2.3 mA	18 V ~ 4.3 V	0.0215 0.00989	5.50 x 4.50 mm	-40℃ ~ 85℃	Qt 1: $ 7,25 Qt 25: $ 6,63	I2C, SPI, UART
References		[1]	[2]	[2]		[3]	[2]	[2]	[2]
[1] http://www.microchip.com/									
[2] https://www.digikey.lv/product-detail/en/microchip-technology/ATSAMB11-ZR210CA/ATSAMB11-ZR210CA-ND/6148940									
[3] http://ww1.microchip.com/downloads/en/DeviceDoc/Ultra-Low-Power-Bluetooth-Low-Energy-SiP-Module-DS70005342B.pdf									
5	SFH 7070	OSRAM Opto Semiconductors	25 mA	3.0 V	0.075	7.5 x 3.9 x 0.9 mm	-40℃ to +85℃	Qt 1: 3,00 € Qt 25: 1,98 € Qt 100: 1,72 €	N/A
References		[1]	[3]	[3]		[3]	[3]	[2]	
[1] https://www.osram.com/os/?									
[2] https://eu.mouser.com/ProductDetail/OSRAM-Opto-Semiconductors/SFH-7070?qs=%2fha2pyFaduiFclofI7qysldR6kC2Kd0kds8ONG8tGXY%3d									
[3] https://media.osram.info/media/resource/hires/osram-dam-2496467/SFH%207070.pdf									
6	SFH 7051	OSRAM Opto Semiconductors	N/F	5 V	N/A	4.7 x 2.5 x 0.9 mm	-40℃ to +85℃	Qt 1: 2,07 € Qt 25:1,37 € Qt 100: 1,19 €	N/A
References		[1]		[3]		[3]	[2]	[2]	
[1] https://www.osram.com/os/?									
[2] https://eu.mouser.com/ProductDetail/OSRAM-Opto-Semiconductors/SFH-7051?qs=%2fha2pyFaduioHwteQmnfD8%252bsIAMIRokoFuTfkrcdVCI%3d									
[3] https://media.osram.info/media/resource/hires/osram-dam-2496464/SFH%207051.pdf									
7	SI1143-M01-GMR	Silicon Labs	4.3 mA	18 V	0.00774	4.9 x 2.85 x12 mm	-40℃ to +85℃	Qt 1: 3,75 € Qt 25:3,46 € Qt 100: 3,09 €	I2C
References		[2]	[2]	[2]		[3]	[2]	[2]	[3]
[1] https://www.silabs.com/									
[2] https://eu.mouser.com/ProductDetail/Silicon-Labs/SI1143-M01-GMR?qs=p9T7GgSe1lHAITpevLkXjw%3D%3D									
[3] https://eu.mouser.com/datasheet/2/368/Si1141-42-43-M01-587398.pdf									
8	AFE4403YZPT	Texas Instruments	N/F	2 V to 3.6 V	N/A	3.07 × 3.07 × 0.5 mm	-20℃ to +70℃	Qt 1: 6,42 € Qt 25: 5,37 € Qt 100: 4,81 €	Serial, SPI
References		[1]		[2]		[3]	[2]	[2]	[2]
[1] http://www.ti.com/									
[2] https://eu.mouser.com/ProductDetail/Texas-Instruments/AFE4403YZPT?qs=sGAEpiMZZMvfFCidbTccA64wB2RZDH1hTHqSvyEEMbI%3d									
[3] http://www.ti.com/lit/ds/symlink/afe4403.pdf									
9	SparkFun Particle Sensor Breakout – MAX30105	Makerlab Electronics	Typ. 0.6 mA Max. 11 mA	3.3 V	0.00198 0.00363	5.6 x 3.3 x 15 5 mm	-40℃ to +85℃	Qt 1: 14,65 €	I2C
References		[1]	[2]	[1]		[2]	[2]	[3]	[1]
[1] https://www.makerlab-electronics.com/product/sparkfun-particle-sensor-breakout-max30105/									
[2] https://cdn.sparkfun.com/assets/learn_tutorials/5/7/7/MAX30105_3.pdf									
[3] https://www.exp-tech.de/sensoren/biometrisch/7880/sparkfun-particle-sensor-breakout-max30105									

Table 12. Proposed temperature devices and characteristics details.

