

**SYSTEM FOR GENERATING, TRANSMITTING AND RECEIVING
AUXILIARY SIGNALS
AND METHODS USEFUL IN CONJUNCTION THEREWITH**

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REFERENCE TO CO-PENDING APPLICATIONS – none.

FIELD OF THE INVENTION

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The present invention relates generally to wireless communication systems and more particularly to transmission and reception enhancement in wireless communication systems.

BACKGROUND AND SUMMARY OF THE INVENTION

Typically communication systems and protocols include several channels and signals that together operate as a comprehensive wireless standard, system or protocol. Each signal or channel has its own role. There are physical channels and there are logical channels as well. There are for example control channels that are responsible of transferring control information between the wireless communication nodes. In addition there are data/traffic channels that are responsible of transferring the user data between the nodes. Examples of these various channels for the LTE standard are described at Figure 3.

Sometimes there are cases in which the features of specific signal and/or channel and/or part of the transmission and/or part of signal and/or part of channel (will be termed "Important Signal") of a communication system or protocol are not suitable for specific need of a user that wants to use this standard/protocol in a new scenario and/or is very important for the user and therefore proper reception of it is vital for the user. In example, scenarios with higher interference as a result of many nearby small cells in a cellular network or in another example, in mobile relays network that uses a protocol that is planned for a static network (such as but not limited to the first releases of the LTE). In these cases there is a need to adapt the specific signal/channel/transmission or to replace it by additional auxiliary signal.

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Layer 1, 2 and 3 relays are known.

Many different communication protocols such as but not limited to LTE, 3G UMTS, WiMAX, WiFi, OFDMA, CDMA and TDMA are known.

Receivers which recognize elements of a known protocol, such as cyclic prefixes, are known.

5 Published PCT application NO. WO2014188414 describes a receiver, system and method for frequency diversity communications using beacon and methods useful in conjunction therewith and is hereby incorporated by reference.

10 The disclosures of all publications and patent documents mentioned in the specification, and of the publications and patent documents cited therein directly or indirectly, and of specifications of mentioned protocols are hereby incorporated by reference.

15 Algorithms which lock onto the frequency of a signal are known. These algorithms tend to be more successful when operating on simple signals, or signals having statistical characteristics selected to facilitate rapid measurement of frequency. For example, these algorithms tend to be more successful when operating on CW signals, as opposed to complex information-carrying signals.

SUMMARY OF THE INVENTION

20 In accordance with an aspect of the presently disclosed subject matter, there is provided a wireless communication system according to any of the claims herein, but wherein each of the claims depends from all previous claims.

BRIEF DESCRIPTION OF THE DRAWINGS

25 Certain embodiments of the present invention are illustrated in the following drawings:

FIG. 1a (Prior Art) depicts a typical wireless communication system comprising a transmitter and a receiver.

30 FIG. 1b depicts a typical cell or other network portion in a wireless e.g. cellular communication system.

FIG. 1c depicts a cellular system comprising a plurality of cells; each of the cells e.g. as described above with reference to Fig. 1b.

Fig. 2 depicts an OFDMA radio frame (either downlink or uplink), in an OFDMA FDD communication system implementing add-on auxiliary signal according to certain embodiments of the invention.

Fig. 3 depicts LTE FDD radio frame (either downlink or uplink) implementing
5 add-on auxiliary signal according to embodiments of the invention.

Fig. 4 depicts a CDMA FDD radio frame (either downlink or uplink), in a CDMA communication system implementing add-on auxiliary signal according to certain embodiments of the invention.

Fig. 5 depicts a TDMA radio frame, in a TDMA communication system
10 implementing add-on auxiliary signal according to certain embodiments of the invention.

Fig. 6a depicts a wireless communication system incorporating an add-on auxiliary signal couple apparatuses at the transmitter side (AST, typically downstream of the Tx) and at the receiver side (Auxiliary Signal Receiver (ASR), typically
15 upstream of the Rx).

Fig. 6b illustrates a variation on the apparatus of Fig. 6a in which the Tx and Rx communicate directly, wirelessly, and the auxiliary signal transmitter (AST) and Auxiliary Signal Receiver (ASR) communicate in parallel, also wirelessly.

Fig. 6c illustrates a variation on the apparatus of Fig. 6a in which the Tx and
20 Rx communicate directly, wirelessly, and the auxiliary signal transmitter (AST) and Auxiliary Signal Receiver (ASR) communicate in parallel, also wirelessly; also, the Tx and auxiliary signal transmitter (AST) communicate wirelessly between them as do the Rx and Auxiliary Signal Receiver (ASR).

Fig. 7a,7b,7c,7d are simplified illustrations of the frequency behavior effect
25 when using the auxiliary signal apparatuses (AST+ASR). In particular, Fig. 7 shows the system before using the AST+ASR and Figures 7b,7c,7d shows various alternatives of the same system after using the AST+ASR.

Fig. 8 is an illustration of the spectrum usage and allocation, as being changed along the time progress, with an auxiliary signal allocated according to a first
30 embodiment of the present invention.

Fig. 9 is an illustration of the spectrum usage and allocation, as being changed along the time progress, with an auxiliary signal allocated according to a second embodiment of the present invention.

Fig. 10 is an illustration of the spectrum usage and allocation, as being changed along the time progress, with an auxiliary signal allocated according to a second embodiment of the present invention.

Fig. 11 is an illustration of an auxiliary signal allocation according to a third
5 embodiment of the present invention.

Fig. 12 is an illustration of an auxiliary signal allocation according to a fourth embodiment of the present invention.

Fig. 13 is an illustration of an auxiliary signal allocation according to a fifth
10 embodiment of the present invention.

Fig. 14a, 14b, 14c are internal block diagram of an examples of implementation of the Auxiliary Signal Transmitter (AST) portion of the auxiliary signal apparatus comprising an auxiliary Signal generator, according to an embodiment of the present invention.

Figs. 15a, 15b depicts internal block diagram of an example implementation of
15 the Auxiliary Signal Receiver (ASR) portion of the auxiliary signal apparatus comprising an auxiliary Signal receiver, according to an embodiment of the present invention.

Figs. 16, 17 depicts block diagrams of example of implementation of auxiliary signal transmitter (AST)/Auxiliary Signal Receiver (ASR) with the auxiliary signal
20 manipulator/de-manipulator being spreading/de-spreading (spread spectrum) signal according to an embodiment of the present invention.

Figs. 18, 19 depicts block diagrams of example of implementation of auxiliary signal transmitter (AST)/Auxiliary Signal Receiver (ASR) with the auxiliary signal manipulator/de-manipulator being frequency converter according to an embodiment
25 of the present invention.

Figs. 20-21 show embodiments of the present invention which increase power efficiency during usage of the Auxiliary Signal Receiver (ASR).

Fig. 22 is a simplified flowchart illustration of an improved communication method for use cases in which certain portions ("important signal" or "needed
30 signal") of a signal ("original signal") are on the one hand of particular interest in a given situation but on the other hand are not adequately received in that situation.

Computational components described and illustrated herein can be implemented in various forms, for example, as hardware circuits such as but not

limited to custom VLSI circuits or gate arrays or programmable hardware devices such as but not limited to FPGAs, or as software program code stored on at least one intangible computer readable medium and executable by at least one processor, or any suitable combination thereof. A specific functional component may be formed by one
5 particular sequence of software code, or by a plurality of such, which collectively act or behave or act as described herein with reference to the functional component in question. For example, the component may be distributed over several code sequences such as but not limited to objects, procedures, functions, routines and programs and may originate from several computer files which typically operate
10 synergistically.

Data can be stored on one or more intangible computer readable media stored at one or more different locations, different network nodes or different storage devices at a single node or location.

It is appreciated that any computer data storage technology, including any type
15 of storage or memory and any type of computer components and recording media that retain digital data used for computing for an interval of time, and any type of information retention technology, may be used to store the various data provided and employed herein. Suitable computer data storage or information retention apparatus may include apparatus which is primary, secondary, tertiary or off-line; which is of
20 any type or level or amount or category of volatility, differentiation, mutability, accessibility, addressability, capacity, performance and energy use; and which is based on any suitable technologies such as semiconductor, magnetic, optical, paper and others.

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DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

Certain embodiments include an improved mobile and/or cellular and/or wireless communication system particularly suited for use-cases in which certain
30 portions of a signal ("original signal") are on the one hand of particular interest in a given typically ad-hoc situation but on the other hand are not adequately received in that situation. These signal portions of particular interest are termed herein the "important signal" or "needed signal". for example, these portions might currently be utilized for a purpose which differs from the original purpose (e.g. different range,

different channel model, different interference scenario, etc.) envisaged by a particular protocol.

Whether for this reason or any other, these portions are currently being
5 transmitted at a range or noise level for which they are not suited e.g. because the original protocol did not envisage that these portions would be transmitted under these conditions. And/or, for example, these portions are currently being transmitted in the presence of more base stations than originally contemplated or using mobile base stations rather than stationary base stations, and for one or more of these reasons, say,
10 the portions are not being adequately received. It is appreciated that e.g. if transmission of a signal occurs under different conditions than earlier used or envisaged, some (first) components of the signal may be received perfectly adequately (at least for the purpose of a certain use-case) whereas other (second) components of the signal may be received inadequately. Given another use case and/or different
15 conditions, the first components of the signal may be received inadequately (at least for the purpose of the current certain use-case) whereas other (second) components of the signal may be received adequately.

To handle this type of occurrence, an auxiliary signal may be generated to
20 "bridge" between the imperfect abilities of the transmitters in the new situation, and the specific needs of the receivers in the same situation. Typically, the auxiliary signal is generated from the original signal and is transmitted in addition thereto (e.g. simultaneously with) rather than instead of. It can be implemented, e.g., when the important signal is periodic signal such as the case in typical synchronization signals
25 or common broadcast channels of wireless protocols. The functionality which transmits the auxiliary signal is termed herein the AST (auxiliary signal transmitter); the functionality which receives the auxiliary signal is termed herein the ASR (auxiliary signal receiver).

