[Continued on next page]
Declarations under Rule 4.17:
— as to applicant’s entitlement to apply for and be granted a patent (Rule 4.17(I))
— as to the applicant’s entitlement to claim the priority of the earlier application (Rule 4.17(H))

Published:
— with international search report (Art. 21(3))
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))
A SYSTEM AND/OR METHOD FOR DETERMINING THE LOCATION OF A TRANSMITTER

FIELD OF THE INVENTION

The present invention relates to a method and system for determining a location of a transmitter using trilateration and time-of-flight information and providing an output signal in response to the transmitter being determined as not located in a pre-determined zone.

BACKGROUND

Whilst carrying out normal duties on a maritime vessel or structure, there is a risk that one or more of the individuals that are on the vessel or structure, such as the crew members, may fall overboard. There is also a risk that the individuals may fall from the vessel without being noticed by others that are on the vessel. It is important that any crew member or indeed any other individual falling from the vessel is noticed as soon as possible in order to improve the likelihood of locating the individual that is in the water and achieving a successful rescue.

A number of conventional systems exist for detecting if an individual has fallen overboard from a vessel. However, none of the conventional systems are able to accurately determine the location of the individual once that individual has fallen into the water. As a result, the process of rescuing the individual can be ineffective, lengthy and time consuming, and the rescue vessel may have to search a large area of the water to find the individual which increases the time spent in the water and the individual not being found alive.

There is therefore a need for a safety system for use with maritime vessels which is capable of accurately determining the position of an individual, such as a crew member, on a vessel and/or in the water. There is also a need for a safety system which helps to minimise the risk of an individual falling overboard.

SUMMARY OF THE INVENTION

The present invention relates to a method and system for determining a location of a transmitter using trilateration and time-of-flight information and providing an output signal in response to the transmitter being determined as not located in a pre-determined zone.
The present invention may be used as a safety system for use in the maritime industry for alerting when an individual is at risk of falling overboard or has fallen overboard from a maritime vessel or structure. The present invention may comprise a transmitter that is wearable by an individual.

According to a first aspect there is provided a system for determining a location of a transmitter, the system comprising a transmitter, three or more receivers, arranged for determining a location of the transmitter using trilateration and time-of-flight information, and a control unit, arranged to generate an output signal in response to the transmitter being determined as not located in a pre-determined zone.

The system may comprise a transmitter that is wearable.

The transmitter may be one of a wristband, a neck pendant, a personnel worn device, and a tag to be placed on marine equipment.

The transmitter may be a wireless tag with a unique identification.

The system may be a maritime tracking system.

The control unit and three receivers may be mountable on a maritime vessel or a maritime structure. The control unit may further be formed as part of an existing control unit on the maritime vessel or maritime structure.

The system may be used to assist man overboard situations and/or track crew members of a maritime vessel or a maritime structure.

The output signal may be an alarm generated at one or more of the control unit, the transmitter, and/or at least one receiver.

The system may comprise a plurality of transmitters.

The pre-determined zone may correspond to a safe area defined on a maritime vessel or a maritime structure.
The transmitter and three receivers may be transceivers.

The control unit may comprise information about the environment in which the receivers are deployed. The information may further be related to structural dimensions of a maritime vessel or a maritime structure.

One or more of the control unit, the transmitter, and at least one of the receivers may comprise a microcontroller for processing time-of-flight information.

One of the receivers or the transmitter or the control unit may be configurable to define the pre-determined zone.

The system may further comprise a memory unit and/or a GPS module. The memory unit and/or the GPS module may further be located within the transmitter.

According to a second aspect there is provided a maritime tracking device comprising a wearable transmitter arranged to receive and/or transmit signals.

The device may be arranged to receive and/or transmit time-of-flight information for tracking applications based on trilateration.

The device may be one of a wristband, a neck pendant, a personnel worn device, and a tag to be placed on marine equipment.

The device may further comprise one or more of an alarm, a vibrate function, a light emitting device, and a screen.

The device may be arranged to generate an output signal.

The device may be a safety device for assisting man overboard situations and/or tracking crew members on a maritime vessel or a maritime structure.
According to a third aspect there is provided a method for determining a location of a transmitter, the method comprising the steps of arranging three or more receivers, arranging a control unit for generating an output signal, and determining the location of the transmitter using trilateration and time-of-flight information, wherein the output signal is generated in response to the transmitter being determined as not located in a pre-determined zone.

The transmitter may be the device of the second aspect of the invention.

At least three of the three or more receivers may be arranged in a triangular layout in a single plane.

The three or more receivers may be arranged in a plane that is parallel to a plane of the pre-determined zone.

The three or more receivers may be arranged in a plane that is perpendicular to a plane of the pre-determined zone.

The method for determining the location of the transmitter may use the system of the first aspect of the invention.

The method may be used to assist man overboard situations and/or track crew members of a maritime vessel or a maritime structure.

In a further aspect there is provided a method and/or system and/or device substantially as herein described with reference to, and as shown in, the accompanying drawings.

Each aspect can be carried out independently of the other aspects or in combination with one or more of the other aspects.

BRIEF DESCRIPTION OF THE DRAWINGS

Various features and advantages of the present disclosure will be apparent from the detailed description which follows, taken in conjunction with the accompanying drawings,
which together illustrate, by way of example only, features of the present disclosure, and
wherein:

Figure 1 is a schematic illustration showing a system for determining a location of a
transmitter;

Figure 2A is a schematic block diagram of a transmitter;
Figure 2B is an illustration of a transmitter;
Figure 3A is a schematic block diagram of a receiver;
Figure 3B is an illustration of a receiver;
Figure 4 is a schematic block diagram of a control unit;
Figure 5 is a schematic block diagram of a system according to an embodiment of the
invention;
Figures 6A-E are illustrations of different arrangements of the receivers of the system;
Figure 7A is a schematic illustration of a view from above a maritime vessel comprising a
system according to an embodiment of the invention;
Figures 7B-D are schematic illustrations of pre-determined zones for a maritime vessel;
Figure 8 is a flow chart of a method according to an embodiment of the invention;
Figure 9 is a flow chart illustrating a method according to one embodiment of the present
invention when the device goes out of range;
Figure 10 is a flow chart illustrating a method of activating the alarm mode of the
transmitter; and
Figure 11 is a flow chart for a method according to an embodiment of the invention.

Example embodiments are described below in sufficient detail to enable those of ordinary
skill in the art to embody and implement the systems and processes herein described. It
is important to understand that embodiments can be provided in many alternate forms
and should not be construed as limited to the examples set forth herein.

Accordingly, while embodiments can be modified in various ways and take on various
alternative forms, specific embodiments thereof are shown in the drawings and described
in detail below as examples. There is no intent to limit to the particular forms disclosed
and as well as individual embodiments the invention is intended to cover combinations of
those embodiments as well. On the contrary, all modifications, equivalents, and
alternatives falling within the scope of the appended claims should be included. Elements
of the example embodiments are consistently denoted by the same reference numerals throughout the drawings and detailed description where appropriate.

The terminology used herein to describe embodiments is not intended to limit the scope. The articles "a," "an," and "the" are singular in that they have a single referent, however the use of the singular form in the present document should not preclude the presence of more than one referent. In other words, elements referred to in the singular can number one or more, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "comprising," "includes," and/or "including," when used herein, specify the presence of stated features, items, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, items, steps, operations, elements, components, and/or groups thereof.

Unless otherwise defined, all terms (including technical and scientific terms) used herein are to be interpreted as is customary in the art. It will be further understood that terms in common usage should also be interpreted as is customary in the relevant art and not in an idealized or overly formal sense unless expressly so defined herein.

DETAILED DESCRIPTION

The present invention relates to a method and system for determining a location of a transmitter using trilateration and time-of-flight information and providing an output signal in response to the transmitter being determined as not located in a pre-determined zone. In particular but not exclusively the present invention relates to a maritime safety system comprising a time of flight positioning system which uses trilateration.

Trilateration

A location of a transmitter can be determined using trilateration and time-of-flight information. Trilateration will be described herein as relating to the process of determining an absolute or relative location of a transmitter based on measurement of distance from a set of receivers to the transmitter using the geometry of circles, spheres or triangles.
Trilateration requires at least three receivers or transceivers to determine the location of a transmitter or further transceiver. For example, three receivers can be used to provide two possible locations for the transmitter, and the locations of each receiver relative to the other receivers is required to determine at which of the two possible locations the transmitter is situated. Consider a sphere around each receiver: (i) the first and second receivers are used to define a ring where their spheres intersect, (ii) the third receiver is used to define two possible locations for the transmitter where the third sphere intersects that ring, (iii) the relative distances from the centres of each sphere is calculated, and (iv) the relative locations of the three receivers is used to determine the location of the transmitter.

It should be noted that in contrast to triangulation which involves the measurement of angles, trilateration does not rely on measurement of angles.