Temperature										
Characteristics										
No	Products	Manufacturer	Current Consumption	Supply Voltage	Power Consumption	Size	Temperature	Price	Interface	Accuracy
1	*MAX30205MTA+*	Maxim Integrated	600 µA (typ)	2.7 V to 3.3 V	0.00198	3 x 3 x 0.75 mm	0 C ~ 50℃	Qt 1: 1,48 € Qt 25:1,39 € Qt 100: 1,35 €	2-Wire, I2C	+/- 0.1C
References		[1]	[2]	[2]		[2]	[2]	[2]	[2]	[2]
[1] https://www.maximintegrated.com/en.html										
[2] https://eu.mouser.com/ProductDetail/Maxim-Integrated/MAX30205MTA+?qs=sGAEpiMZZMvVdBIXEaMJhDaKtyJFjnZ3HnTSa3L6wss%3d										
2	*Fever click (MIKROE-2554)*	MikroElektronika	5 mA	3.3V	0.0165	42.9 x 25.4 mm	0 C ~ 50℃	Qt 1: 9,02 €	GPIO,I2C	0.1℃
References		[1]	[1]	[1]		[1]	[1]	[2]	[1]	[1]
[1] https://www.mikroe.com/fever-click										
[2] https://eu.mouser.com/ProductDetail/MikroElektronika/MIKROE-2554?qs=%2fha2pyFadugvpU3FkuzwO%252b3ZXT4dPg8kYawNXGcjJFvukwR9T4iUmA%3d%3d										
3	*BMP180*	Bosch Sensortec	32 uA	3 V	0.000096	15 x 13.5 x 2.6 mm	-40℃ ~ 85℃	Qt 1: $ 5.70 (4.88 €)	I2C	+-3.6 Fahrenheit (+-2 Celsius)
References		[1]	[2]	[2]		[3]	[2]	[3]	[2]	[3]
[1] https://www.bosch-sensortec.com/										
[2] https://eu.mouser.com/ProductDetail/Bosch-Sensortec/BMP180?qs=sGAEpiMZZMsrChSOYEGTCcbpL13VfRyojs5HQb1tBiU%3d										
[3] https://www.addicore.com/BMP180-Barometric-Pressure-Sensor-p/230.htm										
4	*HDC2010YPAR*	Texas Instruments	550 µA (@VDD=1.8V)	1.62 V to 3.6 V	0.00099	1.5 x 1.5 x 0.675 mm	-40℃ ~ 85℃	Qt 1: 2,11 € Qt 10:1,79 € Qt 100: 1,44 €	I2C	+/- 0.2 C
References		[1]	[2] [3]	[2]		[3]	[2]	[2]	[2]	[2]
[1] http://www.ti.com/										
[2] https://eu.mouser.com/ProductDetail/Texas-Instruments/HDC2010YPAR?qs=%2fha2pyFadujrC4I4MTLDdMvZ8xJLYO62tfhVgNlweY7IcqeYafgb5g%3d%3d										
[3] http://www.ti.com/lit/ds/symlink/hdc2010.pdf										
5	*TMP116NAIDRVR*	Texas Instruments	3.5 µA	1.9 V to 5.5 V	0.00001925	2 x 2 mm	-55℃ to 150℃	Qt 1: 2,50 € Qt 25:1,61 € Qt 100: 1,36 €	I2C	+/- 0.4 C
References		[1]	[3]	[2]		[3]	[2]	[2]	[2]	[2]
[1] http://www.ti.com/										
[2] https://eu.mouser.com/ProductDetail/Texas-Instruments/TMP116NAIDRVR?qs=sGAEpiMZZMunegBHAOsZD%2fOGDRwtPYZII%2fkrxRrWCe9eSJLSoy5IWg%3d%3d										
[3] http://www.ti.com/lit/ds/symlink/tmp116.pdf										
6	*MLX90614ESF*	ICStation	Typ: 1 mA Max: 2 mA	5V	0.005 0.01	19.38 x 11.2 mm (board)	-40℃ ~ 85℃	Qt 1: $ 9.74	PWM, SMBus	0.5 C
References		[1]	[2]	[1]		[1]	[1]	[1]	[2]	[1]
[1] http://www.icstation.com/mlx90614esf-human-body-infrared-temperature-sensor-contact-temperature-module-p-9911.html										
[2] https://www.sparkfun.com/datasheets/Sensors/Temperature/SEN-09570-datasheet-3901090614M005.pdf										
7	*SI7051-A20-IM*	Silicon Labs	90 uA 195 nA average current @ 1 Hz	1.9 V ~ 3.6 V	0.000324 0.000000702	2 x 2 mm	-40℃ ~ 125℃	Qt 1: 1,95 € Qt 25:1,78 € Qt 100: 1,62 €	I2C	+/- 0.1C
References		[1]	[2] [3]	[2]		[3]	[2]	[2]	[2]	[2]
[1] https://www.silabs.com/										
[2] https://eu.mouser.com/ProductDetail/Silicon-Labs/SI7051-A20-IM?qs=sGAEpiMZZMucenltShoSnkzps25%2fjXuQwESTpp87b7bFuXOY9MFBsg%3d%3d										
[3] https://eu.mouser.com/datasheet/2/368/Si7050-1-3-4-5-A20-907443.pdf										

Table 13. Proposed ECG devices and their characteristics.