30 The AST may be integrally formed with the Tx (transmitter) or may be separate e.g. retrofit or/and add-on. Similarly, The ASR may be integrally formed with the Rx (receiver) or may be separate e.g. retrofit or/and add-on. The ASR may (Figs. 6a, 6b, 6c) or may not be co-located with the Rx; if it is not then wireless ASR-Rx communication may be provided e.g. as shown in Fig. 6b. Similarly, The AST

may (Figs. 6a, 6c) or may not be co-located with the Tx; if it is not then wireless AST-Tx communication may be provided e.g. as shown in Fig. 6b. However typically, the AST and Tx communication is good enough (e.g. the two device are physically close enough or are communicating under conditions which are good enough) to ensure that the important signal is received accurately by the AST or at least is received well enough to enable the AST to fix the important signal before sending it to the ASR. Similarly, typically, the ASR and Rx communication is good enough (e.g. the two device are physically close enough or are communicating under conditions which are good enough) to ensure that the important signal can be transmitted adequately from the ASR to the Rx.

Co-location of the ASR-Rx (or wireless communication therebetween) is independent of whether or not the AST and Tx are co-located (or have wireless communication therebetween) and vice versa.

Typically, the auxiliary signal is generated from the original signal by suitably augmenting or modifying or enhancing or strengthening the "important signal" within the original signal. The important signal (at least) may pass from the original signal's Tx to the AST either via direct physical connection (e.g. wire) or wirelessly.

According to certain embodiments, e.g. as shown in Figs. 14, 14b, 14c, a needed signal detector receives the original signal from the transmitter and identifies the needed signal therewithin. (The receiver end may also provide information, to the transmitter end, about the extent to which the Rx is or is not receiving these needed component/s successfully e.g. as described in detail below.) The needed signal detector may be pre-programmed or pre-configured to identify the needed signal, or may receive dynamic information identifying needed components for a given dynamic use-case and/or communication situation.

It may be the case that the AST and other components e.g. of fig. 14, 14b, 14c may be programmed differently at different times e.g. re-programmed or dynamically configured over time. The needed signal detector may have different modes of operation, e.g., operational or non-operational, and thereafter it makes one or more blocks within the AST operational or non-operational.

For example, the detector 842 may be pre-programmed, or be dynamically configured, to identify a synchronization signal or a broadcast channel or a control

channel or an uplink map or a downlink map, or any combination thereof, as the needed/important signal.

5 An auxiliary signal generating functionality may receive the needed (i.e. "important") signal from the detector and may determine that the needed signal requires adaptation/enhancement if the needed signal is to be adequately received by the Rx (e.g. it gets feedback from the ASR regarding the reception conditions at the receiver side); the auxiliary signal generating functionality then generates an auxiliary signal which will ensure this. For example, the auxiliary signal generating
10 functionality may use more power to transmit the needed signal and/or may transmit at a frequency (e.g. as shown in Figs. 18 - 19) which is known to provide better reception given the current communication situation and/or may present the needed signal as a different waveform.

15 It is appreciated that the auxiliary signal generating functionality may comprise an auxiliary signal generator 14830 and/or an auxiliary signal manipulator 14831. Typically, generator 14830 generates the auxiliary signal's baseband and the manipulator 18931 performs manipulation on the baseband such as but not limited to any or all of: up frequency conversion, down frequency conversion, spreading of the
20 baseband, increasing the power.

 The baseband generated by generator 14830 may even be identical to that of the original signal. Alternatively, the generator 14830 may use stronger error correction code relative to the original signal, and/or may decrease or otherwise
25 modify modulation, and/or may change the OFDM or PSK or FSK and/or otherwise "strengthen" or provide added robustness to the auxiliary signal's baseband relative to the original signal thereby to allow the auxiliary signal to be received even, say, in noisier (lower SNR) conditions. For example, it is known in the art which type of modulation is suitable for each specific level of SNR. The level of SNR may be
30 known in advance, or received from an external source, or may be received dynamically from the Rx end or may be derived from information received dynamically from the Rx end.

Typically, the auxiliary signal is then transmitted (either on its own or incorporated into the original signal) from the AST e.g. to the ASR (or even direct to the Rx). So, the ASR and/or Rx may receive the original signal and the auxiliary signal, and/or may receive a signal which is similar to the original signal except that the important signal therein is replaced by the auxiliary signal generated by generator 14830.

To allow the auxiliary signal generator 14830 to determine whether or not the needed signal requires adaption, and which adaptation if so, if the needed signal is to be adequately received by the Rx, the Rx may comprise apparatus (incorporated within the AS de-manipulator and/or AS receiver and/or the AST antenna assembly) which may be conventional, for diagnosing quality of reception of the received important signal and how the quality, if low, may be remedied. Known techniques in detection and estimation theory may be employed for this purpose. "Detection and Estimation for Communication and Radar Systems" by Kung Yao, Flavio Lorenzelli and Chiao-En Chen, published January 2013 by Cambridge University Press, describes this known field.

According to certain embodiments, channel information may pass from the ASR back to the AST. If the ASR and AST are respectively close enough to the Rx and Tx such that the Tx-Rx and AST-ASR channels are similar, the channel information reaching the AST will also characterize the Rx-Tx channel.

According to certain embodiments, the AST transmits the auxiliary signal continuously but the ASR only receives when in an active state; this state may be triggered by the receiver 020 if reception of the original signal as a whole or only of the important signal, if known to the receiver, is deemed inadequate. This is advantageous in power-saving use cases e.g. if the receiver is battery-powered (e.g. a mobile phone's receiver).

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It is appreciated that the methods and devices described in co-pending "Partial downlink repeater apparatus and methods useful in conjunction therewith", published as WO 2014068555 A1, may be used as would seem appropriate to the ordinarily skilled man of the art, to implement any of the following: needed signal detector 840

of Fig. 14; auxiliary signal generator 14830 of Fig. 14; auxiliary signal manipulator 14831 and both controllers and summer also in Fig. 14; components 15930, 15935, 15910, 15940 and the controller 970 in Fig. 15a.

5 The terms "channel" (or signal) is on occasion used herein to denote a portion of a signal (of a larger signal). The portion may be a physical portion, contiguous or non-contiguous, e.g. of the time-axis of a signal's frame and/or of the frequency-axis of a signal's frame. The portion may also be defined as a logical portion e.g. a defined item of information whose location within the signal, given a particular protocol, is
10 known. The item of information may comprise actual user data but more typically comprises "protocol meta-data" such as, say, a synchronization signal or control signal e.g. an indication of a broadcast channel, used by the receiver for receiving and extracting the actual user data.

15 Certain example embodiments are now described with reference to the drawings.

 FIG. 1a (Prior Art) depicts a typical wireless communication system comprising a transmitter 010 having a transmitting antenna 015, which transmits a wireless signal 030 through a channel 025. The wireless signal is then received e.g.
20 using a receiving antenna 035 by a receiver 020.

 FIG. 1b depicts a typical cell or other network portion in a wireless e.g. cellular communication system.

 This embodiment typically includes a typical cell or other network portion 100 in a wireless e.g. cellular communication system. A base station 101 transmits and
25 receives signals to and from a plurality of mobile stations within its geographical coverage area. Such mobile stations are noted as 103 and 104. Each mobile station typically transmits an Uplink signal 102b to base station 101, and receives a Downlink signal 102a from base station 101. The communication system may be a cellular system, or alternatively any other wireless network.

30 The wireless (e.g.) communication system may implement one of the cellular standards, one of the wireless communication standards, or may implement some proprietary communication signals and protocols. For example, a cellular communication system may implement the 3GPP LTE standard, the WiMAX standard, the 3GPP WCDMA, HSPA or any other cellular standard. As a further

example, the wireless communication system may implement one of the 802.11 WiFi standards.

Downlink 102a and Uplink 102b signals may be transmitted using TDMA, CDMA, FDMA, OFDMA, or any other method or combination of methods.

5 FIG. 1c depicts a cellular system comprising a plurality of cells, each of the cells e.g. as described above with reference to Fig. 1b.

10 This embodiment typically includes a cellular system comprising a plurality of cells 100, each of which is described above regarding Fig. 1b. Some of the mobile stations may receive the downlink signals from their serving base stations in low quality. Such low quality signals may be caused by multipath, fading, inter-cell interferences, attenuation, or any other cause or combination of such. In such conditions, it may be difficult for the mobile station to maintain proper reception of the downlink signals from the base station.

15 For example, in one of the cells, base station 101 serves the mobile stations 103 and 104, amongst other mobile stations. Mobile station 104 also resides within the geographical coverage area of base station 101a; therefore mobile station 104 receives downlink signals from 2 base stations 101 and 101a, which causes lower quality reception of the desired downlink signal from base station 101.

20 Typically, in a cellular or wireless communication system, some of the downlink or/and uplink transmissions may include portions which are deemed more important or critical than other portions. Such important/critical portions are referred to as "Important signal/s" or "Needed Signal/s" herein below.

25 One example of an Important (or "Needed") signal is downlink synchronization signals, which may be deemed critical for the proper reception of the remaining downlink transmission. Another example is control and management messages, such as but not limited to, for example, the DL-MAP signal in WiMAX, the PDCCH or PBCH signal/channels in LTE and CCPCH signal in 3G UMTS, that the base station sends to the mobile stations; such control and management messages may be deemed critical for proper reception of the downlink transmission.

30 Another example of a signal which may be deemed Important is a portion of a downlink signal addressed to a mobile station which receives the downlink transmission in low quality, as described above. Another example is a portion of a downlink signal addressed to a mobile station which is a preferred mobile station (e.g. is deemed to have greater importance or higher priority over other mobile stations).

Such Important signals may vary from time to time, or from frame to frame. Such variations may be for example in the content (information) carried by the important signal, or in the important signal allocation within the frame. A signal deemed important at time T1, may no longer be deemed important at time T2. A signal deemed important in frame Fm1, may no longer be deemed important in later frame Fm2. Alternatively, the Important signals may be fixed over a sequence of frames or of time, in terms of the important signals' content and/or in terms of important signals' allocation. Further alternatively, the Important signals may vary gradually, for example may be fixed for several consecutive frames and then be deemed to have changed.