**Time-of-flight Positioning**

Time-of-flight information or positioning is used herein to refer to a system capable of determining distance by measuring the time of propagation of pulsed signals between a transmitter and a receiver. When the locations of at least three receivers are known, trilateration can be used to determine a location of a transmitter.

Transceivers that can both transmit and receive communications, for example via radio signals, may be used instead of, or in addition to, receivers and one or more transmitters. Another time-of-flight system may be described as a time-to-reply system which also determines distance by measuring a time difference of arrival of signals between a set of transceivers. In one possible system a transceiver sends a signal (a pulse, for example) and uses a counter to measure the elapsed time until a reply from a second transceiver is received. For example, a pulsed signal may be sent from a set of transceivers at known locations to a transceiver for which its position is to be determined. The pulsed signal may be sent to the transceiver with the unknown location and a counter used to measure the elapsed time for reply.

The present invention may use any known and suitable signalling mechanism to provide time-of-flight data, including optical and/or radio signals.
In some embodiments a radio wave based system may be employed. The time-of-flight positioning means may be configured in any suitable way. In the case of a periodic signal, each pulse of the signal can be coded so as to include a unique identifier for the pulse. In a simple case, the coding can be an identification of a transmitter unit. Accordingly, each receiver will receive a signal including data representing the ID of the transmitter that sent the pulse. As the pulse will be received by different receivers at different times, the distance to the transmitter unit from respective ones of the receivers can be calculated. Thereafter, three such distances can be used to calculate the position of the transmitter unit.

It will be appreciated that each receiver includes means for determining the time at which a signal is received, so that the difference between receipt times of a pulse can be determined. In this connection, timing units of receiver units can be provided to enable the time of receipt of a signal at a receiver to be compared with other times of receipt at other receivers to determine the differences in reception time. The receivers and transmitter may have a wired connection with a common clock source or a wireless connection with a GPS timing signal.

The preferred system uses a time-to-reply system with transceivers that do not require a wired connection and do not require a shared clock source.

**The System**

Figure 1 shows a system 100 for determining the location of a transmitter 101. The system comprises a transmitter, three or more receivers 102-104 and a control unit 105. The three or more receivers are arranged such that they allow determination of a location of the transmitter using trilateration and time-of-flight information. For example, the way in which the three receivers are arranged relative to each other is important when relying on trilateration. The control unit is arranged to generate an output signal in response to the transmitter being determined as not located in a pre-determined zone.

The pre-determined zone may be represented by a perimeter inside which represents a safe zone or area and outside which represents a non-safe area.

The system may be used in a maritime environment or in the maritime industry. For example, the pre-determined zone may be a perimeter or area of a maritime vessel or
structure and the system used for safety purposes to protect crew members on-board.
The system may be used for tracking the location of crew members aboard the maritime
vessel. The methods and systems described herein are particularly advantageous if used
with an individual who is a crew member of a water vessel or maritime vessel since they
are in a working environment and will be more at risk of falling over-board. The system
may be used to assist in man over-board situations.

The system may be used for tracking people or objects and may provide real-time
tracking of crew members on-board a maritime vessel. A transmitter may be worn by
each crew member. Each transmitter may be armed if inside the pre-determined zone or
safe zone. When a crew member disembarks or leaves the vessel they have the option to
disarm the transmitter. When embarking on the vessel, the transmitter may alert the
wearer to arm or re-arm the transmitter manually, alternatively the system may
automatically arm the transmitter when it is detected as being back on-board and inside
the safe zone. This enables real-time tracking of crew on-board since the system is
arranged for monitoring the position of each transmitter in real-time. An example range
of the system may be up to 300 meters between the receivers and each transmitter, with
a positioning accuracy of 20 centimetres. In another example the range of the system
may be up to 500 meters. It is also envisaged that the range of the system may be further
improved with a higher positioning accuracy as technology advances. It is to be
understood that the control system of the present invention may be operable to
determine only one, or a plurality of the user locations as described herein, in any
combination.

The control system is operable to determine whether the crew members or passengers
are:
  i. within a designated safe area; and/or
  ii. at the perimeter or within a region adjacent the perimeter of the pre-determined
      zone; and/or
  iii. outside of the designated safe area and still on-board a vessel (i.e. between the
       perimeter of the safe zone and a perimeter of the vessel); and/or
  iv. outside the designated safe area and not on board the vessel.
The maritime vessel or structure may be a: watercraft, boat, (luxury) yacht, canal boat, ship, cruise ship, canoe, dinghy, ferry, barge, hovercraft, fishing boat, trawler, tug boat, oil tanker. Alternatively, the maritime vessel or structure may be a marine environment such as: an oil rig, a marina, a dock, or the like.

The system may be usable for an "individual", which may mean, for example, a crew member or other human passenger (adult or child), or even an animal (such as a pet). The system may also be used to track cargo or other inanimate object(s) such as a fishing buoy or a marker buoy.

Each component within the system 100 will now be described in more detail.

Transmitter(s)

The transmitter of the system will now be described. Figure 2A shows a block diagram of a transmitter 101 according to the present invention. Microcontroller unit (MCU) 200 of the transmitter 101 is operable to control a display 201 of the transmitter, which can be used to display a battery status and/or to display information relating to the position of a user of the transmitter. For example, the display can indicate the proximity of the user to a peripheral region of a vessel and/or if the user is within the pre-determined zone.

The display 201 can be, for example, an LCD or similar low power display and/or can comprise one or more lights such as light emitting diodes (LEDs) for example, which may be of various colours and which may be controlled using MCU 200 to modify colour, colour combinations and/or brightness and so on in order to provide visual cues, alerts or warnings for a user.

The transmitter 101 includes an accelerometer 202. In an example, data from the accelerometer representing movements of the transmitter can be used by MCU 200 to determine if the motion of the transmitter 101 is indicative of motion that suggests that the user of the transmitter unit 101 is, for example, falling over-board from a vessel. For example, a period of lowered acceleration of the transmitter 101 can indicate that a user is falling, as can an acceleration the magnitude of which exceeds a predetermined threshold for example. MCU 200 can generate an alarm signal for transmission by the transmitter to a remote device in the case that an acceleration of the transmitter 101 is detected that exceeds a pre-determined threshold value stored in a memory (not shown).
of the transmitter. It should be noted that each transmitter may not be required to be water activated since each transmitter may be located within a waterproof coating.

The transmitter 101 includes a vibration motor 203 that can be used to provide tactile feedback to a user. For example, the transmitter can be made to vibrate by MCU 200 to indicate any one or more of a low battery condition, user position within or near a pre-defined area or zone and so on. The tactile feedback can be in addition to, or in place of visual indications using display 201. A pushbutton 204 can be provided on each transmitter for actuation by the user of the transmitter. The button 204 can be used in order to control or disarm certain functions of the transmitter.

An emergency light 205 can be provided, which can be activated by MCU 200 in the event that, for example, the user of the device is detected to be at the periphery of or outside of a pre-determined region to notify the user. The MCU 200 may achieve this notification based on signals exchanged with a control unit or via GPS. The light 205 can be a high intensity LED(s) for example, that can be used by the user to illuminate their surroundings and/or to provide a visual location indicator for the user in the event that they fall over-board for example. Accordingly, the light 205 may be operable to pulse and may be any suitable colour such as white, red or green and so on.

A time of flight radio unit 206 is provided, coupled to an antenna 207. The radio unit 206 can be controlled by MCU 200 to provide a time-of-flight signal as described above, such as a pulsed radio frequency signal for example. The antenna 207 may be any suitable antenna, such as a patch or micro-strip antenna for example, which has a low profile and which can therefore be mounted in a flat surface such as for a wristband.

An induction coil 208 within the transmitter can draw power from an electromagnetic field of a charger when in close proximity thereto, for conversion to electrical current using power receiver 209 to charge a battery 210 of the transmitter via a power management unit 211 controlled by MCU 200. For example, power management unit 211 can detect a state of charge or discharge of the battery 210 and can be controlled using MCU 200 to modify a rate of charge of the battery 210, including isolating the battery 210 to prevent overcharging for example.
The system may comprise a transmitter that may be worn by an individual. Figure 2B shows a wearable transmitter in the form of a wristband. The transmitter may be a personnel worn device or a (standard) tag to be placed on marine equipment. The transmitter may be a neck pendant or tag for a lifejacket or even a tag for a crate. Each transmitter is configured to transmit signals to be received at a receiver or control unit. Each receiver is configured to receive signals transmitted by the transmitter and may be located on-board the vessel. The wearable transmitter may be used as a safety or tracking device in the marine industry and may be used to assist man over-board situations. The transmitter may comprise a screen, such as a capacitive touchscreen.