ECG									
Characteristics									
No	**Products**	**Manufacturer**	**Current Consumption**	**Supply Voltage**	**Power Consumption**	**Size**	**Temperature**	**Price**	**Interface**
1	***AD8232ACPZ-R7***	Analog Devices	Typ: 170 µA Max: 230 µA	2 V to 3.5 V	0.000595 0.000805	4 mm × 4 mm	-40℃ ~ 85℃	Qt 1: 2,81€ Qt 25:2,26 € Qt 100: 2,06 €	N/A
References		[1]	[3]	[1]		[1]	[1]	[1]	
[1] http://www.analog.com/en/index.html									
[2] https://eu.mouser.com/ProductDetail/Analog-Devices/AD8232ACPZ-R7?qs=sGAEpiMZZMv9Q1JI0Mo%2ftTwzkje34X4F									
[3] https://eu.mouser.com/datasheet/2/609/AD8232-877697.pdf									
2	***AD8232ACPZ-RL***	Analog Devices	Typ: 170 µA	2 V to 3.5 V	0.000595	4 × 4 mm	-40℃ ~ 85℃	Qt 1: 1,46 €	N/A
References		[1]	[3]	[2]		[2]	[2]	[2]	
[1] http://www.analog.com/en/index.html									
[2] https://eu.mouser.com/ProductDetail/Analog-Devices/AD8232ACPZ-RL?qs=sGAEpiMZZMv9Q1JI0Mo%2ftT%252bB6o0WHHfc									
[3] https://eu.mouser.com/datasheet/2/609/AD8232-877697.pdf									
3	***MAX86150EFF+T***	Maxim Integrated	Typ: 340 µA Max: 750 µA	1.8 V	0.000612 0.00135	3.3 x 5.6 x 1.3mm	-40℃ ~ 85℃	Qt 1: 3,41€	I2C
References		[1]	[3]	[2]		[3]	[2]	[2]	[3]
[1] https://www.maximintegrated.com/en.html									
[2] https://eu.mouser.com/ProductDetail/Maxim-Integrated/MAX86150EFF+T?qs=%2fha2pyFaduhRnHfU1QGG47Sfo0NIj3t7nbQaO6Pwr2vkbnBCUXdljg%3d%3d									
[3] https://eu.mouser.com/datasheet/2/256/MAX86150-1282822.pdf									
4	***MAX30003CTI+***	Maxim Integrated	Typ: 77µA	1.1 to 2 V	0.000085	5 x 5 x 0.75mm	0 C to + 70℃	Qt 1: 4,54 € Qt 10:4,31€ Qt 25: 4,23 €	Serial, SPI
References		[1]	[3]	[2]	[3]	[3]	[2]	[2]	[2]
[1] https://www.maximintegrated.com/en.html									
[2] https://eu.mouser.com/ProductDetail/Maxim-Integrated/MAX30003CTI+?qs=sGAEpiMZZMtQRtO1VXT3j438XKYAL8r3py6k78EW54k%3d									
[3] https://eu.mouser.com/datasheet/2/256/MAX30003-1020789.pdf									
5	***PS25205B***	Plessey	Typ: 15 mA	±2.4 V to ±5.5 V	0.00825	10.5 x 10.5 x 3.45 mm	-25℃ ~ 75℃	N/A	N/A
References		[1]	[3]	[3]		[2]	[2]		
[1] http://www.plesseysemiconductors.com/									
[2] https://eu.mouser.com/ProductDetail/Plessey-Semiconductors/PS25205B?qs=MI2zuikz5V9BbG4wo4Hs%2fw==									
[3] https://eu.mouser.com/datasheet/2/613/plesseysemiconductors_PS25205B-1215830.pdf									
6	***PS25251***	Plessey Semiconductors	Min: 0.6 mA Typ: 2.0 mA Max: 3.5 mA	5V	0.003 0.01 0.0175	10 x 10 x 2 mm	-25℃ ~ 75℃	Qt 1: 66,73 € Qt 25:58,83 € Qt 100: 56,13 €	N/A
References		[1]	[3]	[2]		[2]	[2]	[2]	