Fig. 6a depicts a wireless communication system incorporating an add-on auxiliary signal couple apparatuses at the transmitter 010 side (Auxiliary Signal Transmitter (AST) 620) and at the receiver 020 side (Auxiliary Signal Receiver (ASR) 640) according to an embodiment of the present invention.

Transmitter 010 typically resides in a wireless communication network node, e.g. 101, 103 or 104 of Fig 1b. Receiver 020 typically resides in an additional wireless communication network node. For example, transmitter 010 may reside in mobile node 103 and receiver 020 may reside in base station 101. Typically, transmitter 010 has the capacity to communicate with receiver 020 over channel 025 according to a given communication protocol, e.g. LTE, WiMAX, WiFi, 3G cellular, Bluetooth, etc. The communication protocol may for example be an OFDM, OFDMA, CDMA, TDMA, FDMA protocol. Typically, transmitter 010 has the capacity to communicate with receiver 020 at a given ("original") center frequency.

At the transmitter side an Auxiliary Signal Transmitter (AST) 620 may be added. The interface 610 between the transmitter 010 and the Auxiliary Signal Transmitter (AST) 620 may be optionally at the RF frequency (e.g. the prior antenna interface at high power or at the RF frequency at low power before the power amplifier). Optionally it may be implemented at the IF (intermediate frequency) that may be typically low-power. Optionally it may be implemented at the base-band. At the receiver side, an Auxiliary Signal Receiver (ASR) 640 may be added. Accordingly, the interface between the Auxiliary Signal Receiver (ASR) 640 and the receiver 020 may be optionally in accordance with all the alternatives described above regarding the Auxiliary Signal Transmitter (AST) 620 and the transmitter 010. The function of the Auxiliary Signal Transmitter (AST) is to add the auxiliary signal to the

communication system (which in the illustrated example is wireless but alternatively may be wired) in addition to the original signal. The Auxiliary Signal Transmitter (AST) 620 is then typically connected to a transmitting antenna 622 that typically is suited to the auxiliary signal characteristics, e.g. covers all the shifted frequencies that are implemented by the Auxiliary Signal Transmitter (AST). Optionally, additional components may be added between the Auxiliary Signal Transmitter (AST) and the antenna, e.g. a PA (Power Amplifier) and/or filters. In a similar manner, the receiving antenna 635 also typically is suited to the auxiliary signal characteristics, e.g. covers all the shifted frequencies and then is typically interfaced to Auxiliary Signal Receiver (ASR) 640 which typically receives the auxiliary signal and extracts therefrom the received Important signal or some of its characteristics (also termed herein parameters or features) 650 and then transfers the received signal or its extracted characteristics to the receiver 020. Thereafter, the received important signal 650 is received correctly by the receiver 020. Optionally, additional components may be added between the Auxiliary Signal Receiver (ASR) and the antenna, e.g. a LNA (Low Noise Amplifier) and/or filters.

In Fig. 6a the signal in the air 630 typically includes both the original signal and the auxiliary signal.

Typically, Transmitter 010 and Receiver 020 are standard (e.g. cellular) apparatuses, and may be off-the-shelf equipment operative to communicate with each other.

Typically, when the auxiliary signal center frequency varies along time, the frequency conversion (shift) varies in time, e.g. such that a different frequency shift is performed on the Auxiliary signal (typically not on the original signal) by the Auxiliary Signal Transmitter (AST) and Auxiliary Signal Receiver (ASR) over time, e.g. the alternative center frequency is changed from time to time during the communication between the receiver 020 and the transmitter 010. Optionally, a new frequency shift is performed periodically e.g. every predetermined time interval. Optionally, a new frequency shift is performed non-periodically, e.g. according to a predetermined control. Optionally, a new frequency shift is performed (or the important signal is inserted within the original signal transmission) during non-important signals of the transmission, thus minimizing the interference and the degradation to the received original transmission. Examples for placing a frequency

shift or auxiliary signal/s at non important signals of the original signal/transmission are further described regarding Figures 2-5 below.

Optionally, the frequency shift of the auxiliary signal is taken from a predetermined list of frequency shifts. Further optionally, the frequency shift of the auxiliary signal is selected consecutively from said list. Alternatively, the frequency shift of the auxiliary signal is taken or configured from an external system. Alternatively, the frequency shift is computed according to a predetermined algorithm. Alternatively, an auxiliary Signal generator may generate several signals e.g. simultaneously, and these together may constitute an auxiliary Signal.

Fig. 6b describes an alternative implementation of AST and ASR as separate units with wireless interfaces 1610 and 1650 between the ASR and AST and the transmitter and the receiver. It can be seen that in this system configuration there is the original signal 1630 that is transmitted from the transmitter 010 and the receiver 020, and in addition there is the auxiliary signal 027 that is transmitted between the AST 1620 and ASR 1640. It can be seen that the AST 1620 has its own receiving antenna 1623 that received the transmitted original signal that is received by the AST 1610, and in addition it also has transmitting antenna 1622 that is transmitting the auxiliary signal.

Similarly, the ASR 1640 may typically have two antennas, receiving antenna 1635 for the reception of the auxiliary signal 027 and additional transmitting antenna 1636 for the transmission of the ASR-transmitted important signal 1650.

The auxiliary signal 027 may be with the same characteristics as the important signal within the AST-received original signal 1610. Alternatively, the auxiliary signal 027 may have different characteristics then the AST-received original signal 1610. These characteristics may include modulation, error-correction code, bandwidth, data-rate, power, center frequency, portion of the important signal (physical or logical), etc.

Fig. 6c describes additional implementation of AST and ASR as interfaced units with direct interfaces (e.g. wired - in example copper or optical) between the ASR and AST and the transmitter and the receiver (these direct interfaces are 1611 and 1651). It can be seen that in this system configuration there is the original signal 1630 that is transmitted from the transmitter 010 and the receiver 020, and in addition there is the auxiliary signal 027 that is transmitted between the AST 1621 and ASR 1641. It can be seen that the AST 1621 has direct interface 1611 to the transmitter, in

this interface it received the important signal information. The important signal information may be implemented typically in several alternatives: first example is by transmitting the original signal in this interface 1611 (either in radio frequency [RF], intermediate frequency [IF] or baseband) and then the AST will extract from this
 5 original signal the important signal itself, second example may be by transmitting only the important signal in this interface 1611, third example may be by transferring in this interface 1611 only the data/information that is coded/implemented within the important signal (e.g. all or some of the bits that are coded within the important signal or e.g. the synchronization characteristics of the important signal such as
 10 timing, frequency and gain, etc.). The AST 1621 has also transmitting antenna 1622 that is transmitting the auxiliary signal.

Similarly, the ASR 1640 may typically have receiving antenna 1635 for the reception of the auxiliary signal 027 and additional direct interface 1651 to the receiver 020 for the transmission of the ASR-transmitted important signal
 15 information. Similarly, the ASR-transmitted important signal information may be implemented typically in several alternatives: first example is by transmitting the important signal itself in this interface 1651 (either in radio frequency [RF], intermediate frequency [IF] or baseband), second example may be by transferring in this interface 1651 only the data/information that is coded/implemented within the
 20 important signal (e.g. all or some of the bits that are coded within the important signal or e.g. the synchronization characteristics of the important signal such as timing, frequency and gain, etc.).

The auxiliary signal 027 may be with the same characteristics as the important signal within the AST-received original signal 1610. Alternatively, the auxiliary
 25 signal 027 may have different characteristics than the AST-received original signal 1610. These characteristics may include modulation, error-correction code, bandwidth, data-rate, power, center frequency, portion of the important signal (physical or logical), etc.

It should be noted that figures 6a and 6b and 6c are only some examples of
 30 system configurations for the implementation of auxiliary signal. Any combination of these examples is also an embodiment incorporated. For example, a system with direct interface between the transmitter and the AST (as described in Fig. 6c) and wireless interface between the ASR and the receiver (as described in Fig. 6b). Or alternatively a system with wireless interface between the transmitter and the AST (as

described in Fig. 6b) and direct interface between the ASR and the receiver (as described in Fig. 6c). Or alternatively and combination of transmitter $\leftrightarrow$ AST interface of figures 6a, 6b, 6c and ASR $\leftrightarrow$ receiver interface of figures 6a, 6b, 6c.

5 Figs. 7a – 7b are simplified illustrations of the frequency behavior effect when using the auxiliary signal apparatuses (ASR+AST) in which the auxiliary signal covers portion or all the original signal bandwidth.

Fig. 7a (Prior art) depicts the situation before using the ASR+AST. It may be seen that the original signal 2010 is located at the original center frequency and covers some bandwidth.

10 Fig. 7b depicts the situation after using the ASR+AST, according to an embodiment of the present invention. It can be seen that there are two signals: the original signal 201 and also the auxiliary signal 2020. In this figure it can be seen according to certain embodiments of the invention that the bandwidth of the auxiliary signal covers/occupy the same bandwidth of the original signal. Similarly to Fig. 7b.,
 15 Fig 7c exemplify auxiliary signal 2030 that covers/occupy part of the bandwidth of the original signal. Similarly to Fig. 7b., Fig 7d exemplify auxiliary signal 2040 that occupy bandwidth that is wider than the original signal that covers all the bandwidth of the original signal 2010. Any othe example may also be included in this invention such as auxiliary signal covering part of the bandwidth of the original signal and also
 20 bandwidth outside the original signal. In addition, the auxiliary signal may be continuous in the time domain or may be non-continuous in the time domain. Several example of non-continuous time domain will be presented in the following figures (e.g. 2, 3, 4, 5).

Fig. 2 depicts an OFDMA/OFDM radio frame 200 (either downlink or
 25 uplink), in an OFDMA FDD or TDD communication system implementing auxiliary signal according to certain embodiments of the invention.

This embodiment typically includes an OFDMA (or OFDM) radio downlink frame 200, in an OFDMA (or OFDM) communication system. Frame 200 typically comprises a plurality of OFDM symbols 210 in the time domain, and/or a plurality of
 30 subcarriers 220 in the frequency domain. An optional Gap 201 may be placed between successive frames 200. An optional Cyclic Prefix 203 may be provided e.g. between successive OFDM symbols in the time domain. A basic resource which may be allocated in the downlink transmission frame is resource element 202, which is the transmission of one subcarrier during one OFDM symbol length in time.