The, or each, transmitter may be located within a wearable item configured to be worn by an individual. With reference to Figure 2B, the transmitter 101 may be provided within a waterproof outer case of a band 212 such as a wrist band. The wrist band 212 is adjustable in size to provide a secure fit to the wrist of a user (not shown). The wrist band 212 may be fastened by any suitable, preferably adjustable, fastening means. It is to be understood that the transmitter unit may be located at any suitable location on the wrist band 212.

The wrist band is designed to be worn at all times by an individual/user of the system. It is preferred that the transmitter unit comprises a waterproof outer case. The wrist band is formed from soft and durable material to maximise comfort and lifetime of the wrist band. The wrist band comprises a flexible silicone layer located to be worn adjacent the body of the user, such as close to the skin. The wrist band provides the user with complete freedom and does not hinder the user's daily duties/activities on board the vessel. As a result, the wrist band of the present invention minimises the risk of a user forgetting to wear the transmitter and accidentally falling from the vessel undetected.

Each transmitter or wireless tag may have a unique identification number. The ID number of the transmitter may be used to identify an individual to which the transmitter has been allocated.

The system may comprise one transmitter or a plurality of transmitters. Each transmitter worn by an individual may act as a personal alarm unit which may be wrist-worn. The transmitter may comprise an automatic or manual alarm function which the individual
may arm or disarm. The transmitter is arranged to generate an output signal that acts as an alarm to the individual and/or other individuals. Preferably at least one transmitter comprises at least one alarm mechanism. The output signal may correspond to an alarm comprising a vibrate function and/or lights to signal to the individual that they are approaching or are no longer within the pre-determined safe zone. In the event that an individual's transmitter raises an alert, other transmitters of other individuals in the vicinity may also be configured to alert those other individuals that someone is approaching or are no longer within the pre-determined safe zone.

Each transmitter may be replaced by a transceiver. Each transmitter is arranged to receive and/or transmit signals for tracking applications and is arranged to receive and/or transmit time-of-flight information for the tracking applications. Each transmitter is arranged to communicate with a receiver and/or control unit of the system. Each transmitter acts as a time-of-flight positioning device or safety device that works according to a pre-configured proximity or set perimeter. The tracking of individuals is based on location methods relying on trilateration. Each transmitter may be operable at a distance of up to 500 meters from a receiver(s) and/or control unit, however greater distance ranges are also envisaged. The system may comprise one control unit or a plurality of control units.

The system may further comprise a wireless charger for each transmitter, receiver, transceiver and/or control unit. It is envisaged that at least one of the transmitter unit and/or control unit is chargeable, for example via inductive charging. Alternatively the components of the system may be charged by other means such as solar power or piezoelectric devices that charge through movement.

The pre-determined zone may be a safe zone perimeter for a maritime vessel, where the safe zone is set by an individual wearing the transmitter and walking along the perimeter so as to set the safe zone for the vessel.

In a preferred embodiment, a transmitter unit is configured to be used with a time of flight positioning system of a safety system using trilateration, in which the transmitter unit is located within a wristband to be worn by a user. Preferably, the safety system is used in a maritime environment.
Receivers

The three or more receivers of the system will now be described. Figure 3A shows a receiver according to the present invention. The receiver unit 102-104 includes a time of flight radio unit 301 coupled to an antenna 302 operable to receive signals transmitted by antenna 207 of unit 101. Received signals can be processed using MCU 303 in order to determine, for example, an identification of a wristband unit from which the signal originates, such as by using an identifier embedded or otherwise provided in a signal (such as in a header portion of a signal) for example, and to calculate a distance from receiver 102-104 of the identified wristband from which the received signal originates.

Alternatively, a signal may be modulated in a predetermined manner for different users. It is possible with enough channels on the wristband, that the frequency of a signal may be used as an identifier with different wristband units operable to emit a pulsed RF signal at different frequencies, which may be useful to avoid signal collision if multiple wristband units are in use. Accordingly, an identifier may be in the form of a specific and known frequency of emitted signal for a wristband unit.

In this connection, multiple signals may be received and processed by MCU 303 relating to multiple wristband units, respective ones of which can be identified using unique identifiers for example, thereby enabling the distance of the wristbands from receiver 102-104 to be determined. Each receiver 102-104 can include an indication light 304 and audio alert device 305, either or both of which can be used to provide an indication of, for example, a malfunction of receiver 102-104, or to provide a visual and/or audible alert or warning indicating that a wristband distance has been calculated that is greater than a predefined threshold distance value, which may indicate that the user of that wristband has strayed beyond a safe predefined area of a vessel for example.

Each receiver 102-104 can be powered using a DC power 306 input to the unit that can be regulated and/or monitored using a power management unit 307 controlled by MCU 303. A communications radio unit 308 is coupled to an antenna 309, and can be used to provide data for reception to a remote device, and receive data from a remote device.

For example, data representing the distance of a wristband from the receiver 102-104 can be transmitted from the receiver 102-104. The receiver and control unit may have a wireless or wired connection. The communications radio unit may use time-of-flight. Update information may be received by radio unit 301 in order to update the MCU 303. For example, a firmware portion of the MCU 303 may be updated periodically such as in
the event that a predefined zone or region associated with a vessel changes or is modified. For example, a receiver may be moved to a different vessel with a different size and shape, thereby requiring an update for a predefined region on that vessel and/or a threshold distance and/or an update relating to identifiers for wristband units to accommodate a potential change of users and augmentation (or reduction) in number of users for example. The MCUs may or may not have ship-specific firmware and may or may not be updated, for example the control unit may perform all of the necessary calculations and store all configurable data. Each receiver 102-104 may be configured to transmit raw data to a control unit, where the control unit is arranged to update information and is configured with firmware for processing of the information according to the pre-determined zone of a maritime vessel for example. Alternatively or additionally, each of the receivers may be configured to process information, i.e. beyond simply relaying raw data.

An example receiver is shown in Figure 3B. The receiver units may have any suitable size and shape. In the embodiment illustrated in the Figures, each receiver unit is discrete in size so as to minimise any potential risk of interference with the operation of normal duties of the user(s).

Each of the three or more receivers may be replaced by three or more transceivers respectively. The three or more receivers are strategically positioned to allow determination of the location of the transmitter using trilateration. Preferably, at least three of the three or more receivers are arranged in a triangular layout.

The receiver units 102-104 are operable to receive signals from the transmitter 101. In an example, the transmitter 101 can transmit a periodic or continuous radio frequency signal for reception by the receivers 102-104. The signal can include an identification number or other suitable identifier associated or otherwise linked with the transmitter 101 to enable multiple signals to be differentiated and to enable the position of individual transmitters 101 to be determined. For example, the receiver units may be operable to receive signals from the transmitter 101 of multiple wristbands. In an example, up to twenty wristbands corresponding to twenty different users are provided. In other examples, more than twenty wristbands are provided for numerous users. The present invention therefore provides a system which is capable of accurately locating the position
of multiple users simultaneously to enable real-time tracking of users that may be onboard a maritime vessel.

**Control Unit**

The control unit of the system will now be described with reference to Figure 4. The control unit 105 includes an antenna 400 coupled to a communications radio unit 401, which is operable to transmit and receive signals. For example, a signal can be received from a receiver 102-104 representing the identity and distance of a transmitter 101. The communications radio unit 401 may comprise a wired connection and use time-of-flight.

Multiple such signals can be received from multiple different receivers 102-104 on a maritime vessel. The control unit 105 can use the multiple signals comprising data representing the identity and distance of a transmitter 101 from respective ones of the receivers 102-104 to determine the position of the transmitter using trilateration using MCU 402. Information representing the position of multiple transmitters can be displayed on a display 403, which can be a touchscreen display for example that can allow a user to select a user of a wristband whose position may be displayed on the display 403 to enable further information to be provided for that user, such as their personal details and/or role and so on. This may be useful to help determine if the user in question is not in an area of the vessel which they typically should be, which can indicate a potential hazard situation in the event that the user is not familiar with the area in which they find themselves for example.

The control unit 105 may include a GPS module 404 that can be used to provide a position for the control unit 105 and/or a timing signal that can be transmitted to a receiver 102-104 using the radio unit 401. The control unit 105 may be powered using a DC input source 405 controlled by a power management controller 406.

The control unit 105 can be provided in a navigation area of a vessel, and may be fixed in position, such as within a control panel of the vessel. Alternatively, the control unit 105 can be a mobile unit that can be carried or moved around the vessel by a user. For example, the control unit may be a handheld electronic device and/or may be mountable on the vessel either as an integral feature or retro-fitted to the vessel. In an embodiment, the control unit 105 is a communication device such as a tablet computer. It is to be understood that the control unit may be any suitable electronic device, for example a
handheld electronic device such as a mobile phone, or may be a device that is integral with or retro-fitted to a vessel.