[1] http://www.plesseysemiconductors.com/									
[2] https://eu.mouser.com/ProductDetail/Plessey-Semiconductors/PS25251?qs=sGAEpiMZZMttKWgNLnZcJrxK%2f3cZBio4									
[3] https://eu.mouser.com/datasheet/2/613/ps25251-epic-qfn-sensor-electrophysiology-high-gai-1218582.pdf									
7	***Si1171***	Silicon Labs	N/A	1.71 V to 3.63 V	N/A	3.7 × 7.0 × 1.1 mm	-40℃ ~ 85℃	N/A	I2C, SPI
References		[1]		[2]		[2]	[1]		[1]
[1] https://www.silabs.com/									
[2] https://www.silabs.com/documents/public/data-shorts/si1171-short.pdf									
[3] https://www.silabs.com/products/sensors/biometric/si117x									
8	***ADS1298RIZXGR***	Texas Instruments	500 uA	1.65 V to 3.6 V	0.0018	8.00 × 8.00 mm	-40℃ ~ 85℃	Qt 1: 22,46 €	Serial, SPI
References		[1]	[3]	[2]		[3]	[2]	[2]	[2]
[1] http://www.ti.com/									
[2] https://eu.mouser.com/ProductDetail/Texas-Instruments/ADS1298RIZXGR?qs=sGAEpiMZZMsj2w6QBC0lcgxQtqDcAIcV									
[3] http://www.ti.com/lit/ds/symlink/ads1298r.pdf									
9	***Micro ECG***	ITEAD	N/A	3.3 V	N/A	22 X 26 X 16 mm	N/A	Qt 1: $ 11.00 (9, 43 €)	UART, BLE
References		[1]		[1]		[1]		[1]	[1]
[1] https://www.itead.cc/microecg.html									
[2] https://www.itead.cc/wiki/MicroECG									

Table 14. Proposed accelerometer devices and characteristics details.

Accelerometer										
Characteristics										
No	Products	Manufacturer	Current Consumption	Supply Voltage	Power Consumption	Size	Temperature	Price	Interface	Range
1	*MPU 9255*	InvenSense Inc.	3.2 mA	2.4 V – 3.6 V	0.01152	3 x 3 x1mm	-40℃ to 85℃	N/A	I2C	±4800µT
References		[1]	[1]	[2]		[2]	[1]		[1]	[2]
[1] https://store.fut-electronics.com/collections/new-products/products/mpu-9255-3-axis-gyroscope-3-axis-accelerometer-3-axis-magnetometer										
[2] https://cdn.shopify.com/s/files/1/0672/9409/files/MPU-9255-Datasheet.pdf?2480024214820136720										
[*]https://www.amazon.com/UCTRONICS-MPU-9255-compass-Accelerometer-Gyroscope/dp/B01DIGRR8U										
2	*AIS1120SXTR*	STMicroelectronic	6 mA	3.13 V to 3.47 V	0.02082	4.9 x 6 x 175 mm	-40 ℃ to +105 ℃	Qt 1: 5,21€ Qt 10:4,43 € Qt 100: 3,84 €	SPI	Full-scale range: ±114
References		[1]	[3]	[2]		[3]	[2]	[2]	[2]	[3]
[1] https://www.st.com/										
[2] https://eu.mouser.com/ProductDetail/STMicroelectronics/AIS1120SXTR?qs=%2fha2pyFadujz3jmjWPaCWwe%2fGhuiR%252bh1N1UF0YLynZaVbrT%2fVdyNtQ%3d%3d										
[3] https://eu.mouser.com/datasheet/2/389/ais1120sx-1078943.pdf										
3	*H3LIS331DLTR*	STMicroelectronic	10 µA	2.16 V to 3.6 V	0.000036	3 x 3 x10 mm	-40℃ to 85℃	Qt 1: 8,94 € Qt 25:7,71€ Qt 100: 6,69 €	I2C, SPI	full scales of ±100g/ ±200g/±40g