In the OFDMA (or OFDM) frame 200 there are several locations (in the frequency/time domains) that the auxiliary signal can be inserted within the original signal, e.g. as described above with reference to Figs. 6a,6b,6c, may be implemented. Each of these locations typically implements a different auxiliary signal appearing rate. For example, the auxiliary signal may be inserted/transmitted during the cyclic prefix (CP) 203 of an OFDM/OFDMA symbol 210. The auxiliary signal may be inserted/transmitted during the cyclic prefix (CP) of every symbol or during the cyclic prefix (CP) of every several symbols. Alternatively, the auxiliary signal may be inserted/transmitted during un-important symbol duration (or during empty symbol – a symbol time that no data is transmitted). Alternatively, the auxiliary signal may be inserted/transmitted during the time gap 201 between consecutive frames. Each of the above examples may be regarded as a "non-important signal" of the transmission, in that improper reception of these signals is not as harmful to the receiver as other (critical/important) signals.

In another embodiment of the present invention which includes an OFDMA radio frame, an OFDMA TDD (Time Division Duplex) communication system add-on auxiliary signal is implemented according to certain embodiments of the invention. In the TDD system, both DL (downlink) and UL (uplink) frames may occupy the same frequency (center frequency) and are typically transmitted alternately. Between each one of these two frames there are typically guard gaps (e.g. between DL and UL, and between UL and DL). In each one, e.g., of these guard gaps the auxiliary signal may be inserted/transmitted. In this implementation, the rate of the auxiliary signal appearance is therefore typically the frames' shift rate. Typically, all locations in the frame described in Fig. 2 may also be used in the TDD system.

Fig. 3 depicts an LTE FDD downlink radio frame (but the embodiments herein may also be implemented similarly also for uplink radio frame) implementing auxiliary signal according to embodiments of the invention. The embodiment of Fig. 3 illustrates an LTE radio downlink (DL) frame 300 which has a duration of, say, 10msec, in an LTE cellular communication system. Frame 300 typically comprises a plurality of LTE physical resource blocks (PRBs) 307 which may for example be a subset of 6 OFDMA symbols in time and 12 sub-carriers in frequency. The DL (downlink) frame also comprises LTE sub-frames such as but not limited to that shown at reference numeral 310 (its duration is, say, 1msec). The LTE DL (downlink) frame in the illustrated embodiment, is of the FDD (Frequency Division Duplex) type,

however TDD (Time Division Duplex) type of DL (downlink) frames may be employed similarly.

As shown, the LTE DL (downlink) frame includes several physical channels or signals e.g. some or all of: Physical DL (downlink) Control Channel (PDCCH) 301, Physical DL (downlink) Shared Channel (PDSCH) 302, Secondary Synchronization Signal (SSS) 303, Primary Synchronization Signal (PSS) 304 and Physical Broadcast Channel (PBCH) 305. Each of these channels or signals or any subset thereof may be deemed critical to LTE system operation.

Since LTE FDD is OFDMA, then the locations for the auxiliary signal in the frame that were described above regarding Fig. 2 may also be used in the LTE FDD system.

A further embodiment of the present invention includes an LTE TDD radio frame implementing add-on auxiliary signal. Since LTE TDD is OFDMA, then all the locations for the auxiliary signal in the frame that were described above regarding OFDMA TDD may also be used in the LTE TDD system.

Fig. 4 depicts a CDMA FDD radio frame (either downlink or uplink), in a CDMA communication system implementing auxiliary signal according to certain embodiments of the invention. In the CDMA frame 400 there are several locations (in the time domain) that the auxiliary signal may be inserted/transmitted. Each of these locations typically implements auxiliary signal appearance rates. For example, the auxiliary signal may be inserted/transmitted during the gap between slots/symbols 403 of a CDMA symbol/slot 410. The auxiliary signal may be inserted/transmitted every symbol/slot or every several symbols/slots. Alternatively, the auxiliary signal may be inserted/transmitted during un-important symbol/slot duration (or during empty symbol/slot – a symbol/slot time that no data is transmitted). Alternatively the auxiliary signal may be inserted/transmitted during the time gap 401 between consecutive frames. Each of the above examples may be regarded as a "non-important signal" of the transmission, in that improper reception of these signals is not as harmful to the receiver as other (critical/important) signals.

Another embodiment of the present invention includes a CDMA TDD radio frame in a CDMA communication system implementing auxiliary signal according to certain embodiments of the invention. In the TDD system, both DL (downlink) and UL (uplink) frames occupy the same frequency (center frequency) and are transmitted alternately. Between each one of these two frames there are typically guard gaps (e.g.

between DL and UL, and/or between UL and DL). In each one, typically, of these guard gaps the auxiliary signal may be implemented. In this implementation, the rate of the auxiliary signal appearance is therefore typically the frames' shift rate. All the locations in the frame that were described in Fig. 4 may also be used in the TDD system.

Fig. 5 depicts a TDMA radio frame, in a TDMA communication system implementing auxiliary signal according to certain embodiments of the invention. In the TDMA frame 500 there are several locations (in the time domain) that the auxiliary signal may be inserted/transmitted. Each of these locations typically implements different auxiliary signal appearance rates. For example, the auxiliary signal may be inserted/transmitted during the gap between slots 503 of a TDMA symbol 510. The auxiliary signal may be inserted/transmitted every slot or every several slots. Alternatively, the auxiliary signal may be inserted/transmitted during un-important slot duration (or during empty slot – a slot time that no data is transmitted). Alternatively, the auxiliary signal may be inserted/transmitted during the time gap 501 between consecutive frames. Each of the above examples may be regarded as a "non-important signal" of the transmission, in that improper reception of these signals is not as harmful to the receiver as other (critical/important) signals.

Figs. 14, 14b, 14c, 16, 18 depicts a more detailed block diagram of an examples of the Auxiliary Signal Transmitter (AST) component of the auxiliary signal apparatus comprising an auxiliary Signal generator, according to further embodiments of the present invention. In this embodiments, Auxiliary Signal Transmitter (AST) 620 comprises a Important Signal detector 840, an Auxiliary Signal Generator 14830, and optionally auxiliary signal manipulator frequencies selector 18860/14831/16831/18831. In the case of an OFDM communication protocol, important signal detector 840 may include OFDM Important Signal Detector, operative to detect predetermined portions of the OFDM signal. Alternatively, in the case of a CDMA communication protocol, important signal Important Signal Detector 840 may include CDMA Important Signal Detector, operative to detect predetermined portions of the CDMA signal. Alternatively, according to the communication protocol and the important signal characteristics, important signal Important Signal Detector 840 is operative to detect and receive the important signal or the important signal information as defined above.

In Fig. 18, typically the important signalImportant Signal Detector 840 is operative to detect and/or receive predetermined portions (e.g. Important Signal) of the relevant communication protocol signal, in example as described above regarding figures 2-6a. Typically, upon detection of said predetermined portion, the important
 5 signalImportant Signal Detector 840 may synchronizes the Auxiliary Signal Frequency Converter 62018831 to perform a change in the alternative center frequency, e.g. to perform a change in the active frequency shift of the auxiliary signal. Auxiliary Signal Frequency Converter 62018831 is the actual component that performs the frequency conversion. The new alternative center frequency may
 10 optionally be determined by a frequencies selector 18860. Further optionally, a controller 870 resides in Auxiliary Signal Transmitter (AST) 620, for controlling the operation of its process. Optionally, the change in the alternative center frequency is made upon several consecutive detections of said predetermined portion. Further optionally, the change in the alternative center frequency is determined by some
 15 predefined criteria taking into account the detection of said predetermined portion.

Optionally, some predetermined portions of the signal, in which the frequency conversion/shift may be implemented or the auxiliary signal may be inserted, are "non-important signals" of the transmission, in that improper reception of these portions/regions is not as harmful to the receiver as other (critical/important) signals.
 20 Some examples of such portions/regions are described above regarding Figures 2-5, and also hereinbelow.

Some examples of the operation of the Important Signal Detector 840 are:

- a. In the case of a OFDM or OFDMA communication protocol, the Important
 25 Signal Detector 840 may be operative to detect the Cyclic Prefix (CP) of the OFDM/OFDMA symbols, and to synchronize the Auxiliary Signal Transmitter 620 to perform a change in the alternative center frequency during the transmission of the CP.
- b. In the case of a frame-based communication protocol, where a GAP or some guard period is placed between successive frames, the Important Signal
 30 Detector 840 may be operative to detect said GAP or guard period, and to synchronize the Auxiliary Signal Transmitter 620 to perform a change in the alternative center frequency during said GAP or guard period.
- c. In the case of a TDD communication protocol, where a GAP or some guard period is placed between the uplink subframe and the downlink subframe, the

Important Signal Detector 840 may be operative to detect said GAP or guard period, and to synchronize the Auxiliary Signal Transmitter 620 to perform a change in the alternative center frequency during said GAP or guard period.

- 5 d. In the case of a frame-based communication protocol, where an empty region (e.g. empty symbol as described above) is placed within the frames, the Important Signal Detector 840 may be operative to detect the empty region, and to synchronize the Auxiliary Signal Transmitter 620 to perform a change in the alternative center frequency during the empty region.
- 10 e. In the case of a frame-based communication protocol, where a preamble or other known signal is placed within the frame, the Important Signal Detector 840 may be operative to detect the preamble or other known signal, and to synchronize the Auxiliary Signal Transmitter 620 to perform a change in the alternative center frequency during non-important signals (e.g. un-important symbol duration as described above).

15

In one embodiment of the present invention, an additional auxiliary signal is transmitted by Auxiliary Signal Transmitter (AST) 620 to be received by Auxiliary Signal Receiver (ASR) 640, e.g. to help Auxiliary Signal Transmitter (AST) 620 and Auxiliary Signal Receiver (ASR) 640 to better coordinate their operation, e.g. as
20 described below. This signal, or any similar signal which facilitates coordination of such operations, may be termed a "additional Auxiliary Signal" signal.