When the control unit 105 is mounted on a maritime vessel the control unit 105 may be formed as part of an existing control unit on the maritime vessel, i.e. forming part of the vessel's own system (instead of supplying an additional control unit). The control unit may contain all vessel-specific information. For example, the control unit may be operable to store parameters corresponding to the shape and dimensions of a pre-determined safe zone within the boundaries of the deck of the vessel, or other information related to the structural dimensions of the maritime vessel or structure. The control unit may also comprise information about the environment in which the receivers are deployed.

The control system can be in communication with the transmitter 101 of a wristband to locate the position of each user using time of flight positioning. It is envisaged that the control unit is configured to define the parameters of at least one designated safe zone within the boundaries of the vessel or structure, and in which the control unit is operable to activate the alarm mechanism in response to determining that at least one individual is on the perimeter of or outside of the pre-determined safe zone. For example the MCU 402 may store the details of the defined pre-determined safe zone, in which an individual determined to be outside the pre-determined zone will cause the MCU to output a signal which may be an alert. The alert may be a central alarm at the control unit, for example to alert crew members aboard the vessel, or may be a localised alarm at the transmitter detected to be not located in the pre-determined zone. When each transmitter is determined as located within the pre-determined zone, no signal may be output by the control unit and no alert will be issued. The MCU of the control unit is configured for processing signals received and/or transmitted between the transmitter and three or more receivers.

An example system 500 is illustrated in Figure 5, where the system comprises three or more receivers 102-104 (only one receiver is shown), a transmitter 101 and a control unit 105. The control unit and the transmitter are operable to be charged, typically charging is by inductive charging using an inductive charger. The system 500 may further comprise an inductive charger 501. Figure 5 shows a wireless charger 501, transmitter 101, control unit 105 and receivers 102-104.
An inductive charger 501 comprising at least one induction coil 502 is operable, when energised, to create an alternating EM field. Respective induction coils 208 within the transmitter 101 and/or control unit 105 (not shown) can draw power from the EM field of the charger 501 when in close proximity thereto, for conversion to electrical current to charge a battery of the control unit 105 or transmitter 101 (and/or wristband unit). The coil 502 can be energised using a wireless power transmitter unit 503 that is operable to be powered from an input DC power supply 504 that can be switched on and off and controlled so as to modify the magnitude of supplied power to the charger 501, for example using a power management unit 505 controlled by a microcontroller unit 506.

The system 500 may be located on board a vessel. The receivers use trilateration to determine the position of the transmitter and hence a user. It is to be understood that the control system may include any suitable number of receivers such that the system can locate a transmitter using trilateration and time of flight positioning, i.e. the system comprises more than three receivers. The system and the transmitter units worn by the users provide real-time tracking of the users on board.

A DC input for any of the components of the system depicted in Figure 5 can be a standalone source for the component in question, or can be provided from the main power source of a vessel. Each antenna for the various components may be a patch or micro-strip antenna, or any other suitable antenna such as a dipole antenna and so on. Each MCU of the respective components may be configured for processing time-of-flight information.

It is envisaged that the system 500 is operable to define the parameters of at least one pre-determined zone, where the zone may be a designated safe zone within the boundaries of a vessel, and in which the system 500 is operable to activate at least one alarm mechanism in response to determining that the at least one individual is on the perimeter of or outside the pre-determined safe zone. The parameters of the at least one pre-determined zone may include the perimeter or boundary of the designated safe zone.
In some embodiments a plurality of pre-determined zones may be defined. For example, when the system 500 is installed on a maritime vessel or structure, there may be a plurality of pre-determined zones defined, wherein each respective zone may correspond to different levels of access of each individual or different safe zones on the vessel or structure. In some embodiments, a safe zone may be defined as being an area on the deck on which users can perform their normal duties with minimal or no potential risk of falling into the water. The safe zone may be any suitable shape and have any suitable dimensions depending on the particular requirements for the vessel or structure.

In a preferred embodiment, the system 500 operates as a man over-board system which is operable to adjust the parameters of the safe zone(s). The parameters can be the position of or the area covered by the safe zone(s).

The system 500 may use time of flight positioning to determine and/or track the location of the one or more individuals relative to the pre-determined zone by communicating with the transmitter. The system may communicate via radio time-of-flight or optical signals that may be pulsed and comprising a time difference. For example, each transmitter may transmit signals periodically or continuously to the receivers to provide real-time tracking of the transmitters. In the case of a continuous signal, the signal can include frames, with each respective frame including a unique frame identification or similar, so that reception of the continuous signal at different locations can be used to determine position of the transmitter by comparing a time of receipt of one or more specific frames of the signal. For example, each frame can include data representing the ID of a transmitter. The control unit 105 then uses time-of-flight positioning to determine the location of each transmitter based on the signals received by the receivers from each transmitter. For example, the difference in time of reception of a signal from a transmitter at different receivers can be used to determine the relative position of a transmitter, since the speed of the signal carrier is known (for example, as the speed of light is known and the refractive index of the medium through which radio signals are travelling is known, e.g. that of air and/or water).

The system 500 may further comprise at least one memory unit and/or a Global Positioning System (GPS) module. The memory unit may be used to store the real-time position of the transmitter and/or the last known recorded position of the transmitter.
The GPS module may optionally be located within the transmitter. In an example, the receivers can receive a timing signal using a GPS module that can be provided in communication with receiver units, and which can receive a GPS signal including a timing component that can be used by each component of the system 500. The GPS signal may be used by a system operating with pulsed or continuous communication signals. The GPS system can also be linked to a grid reference database that can then be used to send precise coordinates, for the position of each receiver and any data from the transmitter as to its position relative to the receiver, to rescue services so they can locate the individual wearing the transmitter more efficiently using trilateration.

Arrangement of Receivers

Each of the three or more receivers relative to each other should be strategically located for determining the position of a transmitter using trilateration and time-of-flight positioning. Figures 6A-E show example arrangements of the receivers (or transceivers) for determining a location of a transmitter using trilateration. Each of the three or more receivers is labelled R1, R2, R3 and the control unit is labelled C. In each figure, a profile view and plan view of a maritime vessel having the receivers and control unit is shown. In each of the Figures 6A-E, the control unit is located on the deck in the middle of the vessel and may form part of the vessel's own control system. The height of the deck above sea level may therefore be taken into consideration when determining a man overboard situation based on the determined position of a transmitter. The pre-determined safe zone may be defined as the deck of the vessel.

A preferred arrangement is shown in Figure 6A comprising three receivers. The receivers R1-R3 are arranged in a plane parallel to the deck that is offset from the plane of the deck. The receivers R1-R3 are arranged in a triangular layout, with R2 and R3 on either side of the middle of the vessel and R1 located towards the bow. Using this arrangement of the receivers, only three receivers are required for accurately determining the location of one or more transmitters. Using this physical arrangement of the receivers R1-R3, and providing one or more additional receivers positioned in the plane formed by the initial three receivers R1-R3, provides an increase in accuracy and/or coverage of the system, for example the range may be increased using more than three receivers. Using more than three receivers also provides redundancy in the system. For example, a careful selection of the physical layout of each receiver relative to the others provides a system
that is more reliable and more efficient that effectively operates using a minimal number of components (receivers).

Other arrangements comprising more than three receivers are shown in Figures 6B-E. Figures 6B-E illustrate example receiver arrangements using four receivers to locate a transmitter, and where other arrangements using four receivers to locate a transmitter are also possible but which are not shown.

Figure 6B shows the receivers R1-R3 arranged in a triangular layout in the plane of the deck, with R2 and R3 on either side of the middle of the vessel and R1 located towards the bow. The receivers R1-R3 are arranged in the same plane on the deck. A fourth receiver R4 is required to determine the exact location of a transmitter from two possible locations. The fourth receiver R4 may be positioned as shown in Figure 6B.

Figure 6C shows the receivers R1-R3 arranged in a triangular layout when viewed along the profile of the vessel, and a linear layout when viewed in plan (from above). The receivers R1-R3 are positioned along the vessel from the bow to the stern of the vessel. The receivers R1-R3 are arranged in a plane that is perpendicular to the plane of the predetermined safe zone of the deck. R1 is located at the bow. R2 is located on the mast in the middle of the vessel. R3 is located at the stern. The receivers R1 and R3 are arranged in the same plane as the deck and the control unit. A receiver unit may be placed atop the mast of the vessel and the receiver units are arranged to provide an accurate time of flight position of the transmitter to within a distance of up to 5m, preferably up to 2m, more preferably up to 1m, for example to within 20 cm of the actual position of the transmitter. In this example, a fourth receiver is required and located outside of the plane formed by the initial three receivers R1-R3, in order to determine whether the transmitter is located on the port or starboard side of the vessel. For example, the fourth receiver R4 may be positioned as shown in Figure 6C outside the plane defined by R1-R3.