References		[1]	[2]	[2]		[3]	[2]	[2]	[2]	[3]
[1] https://www.st.com/										
[2] https://eu.mouser.com/ProductDetail/STMicroelectronics/H3LIS331DLTR?qs=sGAEpiMZZMtlnWhFp5JOwGi5lG47hwOp										
[3] https://eu.mouser.com/datasheet/2/389/h3lis331dl-954720.pdf										
4	*ADXL335BCPZ*	Analog Devices	350 uA	18 V to 3.6 V	0.00126	4 x 4 x 145 mm	-40 ℃ to +85 ℃	Qt 1: 4,67 € Qt 25:3,95 € Qt 100: 3,53 €	N/A	Full-scale range: ±3 g
References		[1]	[2]	[2]		[3]	[2]	[2]		[3]
[1] http://www.analog.com/en/index.html										
[2] https://eu.mouser.com/ProductDetail/Analog-Devices/ADXL335BCPZ?qs=sGAEpiMZZMv9Q1JI0Mo%2ftQXOZcxOM%2f%2f7										
[3] https://eu.mouser.com/datasheet/2/609/ADXL335-879233.pdf										
5	*EVAL-ADXL335Z*	Analog Devices	350 µA	18 V to 3.6 V	0.00126	4 x 4 mm	-40 ℃ to +105 ℃	Qt 1: 33,58 €	N/A	Full-scale range: ±3 g
References		[1]	[3]	[3]		[2]	[3]	[2]		[3]
[1] http://www.analog.com/en/index.html										
[2] https://eu.mouser.com/ProductDetail/Analog-Devices/EVAL-ADXL335Z?qs=%2fha2pyFadui5lmDlqpwGtyiICGiFHi4gjwB4xg0MdoNcZLMK49v4pg%3d%3d										
[3] https://eu.mouser.com/datasheet/2/609/ADXL335-879233.pdf										
6	*101020051*	Seeed Studio	350 µA @ 3V	3 V to 5 V	0.00105	4 x 4 x 145 mm	N/A	Qt 1: 8,12 €	N/A	Full-scale range: ±3 g
References		[1]	[3]	[2]		[3]		[2]		[3]
[1] https://www.seeedstudio.com/										
[2] https://eu.mouser.com/ProductDetail/Seeed-Studio/101020051?qs=sGAEpiMZZMvxSQPygxWTpSjUykpflTX68rFDIgMFQCk%3d										
[3] https://eu.mouser.com/datasheet/2/744/Seeed_101020051-1217452.pdf										
7	*MMA8452QR1*	NXP / Freescale	6 µA to 165 µA	195 V to 3.6 V	0.0000117 to 0.000594	3 x 3 x 1 mm	-40 ℃ to 85℃	Qt 1: 2,17 € Qt 25:1,49 € Qt 100: 1,15 €	I2C	full scales of ±2 g/±4 g/±8 g
References		[1]	[3]	[2]		[3]	[2]	[2]	[2]	[3]
[1] https://www.nxp.com/										
[2] https://eu.mouser.com/ProductDetail/NXP-Freescale/MMA8452QR1?qs=sGAEpiMZZMs5J6Fwfw6CO1HjGVnOExhk										
[2] https://eu.mouser.com/datasheet/2/302/MMA8452Q-1126985.pdf										
8	*BMA400*	Bosch Sensortec	Max. perform.: 14 µA Typical use case: < 8 µA Low power use case: < 4 µA	162 V to 3.6 V	0.0000504 0.0000288 0.0000144	2 x 2 x 0.65 m^3	-40℃ ~ 85℃	Qt 1: 3,00 € Qt 25:1,93 € Qt 100: 1,63 €	SPI, I2C	±2 g, ±4 g, ±8 g, ±16 g
References		[1]		[1]		[1]	[1]	[2]	[1]	[1]
[1] https://www.bosch-sensortec.com/bst/products/all_products/bma400_1										
[2] https://www.digikey.com/product-detail/en/bosch-sensortec/BMA456/828-1075-1-ND/7401320										