Typically, Auxiliary Signal Transmitter (AST) 620 comprises an auxiliary Signal generator 14830, which generates the Auxiliary signal. Alternatively or in addition, the Auxiliary signal may be generated by an external source.

- 25 Optionally this Auxiliary signal may be predetermined or may vary over time, or have a portion which varies, and another portion which is predetermined.

Typically, the Auxiliary signal is transmitted at a second alternative center frequency. The transmission of the auxiliary signal is in addition to the transmission of the original signal of the communication protocol at the first alternative center
30 frequency. First and second alternative frequencies may be the same frequencies, and may be different frequencies.

Typically, the Auxiliary signal may be used by the Auxiliary Signal Receiver (ASR) to achieve e.g. some or all of the following example objectives:

1. This Auxiliary signal may be used for better frequency estimation and synchronization of the ASR 640 or/and the receiver 020.
2. This Auxiliary signal may be used for better timing estimation and synchronization of the ASR 640 or/and the receiver 020.
- 5 3. This Auxiliary signal may be used for better channel or gain estimation of the ASR 640 or/and the receiver 020.
4. This Auxiliary Signal may be used for delivering control data between the network nodes (e.g. between the Auxiliary Signal Transmitter (AST) and the Auxiliary Signal Receiver (ASR) or/and between the transmitter 010 and the receiver 020). Such control data is, for example, the next frequency shift of the original signal and/or the Auxiliary signal (or the next frequency shifts list) that will be executed by the Auxiliary Signal Transmitter (AST). Another example of such control data is the location within the frame that the frequency shift will occur (examples of such locations/portions are described above with regard to Figures 2-5). Additional information may include other auxiliary signal information as defined/described above.

The Auxiliary Signal Generator 14830 may optionally interface 829 the Important Signal Detector 840 such that relevant inputs from the Important Signal Detector 840 can be provided to the Auxiliary Signal Generator 14830. These inputs and information may for example comprise the inputs described in the examples of the operation of the Important Signal Detector 840 above (such as but not limited to the inputs from the Important Signal Detector 840 to the Auxiliary Signal Transmitter 620).

25 After generating the base-band Auxiliary signal at the Auxiliary Signal Generator 14830, the Auxiliary signal may be manipulated by the Auxiliary Signal Manipulator 14831/16831/18831 18831.

In case that the manipulator is a frequency converter, such as in Fig. 18, the new Auxiliary Signal center frequency may optionally be determined by a frequencies selector 18860. Further optionally, a controller 870 resides in Auxiliary Signal Transmitter (AST) 620, for controlling the operation of its process. Optionally, the change in the alternative Auxiliary Signal center frequency is made upon several consecutive detections of said predetermined portion. Further optionally, the change

in the alternative Auxiliary Signal center frequency is determined by some predefined criteria taking into account the detection of said predetermined portion.

Optionally, the center frequency can be fixed over a period time. Further optionally, the frequency shift of the Auxiliary Signal Transmitter 620 and the
 5 Auxiliary Signal Frequency Converter 18831 are the same (the same frequency that, e.g. the Frequencies Selector provides these two converters at a certain time).

Optionally, said auxiliary signal may be a Continuous Wave (CW), a signal frequency tone, a multiple of tones, or any other predetermined signal. Further optionally, the auxiliary signal may be transmitted periodically.

10 Alternatively, the auxiliary signal may be a modulated signal, carrying information. Such information may be, for example, the current first alternative center frequency, the first alternative center frequency for the next change, the second alternative center frequency for the next change, etc.

15 Fig. 19 depicts a more detailed block diagram of an example of the Auxiliary Signal Receiver (ASR) component of the auxiliary signal apparatus comprising an auxiliary Signal receiver, according to a further embodiment of the present invention. In this embodiment, Auxiliary Signal Receiver (ASR) 640 comprises a Important Signal Detector 17910, an Auxiliary Signal Receiver 15940, and optionally a
 20 frequencies selector 19990. In the case of an OFDM communication protocol, Important Signal Detector 17910 comprises an OFDM synchronization detector, operative to detect predetermined portions of the OFDM signal. Alternatively, in the case of a CDMA communication protocol, Important Signal Detector 17910 comprises a CDMA synchronization detector, operative to detect predetermined
 25 portions of the CDMA signal. Alternatively, according to the communication protocol, Important Signal Detector 17910 is operative to detect and receive predetermined portions of the relevant communication protocol signal.

Typically, Important Signal Detector 17910 is operative to detect predetermined portions of the relevant communication protocol signal in which the
 30 frequency conversion/shift may be realized, as described above regarding figures 2-6a. Typically, upon detection of said predetermined portion, the Important Signal Detector 17910 synchronizes the Auxiliary Signal Receiver 15940 to perform a change in the alternative center frequency, e.g. to perform a change in the active frequency shift. Auxiliary Signal Frequency Converter 19930 is the actual component

that performs the frequency conversion. The new alternative center frequency may optionally be determined by a frequencies selector 19990. Further optionally, a controller 970 resides in Auxiliary Signal Receiver (ASR) 640, for controlling the operation of its process. Optionally, the change in the alternative center frequency is made upon several consecutive detections of said predetermined portion. Further optionally, the change in the alternative center frequency is determined by some predefined criteria taking into account the detection of said predetermined portion.

Optionally, Important Signal Detector 17910 may use the received signal 635 (e.g. the signal which is received at the alternative center frequency) for the purpose of detection and synchronization. Optionally, Important Signal Detector 17910 may use the signal 650 (e.g. the signal which has the original center frequency) for the purpose of detection and synchronization. Further optionally, Important Signal Detector 17910 may use both signals, 635 and 650.

Optionally, said predetermined portions of the signal, in which the frequency conversion/shift may be realized, are "non-important signals" of the transmission, in that improper reception of these portions/regions is not as harmful to the receiver as other (critical) signals. Some examples of such portions/regions are described above regarding Figures 2-5, and also herein below.

Some examples of the operation of the Important Signal Detector 840 are:

- a. In the case of a OFDM or OFDMA communication protocol, the Important Signal Detector 17910 may be operative to detect the Cyclic Prefix (CP) of the OFDM/OFDMA symbols, and to synchronize the Auxiliary Signal Receiver 15940, e.g. to perform a change in the alternative center frequency during the reception of the CP.
- b. In the case of a frame-based communication protocol, where a GAP or some guard period is placed between successive frames, the Important Signal Detector 17910 may be operative to detect said GAP or guard period, and to synchronize the Auxiliary Signal Receiver 15940 to perform a change in the alternative center frequency during said GAP or guard period.
- c. In the case of a TDD communication protocol, where a GAP or some guard period is placed between the uplink subframe and the downlink subframe (or vice versa), the Important Signal Detector 17910 may be operative to detect said GAP or guard period, and to synchronize the Auxiliary Signal Receiver

15940 to perform a change in the alternative center frequency during said GAP or guard period.

- d. In the case of a frame-based communication protocol, where an empty region (e.g. empty symbol as described above) is placed within the frames, the Important Signal Detector 17910 may be operative to detect said empty region, and to synchronize the Auxiliary Signal Receiver 15940 to perform a change in the alternative center frequency during said empty region.
- e. In the case of a frame-based communication protocol, where a preamble or other known signal is placed within the frame, the Important Signal Detector 17910 may be operative to detect the preamble or other known signal, and to synchronize the Auxiliary Signal Receiver 15940 to perform a change in the alternative center frequency during non-important signals (e.g. un-important symbol duration as described above).

Fig. 8 is an illustration of the spectrum usage and allocation, as being changed along the time progress, with an auxiliary signal (AS) allocated according to a first embodiment of the present invention.

Fig. 9 is an illustration of the spectrum usage and allocation, as being changed along the time progress, with an auxiliary signal allocated according to a second embodiment of the present invention.

Fig. 11 is an illustration of an auxiliary signal allocation according to a third embodiment of the present invention.

Fig. 12 is an illustration of an auxiliary signal allocation according to a fourth embodiment of the present invention.

Fig. 13 is an illustration of an auxiliary signal allocation according to a fifth embodiment of the present invention.

Fig. 8 is an illustration of an example of the spectrum usage and allocation, as being changed along the time progress, with an auxiliary signal (AS) allocated according to an embodiment of the present invention. In this example the Auxiliary Signal covers different frequency allocations than the main (=original) signal. This example shows a constant offset of the center frequency of the Auxiliary Signal with respect to the center frequency of the main signal. It can be seen that the Auxiliary Signal and the main signal have the same frequency shifts over time. Optionally, this behavior can be cyclic (if there is a fixed list of frequency shifts of the main signal,

and it is executed in a cyclic order, meaning implementing the frequency shift in a sequential order and that after executing the last frequency shift in the list, the next frequency shift is again the first frequency shift in the list). Optionally, the behavior can be non-cyclic (no cyclic order of frequency shifts) and may be determined

5 according a predetermined algorithm. Optionally the frequency shifts enable orthogonal coverage of bandwidths of the main or Auxiliary signals, meaning e.g. that there is no overlap of frequencies (bandwidth wise) between all the bandwidths of the main signal and/or the Auxiliary Signal along the different frequency shifts (as can be seen at time steps "k" to time step "k+4"). Optionally the frequency shifts enable non-

10 orthogonal coverage of bandwidths of the main or Auxiliary signals (as can be seen at time steps "k-1" with respect to time steps "k" and to time step "k+2" because e.g. main signal 1010 at time step "k-1" covers part of the same frequencies as main signal 1011 of time step "k" and main signal 1013 of time step "k+2". Further optionally, the frequency shifts enable a combination of the two frequency shift schemes over time

15 (orthogonal and non-orthogonal). There may be non-constant frequency offset between the Auxiliary signal and the main signal, in other embodiments of present invention.