Figure 6D shows at least four receiver units R1-R4 spaced apart from each other on the deck of the vessel. The receiver units R1-R3 and control unit are aligned along the length of the vessel in the same plane as the deck. Preferably, for the purposes of providing an accurate time of flight position for a transmitter unit, at least two of the receiver units R1 and R3 are positioned substantially at either end of the vessel. Another receiver unit R2
can be placed in any desired location in between the two units R1 and R3 at the vessel’s extremities. The fourth receiver is placed outside the plane defined by the initial three receivers R1-R3. In this example, more than three receivers are required to determine the location of the transmitter on the port or starboard side and the location of the transmitter relative to the safety plane on the deck, i.e. the height of the crew member above sea level.

Figure 6E shows the receivers R1-R3 arranged in a linear layout in a plane perpendicular to that of the deck of the vessel, with R1 on the deck, R2 midway up the mast and R3 located at the top of the mast in the middle of the vessel. In this example, three receivers provide information on the height of the transmitter above or below the pre-determined zone on the deck, however a further receiver (or receivers) is required to provide information about the horizontal position of the transmitter beyond the distance from the mast (i.e. the distance from the mast may be determined but the precise position of the transmitter on a circular path surrounding the mast must also be determined).

In the examples shown in Figures 6C and 6E, where the plane of the receivers is perpendicular to the pre-determined safe zone, placing a fourth receiver outside of the plane formed by the initial three receivers allows determination at which of two possible points the transmitter is located (i.e. port or starboard).

In general, the following table illustrates example requirements of the relative configurations/layouts of the receivers in the system for determining the exact position of a transmitter.

<table>
<thead>
<tr>
<th>Minimum number of receivers in system?</th>
<th>3</th>
<th>4</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plane of receivers parallel to plane of pre-determined zone/deck?</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Plane of receivers perpendicular to plane of pre-determined zone/deck?</td>
<td>No</td>
<td>Yes (R1-R3)</td>
<td>No</td>
</tr>
<tr>
<td>Plane of receivers offset from the plane of the pre-determined zone/deck?</td>
<td>Yes</td>
<td>n/a</td>
<td>No</td>
</tr>
<tr>
<td>Example shown:</td>
<td>Fig. 6A</td>
<td>Fig. 6C, 6E</td>
<td>Fig. 6B, 6D</td>
</tr>
</tbody>
</table>
It is however to be understood that the receiver units and control unit can be arranged in any suitable configuration on the vessel and the examples shown in Figures 6A-E are in no way limiting. These examples illustrate the use of three or four receivers arranged to determine the location of a transmitter, however additional receivers may be used. The location of the transmitter in each example described is achieved using trilateration and time-of-flight data processing.

In some examples, at least two of the three or more receivers may have high antennae to compensate for positioning on a metal vessel. Each of the receivers may have a range of sizes for the antennas to suit certain sized boats. At least one of the three or more receivers may operate with Bluetooth®. At least one of the three or more receivers may be fitted with an alarm function.

Examples of the System in Use

The control unit is configured to determine the location of each transmitter or individual wearing a transmitter relative to the receivers or vessel upon which the receivers are mounted. The control unit achieves this by detecting the signals transmitted from each transmitter using the three or more receivers, and determining the location of each transmitter using trilateration and time-of-flight positioning.

Figures 7A-D show schematic illustrations of a view from above a maritime vessel comprising a system 500 mounted on a maritime vessel having pre-determined safety zones according to an embodiment of the invention. In particular, figures 7B-D show examples of pre-determined zones 701, 704, 705 for a maritime vessel 702.

Figure 7A shows the system 500 configured for determining that a first user A is located within the safe zone 701 of the vessel 702, and no further action is required in respect of this user. The system identifies that user A is present on board the vessel 702 and within the safe zone 701. However, if user A then moves outside of the safe zone 701, the transmitter or wristband may be configured to signal an alarm to the user and providing the user with the option to disarm the alarm mechanism before a central alarm mechanism of the system 500 is activated, i.e. the system 500 may also determine that user A has crossed the perimeter of the designated safe zone 701 and remains on the
vessel 702. The control unit 105 may immediately activate the alarm mechanism or
vibrational alarm provided on the corresponding wristband of user A.

The system may also determine that a second user B is located outside of the safe zone
701 of the vessel and within range of the receivers 703. User B is no longer on board the
cessel and is within the range of the system 500. In this instance, the system is configured
to operate a local alarm mechanism of the transmitter or wristband of the second user B.
The user B may then activate a central alarm mechanism by pressing a button on their
wristband to activate the central alarm of the system 500. When the wristband is
activated it provides an opportunity for user B to disarm the local alarm mechanism. If
user B does not disarm their local alarm mechanism, the transmitter or wristband may be
configured to activate the central alarm of the system 500 after a pre-determined lapse of
time from activation of the local alarm. As user B remains within range of the receivers,
user B may re-initiate an alarm signal even if they have previously disarmed the
transmitter or wristband. The system 500 will continue to record the position of the user
B until the user is located beyond the range 703 of the system, for example beyond 300
meters, or more preferably beyond 500 meters of the vessel. If the user B drifts beyond
the range of the system 500, the system will record the last known coordinates, the
velocity and trajectory of the transmitter or user.

The control system may further determine that a third user C is no longer on the vessel
and is beyond the safe zone 701 and range of the receivers 703. The user C may
however not activate the alarm mechanism of the system 500. Instead, the system 500
may have provided real-time tracking of the user C from the moment the transmitter left
the pre-determined safe zone and the individual had fallen overboard. For example, the
wristband may continue to vibrate, and/or the LEDs may "count down" during the initial
alarm period prompting the user to disarm the alarm mechanism. If the transmitter was
in an alarm mode prior to moving beyond the range of the system, the system will record
the last known position of the transmitter. The system 500 is then configured to record
one or more of: the last known location of the third user C, the time the last known
location of the third user C was known, the velocity of the vessel, and the trajectory of
the vessel. This information may be stored in a memory within the control unit 105.
Also with reference to user C, in another example if the transmitter was not in an alarm mode before moving beyond the range of the system, for example the user was deliberately leaving the vessel, the system may not record the last position of the user. Furthermore, as the wristband of user C is out of range, the wristband can no longer communicate with the system. The user C may have disarmed the alarm mechanism by any suitable means, such as for example by operating a control button or switch on the transmitter or wristband, or by tapping the wristband in a pre-determined manner. Failure of the user C to disarm the alarm mechanism within the alarm period will result in the alarm mechanism of the system 500 being activated.

The control unit 105 may analyse the signals received by the receivers 102-104 from the transmitter 101 of each wristband of each user A, B, C. If the control unit determines that each user A, B, C is located within the safe zone 701 of the vessel then no further action is required and the control unit may continue to monitor the signals transmitted from the transmitter unit of each wristband to determine any real-time changes in the respective locations of each user.

It is to be understood that the system 500 can be used to locate any suitable number of transmitters or users, including for example a single user or a plurality of users.

In one application of the system 500 when used as a man over-board safety system, the system 500 may be used for tracking the location of one or more individuals on the vessel and to cause a local and/or central alarm or alert status if one or more of the individuals is outside a pre-determined safe zone defined for the vessel and/or for alerting a user if they approach the periphery of the zone. The position of each individual relative to the vessel is determined using time-of-f light positioning and trilateration. At least one alarm mechanism(s) may alert the at least one individual when the individual(s) is:

   a) at the perimeter or within a region adjacent the perimeter of the vessel, and/or
   b) outside the perimeter of the watercraft and so not on board the watercraft in order to reduce the risk of an individual falling overboard or to facilitate a rescue of said individual.

A method for determining the location of a transmitter is disclosed. The location of a user of the transmitter relative to receivers may be monitored in real-time using
trilateration and time-of-flight technology. A safety zone may be pre-determined and the transmitter(s) may be monitored relative to the pre-determined zone, for example when a transmitter is determined as located outside the pre-determined zone. Three or more receivers and a transmitter may be used; alternatively the receivers and transmitter(s) may be replaced by transceivers.

With reference to Figure 8, the three or more receivers may be arranged 801, for example in a triangular layout, so as to allow determination of the location of a transmitter using trilateration and time-of-flight information 803. A control unit may be arranged for generating an output signal 802 in the event that the transmitter(s) is determined as not located within the pre-determined zone 804.

For example, the method may comprise the following steps:

1. Accurately set a safety zone (or radius safety zone) around perimeter of vessel or structure.
2. All synced inside the safe zone will not cause an alarm to trigger.
3. All synced-up transmitters (wristbands or tags) that leave the safety zone or cross the safe zone perimeter will send an alarm to a control unit (or base station) via receivers and to any other compatible transmitters.
4. When the transmitter(s) (wristbands or tags) has left the safe zone the alarm information will be immediately sent on screen to the control unit, where this information may comprise:
   a. Transmitter ID
   b. Time
   c. Real-time distance from control unit (when in range)
   d. Real-time GPS co-ordinates (when in range)
   e. An on screen arrow to direct the vessel back to the GPS co-ordinates
   f. If the transmitter leaves the range of the system, all last known location information may also be shown on screen.
5. If out of range, once the vessel returns to the last known co-ordinates of the transmitter, the system will automatically pick up the transmitter when back in range.
6. All alarms have to be accepted by a responsible person(s) on-board the vessel in a certain user-set time. If not accepted, the system could then possibly

26
communicate with existing systems on-board the vessel, such as via very high frequency radio signals (VHF) and/or automatic identification systems (AIS), to possibly relay a larger distress signal to other vessels in the area.

7. Other transmitters with a screen will also be alerted and receive an onscreen message with the transmitter ID information to assist in the distress quickly.

8. All transmitters when in alarm mode will flash white LEDs and vibrate (if enabled).

9. A manual alarm may be triggered at any time from the transmitter by pressing buttons in a certain sequence.

10. Alarms may be dismissed or turned off from both the control unit (or base station) and the transmitter.

The screen of the control unit may indicate a plane of the water level relative to the plane of the safety zone of the vessel, which may help indicating that a transmitter may be located at water level for a man overboard situation. The method may comprise the step of alerting a user when the user is determined to be at or is approaching the perimeter of a designated safe zone, or the user is outside of a designated safe zone. Preferably the method further comprises operating the at least one alarm mechanism(s) when the system determines that at least one transmitter is: a) at the perimeter of or in a region adjacent to the perimeter of a vessel; and/or b) is not located within the safe zone and so is not within the perimeter of the vessel or on board the vessel.

Pre-determined Zone

In some embodiments the safe zone extends beyond the perimeter of the vessel, for example as shown in Figures 7A and 7B. The safe zone 701 may extend just beyond the perimeter of the vessel. In other embodiments the safe zone may extend to exactly the perimeter of the vessel. In the embodiment illustrated in Figure 7C, the perimeter of the safe zone 704 is spaced apart from and located inwardly of the edge or perimeter of the vessel 702 by a predetermined minimum distance. The separation between the perimeter of the safe zone 704 and the perimeter of the vessel 702 may be uniform. However, as shown in Figure 7D, in some embodiments the separation between the perimeter of the safe zone 705 and the perimeter of the vessel 702 may vary. The variation in the separation between the perimeter of the vessel 702 and the perimeter of the safe zone 705 may vary depending on a number of factors, including the particular shape of the
vessel, the position of equipment on the deck of the vessel, or other safety features on
the deck which act to prevent users falling overboard.

An initial set-up or configuration of the pre-determined safe zone may be required prior
to activation of the system 500. For example, the receivers and/or transmitter(s) are
configurable to define the pre-determined zone, for example by an individual wearing the
transmitter and walking around the vessel or structure in order to store the pre-
determined safe zone for a particular vessel or structure, for example in a memory of the
control unit 105. Once the pre-determined zone(s) is set up for a particular vessel or
structure, the pre-determined zone(s) may be re-configured as desired, for example to
avoid false alarms or alerts.

The designated safe zone may have any suitable shape and dimensions according to the
shape of the vessel. The designated safe zone is typically an area of the vessel well within
the outer boundary of the vessel and may be located within a central region of the deck
of the vessel. The designated safe zone may correspond to an inner region of the deck of
the vessel spaced inwardly from the perimeter of the vessel. The designated safe zone
may be an inner region of the deck of the vessel spaced an equal distance from the
perimeter of the vessel. Alternatively, the distance between the perimeter of the safe
zone and the perimeter of the vessel may vary along the perimeter of the vessel
depending on the particular requirements. The designated safe zone may, in some
embodiments, extend beyond the perimeter of the vessel, for example by at least one
metre from the vessel perimeter, and more preferably two metres from the vessel
perimeter. This arrangement provides a buffer zone and ensures that the alarm is not
activated while users walk around the periphery of the vessel and so reduces the risk of
false alarms that an individual has fallen over-board.

In a preferred embodiment, the parameters of a designated safe zone are defined within
the boundaries of the vessel and the alarm mechanism of the transmitter unit(s) is
operated to alert the corresponding at least one individual when the individual(s) is
determined to be located at the perimeter of or outside of the safe zone. It is preferred
that the man over-board system has a designated safe zone which is at the perimeter of
the vessel and the control unit is further operable to determine that the at least one
individual is either at the perimeter of or within a region adjacent to the perimeter of the vessel, and/or is outside the perimeter and hence not on board the vessel.

Alarm Procedure

The control unit 105 may be configured to activate the local alarm mechanism of the corresponding transmitter unit(s) prior to activation of the central alarm mechanism of the system 500, or for example of the receivers. Activation of the local alarm of the transmitter provides the user with a warning signal prior to activation of the central alarm mechanism of the system. The time interval between activation of the local alarm mechanism of the transmitter or wristband and activation of the central alarm mechanism of the system may be adjusted as required, for example at the control unit 105. Other alerts may be provided to other marine vessels of systems outside the immediate system 500, for example to a search and rescue team. The other alerts may be effected via satellite and may additionally transmit the GPS co-ordinates of the last known location of the transmitter(s).

The local alarm mechanism of the transmitter may continue to be activated for a pre-determined time period, herein referred to as the alarm period. The duration of the alarm period may be selected according to the particular requirements for the system 500. In one embodiment, the alarm period is 5 seconds. It is to be understood that the alarm period may be greater than or less than 5 seconds. The control unit 105 may be configured to adjust the duration of the alarm period as required. As such, the alarm mechanism of the transmitter unit within a wristband may vibrate to notify the user that the user is outside of the safe zone and that the central alarm mechanism of the system 500 will be activated after a pre-determined time period unless the user disarms the local alarm mechanism. The alarm mechanism of the wristband may vibrate at a frequency of one vibration per second. It is to be understood that the alarm mechanism may vibrate at any suitable frequency. Furthermore, the frequency of vibration of the alarm mechanism may vary over the alarm period, for example the frequency of vibration of the alarm mechanism may increase over time during the alarm period in order to notify the user of the shortening of the period of time within which the user is required to take action by disarming the alarm mechanism.
The transmitter unit of the wristband may also comprise a visual alarm mechanism. The wristband may comprise five LED lights for example. In addition to the vibration alarm mechanism, the alarm mechanism of the transmitter unit may activate the five LED lights on the wristband. It is however to be understood that the alarm mechanism of the wristband may be any suitable signal to notify the user that the user is outside of the designated zone, for example the alarm mechanism may comprise one or more of: audible, visual or vibration signals, or any combination thereof. The five LEDs of the alarm mechanism of the wristband may be configured to be switched off in sequence one by one over regular time periods within the alarm period to notify the user of the "count down" of the alarm period prompting the user to disarm the alarm mechanism. It is however to be understood that the LED lights may be operated in any suitable manner or configuration to notify the user of the requirement to disarm the alarm mechanism within the alarm period.

In an example alarm procedure, in order to activate the alarm mechanism of the system 500, the user may operate the controls of the wristband in a pre-determined manner. For example, the user may press a button on the wristband to activate the central alarm mechanism of the system 500. Alternatively, if the user falls over-board and does not take any action within the pre-determined time interval, the central alarm mechanism of the system 500 will automatically be triggered. In the event that the transmitter leaves the pre-determined zone, the receivers will be used to determine that the transmitter is no longer located in the pre-determined zone and the control unit will relay an alarm to be accepted by personnel on board. If the transmitter has started an alarm process it may flash LEDs, vibrate or show an on screen message to notify the user that an alarm has been successfully raised. The transmitter will also relay information for determining the location, time, distance or other information to the control unit in real-time when in range of the receivers. The control unit will then show all information to personnel and automatically update the information in real-time, and may also indicate an arrow on screen to direct a route back to the transmitter relative to the vessel location using GPS. If the transmitter goes out of range of the receivers, all last known information will be stored at the control unit and displayed on screen with an arrow directing a route back to the last known co-ordinate of the transmitter. If the transmitter then comes back into range of the receivers the real-time updates will be re-initiated. The control unit may have pre-installed software to be able to integrate with other on-board systems for using,
e.g. a vessel plotter to show the relative locations of the vessel and transmitter, engine controls to kill the engine, and any other systems available to aid recovery of the man over-board and relay information. If the alarm raised at the control unit is not accepted by the personnel, pre-installed software may use existing systems of the vessel to relay a larger distress signal to other vessels in the vicinity or to coastguard stations worldwide. Alternatively or additionally the transmitter, after a set amount of time, may have the ability to relay a larger signal to alert other vessels in the vicinity or coast guard stations worldwide. Once the transmitter is deemed safe, the alarm can be dismissed at control unit and/or transmitter, which may also apply for false alarms. If the user does not act before the alarm period expires such that the central alarm is triggered and the user is not in trouble, the user may disarm the central alarm mechanism of the system 500. In one example, in order to deactivate the central alarm system, the user must return to the pre-determined safe zone or operate the wristband in a pre-determined manner, such as for example by operating a control button or switch on the wristband, or by tapping the wristband in for example a pre-determined manner. The system may then take no further action and will not activate a distress alarm to search and rescue or other vessels via satellite or GPS.