Fig. 9 is an illustration of an example of the spectrum usage and allocation, as

20 it changes over time, with an auxiliary signal allocated according to an embodiment of the present invention. In this example the Auxiliary Signal covers part of the frequency allocation of the main signal. This example shows the same center frequency or a constant offset of the center frequency of the Auxiliary Signal with respect to the center frequency of the main signal. It can be seen that the Auxiliary

25 Signal and the main signal have the same frequency shifts over time (optionally they may have different frequency shifts). Optionally this behavior can be cyclic (if there is a fixed list of frequency shifts of the main signal, and it is executed in a cyclic order, meaning implementing the frequency shift in a sequential order, and that after executing the last frequency shift in the list, the next frequency shift is again the first

30 frequency shift in the list). Optionally, the behavior can be non-cyclic (no cyclic order of frequency shifts) and may be determined according a predetermined algorithm. Optionally, the frequency shifts enable orthogonal coverage of bandwidths of the main or Auxiliary signals, meaning e.g. that there is no overlap of frequencies (bandwidth wise) between all the bandwidths of the main signal and/or the Auxiliary

Signal along the different frequency shifts (as can be seen at time steps "k" to time step "k+4"). Optionally the frequency shifts enable non-orthogonal coverage of bandwidths of the main or Auxiliary signals (as can be seen at time steps "k-1" with respect to time steps "k+3" and to time step "k+4" because e.g. main signal 1030 at time step "k-1" covers the same frequencies as main signal 1034 of time step "k+3" and main signal 1035 of time step "k+4". Further optionally the frequency shifts enable a combination of the two frequency shift schemes over time (orthogonal and non-orthogonal). There may be non-constant frequency offset between the Auxiliary signal and the main signal, in other embodiments of present invention. The AS can optionally be transmitted during the same time periods that the main signal is transmitted, or further optionally, during only a part of the time periods of the main signal (as will be illustrated in figures 11, 12 and 13 hereunder).

Fig. 10 is an illustration of an example of the spectrum usage and allocation, as it changes along time, with an auxiliary signal allocated according to an embodiment of the present invention. In this example the main/original signal is located at a fixed center frequency (1050-1055) whereas the Auxiliary Signal (1060-1065) is located in the frequency domain at different center frequencies along time. It can be seen that the Auxiliary Signal may have different frequency shifts. Optionally this behavior (frequency shifts) can be cyclic (if there is a fixed list of frequency shifts, and it is executed in a cyclic order, meaning implementing the frequency shift in a sequential order, and that after executing the last frequency shift in the list, the next frequency shift is again the first frequency shift in the list). Optionally, the behavior can be non-cyclic (no cyclic order of frequency shifts) and may be determined according a predetermined algorithm. Optionally, the frequency shifts enable orthogonal coverage of bandwidths of the main and/or Auxiliary signals, meaning e.g. that there is no overlap of frequencies (bandwidth wise) between all the bandwidths of the main signal and/or the Auxiliary Signal along the different frequency shifts (as can be seen at time steps "k" to time step "k+4"). Optionally the frequency shifts enable non-orthogonal coverage of bandwidths of the main or Auxiliary signals (as can be seen at time steps "k-1" with respect to time steps "k+3" and to time step "k+4" because e.g. auxiliary signal 1060 at time step "k-1" covers the same frequencies as auxiliary signal 1064 of time step "k+3" and auxiliary signal 1065 of time step "k+4". Further optionally the frequency shifts enable a combination of the two frequency shift schemes over time (orthogonal and non-orthogonal). There

may be non-constant frequency offset between the Auxiliary signal and the main signal, in other embodiments of present invention. The AS can optionally be transmitted during the same time periods that the main signal is transmitted, or further optionally, during only a part of the time periods of the main signal.

5 Fig. 11 is an illustration of an example of an auxiliary signal allocation according to an embodiment of the present invention. In this example, an auxiliary signal 1310 being transmitted at only a portion of the frame duration (time) of an OFDMA frame 200 is proposed (e.g. at a non-important signal such as un-important symbol duration). The Auxiliary signal, in this example, covers all the bandwidth of
10 the frame/communication protocol. The same may be applied to any frame based communication protocol.

 Fig. 12 is an illustration of an auxiliary signal allocation according to an embodiment of the present invention. In this example, an auxiliary signal 1320 being transmitted at only a portion of the frame duration (time) of an OFDMA frame 200 is
15 proposed, e.g. at the time GAP between frames. The Auxiliary signal, in this example, covers all the bandwidth of the frame/communication protocol. The same may be applied to any frame based communication protocol.

 Fig. 13 is an illustration of an auxiliary signal allocation according to an embodiment of the present invention. In this example, an auxiliary signal 1330 being
20 transmitted at only a portion of the frame duration (time) of an OFDMA frame 200 is proposed (e.g. at a non-important signal such as un-important resource elements). The Auxiliary signal, in this example, covers part of the bandwidth of the frame/communication protocol. The same may be applied to any frame based communication protocol.

25 Fig. 14 presents detailed block diagram of an AST according to certain embodiments which is suitable e.g. for implementation of the system of figure 6a.

 Fig. 14b presents detailed block diagram of AST according to certain embodiments which is suitable e.g. for implementation of the system of figures 6b and 6c.

30 Fig. 14c presents detailed block diagram of AST according to certain embodiments which is suitable e.g. for implementation of the system of figures 6b and 6c to be used for original signal which is according to cellular standard, e.g. the LTE or LTE-advanced standards, wherein the Important Signal Detector is implemented by using cellular (e.g. LTE) modem 849.

Fig. 15a presents detailed block diagram of ASR according to certain embodiments which is suitable e.g. for implementation of the system of figure 6a.

Fig. 15b presents detailed block diagram of ASR according to certain embodiments which is suitable e.g. for implementation of the system of figures 6b and 6c.

Fig. 16 presents detailed block diagram of AST according to certain embodiments which is suitable e.g. for implementation of the system of figure 6a whereas the AS manipulator is executing spreading 16831 (e.g. as done in CDMA or other spread spectrum techniques) to the baseband AS. The spreading may occupy the same bandwidth of the original signal, or only a portion of the bandwidth of the original signal or may be non-overlapping with the bandwidth of the original signal. Figures 7b, 7c and 7d illustrated the frequency domain presentation of this implementation. In this case the optional block of manipulator controller can be spreading controller that for example determines the spreading codes and/or other characteristics of the spreading.

Fig. 17 presents detailed block diagram of ASR according to certain embodiments which is suitable e.g. for implementation of the system of figure 6a whereas the AS de-manipulator is executing de-spreading 17930 (e.g. as done in CDMA or other spread spectrum techniques).

Similar implementation of manipulator as if figs 16-17, mutatis mustandis for doing spreading to the AS for AS-apparatus configurations as depicted in figures 6b and 6c are also incorporated as embodiments of present invention.

Fig. 18 presents detailed block diagram of AST according to certain embodiments which is suitable e.g. for implementation of the system of figure 6a whereas the AS manipulator is executing frequency conversion 18831 to the baseband/IF/RF of the AS. Figures 8, 9, 10, 13 illustrate the frequency domain presentation of this implementation. In this case the optional block of manipulator controller can be frequency selector 18860 that for example determines the frequency shift list, timing of the shift and any other characteristics of the frequency conversion.

Fig. 19 presents a detailed block diagram of an ASR according to certain embodiments which is suitable e.g. for implementation of the system of figure 6a whereas the AS de-manipulator is executing frequency conversion 19930.

Similar implementation of manipulator as if figs 18-19 for doing frequency conversion to the AS e.g. for AS-apparatus configurations as depicted in figures 6b and 6c are also incorporated as embodiments of present invention.

Figs. 20-21 show other embodiments of present invention. These
 5 embodiments increase power efficiency during usage of the ASR. These embodiments described in this paragraph may be applied to the two exemplified auxiliary signal apparatus configurations of figures 20 and 21. When there is adequate reception of the important signal by the receiver, some or all of the ASR blocks (such as De-Manipulator 15990, Auxiliary Signal manipulator 15930, Important Signal Detector
 10 15910 and Auxiliary Signal Receiver 15940) may be disabled, turned-off or at standby mode and therefore consume less power than when fully operational. In these figures it can be seen that some additional blocks may be provided within the receiver 020. The first block is the "important signal within original signal receiver" 20300 whose functionality is to extract and receive the important signal from the reception of
 15 the original received signal. In case of improper reception at the receiver 020 of the important signal from the original signal, block 20300 informs the ASR triggering block 20100 of such an event, and thereafter the ASR Triggerring block 20100 informs/triggers the ASR controller 970 to activate all ASR 1640/1641 blocks to be fully operational and to transfer to the receiver 020 the ASR-received important signal
 20 (and/or important signal information).

Fig. 22 is a simplified flowchart illustration of an improved communication method for use cases in which certain portions ("important signal" or "needed signal") of a signal ("original signal") are on the one hand of particular interest in a given situation but on the other hand are not adequately received in that situation. The
 25 apparatus of the present invention may be dynamic such that the steps of Fig. 22 may be repeated, each time with different auxiliary signal characteristics, for each of a sequence of different situations. The method of Fig. 22 is also suitable for a posteriori use of a communication protocol in a communication situation which does not fully comply with the communication channel model which explicitly or implicitly
 30 underlies the communication protocol. The term "situation" here includes any characteristic of any device or object or event, within the system or external to the system, which causes the communication protocol to work imperfectly for at least certain use cases. For example, the environment or medium may be more urban or suburban or rural than the protocol originally anticipated. And/or the level of

interference or noise may be different e.g. higher than the protocol originally anticipated. And/or the type of equipment may be different than the protocol originally anticipated; for example LTE protocol assumes that base stations are static whereas mobile base stations including moving relays may in fact be in use. And/or
 5 the type of interference may differ from what the protocol originally anticipated e.g. the interference, in practice, may be of CW type or modulated signal interference or adaptive white Gaussian noise interference whereas the protocol did not envisage these types. And/or the range between the transmitting and receiving ends may be different e.g. longer than the protocol originally anticipated e.g. 20 km instead of 10
 10 km, or any other numerical discrepancy which may cause certain portions ("important signal" or "needed signal") of a signal ("original signal") which are of particular interest in a given situation to be less than adequately received in that situation.