In other examples, the wearable transmitter or wristband has the ability to relay a distress call through the emergency satellite frequency of 406 MHz directly from the wearable device, i.e. not via the base station or control unit.

The system 500 comprises at least one alarm mechanism responsive to signals from the control unit 105. An output signal is provided from at least one of the components of the system 500 in response to a transmitter being determined as not located in the pre-determined zone. The output signal may be an alarm generated at one or more of: the control unit, the transmitter(s), and/or at least one receiver. Some or all of the other transmitters for individuals on the vessel may alert the other crew members to a man overboard situation or an individual being located outside the pre-determined zone. At least one alarm mechanism(s) may be manually operable.

Optionally, the length of time that an individual has spent outside the pre-determined zone may be used to determine which type of alarm is raised, i.e. whether the alarm
status is generated locally for the user and/or centrally where other individuals can also be alerted, including search and rescue teams of other vessels.

The systems and methods of the present invention may further comprise operating a response mechanism, such as for example launching one or more safety buoys or lifeboats to rescue the user(s). The methods of the present invention may further comprise operating a response mechanism when the control system determines that a user(s) is no longer on board of the vessel. The response mechanism may be operated immediately on operation of the alarm mechanism(s) of the system 500 to increase the chances of successful rescue of the user(s).

Other Examples of the System in Use

Figure 9 shows an example flowchart 900 of events for when the device goes out of range of the safe zone 901 of the system, and where the alarm mechanism may be deactivated by the user. The system 500 may signal an instruction 902 to the transmitter 101 for the user to disarm the local alarm mechanism if the transmitter is determined as not located within the pre-determined safe zone. The instruction signal may comprise operating the transmitter or wristband to vibrate and for the LED lights to flash twice. It is to be understood that the instruction signal indicated by the wristband may comprise any combination of visual and/or audible and/or vibrating signals. However, if the user does not disarm the wristband 903, the system sends location data to a central unit 904 to calculate the grid reference of the real-time position of the user. The system continues to monitor 904 the position of the user using trilateration and time-of-flight positioning, provided the user remains within the range of the system. The system of the present invention may be configured such that the user is able to disarm the alarm mechanism for a pre-determined time period (or alarm period). After expiry of the alarm period, the control system again determines the position of the user using time-of-flight processing. If the user does not disarm the wristband within the alarm period 905, the wristband goes into alarm mode 906, which may comprise one static red LED and two flashing alternating white LEDs. It is to be understood that the alarm mode may comprise any combination of audible, visual and vibrational alerts. Alternatively, the user may optionally initiate the alarm manually 907 for example by pushing a button 908 on the wristband.
The user may disarm the wristband once an alarm is initiated for example by tapping the wristband twice, 909, 910 at which point the wristband will confirm this action 911 to the user. However, if the user is still determined by the system to no longer be on the vessel 912, the system repeats the steps described above and re-activates the alarm mechanism of the wristband 906. The user is again prompted by the alarm mechanism to take action and disarm the alarm mechanism 910. If the user disarms the alarm mechanism 910 the system is disarmed for a pre-determined period of time, following which the process is repeated via steps 901 to 906. If the user moves beyond the range of the system, the system will record the last known position of the user 913 and the wristband will alert the user 914 of this change in condition. The system 500 continually monitors whether the wristband has returned to the safe zone 915. If the user then returns to the safe zone 916 the user can disarm the system by tapping the wristband twice 917. If however, the user remains outside of the safe zone 918, the alarm mechanism continues to be activated 919.

When the user leaves the vessel, the user may wish to disarm the wristband as illustrated in step 910 of Figure 9. The system may still first determine if the user is in the safe zone, which may be a region extending up to 2 meters beyond the perimeter of the vessel 901. If the user is not within the safe zone and the user does not disarm the wristband, the wristband may enter the alarm mode 906 as discussed above.

Alternatively, the wristband may be configured such that the user may manually initiate the alarm mechanism to provide a distress signal as shown in Figure 10. To initiate the alarm, the user holds the button down for three seconds 1001. The system sends position data relating to the user to the central unit to determine the grid reference of the user at the last known position. The system continues to track the position of the user using time of flight positioning. The system will continue to track the position of the user provided the user remains within the range of the system 1002. The system may be capable of tracking the user within any suitable range. For example, at a range of up to 1 kilometer, preferably up to 500 meters, and more preferably up to 300 meters from the perimeter of the vessel. If the user moves outside of the range of the system, the system logs the last known position of the user. On activation by the user, the wristband enters the alarm mode as discussed above 1003. The wristband displays one static red LED and two flashing alternating white LEDs. The system continues to monitor the position of the
If the user returns to the safe zone 1005, the user may deactivate the alarm mode by tapping the wristband twice 1006. If however, the user does not return to the safe zone 1007 the alarm continues to be activated 1008.

With reference to Figure 11, the user may arm the wristband when entering the vessel. The wristband may only be armed when the wristband is within the safe zone. The system 500 determines whether the user is within the safe zone on the vessel 1101. The safe zone in this embodiment is a region extending up to 2 meters beyond the perimeter of the vessel. If the user is not within the safe zone 1102 and the user does not wish to arm the device 1103, the system is operable to activate the wristband to periodically provide a reminder signal to the user of the need to arm the wristband 1104. The reminder signal may be any combination of audible, visual and vibrational alerts. The reminder signal may be provided by three flashing lights, text on the screen of the wristband, and a vibrational alert 1104. If the user is in the safe zone 1105 and does not wish to arm the wristband 1103, the system is operable to activate the wristband periodically to provide reminder signals to the user of the need to arm the wristband 1104. If the user is in the safe zone 1105 and wishes to arm the wristband 1106, the user may do so by operating the wristband in a predetermined manner corresponding to activation of the wristband. In the illustrated embodiment, the wristband is reactivated when the user double taps the wristband 1107. Again, the wristband provides a confirmation signal 1108 to confirm to the user of receipt of instructions to arm the wristband. It is to be understood that the confirmation signal may comprise any combination of audible, visual and vibrational alerts. In the illustrated embodiment, the confirmation signal comprises a vibrational alert with three pulses, two quick flashes and a solid light of red for three seconds.

The wristband may indicate to the user that the battery is running low on the wristband. The wristband may be activated or deactivated by the user in a manner as described above. For example, the wristband can be deactivated by the user pressing a button on the wristband twice such that the wristband powers down. The wristband may confirm to the user that the wristband is to power down by vibrating with three pulses and showing two quick flashes and a solid light of green for three seconds. It is to be understood that confirmation may be provided by any combination of audible, visual and vibrational alerts. If the user wishes to activate the wristband, the user may press a
button on the wristband twice for example such that the wristband powers up. The wristband may confirm activation by vibrating with three pulses and two quick flashes and a solid green light for three seconds. It is to be understood that confirmation may be provided by any combination of audible, visual and vibrational alerts.

Other functions of the transmitter may be available for a user. For example, the wristband may comprise additional features such as a clock and/or timer display. The clock and/or timer display may be activated by any suitable mechanism. For example the clock and/or timer display may be displayed to the user when the user taps the wristband with a corresponding predetermined pattern, such as for example a single tap using two fingers using a capacitive multi-touch display. The display may appear for a predetermined time period, such as for example 5 seconds. The display may also indicate whether the wristband is armed or disarmed. The wristband may comprise a battery indicator displaying the amount of charge remaining within the battery of the wristband. The wristband may comprise a battery alarm operable to indicate to the user that the battery charge is running low. This may include providing a vibrational alert to the user, and also sending a message to the control system to indicate that the wristband needs charging.

The system described herein may also comprise receivers that work on a distance radius system which determines the location of a transmitter based on signal strength. For example, a distance radius to a transmitter may be determined by a receiver based on the strength of the signal received from the transmitter.

The system described may also be configured to determine whether a maritime vessel is stopped or moving, for example to drop or disregard the pre-determined zone or safety perimeters when the vessel is docked. The system may also be configured to track hazardous freight containers in rough seas for enhanced security.

Although embodiments of the present invention are discussed above in relation to a wristband, it is to be understood that the transmitter may be located within any suitable item to be worn by a user and is not to be limited to a wristband, for example the device may be an item that can be clipped to an article of clothing. It is also to be understood that the time periods of the method of the invention may be adjusted to suit the requirements of the system. The wristband is described as being operated in certain
manners to disarm/arm the wristband or to initiate the alarm. It is to be understood that
the user may carry out these operations by activating any corresponding switch, button,
or tapping the wristband in any suitable predetermined manner.

5 The system described herein is not limited to a system for the marine industry having a
pre-determined safe zone set up around a maritime vessel or structure. For example the
system may be used as a luxury yacht safety system for tracking the location of one or
more crew members. The system may be used in any industry requiring the tracking of
objects and/or individuals. For example, the system may be used as a land based system,
such as by parents wanting to keep track of the location of children to make sure the
children are safe.
What is claimed is:

5 1. A system for determining a location of a transmitter, the system comprising:
   a transmitter;
   three or more receivers, arranged for determining a location of the transmitter using trilateration
   and time-of-flight information; and
   a control unit, arranged to generate an output signal in response to the
   transmitter being determined as not located in a pre-determined zone.

10 2. A system according to any preceding claim, wherein the transmitter is wearable.

15 3. A system according to any preceding claim, wherein the transmitter is one of: a
   wristband; a neck pendant; a personnel worn device; and a tag to be placed on marine
   equipment.

20 4. A system according to any preceding claim, wherein the transmitter is a wireless
   tag with a unique identification.

25 5. A system according to any preceding claim, wherein the system is a maritime
   tracking system.

6. A system according to any preceding claim, wherein the control unit and three
   receivers are mountable on a maritime vessel or a maritime structure.

25 7. A system according to claim 6, wherein the control unit is formed as part of an
   existing control unit on the maritime vessel or maritime structure.

30 8. A system according to any preceding claim, wherein the system is used to assist
   man overboard situations and/or track crew members of a maritime vessel or a maritime
   structure.
9. A system according to any preceding claim, wherein the output signal is an alarm generated at one or more of: the control unit; the transmitter; and/or at least one receiver.

10. A system according to any preceding claim, comprising a plurality of transmitters.

11. A system according to any preceding claim, wherein the pre-determined zone corresponds to a safe area defined on a maritime vessel or a maritime structure.

12. A system according to any preceding claim, wherein the transmitter and three receivers are transceivers.

13. A system according to any preceding claim, wherein the control unit comprises information about the environment in which the receivers are deployed.

14. A system according to claim 13, wherein the information is related to structural dimensions of a maritime vessel or a maritime structure.

15. A system according to any preceding claim, wherein one or more of: the control unit; the transmitter; and at least one of the receivers, comprises a microcontroller for processing time-of-flight information.

16. A system according to any preceding claim, wherein one of the receivers or the transmitter or the control unit are configurable to define the pre-determined zone.

17. A system according to any preceding claim, further comprising a memory unit and/or a GPS module.

18. A system according to claim 17, wherein the memory unit and/or the GPS module is located within the transmitter.

19. A maritime tracking device comprising a wearable transmitter arranged to receive and/or transmit signals.
20. A device according to claim 19, wherein the device is arranged to receive and/or transmit time-of-flight information for tracking applications based on trilateration.

21. A device according to any of claims 19-20, wherein the device is one of: a wristband; a neck pendant; a personnel worn device; and a tag to be placed on marine equipment.

22. A device according to any of claims 19-21, further comprising one or more of: an alarm; a vibrate function; a light emitting device; and a screen.

23. A device according to any of claims 19-22, wherein the device is arranged to generate an output signal.

24. A device according to any of claims 19-23, wherein the device is a safety device for assisting man overboard situations and/or tracking crew members on a maritime vessel or a maritime structure.

25. A method for determining a location of a transmitter, the method comprising the steps of:

   - arranging three or more receivers;
   - arranging a control unit for generating an output signal; and
   - determining the location of the transmitter using trilateration and time-of-flight information, wherein the output signal is generated in response to the transmitter being determined as not located in a pre-determined zone.

26. A method according to claim 25, wherein the transmitter is the device as claimed in any of claims 19-24.

27. A method according to claim 25 or claim 26, wherein at least three of the three or more receivers are arranged in a triangular layout in a single plane.

28. A method according to any of claims 25-27, wherein the three or more receivers are arranged in a plane that is parallel to a plane of the pre-determined zone.
29. A method according to any of claims 25-28, wherein the three or more receivers are arranged in a plane that is perpendicular to a plane of the pre-determined zone.

30. A method for determining the location of the transmitter using the system as claimed in any of claims 1-18.

31. A method according to claim 25, wherein the method assists man overboard situations and/or tracks crew members of a maritime vessel or a maritime structure.

32. A method and/or system and/or device substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.
FIG. 8

8 / 10

801
Arrange three or more receivers

802
Arrange control unit for generating output signal

803
Determine location of a transmitter using trilateration and time-of-flight information

804
Generate output signal if transmitter determined as not located in a pre-determined zone

FIG. 10

1001
Hold the button down for 3 seconds

1002
Send position data to central unit to calculate grid reference to last known position. Position will continue to be logged using real time tracking until outside of a 300m radius from the safe zone and then log last known position.

1003
Wrist band enters alarm mode; One static red LED, Two flashing alternating white LED’s

1004
Is the wrist band back in the safe zone?

1005
Yes
Disarm by tapping wrist strap twice.

1006

1007
No
Continue alarm mode

1008

SUBSTITUTE SHEET (RULE 26)
Device goes out of safe zone when armed (2m off the vessel)

Do you want to initiate distress alarm

Press button on wristband

Alarm will initiate

Disarm by tapping wrist strap twice.

Send position data to central unit to calculate grid reference to last known position.

Position will continue to be logged using real time tracking until outside of a 300m radius from the safe zone and then log last known position.

Wrist band enters alarm mode;
One static red LED,
Two flashing alternating white LED's

Is the wrist band back in the safe zone?

Disarm by tapping wrist strap twice.

Continue alarm mode

FIG. 9
10/10

1101
Are you in the safe zone?
(2m off the vessel)

1105
Yes

1102
No

1106

1103
Yes

1104
The wrist band will remind the user to arm the device when in the safe zone every 10mins by vibrating with a single pulse, 3 red light flashes and text on screen

1107
Double tap wristband

1108
The device will confirm the selected setting by vibrating with 3 pulses and showing 2 quick flashes and a solid light of red for 3 seconds.

FIG. 11
A. CLASSIFICATION OF SUBJECT MATTER
INV. B63C9/00 G08B21/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
B63C G08B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>wo 2005/045455 A2 (CAMBRIDGE CONSULTANTS [GB]; OSWALD GORDON KENNETH ANDREW [GB]; GEOGHEG) 19 May 2005 (2005-05-19) page 30, line 37 - page 64, line 7; figures 1-29</td>
<td>19-22</td>
</tr>
<tr>
<td>Y</td>
<td>page 1, line 10 - line 26</td>
<td>1-18, 23-32</td>
</tr>
<tr>
<td>A</td>
<td>US 8 998 666 BI (ALBRIGHT STEVEN [US]) 7 April 2015 (2015-04-07) the whole document</td>
<td>1-32</td>
</tr>
</tbody>
</table>

[X] Further documents are listed in the continuation of Box C.  
[X] See patent family annex.

* Special categories of cited documents:
  *A* document defining the general state of the art which is not considered to be of particular relevance
  *E* earlier application or patent but published on or after the international filing date
  *L* document which may throw doubts on priority claim(s) on which is cited to establish the publication date of another citation or other special reason (as specified)
  *O* document referring to an oral disclosure, use, exhibition or other means
  *P* document published prior to the international filing date but later than the priority date claimed
  "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
  "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
  "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
  "A" document member of the same patent family

Date of the actual completion of the international search
27 May 2016

Date of mailing of the international search report
06/06/2016

Name and mailing address of the ISA:
European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016

Martinez, Felipe
### DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>JP 2004 249956 A (YAZAKI CORP) 9 September 2004 (2004-09-09) the whole document</td>
<td>1-32</td>
</tr>
<tr>
<td>Patent document cited in search report</td>
<td>Publication date</td>
<td>Patent family member(s)</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>----------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>JP 2012108141 A</td>
<td></td>
<td>US 2008204322 AI</td>
</tr>
<tr>
<td>US 2005045455 A2</td>
<td></td>
<td>WO 2005045455 A2</td>
</tr>
<tr>
<td>US 4813025 A</td>
<td>14-03-1989</td>
<td>CA 1293320 C</td>
</tr>
<tr>
<td>US 4813025 A</td>
<td></td>
<td>US 4813025 A</td>
</tr>
<tr>
<td>US 9223027 BI</td>
<td></td>
<td>US 9223027 BI</td>
</tr>
<tr>
<td>JP 2004249956 A</td>
<td>09-09-2004</td>
<td>NONE</td>
</tr>
<tr>
<td>US 6414629 BI</td>
<td>02-07-2002</td>
<td>AU 2002254645 AI</td>
</tr>
<tr>
<td>US 6414629 BI</td>
<td></td>
<td>US 6414629 BI</td>
</tr>
<tr>
<td>WO 02086442 A2</td>
<td></td>
<td>WO 02086442 A2</td>
</tr>
</tbody>
</table>