The method of Fig. 22 includes some or all of the illustrated self-explanatory steps, suitably ordered e.g. as shown. Each of the steps may be implemented using
 15 any of the embodiments shown and described in detail herein with reference to Figs. 1 – 21. It is appreciated that more generally, references to the important signal herein may as appropriate be replaced by a representation of characteristics of the important signal other than the signal itself e.g. important signal information as described herein.

According to certain embodiments, channel information passes from the ASR
 20 back to the AST and wherein the ASR and AST are respectively close enough to the Rx and Tx such that the Tx-Rx and AST-ASR channels are similar, hence the channel information reaching the AST will also characterize the Rx-Tx channel.

According to certain embodiments, the ASR determines whether to activate and/or to de-activate and/or to put in standby mode one or more of the ASR's internal
 25 blocks based at least in part on the reception quality of the important signal at the ASR.

Also included in the present invention are the following embodiments:

Embodiment 47. A wireless communication system comprising:

at least one wireless communication network node having a capacity for
 30 communicating with at least one additional wireless communication network node at a given center frequency and according to a given wireless communication protocol; and at least one external frequency converter, external to said node, said converter shifting the received signal of said at least one wireless network node from a first alternative center frequency to said given center frequency, wherein said first

alternative center frequency is changed from time to time during communication between said at least one wireless communication network node and said at least one additional wireless communication network node;
and wherein said external frequency converter is operative to receive an auxiliary
5 signal at a second alternative center frequency.

Embodiment 50. A system according to Embodiment 47 or any of the preceding embodiments wherein said external frequency converter comprises an auxiliary Signal receiver operative to receive said auxiliary signal.

10

Embodiment 65. A system according to Embodiment 47 or any of the preceding embodiments wherein said auxiliary signal is received out of the frequency band of the transmission of said communication protocol.

15 Embodiment 66. A system according to Embodiment 47 or any of the preceding embodiments wherein said auxiliary signal is received within the frequency band of the transmission of said communication protocol.

Embodiment 67. A system according to Embodiment 47 or any of the preceding
20 embodiments wherein said auxiliary signal is received continuously whenever said communication protocol is received.

Embodiment 68. A system according to Embodiment 47 or any of the preceding
25 embodiments wherein said auxiliary signal is received only during partial intervals of the transmission of said communication protocol.

Embodiment 69. A system according to Embodiment 47 or any of the preceding
embodiments wherein said auxiliary signal spans over the whole frequency bandwidth as the transmission of said communication protocol.

30

Embodiment 70. A system according to Embodiment 47 or any of the preceding
embodiments wherein said auxiliary signal spans over only partial frequency
bandwidth as the transmission of said communication protocol.

Embodiment 71. A system according to Embodiment 47 or any of the preceding embodiments wherein said auxiliary signal is a CW signal.

Embodiment 72. A system according to Embodiment 47 or any of the preceding
5 embodiments wherein said auxiliary signal is a predetermined signal.

Embodiment 73. A system according to Embodiment 47 or any of the preceding embodiments wherein said auxiliary signal is a single frequency tone.

10 Embodiment 74. A system according to Embodiment 47 or any of the preceding embodiments wherein said auxiliary signal comprises multiple frequency tones.

Embodiment 75. A system according to Embodiment 47 or any of the preceding
15 embodiments wherein said auxiliary signal is received periodically.

Embodiment 76. A system according to Embodiment 47 or any of the preceding
embodiments wherein said auxiliary signal is carrying information.

20 Embodiment 77. A system according to Embodiment 47 or any of the preceding
embodiments wherein said auxiliary signal is a modulated signal carrying
information.

Embodiment 78. A system according to Embodiment 47 or any of the preceding
embodiments wherein said second alternative center frequency is changed from time
25 to time during communication between said at least one wireless communication
network node and said at least one additional wireless communication network node.

Embodiment 79. A system according to Embodiment 76 or any of the preceding
embodiments wherein said information comprises said first alternative center
30 frequency.

Embodiment 80. A system according to Embodiment 76 or any of the preceding
embodiments wherein said information comprises the first alternative center

frequency for the next change. Typically, the Auxiliary Signal carries information of the frequency to be used when the upcoming frequency change occurs.

5 Embodiment 81. A system according to Embodiment 76 or any of the preceding embodiments wherein said information comprises the second alternative center frequency for the next change.

10 Embodiment 82. A system according to Embodiment 78 or any of the preceding embodiments wherein said first and second alternative center frequencies is changed periodically every predetermined time interval.

15 Embodiment 83. A system according to Embodiment 78 or any of the preceding embodiments wherein said first and second alternative center frequencies are taken from a predetermined list of frequencies.

Embodiment 84. A system according to Embodiment 78 or any of the preceding embodiments wherein said first and second alternative center frequencies are computed by the external frequency converter.

20 Embodiment 85. A system according to Embodiment 78 or any of the preceding embodiments wherein said first and second alternative center frequencies are configured by means external to said external frequency converter.

25 Embodiment 86. A system according to Embodiment 78 or any of the preceding embodiments wherein said external frequency converter comprises a Important Signal Detector, operative to detect predetermined portion of the signal of said communication protocol, and to synchronize said change in said first and second alternative center frequencies during said detected portion of the signal.

30 Embodiment 87. A system according to Embodiment 47 or any of the preceding embodiments wherein said communication protocol comprises an LTE cellular communication protocol.

Embodiment 88. A system according to Embodiment 47 or any of the preceding embodiments wherein said communication protocol comprises a 3G cellular communication protocol.

- 5 Embodiment 89. A system according to Embodiment 47 or any of the preceding embodiments wherein said communication protocol comprises a WiMAX cellular communication protocol.

- Embodiment 90. A system according to Embodiment 47 or any of the preceding
10 embodiments wherein said communication protocol comprises an OFDM communication protocol.

- Embodiment 91. A system according to Embodiment 47 or any of the preceding
15 embodiments wherein said communication protocol comprises an OFDMA communication protocol.

- Embodiment 92. A system according to Embodiment 86 or any of the preceding
embodiments and also to Embodiment 90, wherein said predetermined portion is a
Cyclic Prefix of an OFDM symbol.
20

- Embodiment 93. A system according to Embodiment 86 or any of the preceding
embodiments and also to Embodiment 91, wherein said predetermined portion is a
Cyclic Prefix of an OFDMA symbol.

- 25 Embodiment 94. A system according to Embodiment 86, or any of the preceding
embodiments wherein said predetermined portion is a GAP between successive
frames of said communication protocol.

- Embodiment 95. A system according to Embodiment 86, or any of the preceding
30 embodiments wherein said communication protocol is a TDD protocol, and wherein
said predetermined portion is a GAP between the uplink subframe and the downlink
subframe of said communication protocol.

Embodiment 96. A system according to Embodiment 50 or any of the preceding embodiments wherein said Auxiliary Signal receiver uses said auxiliary signal to synchronize the external frequency converter to said first alternative center frequency.

- 5 Embodiment 97. A system according to Embodiment 50 or any of the preceding embodiments wherein said Auxiliary Signal receiver uses said auxiliary signal to configure the external frequency converter to said first alternative center frequency.

- 10 Embodiment 98. A system according to Embodiment 50 or any of the preceding embodiments wherein said Auxiliary Signal receiver uses said auxiliary signal for timing synchronization of the external frequency converter with regard to said communication protocol.

- 15 Embodiment 99. A system according to Embodiment 50 and also to Embodiment 76, or any of the preceding embodiments wherein said Auxiliary Signal receiver extracts said information from said auxiliary signal.

- 20 Embodiment 100. A system according to Embodiment 99 or any of the preceding embodiments wherein said extracted information is used to configure the external frequency converter to said first alternative center frequency.

- 25 Embodiment 101. A system according to Embodiment 50 or any of the preceding embodiments and also to Embodiment 79, wherein said Auxiliary Signal receiver extracts said information from said auxiliary signal, and wherein said extracted information is used to configure the external frequency converter to said first alternative center frequency.

- 30 Embodiment 102. A system according to Embodiment 50 or any of the preceding embodiments and also to Embodiment 80, wherein said Auxiliary Signal receiver extracts said information from said auxiliary signal, and wherein said extracted information is used to configure the external frequency converter to said first alternative center frequency for the upcoming (e.g. next) change.

Embodiment 103. A system according to Embodiment 50 and also to Embodiment 81, or any of the preceding embodiments wherein said Auxiliary Signal (AS) receiver extracts said information from said auxiliary signal, and wherein said extracted information is used to configure the external frequency converter to said second
5 alternative center frequency for the upcoming (e.g. next) change.

It is appreciated that a single node may include transmitter, receiver, ASR, AST or any sub-combination thereof.

It is appreciated that terminology such as "mandatory", "required", "need" and "must" refer to implementation choices made within the context of a particular
10 implementation or application described herewithin for clarity and are not intended to be limiting since in an alternative implantation, the same elements might be defined as not mandatory and not required or might even be eliminated altogether.

It is appreciated that software components of the present invention including programs and data may, if desired, be implemented in ROM (read only memory) form
15 including CD-ROMs, EPROMs and EEPROMs, or may be stored in any other suitable typically non-transitory computer-readable medium such as but not limited to disks of various kinds, cards of various kinds and RAMs. Components described herein as software may, alternatively, be implemented wholly or partly in hardware, if desired, using conventional techniques. Conversely, components described herein as
20 hardware may, alternatively, be implemented wholly or partly in software, if desired, using conventional techniques.

Included in the scope of the present invention, inter alia, are electromagnetic signals carrying computer-readable instructions for performing any or all of the steps of any of the methods shown and described herein, in any suitable order; machine-
25 readable instructions for performing any or all of the steps of any of the methods shown and described herein, in any suitable order; program storage devices readable by machine, tangibly embodying a program of instructions executable by the machine to perform any or all of the steps of any of the methods shown and described herein, in any suitable order; a computer program product comprising a computer useable
30 medium having computer readable program code, such as executable code, having embodied therein, and/or including computer readable program code for performing, any or all of the steps of any of the methods shown and described herein, in any suitable order; any technical effects brought about by any or all of the steps of any of the methods shown and described herein, when performed in any suitable order; any

suitable apparatus or device or combination of such, programmed to perform, alone or in combination, any or all of the steps of any of the methods shown and described herein, in any suitable order; electronic devices each including a processor and a cooperating input device and/or output device and operative to perform in software
5 any steps shown and described herein; information storage devices or physical records, such as disks or hard drives, causing a computer or other device to be configured so as to carry out any or all of the steps of any of the methods shown and described herein, in any suitable order; a program pre-stored e.g. in memory or on an information network such as the Internet, before or after being downloaded, which
10 embodies any or all of the steps of any of the methods shown and described herein, in any suitable order, and the method of uploading or downloading such, and a system including server/s and/or client/s for using such; and hardware which performs any or all of the steps of any of the methods shown and described herein, in any suitable order, either alone or in conjunction with software. Any computer-readable or
15 machine-readable media described herein is intended to include non-transitory computer- or machine-readable media.

Any computations or other forms of analysis described herein may be performed by a suitable computerized method. Any step described herein may be computer-implemented. The invention shown and described herein may include (a)
20 using a computerized method to identify a solution to any of the problems or for any of the objectives described herein, the solution may include at least one of a decision, an action, a product, a service or any other information described herein that impacts, in a positive manner, a problem or objectives described herein; and (b) outputting the solution.

25 The scope of the present invention is not limited to structures and functions specifically described herein and is also intended to include devices which have the capacity to yield a structure, or perform a function, described herein, such that even though users of the device may not use the capacity, they are, if they so desire, able to modify the device to obtain the structure or function.

30 Features of the present invention which are described in the context of separate embodiments may also be provided in combination in a single embodiment.

For example, a system embodiment is intended to include a corresponding process embodiment. Also, each system embodiment is intended to include a server-centered "view" or client centered "view", or "view" from any other node of the

system, of the entire functionality of the system , computer-readable medium, apparatus, including only those functionalities performed at that server or client or node.

Conversely, features of the invention, including method steps, which are
5 described for brevity in the context of a single embodiment or in a certain order may be provided separately or in any suitable subcombination or in a different order. "e.g." is used herein in the sense of a specific example which is not intended to be limiting. Devices, apparatus or systems shown coupled in any of the drawings may in fact be integrated into a single platform in certain embodiments or may be coupled via any
10 appropriate wired or wireless coupling such as but not limited to optical fiber, Ethernet, Wireless LAN, HomePNA, power line communication, cell phone, PDA, Blackberry GPRS, Satellite including GPS, or other mobile delivery. It is appreciated that in the description and drawings shown and described herein, functionalities described or illustrated as systems and sub-units thereof can also be provided as
15 methods and steps therewithin, and functionalities described or illustrated as methods and steps therewithin can also be provided as systems and sub-units thereof. The scale used to illustrate various elements in the drawings is merely exemplary and/or appropriate for clarity of presentation and is not intended to be limiting.

CLAIMS

1. An improved mobile and/or cellular and/or wireless communication method particularly suited for use-cases in which certain portions ("important signal" or
5 "needed signal") of a signal ("original signal") are on the one hand of particular interest in a given situation but on the other hand are not adequately received in that situation, the method comprising:
generating an auxiliary signal operative e.g. to bridge between at least one imperfect ability of the transmitters in the situation, and specific needs of the receivers
10 in the situation, and/or to improve reception of at least one of: the important signal and important signal information; and
transmitting at least the auxiliary signal to the receiving end such that a representation of characteristics of the important signal, comprising at least one of: the important signal itself and important signal information characterizing the
15 important signal, is replaced or enhanced or augmented by the auxiliary signal, at the receiving end.
2. A method according to claim 1 wherein the generating and transmitting are performed a plurality of times for a plurality of given situations respectively.
20
3. A method according to claim 1 wherein the generating and transmitting are performed using a protocol whose operation was designed assuming a different situation such that the protocol is imperfect in the given situation.
25
4. A method according to any of the preceding claims or claim 1 wherein the auxiliary signal is generated from the original signal and/or from the important signal and is transmitted in addition thereto.
- 30 5. A method according to any of the preceding claims or claim 4 wherein the auxiliary signal is generated from the original signal and/or from the important signal and is transmitted simultaneously therewith.

6. A method according to any of the preceding claims wherein the auxiliary signal is generated and transmitted by an AST and wherein AS-Tx (transmitter to AST) communication is good enough (e.g. the two device are physically close enough or are communicating under conditions which are good enough) to ensure that the
5 important signal is received accurately by the AST or at least is received well enough to enable the AST to fix the important signal before sending it to the ASR.

7. A method according to any of the preceding claims wherein the auxiliary signal is received by an ASR and wherein the ASR-Rx (ASR to receiver) communication is
10 good enough (e.g. the two device are physically close enough or are communicating under conditions which are good enough) to ensure that the important signal can be transmitted adequately from the ASR to the Rx.

8. A method according to any of the preceding claims wherein the auxiliary signal
15 is generated from the original signal and/or from the important signal by suitably augmenting or modifying or strengthening the "important signal" within the original signal.

9. A method according to any of the preceding claims wherein the important
20 signal (at least) may pass from the original signal's Tx to the AST wirelessly.

10. A method according to any of the preceding claims wherein the Tx and AST are co-located.

25 11. A method according to any of the preceding claims or claim 6 wherein the AST includes a needed (e.g. important) signal detector which is pre-programmed to identify the needed (e.g. important) signal within the original signal.

12. A method according to any of the preceding claims wherein the AST includes
30 a needed (e.g. important) signal detector which is programmed to receive dynamic information identifying needed components for a given dynamic use-case and/or communication situation and to use said dynamic information to identify the needed signal within the original signal.

13. A method according to any of the preceding claims wherein the AST includes an auxiliary signal generating functionality operative to receive the needed (i.e. "important") signal from the detector 842 and to determine that the needed signal requires adaption if the needed signal is to be adequately received by the Rx; the auxiliary signal generating functionality then generates an auxiliary signal which will ensure this.

14. A method according to any of the preceding claims or claim 13 wherein the auxiliary signal generating functionality ensures this by performing at least one of:

10 use more power to transmit the needed signal;

transmit at a frequency which is known, given the current communication situation, to provide adequate reception or better reception (relative to a frequency stipulated in a protocol used to transmit the original signal whose underlying assumptions differ from the current situation);

15 present the needed signal as a different waveform; and

transmit using different antenna configuration or multi antenna scheme.

15. A method according to any of the preceding claims or claim 13 wherein the auxiliary signal generating functionality comprises an auxiliary signal generator operative to generate the auxiliary signal's baseband .

20

16. A method according to any of the preceding claims or claims 13 – 25 wherein the auxiliary signal generating functionality comprises an auxiliary signal manipulator which performs manipulation on the baseband and/or intermediate frequency (IF) and/or radio frequency (RF) at the output of the auxiliary signal generating functionality.

25

17. A method according to any of the preceding claims or claim 16 wherein said manipulation includes at least one of:

30 up frequency conversion,

down frequency conversion,

frequency hopping,

spreading (spread spectrum),

increasing the power at which the auxiliary signal is transmitted, and

transmitting using adequate antenna configuration or multi antenna scheme.

18. A method according to any of the preceding claims wherein the auxiliary
5 signal generator provide added robustness to the auxiliary signal's baseband relative to the original signal by performing at least one of:

using better error correction code relative to the original signal e.g. error
correction code which is better, in the given communication situation, than the error
correction code mandated by a protocol used to transmit the original signal,

10 decreasing or otherwise modifying modulation of original signal,
changing the OFDM or PFK or FSK;

using adequate antenna configuration or multi antenna scheme e.g.
configuration or scheme adequate for the given situation e.g. as opposed to the
configuration or scheme mandated by a protocol used to transmit the original signal.

15

19. A method according to any of the preceding claims or claim 15 or 18 wherein
the auxiliary signal generator knows that the auxiliary signal needs to be received in
an inferior situation which is noisier (lower SNR) and/or suffers from more
interference and/or from lower SINR) than the original signal was planned to be
20 received in and wherein the auxiliary signal generator selects at least one
characteristic for the auxiliary signal which is suitable for the specific level of SNR
or/and SINR and/or interference characterizing the inferior situation.

20. A method according to any of the preceding claims or claim 19 wherein the
25 level of SNR or/and SINR is known in advance.

21. A method according to any of the preceding claims or claim 19 wherein the
level of SNR or/and SINR is received from an external source.

30 22. A method according to any of the preceding claims or claim 19 wherein the
level of SNR or/and SINR is received dynamically from the Rx end.

23. A method according to any of the preceding claims or claim 19 wherein the level of SNR or/and SINR is derived from information received dynamically from the Rx end.

5 24. A method according to any of the preceding claims wherein the receiving end comprises apparatus for diagnosing quality of reception of the received important signal and how the quality, if low, may be remedied.

25. A method according to any of the preceding claims wherein channel
10 information passes from the ASR back to the AST and wherein the ASR and AST are respectively close enough to the Rx and Tx such that the Tx-Rx and AST-ASR channels are similar, hence the channel information reaching the AST will also characterize the Rx-Tx channel.

15 26. A method according to any of the preceding claims or claim 6 wherein the AST transmits the auxiliary signal continuously.

27. A method according to any of the preceding claims or claim 7 wherein the ASR only receives when in an active state.

20

28. A method according to any of the preceding claims or claim 27 wherein said active state is triggered by the receiver if reception of the original signal as a whole or only of the important signal, if known to the receiver, is deemed inadequate.

25 29. A method according to any of the preceding claims or claim 27 or 28 wherein the receiver is battery-powered.

30. A method according to any of the preceding claims or claim 24 wherein the ASR determines whether to activate and/or to de-activate and/or to put in standby
30 mode one or more of the ASR's internal blocks based at least in part on the reception quality of the important signal at the ASR.

31. A method according to claim 2 wherein at least one characteristic of the auxiliary signal changes each time the the generating and transmitting are performed,

as a function of the plurality of given situations respectively, thereby to bridge between imperfect abilities of the transmitters which may differ over the plurality of situations, and specific needs of the receivers which may differ over the plurality of situations.